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Economic and Engineering Analyses of the Proposed §316(b) New Facility Rule

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Chapter 1: Introduction and Overview

Introduction

EPA is proposing regulations implementing Section 316(b) of the Clean Water Act (CWA) for new facilities (33 U.S.C. 1326(b)). The proposed rule would establish national requirements applicable to the location, design, construction, and capacity of cooling water intake structures (CWISs) at new facilities. The proposed national requirements would minimize the adverse environmental impact associated with the use of these structures. CWISs may cause adverse impact due to impingement (where fish and other aquatic life are trapped on equipment at the entrance to CWISs) and entrainment (where aquatic organisms, eggs, and larvae are taken into the cooling system, passed through the heat exchanger, and then pumped back out with the discharge from the facility).

EPA is developing these regulations pursuant to a Consent Decree entered on October 10, 1995 in Cronin v. Reilly,[1] a lawsuit brought against the Agency by a coalition of individuals and environmental groups headed by the Riverkeeper (formerly known as the Hudson Riverkeeper). With this rule, EPA will establish best technology available (BTA) standards for new facilities which are point sources under the CWA and which will operate CWISs that withdraw water used for cooling purposes from a water of the United States.

Not covered under this proposed regulation are existing facilities operating CWISs, including existing facilities proposing substantial additions or modifications to their operations. These facilities will be addressed by a separate rule.

Chapter Contents

1.1 Scope of the Proposed Regulation

The *Economic and Engineering Analyses of the Proposed §316(b) New Facility Rule* (EEA) assesses the economic impacts of the proposed §316(b) New Facility Rule. Facilities covered under this regulation include any facility that meets the "new facility" criteria established for this regulation, is considered a point source under Sections 301 or 306 of the CWA, and proposes to operate a CWIS that will withdraw water for cooling purposes from a water of the United States.

For this proposed regulation, EPA divided new facilities into two groups:

- ***Electric generators:*** these are new facilities engaged in the generation of electricity using a steam electric prime mover; and
- ***Manufacturing facilities:*** these are new facilities engaged in a primary economic activity other than electricity generation.

EPA estimates 40 new electric generators and 58 new manufacturing facilities will be subject to the proposed §316(b) New Facility Rule over the next 20 years.

[1] United States District Court, Southern District of New York, 93 Civ. 0314 (AGS).

1.2 Definitions of Key Concepts

This EEA presents EPA's analyses of costs, benefits, and potential economic impacts as a result of the proposed §316(b) regulation. In addition to important economic concepts, which will be presented in the following chapters, understanding this document requires familiarity with a few key concepts applicable to CWA §316(b) and this regulation. This section defines these key concepts.

- ***Cooling Water Intake Structure (CWIS):*** The total physical structure and any associated constructed waterways used to withdraw from a water of the U.S., provided at least twenty-five percent of the water withdrawn is used for cooling purposes. The CWIS extends from the point at which water is withdrawn from the water source to the first intake pump or series of pumps.

- ***Entrainment:*** The incorporation of fish, eggs, larvae, and other plankton with intake water flow entering and passing through a CWIS and into a cooling water system.

- ***Impingement:*** The entrapment of aquatic organisms on the outer part of an intake structure or against screening devices during periods of intake water withdrawal.

- ***Manufacturing Facility.*** An establishment engaged in the mechanical or chemical transformation of materials or substances into new products. Manufacturing facilities are classified under Standard Industrial Classification (SIC) Codes 20 to 39 (U.S. DOL, 2000).

- ***New Facility.*** Any building, structure, facility, or installation which meets the definition of a "new source" or "new discharger" in 40 CFR 122.2 and 122.29(b)(1), (2), and (4); commences construction after the effective date of this rule; and has a new or modified CWIS.

- ***Steam-Electric Generator.*** A facility employing one or more generating units in which the prime mover is a steam turbine. The turbines convert thermal energy (steam or hot water) produced by generators or boilers to mechanical energy or shaft torque. This mechanical energy is used to power electric generators, which convert the mechanical energy to electricity, including combined cycle electric generating units. Electric generators are classified under SIC Major Group 49 (*Electric, Gas, And Sanitary Services*).

1.3 Summary of the Proposed Regulation

Section §316(b) is already in effect, but in the absence of national standards, the implementation has varied widely. The proposed §316(b) New Facility Rule establishes a national framework that would set minimum compliance requirements for the location, design, construction, and capacity of CWISs for new facilities. Facilities are subject to the rule only if they meet the following criteria:

- they use a CWIS to withdraw from a water of the U.S.;

- they have or require a National Pollutant Discharge Elimination System (NPDES) permit issued under section 402 of the Clean Water Act (CWA);

- they have a design intake flow of greater than two million gallons per day (MGD); and

- they use at least twenty-five percent of the water withdrawn for cooling purposes.

The specific requirements of the proposed rule depend on the location of the CWIS and address three of its primary characteristics: (1) design intake flow; (2) design intake velocity, and (3) technologies that minimize I&E of fish eggs and larvae and maximize survival of impinged adult and juvenile fish ("other §316(b) technologies"). The proposed rule also provides for additional, site-specific, requirements defined by the Director.[2]

The following subsections discuss the role of location in the proposed §316(b) New Facility Rule and present the specific BTA standards required under the rule.

a. Location

Location is generally considered one of the most important factors in a CWIS's potential to cause AEI. Everything else being equal, CWISs located in biologically sensitive areas are much more likely to impinge and entrain aquatic organisms than CWISs located in less sensitive areas. As a result, the specific combination of flow, velocity, and technology requirements under the proposed rule depends on the location of the CWIS. Two aspects of location are important: (1) the type of water body from which a facility proposes to draw water, and (2) the proximity of the CWIS to biologically sensitive areas within the water body.

[2] The term "Director" means the State or Tribal Director where there is an approved National Pollutant Discharge Elimination System (NPDES) State or Tribal program, and the Regional Administrator where EPA administers the NPDES program in the State.

❖ *Water body type*

Different types of water bodies have different biological and ecological characteristics and will experience varied impacts from the withdrawal of water by CWISs. The proposed rule groups water bodies into four categories: (1) freshwater rivers or streams, (2) lakes or reservoirs, (3) tidal rivers or estuaries, and (4) oceans. The proposed compliance requirements vary by water body type, with the most sensitive water body types having the most stringent requirements. For the purposes of this rule, these water body types are defined as follows:

- ***Freshwater river or stream*** means a lotic (free-flowing) system that does not receive significant inflows of water from oceans or bays due to tidal action.
- ***Lake*** means any inland body of open water with some minimum surface area free of rooted vegetation and with an average hydraulic retention time of more than seven days. Lakes might be natural water bodies or impounded streams, usually fresh, surrounded by land or by land and a man-made retainer (e.g., a dam). Lakes might be fed by rivers, streams, springs, and/or local precipitation. ***Reservoir*** means any natural or constructed basin where water is collected and stored.
- ***Tidal river*** means the most seaward reach of a river or stream where the salinity is less than or equal to 0.5 parts per thousand (by mass) at a time of annual low flow and whose surface elevation responds to the effects of coastal lunar tides. ***Estuary*** means all or part of the mouth of a river or stream or other body of water having an unimpaired natural connection with open seas and within which the sea water is measurably diluted with fresh water derived from land drainage. The salinity of an estuary exceeds 0.5 parts per thousand (by mass), but is less than 30 parts per thousand (by mass).
- ***Ocean*** means marine open coastal waters with a salinity greater than or equal to 30 parts per thousand (by mass).

Tidal rivers and estuaries are generally considered the most sensitive biological areas among the different water body types. The potential for environmental impact, and therefore the stringency of compliance requirements, for CWISs located in freshwater rivers and streams, lakes and reservoirs, or oceans depends on the specific placement of the CWIS's opening in the source water body. This aspect of location is discussed in the next subsection.

❖ *Proximity to biologically sensitive areas*

In addition to the type of water body, the requirements of the proposed §316(b) New Facility Rule for all water body types except tidal rivers/estuaries depend on the proximity of the CWIS to areas of high biological productivity. This proposed rule considers the littoral zone of a water body to be the area of highest biological productivity. The littoral zone is defined as the area where the physical, chemical, and biological attributes of aquatic systems promote the congregation, growth, and propagation of individual aquatic organisms, including egg, larvae, and juvenile stages.[3]

All parts of tidal rivers and estuaries have the potential for high biological productivity. Therefore, this rule only establishes one set of requirements for CWISs located within these areas. Facilities proposing to locate on a tidal river or estuary are subject to the most stringent set of requirements and are required to employ the broadest suite of technologies.

The term "littoral zone" in a freshwater river/stream or a lake/reservoir is defined as any nearshore area extending from the level of highest seasonal water to (1) the deepest point at which submerged aquatic vegetation can be sustained (the photic zone extending from shore to the substrate receiving one percent of incident light); or (2) where there is a significant change in slope that causes changes in the habitat and/or community structure); or (3) where there is a significant change in the composition of the substrate (e.g., cobble to sand, sand to mud). For freshwater rivers/streams and lakes/reservoirs, the proposed rule defines three categories of proximity to the littoral zone:

- ***Category 1*** establishes requirements for CWISs located *at least 50 meters outside the littoral zone*. CWISs that meet this location criterion are subject to the least stringent set of compliance requirements among the three categories.
- ***Category 2*** establishes requirements for CWISs located *less than 50 meters outside but not inside the littoral zone*. The requirements for Category 2 CWISs are more stringent than those for Category 1 CWISs.
- ***Category 3*** establishes requirements for CWISs located *in the littoral zone*. CWISs that meet this location criterion are subject to the most stringent set of minimum requirements among the three categories.

In oceans, the littoral zone encompasses the photic zone of the neritic region. Neritic waters are those over the continental shelf and include the areas of marine fish and

[3] For the purposes of determining the costs of the proposed §316(b) New Facility Rule, EPA assumed that the littoral zone of freshwater rivers and streams, lakes and reservoirs, and oceans begins at the shore and extends for 25 meters into the water body.

mammal migrations. The photic zone of neritic waters includes those areas that are sufficiently shallow and clear, and allow for light penetration sufficient to support primary productivity. This rule defines two categories of proximity to the littoral zone for CWISs proposing to withdraw cooling water from oceans:

- ***Category 1*** addresses CWISs located *outside the littoral zone*. CWISs in this category have less stringent standards than CWISs located in Category 2.

- ***Category 2*** addresses CWISs located *inside the littoral zone*. These CWISs are subject to the most stringent set of requirements among facilities proposing to withdraw water from oceans.

b. BTA Standards for the Proposed Rule

The proposed §316(b) New Facility Rule specifies a number of standards to minimize AEI. To enhance the economic efficiency of the rule, EPA designed these standards to give facilities maximum flexibility in meeting the regulatory requirements while at the same time achieving the goals of CWA §316(b). The combination and stringency of the compliance requirements depends on the locational variables discussed in the previous section. The proposed approach allows for a trade-off between locational characteristics of a CWIS and most of the other requirements discussed in this section. In general, EPA considers tidal rivers, estuaries, and the littoral zone of freshwater rivers/streams, lakes/reservoirs, and oceans as sensitive biological areas requiring the most stringent BTA requirements.

❖ *Design intake flow*

Intake flow refers to the volume of water that is withdrawn through the intake structure. Apart from location, the intake flow of a CWIS is the primary factor affecting the entrainment of organisms. Organisms entrained include small fish and immature life stages (eggs and larvae) of many species that lack sufficient mobility to move away from the area of the intake structure. Limiting the volume of the water withdrawn from a water body can limit the potential for these organisms to be entrained.

Design intake flow standards restrict the maximum flow a facility may withdraw from a water body. The proposed rule includes two restrictions on intake flows. First, it sets maximum flow rates relative to the flow of the source water body. These flow rates are expressed as a percentage of the water bodies' mean annual flow or volume and, for freshwater rivers and streams, as a percentage of the 7-day low flow for a period of 10 years (7Q10). Second, for some water body type/proximity to the littoral zone combinations, the proposed rule requires that facilities reduce their intake flow to a level that is commensurate with that which could be attained by a closed-cycle recirculating cooling system.

The specific requirements for design intake flow depend on the type of water body and the CWIS's proximity to the water body's littoral zone. These requirements are presented in Figure 1-1 below.

❖ *Design intake velocity*

Velocity refers to the speed with which water is drawn into a CWIS. Apart from location, intake velocity is the primary factor that affects the impingement of fish and other aquatic biota. Two measures of velocities are important in the design of a CWIS: approach velocity is the velocity measured just in front of the screen face or at the opening of the CWIS; through-screen or through-technology velocity is the velocity that is measured through the screen face or just as the organisms are entering the technology.

For most locations, a design intake velocity requirement would restrict the through-screen or through-technology velocity to 0.5 feet per second. Only CWISs located at least 50 meters from the littoral zone of a lake or reservoir would not be subject to a velocity standard.

❖ *Other §316(b) technologies*

The §316(b) New Facility Rule recognizes that it is not always possible for facilities to locate CWISs in areas outside of sensitive biological areas. The proposed rule therefore allows facilities to locate CWISs in sensitive biological areas, as long as they implement additional technologies that help reduce the impact on the aquatic environment. Such other §316(b) technologies include measures that minimize I&E of fish, eggs, and larvae, and technologies that maximize survival of impinged adult and juvenile fish.

Examples of technologies that minimize I&E include technologies that reduce intake velocities so that ambient currents can carry the organisms past the opening of the CWIS; intake screens such as fine mesh screens and Gunderbooms that exclude smaller organisms from entering the CWIS; passive intake systems such as wedge wire screens, perforated pipes, porous dikes, and artificial filter beds; and diversion and/or avoidance systems that serve to guide fish away from the intake before they are impinged or entrained. Examples of technologies that maximize survival of organisms after they have been impinged include fish handling systems such as bypass systems, fish buckets, fish baskets, fish troughs, fish elevators, fish pumps, spray wash systems, and fish sills. These technologies either prevent impingement by diverting organisms away from the CWIS or increase survival of impinged organisms by collecting them off the intake screens, protecting them from further damage, and transferring them back to the source water.

❖ *Additional requirements defined by the Director*

The proposed §316(b) New Facility Rule gives the Director discretionary authority to include more stringent permit conditions, in addition to the minimum requirements of the rule, that are reasonably necessary to minimize adverse environmental impact caused by a CWIS.

Figure 1-1 displays the framework for EPA's proposed §316(b) New Facility Rule.

Figure 1-1: Section 316(b) New Facility Rule Framework

STANDARDS FOR CWISs LOCATED IN A FRESHWATER RIVER OR STREAM

Where CWIS Is Located at Least 50 Meters Outside the Littoral Zone In a Freshwater River or Stream

Total design intake flow of no more than the more stringent of 5% of the source water mean annual flow or 25% of the source water 7Q10
and
Maximum design intake velocity no more than 0.5 ft/s
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

Where CWIS Is Located Less Than 50 Meters Outside the Littoral Zone In a Freshwater River or Stream

Total design intake flow of no more than the more stringent of 5% of the source water mean annual flow or 25% of the source water 7Q10
and
Maximum design intake velocity no more than 0.5 ft/s
and
Reduce intake flow to a level commensurate with that which could be attained by a closed-cycle recirculating cooling water system
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

Where CWIS Is Located Inside the Littoral Zone In a Freshwater River or Stream

Total design intake flow of no more than the more stringent of 5% of the source water mean annual flow or 25% of the source water 7Q10
and
Maximum design intake velocity no more than 0.5 ft/s
and
Reduce intake flow to a level commensurate with that which could be attained by a closed-cycle recirculating cooling water system
and
Implement additional technologies that minimize impingement and entrainment of fish eggs and larvae and maximize survival of impinged adult and juvenile fish
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

STANDARDS FOR CWISs LOCATED IN A LAKE OR RESERVOIR

Where CWIS Is Located at Least 50 Meters Outside the Littoral Zone In a Lake or Reservoir

Total design intake flow must not upset the natural stratification of the source water
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

Where CWIS Is Located Less Than 50 Meters Outside the Littoral Zone In a Lake or Reservoir

Total design intake flow must not upset the natural stratification of the source water
and
Maximum design intake velocity no more than 0.5 ft/s
and
Reduce intake flow to a level commensurate with that which could be attained by a closed-cycle recirculating cooling water system
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

Where CWIS Is Located Inside the Littoral Zone In a Lake or Reservoir

Total design intake flow must not alter the natural stratification of the source water
and
Maximum design intake velocity no more than 0.5 ft/s
and
Reduce intake flow to a level commensurate with that which could be attained by a closed-cycle recirculating cooling water system
and
Implement additional technologies that minimize impingement and entrainment of fish eggs and larvae and maximize survival of impinged adult and juvenile fish
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

STANDARDS FOR CWISs LOCATED IN AN ESTUARY OR TIDAL RIVER

Where CWIS Is Located Anywhere In an Estuary or Tidal River

Total design intake volume must be no more than 1% of the volume of the water column in the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water
and
Maximum design intake velocity no more than 0.5 ft/s
and
Reduce intake flow to a level commensurate with that which could be attained by a closed-cycle recirculating cooling water system
and
Implement additional technologies that minimize impingement and entrainment of fish eggs and larvae and maximize survival of impinged adult and juvenile fish
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

STANDARDS FOR CWISs LOCATED IN THE OCEAN

Where CWIS Is Located Outside the Littoral Zone In the Ocean

Maximum design intake velocity no more than 0.5 ft/s
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

Where CWIS Is Located Inside the Littoral Zone In the Ocean

Maximum design intake velocity no more than 0.5 ft/s
and
Reduce intake flow to a level commensurate with that which could be attained by a closed-cycle recirculating cooling water system
and
Implement additional technologies that minimize impingement and entrainment of fish eggs and larvae and maximize survival of impinged adult and juvenile fish
and
Other requirements as defined by the Director in accordance with § 125.84(f) and (g)

Source: Cooling Water Intake Structures: Section 316(b) New Facility Draft Preamble and Proposed Rule, EPA (2000).

1.4 Structure of the Economic Analysis

The economic analysis in support of the proposed §316(b) New Facility Rule uses separate methodologies for new electric generators and for new manufacturing facilities:

The methodology for ***new electric generators*** relies on data for specific new facilities for which applications have been filed with state permitting authorities as well as results from the Energy Information Administration's (EIA) *Annual Energy Outlook 2000* (U.S. DOE, 1999). EPA estimated the number of new electric generators in scope of the proposed §316(b) New Facility Rule using facility-specific information from a database of planned new electric generation facilities (the NEWGen database; RDI, 2000) and EIA's national generating capacity forecasts (U.S. DOE, 1999). EPA estimated annual compliance costs for each in scope facility based on the expected technical characteristics of the new facilities. The cost estimates are then used to calculate two impact measures: annual compliance costs as a percentage of revenues, and initial compliance costs as a percentage of total plant construction costs.

The economic analysis for ***new manufacturing facilities*** relied on industry-specific growth projections to estimate the number of new manufacturing facilities expected to be in scope of this rule. EPA then used results from the §316(b) *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* (January 1999) on existing facilities to project technical characteristics as well as facility and firm employment and revenues for the new facilities. The cost estimates for new manufacturing facilities are based on these projected technical characteristics. EPA calculated annual compliance costs as a percentage of revenues as a measure of potential economic impacts.

1.5 Organization of the EEA Report

The remaining chapters of this EEA are organized as follows:

- ***Chapter 2: The §316(b) Industries and the Need for Regulation*** provides a brief discussion of the industries affected by this regulation, discusses the environmental impacts from operating CWISs, and explains the need for this regulatory effort.
- ***Chapter 3: Profile of the Electric Power Industry*** presents a profile of the affected facilities, firms, and market for electric generators.
- ***Chapter 4: Profile of Manufacturing Industries*** presents profiles of the affected facilities, firms, and markets for manufacturing facilities.
- ***Chapter 5: Baseline Projections of New Facilities*** describes EPA's methodology and data sources for estimating the number of new electric generators and manufacturing facilities subject to this regulation.
- ***Chapter 6: Facility Compliance Costs*** summarizes the technology costs detailed in Appendix A of this regulation and estimates the costs of compliance for each facility in scope of the proposed rule. The chapter also presents facility compliance costs aggregated to the national level and provides compliance cost estimates for eight additional case study facilities.
- ***Chapter 7: Economic Impact Analysis*** presents the methodology used to estimate the economic impacts of the regulation and presents the impact analysis results.
- ***Chapter 8: Regulatory Flexibility Analysis/SBREFA*** presents EPA's estimates of small business impacts from the proposed §316(b) New Facility Rule.
- ***Chapter 9: UMRA and Other Economic Analyses*** outlines the requirements for analysis under the Unfunded Mandates Reform Act and presents the results of the analysis for this regulation. This chapter also presents the total social cost of the rule and addresses EPA's compliance with Executive Order 13132 on Federalism and the Paperwork Reduction Act of 1995.
- ***Chapter 10: Alternative Regulatory Options*** describes two alternative regulatory options considered by EPA and their costs.
- ***Chapter 11: CWIS Impacts and Potential Benefits*** presents a discussion of environmental impacts resulting from the operation of CWISs and provides a qualitative assessment of potential benefits from the proposed rule.

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Chapter 2: The §316(B) Industries and the Need for Regulation

Introduction

Section 316(b) of the Clean Water Act (CWA) directs EPA to assure that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact. Based on this statutory language, §316(b) is already in effect and should be implemented with each NPDES permit issued to a directly discharging facility. However, in the absence of regulations that establish standards for best technology available (BTA), §316(b) has been applied inconsistently, using a case-by-case approach, for some industries and has not been rigorously applied to many other industries.

The proposed §316(b) New Facility Rule addresses current §316(b) implementation problems by regulating new facilities that operate cooling water intake structures (CWIS), hold a National Pollution Discharge Elimination System (NPDES) permit, and meet certain criteria with respect to their intake flow.[1] While all new CWIS that meet these criteria are subject to the regulation, this economic analysis focuses on facilities in two major sectors: (1) steam electric generators; and (2) four manufacturing industry sectors with substantial cooling water use.

This chapter provides a brief overview of the analyzed sectors, their use of cooling water, and the need for this regulation in so far as relevant for purposes of this analysis.

Chapter Contents

2.1 Overview of Facilities Subject to §316(b) Regulation

The proposed §316(b) New Facility Rule will apply to new ("greenfield") facilities proposing to operate CWIS that directly withdraw water from a water of the United States.

[1] Only facilities that use at least twenty-five percent of their intake flow for cooling purposes and withdraw more than two million gallons per day will be regulated under the proposed §316(b) New Facility Rule.

Existing facilities operating CWIS, including facilities proposing substantial additions or modifications to their operations, are not covered under this regulation. These existing facilities will be addressed by a separate rule.

The following two subsections describe the §316(b) sectors analyzed for this regulatory effort and the new facilities expected to be built within these sectors over the next 20 years. More detail on the two sectors and their facilities, firms, and market characteristics is provided in *Chapter 3: Profile of the Electric Power Industry* and *Chapter 4: Profile of Manufacturing Industries*. An in-depth discussion of how EPA identified and estimated new facilities potentially subject to this regulation is provided in *Chapter 5: Baseline Projection of New Facilities*.

2.1.1 §316(b) Sectors

EPA identified two major sectors for analysis in support of this regulation: (1) steam electric generators; and (2) manufacturing industries with substantial cooling water use. Through past §316(b) regulatory efforts and EPA's effluent guidelines program, the Agency identified steam electric generators as the largest industrial users of cooling water. The condensers that support the steam turbines in these facilities require substantial amounts of cooling water. EPA estimates that traditional steam electric utilities (SIC Codes 4911 and 493) and steam electric nonutility power producers (SIC Major Group 49) account for approximately 92.5 percent of total cooling water intake in the United States (see Table 2-1).

Beyond steam electric generators, other industrial facilities use cooling water in their production processes (e.g., to cool equipment, for heat quenching, etc.). EPA used information from the *1982 Census of Manufactures* to identify four major manufacturing sectors showing substantial cooling water use: (1) Paper and Allied Products (SIC Major Group 26); (2) Chemicals and Allied Products (SIC Major Group 28); (3) Petroleum and Coal Products (SIC Major Group 29); and (4) Primary Metals Industries (SIC Major Group 33). As illustrated in Table 2-1, steam electric utilities, steam electric nonutility power producers, and the four major manufacturing sectors together account for approximately 99 percent of the total cooling water intake in the United States.

Table 2-1: Cooling Water Intake by Sector

Sector† (SIC Code)	Cooling Water Intake Flow††		
	Billion Gal./Yr.	**Percent of Total**	**Cumulative Percent**
Steam Electric Utility Power Producers (49)	70,000	90.9%	90.9%
Steam Electric Nonutility Power Producers (49)	1,172	1.5%	92.4%
Chemicals and Allied Products (28)	2,797	3.6%	96.0%
Primary Metals Industries (33)	1,312	1.7%	97.8%
Petroleum & Coal Products (29)	590	0.8%	98.5%
Paper & Allied Products (26)	534	0.7%	99.2%
Additional 14 Categories†††	607	0.8%	100.0%

† The table is based on reported primary SIC codes.
†† Data on cooling water use are from the *1982 Census of Manufactures*, except for traditional steam electric utilities, which are from the Form EIA-767 database, and the steam electric nonutility power producers, which are from the Form EIA-867 database.
††† 14 additional major industrial categories (major SIC codes) with effluent guidelines.

Sources: 1982 Census of Manufactures; DOE / EIA Form EIA-867 database.

The six sectors identified for analysis comprise a substantial portion of all U.S. industries. As shown in Table 2-2, the six sectors combined account for almost 50,000 facilities and 3 million employees, and more than $1.2 trillion in sales and $120 billion in payroll. The four manufacturing sectors alone account for approximately 20 percent of total U.S. manufacturing sales and 12 percent of manufacturing employment. While existing facilities are not subject to the proposed §316(b) New Facility Rule, construction of new facility subject to the rule is most likely to occur in the same sectors. The economic characteristics of these sectors are therefore relevant to assessing potential economic impacts on facilities subject to the proposed rule.

Table 2-2: Summary Economic Data for Major Industry Sectors Subject to §316(b) Regulation: Facilities, Employment, Estimated Revenue, and Payroll in Millions of 1999 Dollars

Sector (SIC)	Number of Facilities	Employment	Sales, Receipts, or Shipments ($ millions)	Payroll ($ millions)
Utilities & Nonutilities (49)	22,306	844,766	416,642	41,349
Paper & Allied Products (26)	6,509	623,799	165,861	24,640
Chemicals & Allied Products (28)	12,401	843,469	380,405	36,093
Petroleum & Coal Products (29)	2,136	106,863	155,308	4,877
Primary Metals (33)	6,559	509,730	83,488	15,622
All §316(b) Sectors	**49,911**	**2,928,627**	**1,201,704**	**122,581**
Total U.S. Manufacturing	377,673	17,633,977	3,899,538	586,359
§316(b) Manufacturing Sectors as a Percent of Total U.S. Manufacturing[††]	7.3%	11.8%	20.1%	13.9%

[†] Dollar values adjusted from 1997 to 1999 using Producer Price Indexes from the Bureau of Labor Statistics (Series: WPU09–Pulp, Paper, and Allied Products, WPU061–Industrial Chemicals, WPU057–Petroleum Products, Refined, WPU10–Metals and Metal Products, WPU054–Electric Power, WPU00000000–All Commodities).

[††] Only the four §316(b) manufacturing sectors (26, 28, 29, and 33) are included in the percentage. SIC 49 is not part of total U.S. manufacturing.

Sources: 1997 Economic Census: Advance Comparative Statistics for the U.S. 1987 SIC Basis (preliminary data).

2.1.2 New Facilities

This section summarizes the methodology for estimating the number of new steam electric generators and manufacturing facilities that may be subject to §316(b) requirements and presents the results of the analysis.

a. New Steam Electric Generators

EPA identified new steam electric generators subject to the proposed §316(b) New Facility Rule using the following approach:

- EPA used the New Generation Capacity Information Service, or "NEWGen database," created and maintained by RDI Consulting (beta version as of January 2000) to identify planned steam electric generators.
- EPA used information from public sources to determine how many of the new steam electric generators would meet the new facility criteria of this rule.
- Since the NEWGen database does not cover the entire 20-year forecasting period, the identified new generators only represent a subset of all projected future steam electric generators. EPA used steam electric capacity forecasts from the Energy Information Administration's (EIA) Annual Energy Outlook 2000 to extrapolate additional facilities projected to begin operation between 2001 and 2020.

This approach resulted in an estimate of 40 new steam electric generators that meet the new facility criteria specified by this rule.

b. New Manufacturing Facilities

The Agency estimated the number of new manufacturing facilities subject to the proposed §316(b) New Facility Rule using a two-step approach:

- EPA first determined the total number of new facilities in each manufacturing sector known to be a significant user of cooling water.[2] This determination was made using industry-specific growth rates and assumptions about the share of

[2] EPA identified significant users of cooling water at the 4-digit Standard Industrial Classification (SIC) code level, based on the §316(b) *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* (January 1999).

growth that would be met by new facilities (as opposed to expansions at existing facilities).

- EPA then used results from the §316(b) Industry Screener Questionnaire to determine how many of the new facilities in each industry sector would be subject to the proposed §316(b) New Facility Rule.

Based on this approach, EPA estimated that a total of 58 new manufacturing facilities in scope of the proposed §316(b) New Facility Rule will begin operation during the next 20 years. Forty-eight of these facilities are expected to be chemicals manufacturers and ten metals facilities.

Table 2-3 presents the estimated number of new in scope facilities by major sector and 4-digit SIC code.

Table 2-3: Projected Number of In Scope Facilities			
SIC Code	**SIC Description**	**Projected Number of New Facilities Over 20 Years**	
		Total	**In Scope**
Electric Generators			
SIC 49	Electric Generators	205	40
Manufacturing Facilities			
SIC 26	Paper and Allied Products	0	0
SIC 28	Chemicals and Allied Products	568	48
SIC 29	Petroleum Refining And Related Industries	2	0
SIC 33	Primary Metals Industries		
SIC 331	Blast Furnaces and Basic Steel Products	78	8
SIC 333 SIC 335	Primary Aluminum, Aluminum Rolling, and Drawing and Other Nonferrous Metals	22	2
Total Manufacturing		*670*	*58*
Total		**875**	**98**

Source: EPA Analysis, 2000.

EPA also engaged in a consultation process with industry associations and experts. Information obtained from these sources were generally consistent with the calculated estimates.

2.2 THE NEED FOR §316(B) REGULATION

Section 316(b) provides that any standard established to address impacts from CWISs "shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact." To date, no national standard for BTA that will minimize adverse environmental impact (AEI) from CWISs has been established. As a result, many CWISs have been constructed on sensitive aquatic systems with capacities and designs that cause severe damage to the water bodies from which they withdraw water.

Several factors drive the need for this proposed national §316(b) regulation. Each of these factors is discussed in the following subsections.

2.2.1 The Need to Reduce Adverse Environmental Impacts

Adverse environmental impacts occur when facilities impinge aquatic organisms on their CWISs' intake screens, entrain them within their cooling system, or otherwise negatively affect habitats that support aquatic species. Exposure of aquatic organisms to impingement and entrainment (I&E) depends on the location, design, construction, capacity, and operation of a facility's CWIS (U.S. EPA, 1976; SAIC, 1994; SAIC, 1996b). The regulatory goals of §316(b) include the following:

- ensure that the location, design, construction, and capacity of a facility's CWIS reflect BTA for minimizing AEI;
- protect individuals, populations, and communities of aquatic organisms from harm (reduced viability or increased mortality) due to the physical and chemical stresses of I&E; and
- protect aquatic organisms that are indirectly affected by CWIS because of trophic interactions with species that are impinged or entrained.

a. Impingement

Impingement occurs when fish are trapped against CWISs' intake screens by the velocity of the intake flow. Fish may die or be injured as a result of (1) starvation and exhaustion; (2) asphyxiation when velocity forces prevent proper gill movement; (3) abrasion by screen wash spray; and (4) asphyxiation due to removal from water for prolonged periods.

b. Entrainment

Small organisms are entrained when they pass through a plant's condenser cooling system. Damage can result from (1) physical impacts from pump and condenser tubing; (2) pressure changes caused by diversion of cooling water; (3) thermal shock experienced in condenser and discharge tunnels; and (4) chemical toxemia induced by the addition of anti-fouling agents such as chlorine. Mortality of entrained organisms is usually extremely high.

c. Minimizing AEI

Review of the available literature and §316(b) demonstration studies obtained from NPDES permit files has identified numerous documented cases of impacts associated with I&E and the effects of I&E on individual organisms and on populations of aquatic organisms. For example, specific losses attributed to individual steam electric generating plants include the loss of or damage to 3 to 4 billion larvae and post larvae per year,[3] 23 tons of fish and shellfish of recreational, commercial or forage value lost each year,[4] and 1 million fish lost during a three-week study period.[5] The yearly loss of billions of individuals is not the only problem. Often, there is a significant loss to the whole population of the affected species as well. Several studies estimating the impacts of entrainment on populations of key commercial or recreational fish predicted declines in population size. Studies focusing on entrainment mortality in the Hudson River predicted reductions in the year-class strength for 6 species ranging from 4 percent to 79 percent, depending on the species.[6] A modeling effort looking at the impact of entrainment mortality on the population of a selected species in the Cape Fear estuarine system predicted a 15 to 35 percent reduction in the population.[7]

The following are other, more recent, documented impacts occurring as a result of CWIS:

❖ ***Brayton Point***

PG&E Generating's Brayton Point plant (formerly owned by New England Power Company) is located in Mt. Hope Bay, in the northeastern reach of Narragansett Bay, Rhode Island. In order to increase electric generating capacity, Unit 4 was switched from closed-cycle to once-through cooling in 1985. The modification of Unit 4 resulted in an increase in cooling water intake flow of 45 percent. Studies of the CWIS's impacts on fish abundance trends found that Mt. Hope Bay experienced a decline in finfish species of recreational, commercial, and ecological importance.[8] In contrast, species abundance trends were relatively stable in coastal areas and portions of Narragansett Bay which are not influenced by the Brayton Point CWIS. The rate of population decline increased substantially with the full implementation of the once-through cooling mode for Unit 4. The modification of Unit 4 is estimated to have resulted in an 87 percent

[3] *Brunswick Nuclear Steam Electric Generating Plant of Carolina Power and Light Company Located near Southport, North Carolina, Historical Summary and Review of Section 316(b) Issues.* EPA Region IV, September 19, 1979.

[4] *Findings and Determination under 33 U.S.C. Section 1326, In the Matter of Florida Power Corporation Crystal River Power Plant Units 1, 2, and 3. NPDES Permit No. FL0000159.* EPA Region IV, December 2, 1986.

[5] *Impingement Losses at the D.C. Cook Nuclear Power Plant during 1975-1982 with a Discussion of Factors Responsible and Possible Impact on Local Populations,* Thurber, Nancy J. and David J. Jude. Special Report No. 115 of the Great Lakes Research Division. Great Lakes and Marine Waters Center. The University of Michigan. 1985.

[6] *Estimates of Entrainment Mortality for Striped Bass and Other Fish Species Inhabiting the Hudson River Estuary,* Boreman, John and Phillip Goodyear. American Fisheries Society Monograph 4:152-160, 1988.

[7] *Brunswick Nuclear Steam Electric Generating Plant of Carolina Power and Light Company Located near Southport, North Carolina, Historical Summary and Review of Section 316(b) Issues.* EPA Region IV, September 19, 1979.

[8] *Comparison of Trends in the Finfish Assemblages of Mt. Hope Bay and Narragansett Bay in Relation to Operations of the New England Power Brayton Point Station.* Mark Gibson, Rhode Island Division Fish and Wildlife, Marine Fisheries Office, June 1995 and revised August 1996.

reduction in finfish abundance based on a time series-intervention model. These impacts were associated with both I&E and the thermal discharges. Entrainment data indicated that 4.9 billion tautog eggs, 0.86 billion windowpane eggs, and 0.89 billion winter flounder larvae were entrained in 1994 alone. Using adult equivalent analyses, the entrainment and impingement of fish eggs and larvae in 1994 translated to a loss of 30,885 pounds of adult tauton, 20,146 pounds of adult windowpane, and 96,507 pounds of adult winter flounder.

❖ ***San Onofre Nuclear Generating Station***

The San Onofre Nuclear Generating Station (SONGS) is on the coastline of the Southern California Bight, approximately 2.5 miles southeast of San Clemente, California. The marine portions of Units 2 and 3, which are once-through, open-cycle cooling systems, began commercial operation in August of 1993 and 1994, respectively. Since then, many studies have been completed to evaluate the impact of the SONGS facility on the marine environment.[9]

Studies of kelp beds in near-shore waters in the vicinity of the SONGS facility determined that operation of the CWIS resulted in an 80 hectare (197.68 acre) reduction in the area covered by moderate to high density kelp. This represents a 60 percent loss in area. Studies indicated that poor survival and lack of development of new kelp plants was the result of increased turbidity due to withdrawal of intake water at SONGS. The loss of kelp was also determined to be detrimental to fish communities associated with the kelp forests. For example, fish living close to the cobble bottom in the impact area experienced a 70 percent decline in abundance. Fish living in the water column in the impact areas had a 17 percent loss in abundance and a 33 percent decline in biomass relative to control populations. The abundance of large invertebrates in kelp beds also declined for many species, particularly snails.

Estimates of lost midwater fish species due to direct entrainment by CWIS at SONGS are between 16.5 to 45 tons per year. This loss represents a 41 percent mortality rate for fish (primarily northern anchovy, queenfish, and white croaker) entrained by intake water at SONGS. In a normal year, approximately 350,000 juvenile white croaker are estimated to be killed through entrainment at SONGS. This number represents 33,000 adult individuals or 3.5 tons of adult fish. Changes in densities of fish populations within the vicinity of the plant, relative to control populations, were observed in species of queen fish and white croaker. The density of queenfish and white croaker within three kilometers of SONGS decreased by 34 to 63 percent in shallow water samples and 50 to 70 percent in deep water samples.

The main purpose of this regulation is to minimize losses such as those described above.

2.2.2 The Need to Address Market Imperfections

The conceptual basis of environmental legislation in general, and the Clean Water Act and the §316(b) regulation in particular, is the need to correct imperfections in the markets that arise from uncompensated environmental externalities. Facilities withdraw cooling water from a water of the U.S. to support electricity generation, steam generation, manufacturing, and other business activities, thereby impinging and entraining organisms without accounting for the consequences of these actions on the ecosystem or other parties who do not directly participate in the business transactions. In effect, the actions of these §316(b) facilities impose environmental harm or costs on the environment and on other parties (sometimes referred to as *third parties*). These costs, however, are not recognized by the responsible entities in the conventional market-based accounting framework. Because the responsible entities do not account for these costs to the ecosystem and society, they are *external* to the market framework and the consequent production and pricing decisions of the responsible entities. In addition, because no party is compensated for the adverse consequences of I&E, the externality is *uncompensated*.

Business decisions will yield a less than optimal allocation of economic resources to production activities, and, as a result, a less than optimal mix and quantity of goods and services, when external costs are not accounted for in the production and pricing decisions of the §316(b) industries. In particular, the quantity of AEI caused by the business activities of the responsible business entities will exceed optimal levels and society will not maximize total possible welfare. Adverse distributional effects may be an additional effect of the uncompensated environmental externalities. If the distribution of I&E and ensuing AEI is not random among the U.S. population but instead is concentrated among certain population subgroups based on socio-economic or other demographic characteristics, then the uncompensated environmental externalities may produce undesirable transfers of economic welfare among subgroups of the population.

The goal of environmental legislation and subsequent implementing actions, such as the §316(b) regulation that is the subject of this analysis, is to correct environmental externalities by requiring the responsible parties to reduce their actions causing environmental damage. Congress, in

[9] Review of Southern California Edison, San Onofre Nuclear Generating Station (SONGS) 316(b) Demonstration. Prepared by SAIC, July, 20, 1993.

enacting the authorizing legislation, and EPA, in promulgating the implementing regulations, act on behalf of society to minimize environmental impacts (i.e., achieve a lower level of I&E and associated environmental harm). These actions result in a supply of goods and services that more nearly approximates the mix and level of goods and services that would occur if the industries impinging and entraining organisms fully accounted for the costs of their AEI-generating activities. The resulting allocation of economic resources, the mix and quantity of goods and services provided by the economy, and *the quantity of AEI accompanying those activities* will yield a higher net economic welfare to society.

Requiring facilities to minimize their environmental impacts by reducing levels of I&E (i.e., a lower level of environmental harm) is one approach to addressing the problem of environmental externalities. This approach internalizes the external costs by turning the societal cost of environmental harm into a direct business cost – the cost of achieving compliance with the regulation – for the impinging and entraining entities. A facility causing AEI will either incur the costs of minimizing its environmental impacts, or will determine that compliance is not in its best financial interest and will cease the AEI-generating activities. This approach to addressing the problem of environmental externalities will generally result in improved economic efficiency and net welfare gains for society if the cost of reducing the activities causing environmental harm is less than the value of benefits to society from the reduced AEI.

It is theoretically possible to correct the market imperfection by means other than direct regulation. Negotiation and/or litigation, for example, could achieve an optimal allocation of economic resources and mix of production activities within the economy. However, the transaction costs of assembling the affected parties and involving them in the negotiation/litigation process as well as the public goods character of the improvement sought by negotiation or litigation will frequently render this approach to addressing the market imperfection impractical. Although the environmental impacts associated with CWISs have been documented since the first attempt at §316(b) regulation in the late 1970's, implementation of §316(b) to date has failed to address the market imperfections associated with CWISs effectively.

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Chapter 3: Profile of the Electric Power Industry

CHAPTER CONTENTS

INTRODUCTION

This profile compiles and analyzes economic and financial data for the electric power generating industry. It provides information on the structure and overall performance of the industry and explains important trends that may influence the nature and magnitude of economic impacts from the proposed §316(b) New Facility Regulation. While this profile does not specifically address new electric generating facilities subject to the proposed rule, the information presented is nevertheless relevant to new facilities as it describes the market into which new facilities must enter and the existing facilities against which they will compete.

The electric power industry is one of the most extensively studied industries. The Energy Information Administration (EIA), among others, publishes a multitude of reports, documents, and studies on an annual basis. This profile is not intended to duplicate those efforts. Rather, this profile compiles, summarizes, and presents those industry data that are important in the context of the proposed §316(b) New Facility Regulation. For more information on general concepts, trends, and developments in the electric power industry, the last section of this profile, "References," presents a select list of other publications on the industry.

The remainder of this profile is organized as follows:

- Section 3.1 provides a brief overview of the industry, including descriptions of major industry sectors, types of generating facilities, and the entities that own generating facilities.
- Section 3.2 provides data on industry production and capacity.
- Section 3.3 focuses on existing §316(b) facilities. Facilities affected by the proposed rule are new steam electric facilities that require a National Pollutant Discharge Elimination System (NPDES) permit, operate a CWIS to withdraw cooling water from a water of the United States, and withdraw more than two million gallons per day (MGD). This section provides information on the economic and financial, location and technology characteristics of existing facilities with a CWIS and an NPDES permit.
- Section 3.4 provides a brief discussion of factors affecting the future of the electric power industry, including the status of restructuring, and summarizes forecasts of market conditions through the year 2020.

3.1 INDUSTRY OVERVIEW

This section provides a brief overview of the industry, including descriptions of major industry sectors, types of generating facilities, and the entities that own generating facilities.

3.1.1 Industry Sectors

The electricity business is made up of three major functional service components or sectors: *generation*, *transmission*, and *distribution*. These terms are defined as follows (Beamon, 1998; Joskow, 1997):[1]

- The ***generation*** sector includes the power plants that produce, or "generate," electricity.[2] Electric energy is produced using a specific generating technology, e.g., internal combustion engines and turbines. Turbines can be driven by wind, moving water (hydroelectric), or steam from fossil fuel-fired boilers or nuclear reactions. Other methods of power generation include geothermal or photovoltaic (solar) technologies.

- The ***transmission*** sector can be thought of as the interstate highway system of the business – the large, high-voltage power lines that deliver electricity from power plants to local areas. Electricity transmission involves the "transportation" of electricity from power plants to distribution centers using a complex system. Transmission requires: interconnecting and integrating a number of generating facilities into a stable synchronized alternating current (AC) network; scheduling and dispatching all connected plants to balance the demand and supply of electricity in real time; and managing the system for equipment failures, network constraints, and interaction with other transmission networks.

- The ***distribution*** sector can be thought of as the local delivery system – the relatively low-voltage power lines that bring power to homes and businesses. Electricity distribution relies on a system of wires and transformers along streets and underground to provide electricity to residential, commercial, and industrial consumers. The distribution system involves both the provision of the hardware (e.g., lines, poles, transformers) and a set of retailing functions, such as metering, billing, and various demand management services.

Of the three industry sectors, only electricity generation uses cooling water and is potentially affected by §316(b) regulation. The remainder of this profile will focus on the generation sector of the industry.

[1] Terms highlighted in bold and italic font are defined in the glossary at the end of this chapter.

[2] The terms "plant" and "facility" are used interchangeably throughout this profile.

3.1.2 Prime Movers

Electric power plants use a variety of ***prime movers*** to generate electricity. The type of prime mover used at a given plant is determined based on the type of load the plant is designed to serve, the availability of fuels, and energy requirements. Most prime movers use fossil fuels (coal, petroleum, and natural gas) as an energy source and employ some type of turbine to produce electricity. The six most common prime movers are (U.S. DOE, 2000a):

- ***Steam Turbine:*** Steam turbine, or "steam electric" units require a fuel source to boil water and produce steam that drives the turbine. Either the burning of fossil fuels or a nuclear reaction can be used to produce the heat and steam necessary to generate electricity. These units are generally base load units which are run continuously to serve the minimum load required by the system. Steam electric units generate the majority of electricity produced at power plants in the U.S.

- ***Gas Combustion Turbine:*** Gas turbine units burn a combination of natural gas and distillate oil in a high pressure chamber to produce hot gases that are passed directly through the turbine. Units with this prime mover are generally less than 100 megawatts in size, less efficient than steam turbines, and used for peak load operation serving the highest daily, weekly, or seasonal loads. Gas turbine units have quick startup times and can be installed at a variety of site locations, making them ideal for peak, emergency, and reserve-power requirements.

- ***Combined-Cycle Turbine:*** Combined-cycle units utilize both steam and gas turbine prime mover technologies to increase the efficiency of the gas turbine system. After combusting natural gas in gas turbine units, the hot gases from the turbines are transported to a waste-heat recovery steam boiler where water is heated to produce steam for a second steam turbine. The steam may be produced solely by recovery of gas turbine exhaust or with additional fuel input to the steam boiler. Combined-cycle generating units are generally used for intermediate loads.

- ***Internal Combustion Engines:*** Internal combustion engines contain one or more cylinders in which fuel is combusted to drive a generator. These units are generally about 5 megawatts in size, can be installed on short notice, and can begin producing electricity almost instantaneously. Like gas turbines, internal combustion units are generally used only for peak loads.

- ***Water Turbine:*** Units with water turbines, or "hydroelectric units," use either falling water or the force of a natural river current to spin turbines and produce electricity. These units are used for all types of loads.
- ***Other Prime Movers:*** Other methods of power generation include geothermal, solar, wind, and biomass prime movers. The contribution of these prime movers is small relative to total power production in the U.S., but the role of these prime movers may expand in the future because recent legislation includes incentives for their use.

Table 3-1 provides data on the number of utility and nonutility power plants by prime mover. This table includes all plants that have at least one non-retired unit and that submitted Forms EIA-860A (Annual Electric Generator Report - Utilities) or EIA-860B (Annual Electric Generator Report - Nonutilities) in 1998. Plants that use more than one type of prime mover were classified under the prime mover type that accounts for the largest share of the plant's total electricity generation.

Table 3-1: Number of Utility and Nonutility Plants by Prime Mover, 1998

Prime Mover	Utility†	Nonutility†
	Number of Plants	Number of Plants
Steam Turbine	831	962
Combined-Cycle	40	n/a††
Gas Turbine	315	257
Internal Combustion	615	336
Hydroelectric	1,202	355
Other	39	76
Total	3,042	1,986

† See definition of utility and nonutility in Section 3.1.3.
†† Nonutility combined-cycle turbines are reported by their individual gas and steam components and are therefore not identifyable as combined-cycle units.

Source: Form EIA-860A, 1998; Form EIA-860B, 1998.

Only prime movers with a steam electric generating cycle use substantial amounts of cooling water. These generators include steam turbines and combined-cycle turbines. As a result, the analysis in support of the §316(b) regulation focuses on generating plants with a steam electric prime mover. This profile will, therefore, differentiate between steam electric and other prime movers, and only discuss steam electric generation when referring to §316(b) facilities.

3.1.3 Ownership

The U.S. electric power industry consists of two broad categories of firms that own and operate electric generating plants: utilities and nonutilities. Generally, they can be defined as follows (U.S. DOE, 2000a):

- ***Utility:*** A regulated entity providing electric power, traditionally vertically integrated. Utilities may or may not generate electricity. "Transmission utility" refers to the regulated owner/operator of the transmission system only. "Distribution utility" refers to the regulated owner/operator of the distribution system serving retail customers.
- ***Nonutility:*** Entities that generate power for their own use and/or for sale to utilities and others. Nonutility power producers include cogenerators, small power producers, and independent power producers. Nonutilities do not have a designated franchised service area and do not transmit or distribute electricity.

Utilities can be further divided into three major ownership categories: investor-owned utilities, publicly-owned utilities, and rural electric cooperatives. Each category is discussed below.

a. Investor-Owned Utilities

Investor-owned utilities (IOUs) are for-profit businesses that can take two basic organizational forms: the individual corporation and the holding company. An individual corporation is a single utility company with its own investors; a holding company is a business entity that owns one or more utility companies and may have other diversified holdings as well. Like all businesses, the objective of an IOU is to produce a return for its investors. IOUs are entities with designated franchise areas. They are required to charge reasonable and comparable prices to similar classifications of consumers and give consumers access to services under similar conditions. Most IOUs engage in all three activities: generation, transmission, and distribution. In 1998, IOUs operated 1,610 facilities which accounted for more than 66 percent of all U.S. electric utility generation capacity (U.S. DOE, Form EIA-860B).[3]

b. Publicly-Owned Utilities

Publicly-owned electric utilities can be municipalities, public power districts, state authorities, irrigation projects, and other state agencies established to serve their local municipalities or nearby communities. Excess funds or "profits" from the operation of these utilities are put toward community programs and local government budgets, increasing facility efficiency and capacity, and reducing rates. Federally-owned facilities are also included in this category for the purposes of this profile and analysis. Most municipal utilities are nongenerators engaging solely in the purchase of wholesale electricity for resale and distribution. The larger municipal utilities, as well as state and federal utilities, usually generate, transmit, and distribute electricity. In general, publicly-owned utilities have access to tax-free financing and do not pay certain taxes or dividends, giving them some cost advantages over IOUs.

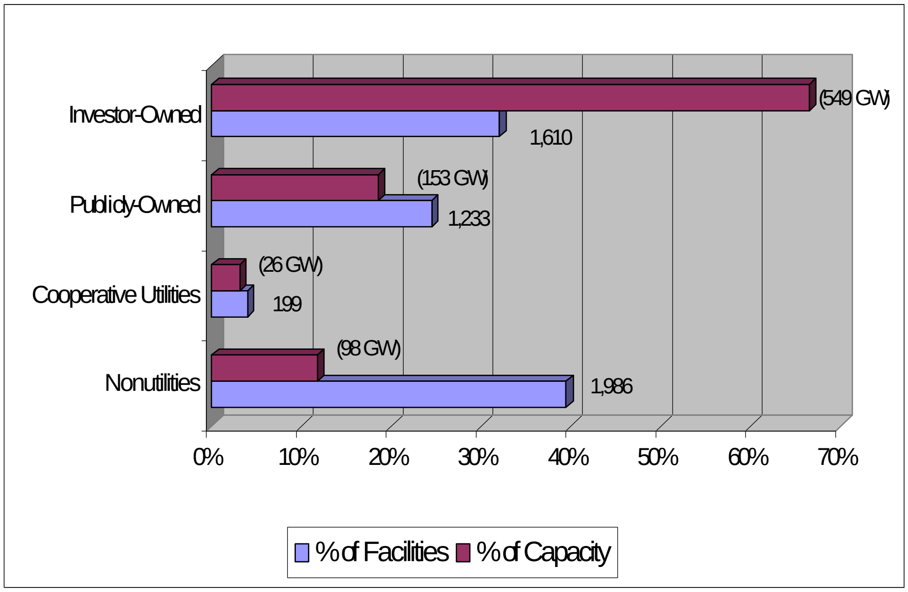
c. Rural Electric Cooperatives

Cooperative electric utilities ("coops") are member-owned entities created to provide electricity to those members. Rural electric cooperatives operated 199 generating facilities in 1998. These utilities, established under the Rural Electrification Act of 1936, provide electricity to small rural and farming communities (usually fewer than 1,500 consumers). Fewer than ten percent of coops generate electricity; most are primarily engaged in distribution. Cooperatives operate in 46 states and are incorporated under state laws. The National Rural Utilities Cooperative Finance Corporation, the Federal Financing Bank, and the Bank of Cooperatives are important sources of financing for these utilities.

Figure 3-1 presents the percent of capacity and generating facilities providing electric power in the U.S. in 1998 by type of ownership. This figure is based on data for all plants that have at least one non-retired unit and that submitted Forms EIA-860A or EIA-860B in 1998. The graphic shows that nonutilities account for the largest percentage of facilities (1,986, or 39 percent), but only represent 12 percent of total U.S. generating capacity. Investor-owned utilities operate the second largest number of facilities and account for 66 percent of total U.S. capacity.

[3] Data for 239 IOU's with at least one non-retired plant.

Figure 3-1: Percent of Capacity and Facilities in the U.S. Electric Power Industry by Ownership Type, 1998



† Capacity is a measure of a generating unit's ability to produce electricity. Capacity is defined as the designed full-load continuous output rating for an electric generating unit.

Source: Form EIA-860A, 1998; Form EIA-861, 1998; Form EIA-860B, 1998.

Plants owned and operated by utilities and nonutilities may be affected differently by the §316(b) regulation due to differing competitive roles in the market. Much of the following discussion therefore differentiates between these two groups.

3.2 Domestic Production

This section presents an overview of U.S. generating capability and electricity generation. Subsection 3.2.1 provides data on generation capability, and Subsection 3.2.2 provides data on generation. Subsection 3.2.3 presents an overview of the geographic distribution of generation plants and capacity.

3.2.1 Generating Capability

Utilities own and operate the majority of the generating capability in the United States (88 percent). Nonutilities owned only 12 percent of the total generating capability in 1998 and produced less than 12 percent of the electricity in the country (U.S. DOE, 1999c). Nonutility capability and generation have increased substantially in the past few years, however, since passage of legislation aimed at increasing competition in the industry. Generation capability for nonutilities has increased 103 percent since 1991, compared with a capability decrease of one percent over the same time period for utilities.[4] Nonutility generation shows an increasing trend since 1991 with the most significant increases occurring in recent years as a result of the move toward a competitive electric power market.

Figure 3-2 shows the growth in utility and nonutility capability from 1991 to 1998. The growth in nonutility capability, combined with a slight decrease in utility capability, has resulted in a modest growth in generating capability overall.

Capacity/Capability

The rating of a generating unit is a measure of its ability to produce electricity. Generator ratings are expressed in megawatts (MW). Capacity and capability are the two common measures:

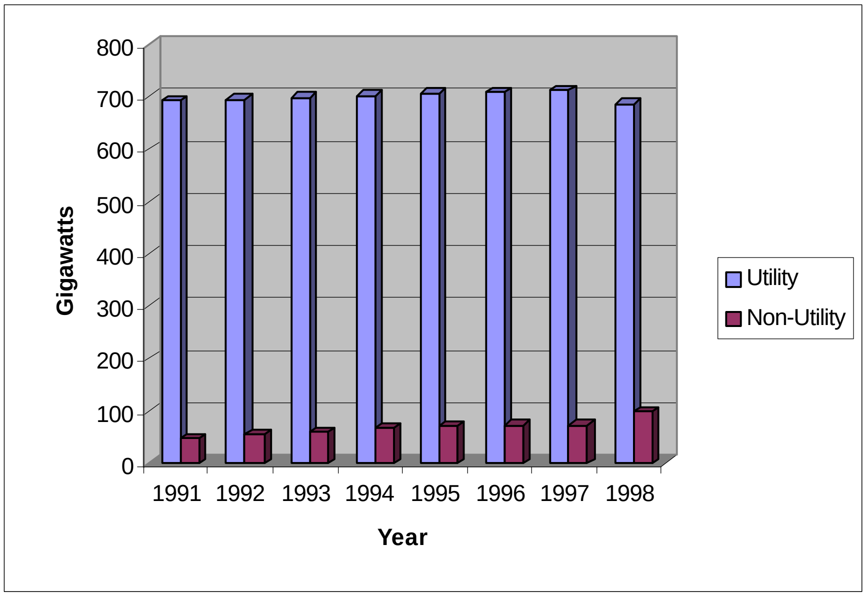
Nameplate capacity is the full-load continuous output rating of the generating unit under specified conditions, as designated by the manufacturer.

Net capability is the steady hourly output that the generating unit is expected to supply to the system load, as demonstrated by test procedures. The capability of the generating unit in the summer is generally less than in the winter due to high ambient-air and cooling-water temperatures, which cause generating units to be less efficient. The nameplate capacity of a generating unit is generally greater than its net capability.

U.S. DOE, 2000a

[4] More accurate data were available starting in 1991, therefore, 1991 was selected as the initial year for trends analysis.

Figure 3-2: Generating Capability, 1991 to 1998



Source: U.S. DOE, 1996b; U.S. DOE,1999c.

3.2.2 Electricity Generation

Total net electricity generation in the U.S. for 1998 was 3,618 billion kWh. Utility-owned plants accounted for 89 percent of this amount. Total net generation has increased by 18 percent over the eight-year period from 1991 to 1998. During this period, nonutilities increased their electricity generation by 71 percent. In comparison, generation by utilities increased by only 14 percent (U.S. DOE, 1999c). This trend is expected to continue with deregulation in the coming years, as more facilities are purchased and built by nonutility power producers.

Table 3-2 shows the change in net generation between 1991 and 1998 by fuel source for utilities and nonutilities.

Measures of Generation

The production of electricity is referred to as generation and is measured in ***kilowatthours (kWh)***. Generation can be measured as:

Gross generation: The total amount of power produced by an electric power plant.

Net generation: Power available to the transmission system beyond that needed to operate plant equipment. For example, around 7% of electricity generated by steam electric units is used to operate equipment.

Electricity available to consumers: Power available for sale to customers. Approximately 8 to 9 percent of net generation is lost during the transmission and distribution process.

U.S. DOE, 2000a

Table 3-2: Net Generation by Energy Source and Ownership Type, 1991 to 1998 (GWh)

Energy Source	Utilities			Nonutilities†			Total		
	1991	1998	% Change	1991	1998	% Change	1991	1998	% Change
Coal	1,551	1,807	17%	39	68	73%	1,590	1,876	18%
Hydropower	280	304	9%	6	14	134%	286	319	11%
Nuclear	613	674	10%	0	0	0%	613	674	10%
Petroleum	111	110	-1%	8	17	124%	119	127	7%
Gas	264	309	17%	127	240	89%	391	550	40%
Renewables††	10	7	-29%	57	66	15%	67	73	8%
Total	2,830	3,212	14%	238	406	71%	3,067	3,618	18%

† Nonutility generation was converted from gross to net generation based on prime mover-specific conversion factors (U.S. DOE, 1996b). As a result of this conversion the total net generation estimates differ slightly from EIA published totals by fuel type.

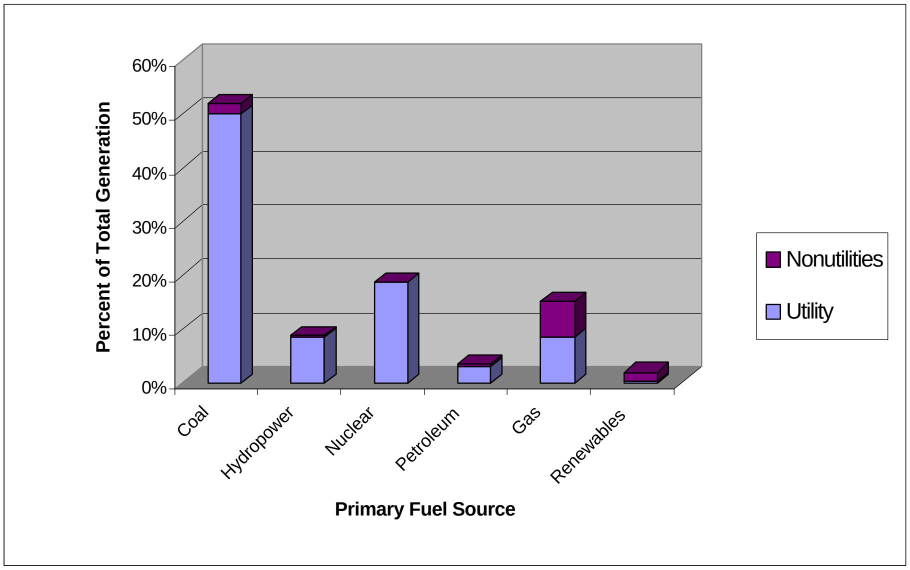
†† Renewables include solar, wind, wood, biomass and geothermal energy sources.

Source: U.S. DOE, 1996b; U.S. DOE,1999c.

As shown in Table 3-2, coal and natural gas generation grew the fastest among the utility fuel source categories, each increasing by 17 percent between 1991 and 1998. Nuclear generation increased by 10 percent, while hydroelectric generation increased by 9 percent. Utility generation from renewable energy sources decreased significantly (29 percent) between 1991 and 1998. Nonutility generation has grown at a much higher rate between 1991 and 1998 with the passage of legislation aimed at increasing competition in the industry. Nonutility hydroelectric generation grew the fastest among the energy source categories, increasing 134 percent from 1991 to 1998. Generation from petroleum-fired facilities, either newly constructed or purchased from utilities, also increased substantially, with a 124 percent increase in generation between 1991 and 1989.

Figure 3-3 shows total net generation for the U.S. by primary fuel source for utilities and nonutilities. Electricity generation from coal-fired plants accounts for 52 percent of total 1998 generation. Electric utilities generate 96 percent (1,807 billion kWh) of the 1,876 billion kWh of electricity generated by coal-fired plants. This represents approximately 56 percent of total utility generation. The remaining 4 percent (68 billion kWh) of coal-fired generation is provided by nonutilities, accounting for 17 percent of total nonutility generation. The second largest source of electricity generation is nuclear power plants, accounting for 19 percent of total generation and approximately 21 percent of total utility generation. Figure 3-3 shows that 100 percent of nuclear generation is owned and operated by utilities. Another significant source of electricity generation is gas fired power plants, which account for 59 percent of nonutility generation and 15 percent of total generation.

Figure 3-3: Percent of Electricity Generation By Primary Fuel Source, 1998



Renewables include biomass, other waste, solar, wind, and geothermal. Hydropower includes conventional and pumped storage.

Source: U.S. DOE,1999c.

The §316(b) regulation will affect facilities differently based on the fuel sources and prime movers used to generate electricity. As mentioned in Section 3.1.2 above, only prime movers with a steam electric generating cycle use substantial amounts of cooling water.

3.2.3 Geographic Distribution

Electricity is a commodity that cannot be stored or easily transported over long distances. As a result, the geographic distribution of power plants is of primary importance to ensure reliable supply of electricity to all customers. The U.S. bulk power system is composed of three major networks, or power grids:

- the ***Eastern Interconnected System***, consisting of one third of the U.S. to the east of the Missouri River;
- the ***Western Interconnected System***, which includes the Southwest and areas west of the Rocky Mountains; and
- the ***Texas Interconnected System***, the smallest of the three, consisting of the majority of Texas.

The Texas system is not connected with the other two systems, while the other two have limited interconnection to each other. The Eastern and Western systems are integrated or have links to the Canadian grid system. The Western and Texas systems have links with Mexico as well.

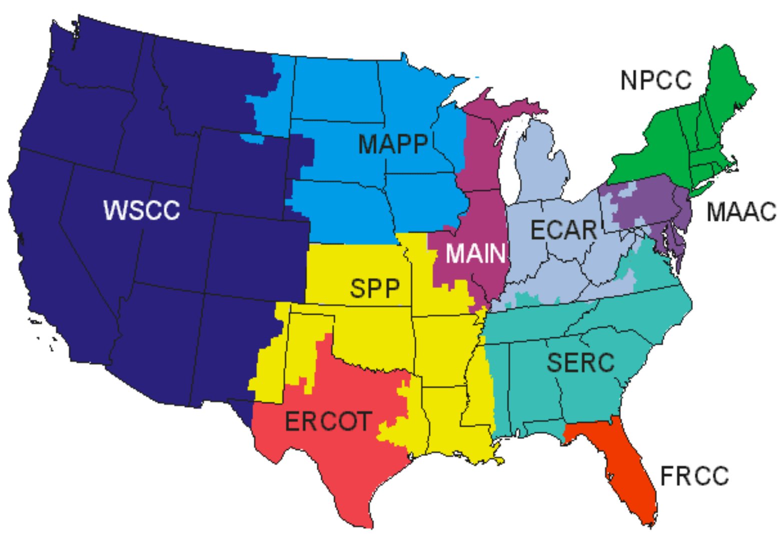
These major networks contain extra-high voltage connections that allow for power transactions from one part of the network to another. Wholesale transactions can take place within these networks to reduce power costs, increase supply options, and ensure system reliability. ***Reliability*** refers to the ability of power systems to meet the demands of consumers at any given time. Efforts to enhance reliability reduce the chances of power outages.

The North American Electric Reliability Council (NERC) is responsible for the overall reliability, planning, and coordination of the power grids. This voluntary organization was formed in 1968 by electric utilities, following a 1965 blackout in the Northeast. NERC is organized into nine regional councils that cover the 48 contiguous states, Hawaii, part of Alaska, and portions of Canada and Mexico. These regional councils are responsible for the overall coordination of bulk power policies that affect their regions' reliability and quality of service. Each NERC region deals with electricity reliability issues in its region, based on available capacity and transmission constraints. The councils also aid in the exchange of information among member utilities in each region and among regions. Service areas of the member utilities determine the boundaries of the NERC regions. Though limited by the larger bulk power grids described in the previous section, NERC regions do not necessarily follow any state boundaries. Figure 3-4 below provides a map of the NERC regions, which include:

- ECAR – East Central Area Reliability Coordination Agreement
- ERCOT – Electric Reliability Council of Texas
- FRCC – Florida Reliability Coordinating Council
- MAAC – Mid-Atlantic Area Council
- MAIN – Mid-America Interconnect Network
- MAPP – Mid-Continent Area Power Pool (U.S.)
- NPCC – Northeast Power Coordinating Council (U.S.)
- SERC – Southeastern Electric Reliability Council
- SPP – Southwest Power Pool
- WSCC – Western Systems Coordinating Council (U.S.)

Alaska and Hawaii are not shown in Figure 3-4. Part of Alaska is covered by the Alaska Systems Coordinating Council (ASCC), an affiliate NERC member. The state of Hawaii also has its own reliability authority (HI).

Figure 3-4: North American Electric Reliability Council (NERC) Regions



Source: EIA, 1996 http://www.eia.doe.gov/cneaf/electricity/chg_str_fuel/html/fig02.html

The §316(b) regulation may affect plants located in different NERC regions differently. Economic characteristics of new facilities affected by the proposed §316(b) New Facility Rule are likely to vary across regions by fuel mix, and the costs of fuel transportation, labor, and construction. Baseline differences in economic characteristics across regions may influence the impact of the §316(b) regulation on profitability, electricity prices, and other impact measures. The proposed §316(b) New Facility Rule may have little or no impact on electricity prices in a particular region if relatively few new plants in the region incur costs under the rule. Conversely, regions that have a large number of new facilities with costs under the proposed §316(b) New Facility Rule could experience a greater impact on electricity prices.

Table 3-3 shows the distribution of all existing utilities, utility-owned plants, and capacity by NERC region. The table shows that while the Mid-Continental Area Power Pool (MAPP) has the largest number of utilities, 24 percent, these utilities only represent five percent of total capacity. Conversely, only five percent of the nation's utilities are located in the Southeastern Electric Reliability Council (SERC). These utilities are generally larger and account for 23 percent of the industry's total generating capacity.

Table 3-3: Distribution of Generation Utilities, Utility Plants, and Capacity by NERC Region, 1998

NERC Region	Generation Utilities		Plants		Capacity	
	Number	% of Total	Number	% of Total	Total MW	% of Total
ASCC	51	6%	166	5%	1,925	0%
ECAR	96	11%	283	9%	110,039	15%
ERCOT	27	3%	106	3%	55,890	8%
FRCC	18	2%	63	2%	38,667	5%
HI	3	0%	16	1%	1,580	0%
MAAC	21	2%	121	4%	56,824	8%
MAIN	62	7%	196	6%	52,916	7%
MAPP	211	24%	398	13%	35,737	5%
NPCC	67	8%	372	12%	46,303	6%
SERC	42	5%	320	11%	164,745	23%
SPP	143	17%	259	9%	45,807	6%
WSCC	125	14%	742	24%	118,349	16%
Total	866	100%	3,042	100%	728,782	100%

Source: Form EIA-860A, 1998; Form EIA-861, 1998.

Table 3-4 shows the distribution of existing nonutility plants and capacity by NERC region. The table shows that the Western Systems Coordinating Council (WSCC) has the largest number of plants, 585, and accounts for the largest share of total nonutility capacity, 29 percent.

Table 3-4: Distribution of Nonutility Plants and Capacity by NERC Region, 1998

NERC Region	Plants		Capacity	
	Number	% of Total	Total MW	% of Total
ASCC	28	1%	401	0%
ECAR	101	5%	7,861	8%
ERCOT	40	2%	7,798	8%
FRCC	62	3%	3,631	4%
HI	8	0%	706	1%
MAAC	95	5%	6,035	6%
MAIN	105	5%	3,361	3%
MAPP	74	4%	1,562	2%
NPCC	384	19%	18,115	19%
SERC	246	12%	13,501	14%
SPP	55	3%	2,319	2%
WSCC	585	29%	27,957	29%
Unknown	203	10%	4,295	4%
Total	1,986	100%	97,542	100%

Source: Form EIA-860B, 1998.

3.3 Existing Plants with CWISs and NPDES Permits

Section 316(b) rulemaking applies to facilities that are point sources under the Clean Water Act and directly withdraw cooling water from a water of the United States. Among power plants, only those facilities employing a steam electric generating technology require cooling water and are therefore of interest to this analysis. Steam electric generating technologies include units with steam electric turbines and combined-cycle units with a steam component.

The following sections describe existing utility and nonutility power plants that would be subject to the proposed §316(b) New Facility Regulation *if they were new facilities*. These are existing facilities that hold a National Pollutant Discharge Elimination System (NPDES) permit and operate a CWIS.[5] The remainder of this chapter will refer to these facilities as "existing §316(b) plants."

Utilities and nonutilities are discussed in separate subsections because the data sources, definitions, and potential factors influencing the magnitude of impacts are different for the two sectors. Each subsection presents the following information:

- ***Ownership type:*** This section discusses existing §316(b) facilities with respect to the entity that owns them. Utilities are classified into investor-

[5] The proposed §316(b) New Facility Regulation only applies to new facilities that withdraw more than two MGD.

owned utilities, rural electric cooperatives, municipalities, and other publicly-owned utilities (see Section 3.1.3). This differentiation is important because EPA is required to separately consider impacts on governments in its regulatory development (see *Chapter 10: UMRA and Other Economic Analyses* for the analysis of government impacts of the proposed §316(b) New Facility Regulation). The utility ownership categories do not apply to nonutilities. The ownership type discussion for nonutilities differentiates between two types of plants: (1) plants that were originally built by nonutility power producers ("original nonutility plants") and (2) plants that used to be owned by utilities but that were sold to nonutilities as the result of industry deregulation ("former utility plants"). For both groups, differentiation by ownership type is important because of the different economic and operational characteristics of the different types.

- ***Ownership size:*** This section presents information on the Small Business Administration (SBA) entity size of the owners of existing §316(b) facilities. EPA is required to consider economic impacts on small entities when developing new regulations (see *Chapter 9: Regulatory Flexibility Analysis/SBREFA* for the small entity analysis of new facilities subject to the proposed §316(b) New Facility Regulation).

- ***Plant size:*** This section discusses the existing §316(b) facilities by the size of their generation capacity. The size of a plant is important because it partly determines its need for cooling water.

- ***Geographic distribution:*** This section discusses plants by NERC region. The geographic distribution of facilities is important because a high concentration of facilities with costs under a regulation could lead to impacts on a regional level. Everything else being equal, the higher the share of plants with costs, the higher the likelihood that there may be economic and/or system reliability impacts as a result the regulation.

- ***Water body and cooling system type:*** This section presents information on the type of water body from which existing §316(b) facilities draw their cooling water and the type of cooling system they operate. The type of source water body determines the compliance requirements of new facilities subject to the proposed §316(b) New Facility Regulation (see *Chapter 6: Regulatory Options* for a discussion of compliance requirements for the different water body types under the proposed §316(b) New Facility Regulation). Cooling systems can be either once-through or recirculating systems.[6] Plants with once-through cooling water systems withdraw between 80 and 98 percent more water than those with recirculating systems.

Water Use by Steam Electric Power Plants

Steam electric generating plants are the single largest industrial users of water in the United States. In 1995:

- steam electric plants withdrew an estimated 190 billion gallons per day, accounting for 39 percent of freshwater use and 47 percent of combined fresh and saline water withdrawals for offstream uses (uses that temporarily or permanently remove water from its source);
- fossil-fuel steam plants accounted for 71 percent of the total water use by the power industry;
- nuclear steam plants and geothermal plants accounted for 29 percent and less than 1 percent, respectively;
- surface water was the source for more than 99 percent of total power industry withdrawals;
- approximately 69 percent of water intake by the power industry was from freshwater sources, 31 percent was from saline sources.

USGS, 1995

3.3.1 Existing §316(b) Utility Plants

EPA identified steam electric prime movers that require cooling water using information from the EIA data collection Forms EIA-767 and EIA-860A.[7] These prime movers include:

[6] Once-through cooling systems withdraw water from the water body, run the water through condensers, and discharge the water after a single use. Recirculating systems, on the other hand, reuse water withdrawn from the source. These systems take new water into the system only to replenish losses from evaporation or other processes during the cooling process. Recirculating systems use cooling towers or ponds to cool water before passing it through condensers again.

[7] Form EIA-767 (Steam-Electric Plant Operation and Design Report) collects annual data from all steam electric utility plants with a generator nameplate rating of 10 MW or larger. Form EIA-860A (Annual Electric Generator Report) collects data used to create an annual inventory of utilities. The data collected includes: type of prime mover; nameplate rating; energy source; year of initial commercial operation; operating status; cooling water source, and NERC region.

- Atmospheric Fluidized Bed Combustion (AB)
- Combined Cycle Steam Turbine with Supplementary Firing (CA)
- Steam Turbine – Common Header (CH)
- Combined Cycle – Single Shaft (CS)
- Combined Cycle Steam Turbine – Waste Heat Boiler Only (CW)
- Steam Turbine – Geothermal (GE)
- Integrated Coal Gasification Combined Cycle (IG)
- Steam Turbine – Boiling Water Nuclear Reactor (NB)
- Steam Turbine – Graphite Nuclear Reactor (NG)
- Steam Turbine – High Temperature Gas-Cooled Nuclear Reactor (NH)
- Steam Turbine – Pressurized Water Nuclear Reactor (NP)
- Steam Turbine – Solar (SS)
- Steam Turbine – Boiler (ST)

Using this list of steam electric prime movers and Form EIA-860A information on the reported operating status of units, EPA identified 871 facilities that have at least one generating unit with a steam electric prime mover. Additional information from Form EIA-767 and the UDI database was used to determine that 678 of the 871 facilities operate a CWIS and hold an NPDES permit. Table 3-5 provides information on the number of utilities, utility plants, and generating units, and the generating capacity in 1998. The table provides information for the industry as a whole, for the steam electric part of the industry, and for the "§316(b)" part of the industry.

Table 3-5: Number of Utilities, Utility Plants, Units, and Capacity, 1998

	Total†	Steam Electric††		Steam Electric with CWIS and NPDES Permit	
		Number	% of Total	Number	% of Total
Utilities	866	312	36%	221	26%
Plants	3,042	871	29%	678	22%
Units	10,208	2,231	22%	1,781	17%
Nameplate Capacity (MW)	728,782	562,117	77%	509,313	70%

† Includes only generating capacity not permanently shut down or sold to nonutilities.
†† Utilities and plants are listed as steam electric if they have at least one steam electric unit.

Source: Form EIA-860A, 1998; UDI Database, 1994.

Table 3-5 shows that the 871 steam electric plants account for only 29 percent of all plants but for 77 percent of all capacity. The 678 plants that withdraw cooling water from a water of the United States and hold an NPDES permit represent 22 percent of all plants, are owned by 26 percent of all utilities, and account for approximately 70 percent of reported utility generation capacity. The remainder of this section will focus on the 678 utility plants that withdraw from a water of the United States and hold an NPDES permit.

a. Ownership Type

Table 3-6 shows the distribution of the 221 utilities that own the 678 existing §316(b) plants as well as the total generating capacity of these entities by type of ownership. Utilities can be divided into three major ownership categories: investor-owned utilities, publicly-owned utilities (including municipalities, and federal and state-owned utilities), and rural electric cooperatives. Table 3-6 shows that 32 percent of plants operated by investor-owned utilities have a CWIS and an NPDES permit. These 523 facilities account for 77 percent of all existing plants with a CWIS and an NPDES permit. In contrast, the percentage of all plants that have a CWIS and an NPDES permit is much lower for the other ownership types: 21 percent for rural electric cooperatives, 9 percent for municipalities, and 10 percent for other publicly owned utilities.

Table 3-6: Existing Utilities, Plants, and Capacity by Ownership Type, 1998

Ownership Type	Utilities			Plants			Capacity (MW)		
	Total Number of Utilities	Utilities with Plants with CWIS and NPDES		Total Number of Plants	Plants with CWIS and NPDES		Total Capacity	Capacity with CWIS and NPDES	
		Number	% of Total		Number	% of Total		MW	% of Total
Investor-Owned	171	127	74%	1,610	523	32%	549,442	435,358	79%
Coop	68	22	32%	199	41	21%	25,860	16,350	63%
Municipal	566	60	11%	841	76	9%	43,477	17,570	40%
Other Public	61	12	20%	392	38	10%	110,003	40,035	36%
Total	866	221	26%	3,042	678	22%	728,782	509,313	70%

Source: Form EIA-860A, 1998; UDI Database, 1994; Form EIA-861, 1998.

b. Ownership Size

EPA used the Small Business Administration (SBA) small entity size standards for SIC code 4911 (electric output of less than 4 million megawatt hours per year) for investor-owned utilities and rural electric cooperatives, and the population-based size standard established for governmental jurisdictions (population of less than 50,000) for publicly owned utilities to make the small entity determination.[8]

Table 3-7 provides information on the total number of utilities and utility plants owned by small entities by type of ownership. The table shows that 62 of the 221 utilities with existing §316(b) plants, or 28 percent, are small. The size distribution varies considerably by ownership type: only 14, or 11 percent, of all investor-owned utilities with existing §316(b) plants are small, compared 36, or 60 percent, of all municipalities. The same is true on the plant level: only four percent of the 523 existing §316(b) plants owned by a investor-owned utility are owned by a small entity. The corresponding percentages for municipalities, other publicly owned utilities, and electric cooperatives are 49 percent, 13 percent, and 32 percent, respectively.

Table 3-7 also shows the percentage of all small utilities and all plants owned by small utilities that comprise the "§316(b)" part of the industry. Nine percent of all small utilities operate existing §316(b) plants. Again, the distribution varies considerably by ownership type: only seven percent of all small municipal utilities operate a §316(b) plant, compared to 29 percent of all small investor-owned utilities. At the plant level, 11 percent of plants operated by investor-owned small entities have CWISs and NPDES permits compared to only five percent of small municipally-owned plants.

[8] SBA defines "small business" as firms with an annual electric output of four million megawatthours or less and "small governmental jurisdictions" as governments of cities, counties, towns, school districts or special districts with a population of less than 50,000 people.

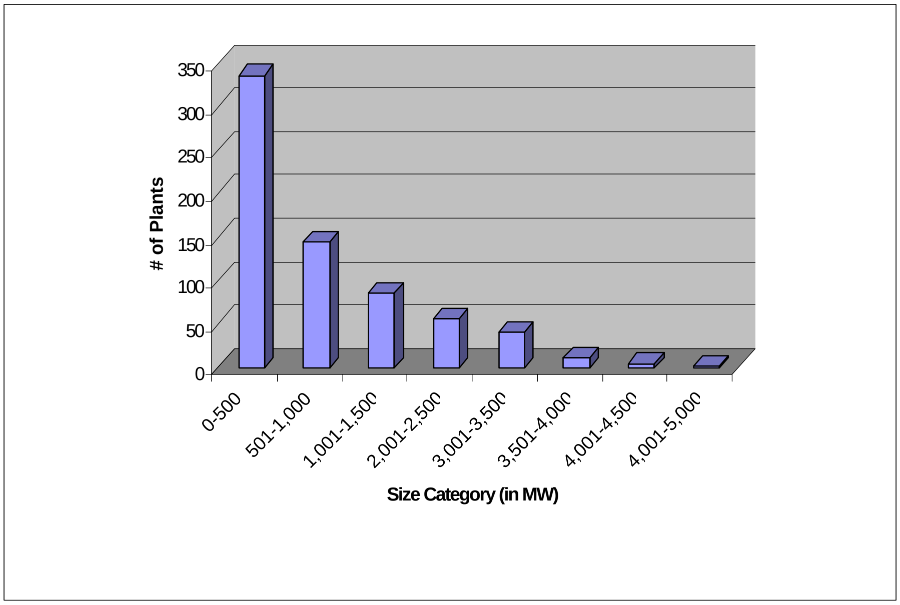
Table 3-7: Small Utilities and Utility Plants by Ownership Type, 1998								
Ownership Type	**Total**				**With CWIS and NPDES Permit**			**Small with CWIS and NPDES/ Total Small**
	Total	**Small**	**Unknown**	**% Small**	**Total**	**Small**	**% Small**	
Utilities								
Investor-Owned	171	48	12	28%	127	14	11%	29%
Coop	68	50	0	74%	22	9	41%	18%
Municipal	566	549	6	97%	60	36	60%	7%
Other Public	61	26	18	43%	12	3	25%	12%
Total	866	673	36	78%	221	62	28%	9%
Plants								
Investor-Owned	1,610	180	48	11%	523	19	4%	11%
Coop	199	145	0	73%	41	13	32%	9%
Municipal	841	765	7	91%	76	37	49%	5%
Other Public	392	82	141	21%	38	5	13%	6%
Total	3,042	1,172	196	39%	678	74	11%	6%

Source: Form EIA-860A, 1998; EIA-861, 1998.

c. Plant Size

EPA also analyzed the steam electric facilities with a CWIS and an NPDES permit with respect to their generating capacity. Of the 678 plants, 336 (50 percent) have a total nameplate capacity of 500 megawatts or less, and 480 (71 percent) have a total capacity of 1,000 megawatts or less. Figure 3-5 presents the distribution of existing utility plants with a CWIS and an NPDES permit by plant size.

Figure 3-5: Number of Existing Utility Plants with CWIS and NPDES Permit by Plant Size, 1998



Source: Form EIA-860A, 1998.

d. Geographic Distribution

Table 3-8 shows the distribution of existing §316(b) utility plants by NERC region. The figure shows that there are considerable differences between the regions in terms of both the number of existing utility plants with a CWIS and an NPDES permit and the percentage of all plants that they represent. Excluding Alaska, which only has one utility plant with a CWIS and an NPDES permit, the percentage of existing §316(b) facilities ranges from six percent in the Western Systems Coordinating Council (WSCC) to 58 percent in the Electric Reliability Council of Texas (ERCOT). The East Central Area Reliability Coordination Agreement (ECAR) has the highest absolute number of existing §316(b) facilities with 124, or 44 percent of all facilities, followed by the Southeastern Electric Reliability Council (SERC) with 122 facilities, or 38 percent of all facilities. The smallest percentage of water use for utilities is observed in the West and Southwest (the WSCC and the Southwest Power Pool, SPP, have the lowest percentages with six and 19 percent, respectively), where water conservation has long been an important issue.

Table 3-8: Utility Plants by NERC Region, 1998

NERC Region	Total Number of Plants	Plants with CWIS and NPDES Permit	
		Number	% of Total
ASCC	166	1	1%
ECAR	283	124	44%
ERCOT	106	61	58%
FRCC	63	32	51%
HI	16	6	38%
MAAC	121	52	43%
MAIN	196	60	31%
MAPP	398	63	16%
NPCC	372	59	16%
SERC	320	122	38%
SPP	259	50	19%
WSCC	742	48	6%
Total	3,042	678	22%

Source: Form EIA-860A, 1998; Form EIA-861, 1998.

e. Water Body and Cooling System Type

The impacts of CWISs on the aquatic habitats from which they withdraw water depend on several factors, including the type of water body, the location of the CWIS relative to sensitive biological areas, the intake flow volume, and the velocity. This section characterizes existing §316(b) utility plants with respect to two of those characteristics: water body type and cooling system type.

Table 3-9 shows that most of the existing utility plants with a CWIS and an NPDES permit draw water from a freshwater river (369, or 54 percent). The next most frequent water body types are lakes or reservoirs with 141 plants (21 percent) and estuaries or tidal rivers with 88 plants (13 percent).

The table also shows that most of these plants, 403 or 59 percent, employ a once-through cooling system. Of the plants that withdraw from an estuary, the most sensitive type of water body, only five percent use a closed cycle system while 85 percent have a once through system. In contrast, 28 percent of plants located on freshwater rivers and on lakes or reservoirs have a closed cycle system.

Table 3-9: Number of Utility Plants by Water Body Type and Cooling System Type

Water Body Type	Cooling System Type								Total
	Closed Cycle		Once Through		Combination		Unknown		
	Number	% of Total	Number	% of Total	Number	% of Total	Number	% of Total	
Estuary	4	5%	75	85%	7	8%	2	2%	88
Lake	39	28%	89	63%	12	9%	1	1%	141
Ocean	1	6%	16	89%	1	6%	0	0%	18
River	102	28%	214	58%	52	14%	1	0%	369
Other/ Unknown	22	35%	9	15%	6	10%	25	40%	62
Total	168	25%	403	59%	78	12%	29	4%	678

Source: Form EIA-767, 1997; UDI database, 1994; Form EIA-860A, 1998.

3.3.2 Existing §316(b) Nonutility Plants

EPA identified nonutility steam electric prime movers that require cooling water using information from the EIA data collection Forms EIA-860B and EIA-867.[9] These prime movers include:

- Atmospheric Fluidized Bed Combustion (AB)
- Combined Cycle – Auxiliary (CA)
- Combined Cycle – Total Unit (CC)
- Steam Turbine – Common Header (CH)
- Combined Cycle – Single Shaft (CS)
- Combined Cycle – Waste(CW)
- Steam Turbine – Geothermal (GE)
- Combined Cycle – ICG (IG)
- Nuclear BWR (NB)
- Steam Turbine Graphite Nuclear Reactor (NG)
- Nuclear HTGR (NH)
- Nuclear LWBR (NL)
- Nuclear PWR (NP)
- Nuclear Unknown (NU)
- Steam Turbine – Flourized Bed (SF)
- Steam Turbine – Solar (SS)
- Steam Turbine – Boiler (ST)

Forms EIA-860B and EIA-867 include two types of nonutilities: facilities whose primary business activity is the generation of electricity, and manufacturing facilities that operate industrial boilers in addition to their primary manufacturing processes. The discussion of existing §316(b) nonutilities focuses on those nonutility facilities that generate electricity as their primary line of business.[10] Manufacturing facilities with industrial boilers are included in the industry profiles in *Chapter 4: Profile of Manufacturing Industries*.

Using the identified list of steam electric prime movers and Form EIA-860B information on the reported operating status of units, EPA identified 422 facilities that have at least one generating unit with a steam electric prime mover. Additional information from the §316(b) Industry Screener determined that 85 of the 422 facilities operate a CWIS and hold an NPDES permit. Table 3-10 provides information on the number of parent entities, nonutility plants, and generating units, and their generating capacity in 1998. The table provides information for the industry as a whole, for the steam electric part of the industry, and for the "§316(b)" part of the industry.

[9] Form EIA-860B (Annual Nonutility Electric Generator Report) is the equivalent of Form EIA-860A for utilities. It is the annual inventory of nonutility plants and collects data on the type of prime mover, nameplate rating, energy source, year of initial commercial operation, and operating status. Form EIA-867 (Annual Nonutility Power Producer Report) is the predecessor of Form EIA-860B. Form EIA-867 contained similar, but more detailed, information to Form EIA-860B but was confidential. The EIA provided EPA with a list of nonutilities with steam electric prime movers from the 1996 Form EIA-867, which formed the basis for the EPA's screener questionnaire and this analysis.

[10] EPA identified manufacturing facilities operating *steam electric* industrial boilers using SIC code information from Form EIA-867. Those facilities were removed from the analysis. The discussion of steam electric nonutilities and nonutilities with CWIS and NPDES permit, therefore, only includes facilities with electricity generation as their main line of business. However, the same information was not available for facilities with non-steam prime movers. Industry totals, therefore, include industrial boilers.

Table 3-10: Number of Nonutilities, Nonutility Plants, Units, and Capacity, 1998

	Total†	Total Steam Electric Nonutilities††	Nonutilities with CWIS and NPDES Permit††
Parent Entities	1,443	349	62
Plants	1,986	422	85
Units	5,161	555	117
Nameplate Capacity (MW)	97,543	39,260	21,627

† Includes all facilities with at least one non-retired unit in Form EIA-860B data (both nonutilities and industrial boilers).
†† Includes only nonutility plants generating electricity as their primary line of business.

Source: Form EIA-860, 1998; Form EIA-860B, 1998; Form EIA-867, 1996; EPA Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

a. Ownership Type

Nonutility power producers that generate electricity as their main line of business fall into two different categories: "original nonutility plants" and "former utility plants."

❖ ***Original nonutility plants***

For the purposes of this analysis, original nonutility plants are those that were originally built by a nonutility. These plants primarily include facilities qualifying under the Public Utility Regulatory Policies Act of 1978 (PURPA), cogeneration facilities, independent power producers, and exempt wholesale generators under the Energy Policy Act of 1992 (EPACT).

EPA identified original nonutility plants with a CWIS and an NPDES permit through the §316(b) *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* which was sent to all nonutilities with a steam electric prime mover listed in the 1996 Form EIA-867. This profile further differentiates original nonutility plants by their primary Standard Industrial Classification (SIC) code, as reported in the screener questionnaire. Reported SIC codes include:

- 4911 – Electric Services
- 4931 – Electric and Other Services Combined
- 4939 – Combination Utilities, Not Elsewhere Classified
- 4953 – Refuse Systems
- 4961 – Steam and Air-Conditioning Supply

❖ ***Former utility plants***

Former utility plants are those that used to be owned by a utility power producer but have been sold to a nonutility as a result of industry deregulation. These were identified from Form EIA-860B by their plant code.[11]

Table 3-11 shows that original nonutilities account for the vast majority of plants (1,942 out of 1,986, or 98 percent). Only 44 out of the 1,986 nonutility plants, or 2 percent, were formerly owned by utilities. However, these 44 facilities account for more than 23 percent of all nonutility generating capacity. Eighty-five of the 1,986 nonutility plants operate a CWIS and hold an NPDES permit. Most of these §316(b) facilities (61, or 72 percent) are original nonutility plants. Only 24 of the 85 §316(b) nonutility plants are former utility plants, but they account for 78 percent of all §316(b) nonutility capacity.

The table also shows that only three percent of all original nonutility plants have a CWIS and an NPDES permit,[12] compared to 55 percent of all former utility plants.

[11] Utility plants have an identification code number that is less than 10,000 whereas nonutilities have a code number greater than 10,000. When utility plants are sold to nonutilities, they retain their original plant code.

[12] This percentage understates the true share of §316(b) nonutility plants because the total number of plants includes industrial boilers while the number of §316(b) nonutilities does not.

Table 3-11: Existing Nonutility Firms, Plants, and Capacity by SIC Code, 1998

SIC Code	Firms			Plants			Capacity (MW)		
	Total Number of Firms	Firms with Plants with CWIS and NPDES		Total Number of Plants	Plants with CWIS and NPDES		Total Capacity	Capacity with CWIS and NPDES	
		Number	% of Total		Number	% of Total		MW	% of Total
4911	1,429[†]	25	3%	1,942	29	3%	75,020,663	1,930,113	6%
4931		11			15			1,981,596	
4939		4			5			377,430	
4953		7			12			404,555	
4961		1			1			8,332	
Former Utility Plants	14[††]	14	100%	44	24	55%	22,522,775	16,924,508	75%
Total	1,443	62	4%	1,986	85	4%	97,543,438	21,626,535	22%

† Individual numbers may not add up to total due to individual rounding.

†† Three firms owning former utility plants do not operate a plant with a CWIS and an NPDES permit. However, three former utility plants with a CWIS and an NPDES permit are not listed in Form EIA-860B. While the number of firms with plants with CWIS and NPDES permit was adjusted to reflect the owners of the three missing plants, the total number of firms was not. The real percentage of firms that own former utility plants with a CWIS and an NPDES permit is therefore less than 100 percent.

Source: Form EIA-860B, 1998.

b. Ownership Size

EPA used the Small Business Administration (SBA) small entity size standards to determine the number of existing §316(b) nonutility plants owned by small firms. Table 4-12 shows that of the 61 original nonutility plants with CWISs and NPDES permits 17 percent are owned by a small entity. Another 26 percent are owned by a firm of unknown size which may also qualify as a small entity.

Information on the business size for former utility plants was not readily available. EPA classified 14 facilities as owned by a large firm because their plant-level electricity generation in 1997 exceeded 4 million MWh, the SBA threshold for SIC code 4911. All other facilities were classified as "unknown" for the purposes of this profile.

Table 4-12: Number of Nonutility Plants with CWIS and NPDES Permit by Firm Size, 1998

SIC Code	Large		Small		Unknown		Total
	No.	% of SIC	No.	% of SIC	No.	% of SIC	
4911	14	48%	6	20%	9	32%	29
4931	10	69%	2	15%	2	15%	15
4939	3	75%	1	25%	0	0%	5
4953	6	50%	1	10%	5	40%	12
4961	1	100%	0	0%	0	0%	1
Total Original Nonutilities	34	57%	10	17%	16	26%	61
Former Utility Plants†	14	58%	0	0%	10	42%	24

† Individual numbers may not add up to total due to individual rounding.

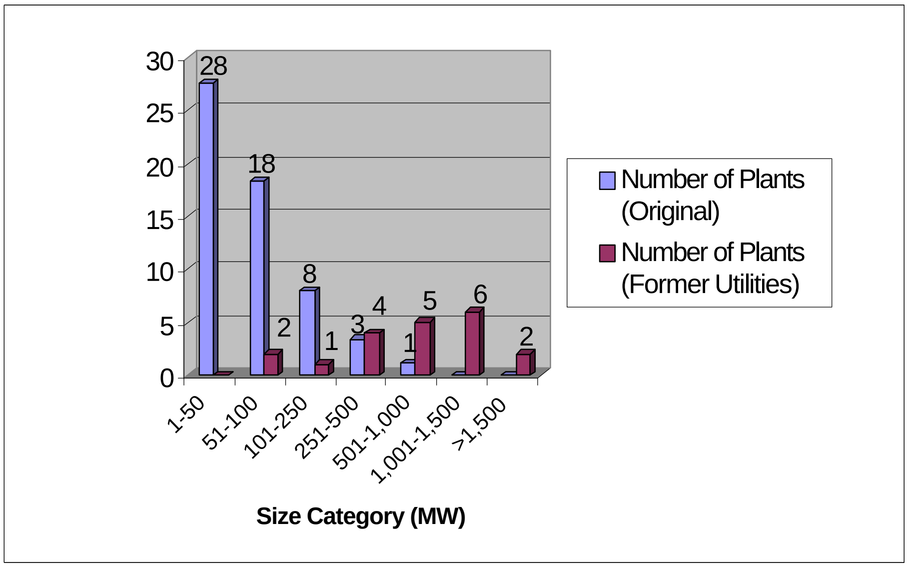
† Information on the size of nonutility firms owning former utility plants was not available. Fourteen facilities were classified as large because their plant-level electricity generation in 1997 exceeded 4 million MWh, the SBA threshold for SIC code 4911. All other facilities were classified as "unknown."

Source: EPA Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; D&B Database, 1999.

c. Plant Size

EPA also analyzed the steam electric nonutilities with a CWIS and an NPDES permit with respect to their generating capacity. Figure 3-7 shows that the original nonutility plants are much smaller than the former utility plants. Of the 61 original utility plants, 28 (46 percent) have a total nameplate capacity of 50 MW or less and 46 (75 percent) have a capacity of 100 MW or less. No original nonutility plant has a capacity of more than 1,000 MW. In contrast, only three (13 percent) former utility plants are smaller than 250 MW while 13 (54 percent) are larger than 500 MW and eight (33 percent) are larger than 1,000 MW.

Figure 3-6: Distribution of Existing Nonutility Plants with In-Scope Characteristics by Capacity, 1998



Data for 78 nonutility plants. Seven plants are listed without steam electric capacity in 1998 EIA-860B.

Source: *Form EIA-860B, 1998; EPA Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.*

d. Geographic Distribution

Table 3-13 shows the distribution of existing §316(b) nonutility plants by NERC region. The figure shows that the Northeast Power Coordinating Council (NPCC) has the highest absolute number of existing §316(b) nonutility plants with 33, or 39 percent of all 85 plants with a CWIS and an NPDES permit, followed by the Western System Coordinating Council (WSCC) with 12 plants.

The East Central Area Reliability Coordination Agreement (ECAR) and the Mid-Atlantic Area Council (MAAC) have the largest percentage of plants with a CWIS and an NPDES permit compared to all nonutility plants, with 11 percent each.[13]

Table 3-13: Nonutility Plants by NERC Region, 1998

NERC Region	Total Number of Plants	Plants with CWIS & NPDES Permit	
		Number	% of Total
ASCC	28	1	4%
ECAR	101	11	11%
ERCOT	40	0	0%
FRCC	62	2	4%
HI	8	0	0%
MAAC	95	10	11%
MAIN	105	1	1%
MAPP	74	1	2%
NPCC	384	33	9%
SERC	246	8	3%
SPP	55	0	0%
WSCC	585	12	2%
Not Available	203	4	2%
Total	**1,986**	**85**	**4%**

Source: Form EIA-860, 1998; Form EIA-860B, 1998; EPA Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

[13] As explained earlier, the total number of plants includes industrial boilers while the number of plants with a CWIS and an NPDES permit does not. Therefore, the percentages are likely higher than presented.

e. Water Body and Cooling System Type

Table 3-14 shows the distribution of existing §316(b) nonutility plants by type of water body and cooling system. Table 3-9 shows that most of the original nonutility plants with a CWIS and an NPDES permit draw water from a freshwater river (38, or 62 percent) while most of the former utility plants withdraw from an ocean (8, or 33 percent).

The table also shows that most of the original nonutility plants (37 or 60 percent) employ a closed cycle cooling system while most of the former utility plants (18, or 75 percent) have a once through system. Ten original nonutility plants withdraw from an estuary, with only two of them employing a closed cycle system. Among the former utility plants, five withdraw from an estuary, all with a once through system.

Table 3-14: Number of Nonutility Plants by Water Body Type and Cooling System Type

Water Body Type	Cooling System								Total
	Closed Cycle		Once Through		Combination		Unknown		
	Number	% of Total	Number	% of Total	Number	% of Total	Number	% of Total	
Original Nonutilities									
Estuary	2	22%	8	78%	0.00	0%	0	0%	10
Lake	10	82%	2	18%	0.00	0%	0	0%	13
Ocean	0	0%	0	0%	0.00	0%	0	0%	0
River	24	64%	13	33%	1.15	3%	0	0%	38
Other/ Unknown	0	0%	0	0%	0.00	0%	0	0%	0
Total	37	60%	23	38%	1	2%	0	0%	61
Former Utility Plants									
Estuary	0	0%	5	100%	0	0%	0	0%	5
Lake	1	100%	0	0%	0	0%	0	0%	1
Ocean	0	0%	8	100%	0	0%	0	0%	8
River	3	50%	3	50%	0	0%	0	0%	6
Other/ Unknown	0	0%	2	50%	0	0%	2	50%	4
Total	4	17%	18	75%	0	0%	2	8%	24

Source: Form EIA-860B, 1998; EPA Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

3.4 INDUSTRY OUTLOOK

This section discusses industry trends that are currently affecting the structure of the electric power industry and may therefore affect the magnitude of impacts from §316(b) regulation. The most important change in the electric power industry is deregulation – the transition from a highly regulated monopolistic to a less regulated, more competitive industry. Subsection 3.4.1 discusses the current status of deregulation. Subsection 3.4.2 presents a summary of forecasts from the Annual Energy Outlook 2000.

3.4.1 Current Status of Industry Deregulation

The electric power industry is evolving from a highly regulated, monopolistic industry with traditionally-structured electric utilities to a less regulated, more competitive industry.[14] The industry has traditionally been regulated based on the premise that the supply of electricity is a natural monopoly, where a single supplier could provide electric services at a lower total cost than could be provided by several competing suppliers. Today, the relationship between electricity consumers and suppliers is undergoing substantial change. Some states have implemented plans that will change the procurement and pricing of electricity significantly, and many more plan to do so during the first few years of the 21st century (Beamon, 1998).

a. Key Changes in the Industry s Structure

Industry deregulation already has and continues to fundamentally change the structure of the electric power industry. Some of the key changes include:

- ***Provision of services:*** Under the traditional regulatory system, the generation, transmission, and distribution of electric power were handled by vertically-integrated utilities. Since the mid-1990s, federal and state policies have led to increased competition in the generation sector of the industry. Increased competition has resulted in a separation of power generation, transmission, and retail distribution services. Utilities that provide transmission and distribution services will continue to be regulated and will be required to divest of their generation assets. Entities that generate electricity will no longer be subject to geographic or rate regulation.

- ***Relationship between electricity providers and consumers:*** Under traditional regulation, utilities were granted a geographic franchise area and provided electric service to all customers in that area at a rate approved by the regulatory commission. A consumer's electric supply choice was limited to the utility franchised to serve their area. Similarly, electricity suppliers were not free to pursue customers outside their designated service territories. Although most consumers will continue to receive power through their local distribution company (LDC), retail competition will allow them to select the company that generates the electricity they purchase.

- ***Electricity prices:*** Under the traditional system, state and federal authorities regulated all aspects of utilities' business operations, including their prices. Electricity prices were determined administratively for each utility, based on the average cost of producing and delivering power to customers and a reasonable rate of return. As a result of deregulation, competitive market forces will set generation prices. Buyers and sellers of power will negotiate through power pools or one-on-one to set the price of electricity. As in all competitive markets, prices will reflect the interaction of supply and demand for electricity. During most time periods, the price of electricity will be set by the generating unit with the highest operating costs needed to meet spot market generation demand (i.e., the "marginal cost" of production) (Beamon, 1998).

b. New Industry Participants

The Energy Policy Act of 1992 (EPACT) provides for open access to transmission systems, to allow nonutility generators to enter the wholesale market more easily. In response to these requirements, utilities are proposing to form Independent System Operators (ISOs) to operate the transmission grid, regional transmission groups, and open access same-time information systems (OASIS) to inform competitors of available capacity on their transmission systems. The advent of open transmission access has fostered the development of power marketers and power brokers as new participants in the electric power industry. Power marketers buy and sell wholesale electricity and fall under the jurisdiction of the Federal Energy Regulatory Commission (FERC), since they take ownership of

[14] Several key pieces of federal legislation have made the changes in the industry's structure possible. The ***Public Utility Regulatory Policies Act*** (PURPA) of 1978 opened up competition in the generation market by creating a class of nonutility electricity-generating companies referred to as "qualifying facilities." The ***Energy Policy Act*** (EPACT) of 1992 removed constraints on ownership of electric generation facilities, and encouraged increased competition in the wholesale electric power business (Beamon, 1998).

electricity and are engaged in interstate trade. Power marketers generally do not own generation or transmission facilities or sell power to retail customers. A growing number of power marketers have filed with the FERC and have had rates approved. Power brokers do not take ownership of electricity and are not regulated by the FERC.

c. State Activities

Many states are taking steps to promote competition in their electricity markets. The status of these efforts varies across states. Some states are just beginning to study what a competitive electricity market might mean; others are beginning pilot programs; still others have designed restructured electricity markets and passed enabling legislation. The following states have already enacted restructuring legislation (U.S. DOE, 2000b):

- Arizona
- Arkansas
- California
- Connecticut
- Delaware
- District of Columbia
- Illinois
- Maine
- Maryland
- Massachusetts
- Michigan
- Montana
- Nevada
- New Hampshire
- New Jersey
- New Mexico
- Ohio
- Oklahoma
- Oregon
- Pennsylvania
- Rhode Island
- Texas
- Virginia
- West Virginia

Even in states where consumer choice is available, important aspects of implementation may still be undecided. Key aspects of implementing restructuring include treatment of ***stranded costs***, pricing of transmission and distribution services, and the design market structures required to ensure that the benefits of competition flow to all consumers (Beamon, 1998).

3.4.2 Energy Market Model Forecasts

This section discusses forecasts of electric energy supply, demand, and prices based on data and modeling by the EIA and presented in the *Annual Energy Outlook 2000* (U.S. DOE, 1999b). The EIA models future market conditions through the year 2020, based on a range of assumptions regarding overall economic growth, global fuel prices, and legislation and regulations affecting energy markets. The projections are based on the results from EIA's National Energy Modeling System (NEMS). The following discussion present EIA's reference case results.

❖ *Electricity Demand*

EIA expects electricity demand to grow by approximately 1.4 percent annually between 1998 and 2020. This growth is driven by an estimated 1.5 percent annual increase in the demand for electricity by residential customers. Residential demand growth results from an increase in the number of households, particularly in the south where most new homes use central air conditioning, as well as increased penetration of consumer electronics. EIA expects electricity demand from the commercial sector to increase by 1.2 percent annually over the same forecast period, largely in response to an annual increase in commercial floor space. Industrial electricity demand is expected to increase by 1.3 percent annually, due mostly to an increase in industrial output.

❖ *Capacity Retirements*

EIA expects total nuclear generation capacity to decline by an estimated 41 percent (40 gigawatts) between 1998 and 2020 due to nuclear power plant retirement. To produce this estimate, EIA compared the costs associated with extending the life of aging nuclear generation facilities to the cost of building new capacity to meet the need for additional electricity generation. EIA determined that plant aging related investments for most nuclear plants would exceed the cost of building new capacity. EIA also expects total fossil fuel-fired generation capacity to decline due to retirements. Retirements of fossil-steam plants is estimated to decrease capacity in this sector by approximately 16 percent (i.e., 28 gigawatts) over the same time period.

❖ *Capacity Additions*

Additional generation capacity will be needed to meet the estimated growth in electricity demand and offset the retirement of existing capacity. The EIA expects plant owners to employ other options, such as life extensions or repowering, before building new capacity. The Agency forecasts that utilities will choose technologies for new generation capacity that seek to minimize cost while meeting environmental and emission constraints. Of the new capacity forecast to come on-line between 1998 and 2020, 90 percent is expected to be combined-cycle or combustion turbine technology. This additional capacity is expected to be fueled by natural gas or both oil and natural gas, and to supply primarily peak and intermediate capacity. Another seven percent of additional capacity is expected to be provided by new coal-fired plants, while the remaining three percent is forecast to come from renewable technologies.

❖ ***Electricity Generation***

EIA expects increased electricity generation from both natural gas and coal-fired plants to meet growing demand and to offset lost capacity due to plant retirements. Coal-fired plants are expected to continue to account for approximately half of the industry's total generation. Although coal-fired generation is predicted to increase steadily between 1998 and 2020, its share of total generation is expected to decrease from 52 percent to an estimated 49 percent. This decrease in the share of coal generation is in favor of less capital-intensive and more efficient natural gas generation technologies. The share of total generation associated with gas-fired technologies is forecast to increase from approximately 14 percent in 1998 to an estimated 31 percent in 2020, replacing nuclear power as the second largest source of electricity generation. Generation from oil-fired plants is expected to decline over the forecast period as oil-fired steam generators are replaced by gas turbine technologies.

❖ ***Electricity Prices***

EIA expects the average wholesale price of electricity, as well as the price paid by customers in each sector (residential, commercial, and industrial), to decrease between 1998 and 2020 as a result of competition among electricity suppliers. Specific market restructuring plans differ from state to state. Some states have begun deregulating their electricity markets; EIA expects most states to phase in increased customer access to electricity suppliers. Increases in the cost of fuels like natural gas and oil are not expected to increase electricity prices; these increases are expected to be offset by reductions in the price of other fuels and shifts to more efficient generating technologies.

GLOSSARY

Combined-Cycle Turbine: An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to heat recovery steam generator for utilization by a steam turbine in the production of electricity. This process increases the efficiency of the electric generating unit.

Distribution: The portion of an electric system that is dedicated to delivering electric energy to an end user.

Electricity Available to Consumers: Power available for sale to customers. Approximately 8 to 9 percent of net generation is lost during the transmission and distribution process.

Energy Policy Act (EPACT): In 1992 the EPACT removed constraints on ownership of electric generation facilities and encouraged increased competition on the wholesale electric power business.

Gas Combustion Turbine: A gas turbine typically consisting of an axial-flow air compressor and one or more combustion chambers, where liquid or gaseous fuel is burned and the hot gases are passed to the turbine. The hot gases expand to drive the generator and are then used to run the compressor.

Generation: The process of producing electric energy by transforming other forms of energy. Generation is also the amount of electric energy produced, expressed in ***watthours (Wh)***.

Gross Generation: The total amount of electric energy produced by the generating units at a generating station or stations, measured at the generator terminals.

Internal Combustion Engine: An internal combustion engine has one or more cylinders in which the process of combustion takes place, converting energy released from the rapid burning of a fuel-air mixture into mechanical energy. Diesel or gas-fired engines are the principal fuel types used in these generators.

Kilowatthours (kWh): One thousand ***watthours (Wh)***.

Nameplate Capacity: The amount of electric power delivered or required for which a generator, turbine, transformer, transmission circuit, station, or system is rated by the manufacturer.

Net Capacity: The amount of electric power delivered or required for which a generator, turbine, transformer, transmission circuit, station, or system is rated by the manufacturer, exclusive of station use, and unspecified conditions for a given time interval.

Net Generation: Gross generation minus plant use from all plants owned by the same utility.

Nonutility: A corporation, person, agency, authority, or other legal entity or instrumentality that owns electric generating capacity and is not an electric utility. Nonutility power producers include qualifying cogenerators, qualifying small power producers, and other nonutility generators (including independent power producers) without a designated franchised service area, and which do not file forms listed in the Code of Federal Regulations, Title 18, Part 141. (http://www.eia.doe.gov/cneaf/electricity/epav1/html/Glossary.htm)

Other Prime Movers: Methods of power generation other than ***steam turbine***, ***combined-cycle***, ***gas combustion turbine***, ***internal combustion engine***, and ***water turbine***. Other prime movers include: geothermal prime mover, solar prime mover, wind prime mover, and biomass prime mover.

Prime Movers: The engine, turbine, water wheel or similar machine that drives an electric generator. Also, for reporting purposes, a device that directly converts energy to electricity, e.g., photovoltaic, solar, and fuel cell(s).

Public Utility Regulatory Policies Act (PURPA): In 1978 PURPA opened up competition in the generation market by creating a class of nonutility electricity-generating companies referred to as "qualifying facilities."

Reliability: Electric system reliability has two components: adequacy and security. Adequacy is the ability of the electric system to supply customers at all times, taking into account scheduled and unscheduled outages of system facilities. Security is the ability of the electric system to withstand sudden disturbances, such as electric short circuits or unanticipated loss of system facilities. (http://www.eia.doe.gov/oiaf/elepri97/glossary.html)

Steam Turbine: A generating unit in which the prime mover is a steam turbine. The turbines convert thermal energy (steam or hot water) produced by generators or boilers to mechanical energy or shaft torque. This mechanical energy is used to power electric generators, including combined cycle electric generating units, which convert the mechanical energy to electricity.

Stranded Costs: The difference between revenues under competition and costs of providing service, including the inherited fixed costs from the previous regulated market. (http://www.eia.doe.gov/oiaf/elepri97/glossary.html)

Transmission: The movement or transfer of electric energy over an interconnected group of lines an associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer.

Utility: A corporation, person, agency, authority, or other legal entity or instrumentality that owns and/or operates facilities within the United States, its territories, or Puerto Rico for the generation, transmission, distribution, or sale of electric energy primarily for use by the public and files forms listed in the Code of Federal Regulations, Title 18, Part 141. Facilities that qualify as cogenerators or small power producers under the Public Utility Regulatory Policies Act (PURPA) are not considered electric utilities. (http://www.eia.doe.gov/cneaf/electricity/epav1/html/Glossary.htm)

Water Turbine: A unit in which the turbine generator is driven by falling water.

Watthour (Wh): An electrical energy unit of measure equal to 1 ampere flowing under pressure of 1 volt at unity power factor.

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Chapter 4: Profile of Manufacturers

INTRODUCTION

Based on the *1982 Census of Manufactures* and information from effluent guideline development materials, EPA identified four industrial categories other than SIC Major Group 49 that are most likely to be affected by the §316(b) regulation. These industries, referred to collectively here as "manufacturers," were selected because of their known use of cooling water. They are Paper and Allied Products (SIC 26), Chemicals and Allied Products (SIC 28), Petroleum and Coal Products (SIC 29), and Primary Metal Industries (SIC 33).

While facilities in other industrial groups also use cooling water and may therefore be subject to §316(b) regulations, their total cooling water intake flow is believed to be small relative to that of the four selected industries. Therefore, this Profile of Manufacturers focuses on the manufacturing groups listed above.

CHAPTER CONTENTS

The remainder of this chapter is divided into five sections:[1]

- 4A: Paper and Allied Products (SIC 26)
- 4B: Chemicals and Allied Products (SIC 28)
- 4C: Petroleum and Coal Products (SIC 29)
- 4D: Steel (SIC 331)
- 4E: Aluminum (SIC 333/335)

Each industry section is further divided into the following four subsections: (1) domestic production, (2) structure and competitiveness, (3) financial condition and performance, and (4) §316(b) facilities. Each sector profile only presents data for SIC codes that were identified in the §316(b) Industry Screener Questionnaire as important users of cooling water directly withdrawn from a water of the United States.[2]

[1] Steel and aluminum are the two dominant products in the U.S. industrial metals industry. These two markets, however, are structured differently and are therefore discussed in two separate profile sections.

[2] The electronic version of this report is comprised of six separate files, one for each of the five industries and one for the glossary of terms.

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4A Paper and Allied Products (SIC 26)

EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* identified five 4-digit SIC codes in the Paper and Allied Products industry (SIC 26) with at least one existing facility that operates a CWIS, holds a NPDES permit, and withdraws more than two million gallons per day (MGD) from a water of the United States, and uses at least 25 percent of its intake flow for cooling purposes (facilities with these characteristics are hereafter referred to as "§316(b) facilities"). For each of the five SIC codes, Table 4A-1 below provides a description of the industry sector, a list of primary products manufactured, the total number of screener respondents, and the number and percent of §316(b) facilities.

Table 4A-1: §316(b) Facilities in the Paper and Allied Products Industry (SIC 26)

SIC	SIC Description	Important Products Manufactured	Number of Screener Respondents: Total	§316(b) Facilities: No.†	§316(b) Facilities: %
2611	Pulp Mills	Pulp from wood or from other materials, such as rags, linters, wastepaper, and straw; integrated logging and pulp mill operations if primarily shipping pulp.	66	43	65.8%
2621	Paper Mills	Paper from wood pulp and other fiber pulp, converted paper products; integrated operations of producing pulp and manufacturing paper if primarily shipping paper or paper products.	286	128	44.5%
2631	Paperboard Mills	Paperboard, including paperboard coated on the paperboard machine, from wood pulp and other fiber pulp; and converted paperboard products; integrated operations of producing pulp and manufacturing paperboard if primarily shipping paperboard or paperboard products.	187	45	23.9%
Total			***539***	***216***	***40.0%***
Other Paper and Allied Products Sectors					
2676	Sanitary Paper Products	Sanitary paper products from purchased paper, such as facial tissues and handkerchiefs, table napkins, toilet paper, towels, disposable diapers, and sanitary napkins and tampons.	4	4	100.0%
Total Paper and Allied Products (SIC 26)					
Total 26			**543**	**219**	**40.4%**

† Information on the percentage of intake flow used for cooling purposes was not available for all screener respondents. Facilities for which this information was not available were assumed to use at least 25% of their intake flow for cooling water purposes The reported numbers of §316(b) facilities may therefore be overstated.

Source: *EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual 1987.*

The responses to the Screener Questionnaire indicate that three main sectors account for the largest numbers of §316(b) facilities in the Paper and Allied Products industry: (1) Pulp Mills (SIC 2611), (2) Paper Mills (SIC 2621), and (3) Paperboard Mills (SIC 2631). Fifty-eight percent of the 219 §316(b) facilities in the Paper and Allied Products industry are paper mills. Paperboard mills and pulp mills account for 21 and 20 percent of facilities, respectively. The remainder of the Paper and Allied Products profile therefore focuses on these three industries.

4A.1 Domestic Production

The Paper and Allied Products industry is one of the top ten U.S. manufacturing industries. It also ranks in the top five sectors in sales of nondurable goods. Growth in the paper industry is closely tied to overall gross domestic product (GDP) growth because nearly all of the industry's products are consumer oriented. Over the past decade, however, exports have taken on an increasingly important role, and growth in a number of key foreign paper and paperboard markets is expected to play an important role in the health and expansion of the U.S. Paper and Allied Products industry in the future (McGraw-Hill, 1999).

The industry is one of the primary users of energy, second only to the chemicals and metals industries. However, 56 percent of total energy used in 1996 to 1997 was self-generated, second only to the chemicals industry (McGraw-Hill, 1999).

a. Output

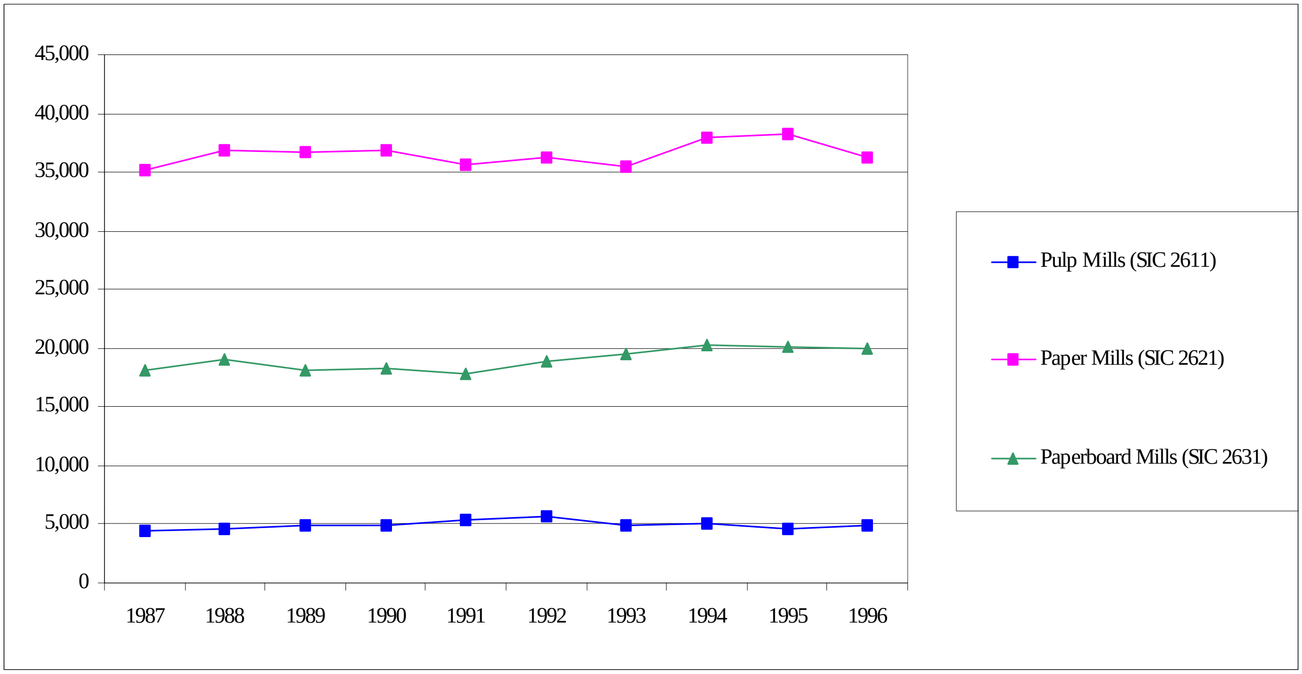
The U.S. Paper and Allied Products industry experienced record sales in 1995. The value of shipments for pulp, paper, and paperboard mills totaled $4.7, $38.2, and $20.2 billion, respectively. In 1996, lower domestic and foreign demand, declining prices, and inventory drawdowns led to a decline in the industry's total shipments by 2.2 percent in real terms (MCGraw-Hill, 1998). More recently, however, consecutive years of increasing demand, slowly increasing prices, higher capacity utilization rates, and inventory drawdowns have led to better industry performance.

Figure 4A-1 shows the trend in ***value of shipments*** and ***value added*** for the three profiled sectors between 1987 and 1996.[3] Value of shipments and value added are two of the most common measures of manufacturing output. They provide insight into the overall economic health and outlook for an industry. Value of shipments is the sum of the receipts a manufacturer earns from the sale of its outputs. It is an indicator of the overall size of a market or the size of a firm in relation to its market or competitors. Value added is used to measure the value of production activity in a particular industry. It is the difference between the value of shipments and the value of inputs used to make the products sold.

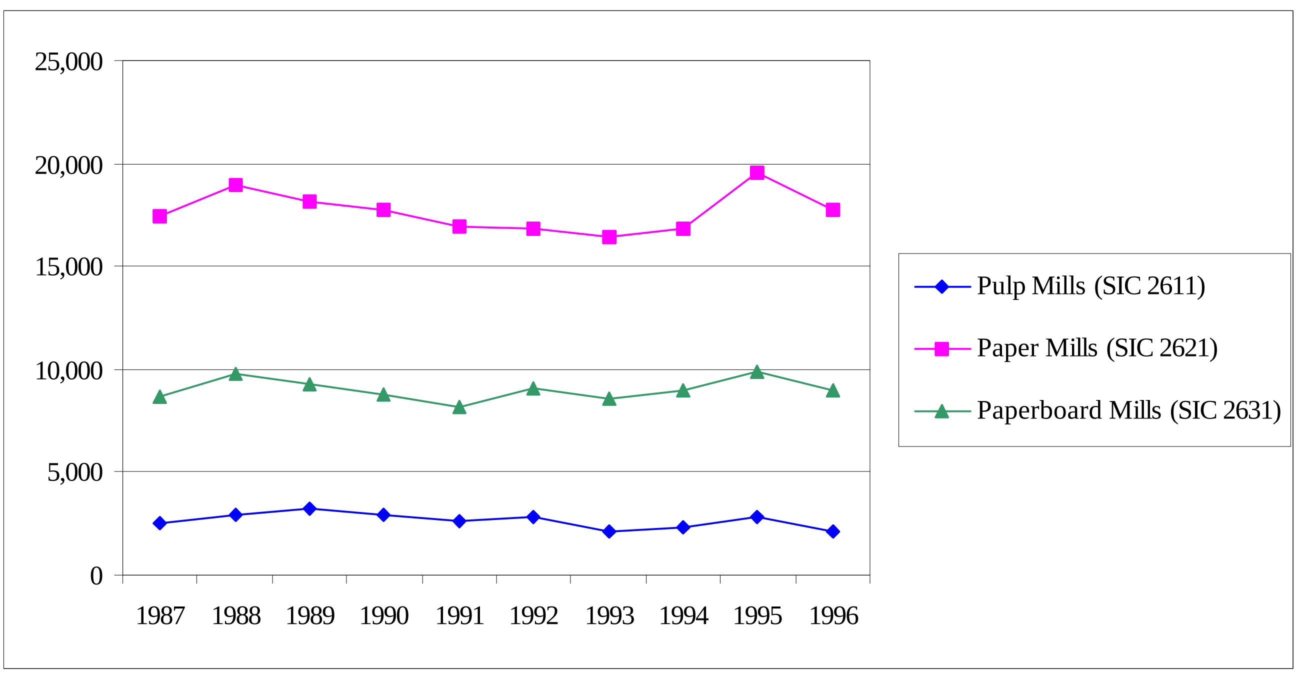
[3] Terms highlighted in bold and italic font are further explained in the glossary.

Figure 4A-1: Value of Shipments and Value Added for Profiled Paper and Allied Products Sectors ($1999 millions)

Value of Shipments ($1999 millions)



Value Added ($1999 millions)



Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

b. Prices

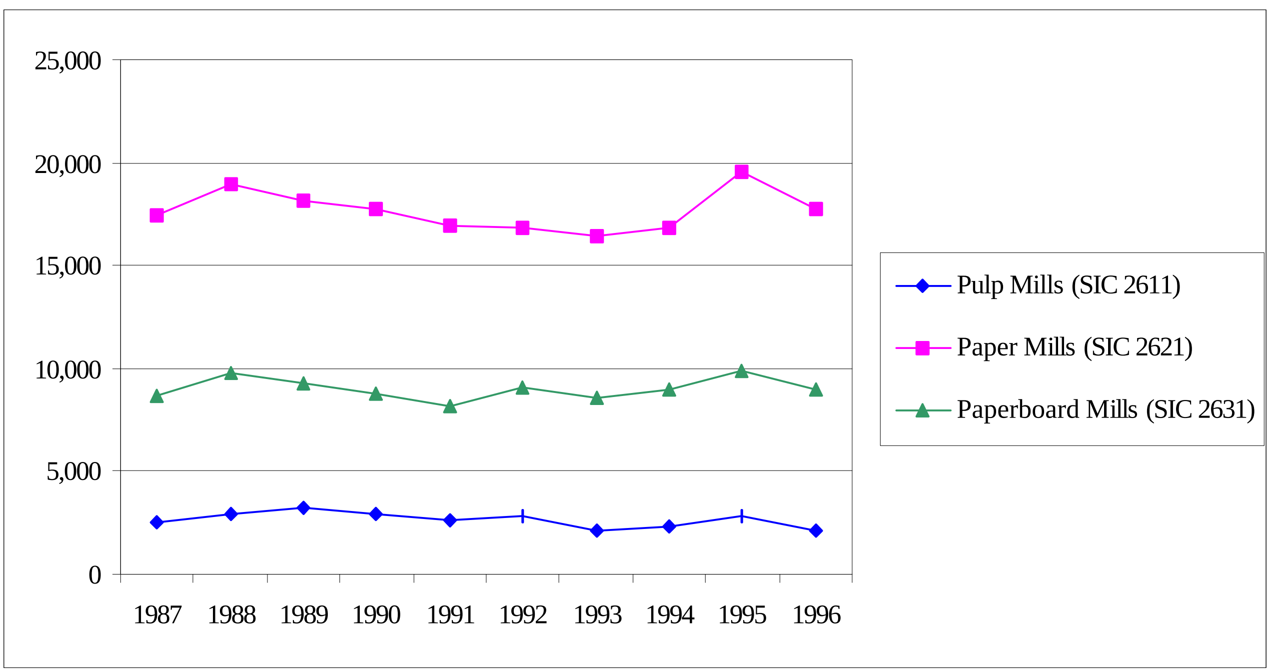
Most products of the Paper and Allied Products industry are commodities. Within these almost purely competitive markets, prices are established by supply and demand. Price levels in the U.S. paper industry are therefore closely tied to domestic and foreign demand as well as industry capacity and operating rates, which determine supply (S&P, 1999).

The paper industry suffered from low prices throughout the early 1990s. These price depressions were the result of the paper boom of the late 1980s which prompted the industry to make heavy investments in capacity expansions. However, lengthy construction periods mean that the new capacity often becomes operational when industry conditions begin to slow. When production of a given paper grade increases just as demand slows, the excess supply gives rise to dramatic price declines. The capacity expansions in the 1980s and weakening demand in the early 1990s thus resulted in overcapacity and a period of supply/demand imbalance which led to low prices and weak operating conditions in the industry (S&P, 1999).

More recently, the industry has grown in a much more disciplined manner: capacity increases in the paper and paperboard sector were limited to 1.9 percent and 1.2 percent in 1997 and 1998, respectively, compared to an average growth rate of 2.5 percent over the 10 preceding years. This is partly the result of firms seeking expansion through the acquisition of existing mills rather than the construction of new facilities, increasing a firm's capacity but not of the industry overall. Prices have started to recover as a result of the reduction in inventories and the better balance between supply and demand. However, the Asian financial crisis, which began in 1997, and the ensuing decrease in demand from affected Asian markets, have somewhat slowed this recovery (S&P, 1999).

Figure 4A-2 shows the ***producer price index*** (PPI) at the 4-digit SIC code for the profiled pulp, paper, and paperboard sectors. The PPI is a family of indexes that measure price changes from the perspective of the seller. This profile uses the PPI to inflate nominal monetary values to constant dollars.

Figure 4A-2: Producer Price Indexes for Profiled Paper and Allied Products Sectors



Source: Bureau of Labor Statistics, Producer Price Index.

c. Number of Facilities and Firms

The Statistics of U.S. Businesses reports that the number of facilities and firms in the Pulp Mills sector has increased by almost 35 percent between 1990 and 1996. One of the reasons for this growth has been the dramatic increase in the number of mills that produce deinked recycled market pulp. These are secondary fiber processing plants that utilize recovered paper and paperboard as their sole source of raw material. Producers of deinked market pulp have experienced strong demand over the past several years in both U.S. and foreign markets. As a result, the U.S. deinked recycled market pulp capacity more than doubled between 1994 and 1998 (McGrraw-Hill, 1998).

Growth in the number of facilities and firms in the other Paper and Allied Products sectors has been considerably slower. These sectors have been characterized by overcapacity in the 1990s which has limited the rate of construction of new facilities. More recently, there have been shutdowns in all three profiled Paper and Allied Products sectors. In 1998 and 1999, 577,000 and 2.5 million tons of paper and paperboard capacity were removed from the capacity base. Over the same period, more than one million tons of pulp capacity were removed (Pponline, 1999).

Tables 4A-2 and 4A-3 present the number of facilities and firms for the three profiled Paper and Allied Products sectors between 1989 and 1996.

Table 4A-2: Number of Facilities for Profiled Paper and Allied Products Sectors

Year	Pulp Mills (SIC 2611)		Paper Mills (SIC 2621)		Paperboard Mills (SIC 2631)	
	Number of Facilities	Percent Change	Number of Facilities	Percent Change	Number of Facilities	Percent Change
1989	46	n/a	322	n/a	221	n/a
1990	46	0%	327	2%	226	2%
1991	53	15%	349	7%	228	1%
1992	44	-17%	324	-7%	222	-3%
1993	46	5%	306	-6%	217	-2%
1994	52	13%	316	3%	218	0%
1995	53	2%	317	0%	219	0%
1996	62	17%	344	9%	228	4%
Percent Change 1989-1996		34.8%		6.8%		3.2%

Source: Small Business Administration, Statistics of U.S. Businesses.

Table 4A-3: Number of Firms for Profiled Paper and Allied Products Sectors						
Year	**Pulp Mills (SIC 2611)**		**Paper Mills (SIC 2621)**		**Paperboard Mills (SIC 2631)**	
	Number of Firms	**Percent Change**	**Number of Firms**	**Percent Change**	**Number of Firms**	**Percent Change**
1990	31	n/a	158	n/a	102	n/a
1991	37	19%	186	18%	102	0%
1992	29	-22%	161	-13%	95	-7%
1993	32	10%	153	-5%	99	4%
1994	37	16%	163	7%	96	-3%
1995	32	-14%	163	0%	93	-3%
1996	43	34%	186	14%	101	9%
Percent Change 1990-1996		38.7%		17.7%		-1.0%

Source: Small Business Administration, Statistics of U.S. Businesses.

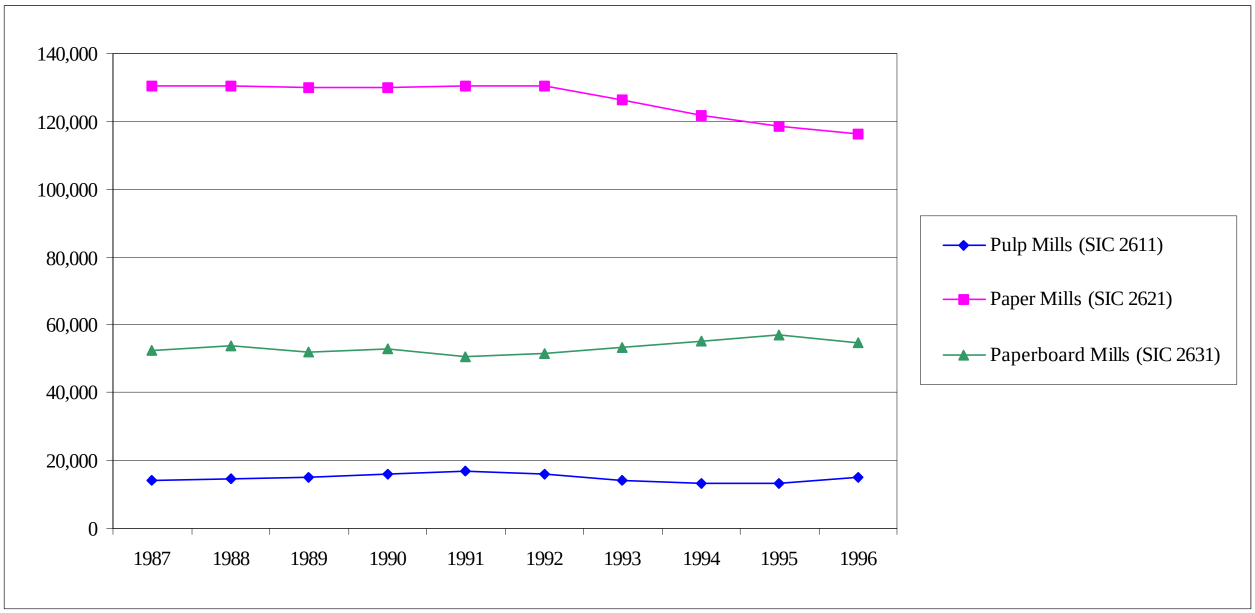
d. Employment and Productivity

The U.S. Paper and Allied Products industry is among the most modern in the world. It has a highly skilled labor force and is characterized by large capital expenditures which are largely aimed at production improvements.

Employment in the three profiled paper industry sectors has remained relatively constant between 1987 and 1992. However, between 1992 and 1996, employment has steadily decreased in the Paper Mills sector. This trend may partly be the result of the continuing globalization process where producers haven striven to implement technological improvements covering distribution, handling, processing, converting, and environmental protection.

Figure 4A-3 below presents employment levels for the three profiled Paper and Allied Products sectors between 1987 and 1996.

Figure 4A-3: Employment for Profiled Paper and Allied Products Sectors



Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

Table 4A-4 presents the change in value added per labor hour, a measure of ***labor productivity***, for each of the profiled industry sectors between 1987 and 1996. The table shows that labor productivity in the Pulp Mills sector has been relatively volatile, posting several double-digit gains and losses between 1987 and 1996. These changes have been primarily driven by fluctuations in value added. Overall, the sector's productivity decreased by 17 percent during this period. The Paper Mills and Paperboard Mills sectors have remained more stable and have experienced overall labor productivity changes of 10 percent and -3 percent, respectively.

Table 4A-4: Productivity Trends for Profiled Paper and Allied Products Sectors, Millions of $1999

Year	Pulp Mills (SIC 2611)				Paper Mills (SIC 2621)				Paperboard Mills (SIC 2631)			
	Value Added	Prod. Hours (mill.)	Value Added/Hour		Value Added	Prod. Hours (mill.)	Value Added/Hour		Value Added	Prod. Hours (mill.)	Value Added/Hour	
			No.	Percent Change			No.	Percent Change			No.	Percent Change
1987	2,554	24	107	n/a	17,479	213	82	n/a	8,668	89	98	n/a
1988	2,881	24	121	13%	18,958	215	88	7%	9,808	91	108	10%
1989	3,199	25	126	4%	18,193	214	85	-4%	9,286	89	104	-4%
1990	2,910	28	105	-17%	17,739	211	84	-1%	8,802	91	97	-7%
1991	2,631	28	95	-9%	16,955	212	80	-5%	8,160	87	94	-3%
1992	2,824	26	107	13%	16,795	215	78	-2%	9,092	88	103	9%
1993	2,119	23	92	-15%	16,414	212	77	-1%	8,609	90	96	-7%
1994	2,354	22	108	18%	16,789	206	82	6%	8,999	94	96	0%
1995	2,813	23	124	15%	19,523	201	97	19%	9,853	98	101	5%
1996	2,128	24	89	-28%	17,733	197	90	-7%	8,995	95	95	-6%
Percent Change 1987-1996			-17%				10%				-3%	

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

e. Capital Expenditures

The Paper and Allied Products industry is a highly capital intensive industry. Capital-intensive industries are characterized by large manufacturing facilities which reflect the economies of scale required to manufacture products efficiently. **New capital expenditures** are needed to extensively modernize, expand, and replace existing capacity to meet growing demand. Consistent high levels of capital expenditures have made the Paper and Allied Products industry one of the most modern industries in the world (Stanley, 2000). The total level of capital expenditures for the pulp, paper, and paperboard industries was $5.8 billion in 1996 (in constant $1999). The Paper Mills and Paperboard Mills sectors accounted for approximately 89 percent of that spending (see Table 4A-5). Most of the spending is for production improvements (through existing machine upgrades, retrofits, or new installed equipment), environmental concerns, and increased recycling (McGraw Hill, 1999).

New capital expenditures for both the Pulp Mills and Paperboard Mills sectors have dramatically increased during the time period of 1987 to 1996, rising 161 and 127 percent, respectively. Most of the investment occurred in the late 1980s, followed by declines in the early 1990s. The capital investments made in the late 1980s was for capacity expansion in response to the paper boom (S&P, 1999). Since 1992, capital spending has leveled off in all three profiled industries. This trend was reversed in 1996, when industry spending returned to the level of the early 1990s as a result of revived orders due to increased global economic activity and dwindling customer inventories (S&P, 1999).

A fair amount of the industry's new capital expenditures has been spent on environmental equipment. The Department of Commerce estimates that environmental spending has accounted for about 14 percent of all capital outlays made by the Paper and Allied Products industry in 1996 (S&P, 1999).

Table 4A-5: Capital Expenditures for Profiled Paper and Allied Products Sectors ($1999 millions)

Year	Pulp Mills (SIC 2611)		Paper Mills (SIC 2621)		Paperboard Mills (SIC 2631)	
	Capital Expenditures ($1999 millions)	Percent Change	Capital Expenditures ($1999 millions)	Percent Change	Capital Expenditures ($1999 millions)	Percent Change
1987	242	n/a	3,346	n/a	1,022	n/a
1988	268	10.4%	3,618	8.1%	1,790	75.1%
1989	530	98.0%	5,435	50.2%	1,842	2.9%
1990	841	58.6%	4,459	-17.9%	3,405	84.8%
1991	998	18.8%	3,879	-13.0%	2,555	-25.0%
1992	800	-19.9%	3,213	-17.2%	2,390	-6.4%
1993	494	-38.2%	3,160	-1.6%	1,984	-17.0%
1994	332	-32.8%	3,491	10.5%	1,911	-3.7%
1995	311	-6.4%	2,327	-33.3%	1,719	-10.0%
1996	632	103.4%	2,884	23.9%	2,321	35.0%
Percent Change 1987- 1996		161%		-14%		127%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

f. Capacity Utilization

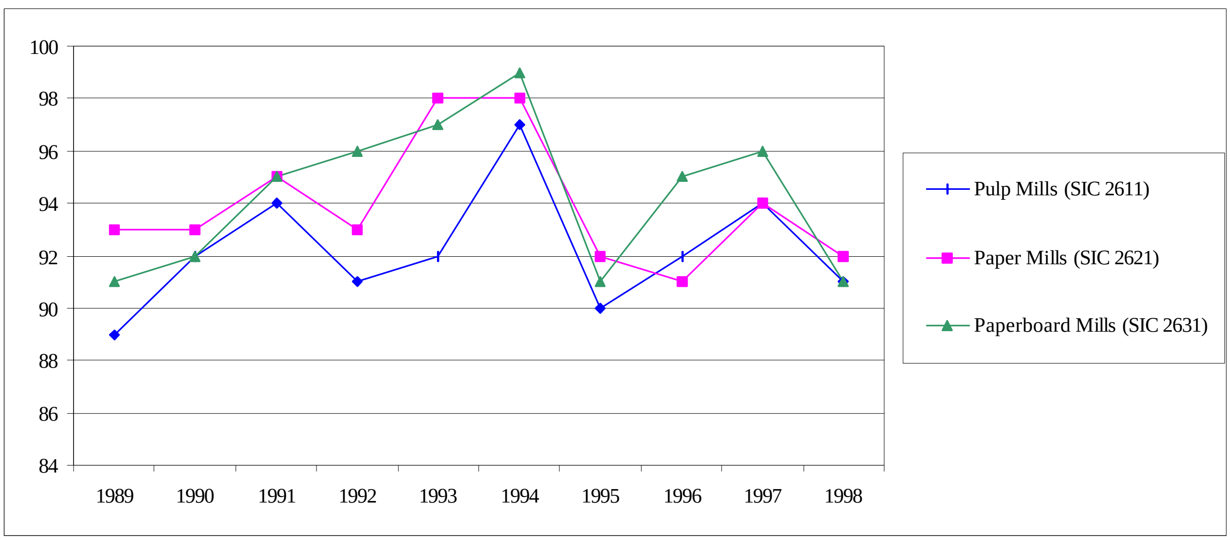
Capacity utilization measures actual output as a percentage of total potential output given the available capacity. Capacity utilization is an index used to identify potential excess or insufficient capacity in an industry and can help project whether new investment is likely.

The capacity utilization trends for all three profiled industries are consistent with the trends in investments, supply, and demand discussed earlier. Capacity utilization rates increased between 1989 and 1994, and then plummeted in 1995. This sharp drop was the result of the inventory drawdown cycle which had begun in 1995 in response to low demand and oversupply (McGraw-Hill, 1999). As inventories were sold off and global economic activity started to pick up, capacity utilization rates began to increase again in 1996 (S&P, 1999).

According to the U.S. Industry and Trade Outlook, a utilization rate in the range of 92 to 96 percent is necessary for the Pulp Mills sector to remain productive and profitable (McGraw-Hill, 1999).

Figure 4A-4 presents the capacity utilization indexes from 1989 to 1998 for the three profiled sectors.

Figure 4A-4: Capacity Utilization Indexes for Profiled Paper and Allied Products Sectors



Source: Department of Commerce, Bureau of the Census, Current Industrial Reports, Survey of Plant Capacity.

4A.2 Structure and Competitiveness of the Paper and Allied Products Industry

Paper and Allied Products companies range in size from giant corporations having billions of dollars of sales, to small producers with revenue bases a fraction of the size. Because all Paper and Allied Products companies use the same base materials in their production, most manufacture more than one product (S&P, 1999).

Most products offered by the Paper and Allied Products makers are commodities. Within these almost purely competitive markets, prices are established by the intersection of supply and demand. To escape the extreme price volatility of commodity markets, many smaller manufacturers have differentiated their products by offering value-added grades. The smaller markets for value-added products make this avenue less available to the larger firms (S&P, 1999).

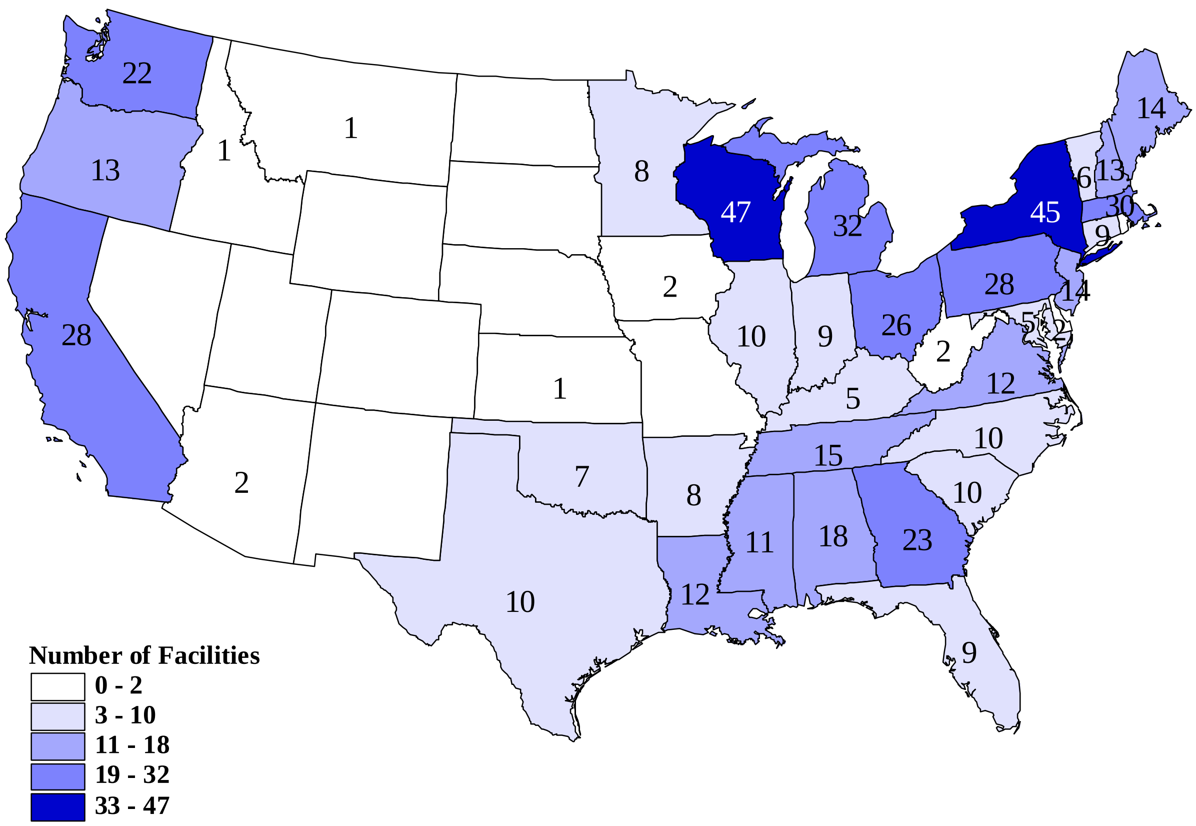
The paper industry has also begun to focus on consolidation. In recent years, most companies with a desire for greater operating capacity have looked to mergers rather than building new pulp or paper mills (S&P, 1999). New capacity additions in 1999 in the Paper and Allied Products industry were at their lowest level in the past ten years and the trend in the future seems to remain the same (Pponline.com, 2000).

a. Geographic Distribution

The geographic distribution of pulp, paper, and paperboard mills varies with the different types of mills. Traditional pulp mills tend to be located in regions where pulp trees are harvested from natural stands or tree farms. The Southeast (GA, AL, NC, TN, FL, MS, KY), Northwest (WA, CA, AK), Northeast (ME) and Northern Central (WI, MI) regions account for the major concentrations of pulp mills. Deinked market pulp plants, on the other hand, are typically located close to a large metropolitan area, which can consistently provide large amounts of recovered paper and paperboard (McGrraw-Hill, 1998).

Paper mills are more widely distributed, located in proximity to pulping operations and/or near converting sector markets. Since the primary market for paperboard products is manufacturing, the distribution of paperboard mills is similar to that of the manufacturing industry in general.

Figure 4A-5: Number of Facilities in Profiled Paper and Allied Products Sectors by State



Source: Department of Commerce, Bureau of the Census, Census of Manufacturers, 1992.

b. Facility Size

Most of the facilities in the three profiled industry sectors fall in the middle employment size categories, with either 100 to 249, or 250 to 499 employees. However, the larger facilities (those with 500 or more employees) account for the majority of the industries' value of shipments.

The number of pulp mills is noticeably smaller than that of paper and paperboard mills, and pulp mills have considerably lower value of shipments. The size distribution of all three profiled sectors, however, is very similar.

- Seventy-one percent of all *Pulp Mills* employ 100 employees or more. These facilities account for approximately 97 percent of the sector's value of shipments.

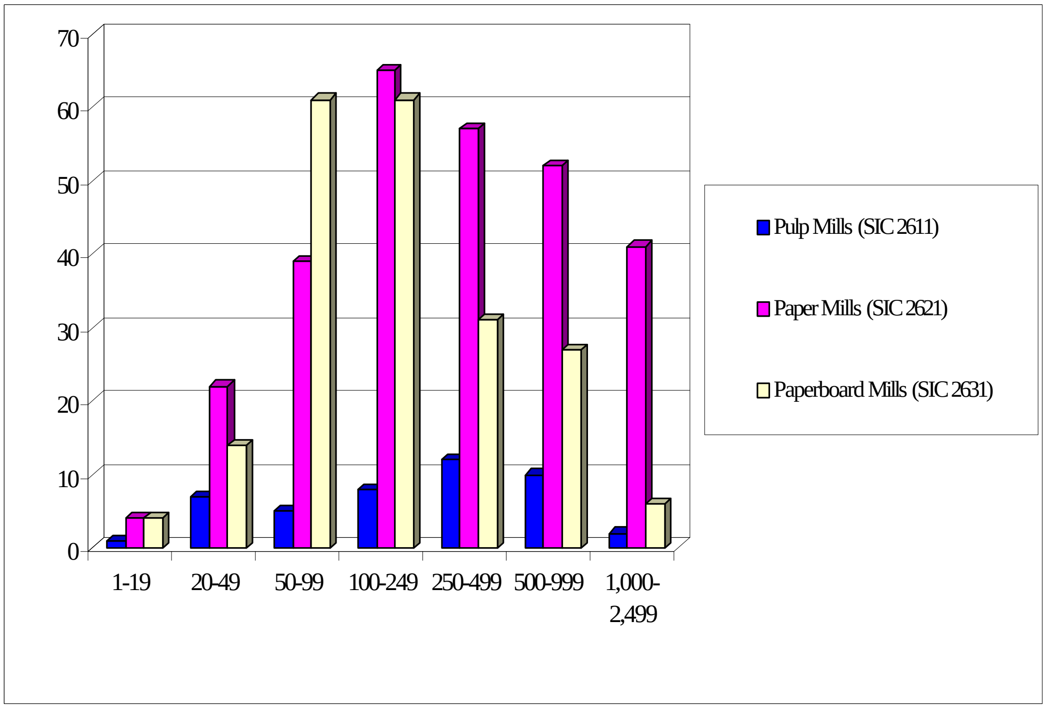
- Thirty-three percent of all *Paper Mills* have more than 500 employees. They account for 71 percent of the sector's value of shipments.

- Sixteen percent of all *Paperboard Mills* employ 500 people or more. These facilities account for 56 percent of the sector's value of shipments.

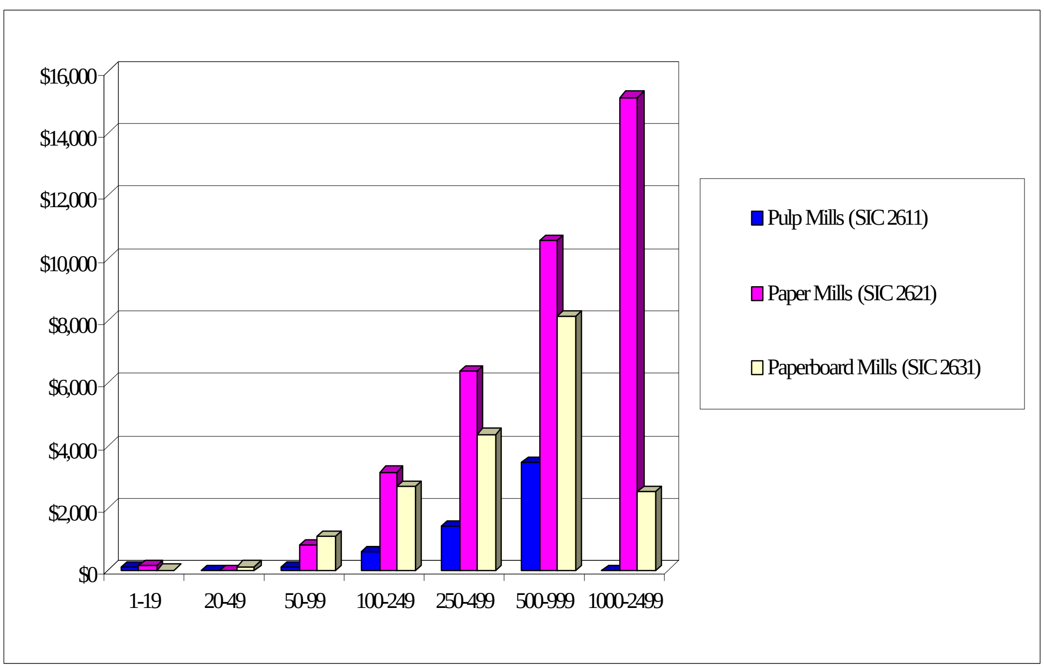
The distribution of the number of facilities and the industries' value of shipment are presented in Figure 4A-6 below.

Figure 4A-6: Number of Facilities and Value of Shipments by Employment Size Category for Profiled Paper and Allied Products Sectors

Number of Facilities (1992)



1992 Value of Shipments (millions of $1999)



Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

c. Firm Size

The Small Business Administration (SBA) defines small firms in the Paper and Allied Products industries according to the firm's number of employees. Firms in SIC codes 2611, 2621, and 2631 are defined as small if they have fewer than 750 employees.

The size categories reported in the Statistics of U.S. Businesses (SUSB) do not coincide with the SBA small firm standard of 750 employees. It is therefore not possible to apply the SBA size thresholds precisely. The SUSB data presented in Table 4A-6 below show the following size distribution in 1996:

- 27 of 43 firms in the *Pulp Mills* sector had less than 500 employees. Therefore, at least 63 percent of firms were classified as small. These small firms owned 31 facilities, or 50 percent of all facilities in the sector.
- 126 of 186 (68 percent) firms in the *Paper Mills* sector had less than 500 employees. These small firms owned 134, or 39 percent of all paper mills.
- 53 of 101 firms in the *Paperboard Mills* sector had less than 500 employees. Therefore, at least 52 percent of paperboard mills were classified as small. These firms owned 54, or 24 percent of all paperboard mills

Table 4A-6 below shows the distribution of firms, facilities, and receipts for each profiled sector by employment size of the parent firm.

Table 4A-6: Number of Firms, Facilities, and Estimated Receipts by Firm Size Category for Profiled Paper and Allied Products Sectors, 1996

Employment Size Category	Pulp Mills (SIC 2611)			Paper Mills (SIC 2621)			Paperboard Mills SIC 2631		
	No. of Firms	No. of Facilities	Estimated Receipts ($1999 millions)	No. of Firms	No. of Facilities	Estimated Receipts ($1999 millions)	No. of Firms	No. of Facilities	Estimated Receipts ($1999 millions)
0-19	14	14	23	50	50	36	20	20	29
20-99	8	8	99	32	33	388	12	12	143
100-499	5	9	95	44	51	2,704	21	22	556
500-2499	6	9	1,011	28	52	3,221	15	25	1439
2500+	10	22	4,034	32	158	26,311	33	149	17405
Total	43	62	5,262	186	344	32,660	101	228	19572

Source: Small Business Administration, Statistics of U.S. Businesses.

d. Concentration and Specialization Ratios

Concentration is the degree to which industry output is concentrated in a few large firms. Concentration is closely related to entry and exit barriers with more concentrated industries generally having higher barriers.

The four-firm ***concentration ratio*** (CR4) and the ***Herfindahl-Hirschman Index*** (HHI) are common measures of industry concentration. The CR4 indicates the market share of the four largest firms. For example, a CR4 of 72 percent means that the four largest firms in the industry account for 72 percent of the industry's total value of shipments. The higher the concentration ratio, the less competition there is in the industry, other things being equal.[4] An industry with a CR4 of more than 50 percent is generally considered concentrated. The HHI indicates concentration based on the largest 50 firms in the industry. It is equal to the sum of the squares of the market shares for the largest 50 firms in the industry. For example, if an industry consists of only three firms with market shares of 60, 30, and 10 percent, respectively, the HHI of this industry would be equal to 4,600 ($60^2 + 30^2 + 10^2$). The higher the index, the fewer the number of firms supplying the industry and the more concentrated the industry. An industry is considered concentrated if the HHI exceeds 1,000.

The concentration ratios for the three profiled industry sectors remained relatively stable between 1987 and 1992. None of the profiled industries are considered concentrated based on the CR4 or the HHI. The Pulp Mills sector has the highest concentration of the three sectors with a CR4 of 48 percent and a HHI of 858 in 1992.

The ***specialization ratio*** is the percentage of the industry's production accounted for by primary product shipments. The ***coverage ratio*** is the percentage of the industry's product shipments coming from facilities from the same primary industry. The coverage ratio provides an indication of how much of the production/product of interest is captured by the facilities classified in an SIC code.

The specialization ratios presented in Table 4A-7 indicate a relatively high degree of specialization for each profiled Paper and Allied Products industry sector.

[4] Note that the measured concentration ratio and the HHF are very sensitive to how the industry is defined. An industry with a high concentration in domestic production may nonetheless be subject to significant competitive pressures if it competes with foreign producers or if it competes with products produced by other industries (e.g., plastics vs. aluminum in beverage containers). Concentration ratios are therefore only one indicator of the extent of competition in an industry.

Table 4A-7: Selected Ratios for Profiled Paper and Allied Products Sectors

SIC Code	Year	Total Number of Firms	Concentration Ratios: 4 Firm (CR4)	8 Firm (CR8)	20 Firm (CR20)	50 Firm (CR50)	Herfindahl-Hirschman Index	Specialization Ratio	Coverage Ratio
2611	1987	26	44%	69%	99%	100%	743	87%	69%
	1992	29	48%	75%	98%	100%	858	81%	72%
2621	1987	122	33%	50%	78%	94%	432	91%	96%
	1992	127	29%	49%	77%	94%	392	90%	95%
2631	1987	91	32%	51%	77%	97%	431	91%	90%
	1992	89	31%	52%	80%	97%	438	92%	89%

Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

e. Foreign Trade

The U.S. Paper and Allied Products industry is the most competitive and highest-volume supplier of paper products in the world because of its modern manufacturing base, effective distribution network and skilled labor force. In recent years, the importance of international trade has grown in the Paper and Allied Products industry particularly because of stagnant domestic sales (McGraw Hill, 1998).

The Paper and Allied Products industry has been in a period of globalization for more than a decade. Many U.S. Paper and Allied Products companies are active exporters, but they also engage in foreign production, converting, and packaging operations, and have joint ventures and direct foreign capital investments in partnerships and ownerships (Stanley, 2000).

Exports play an increasingly important role in the Paper and Allied Products industry. Sixty-five percent of the industry's shipment growth between 1989 and 1998 was derived from export sales. The expansion of international paper markets, however, may also have negative effects. Some of the domestic industry's key trade partners – long a target for any excess U.S. paper production – have started to undertake significant investments in their own world-class production facilities (S&P, 2000).

Exports represented approximately 60 percent of the value of shipments for the Pulp Mills sector in 1996 (see Table 4A-8). Despite improved demand in portions of Europe and Latin America, the Asian financial crisis, which began in 1997, still affects the global pulp industry (Stanley, 2000).

This profile uses two measures of foreign competitiveness: ***export dependence*** and ***import penetration***. Export dependence is the share of value of shipments that is exported. Import penetration is the share of domestic consumption met by imports. Export dependence and import penetration for all of the profiled sectors have remained at relatively constant levels between 1989 and 1996. Imports and exports play a much larger role in the Pulp Mills sector than for the other two sectors. Import penetration and export dependence levels for the Pulp Mills sector were 55 and 61 percent, respectively, in 1996. For the Paper and Paperboard sectors, they were 15 and 11 percent, respectively (see Table 4A-8). Another noticeable difference between the three sectors is the presence of a trade surplus in the Pulp Mills sector and a trade deficit in the Paper Mills and Paperboard Mills sectors.

Table 4A-8 presents trade statistics for each of the profiled Paper and Allied Products industry sectors.

Table 4A-8: Trade Statistics for Profiled Paper and Allied Products Sectors

Year	Value of imports ($1999 millions)	Value of exports ($1999 millions)	Value of Shipments ($1999 millions)	Implied Domestic Consumption†	Import Penetration††	Export Dependence†††
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Pulp Mills (SIC 2611)						
1989	2,321	2,771	4,881	4,430	52%	57%
1990	2,274	2,623	4,977	4,629	49%	53%
1991	2,158	2,942	5,369	4,585	47%	55%
1992	2,179	3,351	5,659	4,487	49%	59%
1993	2,166	2,878	4,966	4,254	51%	58%
1994	2,407	3,111	5,084	4,379	55%	61%
1995	2,519	3,160	4,658	4,017	63%	68%
1996	2,355	3,041	4,988	4,302	55%	61%
Average Annual Growth Rate	*0%*	*1%*	*0%*	*0%*	*1%*	*1%*
Paper and Paperboard Mills (SIC 2621, 2631)						
1989	7,935	3,249	54,909	59,595	13%	6%
1990	8,095	3,778	55,033	59,350	14%	7%
1991	7,817	4,578	53,378	56,616	14%	9%
1992	7,674	4,857	55,081	57,898	13%	9%
1993	8,364	4,851	54,944	58,457	14%	9%
1994	8,039	5,249	58,137	60,927	13%	9%
1995	8,530	5,365	58,407	61,573	14%	9%
1996	8,719	6,038	56,253	58,934	15%	11%
Average Annual Growth Rate	*1%*	*9%*	*0%*	*0%*	*2%*	*9%*

† Implied domestic consumption based on value of shipments, imports, and exports [column d + column b - column c].
†† Import penetration based on implied domestic consumption and imports [column b / column e].
††† Export dependence based on value of shipments and exports [column c / column d].

Source: Department of Commerce, International Trade Administration, Outlook Trends Tables.

4A.3 Financial Condition and Performance

The U.S. Paper and Allied Products industry has a world-wide reputation as a high quality, high volume, and low-cost producer. The industry benefits from many key operating advantages, including a large domestic market; the world's highest per capita consumption; a modern manufacturing infrastructure; adequate raw material, water, and energy resources; a highly skilled labor force; and an efficient transportation and distribution network (Stanley, 2000). Despite these advantages, however, the industry has faced challenges in the past. Domestic sales have stagnated over the past five years, leading the industry to refocus on export sales and direct more resources toward the world market. Leading world producers can no longer focus on the domestic market to achieve sales growth – they must expand their customer base to the world market as globalization in the industry continues into the new millennium (Stanley, 2000).

Financial performance in the Paper and Allied Products industry is closely linked to macroeconomic cycles, both in the domestic market and those of key foreign trade partners, and the resulting levels of demand. Many pulp producers, for example, have not been very profitable during most of the 1990s as chronic oversupply, cyclical demand, rapidly fluctuating operating rates, sharp inventory swings, and uneven world demand has plagued the global pulp market for more than a decade (Stanley, 2000).

Table 4A-9 presents trends in operating margins for the Pulp Mills, Paper Mills, and Paperboard Mills sectors between 1987 and 1996. The table shows fluctuating margins in all three sectors but especially in the Pulp Mills sector. These fluctuation are a reflection of changes in product prices which have resulted from oversupply in the industry.

Year	Value of Shipments	Cost of Materials	Payroll (all employees)	Operating Margin
Pulp Mills (SIC 2611)				
1987	4,524	2,118	561	41%
1988	4,555	1,870	484	48%
1989	4,881	1,938	458	51%
1990	4,977	2,302	533	43%
1991	5,369	2,911	702	33%
1992	5,659	3,063	714	33%
1993	4,966	2,885	727	27%
1994	5,084	2,824	642	32%
1995	4,658	2,140	424	45%
1996	4,988	2,969	635	28%
Paper Mills (SIC 2621)				
1987	35,177	18,077	5,604	33%
1988	36,785	18,402	5,234	36%
1989	36,728	19,181	5,114	34%
1990	36,824	19,663	5,277	32%
1991	35,558	19,177	5,570	30%
1992	36,179	19,831	5,981	29%
1993	35,424	19,550	5,920	28%
1994	37,888	21,246	5,929	28%
1995	38,249	19,850	4,703	36%
1996	36,316	18,904	5,139	34%
Paperboard Mills (SIC 2631)				
1987	18,168	9,051	2,460	37%
1988	18,981	8,657	2,317	42%
1989	18,181	8,426	2,182	42%
1990	18,209	8,927	2,343	38%
1991	17,819	9,236	2,406	35%
1992	18,902	9,385	2,502	37%
1993	19,519	10,453	2,710	33%
1994	20,249	10,652	2,648	34%
1995	20,159	9,888	2,106	40%

Table 4A-9: Operating Margins for Profiled Paper and Allied Products Sectors (Millions $1999)

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

4A.4 Facilities Operating CWISs

In 1982, the Paper and Allied Products industry withdrew 534 billion gallons of cooling water, accounting for approximately 0.7 percent of total industrial cooling water intake in the United States. The industry ranked 5th in industrial cooling water use, behind the electric power generation industry, and the chemical, primary metals, and petroleum industries (1982 Census of Manufactures).

This section presents information from EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* on existing facilities with the following characteristics:

- they withdraw from a water of the United States;
- they hold an NPDES permit;
- they have an intake flow of more than two MGD;
- they use at least 25 percent of that flow for cooling purposes.

These facilities are not "new facilities" as defined by the proposed §316(b) New Facility Rule and are therefore not subject to this regulation. However, they meet the criteria of the proposed rule except that they are already in operation. These existing facilities therefore provide a good indication of what new facilities in these sectors may look like. The remainder of this section refers to existing facilities with the above characteristics as "§316(b) facilities."

a. Cooling Water Uses and Systems

Information collected in the Screener Questionnaire found that an estimated 43 out of 66 pulp mills (65 percent), 128 out of 286 paper mills (45 percent), and 45 out of 187 paperboard mills (24 percent) meet the characteristics of a §316(b) facility. Most §316(b) facilities in the profiled Paper and Allied Products sectors use cooling water for contact and non-contact production line or process cooling, electricity generation, and air conditioning:

- Ninety-four percent of §316(b) *pulp mills* use cooling water for production line (or process) contact or noncontact cooling. The two other major uses of cooling water by pulp mills are electricity generation and air conditioning, with approximately 73 and 64 percent of facilities, respectively.

- Eighty-six percent of §316(b) *paper mills* use cooling water for production line (or process) contact or noncontact cooling. Seventy-four percent also use cooling water for electricity generation and 71 percent for air conditioning.

- Almost all, 98 percent, §316(b) *paperboard mills* use cooling water for production line (or process) contact or noncontact cooling. The two other major uses of cooling water by pulp mills are electricity generation with approximately 79 percent and air conditioning with approximately 80 percent of facilities.

Table 4A-10 shows the distribution of existing §316(b) facilities in the profiled Paper and Allied Products sectors by type of water body and cooling system. The table shows that most of the existing §316(b) facilities have either a once through system (109, or 50 percent) or employ a combination of a once through and closed system (61, or 28 percent). The majority of existing facilities draw water from a freshwater water stream or river (140, or 65 percent). Only one facility (0.5 percent) in the industry withdraws from an ocean, and 11 (5 percent) withdraw from an estuary or tidal river. Most of the CWISs located on an ocean or estuary/tidal river use a once-through cooling system.

Table 4A-10: Number of §316(b) Facilities by Water Body Type and Cooling System for Profiled Paper and Allied Products Sectors

Water Body Type	Closed Cycle		Combination		Once Through		Unknown		Grand Total
	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total	
Pulp Mills (SIC 2611)									
Estuary or Tidal River	1	20%	2	40%	2	40%	0	0%	5
Freshwater Stream or River	7	33%	4	19%	10	48%	0	0%	21
Lake or Reservoir	0	0%	2	22%	4	44%	3	33%	9
Lake or Reservoir/ Freshwater Stream or River	0	0%	8	100%	0	0%	0	0%	8
***Total*†**	***8***	***18%***	***16***	***39%***	***16***	***37%***	***3***	***6%***	***43***
Paper Mills (SIC 2621)									
Estuary or Tidal River	0	0%	1	50%	1	50%	0	0%	2
Freshwater Stream or River	10	12%	21	24%	51	59%	4	5%	86
Lake or Reservoir	5	15%	6	18%	22	65%	1	3%	34
Lake or Reservoir/ Freshwater Stream or River	0	0%	1	20%	4	80%	0	0%	5
Ocean	0	0%	0	0%	1	100%	0	0%	1
***Total*†**	***15***	***12%***	***29***	***23%***	***79***	***62%***	***5***	***4%***	***128***
Paperboard Mills (SIC 2631)									
Estuary or Tidal River	0	0	1	0.25	3	0.75	0	0%	4
Freshwater Stream or River	13	0.393939	9	0.27273	11	0.33333	0	0%	34
Lake or Reservoir	2	0.5	2	0.5	0	0	0	0%	4
Lake or Reservoir/ Freshwater Stream or River	0	0	3	1	0	0	0	0%	3
***Total*†**	***15***	***34%***	***16***	***35%***	***14***	***31%***	***0***	***0%***	***45***
Total Paper and Allied Products Industry (SIC 26)									
Estuary or Tidal River	1	9%	4	36%	6	55%	0	0%	11
Freshwater Stream or River	30	21%	34	24%	72	51%	4	3%	140
Lake or Reservoir	7	15%	10	21%	26	55%	4	9%	47
Lake or Reservoir/ Freshwater Stream or River	0	0%	12	75%	4	25%	0	0%	16
Ocean	0	0%	0	0%	1	100%	0	0%	1
Total†	**38**	**18%**	**61**	**28%**	**109**	**51%**	**8**	**4%**	**216**

† Individual numbers may not add up to total due to independent rounding.

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

b. Facility Size

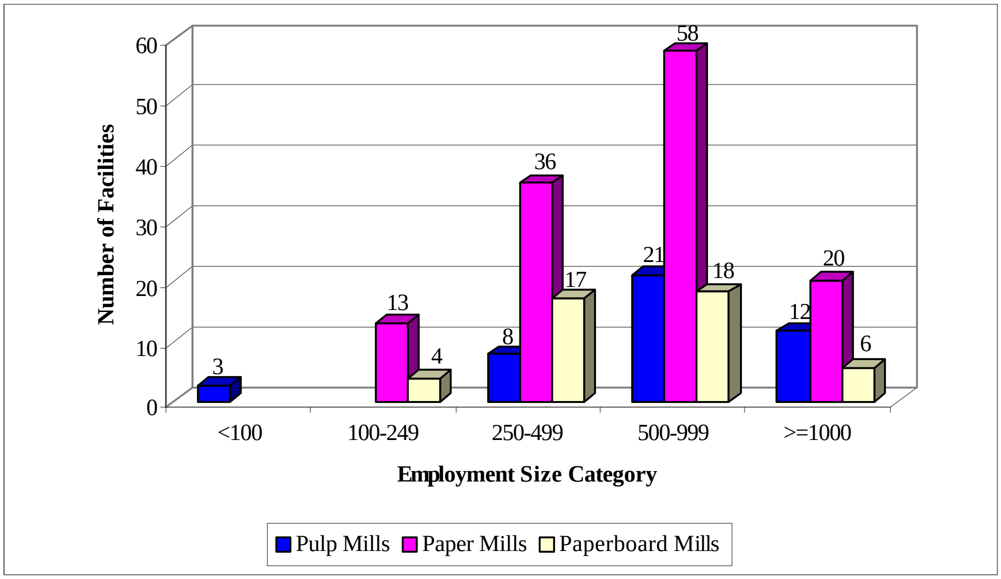
Paper and Allied Product facilities that withdraw more than two MGD from a water of the U.S., hold an NPDES permit, and use at least 25 percent of intake water for cooling purposes are generally larger than facilities that do not meet these criteria:

- Twenty-three percent of all facilities in the overall *Paper Mills* sector have fewer than 100 employees; zero §316(b) facilities in that sector fall into that employment category.
- Twenty-nine percent of all facilities in the *Pulp Mills* sector have fewer than 100 employees compared to 7 percent of the §316(b) facilities.
- Thirty-nine percent of all facilities in the *Paperboard Mills* sector have fewer than 100 employees compared to zero of the §316(b) facilities.

The majority of §316(b) paper mills, 78 or 61 percent, employ 500-999 employees. The §316(b) paperboard mills are more evenly distributed across employment categories with 17 facilities (38 percent) employing 250-499 employees, and 18 facilities (40 percent) employing 500-999 employees.

Figure 4A-7 shows the number of §316(b) facilities in the profiled chemical sectors by employment size category.

Figure 4A-7: Number of §316(b) Facilities by Employment Size for Profiled Paper and Allied Products Sectors



Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

c. Firm Size

EPA used the Small Business Administration (SBA) small entity size standards to determine the number of existing §316(b) facilities in the three profiled Paper and Allied Products sectors that are owned by small firms. Firms in this industry are considered small if they employ fewer than 750 people.

Table 4A-11 shows that §316(b) facilities in this industry are predominantly owned by large firms. Only nine of 216 facilities, or less than five percent, are owned by a small firm. An additional five facilities are owned by firms of unknown size. These may also qualify as small firms. The distribution of facilities by firm size is similar within the three profiled sectors: Six and five percent of pulp and paper mills, respectively, are owned by a small firm. None of the 45 §316(b) facilities in the Paperboard Mills sector are owned by a small firm.

Table 4A-11: Number of §316(b) Facilities in Profiled Paper and Allied Products Sectors by Firm Size

SIC Code	SIC Description	Large		Small		Unknown		Total
		Number	% of SIC	Number	% of SIC	Number	% of SIC	
2611	Pulp Mills	38	89%	3	6%	2	5%	43
2621	Paper Mills	118	93%	6	5%	3	3%	128
2631	Paperboard Mills	45	100%	0	0%	0	0%	45
Total		201	93%	9	4%	5	2%	216

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; D&B Database, 1999.

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4B CHEMICALS AND ALLIED PRODUCTS (SIC 28)

EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* identified sixteen 4-digit SIC codes in the Chemical and Allied Products Industry (SIC 28) with at least one existing facility that operates a CWIS, holds a NPDES permit, withdraws more than two million gallons per day (MGD) from a water of the United States, and uses at least 25 percent of its intake flow for cooling purposes (facilities with these characteristics are hereafter referred to as "§316(b) facilities"). For each of the sixteen SIC codes, Table 4B-1 below provides a description of the industry sector, a list of primary products manufactured, the total number of screener respondents, and the number and percent of §316(b) facilities.

Table 4B-1: §316(b) Facilities in the Chemicals and Allied Products Industry (SIC 28)

SIC	SIC Description	Important Products Manufactured	Number of Screener Respondents		
			Total	§316(b) Facilities	
				No. †	%
Inorganic Chemicals (SIC 281)					
2812	Alkalies and Chlorine	Alkalies, caustic soda, chlorine, and soda ash	28	10	35.7%
2813	Industrial Gases	Industrial gases (including organic) for sale in compressed, liquid, and solid forms	110	4	3.6%
2816	Inorganic Pigments	Black pigments, except carbon black, white pigments, and color pigments	26	4	15.4%
2819	Industrial Inorganic Chemicals, Not Elsewhere Classified	Miscellaneous other industrial inorganic chemicals	271	17	6.3%
Total 281			***435***	***35***	***8.0%***
Plastics Material and Resins (SIC 282)					
2821	Plastics Material and Synthetic Resins, and Nonvulcanizable Elastomers	Cellulose plastics materials; phenolic and other tar acid resins; urea and melamine resins; vinyl resins; styrene resins; alkyd resins; acrylic resins; polyethylene resins; polypropylene resins; rosin modified resins; coumarone-indene and petroleum polymer resins; miscellaneous resins	***305***	***14***	***4.6%***
Organic Chemicals (SIC 286)					
2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments	Aromatic chemicals, such as benzene, toluene, mixed xylenes naphthalene, synthetic organic dyes, and synthetic organic pigments	59	5	8.5%
2869	Industrial Organic Chemicals, Not Elsewhere Classified	Aliphatic and other acyclic organic chemicals; solvents; polyhydric alcohols; synthetic perfume and flavoring materials; rubber processing chemicals; plasticizers; synthetic tanning agents; chemical warfare gases; and esters, amines, etc.	368	53	14.4%
Total 286			***427***	***58***	***13.6%***
Other Chemical Sectors					
2823	Cellulosic Manmade Fibers	Cellulose acetate and regenerated cellulose such as rayon by the viscose or cuprammonium process	7	2	28.6%

Table 4B-1: §316(b) Facilities in the Chemicals and Allied Products Industry (SIC 28)					
SIC	SIC Description	Important Products Manufactured	Number of Screener Respondents		
			Total	§316(b) Facilities	
				No. †	%
2824	Manmade Organic Fibers, Except Cellulosic	Regenerated proteins, and polymers or copolymers of such components as vinyl chloride, vinylidene chloride, linear esters, vinyl alcohols, acrylonitrile, ethylenes, amides, and related polymeric materials	32	6	18.8%
2833	Medicinal Chemicals and Botanical Products	Agar-agar and similar products of natural origin, endocrine products, manufacturing or isolating basic vitamins, and isolating active medicinal principals such as alkaloids from botanical drugs and herbs	33	3	9.1%
2834	Pharmaceutical Preparations	Intended for final consumption, such as ampoules, tablets, capsules, vials, ointments, medicinal powders, solutions, and suspensions	91	4	4.4%
2841	Soaps and Other Detergents, Except Speciality Cleaners	Soap, synthetic organic detergents, inorganic alkaline detergents	36	4	11.1%
2873	Nitrogenous Fertilizers	Ammonia fertilizer compounds and anhydrous ammonia, nitric acid, ammonium nitrate, ammonium sulfate and nitrogen solutions, urea, and natural organic fertilizers (except compost) and mixtures	60	8	13.3%
2874	Phosphatic Fertilizers	Phosphoric acid; normal, enriched, and concentrated superphosphates; ammonium phosphates; nitro-phosphates; and calcium meta-phosphates	37	4	10.8%
2892	Explosives	Explosives excluding ammunition for small arms and fireworks	10	1	10.0%
2899	Chemicals and Chemical Preparations, Not Elsewhere Classified	Fatty acids; essential oils; gelatin (except vegetable); sizes; bluing; laundry sours; writing and stamp pad ink; industrial compounds; metal, oil, and water treating compounds; waterproofing compounds; and chemical supplies for foundries	162	5	3.1%
Total Other			***468***	***37***	***7.9%***
Total Chemicals and Allied Products (SIC 28)					
Total 28			**1,635**	**144**	**8.8%**

† Information on the percentage of intake flow used for cooling purposes was not available for all screener respondents. Facilities for which this information was not available were assumed to use at least 25% of their intake flow for cooling water purposes The reported numbers of §316(b) facilities may therefore be overstated.

†† SIC code 281 is officially titled "Industrial Inorganic Chemicals." However, to avoid confusion with SIC code 2819, "Industrial Inorganic Chemicals, Not Elsewhere Classified," this profile will refer to SIC code 281 as the "Inorganic Chemicals sector."

††† SIC code 286 is officially titled "Industrial Organic Chemicals." However, to avoid confusion with SIC code 2869, "Industrial Organic Chemicals, Not Elsewhere Classified," this profile will refer to SIC code 286 as the "Organic Chemicals sector."

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual 1987.

The responses to the Screener Questionnaire indicate that three main chemical sectors account for the largest numbers of §316(b) facilities: (1) Inorganic Chemicals (including SIC codes 2812, 2813, 2816, and 2819); (2) Plastics Material and Resins (SIC code 2821); and (3) Organic Chemicals (including SIC codes 2865 and 2869). Of the 144 §316(b) facilities in the Chemical industry, 58 facilities, or 40 percent, belong to the Organic Chemicals sector, 35, or 24 percent, belong to the Inorganic Chemicals sector, and 14, or 5 percent, belong to the Plastics and Resins sector. The remainder of the Chemicals and Allied Products profile therefore focuses on these three industry groups.

4B.1 Domestic Production

The U.S. Chemical and Allied products industry comprises a wide array of companies that, in total, produce more than 70,000 different chemical substances. These products range from commodity materials used in other industries to finished consumer products such as soaps and detergents. The industry accounts for a higher share (nearly 12 percent) of the U.S. manufacturing gross domestic product (GDP) than any other industry sector, and produces approximately two percent of total national gross domestic product (McGraw-Hill, 1998).

Inorganic and organic chemicals are the major outputs of the chemical industry. They are derived from crude oil, natural gas, and various other natural resources. Raw materials containing hydrocarbons such as oil, natural gas, and coal are primary feedstocks for the production of organic chemicals. Inorganic chemicals are chemicals that do not contain carbon but are produced from other gases and minerals (McGraw-Hill, 1998).

The Chemicals and Allied products industry is highly energy intensive. It is one of the largest industrial users of electric energy and also consumes large amounts of oil and natural gas. In total, the industry accounts for approximately seven percent of total U.S. energy consumption, including 11 percent of all natural gas use. Just over 50 percent of the industry's energy consumption is used as feedstock in the production of chemical products. The remaining energy consumption is for fuel and power for production processes. Oil accounts for approximately 42 percent of total energy consumption by the industry. For some products, e.g., petrochemicals, energy costs account for up to 85 percent of total production costs. Overall, total energy costs represent seven percent of the value of chemical industry shipments (S&P, 2000).

a. Output

Figure 4B-1 shows the trend in ***value of shipments*** and ***value added*** for the three profiled sectors between 1988 and 1996.[1] Value of shipments and value added are two of the most common measures of manufacturing output. They provide insight into the overall economic health and outlook for an industry. Value of shipments is the sum of the receipts a manufacturer earns from the sale of its outputs. It is an indicator of the overall size of a market or the size of a firm in relation to its market or competitors. Value added is used to measure the value of production activity in a particular industry. It is the difference between the value of shipments and the value of inputs used to make the products sold.

The Organic Chemicals sector (SIC 281) experienced a significant decrease in both value of shipments and value added between 1994 and 1996. This decrease is a function of increased competition in the global market for petrochemicals which comprise the majority of organic chemical products. The increased competition stems from the considerable capacity expansions for these products seen in developing nations in recent years (McGraw-Hill, 1998).

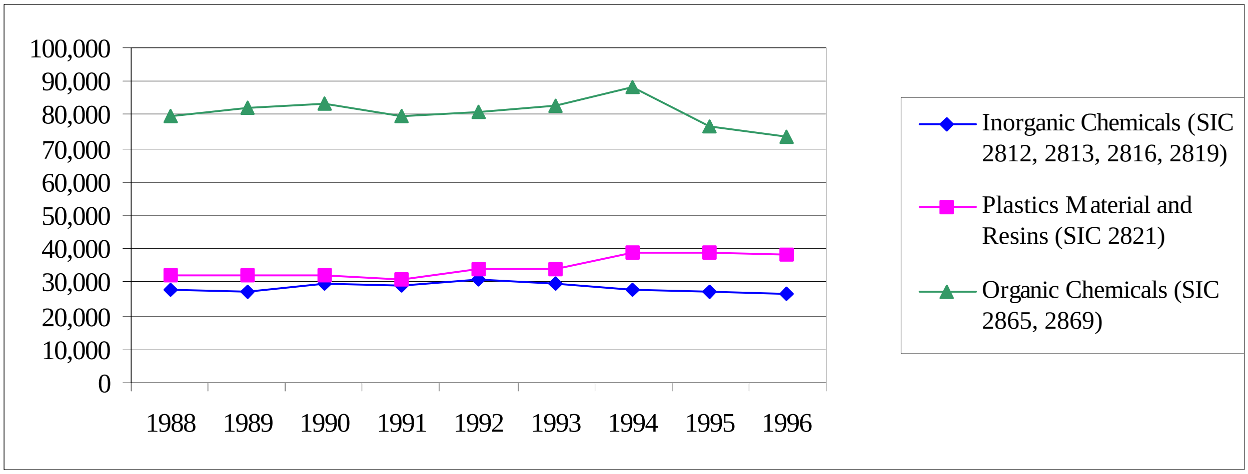
The Plastics Material and Resin (SIC 2821) and Inorganic Chemicals (SIC 286) sectors have remained relatively stable over the period between 1988 and 1996. The stability in these industry sectors reflects various trends in the markets for their products which are heavily influenced by the overall health and stability of the U.S. economy. In the early 1990s, domestic producers benefitted from the relatively weak dollar which made U.S. products more competitive in the global market. In more recent years, the strength of the U.S. economy has bolstered domestic end-use markets, offsetting the reductions in exports that have resulted from increased global competition and a strengthened dollar (McGraw-Hill, 1998).

Figure 4B-1 shows the trend in value of shipments and value added for the three profiled chemicals sectors between 1988 and 1996.

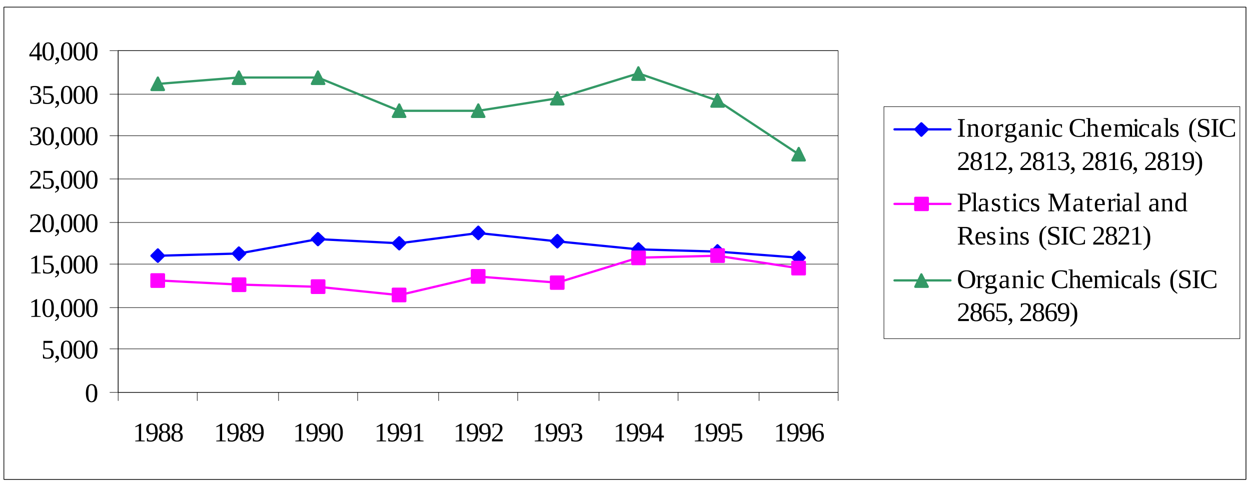
[1] Terms highlighted in bold and italic font are further explained in the glossary.

Figure 4B-1: Value of Shipments and Value Added for Profiled Chemical Sectors ($1999 million)

Value of Shipments ($1999 million)



Value Added ($1999 million)



Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

b. Prices

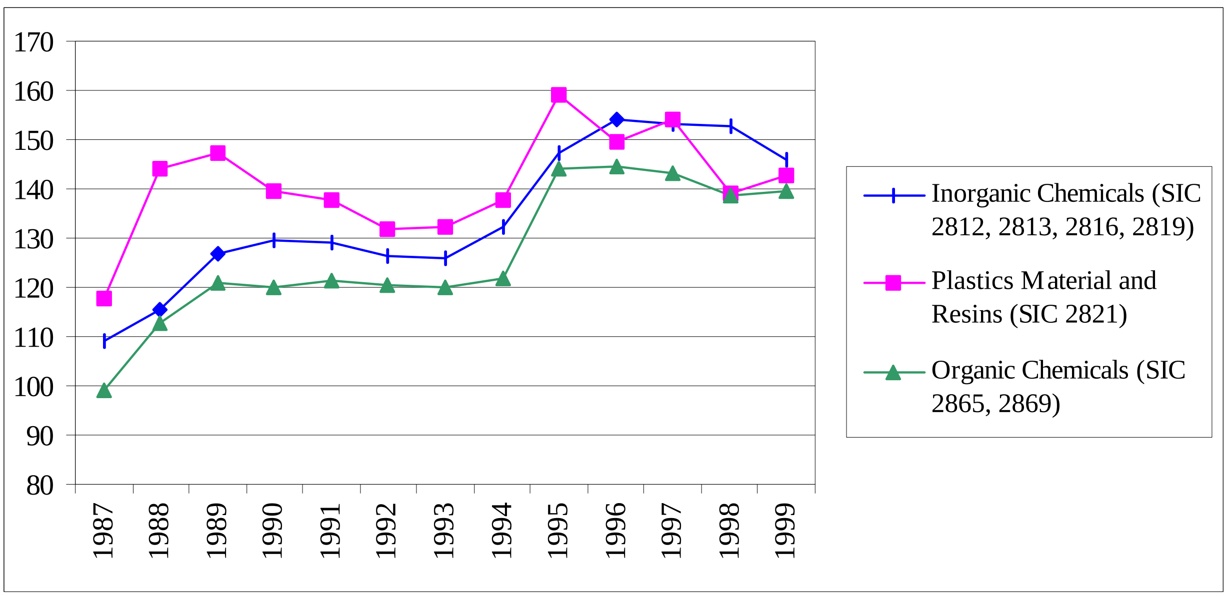
Selling prices for the products of the Organic and Inorganic Chemical sectors have increased from 1987 to 1989 and remained stable through 1994. Between 1994 and 1995, prices increased sharply, followed by a period of stable prices through 1997. Prices for plastics material and resins followed a trend similar to the other two chemical industry sectors but with larger fluctuations (see Figure 4B-2).

The fluctuations in chemical and plastics prices are in part a function of energy prices. Basic petrochemicals, which comprise the majority of organic chemical products, require energy input which can account for up to 85 percent of total production costs. The prices of natural gas and oil therefore influence the production costs and the selling price for these products. High basic petrochemical prices eventually trickle down to affect prices for chemical intermediates and final end products, including organic chemicals and plastics.

Another factor influencing prices for commodity chemical products is the cyclical nature of market supply and demand conditions. The Plastics, and Organic and Inorganic Chemical sectors are characterized by large capacity additions which can lead to fluctuations in prices in response to imbalances in supply and demand.

Figure 4B-2 shows the ***producer price index*** (PPI) at the 4-digit SIC code for the profiled chemical sectors. The PPI is a family of indexes that measure price changes from the perspective of the seller. This profile uses the PPI to inflate nominal monetary values to constant dollars.

Figure 4B-2: Producer Price Indexes for Profiled Chemical Sectors



Source: Bureau of Labor Statistics, Producer Price Index.

c. Number of Facilities and Firms

According to the Statistics of U.S. Businesses, the number of facilities in the Organic and Inorganic Chemical sectors remained relatively stable between 1989 and 1996. Table 4B-2 shows a downward trend in the number of facilities producing inorganic chemical products following a peak in 1991. This decrease is likely the result of the recent trend towards consolidation in the inorganic chemical sector. Consolidation is a means of paring costs with companies making acquisitions and consolidating operations in an attempt to reduce costs and achieve economies of scale (S&P, 2000).

While the Organic and Inorganic Chemical sectors have remained stable, the Plastics Material and Resins sector has experienced a significant increase in the number of facilities reported between 1993 and 1996. This increase reflects the fragmentation of the plastics market with a large number of plastics and resins being produced for a number diverse markets. The Plastics sector, like the Organic and Inorganic Chemical sectors, has experienced a trend toward consolidation. However, the largest industry sectors tend to be less consolidated than the smaller specialty product sectors where a small number of producers dominate (McGraw-Hill, 1999).

Table 4B-2: Number of Facilities for Profiled Chemical Sectors

Year	Inorganic Chemicals (SIC 2812, 2813, 2816, 2819)		Plastics Material and Resins (SIC 2821)		Organic Chemicals (SIC 2865, 2869)	
	Number of Facilities	Percent Change	Number of Facilities	Percent Change	Number of Facilities	Percent Change
1989	1,387	n/a	504	n/a	844	n/a
1990	1,421	2%	517	3%	837	-1%
1991	1,508	6%	529	2%	851	2%
1992	1,466	-3%	460	-13%	888	4%
1993	1,476	1%	502	9%	908	2%
1994	1,460	-1%	499	-1%	902	-1%
1995	1,425	-2%	558	12%	907	1%
1996	1,396	-2%	630	13%	868	-4%
Percent Change 1989-1996		1%		25%		3%

† There is significant variation in facility and firm counts that occur across data sources due to many factors including reporting and definitional differences.

Source: Small Business Administration, Statistics of U.S. Businesses.

The trend in the number of firms between 1989 and 1996 has been similar to the number of facilities. The number of firms remained relatively stable for both the Organic and Inorganic Chemical sectors. The Plastics Material and Resins sector experienced a significant increase in the number of firms reported between 1993 and 1996 increasing from 284 to 403 firms.

Table 4B-3 shows the number of firms in the three profiled chemical sectors between 1990 and 1996.

Table 4B-3: Number of Firms for Profiled Chemical Sectors

Year	Inorganic Chemicals (SIC 2812, 2813, 2816, 2819)		Plastics Material and Resins (SIC 2821)		Organic Chemicals (SIC 2865, 2869)	
	Number of Firms	Percent Change	Number of Firms	Percent Change	Number of Firms	Percent Change
1990	640	n/a	301	n/a	579	n/a
1991	678	6%	319	6%	584	1%
1992	699	3%	255	-20%	611	5%
1993	683	-2%	284	11%	648	6%
1994	677	-1%	295	4%	644	-1%
1995	657	-3%	343	16%	644	0%
1996	625	-5%	403	17%	596	-7%
Percent Change 1990-1996		-2%		34%		3%

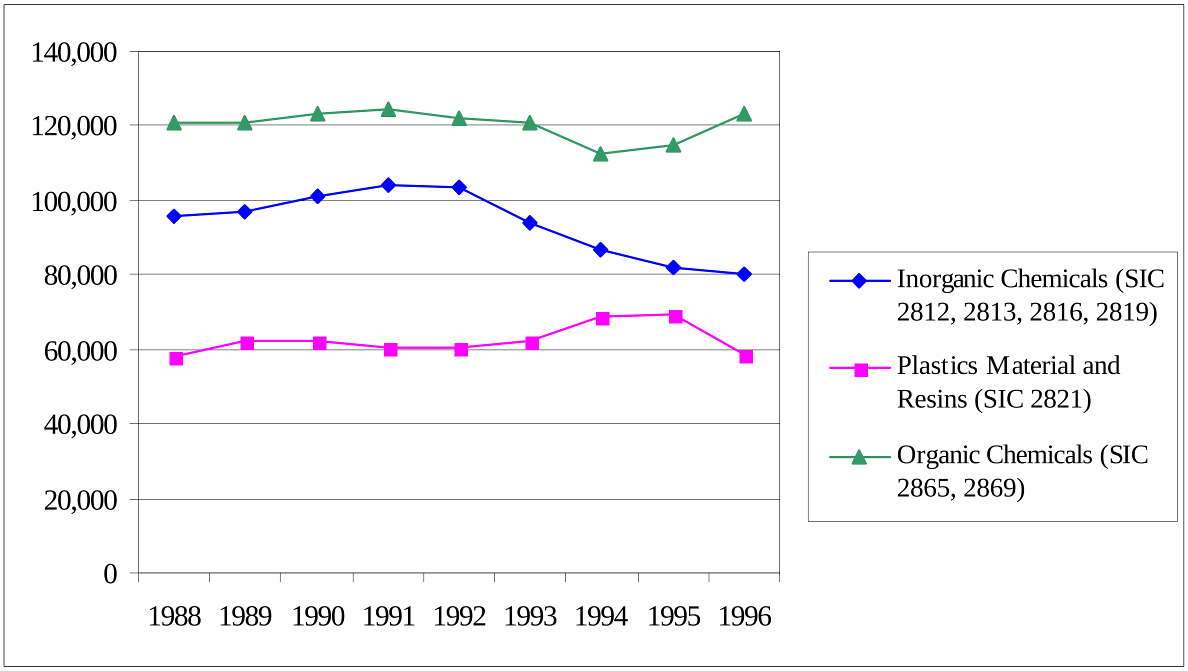
† There is significant variation in facility and firm counts that occur across data sources due to many factors including reporting and definitional differences.

Source: Small Business Administration, Statistics of U.S. Businesses.

d. Employment and Productivity

Employment is a measure of the level and trend of activity in an industry. Figure 4B-3 below provides information on employment from the Annual Survey of Manufactures. With the exception of minor short-lived fluctuations, employment in the Organic Chemical and Plastics and Resins sectors remained stable between 1992 and 1996. The Inorganic Chemicals sector, however, experienced a significant decrease in employment from 103,400 to 80,200 employees over the same time period. This decrease reflects the industry's restructuring and downsizing efforts intended to reduce costs in response to competitive challenges.

Figure 4B-3: Employment for Profiled Chemical Sectors



Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

Table 4B-4 presents the change in value added per labor hour, a measure of ***labor productivity***, for each of the profiled industry sectors between 1988 and 1996. The trends in each sector, particularly Plastic Materials and Resins and Organic Chemicals, show considerable volatility throughout the early and mid 1990s. The gains in productivity in the Inorganic Chemicals sector likely reflects facilities' attempts to reduce costs by restructuring production and materials handling processes in response to maturing domestic markets and increased global competition (S&P, 2000). The decreases in the labor productivity of the Organic Chemicals sector is a function of the sharp declines in value added resulting from increased competition in the global market for petrochemicals.

Table 4B-4: Productivity Trends for Profiled Chemical Sectors, Millions of $1999

Year	Inorganic Chemicals (SIC 2812, 2813, 2816, 2819)				Plastics Material and Resins (SIC 2821)				Organic Chemicals (SIC 2865, 2869)			
	Value Added	Prod. Hours (mill.)	Value Added/Hour		Value Added	Prod. Hours (mill.)	Value Added/Hour		Value Added	Prod. Hours (mill.)	Value Added/Hour	
			No.	% Change			No.	% Change			No.	% Change
1988	16,020	114	141	n/a	13,087	80	164	n/a	36,058	152	238	n/a
1989	16,291	109	150	6%	12,594	84	150	-8%	36,947	155	239	1%
1990	17,880	115	156	4%	12,484	83	151	1%	36,816	156	236	-1%
1991	17,366	121	144	-8%	11,403	81	141	-7%	32,863	156	211	-11%
1992	18,643	120	155	8%	13,538	79	172	22%	33,025	155	213	1%
1993	17,811	108	165	6%	12,902	81	159	-8%	34,488	156	221	4%
1994	16,703	101	166	0%	15,871	89	178	11%	37,308	146	256	16%
1995	16,561	100	165	0%	15,907	92	173	-2%	34,106	147	232	-9%
1996	15,774	97	163	-1%	14,614	81	181	5%	27,827	158	176	-24%
Percent Change 1988-1996				15%				11%				-26%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

e. Capital Expenditures

The chemicals industry is relatively capital-intensive, with aggregate capital spending of $28.4 billion in 1998 (S&P, 2000). Capital-intensive industries are characterized by large, technologically complex manufacturing facilities which reflect the economies of scale required to manufacture products efficiently. ***New capital expenditures*** are needed to extensively modernize, expand, and replace existing capacity to meet growing demand. All three profiled chemical industry sectors have experienced substantial increases in capital expenditures over the past ten years. Table 4B-5 shows that capital expenditures in the Inorganic Chemicals, the Plastics, and the Organic Chemicals sectors have increased by 85, 75, and 41 percent, respectively, over the past ten years. Much of this growth in capital expenditures is driven by investment in capacity expansions worldwide to meet the increase in global demand for chemical products. The continued globalization of the chemical industry has expanded markets and provided U.S. producers with the opportunity to invest in foreign markets and improve their international competitiveness. Domestically, the continued substitution of synthetic materials for other basic materials and rising living standards has resulted in consistent growth in the demand for chemical commodities (S&P, 2000).

Table 4B-5: Capital Expenditures for Profiled Chemical Sectors ($1999 millions)

Year	Inorganic Chemicals (SIC 2812, 2813, 2816, 2819)		Plastics (SIC 2821)		Organic Chemicals (SIC 2865, 2869)	
	Capital Expenditures	Percent Change	Capital Expenditures	Percent Change	Capital Expenditures	Percent Change
1987	1,028	n/a	1,514	n/a	n/a	n/a
1988	1,043	1%	1,592	5%	4,326	n/a
1989	1,513	45%	1,906	20%	5,149	19%
1990	1,475	-3%	2,494	31%	6,517	27%
1991	1,535	4%	2,332	-7%	6,637	2%
1992	1,742	14%	1,850	-21%	6,105	-8%
1993	1,345	-23%	2,079	12%	5,221	-14%
1994	1,449	8%	2,630	27%	4,464	-15%
1995	1,735	20%	2,099	-20%	4,960	11%
1996	1,900	9%	2,657	27%	6,107	23%
Percent Change 1987-1996		85%		75%		41%

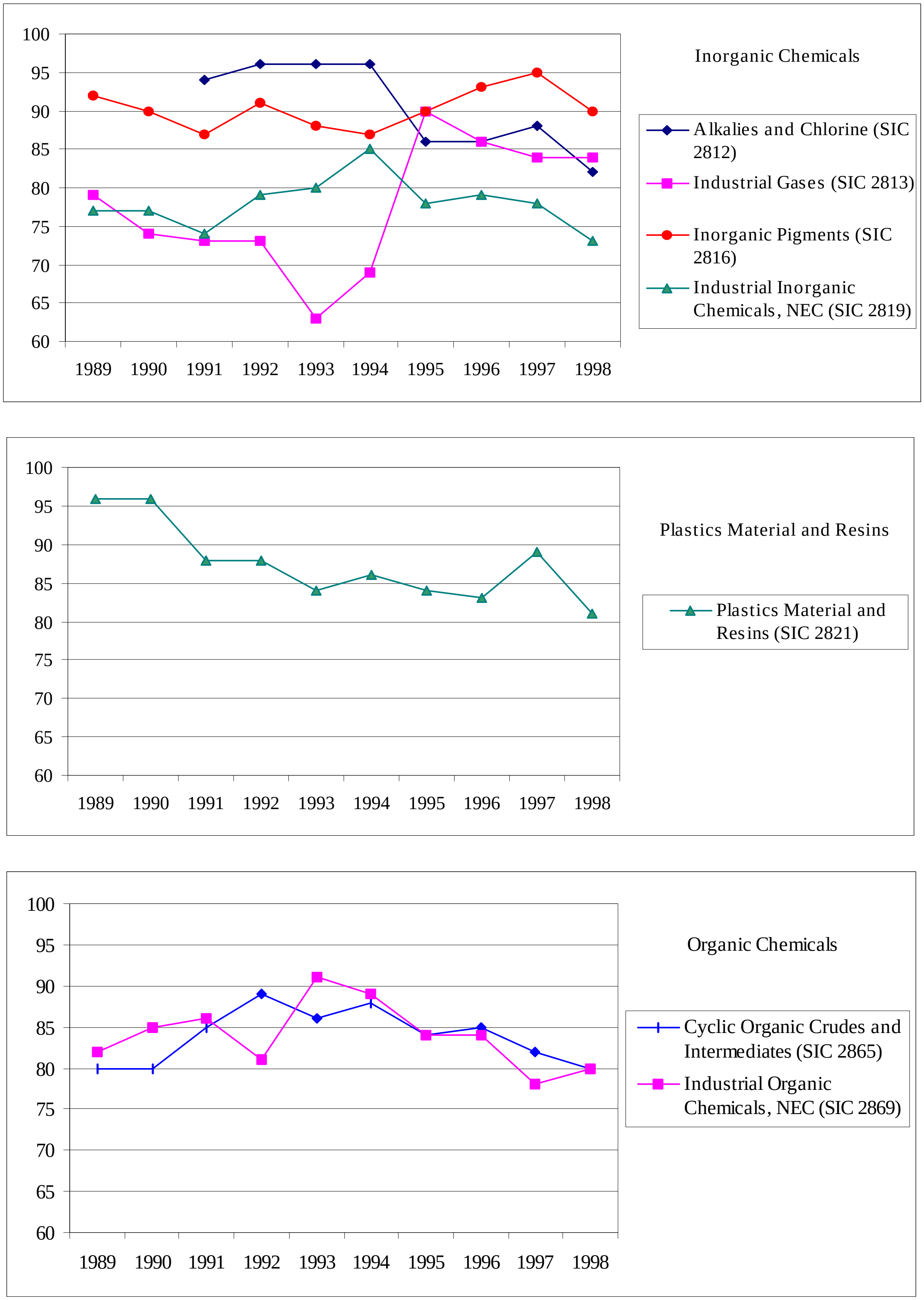
Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

f. Capacity Utilization

Capacity utilization measures actual output as a percentage of total potential output given the available capacity and is used as a key barometer of an industry's health. Capacity utilization is an index used to identify potential excess or insufficient capacity in an industry which can help project whether new investment is likely. To take advantage of economies of scale, chemical commodities are typically produced in large facilities. Capacity additions in this industry are often made on a relatively large scale and can substantially affect the industry's capacity utilization rates. Figure 4B-4 presents the capacity utilization index from 1989 to 1998 for specific 4-digit SIC codes within each of the profiled sectors in the chemicals industry. Capacity utilization in the Organic Chemicals sector has remained stable throughout the 1990s with only moderate fluctuations between 1989 and 1998. The Plastics and Resins sector has experienced a consistent downward trend as a result of the considerable consolidation of the industry in the last decade.

Overall, the Inorganic Chemicals sector has demonstrated the most volatility in capacity utilization between 1989 and 1998. The chlor-alkali industry (SIC code 2812) has experienced an almost consistent decline in the capacity utilization index since its high of 96 percent from 1992 through 1994. This decrease reflects the enactment of treaties and legislation designed to reduce the emission of chlorinated compounds into the environment. These regulations decreased the demand for chlorine which, together with caustic soda, accounts for more than 75 percent of production by this sector. As demand for chlorine declined, prices weakened and capacity utilization contracted. The significant increase in capacity utilization in the industrial gases sector (SIC code 2813) in the mid 1990s reflects the expansion of key end-use markets such as the chemicals, primary metals, and electronics industries. In contrast, capacity utilization in the pigments and other inorganic chemicals sectors (SIC codes 2816 and 2819) remained relatively stable between 1989 and 1998. The stability in these sectors reflects the fact that these are essentially mature markets where the demand for products tend to track growth in gross domestic product (GDP) (McGraw-Hill 1999).

Figure 4B-4: Capacity Utilization Indexes for Profiled Chemical Sectors



Source: Department of Commerce, Bureau of the Census, Current Industrial Reports, Survey of Plant Capacity.

4B.2 Structure and Competitiveness of the Chemical and Allied Products Industry

The chemicals industry continues to restructure and reduce costs in response to competitive challenges, including global oversupply for commodities. In the early 1990s, the chemical industry's cost-cutting came largely from restructuring and downsizing. The industry recently has moved toward trying to improve productivity. The industry's trend towards consolidation is another means of cutting costs. In general, companies seeking growth within maturing industry sectors are making acquisitions to achieve production or marketing efficiencies. The Plastics Material and Resins sector (SIC code 282), for example, has recently experienced sizable consolidations (S&P, 2000).

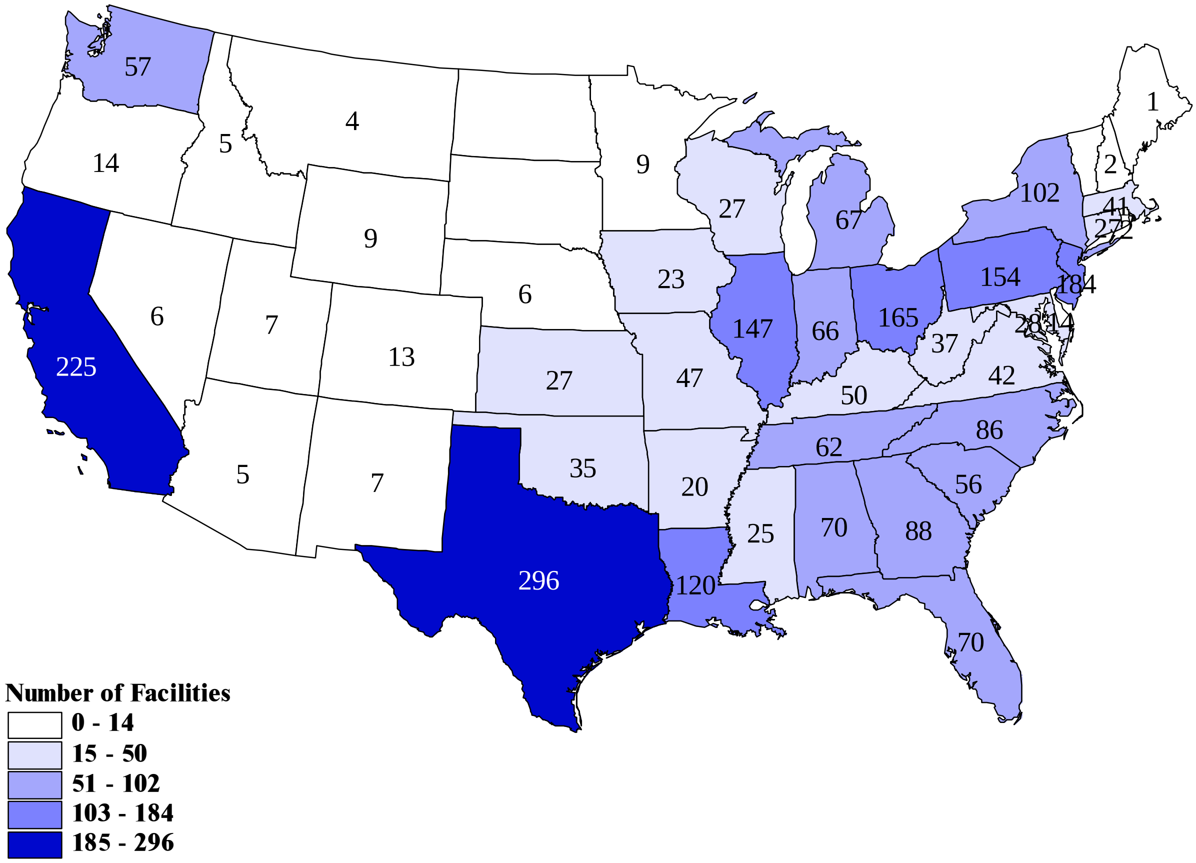
a. Geographic Distribution

Chemical manufacturing facilities are located in every state but almost two-thirds of U.S. chemical production is concentrated in ten states. Given the low value of many commodity chemicals and the handling problems posed by products such as industrial gases, nearly two-thirds of the tonnage shipped was transported less than 250 miles in 1998 (S&P, 2000).

The Industrial Organic Chemical sector is geographically diverse. Cyclic crudes and intermediates (SIC 2865) and unclassified industrial organic chemicals (SIC 2869) are concentrated in Texas, New Jersey, Ohio, California, New York, and Illinois. Facility sites are typically chosen for their access to raw materials such as petroleum and coal products and to transportation routes. In addition, since much of the market for organic chemicals is the chemical industry, facilities tend to cluster near such end-users (U.S. EPA, 1995a).

Inorganic Chemical facilities (SIC 281) are typically located near consumers and, to a lesser extent, raw materials. The largest use of inorganic chemicals is in industrial processes for the manufacture of chemicals and nonchemical products. Facilities are therefore concentrated in the heavy industrial regions along the Gulf Coast, both East and West coasts, and the Great Lakes region. Since a large portion of the inorganic chemicals produced are used by the Organic Chemicals manufacturing industry, the geographical distribution of inorganic facilities is very similar to that of organic chemicals facilities (US EPA, 1995b). Facilities in the Plastics Material and Resins sector (SIC 2821) are concentrated in the heavy industrial regions, similar to both the organic and inorganic chemicals facilities.

Figure 4B-5: Number of Chemical Facilities by State for Profiled Chemical Sectors



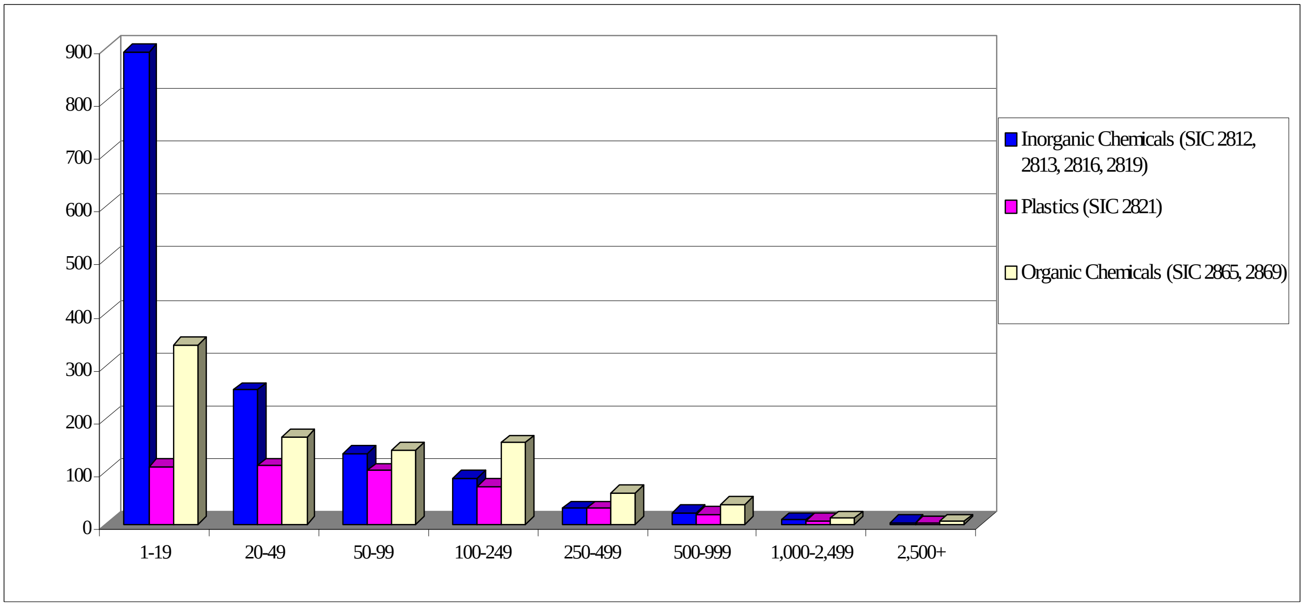
Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

b. Facility Size

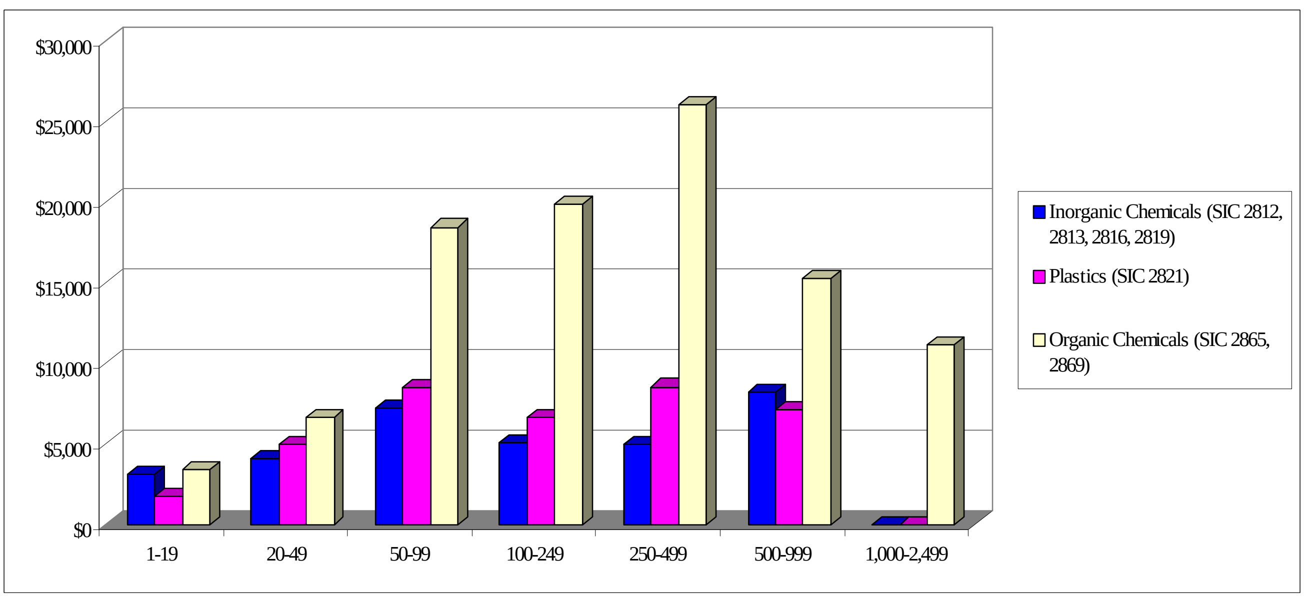
The three profiled chemicals industry sectors are characterized by a large number of small facilities, with more than 67 percent of facilities employing fewer than 50 employees and only eight percent employing 250 or more employees. However, the larger facilities in the three sectors account for the majority of the industries' output. This fact is most pronounced in the Inorganic Chemicals sector where facilities with fewer than 20 employees account for 63 percent of all facilities but for only 8 percent of the industry's value of shipments. In the Organic Chemicals sector, approximately 29 percent of all facilities employ 100 employees or more. These facilities account for about 87 percent of the value of shipments for the industry. Similarly, facilities in the Plastics Industry with more than 100 employees account for only 29 percent of all facilities but for 80 percent of the industry's value of shipments (see Figure 4B-6 below).

Figure 4B-6: Number of Facilities and Value Added by Employment Size Category for Profiled Chemical Sectors

Number of Facilities (1992)



1992 Value of Shipments (millions $1999)



Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

c. Firm Size

The Small Business Administration (SBA) defines small firms in the chemical industries according to the firm's number of employees. Firms in the Inorganic Chemicals sector (SIC codes 2812, 2813, 2816, 2819) and in Industrial Organic Chemicals, NEC (SIC code 2869) are defined as small if they have 1,000 or fewer employees; firms in Plastics Material and Resins (SIC 2821) and Cyclic Organic Crudes and Intermediates (SIC code 2865) are defined as small if they have 750 or fewer employees.

The size categories reported in the Statistics of U.S. Businesses (SUSB) do not coincide with the SBA small firm standards of 750 and 1,000 employees. It is therefore not possible to apply the SBA size thresholds precisely. The SUSB data presented in Table 4B-6 show that in 1996, 483 of 625 firms in the Inorganic Chemicals sector had less than 500 employees. Therefore, at least 77 percent of firms in this sector were classified as small. These small firms owned 545 facilities, or 39 percent of all facilities in the sector. In the Plastics and Resins Industry sector, 309 of 403 firms, or 77 percent, had less than 500 employees in 1996. These small firms owned 328 of 630 facilities (52 percent) in the sector. In the Organic Chemicals Industry sector, 71 percent of facilities (423 of 596) had fewer than 500 employees, owning 53 percent of all facilities in that sector.

Table 4B-6 below shows the distribution of firms, facilities, and receipts in the Inorganic Chemicals, Plastics Material and Resins, and Organic Chemicals sectors by the employment size of the parent firm.

Table 4B-6: Number of Firms, Facilities and Estimated Receipts by Firm Size Category for Profiled Chemical Sectors (1996)

Employment Size Category	Inorganic Chemicals (SIC 2812, 2813, 2816, 2819)			Plastics Material and Resins (SIC 2821)			Organic Chemicals (SIC 2865, 2869)		
	No. of Firms	Number of Establish-ments	Estimated Receipts ($1999 millions)	No. of Firms	Number of Establish-ments	Estimated Receipts ($1999 millions)	No. of Firms	Number of Establish-meats	Estimated Receipts ($1999 millions)
0-19	296	296	380	195	195	457	219	220	642
20-99	124	140	1,238	77	77	1,341	139	149	2,638
100-499	63	109	2,589	37	56	3,011	65	94	4,845
500-2,499	51	199	3,457	35	93	5,318	61	119	9,499
2500+	91	652	20,318	59	209	28,123	112	286	56,572
Total	625	1,396	27,981	403	630	38,251	596	868	74,195

Source: Small Business Administration, Statistics of U.S. Businesses.

d. Concentration and Specialization Ratios

Concentration is the degree to which industry output is concentrated in a few large firms. Concentration is closely related to entry and exit barriers with more concentrated industries generally having higher barriers.

The four-firm ***concentration ratio*** (CR4) and the ***Herfindahl-Hirschman Index*** (HHI) are common measures of industry concentration. The CR4 indicates the market share of the four largest firms. For example, a CR4 of 72 percent means that the four largest firms in the industry account for 72 percent of the industry's total value of shipments. The higher the concentration ratio, the less competition there is in the industry, other things being equal.[2] An industry with a CR4 of more than 50 percent is generally considered concentrated. The HHI indicates concentration based on the largest 50 firms in the industry. It is equal to the sum of the squares of the market shares for the largest 50 firms in the industry. For example, if an industry consists of only three firms with market shares of

[2] Note that the measured concentration ratio and the HHF are very sensitive to how the industry is defined. An industry with a high concentration in domestic production may nonetheless be subject to significant competitive pressures if it competes with foreign producers or if it competes with products produced by other industries (e.g., plastics vs. aluminum in beverage containers). Concentration ratios are therefore only one indicator of the extent of competition in an industry.

60, 30, and 10 percent, respectively, the HHI of this industry would be equal to 4,600 ($60^2 + 30^2 + 10^2$). The higher the index, the fewer the number of firms supplying the industry and the more concentrated the industry. An industry is considered concentrated if the HHI exceeds 1,000.

Of the profiled Chemicals and Allied Products, only Alkalies and Chlorine (SIC 2812), Industrial Gases (SIC 2813), and Inorganic Pigments (SIC 2816) would be considered highly concentrated based on their CR4 and HHI values. These industries are characterized by heavy capital and technology requirements and large potential safety and environmental liabilities which present barriers to entry into the industry. In contrast, Industrial Inorganic Chemicals, NEC (SIC 2819), Plastics Material and Resins (SIC 2821), Cyclic Crudes and Intermediates (SIC 2865), and Industrial Organic Chemicals, NEC (SIC 2869) would be considered competitive but not concentrated.

The ***specialization ratio*** is the percentage of the industry's production accounted for by primary product shipments. The ***coverage ratio*** is the percentage of the industry's product shipments coming from facilities from the same primary industry. The coverage ratio provides an indication of how much of the production/product of interest is captured by the facilities classified in an SIC code. The specialization ratios presented in Table 4B-7 indicate a relatively high degree of specialization for each profiled chemical industry sector.

Table 4B-7: Selected Ratios for Four-Digit SIC Codes for Profiled Chemical Sectors

SIC Code	Year	Concentration Ratios					Specialization Ratio	Coverage Ratio
		4 Firm (CR4)	8 Firm (CR8)	20 Firm (CR20)	50 Firm (CR50)	Herfindahl-Hirschman Index		
Inorganic Chemicals								
2812	87	72%	93%	99%	100%	2,328	86%	65%
	92	75%	90%	99%	100%	1,994	76%	75%
2813	87	77%	88%	95%	98%	1,538	98%	94%
	92	78%	91%	96%	99%	1,629	96%	94%
2816	87	64%	76%	94%	99%	1,550	94%	89%
	92	69%	79%	93%	99%	1,910	95%	89%
2819	87	38%	49%	68%	84%	468	91%	80%
	92	39%	50%	68%	85%	677	91%	82%
Plastics Material and Resins								
2821	87	20%	33%	61%	89%	248	88%	81%
	92	24%	39%	63%	90%	284	86%	80%
Organic Chemicals								
2865	87	34%	50%	77%	96%	542	80%	61%
	92	31%	45%	72%	94%	428	86%	61%
2869	87	31%	48%	68%	86%	376	75%	84%
	92	29%	43%	67%	86%	336	76%	85%

Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

e. Foreign Trade

The chemicals industry is the largest exporter in the United States. The industry generates more than 10 percent of the nation's total exports. The industry's highest exports were $69.5 billion in 1997. Exports were lower in 1998 because the Asian economic crisis led to a reduction in sales to that region in 1998. U.S. imports of chemicals, mainly from Western Europe, rose an estimated 11 percent in 1999 (S&P, 2000).

This profile uses two measures of foreign competitiveness: ***export dependence*** and ***import penetration***. Export dependence is the share of value of shipments that is exported. Import penetration is the share of domestic consumption met by imports. Table 4B-8 presents trade statistics for each of the profiled chemical sectors. Both export dependence and import penetration have experienced modest positive trends in each of these sectors between 1989 and 1996. Globalization of the market has become a key factor influencing foreign competitiveness in the Inorganic Chemicals sector (SIC 281). In recent years import penetration has been increasing at a slightly higher rate than export dependence in this sector due to a strengthened U.S. dollar, weakness in the European and Japanese markets, and increased production in lower-cost developing nations (McGraw-Hill, 1998). Increased globalization has also been a dominant trend affecting trade statistics in the Plastics Material and Resins sector (SIC 2821). Imports and exports of plastics and resins have increased significantly over the past eight years reflecting the continued growth in the global market. Import penetration has grown more quickly than export dependence in this sector due to declining export opportunities and increased competition from imports driven by increased foreign capacity. The U.S. remains a net exporter of plastics and resins, despite these trends. The market for organic chemicals, particularly petrochemicals, has become increasingly competitive. Significant capacity expansions for petrochemicals worldwide have increased competition from imports and begun to limit export opportunities. Nevertheless, exports in Organic Chemicals (SIC 2865, 2869) have remained slightly higher than imports between 1989 and 1996.

Table 4B-8: Trade Statistics for Profiled Chemical Sectors						
Year	Value of imports ($1999 millions)	Value of exports ($1999 millions)	Value of Shipments ($1999 millions)	Implied Domestic Consumption†	Import Penetration††	Export Dependence†††
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Inorganic Chemicals, Except Pigments (SIC 2812, 2813, 2819)						
1989	4,880	5,540	24,331	23,671	21%	23%
1990	4,955	5,342	26,913	26,526	19%	20%
1991	4,917	5,727	27,054	26,244	19%	21%
1992	4,921	6,060	28,412	27,273	18%	21%
1993	4,753	5,674	27,139	26,218	18%	21%
1994	5,170	5,728	23,809	23,251	22%	24%
1995	5,400	5,949	22,639	22,090	24%	26%
1996	5,707	5,819	22,161	22,049	26%	26%
Average Annual Growth Rate	*2%*	*1%*	*-1%*	*-1%*	*3%*	*2%*
Plastics Materials and Resins (SIC 2821)						
1989	1,506	5,351	32,241	28,396	5%	17%
1990	1,854	6,411	32,067	27,510	7%	20%
1991	1,838	7,645	30,616	24,809	7%	25%
1992	2,234	7,592	33,917	28,559	8%	22%
1993	2,718	7,751	34,049	29,016	9%	23%
1994	3,401	8,739	38,687	33,349	10%	23%
1995	3,668	9,284	39,094	33,478	11%	24%
1996	3,986	10,106	38,275	32,155	12%	26%
Average Annual Growth Rate	*15%*	*10%*	*2%*	*2%*	*13%*	*7%*
Organic Chemicals, Except Gum & Wood (SIC 2865, 2869)						
1989	6,727	11,455	82,187	77,459	9%	14%
1990	7,307	11,404	83,428	79,331	9%	14%
1991	7,585	11,664	79,863	75,784	10%	15%
1992	8,388	11,674	81,089	77,803	11%	14%
1993	8,530	12,159	82,534	78,905	11%	15%
1994	9,917	14,191	88,238	83,964	12%	16%
1995	10,244	15,142	76,611	71,713	14%	20%
1996	11,125	13,690	73,253	70,688	16%	19%
Average Annual Growth Rate	*7%*	*3%*	*-2%*	*-1%*	*9%*	*4%*

† Implied domestic consumption based on value of shipments, imports, and exports [column d + column b - column c].
†† Import penetration based on implied domestic consumption and imports [column b / column e].
††† Export dependence based on value of shipments and exports [column c / column d].

Source: Department of Commerce, International Trade Administration, Outlook Trends Tables.

4B.3 Financial Condition and Performance

The chemical industry is generally characterized by large plant sizes and technologically complex production processes reflecting the economies of scale required to manufacture chemicals efficiently. Because of the high fixed costs associated with chemical manufacturing operations, larger production volumes are required to spread these costs over a greater number of units in order to maintain profitability. ***Operating margins*** for chemical producers are generally volatile due to rapid changes in selling prices, raw material costs, energy costs, and production levels. Other factors that affect margins for chemical producers include costs associated with businesses recently acquired or divested, major new capacity additions, or environmental costs (S&P, 2000).

Facing increased global competition, the U.S. chemical industry has restructured and reduced costs to maintain profitability and operating margins. Cost-cutting efforts in the early 1990s came largely from restructuring and downsizing, particularly in the Inorganic Chemicals sector. The industry has recently shifted toward consolidation as a means of paring costs by achieving production or marketing efficiencies while maintaining growth in maturing markets (S&P, 2000). These transactions are typically small scale involving individual product lines or facilities and are most common in the Organic Chemical and Plastics and Resins Industry sectors.

Table 4B-9 presents operating margins for each of the profiled chemical sectors between 1987 and 1996.

Table 4B-9: Operating Margins for Profiled Chemical Sectors, (Millions of $1999)				
Year	**Value of Shipments**	**Cost of Materials**	**Payroll (all employees)**	**Operating Margin**
Inorganic Chemicals (SIC 2812, 2813, 2816, 2819)				
1987	25,544	10,994	3,968	41.4%
1988	27,576	11,725	4,055	42.8%
1989	27,308	11,122	3,925	44.9%
1990	29,635	12,354	4,247	44.0%
1991	29,286	12,001	4,480	43.7%
1992	30,604	12,016	4,701	45.4%
1993	29,686	11,894	4,366	45.2%
1994	27,781	11,032	4,098	45.5%
1995	27,155	10,706	3,648	47.1%
1996	26,429	10,771	3,570	45.7%
Plastics Material and Resins (SIC 2821)				
1987	31,870	18,713	2,436	33.6%
1988	31,842	19,173	2,152	33.0%
1989	32,241	19,673	2,310	31.8%
1990	32,067	19,850	2,545	30.2%
1991	30,616	19,254	2,568	28.7%
1992	33,917	20,412	2,895	31.3%
1993	34,049	21,048	3,021	29.3%
1994	38,687	22,913	3,251	32.4%
1995	39,094	23,539	2,972	32.2%
1996	38,275	23,700	2,734	30.9%
Organic Chemicals (SIC 2865, 2869)				
1988	79,916	44,562	6,152	36.5%
1989	82,187	45,531	6,037	37.3%
1990	83,428	47,294	6,556	35.5%
1991	79,863	46,779	6,702	33.0%
1992	81,089	48,290	6,869	32.0%
1993	82,534	48,006	7,125	33.2%
1994	88,238	51,032	7,012	34.2%
1995	76,611	42,985	5,882	36.2%
1996	73,253	45,565	6,533	28.9%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

4B.4 Facilities Operating CWISs

In 1982, the Chemical and Allied Products industry withdrew 2,797 billion gallons of cooling water, accounting for approximately 3.6 percent of total industrial cooling water intake in the United States. The industry ranked 2nd in industrial cooling water use behind the electric power generation industry (1982 Census of Manufactures).

This section presents information from EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* on existing facilities with the following characteristics:

- they withdraw from a water of the United States;
- they hold an NPDES permit;
- they have an intake flow of more than two MGD;
- they use at least 25 percent of that flow for cooling purposes.

These facilities are not "new facilities" as defined by the proposed §316(b) New Facility Rule and are therefore not subject to this regulation. However, they meet the criteria of the proposed rule except that they are already in operation. These existing facilities therefore provide a good indication of what new facilities in these sectors may look like. The remainder of this section refers to existing facilities with the above characteristics as "§316(b) facilities."

a. Cooling Water Uses and Systems

Information collected in Screener Questionnaire found that an estimated 35 out of 435 inorganic chemical facilities (8 percent), 14 out of 305 plastics facilities (5 percent), and 58 out of 427 organic chemical facilities (14 percent) meet the characteristics of a §316(b) facility. Most §316(b) facilities in the profiled Chemical and Allied Products sectors use cooling water for contact and non-contact production line or process cooling, electricity generation, and air conditioning:

- All §316(b) *inorganic chemical* facilities use cooling water for production line (or process) contact or noncontact cooling. The two other major uses of cooling water are electricity generation and air conditioning, with approximately 31 and 27 percent of facilities, respectively.

- All §316(b) *plastics* facilities use cooling water for production line (or process) contact or noncontact cooling. Fifty, 22, and six percent also use cooling water for air conditioning, electricity generation, and other uses.

- Nintey-four percent of §316(b) *organic chemicals* facilities use cooling water for production line (or process) contact or noncontact cooling. Forty-five, 41, and 17 percent of facilities use cooling water for air conditioning, other uses, and electricity generation, respectively.

Table 4B-10 shows the distribution of existing §316(b) facilities in the profiled chemical sectors by type of water body and cooling system. The table shows that most of the existing §316(b) facilities have either a once through system (56, or 52 percent) or employ a combination of a once through and closed system (30, or 28 percent). The majority of existing facilities draw water from a freshwater water stream or river (82, or 77 percent).

Table 4B-10: Number of §316(b) Facilities by Water Body and Cooling System Type for Profiled Chemical Sectors

Water Body Type	Cooling System						
	Closed Cycle		Once Through		Combination		Total
	Number	% of Total	Number	% of Total	Number	% of Total	
Inorganic Chemicals (SIC 2812, 2813, 2816, 2819)							
Estuary or Tidal River†	0	0%	3	39%	5	61%	9
Freshwater Stream or River	2	13%	9	56%	5	31%	17
Ocean	0	0%	9	100%	0	0%	9
Total††††	***2***	***6%***	***22***	***63%***	***10***	***30%***	***35***
Plastics Material and Resins (SIC 2821)							
Estuary or Tidal River††	0	0%	0	0%	1	100%	1
Freshwater Stream or River	0	0%	4	33%	8	67%	12
Lake or Reservoir	0	0%	1	100%	0	0%	1
Total††††	***0***	***0%***	***5***	***36%***	***9***	***64%***	***14***
Organic Chemicals (SIC 2865, 2869)							
Estuary or Tidal River	0	0%	4	100%	0	0%	4
Freshwater Stream or River†††	18	34%	24	45%	11	21%	53
Ocean	0	0%	1	100%	0	0%	1
Total††††	***18***	***31%***	***29***	***50%***	***11***	***19%***	***58***
Total for Profiled Chemical Facilities (SIC 28)							
Estuary or Tidal River†	0	0%	7	50%	6	43%	14
Freshwater Stream or River	20	24%	37	45%	24	29%	82
Ocean	0	0%	10	100%	0	0%	10
Lake or Reservoir	0	0%	1	100%	0	0%	1
Total††††	**20**	**19%**	**56**	**52%**	**30**	**28%**	**107**

† One of the inorganic chemical facilities on an estuary or tidal river also has a CWIS on a lake or reservoir.
†† One plastics facility on an estuary or tidal river also has a CWIS on a lake or reservoir.
††† One of the organic chemicals facilities on a freshwater stream or river also has a CWIS on a lake or reservoir.
†††† Individual numbers may not add up to total due to independent rounding.

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

b. Facility Size

Chemical facilities that withdraw more than two MGD from a water of the U.S., hold an NPDES permit, and use at least 25 percent of intake water for cooling purposes are generally larger than facilities that do not meet these criteria:

- Ninety percent of all facilities in the Inorganic Chemicals sector have fewer than 100 employees but only 34 percent of §316(b) facilities in that sector fall into that employment category.

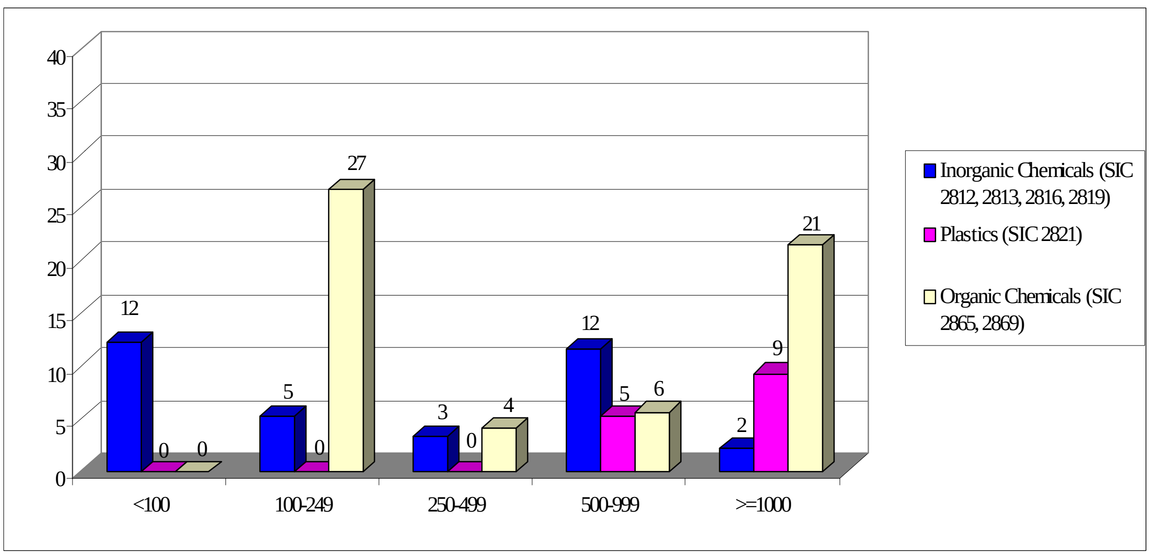
- Seventy-one percent of all facilities in the Plastics and Resins and the Organic Chemicals sectors have fewer than 100 employees compared to none of the §316(b) facilities in those sectors.

- The majority of §316(b) plastics facilities (64 percent) employ over 1,000 employees.

- §316(b) industrial organic facilities are more evenly distributed across employment categories with 23 facilities (43 percent) employing 100 to 249 employees and 21 facilities (39 percent) employing over 1,000 employees.

Figure 4B-7 shows the number of §316(b) facilities in the profiled chemical sectors by employment size category.

Figure 4B-7: Number of §316(b) Facilities by Employment Size Category for Profiled Chemical Sectors



Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

c. Firm Size

EPA used the Small Business Administration (SBA) small entity size standards to determine the number of existing §316(b) facilities in the three profiled chemical sectors that are owned by small firms. Firms in the Inorganic Chemicals sector (SIC codes 2812, 2813, 2816, 2819) and in Industrial Organic Chemicals, NEC (SIC code 2869) are defined as small if they have 1,000 or fewer employees; firms in Plastics Material and Resins (SIC 2821) and Cyclic Organic Crudes and Intermediates (SIC code 2865) are defined as small if they have 750 or fewer employees.

Table 4B-11 shows that of the 35 §316(b) facilities in the Inorganic Chemicals sector, five, or 14 percent, are owned by a small firm. None of the 19 §316(b) facilities in the Plastics sector are owned by a small firm. In the Organic Chemicals sector, four of the 58 §316(b) facilities, or seven percent, are owned by a small firm. Another two facilities, or two percent, are owned by a firm of unknown size which may also qualify as a small firm.

Table 4B-11: Number of §316(b) Facilities by Firm Size for Profiled Chemical Sectors

SIC Code	Large		Small		Unknown		Total
	No.	% of SIC	No.	% of SIC	No.	% of SIC	
Inorganic Chemicals (SIC 2812, 2813, 2816, 2819)							
2812	10	100%	0	0%	0	0%	10
2813	4	100%	0	0%	0	0%	4
2816	0	0%	4	100%	0	0%	4
2819	16	94%	1	6%	0	0%	17
Total	***30***	***86%***	***5***	***14%***	***0***	***0%***	***35***
Plastics Material and Resins (SIC 2821)							
2821	14	100%	0	0%	0	0%	14
Organic Chemicals (SIC 2865, 2869)							
2865	5	100%	0	0%	0	0%	5
2869	46	88%	4	8%	2	4%	53
Total	***51***	***89%***	***4***	***7%***	***2***	***4%***	***58***
Total for Profiled Chemical Facilities (SIC 28)							
Total	**95**	**89%**	**9**	**9%**	**2**	**2%**	**107**

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; D&B Database, 1999.

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4C PETROLEUM AND COAL PRODUCTS (SIC CODE 29)

EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* identified two 4-digit SIC codes in the Petroleum and Coal Products Industry (SIC 29) with at least one existing facility that operates a CWIS, holds a NPDES permit, and withdraws more than two million gallons per day (MGD) from a water of the United States, and uses at least 25 percent of its intake flow for cooling purposes (facilities with these characteristics are hereafter referred to as "§316(b) facilities"). For both SIC codes, Table 4C-1 below provides a description of the industry sector, a list of primary products manufactured, the total number of screener respondents, and the number and percent of §316(b) facilities.

Table 4C-1: §316(b) Facilities in the Petroleum and Coal Products Industry (SIC 29): Weighted Screener Survey Respondents

SIC	SIC Description	Important Products Manufactured	Number of Facilities		
			Total	§316(b) Facilities	
				No.†	%
2911	Petroleum Refining	Gasoline, kerosene, distillate fuel oils, residual fuel oils, and lubricants, through fractionation or straight distillation of crude oil, redistillation of unfinished petroleum derivatives, cracking, or other processes; aliphatic and aromatic chemicals as byproducts	163	28	17.2%
2999	Products of Petroleum and Coal, Not Elsewhere Classified	Packaged fuel, powdered fuel, and other products of petroleum and coal, not elsewhere classified	8	1	12.5%
Total Petroleum and Coal Products (SIC 29)					
Total 29			**171**	**29**	**15.8%**

† Information on the percentage of intake flow used for cooling purposes was not available for all screener respondents. Facilities for which this information was not available were assumed to use at least 25% of their intake flow for cooling water purposes The reported numbers of §316(b) facilities may therefore be overstated.

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures; Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual 1987

Responses to the Screener Questionnaire indicate that one sector, Petroleum Refining (SIC code 2911), accounts for 97 percent of the §316(b) facilities in SIC 29. This profile therefore focuses on facilities in the Petroleum Refining sector.

4C.1 Domestic Production

The petroleum refining industry accounts for about 4 percent of the value of shipments of the entire manufacturing sector and for 0.4 percent of the manufacturing sector's employment (U.S. Department of Energy, 1999a). According to the Annual Survey of Manufactures, petroleum refineries had a value of shipments of approximately $158 billion dollars ($1996) and employed 67,200 people (U.S. DOC 1996). Petroleum products contribute approximately 40 percent of the total energy used in the United States, including virtually all of the energy consumed in transportation (U.S. Department of Energy, 1999a).

U.S. DOE Energy Information Administration (EIA) data report that there were 159 operable petroleum refineries in the U.S. as of January 1999, of which 155 were operating and four were idle.[1] Some data reported in this profile are taken from EIA publications. Readers should keep in mind that the Census data reported for SIC code 2911 cover a somewhat broader range of facilities than do the DOE/EIA data, and the two data sources are therefore not entirely

[1] In addition, there are two operating refineries in Puerto Rico and one in the Virgin Islands.

comparable.[2]

The petroleum industry includes exploration and production of crude oil, refining, transportation and marketing. Petroleum refining is a capital-intensive production process that converts crude oil into a variety of refined products. Refineries range in complexity, depending on the types of products produced. Nearly half of all U.S. refinery output is motor gasoline.

The number of U.S. refineries has declined by almost half since the early 1980s. The remaining refineries have improved their efficiency and flexibility to process heavier crude oils, by adding "downstream" capacity.[3] While the number of refineries has declined, the average refinery capacity and utilization has increased, resulting in an increase in domestic refinery production overall.

a. Output

Nominal ***value of shipments*** and ***value added*** for petroleum refineries increased by 33 and 26 percent, respectively, from 1988 to 1996.[4] Adjusted for changes in petroleum product prices, real value of shipments was fairly constant over this period, despite a decline in the number of operating refineries (see Figure 4C-1).

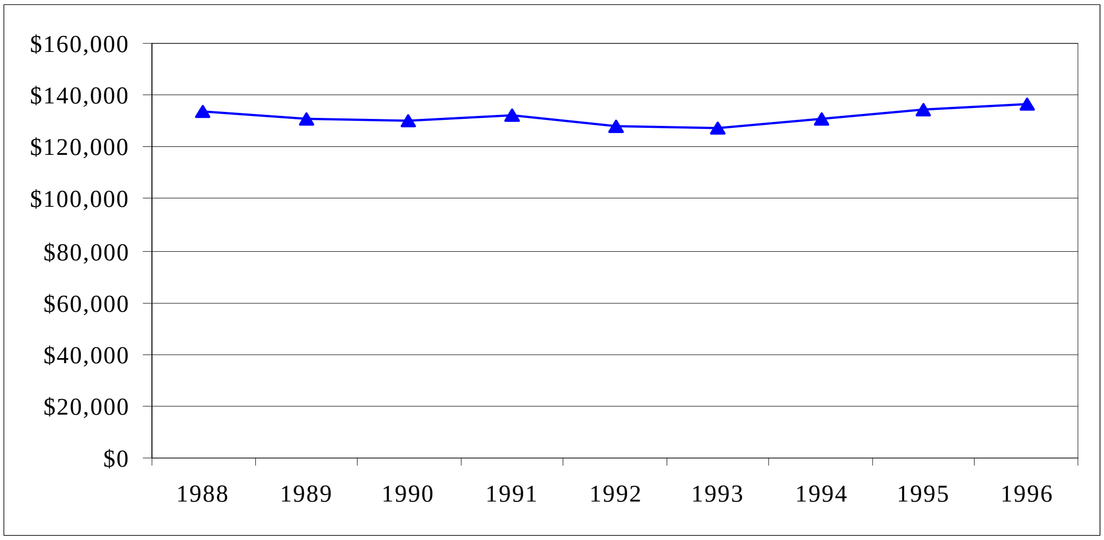
[2] For comparison, preliminary 1997 Census data included 244 establishments for NAICS 3241/SIC 2911, whereas DOE/EIA reported 164 operable refineries as of January 1997.

[3] The first step in refining is atmospheric distillation, which uses heat to separate various hydrocarbon components in crude oil. Beyond this basic step are more complex units (generally referred to as "downstream" from the initial distillation) that increase the refinery's capacity to produce a wide range of crude oils and increase the yield of lighter (low-boiling point) products such as gasoline. These downstream operations include vacuum distillation, cracking units, reforming units and other processes (U.S. Department of Energy, 1999a).

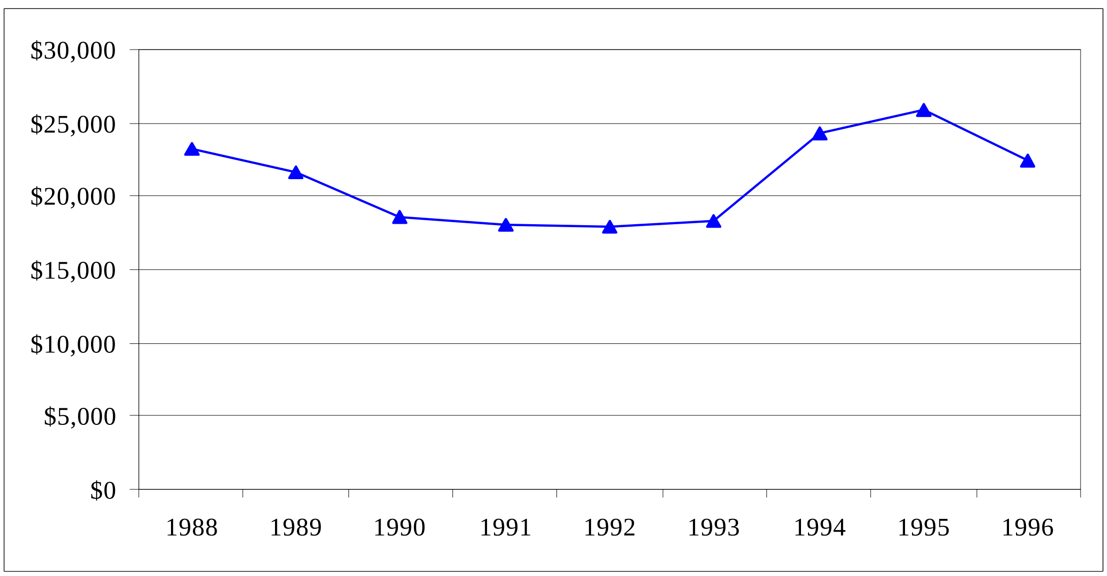
[4] Terms highlighted in bold and italic font are further explained in the glossary.

Figure 4C-1: Value of Shipments and Value Added for Petroleum Refineries ($1999 million)

Value of Shipments ($1999 million)



Value Added ($1999 millions)



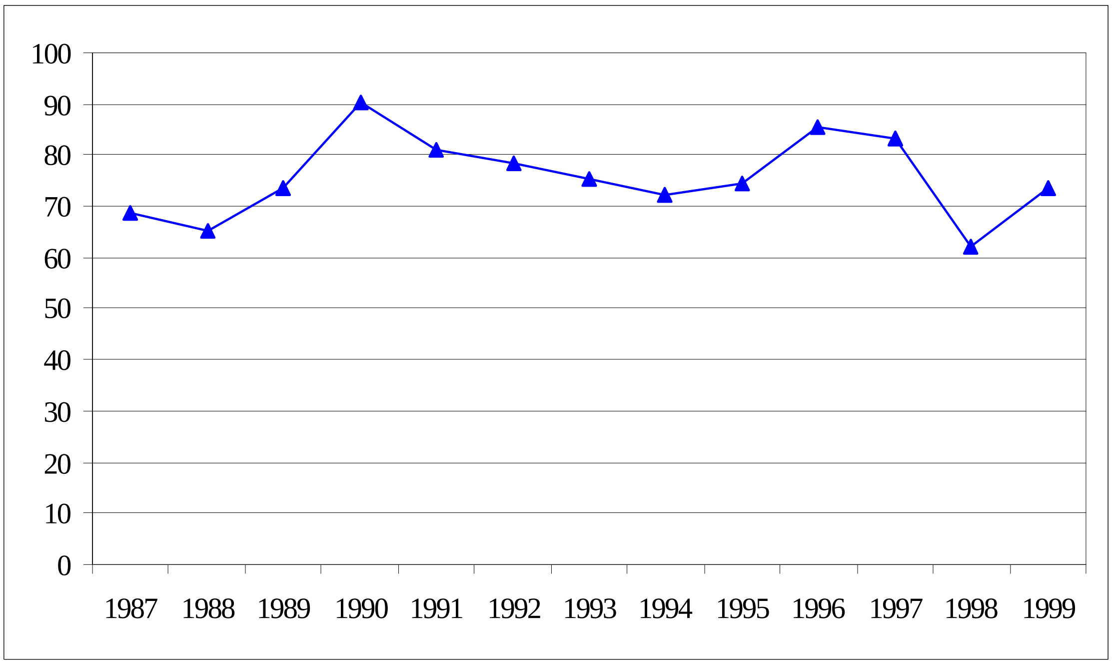
Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures

b. Prices

Figure 4C-2 shows the ***producer price index*** (PPI) for the Petroleum Refinery sector. The PPI is a family of indexes that measure price changes from the perspective of the seller. This profile uses the PPI to inflate nominal monetary values to constant dollars.

The PPI for refined petroleum products showed substantial fluctuations in petroleum product prices between 1988 and 1999, as shown in Figure 4C-2.

Figure 4C-2: Producer Price Index for Petroleum Refineries

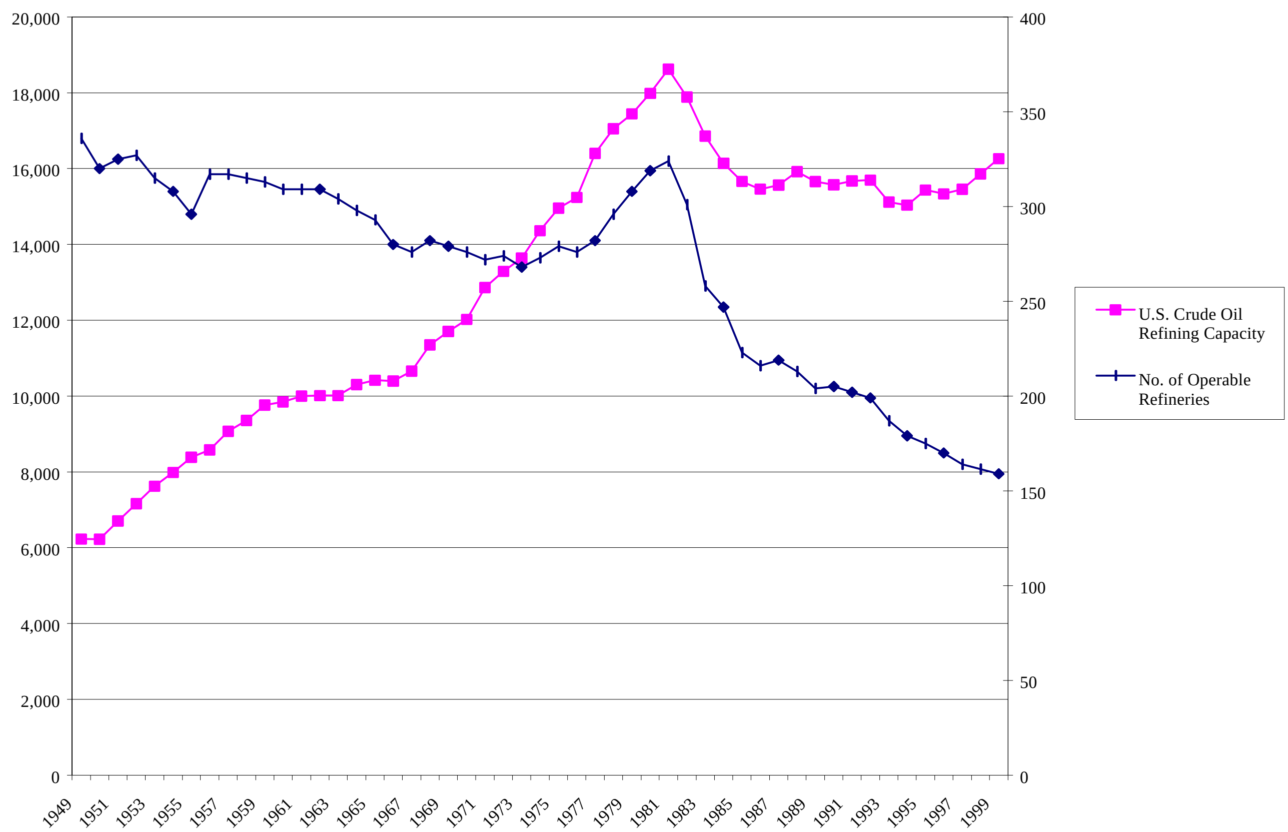


Source: Bureau of Labor Statistics, Producer Price Index.

c. Number of Facilities and Firms

Figure 4C-3 shows historical trends in the numbers of refineries and refinery capacity. This figure shows that the number of operable refineries fell substantially between 1980 and 1999. This decrease resulted in part from the elimination of the Crude Oil Entitlements Program in the early 1980s. The Entitlements Program encouraged smaller refineries to add capacity throughout the 1970s. After the program was eliminated, surplus capacity and falling profit margins led to the closure of the least efficient capacity (U.S. Department of Energy, 1999a).

Figure 4C-3: Trends in Numbers of Refineries and Refining Capacity



† Capacity data were not compiled in 1998. Estimates shown here for that date are the average of the 1997 and 1999 values.

Source: U.S. Department of Energy, Energy Information Administration, Petroleum Supply Annual, various years.

Data from the Statistics of U.S. Businesses for SIC 2911 (Table 4C-2) shows that the number of firms reporting petroleum refining as their primary business has also declined overall since 1990.

Table 4C-2: Number of Firms and Facilities for Petroleum Refineries

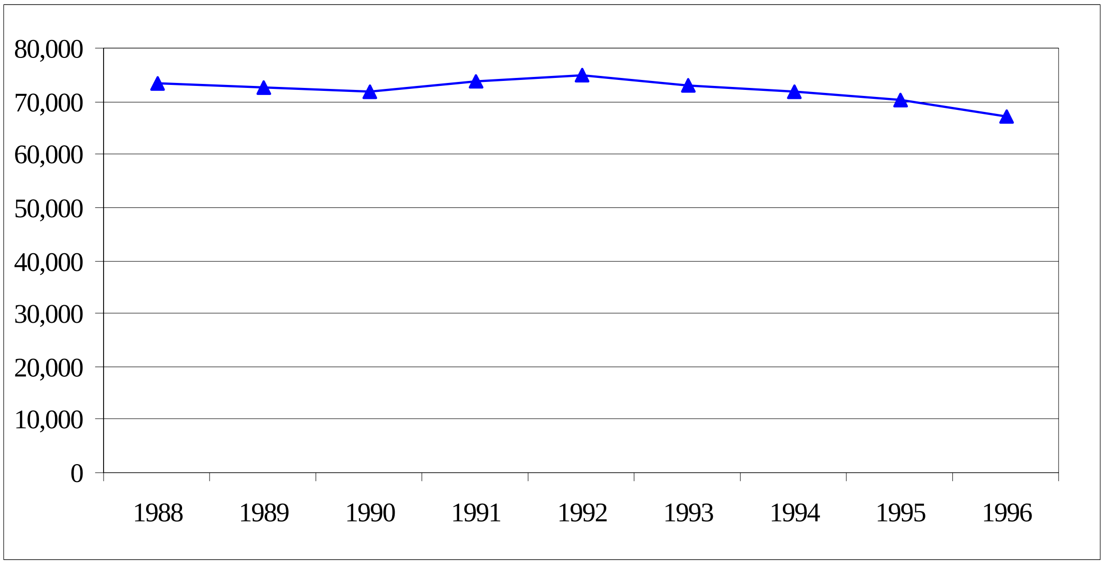
Year	Firms		Facilities	
	Number	Percent Change	Number	Percent Change
1990	215	n/a	340	n/a
1991	215	0%	346	2%
1992	185	-14%	303	-12%
1993	148	-20%	251	-17%
1994	161	9%	265	6%
1995	150	-7%	251	-5%
1996	173	15%	275	10%
Percent Change 1990 - 1997		-20%		-19%

Source: Small Business Administration, Statistics of U.S. Businesses.

d. Employment and Productivity

Employment levels in the petroleum refining industry declined by 8.2 percent between 1988 and 1996, to 67,200 employees, as shown in Figure 4C-4. After increasing in the early 1990s, employment at petroleum refineries has declined since 1992, reflecting overall industry consolidation.

Figure 4C-4: Employment for Petroleum Refineries



Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

Production hours have remained stable between 1988 and 1996. There has been no change in total production hours, and a net reduction of 3 percent in real value added per production hour over the same period (see Table 4C-3).

Table 4C-3: Productivity Trends for Petroleum Refineries

Year	Production Hours (mill.)	Value Added ($1999, millions)	Real Value Added/Hour ($ 1999)	Growth Rates		
				Production Hours	Value Added	Real Value Added/Hour
1988	16,020	114	226	n/a	n/a	n/a
1989	16,291	109	206	1.9%	-7.3%	-9.1%
1990	17,880	115	176	1.0%	-13.6%	-14.4%
1991	17,366	121	168	0.9%	-3.4%	-4.3%
1992	18,643	120	165	1.9%	-0.3%	-2.1%
1993	17,811	108	171	-1.8%	2.0%	3.9%
1994	16,703	101	221	2.8%	32.5%	28.9%
1995	16,561	100	242	-2.7%	6.9%	9.9%
1996	15,774	97	218	-3.7%	-13.5%	-10.1%
1988-1997 Growth Rate				0.0%	-3.6%	-3.6%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

e. Capital Expenditures

Petroleum industry capital expenditures increased substantially between 1988 and 1996 in real terms: in 1996 the industry spent $4.5 billion in constant 1999 dollars, as compared with $2.6 billion (1999$) in 1988. Environmentally-related investments have accounted for a substantial portion of these capital expenditures. Figure 4C-5 shows pollution control expenditures reported by American Petroleum Institute (API) members (in current dollars). Expenditures to control current environmental releases (air, water and waste) account for the largest portion of total pollution control expenditures. Of the total 1996 expenditures, approximately 3.8 billion (72 percent) was related to control of air emissions from refineries.

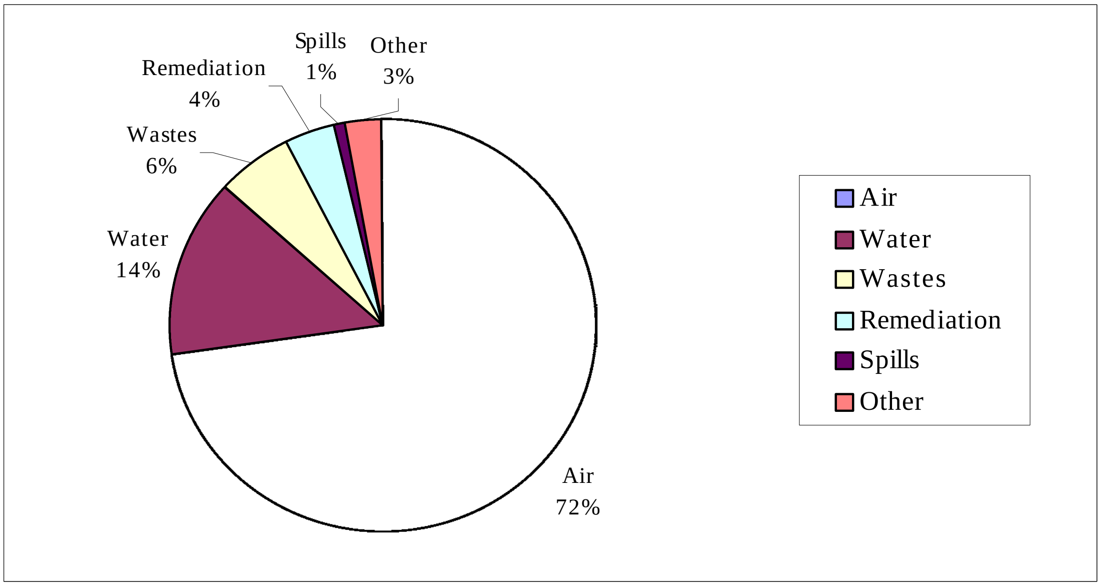
Table 4C-4: Capital Expenditures for Petroleum Refineries

Year	Capital Expenditures ($1999 millions)
1988	2,618
1989	2,987
1990	3,119
1991	5,095
1992	5,771
1993	5,858
1994	5,631
1995	5,805
1996	4,484

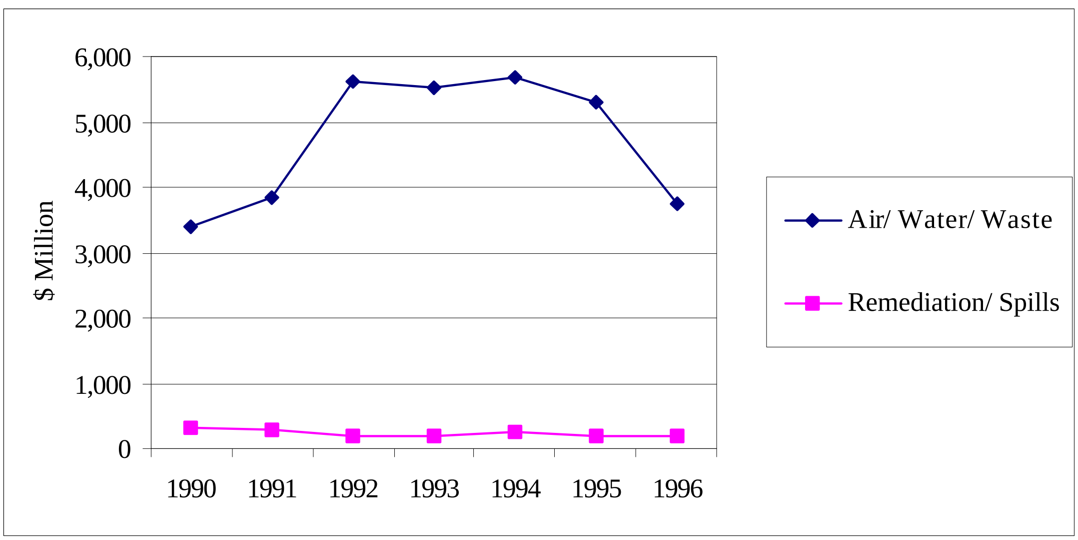
Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures

Figure 4C-5: Environmental Expenditures by Type and Medium for Petroleum Refineries

By Type, 1966



By Medium



Source: American Petroleum Institute, STEP Report.

f. Capacity Utilization

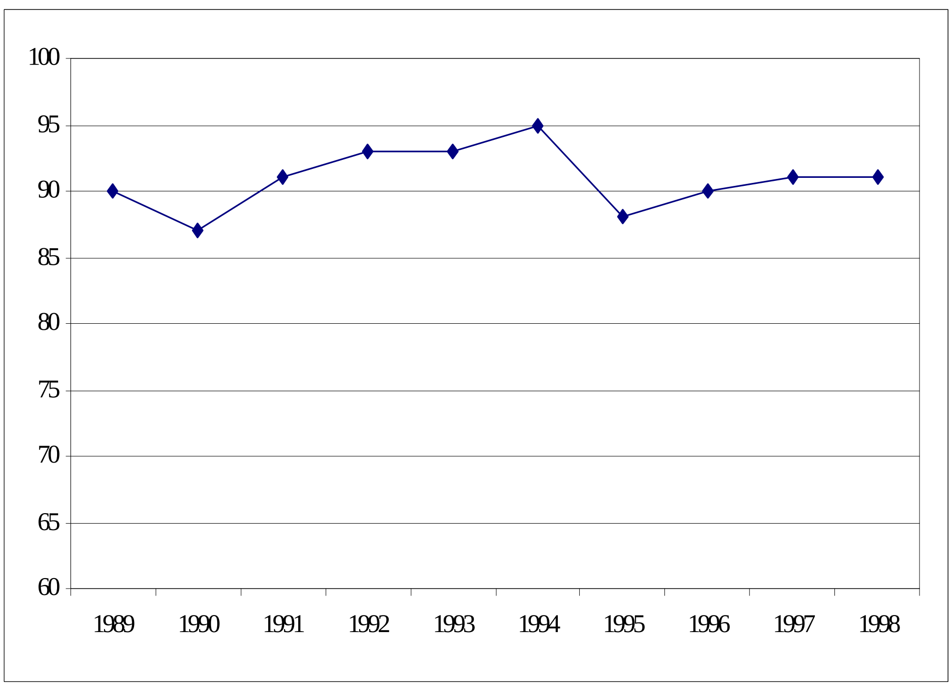
The most commonly-used measure of refinery capacity is expressed in terms of crude oil distillation capacity. EIA defines refinery capacity utilization as input divided by calendar day capacity. Calendar day capacity is the maximum amount of crude oil input that can be processed during a 24-hour period with certain limitations. Some downstream refinery capacities are measured in terms of "stream days", which is the amount a unit can process running full capacity under optimal crude and product mix conditions for 24 hours (U.S. DOE, 1999a). Downstream capacities are reported only for specific units or products, and are not summed across products, since not all products could be produced at the reported levels simultaneously.

Much recent investment in petroleum refineries has been to expand and de-bottleneck units downstream from distillation, partially in response to environmental requirements. Changes in refinery configurations have included adding catalytic cracking units, installing additional sulfur removal hydrotreaters, and using manufacturing additives such as oxygenates. These process changes have resulted from two factors:

- processing of heavier crudes with higher levels of sulfur and metals; and
- regulations requiring gasoline reformulation to reduce volatiles in gasoline and production of diesel fuels with reduced sulfur content (EPA/OSW 1996).

Figure 4C-6 below shows the increase in overall capacity utilization in the petroleum industry from 1987 to 1998, as reported by the Census Bureau. Figure 4C-6 shows that overall refinery utilization has remained high over this period. Utilization of specific portions of refinery capacities may vary, however, as the industry adjusts to changes in the desired product mix and characteristics.

Figure 4C-6: Capacity Utilization Index for Petroleum Refineries



Source: Department of Commerce, Bureau of the Census, Current Industrial Reports, Survey of Plant Capacity.

4C.2 Structure and Competitiveness of the Petroleum Industry

The petroleum refining industry in the United States is made up of integrated international oil companies, integrated domestic oil companies, and independent domestic refining/marketing companies. In general, the petroleum industry is highly integrated, with many firms involved in more than one sector. Large companies referred to as the "majors" are fully integrated across crude oil exploration and production, refining, and marketing. Smaller, nonintegrated companies referred to as the "independents" generally specialize in one sector of the industry.

Like the oil business in general, refining has been dominated in the 1990s by integrated internationals, specifically a few large companies such as Exxon Corporation, Mobil Corporation[5], and Chevron Corporation – all of which ranked in the top ten of Fortune's 500 sales ranking.

Substantial diversification by major petroleum companies into other energy and non-energy sectors was financed by high oil prices in the 1970s and 1980s. With lower profitability in the 1990s, the major producers began to exit nonconventional energy operations (e.g., oil shale) as well as coal and non-energy operations in the 1990s. Some have recently ceased chemical production.

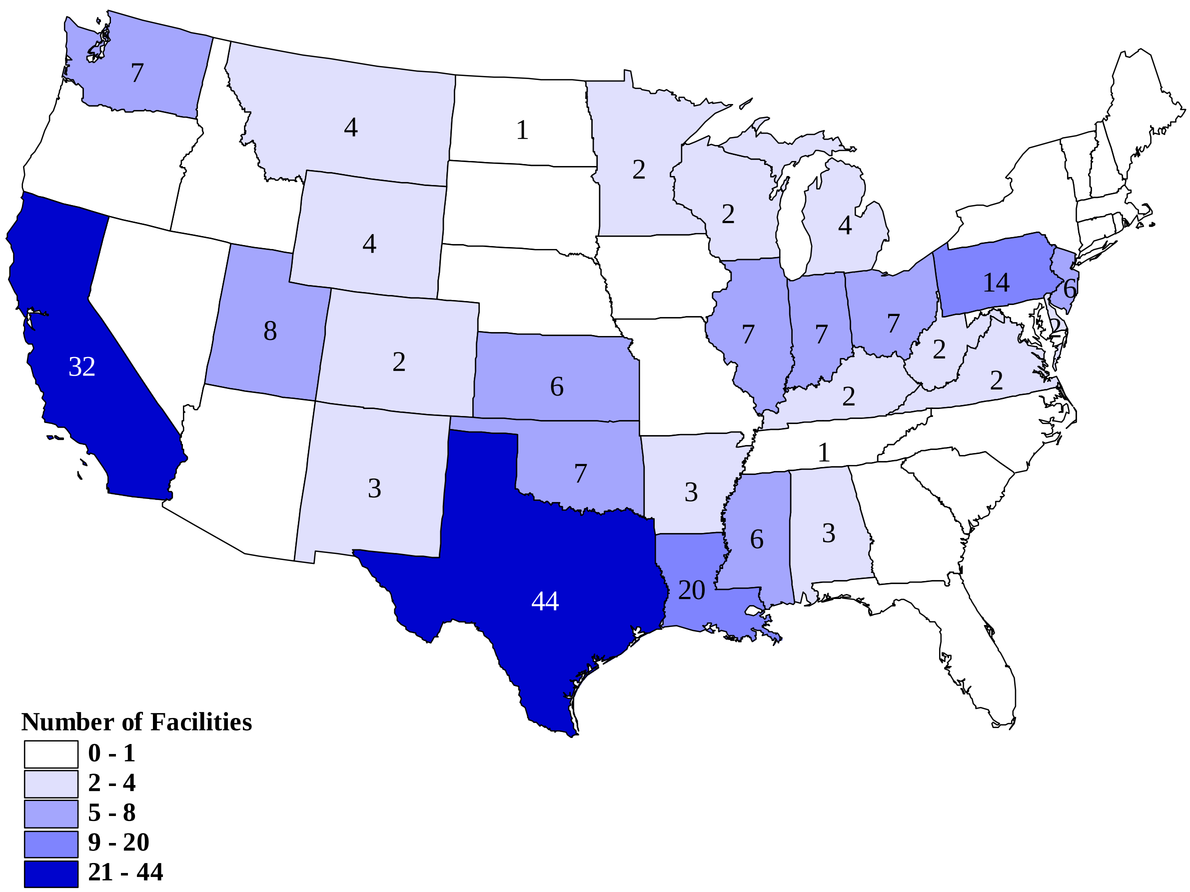
During the 1990s, several mergers, acquisitions, and joint ventures occurred in the petroleum refining industry in an effort to cut cost and increase profitability. This consolidation has taken place among the largest firms (as illustrated by the acquisition of Amoco Corporation by the British Petroleum and the mega-merger of Exxon and Mobil Corporation) as well as among independent refiners and marketers (e.g., the independent refiner/marketer Ultramar Diamond Shamrock (UDS) acquired Total Petroleum North America in 1997) (U.S. DOE, 1999b). BP Amoco recently announced a deal to sell its 250,000 barrel per day Alliance refinery in Louisiana to the leading U.S. independent refining and marketing company Tosco Corp.

[5] Exxon and Mobil Corporations have recently merged into one company.

a. Geographic Distribution

Petroleum refining facilities are concentrated in areas near crude oil sources and near consumers. The cost of transporting crude oil feed stocks and finished products is an important influence on the location of refineries. Most petroleum refineries are located along the Gulf Coast and near the heavily industrialized areas of both the east and west coasts (U.S. DOE, 1997b). Figure 4C-7 below shows the distribution of U.S. petroleum refineries. In 1992, there were 44 refineries in Texas, 32 in California, and 20 in Louisiana, accounting for 43 percent of all facilities in SIC code 2911 in the United States.

Figure 4C-7: Geographic Distribution of Petroleum Refineries



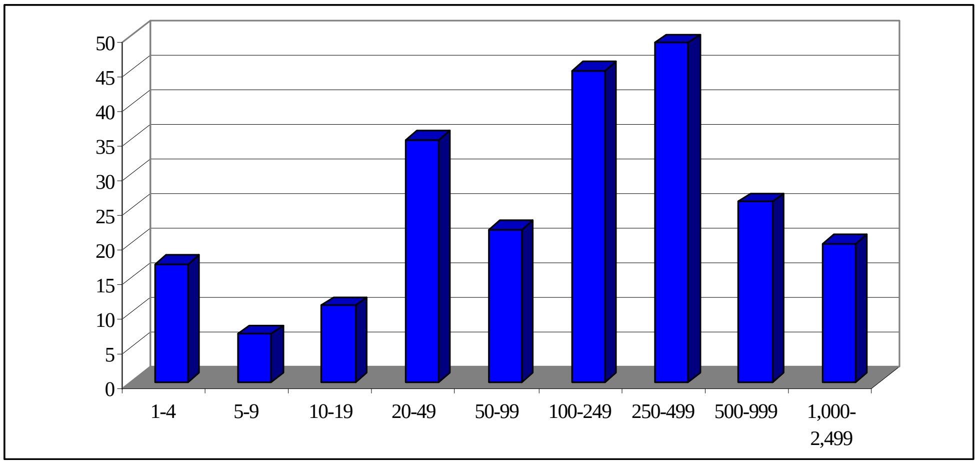
Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

b. Establishment Size

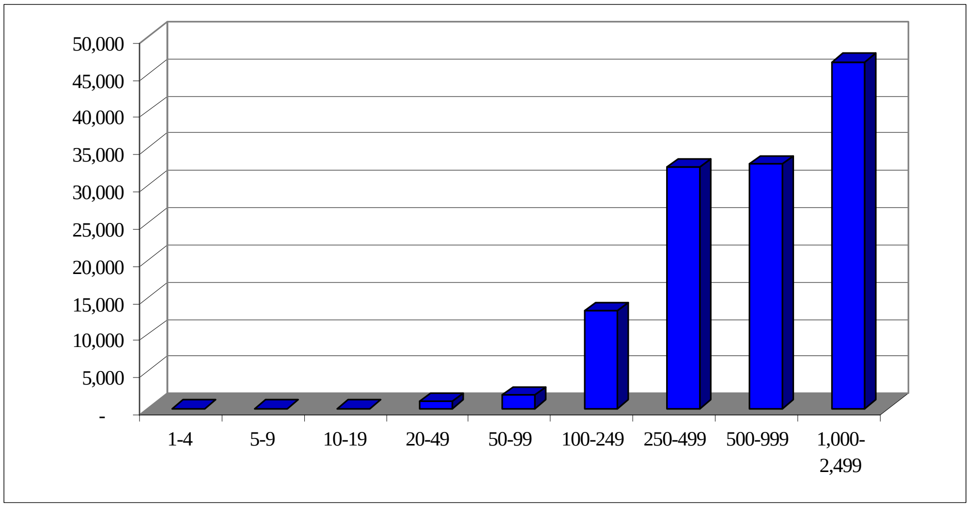
A substantial portion of the facilities in SIC code 2911 are large facilities, with 41 percent having 250 or more employees. Figure 4C-8 shows that approximately 87 percent of the value of shipments for the industry is produced by the 41 percent of establishments with more than 250 employees. Establishments with more than 1,000 employees are responsible for approximately 36 percent of all industry shipments.

Figure 4C-8: Value of Shipments and Number of Facilities for Petroleum Refineries by Employment Size Category

Number of Facilities



1992 Value of Shipments ($1999, millions)



Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

c. Firm Size

The Small Business Administration defines a small firm for SIC code 2911 as a firm with 1,500 or fewer employees. The size categories reported in the Statistics of U.S. Businesses (SUSB) do not correspond with the SBA size classifications. It is therefore not possible to apply the SBA size threshold precisely. Table 4C-5 below shows the distribution of firms, establishments, and receipts in SIC code 2911 by the employment size of the parent firm. The SUSB data show that 122 of the 275 SIC 2911 establishments reported for 1996 (44 percent) are owned by very large firms (those with 2,500 employees or more), 127 (46 percent) are owned by small firms (those with fewer than 500 employees), and 26 establishments (9 percent) are owned by firms that are of unknown size but that are not very small (those with between 500 and 2,499 employees).

Table 4C-5: Number of Firms, Establishments, and Estimated Receipts for Petroleum Refineries by Firm Employment Size Category (1996)

Employment Size Category	Number of Firms	Number of Establishments	Estimated Receipts ($1999 millions)
0-19	66	67	300
20-99	23	24	1,019
100-499	29	36	6,065
500-2499	15	26	9,928
2500+	40	122	108,495
Total	173	275	125,808

Source: Small Business Administration, Statistics of U.S. Businesses.

d. Concentration and Specialization Ratios

Concentration is the degree to which industry output is concentrated in a few large firms. Concentration is closely related to entry and exit barriers with more concentrated industries generally having higher barriers.

The four-firm ***concentration ratio*** (CR4) and the ***Herfindahl-Hirschman Index*** (HHI) are common measures of industry concentration. The CR4 indicates the market share of the four largest firms. For example, a CR4 of 72 percent means that the four largest firms in the industry account for 72 percent of the industry's total value of shipments. The higher the concentration ratio, the less competition there is in the industry, other things being equal.[6] An industry with a CR4 of more than 50 percent is generally considered concentrated. The HHI indicates concentration based on the largest 50 firms in the industry. It is equal to the sum of the squares of the market shares for the largest 50 firms in the industry. For example, if an industry consists of only three firms with market shares of 60, 30, and 10 percent, respectively, the HHI of this industry would be equal to 4,600 ($60^2 + 30^2 + 10^2$). The higher the index, the fewer the number of firms supplying the industry and the more concentrated the industry. An industry is considered concentrated if the HHI exceeds 1,000.

The petroleum industry is considered competitive, based on C4 and the HHI. The CR4 and the HHI for SIC code 2911 are both below the benchmarks of 50 percent and 1,000, respectively.

The ***specialization ratio*** is the percentage of the industry's production accounted for by primary product shipments. The ***coverage ratio*** is the percentage of the

[6] Note that the measured concentration ratio and the HHF are very sensitive to how the industry is defined. An industry with a high concentration in domestic production may nonetheless be subject to significant competitive pressures if it competes with foreign producers or if it competes with products produced by other industries (e.g., plastics vs. aluminum in beverage containers). Concentration ratios are therefore only one indicator of the extent of competition in an industry.

industry's product shipments coming from facilities from the same primary industry. The coverage ratio provides an indication of how much of the production/product of interest is captured by the facilities classified in an SIC code. The specialization and coverage ratios presented in Table 4C-6 show a very high degree of specialization by petroleum refineries in 1987 and 1992: 99 percent of the value of shipments from SIC code 2911 establishments were classified as SIC code 2911 petroleum products. In addition, SIC code 2911 establishments accounted for 99 percent of the value of all petroleum products shipped domestically.

Table 4C-6: Selected Ratios for Petroleum Refineries

SIC Code	Year	Total Number of Firms	Concentration Ratios					Specialization Ratio	Coverage Ratio
			4 Firm (CR4)	8 Firm (CR8)	20 Firm (CR20)	50 Firm (CR50)	Herfindahl-Hirschman Index		
2911	1987	200	32%	52%	78%	95%	435	99%	99%
	1992	132	30%	49%	78%	97%	414	99%	99%

Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

e. Foreign Trade

The United States consumes more petroleum than it produces, requiring net imports of both crude oil and products to meet domestic demand. In 1997, the U.S. imported 8.23 million barrels per day (MBD) of crude oil, or 56 percent of the total crude oil supply of 14.77 MBD, and imported 1.94 MBD of refined products. These refined product imports represented ten percent of the 18.62 MBD of refined products supplied to U.S. consumers. The U.S. exported 0.9 MBD of refined products in 1997.

Imports of refined petroleum products have fluctuated since 1985. Imports rose to 2.3 MB in the early 1980s, due to rapid growth in oil consumption, especially consumption of light products, which exceeded the growth in U.S. refining capacity. Imports then declined as a result of the 1990/91 recession and a surge in upgrading of refinery capacity resulting primarily from Clean Air Act Amendment and other environmental requirements (U.S. DOE, 1997b). Imports are now increasing and are expected to continue growing through 2002.

Until the early 1980s, petroleum product exports consisted primarily of petroleum coke, because trade in most other products was restricted by allowances. Export license requirements for various petroleum products imposed in 1973 were eliminated in the late 1981, however, and exports of other products began to grow. Petroleum exports continue to include heavy products such as residual fuel oil and petroleum coke, which are produced as co-products with motor gasoline and other light products. Production of these heavier products often exceeds U.S. demand, and foreign demand absorbs the excess. Petroleum coke is the leading petroleum export product, accounting for 30 percent of petroleum exports in 1997, followed by distillate fuel oil (15 percent of exports) and motor gasoline (almost 14 percent) (U.S. DOE, 1997a). Exports generally reflect foreign demand, but other factors influence exports as well. For example, exports of motor gasoline increased due to high prices in Europe at the time of the 1990 Persian Gulf crisis. U.S. refiners and marketers have gained experience in marketing to diverse world markets, and U.S. products are now sold widely abroad (U.S. DOE, 1997b). The real value of petroleum exports fluctuated during the years 1989 to 1996, as reported by the International Trade Administration, with an overall increase of approximately 23 percent over the entire period (see Table 4C-7).

Table 4C-7: Foreign Trade Statistics for Petroleum Refineries

Year	Value of imports ($1999 millions)	Value of exports ($1999 millions)	Value of Shipments ($1999 millions)	Implied Domestic Consumption[1]	Import Penetration[2]	Export Dependence[3]
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1989	11,798	4,318	131,192	138,672	9%	3%
1990	11,656	4,891	130,218	136,983	9%	4%
1991	9,907	5,782	132,272	136,397	7%	4%
1992	9,574	5,413	128,061	132,222	7%	4%
1993	9,535	5,521	127,196	131,210	7%	4%
1994	9,454	5,054	131,182	135,581	7%	4%
1995	8,659	5,269	134,380	137,771	6%	4%
1996	15,971	5,436	136,387	146,922	11%	4%
Average Annual Growth Rate	*4%*	*3%*	*1%*	*1%*	*3%*	*4%*

[1] Implied domestic consumption based on value of shipments, imports, and exports [column d + column b - column c].
[2] Import penetration based on implied domestic consumption and imports [column b / column e].
[3] Export dependence based on value of shipments and exports [column c / column d].

Source: Department of Commerce, International Trade Administration, Outlook Trends Tables.

4C.3 Financial Condition and Performance

Refiners' profitability depends on the spread between product prices and crude oil and other input prices (the gross refining margin), investment costs, and operating costs. Operating costs in turn reflect facility configurations (complexity), scale and efficiency, the mix of high-end versus low-end products produced, and location. Refinery yields vary with refinery configuration, operating practices, and crude oil characteristics. Revenues earned from a barrel of crude depend on the prices of different products, the mix of products produced, and the refinery yield for each product. Relatively small swings in the price of gasoline (which represents the largest product output) and the price of crude oil can cause large changes in cash margins and refinery profits.

Returns on investments to produce higher quality products from a given mix of crude oil (or to produce a given product mix from heavier crude oil) depend on the differentials between high and low quality crude. Price discounts for low quality crude have not always been enough to earn competitive returns on investments in extra coking and sulfur removal capacity.

Throughout the 1990s, the U.S. refining and marketing industry was characterized by unusually low product margins, low profitability, and substantial restructuring. These low profit margins were the result of three different factors: (1) increases in operating costs as a result of governmental regulations; (2) expensive upgrading of processing units to accommodate lower-quality crude oils;[7] and (3) upgrading of operations to adapt to changes in demand for refinery products.[8] A combination of higher cost as a result of these three trends and lower product prices as a result of competitive pressures has led to lower profits (American Petroleum Institute, 1999).

In the late 1990s, the U.S. majors aggressively pursued cost-

[7] Crude oils processed by U.S. refineries have become heavier and more contaminated with materials such as sulfur. This trend reflects reduced U.S. dependence on the more expensive high gravity ("light"), low sulfur ("sweet") crude oils produced in the Middle East and greater reliance on crude oil from Latin America (especially Mexico and Venezuela), which is relatively heavy and contains higher sulfur ("sour") (U.S. DOE, 1999a).

[8] Demand for lighter products such as gasoline and diesel fuel has increased, and demand for heavier products has decreased.

cutting throughout their operations (Rodekohr, 1999). There were improvements in both gross and net margins.[9] Reductions in costs resulted from:

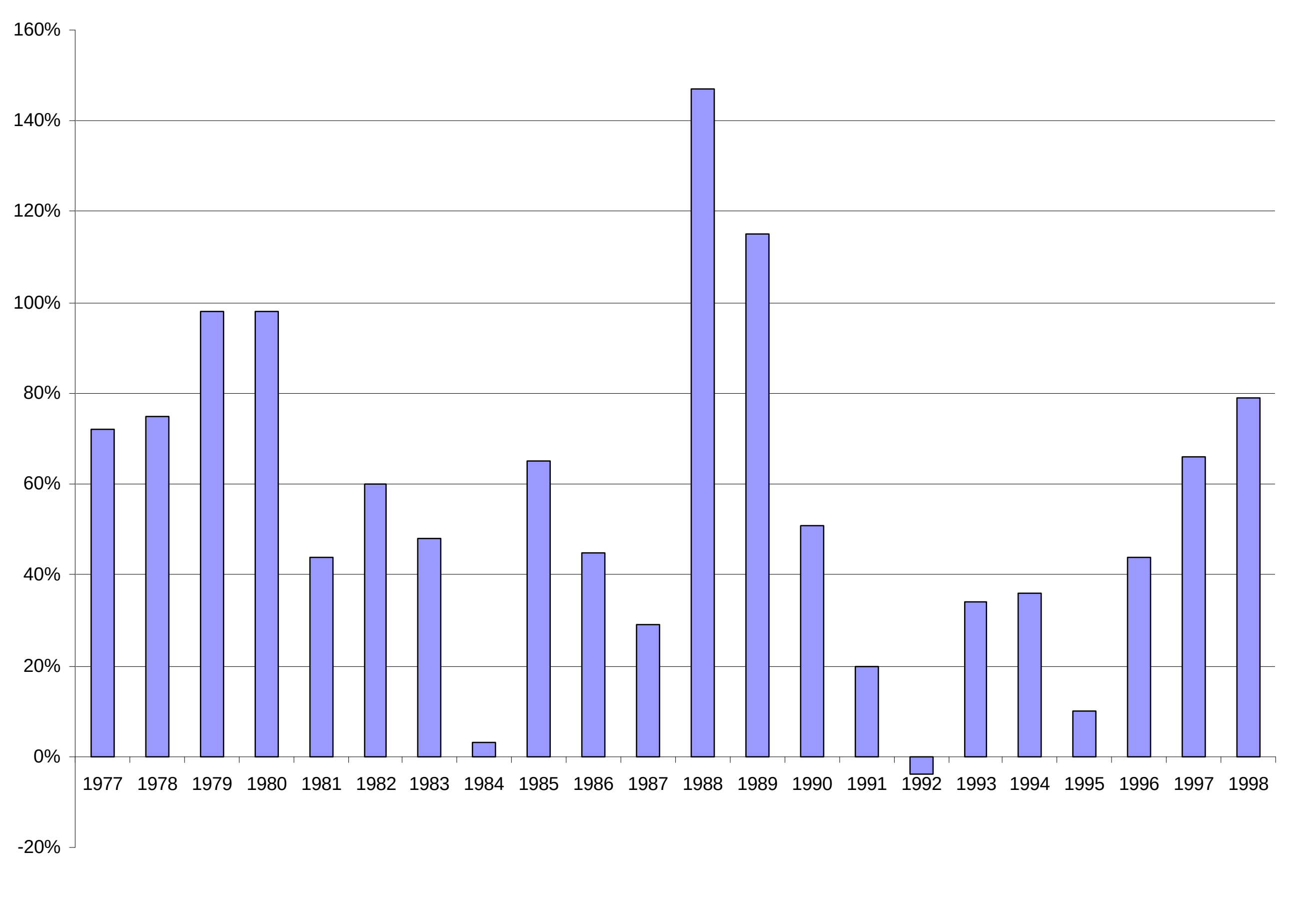
- divesting marginal refineries and gasoline outlets;
- divesting less profitable activities (e.g., gasoline credit cards);
- reducing corporate overhead costs, including eliminating redundancies through restructuring;
- outsourcing some administrative activities; and
- use of new technologies requiring less labor.

Financial performance again declined in 1998, due to low prices and high inventories resulting from reduced worldwide oil demand. Figure 4C-9 shows the substantial fluctuation in return on investment from 1977 through 1996, including the relatively low returns in the early 1990s.[10]

[9] Gross margin is revenues per refined product barrel less raw materials cost (i.e., average product price minus average crude oil cost). Net margin is gross margin minus operating costs (all out-of-pocket refining and retailing expenses such as energy costs and marketing costs.)

[10] The Financial Reporting System (FRS) is described in U.S. DOE, 1997a. Quarterly financial results are collected for a group of specialized refiner/marketers and major integrated petroleum companies. Data are reported separately for their U.S. refining/marketing lines of business. Companies drop in and out of the survey as a result of acquisitions and mergers. Data include only the U.S. operations for foreign affiliates (BP American, Fina, Shell Oil) but worldwide operations for U.S.-based companies. The surveyed companies account for approximately 80 percent of total U.S. companies' worldwide investment in petroleum and natural gas, and approximately 25 percent of worldwide refining capacity (excluding State Energy Companies) (Rodekohr, 1999).

Figure 4C-9: U.S. Petroleum and Natural Gas Refining and Marketing, Return on Investment 1977 - 1996



Source: U.S. DOE, Financial Reporting System (FRS) historical data.

Table 4C-8 below shows trends in estimated operating margins for the petroleum refining industry, based on Census data for SIC code 2911. Margins decreased two percent overall between 1988 and 1996, from 15.6 percent to 13.6 percent. Throughout this period, margins fluctuated, but not sharply.

Table 4C-8: Operating Margins for Petroleum Refineries

Year	Value of Shipments	Cost of Materials	Payroll (all employees)	Operating Margin
1988	$133,729	$109,523	$3,296	15.6%
1989	$131,192	$110,522	$2,984	13.5%
1990	$130,218	$113,167	$2,610	11.1%
1991	$132,272	$112,735	$3,137	12.4%
1992	$128,061	$109,891	$3,418	11.5%
1993	$127,196	$107,933	$3,656	12.3%
1994	$131,182	$107,547	$3,884	15.1%
1995	$134,380	$108,785	$3,750	16.3%
1996	$136,387	$114,654	$3,225	13.6%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

4C.4 Facilities Operating Cooling Water Intake Structures

In 1982, the Petroleum and Coal Products industry (SIC 29) withdrew 590 billion gallons of cooling water, accounting for approximately 0.8 percent of total industrial cooling water intake in the United States. The industry ranked 4th in industrial cooling water use, behind the electric power generation industry, and the chemical and primary metals industries (1982 Census of Manufactures).

This section presents information from EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* on existing facilities with the following characteristics:

- they withdraw from the waters of the United States;
- they hold an NPDES permit;
- they have an intake flow of more than two MGD;
- they use at least 25 percent of that flow for cooling purposes.

These facilities are not "new facilities" as defined by the proposed §316(b) New Facility Rule and are therefore not subject to this regulation. However, they meet the criteria of the proposed rule except that they are already in operation. These existing facilities therefore provide a good indication of what new facilities in these sectors may look like. The remainder of this section refers to existing facilities with the above characteristics as "§316(b) facilities."

a. Cooling Water Uses and Systems

Information collected in the Screener Questionnaire found that an estimated 28 out 163 facilities, or 17 percent, meet the characteristics of a §316(b) facility. Ninety-six percent of these facilities use cooling water for production line (or process) contact or noncontact cooling. Approximately 39 and 31 percent of the §316(b) facilities also reported use of cooling water in electricity generation and air conditioning, respectively.

Table 4C-9 shows the distribution of existing §316(b) petroleum refineries by type of water body and cooling system. Thirteen facilities, or 46 percent, obtain their cooling water from either a freshwater stream or river. Thirty-nine percent of refineries obtain their cooling water from either an estuary or a tidal river. The other two sources of cooling water reported for petroleum refineries were oceans and lakes/reservoirs, accounting for approximately seven percent each.

The most common cooling water system used by petroleum refineries is a once-through cooling system, representing approximately 47 percent of all systems used by refineries. Thirty-four percent of all refineries use a closed cycle cooling system. The remaining 18 percent use a combination cooling system. Most §316(b) refineries are located on either an estuary tidal river (11 facilities) or a freshwater river/stream (13 facilities).

Table 4C-9: Number of Petroleum Refining Facilities by Water Body Type and Cooling System Type

Water Body Type	Cooling System						Total
	Closed Cycle		Once Through		Combination		
	Number	% of Total	Number	% of Total	Number	% of Total	
Estuary or Tidal River	2	20%	7	60%	2	20%	11
Freshwater Stream or River	6	50%	4	34%	2	17%	13
Lake or Reservoir	1	49%	1	51%	0	0%	2
Ocean	0	0%	1	50%	1	50%	2
Total†	***10***	***34%***	***13***	***47%***	***5***	***19%***	***28***

† Individual numbers may not add up to total due to independent rounding.

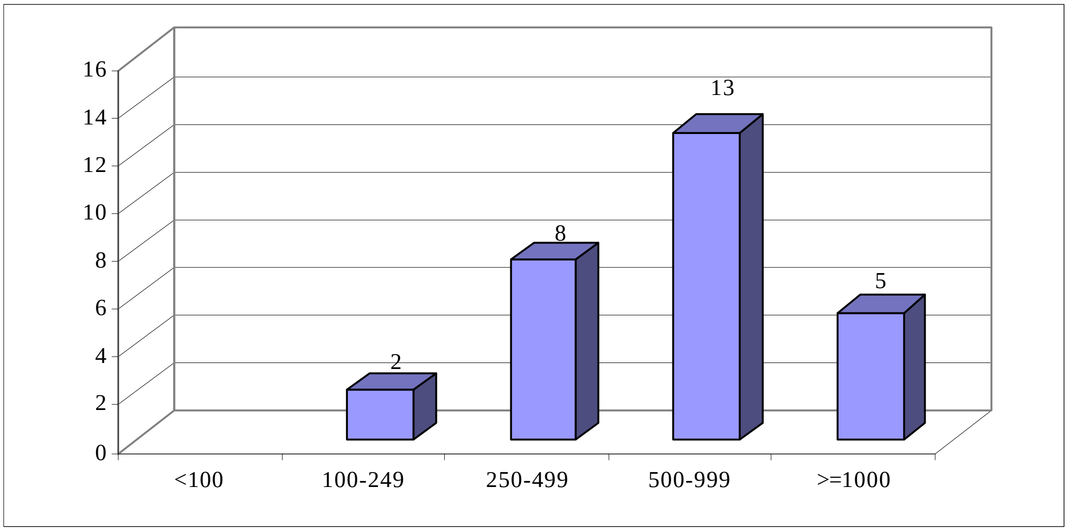
Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

According to the American Petroleum Institute and EPA, water use in the petroleum refining industry has been declining because facilities are increasing their reuse of water. These restrictions are likely to reduce §316(b)-related costs, and a complete phase out of once-through cooling water in refineries is expected (U.S. EPA, 1996).

b. Facility Size

§316(b) facilities in SIC code 2911 are somewhat larger on average than the average employment size distribution of the industry as a whole, as reported in the Census. Figure 4C-10 shows the number of §316(b) facilities by employment size category. Sixty-four percent of §316(b) refineries employ over 500 people and all employ over 100 employees.

Figure 4C-10: Number of §316(b) Petroleum Refineries by Employment Size Category



Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

c. Firm Size

EPA used the Small Business Administration (SBA) small entity thresholds to determine the number of existing §316(b) petroleum refineries owned by small firms. Firms in this industry are considered small if they employ fewer than 1,500 people. Table 4C-10 shows that 92 percent of all §316(b) petroleum refineries are owned by large firms. There are no §316(b) petroleum refining facilities that are owned by a firm known to be small, and only eight percent are owned by a firm of unknown size which might qualify as a small firm.

Table 4C-10: Number of §316(b) Petroleum Refineries by Firm Size

SIC Code	Large		Small		Unknown		Total
	No.	% of SIC	No.	% of SIC	No.	% of SIC	
2911	26	92%	0	0%	2	8%	28

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; D&B Database, 1999.

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4D STEEL (SIC 331)

EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* identified five 4-digit SIC codes in the Steel Works, Blast Furnaces, and Rolling and Finishing Mills Industries (SIC 331) with at least one existing facility that operates a CWIS, holds a NPDES permit, withdraws more than two million gallons per day (MGD) from a water of the United States, and uses at least 25 percent of its intake flow for cooling purposes (facilities with these characteristics are hereafter referred to as "§316(b) facilities"). For each of the five SIC codes, Table 4D-1 below provides a description of the industry sector, a list of primary products manufactured, the total number of screener respondents, and the number and percent of §316(b) facilities.

Table 4D-1: §316(b) Facilities in the Steel Industry (SIC 331)

SIC	SIC Description	Important Products Manufactured	Number of Screener Respondents		
			Total	§316(b) Facilities	
				No.[†]	%
Steel Mills (SIC 3312)					
3312	Steel Works, Blast Furnaces (Including Coke Ovens), and Rolling Mills	Hot metal, pig iron, and silvery pig iron from iron ore and iron and steel scrap; converting pig iron, scrap iron, and scrap steel into steel; hot-rolling iron and steel into basic shapes, such as plates, sheets, strips, rods, bars, and tubing; merchant blast furnaces and byproduct or beehive coke ovens	***158***	***38***	***24.1%***
Steel Products (SICs 3315, 3316, 3317)					
3315	Steel Wiredrawing and Steel Nails and Spikes	Drawing wire from purchased iron or steel rods, bars, or wire; further manufacture of products made from wire; steel nails and spikes from purchased materials	122	3	2.5%
3316	Cold-Rolled Steel Sheet, Strip, and Bars	Cold-rolling steel sheets and strip from purchased hot-rolled sheets; cold-drawing steel bars and steel shapes from hot-rolled steel bars; producing other cold finished steel	60	9	15.0%
3317	Steel Pipe and Tubes	Production of welded or seamless steel pipe and tubes and heavy riveted steel pipe from purchased materials	130	1	0.8%
Total Steel Products			***312***	***13***	***4.2%***
Other Sectors					
3313	Electrometallurgical Products, Except Steel	Ferro and nonferrous metal additive alloys by electrometallurgical or metallothermic processes, including high percentage ferroalloys and high percentage nonferrous additive alloys	***6***	***1***	***16.7%***
Total Steel (SIC 331)					
Total 331			**476**	**52**	**10.9%**

† Information on the percentage of intake flow used for cooling purposes was not available for all screener respondents. Facilities for which this information was not available were assumed to use at least 25% of their intake flow for cooling water purposes The reported numbers of §316(b) facilities may therefore be overstated.

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures; Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual 1987

The responses to the Screener Questionnaire indicate that two main steel sectors account for the largest numbers of §316(b) facilities: (1) Steel Mills (SIC code 3312) and (2) Steel Products (SIC codes 3315, 3316, and 3317). Of the 52 §316(b) facilities in the steel industry 38, or 73 percent, are steel mills, and 13, 25 percent, are steel products facilities. The remainder of the steel industry profile therefore focuses on these two industry sectors.

4D.1 Domestic Production

Steel is one of the dominant products in the U.S. industrial metals industry. For most of the twentieth century the U.S. steel industry consisted of a few large companies utilizing an integrated steelmaking process to produce the raw steel used in a variety of commodity steel products. The integrated process requires massive capital investment to process coal, iron ore, limestone, and other raw materials into molten iron, which is then transformed into finished steel products (S&P, 2000). In recent decades, the integrated steel industry has undergone a dramatic downsizing as a result of increased steel imports, decreased consumption by the auto industry, and the advent of minimills, small regional steelmakers producing limited products and using a less capital-intensive process (S&P, 2000).

The steel industry is the fourth largest energy-consuming sector. Energy costs account for approximately 20 percent of the total cost to manufacture steel. Steelmakers use coal, oil, electricity, and natural gas to fire furnaces and run process equipment. Minimill producers require large quantities of electricity to operate the electric arc furnaces used to melt and refine scrap metal while integrated steelmakers are dependent on coal for up to 60 percent of their total energy requirements (McGraw-Hill, 1998).

a. Output

The two most common measures of manufacturing output are ***value of shipments*** and ***value added***.[1] Historical trends provide insight into the overall economic health and outlook for an industry. Value of shipments is the sum of the receipts a manufacturer earns from the sale of its outputs. It is an indicator of the overall size of a market or the size of a firm in relation to its market or competitors. Value added is used to measure the value of production activity in a particular industry. It is the difference between the value of shipments and the value of inputs used to make the products sold.

Figure 4D-1 presents the trend in value of shipments and value added for steel mills and steel products. The steel products sector experienced a slow yet steady increase in both value of shipments and value added between 1987 and 1996. This upward trend is the result of the increasing global demand for steel due to growing automotive and construction markets and stronger economies in developing regions with substantial infrastructure needs (McGraw-Hill, 1998).

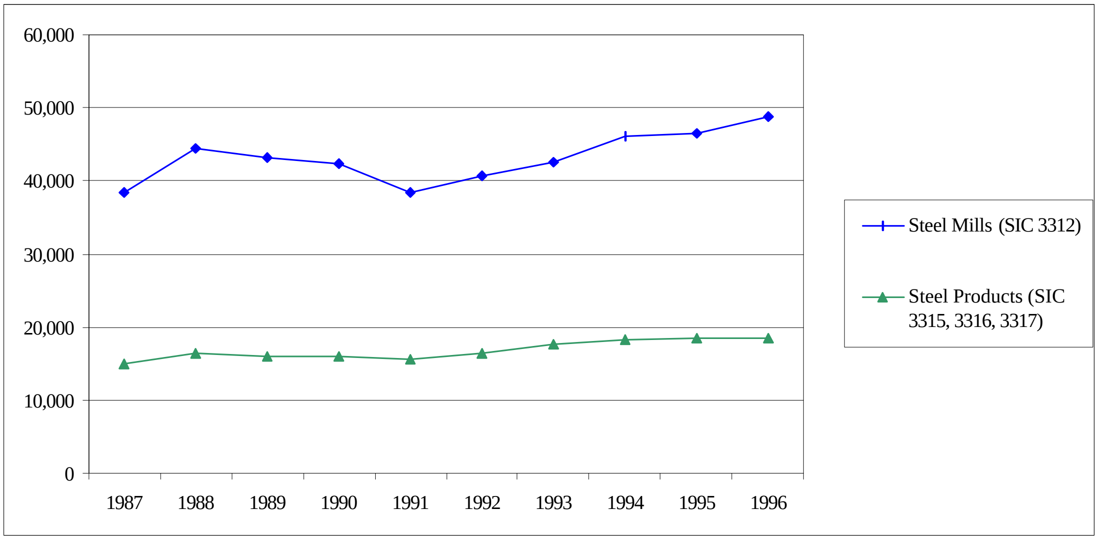
Between 1987 and 1996, value of shipments and value added for steel mills have increased by 27 and 26 percent, respectively. The most significant gains occurred after the demand for steel mill products bottomed out in the early 1990s. There is a strong link between the U.S. steel industry and the auto and construction industries and the national economy overall. The economic expansion in recent years has increased demand for steel products. Another important factor in the resurgence in the demand for steel mill products is the technological advancements that have improved the competitiveness of U.S. steel. The development of the thin slab caster/rolling mill in 1989 allowed minimills to produce flat rolled steel, which accounts for 60 percent of domestic shipments, with substantially lower capital and energy costs (McGraw-Hill, 1998).

Figure 4D-1 shows the trend in value of shipments and value added for the two profiled steel sectors between 1987 and 1996.

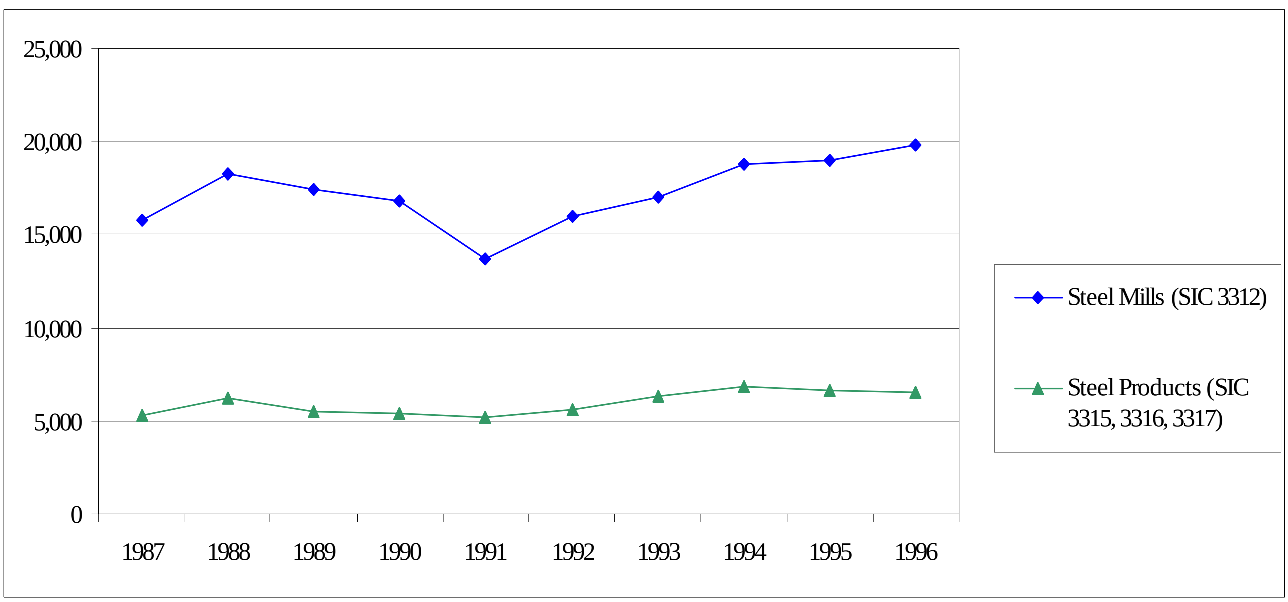
[1] Terms highlighted in bold and italic font are further explained in the glossary.

Figure 4D-1: Real Value of Shipments and Value Added for Profiled Steel Industry Sectors ($1999 million)

Value of Shipments ($1999 millions)



Value Added ($1999 millions)



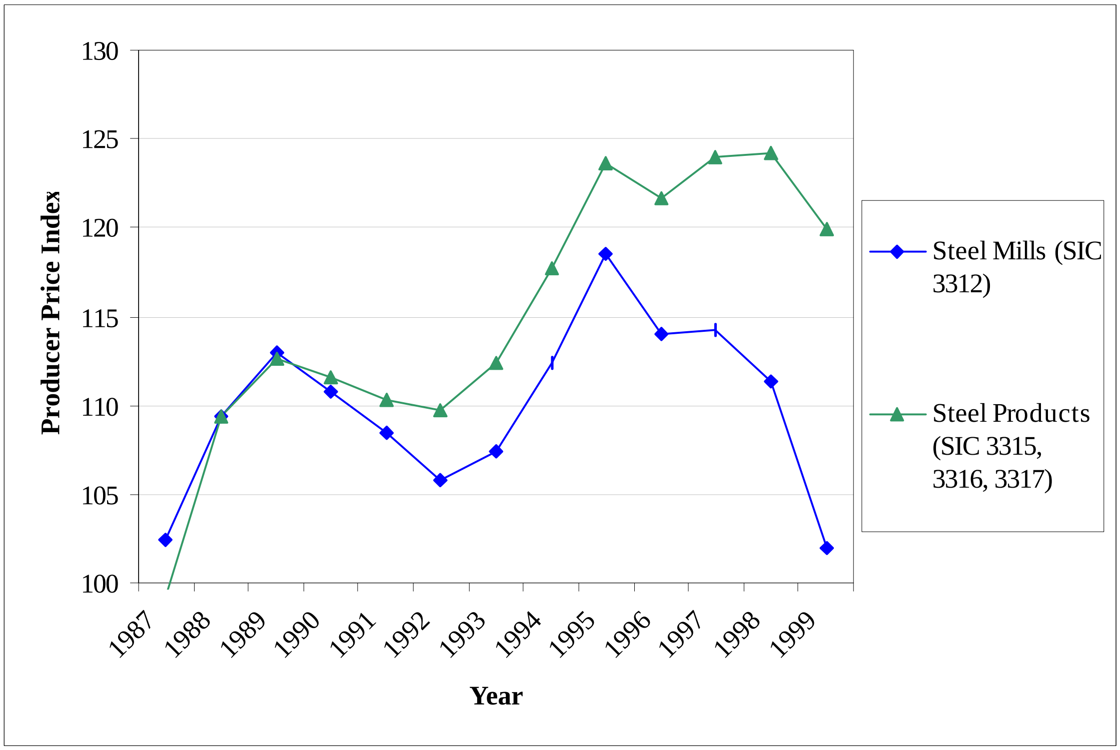
Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

b. Prices

The ***Producer Price Index*** (PPI) is a family of indexes that measure price changes from the perspective of the seller. It is an indicator of product prices and is used to inflate nominal monetary values to constant dollars. This profile uses PPIs at the 4-digit SIC code level to convert nominal values to 1999 dollars.

Figure 4D-2 below shows that selling prices for steel products and steel mill products follow very similar trends. Prices increased from 1987 to 1989 and then decreased until bottoming out in 1993. After this decrease, prices rebounded sharply through 1995 before eroding again. The decrease in prices between 1988 and 1992 reflects the sharp decrease in demand for steel products which resulted, in part, from a declining global economy and decreases in the demand for consumer durable goods, such as cars and appliances. This decrease in demand for steel-containing products led to an oversupply in steel and a substantial decline in prices. The recovery in prices reflects a general economic recovery and the concomitant increase in demand for steel products from the auto and construction markets. The fluctuation in prices since the mid 1990s reflects the limited ability of steel makers to raise prices despite increased demand. An increased supply in low cost imports from foreign sources has kept prices from increasing significantly (McGraw-Hill, 1998).

Figure 4D-2: Producer Price Index for Profiled Steel Industry Sectors



Source: Bureau of Labor Statistics, Producer Price Index.

c. Number of Facilities and Firms

The number of steel mills fluctuated significantly between 1989 and 1996. Table 4D-2 shows substantial decreases in the number of facilities in 1992 and 1993 due to a significant decrease in the global demand for steel products and the resulting overcapacity. This decrease was followed by a significant recovery in 1995 and 1996. The reversal reflects the increased use of steel by the major steel using industries such as construction (McGraw-Hill, 1998). The increase in demand for steel led to an expansion in steelmaking capacity which has been increasingly dominated by smaller, more energy efficient minimills in favor of the larger integrated mills (S&P, 2000).

In contrast to the volatility in the number of steel mills, the number of facilities in the Steel Products sector has remained relatively stable for the past eight years with only small decreases between 1994 and 1996.

Table 4D-2: Number of Facilities in the Profiled Steel Industry Sectors

Year	Steel Mills (SIC 3312)		Steel Products (SIC 3315, 3316, 3317)	
	Number of Facilities	Percent Change	Number of Facilities	Percent Change
1989	476	n/a	784	n/a
1990	497	4.4%	776	-1.0%
1991	531	6.8%	807	4.0%
1992	412	-22.4%	831	3.0%
1993	343	-16.7%	833	0.2%
1994	339	-1.2%	804	-3.5%
1995	391	15.3%	791	-1.6%
1996	483	23.5%	770	-2.7%
Percent Change 1989-1996		1.5%		-1.8%

Source: Small Business Administration, Statistics of U.S. Businesses.

The trend in the number of firms over the period between 1990 and 1996 has been similar to the trend in the number of facilities in both industry sectors. The number of firms in the Steel Mill sector decreased from a high of 433 in 1991 to a low of 258 in 1994. This decrease was followed by an expansion in the number of firms to 397 in 1996, an increase of more than 53 percent in two years. The number of firms in the Steel Products sector has decreased steadily in recent years from its peak of 661 in 1992.

Table 4D-3 shows the number of firms in the two profiled steel sectors between 1990 and 1996.

Table 4D-3: Number of Firms in the Profiled Steel Industry Sectors

Year	Steel Mills (SIC 3312)		Steel Products (SIC 3315, 3316, 3317)	
	Number of Firms	Percent Change	Number of Firms	Percent Change
1990	408	n/a	597	n/a
1991	433	6.1%	635	6.4%
1992	321	-25.9%	661	4.1%
1993	261	-18.7%	641	-3.0%
1994	258	-1.1%	618	-3.6%
1995	309	19.8%	607	-1.8%
1996	397	28.5%	583	-4.0%
Percent Change 1990-1996		-2.7%		-2.3%

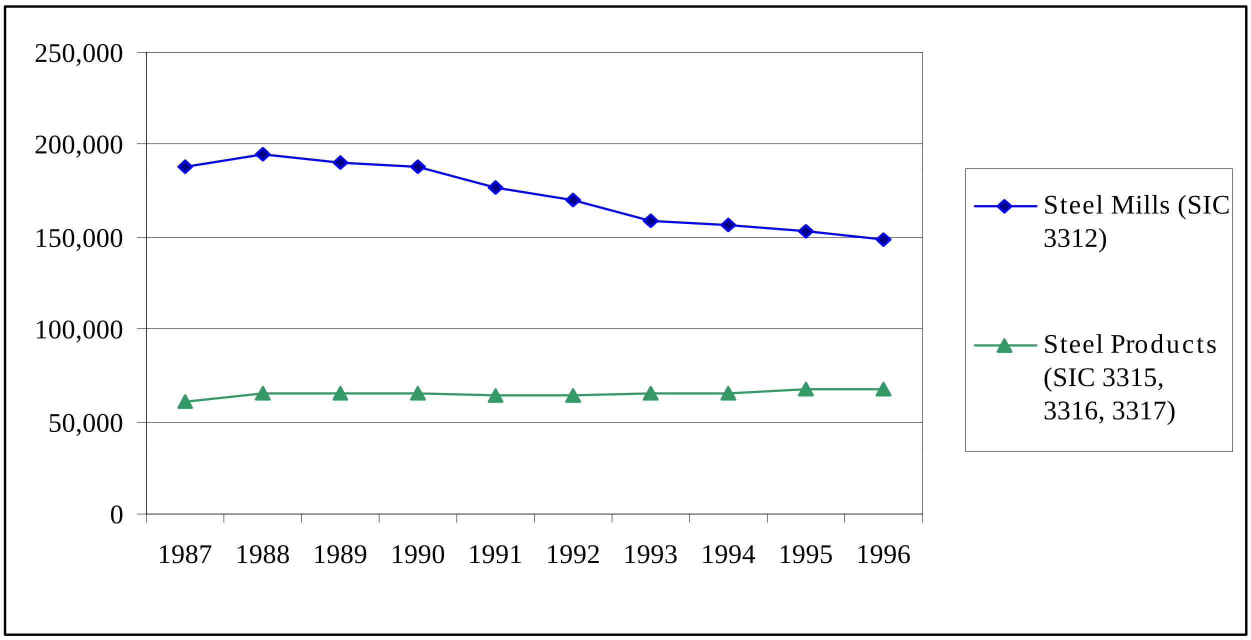
Source: Small Business Administration, Statistics of U.S. Businesses.

d. Employment and Productivity

Employment is a measure of the level and trend of activity in an industry. Figure 4D-3 below provides information on employment from the Annual Survey of Manufactures for the Steel Mills and Steel Products sectors. The figure shows that employment levels in the Steel Mills industry decreased by a total of 21 percent between 1987 and 1996. Employment is a primary cost component for steelmakers, accounting for approximately 30 percent of total costs (McGraw-Hill, 1998). Lowering labor costs enabled the steel mills to improve profitability and competitiveness given the limited opportunity to raise prices in the competitive market for steel products. The steady declines in employment reflects the aggressive efforts made by steel mills to improve worker productivity in order to cut labor costs and improve profits (McGraw-Hill, 1998).

Employment in the Steel Products sector over the same time period shows a steady positive trend, increasing by 12 percent between 1987 and 1996. This increase in employment is due to continued growth in the demand for steel products driven by a strong market for steel-containing durable goods and the increased steel-intensity of the economy, including a significant increase in the use of steel by the construction industry (McGraw-Hill, 1998).

Figure 4D-3: Employment for Profiled Steel Industry Sectors



Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

Table 4D-4 presents the change in value added per labor hour, a measure of ***labor productivity***, for the Steel Mill and Steel Products sectors between 1987 and 1996. Labor productivity at steel mills has increased substantially over this time period. Value added per labor hour increased 47 percent between 1987 and 1996. This increase reflects the efforts by steel mills to improve worker productivity in order to cut labor costs and improve profits. Much of the increase in labor productivity can be attributed to the restructuring of the U.S. steel industry and the increased role of minimills in production. Minimills are capable of producing rolled steel from scrap with substantially lower labor needs than integrated mills (McGraw-Hill, 1998). Labor productivity in the steel products sector has fluctuated somewhat but remained generally stable, increasing five percent from 1987 to 1996.

Table 4D-4: Productivity Trends for the Profiled Steel Industry Sectors, Millions of $1999

Year	Steel Mills (SIC 3312)				Steel Products (SIC 3315, 3316, 3317)			
	Value Added	Production Hours (millions)	Value Added/Hour		Value Added	Production Hours (millions)	Value Added/Hour	
			Number	Percent Change			Number	Percent Change
1987	15,743	306	51	n/a	5,289	96	55	n/a
1988	18,233	324	56	9%	6,195	103	60	9%
1989	17,455	348	50	-11%	5,550	104	53	-11%
1990	16,831	315	53	7%	5,438	105	52	-3%
1991	13,707	279	49	-8%	5,151	101	51	-1%
1992	15,974	277	58	17%	5,649	101	56	10%
1993	17,008	268	64	10%	6,278	107	59	5%
1994	18,824	266	71	11%	6,821	108	63	7%
1995	18,939	262	72	2%	6,589	113	58	-7%
1996	19,784	260	76	5%	6,578	114	58	-1%
Percent Change 1988-1996				15%				11%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

e. Capital Expenditures

Steel production is a relatively capital intensive process. Capital-intensive industries are characterized by large, technologically complex manufacturing facilities which reflect the economies of scale required to manufacture products efficiently. The integrated production process requires large capital investments of approximately $2,000 per ton of capacity for plants and equipment to support the large-scale production capacities needed to keep unit costs low. The nonintegrated process employed in minimills is significantly less capital intensive with capital costs of approximately $500 per ton of capacity (McGraw-Hill, 1998).

New capital expenditures are needed to modernize, expand, and replace existing capacity to meet growing demand. Capital expenditures in the Steel Mills and the Steel Products sectors between 1987 and 1996 are presented in Table 4D-5 below. The table shows that while capital expenditures in the Steel Mills sector haveexperienced dramatic fluctuations from one year to another, the level of capital expenditures by Steel Mills more than doubled between 1987 and 1996. The majority of this increase was realized in the late 1980s and early 1990s when capital expenditures increased by a total of 131 percent from 1987 to 1991. This substantial increase coincides with the advent of thin slab casting, a technology that allowed minimills to compete in the market for flat rolled sheet steel. Thin slab casting is the industry's largest and most lucrative segment, accounting for approximately 60 percent of demand. The significant decreases in capital expenditures by steel mills that followed this expansion reflects the bottoming out of the demand for steel products in the early 1990s. The recovery in capital expenditures in the mid 1990s has likely resulted from the recovery in the demand for steel which is due to an increase in the steel-intensity of the economy and growth in important end use markets (McGraw-Hill, 1998).

The 20 percent growth in the Steel Products sector has been much more modest, but the fluctuations are equally dramatic.

Table 4D-5: Capital Expenditures for the Profiled Steel Industry Sectors ($1999 millions)

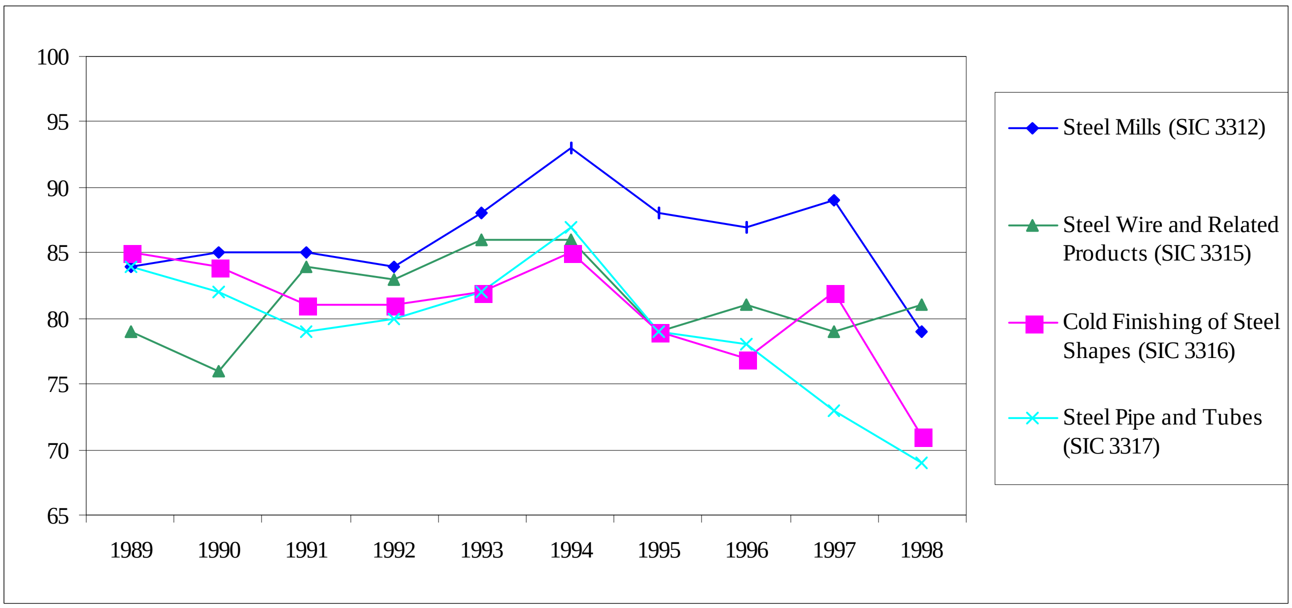
Year	Steel Mills (SIC 3312)		Steel Products (SIC 3315, 3316, 3317)	
	Capital Expenditures ($1999 millions)	Percent Change	Capital Expenditures ($1999 millions)	Percent Change
1987	1,216	n/a	478	n/a
1988	1,765	45.2%	351	-26.7%
1989	2,255	27.8%	499	42.2%
1990	2,351	4.3%	489	-1.9%
1991	2,810	19.5%	385	-21.4%
1992	2,131	-24.2%	388	0.7%
1993	1,689	-20.7%	410	5.9%
1994	2,372	40.4%	522	27.2%
1995	2,365	-0.3%	490	-6.1%
1996	2,522	6.6%	576	17.4%
Percent Change 1987-1996		107.4%		20.5%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

f. Capacity Utilization

Capacity utilization measures actual output as a percentage of total potential output given the available capacity and is used as a key barometer of an industry's health. Capacity utilization is an index used to identify potential excess or insufficient capacity in an industry which can help to project whether new investment is likely. Figure 4D-4 presents the capacity utilization index from 1989 to 1998 for the 4-digit SIC codes that make up the Steel Mill and Steel Products sectors. As shown in the figure, the index follows similar trends in each SIC code. For all sectors, capacity utilization peaked in 1994 and has decreased through the late 1990s. This trend reflects the over-capacity in the U.S. steel industry that has followed the substantial capacity additions in the late 1980s and early 1990s.

Figure 4D-4: Capacity Utilization Index for Profiled Steel Industry Sectors



Source: Department of Commerce, U.S. Census Bureau, Current Industrial Reports, Survey of Plant Capacity.

4D.2 Structure and Competitiveness of the Steel Industry

The companies that manufacture steel operate in a highly capital intensive industry. The steel mill industry is comprised of two different kinds of companies, integrated mills and minimills. The integrated steelmaking process requires expensive plant and equipment purchases that will support production capacities ranging from two million to four million tons per year. Until the early 1960s integrated steelmaking was the dominant method of steel manufacturing in the U.S. Since then, the integrated steel business has undergone dramatic downsizing due in part to the advent of minimills, increased imports, and reduced consumption by the auto industry which caused the industry to lose a substantial amount of tonnage. The increased unit costs as a result of decreases in tonnage has caused bankruptcy, plant closures, and mergers. These trends have reduced the number of integrated steelmakers (S&P, 2000).

Minimills vary in size from capacities of 150,000 tons at small facilities to larger facilities with annual capacities of between 400,000 tons and two million tons. Integrated companies have significant capital costs of approximately $2,000 per ton of capacity compared with minimills' $500 per ton. Because their production method does not require as much of an investment in capital equipment as integrated steelmakers, minimills have been able to lower prices driving integrated companies out of many of the commodity steel markets (S&P, 2000).

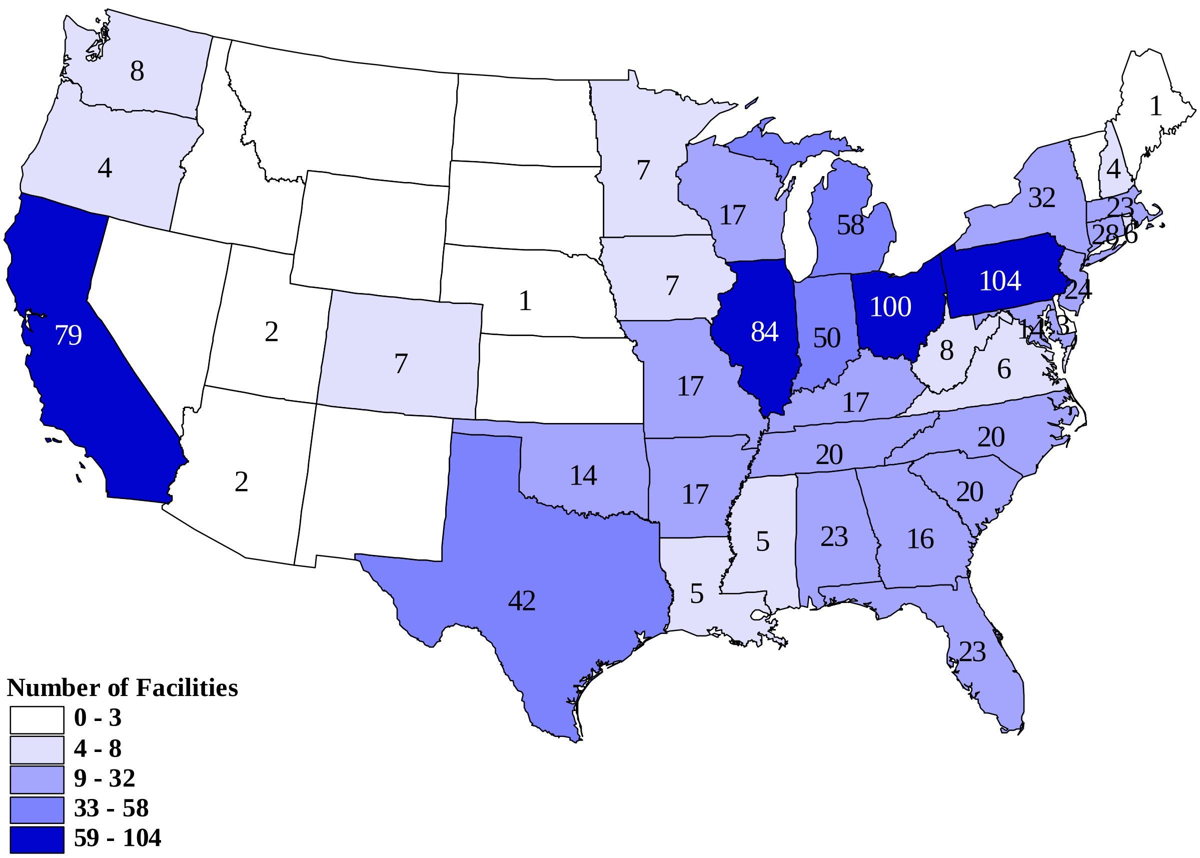
The large reduction in the initial capital investment has made it easier for minimills to enter the market. There were 22 publicly listed producers in the U.S. steel market as of late 1999, a sharp contrast to the oligopoly that prevailed earlier in this century (S&P, 2000).

a. Geographic Distribution

Steel mills are primarily concentrated in the Great Lakes Region (New York, Pennsylvania, Ohio, Indiana, Illinois, and Michigan). Historically, mill sites were selected for their proximity to water (both for transportation and for use in cooling and processing) and the sources of their raw materials, iron ore and coal. The geographic concentration of the industry has begun to change as minimills can be built anywhere where electricity and scrap are available at a reasonable cost and where a local market exists (EPA, 1995). The Steel Products sector is concentrated in the Great Lakes region and California. Ohio, Illinois, Pennsylvania, Michigan, and California manufactured 41 percent of all steel products in the U.S.

Figure 4D-5 below shows the distribution of U.S. steel mills and steel products facilities.

Figure 4D-5: Geographical Distribution of Facilities in the Profiled Steel Industry Sectors



Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

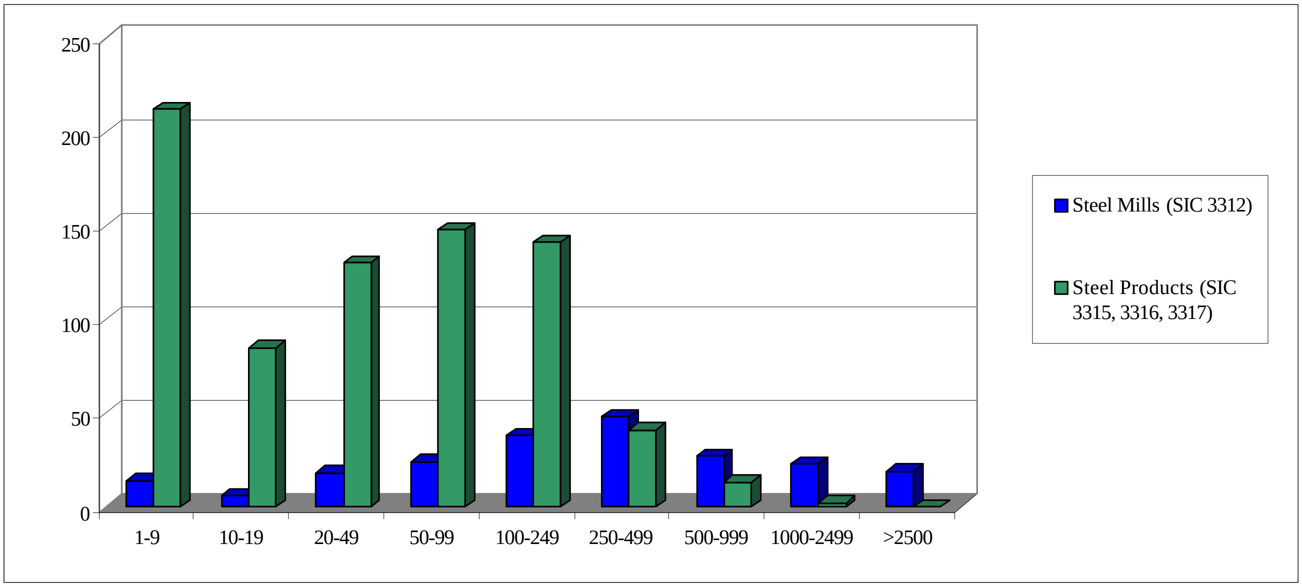
b. Facility Size

Steel making at both integrated mills and minimills is characterized by relatively large facilities, with 71 percent of all steel mills employing 100 or more employees. Figure 4D-6 shows that in 1992, the vast majority, approximately 98 percent, of the value of shipments for the industry was produced by facilities with more than 100 employees. Facilities with more than 1,000 employees accounted for approximately 69 percent of all steel mill shipments.

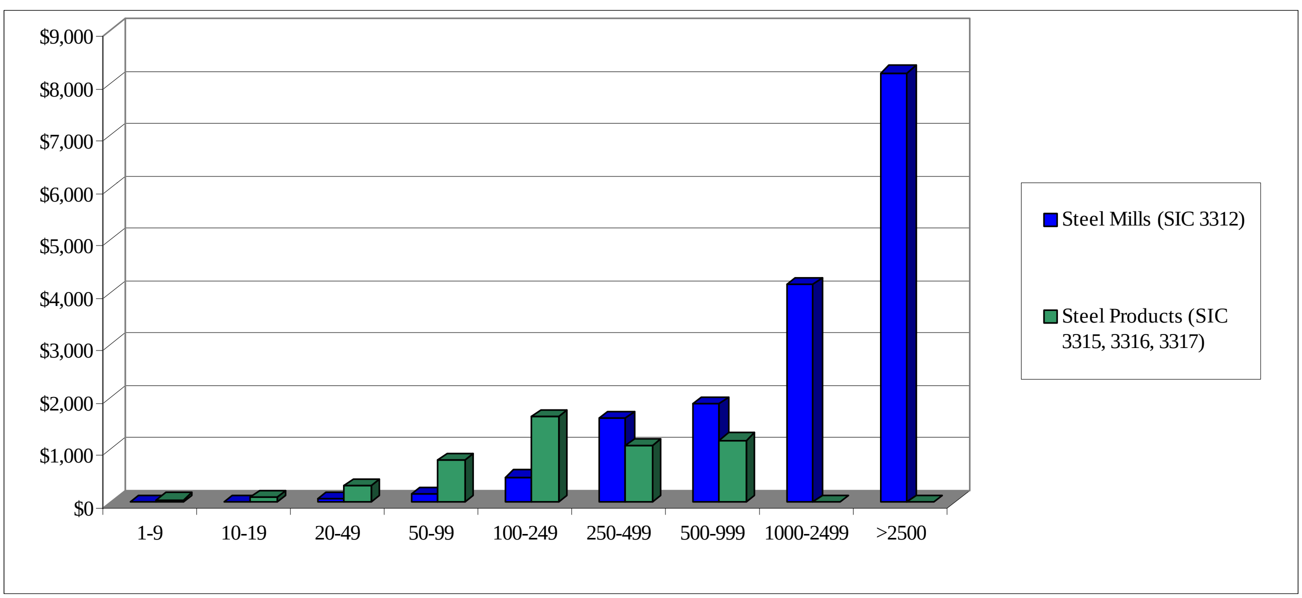
The Steel Products sector is characterized by smaller facilities than steel making with only 26 percent of facilities in the steel product industry employing 100 or more employees. While the majority of facilities in the Steel Products sector employ less than 100 people, most of the output from this sector is produced at the largest facilities. Figure 4D-6 shows that steel products facilities with more than 100 employees account for approximately 74 percent of the industry's shipments.

Figure 4D-6: Value of Shipments and Number of Facilities by Employment Size Category for the Profiled Steel Industry Sectors

Number of Facilities, 1992



1992 Value of Shipments (millions $1999)



Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

c. Firm Size

The Small Business Administration (SBA) defines small firms in the profiled steelteel industries according to the firms' number of employees. Firms in both Steel Mills (SIC 3312) and Steel Products (SIC 3315, 3316, and 3317) sectors are defined as small if they have 1,000 or fewer employees. Table 4D-6 below shows the distribution of firms, facilities, and receipts by the employment size of the parent firm.

The size categories reported in the Statistics of U.S. Businesses (SUSB) do not coincide with the SBA small firm standard of 1,000 employees. It is therefore not possible to apply the SBA size thresholds precisely. The SUSB data presented in Table 4D-6 show that in 1996, 316 of 397 firms in the Steel Mills sector had less than 500 employees. Therefore, at least 80 percent of firms in this sector were classified as small. These small firms owned 320 facilities, or 66 percent of all facilities in the sector, and accounted for approximately 6 percent of industry receipts. In contrast, the 34 largest firms that employ over 2,500 employees own 19 percent of all facilities in SIC 3312 and are responsible for approximately 77 percent of all industry receipts.

Of the 583 ultimate parent firms with facilities that manufacture steel products, 470, or 81 percent, employ fewer than 500 employees, and are therefore considered small businesses. Small firms own approximately 68 percent of facilities in the industry and account for 34 percent of industry receipts. The 49 large firms that employ over 2,500 employees own 100 of the 770 facilities in SIC codes 3315, 3316, and 3317 and are responsible for approximately 30 percent of all industry receipts.

Table 4D-6: Number of Firms, Facilities, and Estimated Receipts in the Profiled Steel Industry Sectors by Employment Size Category, 1996

Employment Size Category	Steel Mills (SIC 3312)			Steel Products (SIC 3315, 3316, 3317)		
	Number of Firms	Number of Facilities	Estimated Receipts ($1999 millions)	Number of Firms	Number of Facilities	Estimated Receipts ($1999 millions)
0-19	233	233	296,228	237	237	324
20-99	50	51	463,410	125	131	1,539
100-499	33	36	2,013,477	108	153	4,093
500-2,499	47	73	8,662,285	64	149	6,382
2,500+	34	90	38,343,865	49	100	5,397
Total	397	483	49,779,265	583	770	17,734

Source: Small Business Administration, Statistics of U.S. Businesses.

d. Concentration and Specialization Ratios

Concentration is the degree to which industry output is concentrated in a few large firms. Concentration is closely related to entry and exit barriers with more concentrated industries generally having higher barriers.

The four-firm ***concentration ratio*** (CR4) and the ***Herfindahl-Hirschman Index*** (HHI) are common measures of industry concentration. The CR4 indicates the market share of the four largest firms. For example, a CR4 of 72 percent means that the four largest firms in the industry account for 72 percent of the industry's total value of shipments. The higher the concentration ratio, the less competition there is in the industry, other things being equal.[2] An industry with a CR4 of more than 50 percent is generally considered concentrated. The HHI indicates concentration based on the largest 50 firms in the industry. It is equal to the sum of the squares of the market shares for the largest 50 firms in the industry. For example, if an industry consists of only three firms with market shares of 60, 30, and 10 percent, respectively, the HHI of this industry would be equal to 4,600 ($60^2 + 30^2 + 10^2$). The higher the index, the fewer the number of firms supplying the industry and the more concentrated the industry. An industry is considered concentrated if the HHI exceeds 1,000.

[2] Note that the measured concentration ratio and the HHF are very sensitive to how the industry is defined. An industry with a high concentration in domestic production may nonetheless be subject to significant competitive pressures if it competes with foreign producers or if it competes with products produced by other industries (e.g., plastics vs. aluminum in beverage containers). Concentration ratios are therefore only one indicator of the extent of competition in an industry.

The Steel Mills (SIC 3312) and Steel Products sectors (SICs 3315, 3316, 3317) are considered competitive, based on standard measures of concentration. The CR4 and the HHI for all the relevant SIC codes are below the benchmarks of 50 percent and 1,000, respectively. The concentration ratios presented in Table 4D-7 indicate that the majority of the output generated in these industry sectors is not concentrated in a few large firms. Moreover, the table shows that each of the industry sectors has became more competitive between 1987 and 1992.

The ***specialization ratio*** is the percentage of the industry's production accounted for by primary product shipments. The ***coverage ratio*** is the percentage of the industry's product shipments coming from facilities from the same primary industry. The coverage ratio provides an indication of how much of the production/product of interest is captured by the facilities classified in an SIC code.

The specialization and coverage ratios in Table 4D-7 show a high degree of specialization by steel mills indicating that the majority of production of steel mills is accounted for by primary product shipments.

Table 4D-7: Selected Ratios for the Profiled Steel Industry Sectors

SIC Code	Year	Total Number of Firms	Concentration Ratios					Specialization Ratio	Coverage Ratio
			4 Firm (CR4)	8 Firm (CR8)	20 Firm (CR20)	50 Firm (CR50)	Herfindahl-Hirschman Index		
Steel Mills									
3312	1987	271	44%	63%	81%	94%	607	98%	97%
	1992	135	37%	58%	81%	96%	551	98%	97%
Steel Products									
3315	1987	274	21%	34%	54%	78%	212	96%	88%
	1992	271	19%	32%	54%	80%	201	96%	88%
3316	1987	156	45%	62%	82%	95%	654	80%	94%
	1992	158	43%	60%	81%	96%	604	80%	95%
3317	1987	155	23%	34%	58%	85%	242	91%	92%
	1992	166	19%	31%	53%	80%	194	95%	97%

Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

e. Foreign Trade

The global market for steel has become and still remains extremely competitive. From 1945 until 1960, the U.S. steel industry enjoyed a period of tremendous prosperity and was a net exporter until 1959. However, by the early 1960s, foreign steel industries had thoroughly recovered from World War II and had begun construction of new plants that were more advanced and efficient than the U.S. integrated steel mills. Foreign producers also enjoyed lower labor costs allowing them to take substantial market share from U.S. producers (S&P, 2000). This increased competition from foreign producers combined with decreased consumption in some key end use markets served as a catalyst for the restructuring and downsizing of the U.S. steel industry. The industry has emerged from this restructuring considerably smaller, more technologically advanced and internationally competitive.

This profile uses two measures of foreign competitiveness: ***export dependence*** and ***import penetration***. Export dependence is the share of value of shipments that is exported. Import penetration is the share of domestic consumption met by imports. Table 4D-8 presents trade statistics for the profiled steel industry sectors from 1989 to 1996. The table shows that the trends in both export dependence and import penetration have been relatively stable. Historically, the U.S. steel industry has exported a relatively small share of shipments when compared to steel industries in other developed nations (McGraw-Hill, 1998). In 1995, U.S. exports rose to the highest level since 1941, yet steel exports only accounted for 7 percent of shipments that year. Imports as a percentage of implied domestic consumption rose slightly from 14 percent in 1993 to 17 percent in 1994 and remained at that level through 1996. This gradual increase in imports reflects excess steel capacity worldwide and the competitiveness of foreign steel producers.

Table 4D-8: Trade Statistics for the Profiled Steel Industry Sectors

Year	Value of imports ($1999 millions)	Value of exports ($1999 millions)	Value of Shipments ($1999 millions)	Implied Domestic Consumption[1]	Import Penetration[2]	Export Dependence[3]
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1989	9,844	3,058	59,203	65,990	15%	5.2%
1990	9,244	3,066	58,321	64,499	14%	5.3%
1991	8,767	4,064	53,958	58,662	15%	7.5%
1992	9,034	3,388	57,036	62,682	14%	5.9%
1993	9,662	3,104	60,099	66,657	14%	5.2%
1994	13,335	3,179	64,361	74,517	18%	4.9%
1995	12,178	4,616	65,147	72,709	17%	7.1%
1996	13,356	4,190	67,197	76,363	17%	6.2%
Average Annual Growth Rate	*4%*	*5%*	*2%*	*2%*	*2%*	*3%*

[1] Implied domestic consumption based on value of shipments, imports, and exports [column d + column b - column c].
[2] Import penetration based on implied domestic consumption and imports [column b / column e].
[3] Export dependence based on value of shipments and exports [column c / column d].

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures; U.S. Dept. of Commerce, Bureau of the Census, International Trade Administration. Outlook Trends Table, 1997.

4D.3 Financial Condition and Performance

The steel industry is generally characterized by relatively large plant sizes and technologically complex production processes which reflect the economies of scale required to manufacture steel efficiently. Because of the high fixed costs associated with steel manufacturing operations, larger production volumes are required to spread these costs over a greater number of units in order to maintain profitability. ***Operating margins*** for steel producers can be volatile due to changes in raw material costs, energy costs, and production levels (S&P, 2000).

Table 4D-9 presents trends in operating margins for steel mills and steel products manufacturers. The table shows that operating margins were relatively stable in both industry sectors between 1987 and 1996. The significant decrease in operating margins for steel mills and, to a lesser extent, steel products producers resulted from a significant decrease in steel consumption worldwide (McGraw-Hill, 1998).

Table 4D-9: Operating Margins for the Profiled Steel Industry Sectors (Millions $1999)

Year	Steel Mills (SIC 3312)				Steel Products (SIC 3315, 3316, 3317)			
	Value of Shipments	Cost of Materials	Payroll (all employees)	Operating Margin	Value of Shipments	Cost of Materials	Payroll (all employees)	Operating Margin
1987	$38,418	$22,782	$6,397	24.1%	$14,864	$9,591	$1,982	22.1%
1988	$44,371	$26,877	$6,558	24.6%	$16,460	$10,594	$2,015	23.4%
1989	$43,195	$26,140	$6,464	24.5%	$16,008	$10,481	$1,950	22.3%
1990	$42,301	$25,739	$6,746	23.2%	$16,020	$10,548	$2,039	21.4%
1991	$38,368	$24,249	$6,530	19.8%	$15,591	$10,341	$2,045	20.6%
1992	$40,699	$24,480	$6,783	23.2%	$16,337	$10,628	$2,184	21.6%
1993	$42,526	$25,547	$6,649	24.3%	$17,573	$11,322	$2,293	22.5%
1994	$46,046	$27,488	$6,612	25.9%	$18,314	$11,661	$2,253	24.0%
1995	$46,579	$27,962	$6,441	26.1%	$18,569	$12,131	$2,234	22.6%
1996	$48,773	$29,257	$6,668	26.3%	$18,424	$11,868	$2,319	23.0%
Percent Change 1987-1996	27%	28%	4%		24%	24%	17%	

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

4D.4 Facilities Operating Cooling Water Intake Structures

In 1982, the Primary Metals industries withdrew 1,312 billion gallons of cooling water, accounting for approximately 1.7 percent of total industrial cooling water intake in the United States. The industry ranked 3rd in industrial cooling water use, behind the electric power generation industry, and the chemical industry (1982 Census of Manufactures).

This section presents information from EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* on existing facilities with the following characteristics:

- they withdraw from a water of the United States;
- they hold an NPDES permit;
- they have an intake flow of more than two MGD;
- they use at least 25 percent of that flow for cooling purposes.

These facilities are not "new facilities" as defined by the proposed §316(b) New Facility Rule and are therefore not subject to this regulation. However, they meet the criteria of the proposed rule except that they are already in operation. These existing facilities therefore provide a good indication of what new facilities in these sectors may look like. The remainder of this section refers to existing facilities with the above characteristics as "§316(b) facilities."

a. Cooling Water Uses and Systems

Information collected in EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* found that an estimated 38 out of 158 steel mills (24 percent) and 13 out of 312 steel product manufacturers (4 percent) meet the characteristics of a §316(b) facility.

Minimills use electric-arc-furnace (EAF) to make steel from ferrous scrap. The electric-arc-furnace is extensively cooled by water and recycled through cooling towers (U.S. EPA, 1995).

Most §316(b) facilities in the profiled Steel sectors use cooling water for contact and non-contact production line or process cooling, electricity generation, and air conditioning:

- All §316(b) steel mills use cooling water for production line (or process) contact or noncontact cooling. The two other major uses of cooling water by steel mills are electricity generation and air conditioning, accounting for approximately 38 and 48 percent, respectively.

- All §316(b) steel product facilities use cooling water for production line (or process) contact or noncontact cooling. Electric generation and other uses are the two other uses of cooling water, both accounting for approximately 8 percent.

Table 4D-10 shows the distribution of existing §316(b) facilities in the profiled steel sectors by type of water body and cooling system. The table shows that most of the existing §316(b) facilities have either a once through system (22, or 43 percent) or employ a combination of a once through and closed system (21, or 40 percent). The largest proportion of existing facilities draw water from a freshwater stream or river (25, or 49 percent).

Table 4D-10: Number of §316(b) Facilities in the Profiled Steel Industry Sectors by Water Body Type and Cooling System Type

Water Body Type	Cooling Systems								
	Closed Cycle		Combination		Once Through		Unknown		Total
	Number	% of Total	Number	% of Total	Number	% of Total	Number	% of Total	
Steel Mills (SIC 3312)									
Estuary or Tidal River	0	0%	0	0%	5	100%	0	0%	5
Freshwater Stream or River	1	4%	14	60%	5	23%	3	13%	24
Lake or Reservoir	1	13%	5	61%	2	26%	0	0%	9
***Total*†**	***2***	***6%***	***19***	***52%***	***13***	***34%***	***3***	***8%***	***38***
Steel Products (SIC 3315, 3316, 3317)									
Freshwater Stream or River	0	0%	0	0%	9	100%	0	0%	9
Lake or Reservoir	0	0%	1	100%	0	0%	0	0%	1
Lake or Reservoir/Freshwater Stream or River	3	100%	0	0%	0	0%	0	0%	3
***Total*†**	***3***	***23%***	***1***	***9%***	***9***	***69%***	***0***	***0%***	***13***
Total for Profiled Steel Industry (SIC 3312, 3315, 3316, 3317)									
Estuary or Tidal River	0	0%	0	0%	5	100%	0	0%	5
Freshwater Stream or River	1	3%	14	43%	14	44%	3	10%	33
Lake or Reservoir	1	11%	6	66%	2	23%	0	0%	10
Lake or Reservoir/Freshwater Stream or River	3	100%	0	0%	0	0%	0	0%	3
***Total*†**	***5***	***10%***	***21***	***40%***	***22***	***43%***	***3***	***6%***	***51***

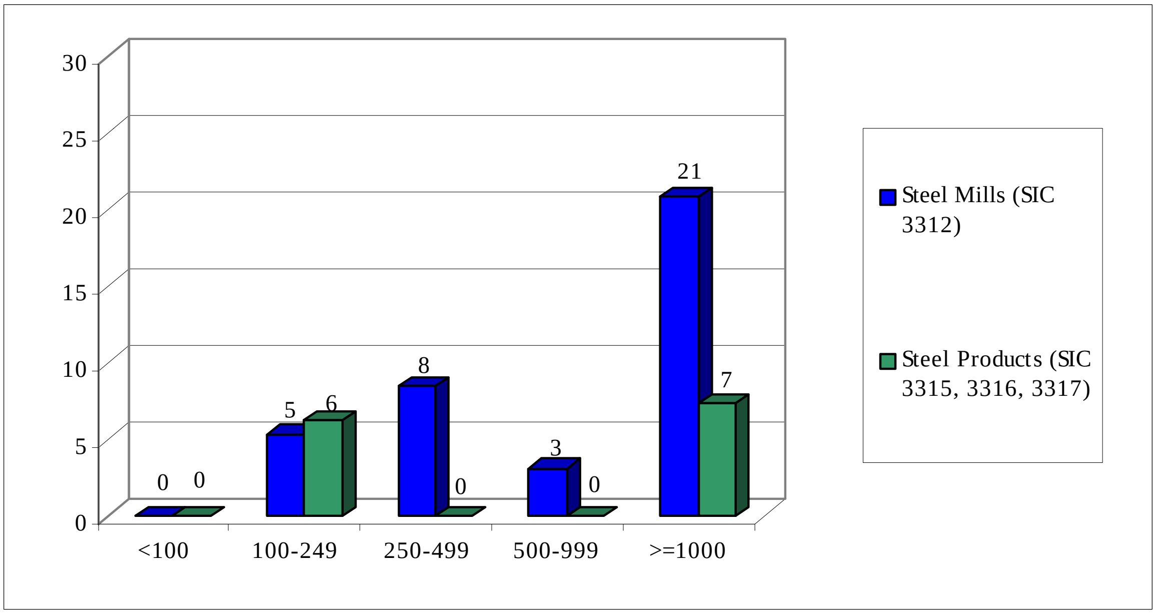
† Individual numbers may not add up to total due to independent rounding.

Source: *EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures*, *1999.*

b. Facility Size

The distribution of employment for both §316(b) steel mills and steel products facilities follow the same general pattern as employment distribution in their respective industries. Steel mills predominantly employ over 1,000 people while steel product manufacturers tend to be much smaller.

Figure 4D-7: Number of §316(b) Facilities in the Profiled Steel Industry Sectors by Employment Size



Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

d. Firm Size

EPA used the Small Business Administration (SBA) small entity size standards to determine the number of existing §316(b) profiled chemical industry facilities owned by small firms. Table 4D-11 shows that of the 38 §316(b) steel mills 22 percent are owned by small firms. There are no §316(b) steel product facilities that are owned by a small firm.

Table 4D-11: Number of §316(b) Facilities by Firm Size for the Profiled Steel Sectors

SIC Code	Large		Small		Total
	Number	% of SIC	Number	% of SIC	
Steel Mills (SIC 3312)					
3312	29	78%	8	22%	38
Steel Products (SIC 3315, 3316, 3317)					
3315	3	100%	0	0%	3
3316	9	100%	0	0%	9
3317	1	100%	0	0%	1
Total†	13	100%	0	0%	13
Total for Profiled Steel Facilities (SIC 3312, 3315, 3316, 3317)					
Total†	42	83%	8	17%	51

†Individual numbers may not add up to total due to independent rounding.

Source: *EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; D&B Database.*

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4E Aluminum (SIC 333/5)

EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* identified four 4-digit SIC codes in the nonferrous metals industries (SIC codes 333/335) with at least one existing facility that operates a CWIS, holds a NPDES permit, withdraws more than two million gallons per day (MGD) from a water of the United States, and uses at least 25 percent of its intake flow for cooling purposes, (facilities with these characteristics are hereafter referred to as "§316(b) facilities"). For each of the four SIC codes. Table 4E-1 below provides a description of the industry sector, a list of products manufactured, the total number of screener survey respondents (weighted to represent national results), and the number and percent of §316(b) facilities.

Table 4E-1: §316(b) Facilities in the Nonferrous Industries (SIC 333/335)

SIC	SIC Description	Important Products Manufactured	Number of Screener Respondents (Weighted)		
			Total	§316(b) Facilities	
				No. †	%
Primary Aluminum Production and Aluminum Shapes (SIC 3334 & 3353)					
3334	Primary Production of Aluminum	Producing aluminum from alumina and in refining aluminum by any process	31	10	32.6%
3353	Aluminum Sheet, Plate, and Foil	Flat rolling aluminum and aluminum-base alloy basic shapes, such as rod and bar, pipe and tube, and tube blooms; producing tube by drawing	57	6	10.9%
Total			***88***	***16***	***18.5%***
Other SIC 333/335					
3339	Primary Smelting and Refining of Nonferrous Metals, Except Copper and Aluminum	Smelting and refining nonferrous metals, except copper and aluminum	6	1	19.6%
3357	Drawing and Insulating of Nonferrous Wire	Drawing, and/or insulating wire and cable of nonferrous metals from purchased wire bars, rods, or wire; insulated fiber optic cable	48	0	0.0%
Total			***53***	***1***	***2.1%***
Total Nonferrous					
Total 333/5			**141**	**17**	**12.3%**

† Information on the percentage of intake flow used for cooling purposes was not available for all screener respondents. Facilities for which this information was not available were assumed to use at least 25% of their intake flow for cooling water purposes The reported numbers of §316(b) facilities may therefore be overstated.

Source: *EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual 1987.*

The responses to the Screener Questionnaire indicate that aluminum producers account for the largest number of nonferrous metals §316(b) facilities. Of the 17 §316(b) facilities in the four nonferrous SIC codes, 16 facilities, or 94 percent, are either primary aluminum producers (SIC code 3334) or producers of flat-rolled aluminum and aluminum shapes (aluminum sheet, plate and foil, SIC code 3353.) This profile therefore focuses on the primary aluminum production and aluminum shapes sectors.

4E.1 Domestic Production

Commercial production of aluminum using the electrolytic reduction process, known as the Hall-Heroult process, began in the late 1800s. The production of primary aluminum involves mining bauxite ore and refining it into alumina, one of the feedstocks for aluminum metal. Direct electric current is used to split the alumina into molten aluminum metal and carbon dioxide. The molten aluminum metal is then collected and cast into ingots. Technological improvements over the years have improved the efficiency of aluminum smelting, with a particular emphasis on reducing energy requirements. There is currently no commercially viable alternative to the electrometallurgical process (Aluminum Association, 2000).

Almost half of all U.S.-produced aluminum (48.1 percent of U.S. output in 1998) comes from recycled scrap. Recycling consists of melting used beverage cans and scrap generated from operations. Recycling saves approximately 95 percent of the energy costs involved in primary smelting from bauxite (S&P, 2000). No secondary smelters (included, along with secondary smelting of other metals, in SIC code 3341) were reported in EPA's screener survey. These facilities are therefore not addressed in this profile.

Facilities in SIC code 3353 produce semifabricated products from primary or secondary aluminum. Examples of semifabricated aluminum products include (Aluminum Association, undated):

- sheet (cans, construction materials and automotive parts);
- plate (aircraft and spacecraft fuel tanks);
- foil (household aluminum foil, building insulation and automotive parts)
- rod, bar and wire (electrical transmission lines); and
- extrusions (storm windows, bridge structures and automotive parts).

U.S. aluminum companies are generally vertically integrated. The major aluminum companies own large bauxite reserves, mine bauxite ore and refine it into alumina, produce aluminum ingot, and operate the rolling mills and finishing plants used to produce semifabricated aluminum products (S&P, 2000).

a. Output

The largest single source of demand for aluminum is the transportation sector, primarily the manufacture of motor vehicles. Demand for lighter more fuel efficient vehicles has led to increased demand for aluminum in auto manufacturing, at the expense of steel (S&P, 2000). Production of beverage cans is also a major use of aluminum sheet, and aluminum has almost entirely replaced steel in the beverage can market. Other major uses of aluminum include construction (including aluminum siding, windows and gutters) and consumer durables (source).

Demand for aluminum reflects the overall state of the domestic and world economies, as well as long-term trends in materials use in major end-use sectors. The years 1990 through 1999 have include strong demand for aluminum from domestic sources and variable demand from overseas customers, due in large part to stagnant economies in Asia in the late 1990s.

Table 4E-2 shows trends in output of aluminum by primary aluminum producers and recovery of aluminum from old and new scrap. Secondary production has grown from 37 percent to almost half of total domestic supply over the period from 1990 to 1999.

Table 4E-2: Quantities of Aluminum Produced (thousand metric tons)

Year	Aluminum Ingot	
	Primary Production	Secondary Production (from old & new scrap)
1990	4,048	2,390
1991	4,121	2,290
1992	4,042	2,760
1993	3,695	2,940
1994	3,299	3,090
1995	3,375	3,190
1996	3,577	3,310
1997	3,063	3,550
1998	3,713	3,440
1999†	3,800	3,490

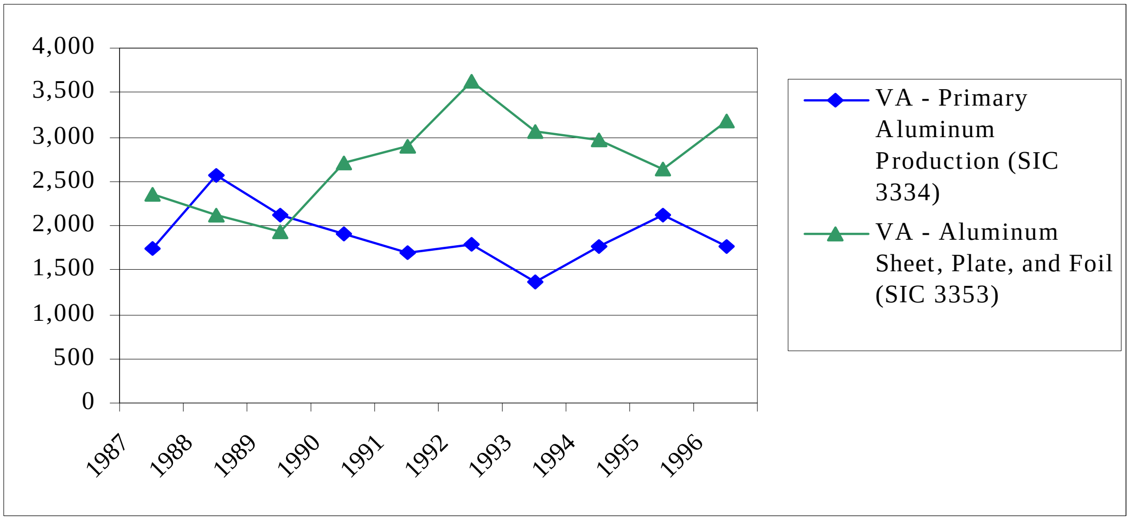
† Forecast

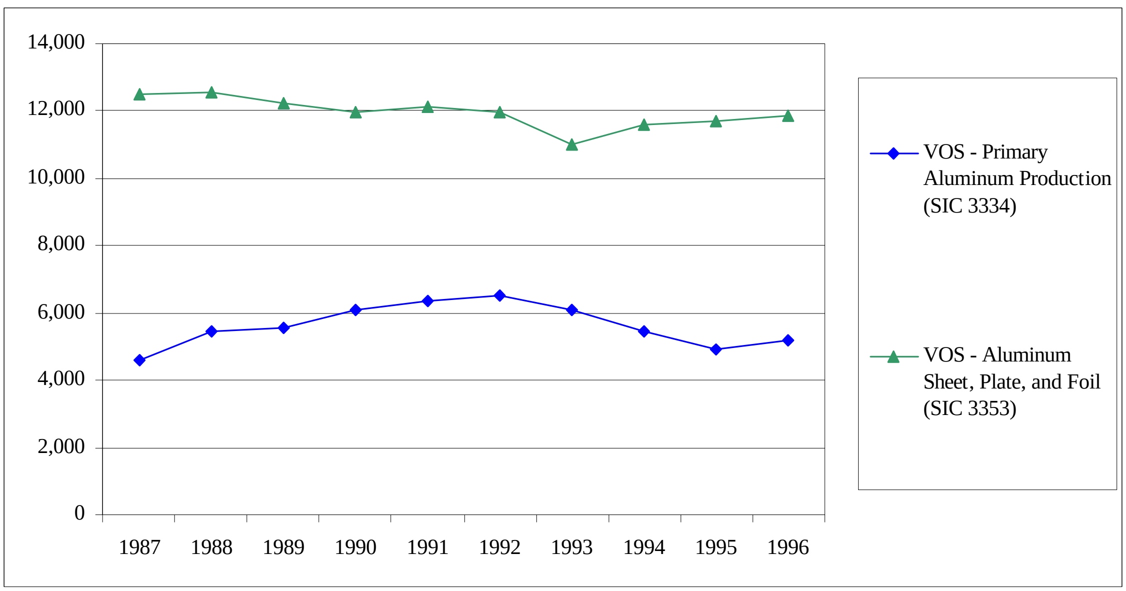
Source: U.S. Industry and Trade Outlook '99, American Metal Market Metal Statistics 1999, USGS 2000.

Value of shipments and ***value added*** are two measures of the value of manufacturing output.[1] Figure 4E-1 presents trends in value of shipments and value added for the primary aluminum and aluminum sheet, plate, and foil sectors between 1987 and 1996.

[1] Terms highlighted in bold and italic font are further explained in the glossary.

Figure 4E-1: Real Value of Shipments and Value Added for Profiled Aluminum Sectors ($1999 million)





Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

Figure 4E-1 shows that real value added and value of shipments in the primary aluminum sector decreased steadily from 1988 to 1993. This decrease coincided with a period of rapidly declining prices resulting from a decrease in the demand for aluminum and oversupply in the global market that occurred when large amounts of Russian aluminum entered the market in the early 1990s. The recovery in the mid-1990s resulted from an increased demand for aluminum, driven by increased consumption by the transportation, container, and construction sectors.

Value added in the aluminum sheet, plate, and foil sector increased between 1989 and 1992 and decreased thereafter. Demand for semifinished aluminum products reflects demand from the transportation, container, and building industries. The increases in value added through the early 1990s were fueled by strong demand from the container and packaging sector. The decreases seen in the mid-1990s reflect a decrease in demand from this sector resulting from improved technology for producing aluminum cans and a stagnant demand for products packaged in cans.

Value of shipments for both of the profiled aluminum sectors follow similar trends between 1989 and 1996.

b. Prices

Figure 4E-2 shows the ***producer price index*** (PPI) at the 4-digit SIC code for the profiled aluminum sectors. The PPI is a family of indexes that measure price changes from the perspective of the seller. This profile uses the PPI to inflate nominal monetary values to constant dollars. Sharp changes in prices reflect the cyclical nature of this industry and major changes in world markets.

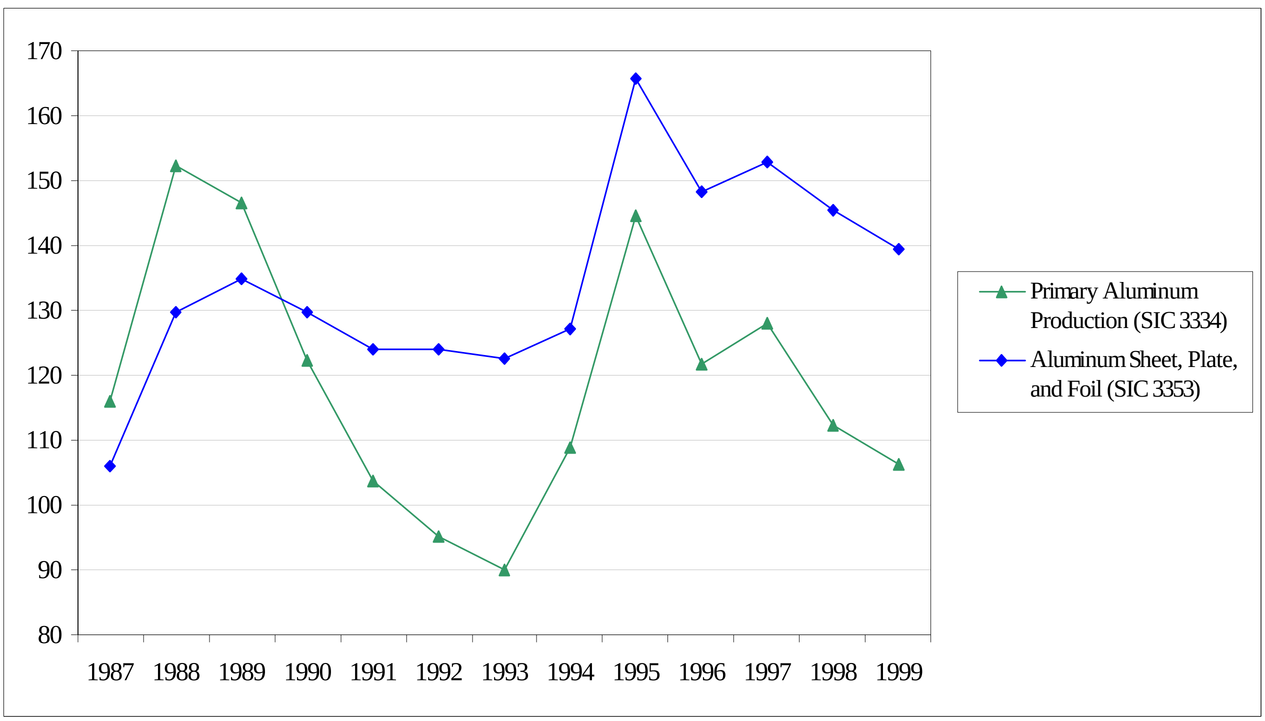
During the early 1980s, the aluminum industry experienced oversupply, high inventories, excess capacity, and weak demand, resulting in falling prices for aluminum. By 1986, much of the excess capacity had been permanently closed, inventories had been worked down, and worldwide demand for aluminum increased dramatically. This resulted in dramatic price increases through 1988.

In the early 1990s, the dissolution of the Soviet Union had a major impact on aluminum markets. Large quantities of Russian aluminum that had formerly been consumed internally, primarily in military applications, were sold in world markets to generate hard currency. At the same time, world demand for aluminum was decreasing. The result was increasing inventories and depressed aluminum prices.

The United States and five other primary aluminum producing nations signed an agreement in January 1994 to curtail global output, in response to the sharp decline in aluminum prices. At the time of the agreement, there was an estimated global overcapacity of 1.5 to 2.0 million metric tons per year (S&P, 2000).

By the mid-1990s, production cutbacks, increased demand, and declining inventories led to a sharp rebound of prices. Prices have again declined since the late 1990s, when the economic crises in Asian markets reduced the demand for aluminum (USGS, 2000). Russian exports remain high, and there is a continuing potential for depressed prices if substantial amounts of idled capacity are brought back on-line in response to improving world economic conditions.

Figure 4E-2: Producer Price Indexes for Profiled Aluminum Sectors



Source: Bureau of Labor Statistics, Producer Price Index.

c. Number of Facilities and Firms

The primary aluminum sector is dominated by a few very large integrated, multinational U.S. companies which own the majority of smelting facilities operating today. In 1999, there were 23 primary aluminum reduction plants operating in the U.S., owned by 12 companies (USGS, 2000). These 12 companies owned total primary capacity of 4.2 million metric tons. The three largest firms account for 62 percent of U.S. primary capacity (Alcoa Inc. for 45 percent, Reynolds for almost 11 percent, and Kaiser Aluminum Corp. for almost 7 percent) (S&P, 2000).

Statistics of U.S. Businesses data show considerable variation in the number of primary aluminum facilities between 1989 and 1996. Table 4E-3 shows that the number of primary aluminum facilities decreased by 30 percent between 1991 and 1995, with the majority of this decrease, 27 percent, occurring between 1991 and 1993. The fluctuation in the number of facilities reflects the market conditions described earlier.

The number of facilities in the aluminum sheet, plate, and foil sector has shown a more consistent trend, increasing each year except 1993. The upward trend in numbers of facilities in the early 1990s reflects the high levels of capacity utilization and dramatic increase in demand for aluminum prevalent at that time. The sharp decrease in the number of facilities in 1993 resulted from declining economic conditions and oversupply in the global market for aluminum. This decrease was followed by another period of increases in the number of facilities.

Table 4E-3: Number of Facilities for Profiled Aluminum Sectors

Year	Primary Aluminum Production (SIC 3334)		Aluminum Sheet, Plate, and Foil (SIC 3353)	
	Number of Establishments	Percent Change	Number of Establishments	Percent Change
1989	56	n/a	61	n/a
1990	54	-3.6%	64	4.9%
1991	57	5.6%	73	14.1%
1992	52	-8.8%	73	0.0%
1993	44	-15.4%	63	-13.7%
1994	41	-6.8%	69	9.5%
1995	40	-2.4%	76	10.1%
1996	51	27.5%	81	6.6%
Percent Change 1989-1996		-8.9%		32.8%

Source: Small Business Administration, Statistics of U.S. Businesses.

The trend in the number of firms over the period between 1989 and 1996 has been similar to the trend in the number of facilities in both industry sectors. Table 4E-4 presents information on the number of firms in each sector between 1989 and 1996.

Table 4E-4: Number of Firms for Profiled Aluminum Sectors				
Year	**Primary Aluminum Production (SIC 3334)**		**Aluminum Sheet, Plate, and Foil (SIC 3353)**	
	Number of Firms	**Percent Change**	**Number of Firms**	**Percent Change**
1990	38	n/a	43	n/a
1991	41	7.9%	53	23.3%
1992	36	-12.2%	53	0.0%
1993	33	-8.3%	45	-15.1%
1994	30	-9.1%	47	4.4%
1995	30	0.0%	51	8.5%
1996	40	33.3%	56	9.8%
Percent Change 1990-1996		5.3%		30.2%

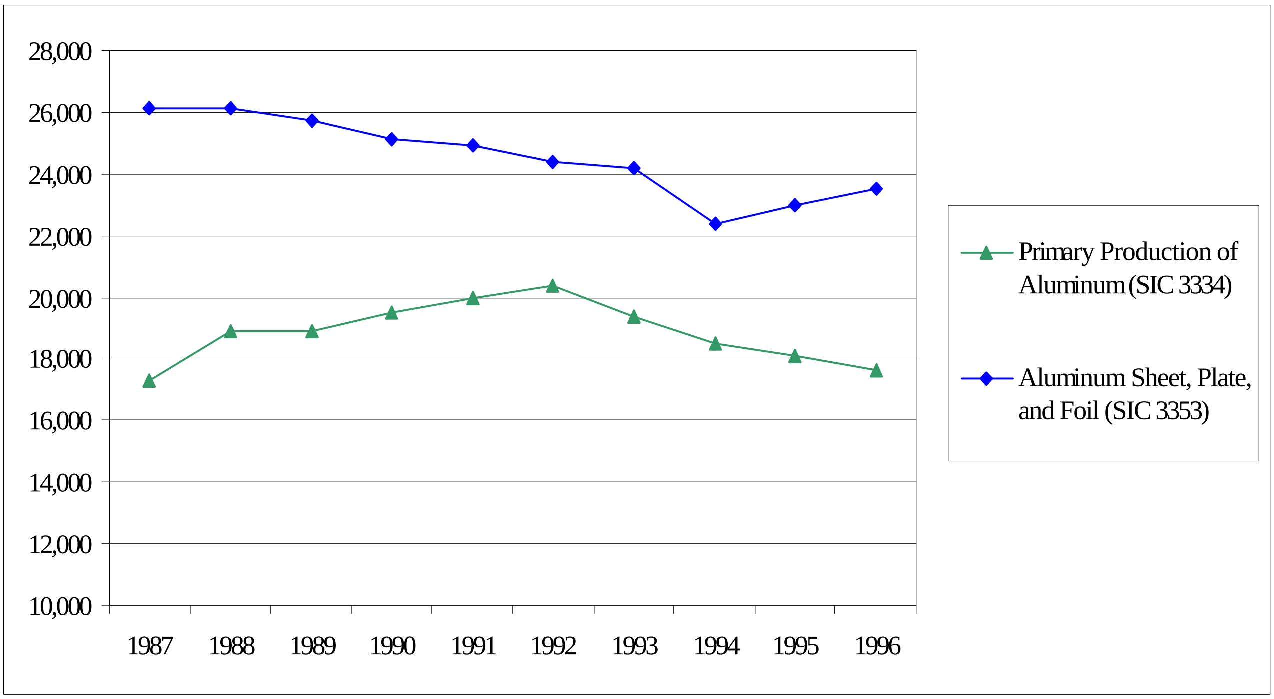
Source: Small Business Administration, Statistics of U.S. Businesses.

d. Employment and Productivity

Figure 4E-3 below provides information on employment from the Annual Survey of Manufactures for the primary aluminum and aluminum plate, sheet, and foil sectors. The figure shows that employment trends in the primary aluminum production sector increased throughout the late 1980s and early 1990s. Employment in this sector declined each year from its peak in 1992 through 1996 as a result of the market conditions described previously.

Employment in the aluminum sheet, plate, and foil sector has been declining since 1987. There were 26,100 people employed in the aluminum sheet sector in 1987 but only 23,500 in 1996. This decrease in employment reflects the technological advances seen in the production of aluminum cans, a major end user of aluminum sheet and foil, and a decreased demand from the container and packaging sector (McGraw-Hill, 1998).

Figure 4E-3: Employment for Profiled Aluminum Sectors



Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

Table 4E-5 presents the change in value added per labor hour, a measure of ***labor productivity***, for the primary aluminum and aluminum plate, sheet, and foil sectors between 1987 and 1996. The trend in labor productivity in both sectors has shown a fair amount of volatility over this period. Value added per hour in the primary aluminum sector decreased 47 percent between 1988 and 1993 but only one percent between 1987 and 1996.

Value added per hour in the aluminum sheet, plate, and foil sector saw substantial increases in the early 1990s improving by 48 percent between 1989 and 1992 and 40 percent between 1988 and 1996.

Table 4E-5: Productivity Trends for Profiled Aluminum Sectors

Year	Primary Production of Aluminum (SIC 3334)				Aluminum Sheet, Plate, and Foil (SIC 3353)			
	Value Added (million $1999)	Production Hours (millions)	Value Added/Hour		Value Added (million $1999)	Production Hours (millions)	Value Added/Hour	
			$1999	Percent Change			$1999	Percent Change
1987	1740	28	63	n/a	2356	40	59	n/a
1988	2559	32	80	27%	2109	41	51	-13%
1989	2127	30	70	-12%	1928	41	47	-8%
1990	1917	32	60	-15%	2700	40	68	44%
1991	1691	32	53	-12%	2900	39	74	8%
1992	1799	32	56	6%	3630	40	91	23%
1993	1354	29	47	-16%	3065	39	79	-13%
1994	1753	27	65	40%	2967	37	81	2%
1995	2113	28	75	15%	2633	38	69	-15%
1996	1763	29	62	-17%	3174	39	82	19%
Percent Change 1988-1996				-1%				40%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

e. Capital Expenditures

Aluminum production is a highly capital intensive process. Capital expenditures are needed to modernize, replace, and when market conditions warrant, expand capacity. Environmental issues also require major capital expenditures. Possible measures required to reduce greenhouse gas (GHG) emissions may require significant expenditures by aluminum producers. The industry expects to spend a few hundred million dollars to reduce toxic air emissions by half and to reduce particulate emissions under Clean Air Act requirements (McGraw-Hill, 1998).

Capital expenditures in the primary aluminum and aluminum plate, sheet, and foil sectors between 1987 and 1996 are presented in Table 4E-6 below. The table shows that capital expenditures in the primary aluminum sector increased throughout the early 1990s, peaking in 1993. This period of increased capital investment was followed by a significant decrease of 54 percent between 1993 and 1995. These decreases resulted from the production cutbacks and capacity reductions implemented in response to oversupply conditions prevalent in the market for aluminum.

Capital expenditures in the aluminum plate, sheet, and foil sector have also fluctuated considerably between 1987 and 1996. Producers of aluminum plate, sheet and foil reduced capital expenditures by 35 percent between 1988 and 1996.

Table 4E-6: Capital Expenditures for Profiled Aluminum Sectors ($1999 millions)

Year	Primary Aluminum Production (SIC 3334)		Aluminum Sheet, Plate, and Foil (SIC 3353)	
	Capital Expenditures	Percent Change	Capital Expenditures	Percent Change
1987	159	n/a	578	n/a
1988	103	-35%	564	-2%
1989	132	29%	571	1%
1990	163	24%	733	28%
1991	213	30%	638	-13%
1992	240	13%	470	-26%
1993	197	-18%	275	-42%
1994	118	-40%	300	9%
1995	111	-5%	319	6%
1996	181	62%	376	18%
Percent Change 1987-1996		14%		-35%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

f. Capacity Utilization

Capacity utilization measures actual output as a percentage of total potential output given the available capacity. Capacity utilization reflects excess or insufficient capacity in an industry and is an indication of whether new investment is likely.

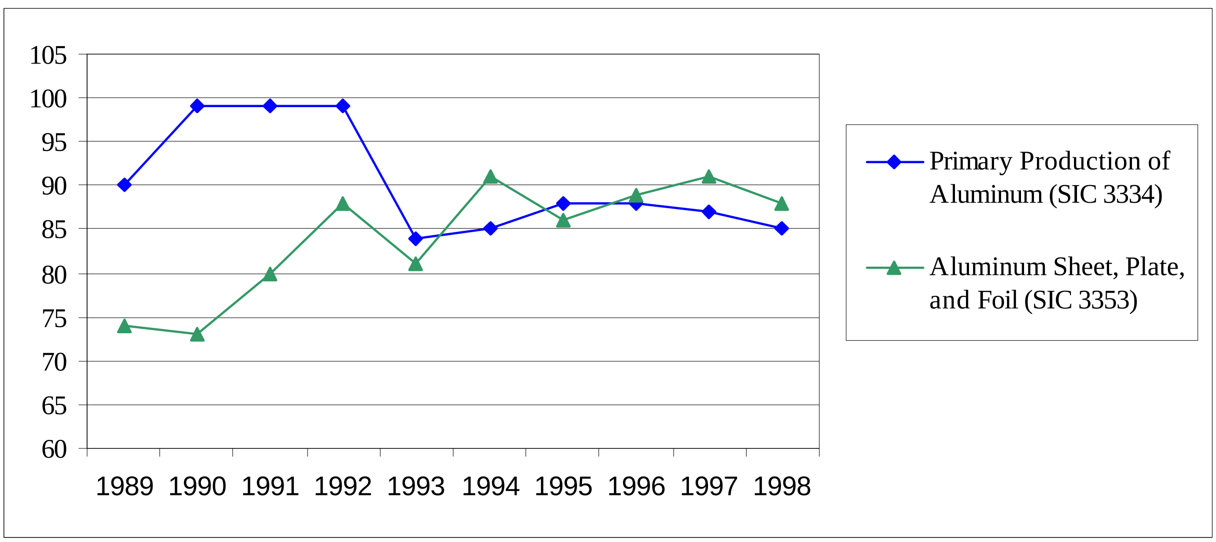
Figure 4E-4 presents the capacity utilization index from 1989 to 1998 for the primary aluminum and aluminum sheet, plate, and foil sectors. The figure shows that for most of the 1990s, the primary aluminum industry was characterized by excess capacity. The capacity utilization index for this sector was near 100 percent between 1990 and 1992, and then decreased sharply in 1993 as large amounts of Russian aluminum entered the global market for the first time (McGraw-Hill, 1999). Capacity utilization remained low through 1996, reflecting the continued oversupply in the global aluminum market.

There continues to be a substantial amount of idled capacity in the U.S. that could be brought on-line as demand improves, which is likely to limit construction of new capacity and to limit price increases for aluminum (S&P, 2000). The annual USGS report on aluminum for 1998 reported that capacity expansions were being planned or studied at three primary smelters, that capacity was being brought back on-line at five facilities, and that capacity had been or would soon be idled at another four smelters during 1998. There has not been any new smelter capacity constructed in the United States since 1980 (McGraw-Hill, 1999). Deregulation of the U.S. power industry may encourage some smelter expansions in the U.S., if electricity prices decrease significantly once electricity markets are deregulated .

There are some aluminum minimills in the U.S., but in contrast to the steel industry, their impact on the profitability of traditional aluminum companies has been limited. Aluminum minimills are not able to produce can sheet of the same quality as that produced by integrated facilities. They are able to compete only in production of commodity sheet products for the building and distributor markets, which are considered mature markets. According to Standard & Poor's, construction of new minimill capacity is unlikely given the potential that added capacity would drive down prices in the face of slow growth in the markets for minimill products (S&P, 2000).

Capacity utilization in the aluminum sheet, plate, and foil sector has fluctuated but shows an overall positive trend between 1989 and 1998. This positive trend is largely driven by the continued strength of rolled aluminum products which account for more than 50 percent of all shipments from the aluminum industry. Increased consumption by the transportation sector, the largest end-use sector for aluminum, is responsible for bringing idle capacity into production (McGraw-Hill 1999).

Figure 4E-4: Capacity Utilization Index for Profiled Aluminum Sectors



Source: Department of Commerce, Bureau of the Census, Current Industrial Reports, Survey of Plant Capacity.

4E.2 Structure and Competitiveness

Aluminum production is a highly-concentrated industry. A number of large mergers among aluminum producers that have occurred recently that will increase the degree of concentration in the industry. For example, Alcoa (the largest aluminum producer) acquired Alumax (the third largest producer) in 1998. Some sources speculate that, with increased consolidation resulting from mergers, aluminum producers might refrain from returning idle capacity to production as demand for aluminum grows. This could reduce the cyclical volatility in production and aluminum prices that has characterized the industry in the past (S&P, 2000).

a. Geographic Distribution

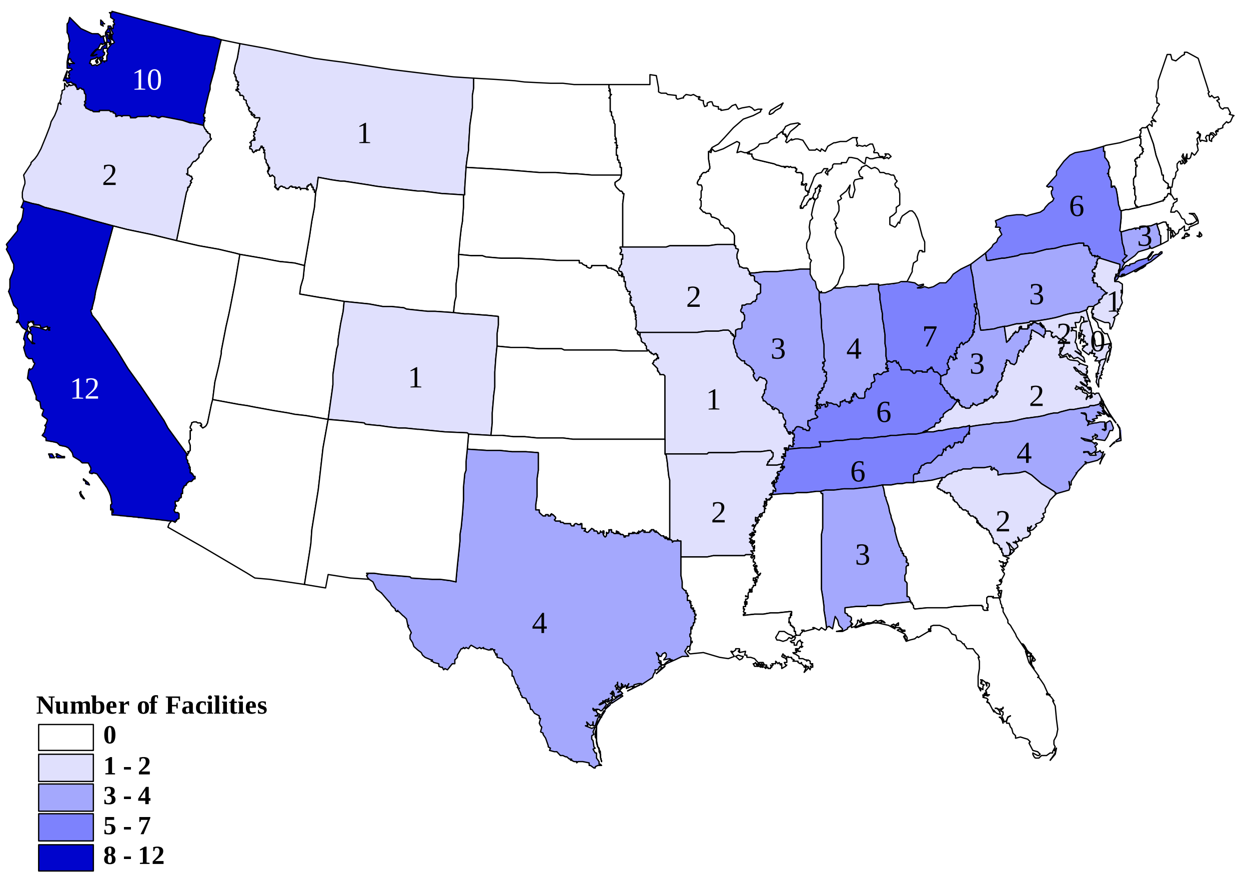
The cost and availability of electricity is a driving force behind decisions on the location of new or expanded smelter capacity.

The primary aluminum producers (SIC 3334) are generally located in the Pacific Northwest (OR, MT, WA) and the Ohio River Valley (IL, IN, KY, MI, MO, OH, PA). In 1998, approximately 39 percent of the domestic production capacity was located in the Pacific Northwest and 32 percent in the Ohio River Valley. Primary smelters are located in these regions due to the abundant supplies of hydroelectric and coal-based energy.

The aluminum sheet, plate, and foil industry is located principally in California and the Appalachian Region (Alabama, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia).

Figure 4E-5 shows the distribution of all facilities in both profiled aluminum sectors (primary smelters and semifabricated product producers), based on the 1992 Census of Manufactures.

Figure 4E-5: Number of Facilities by State for Profiled Aluminum Sectors

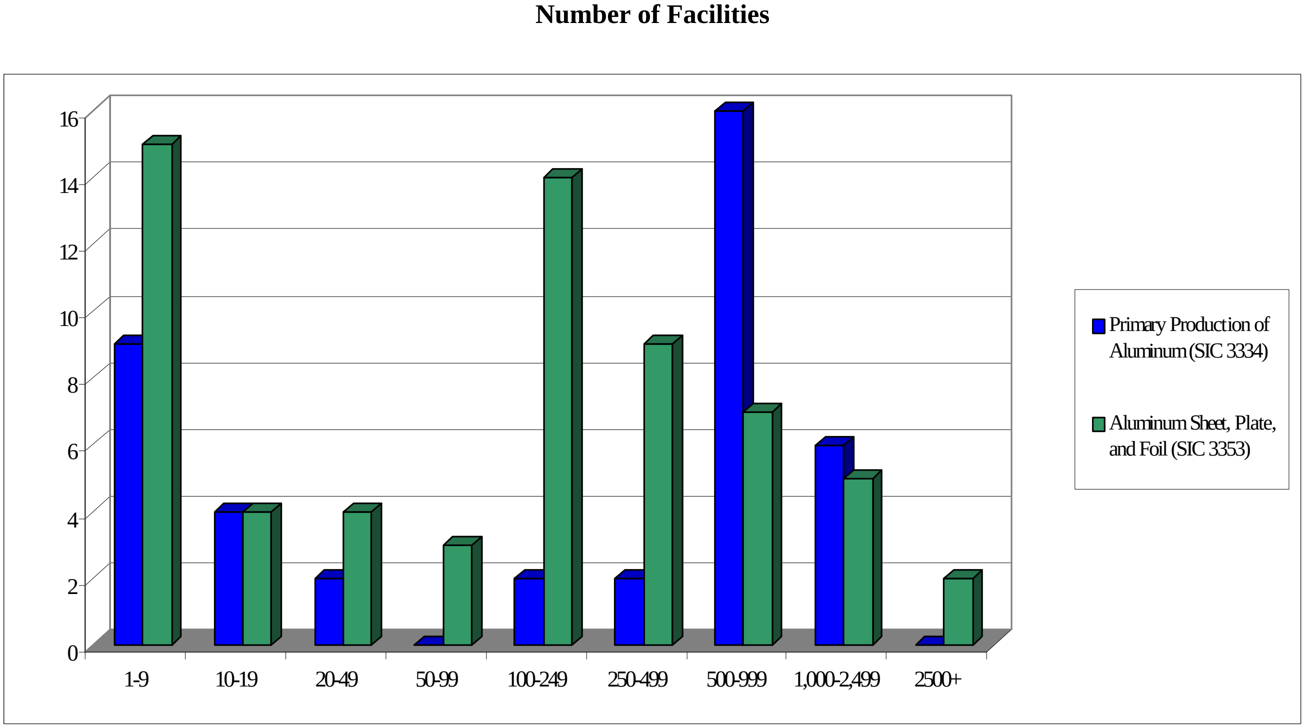


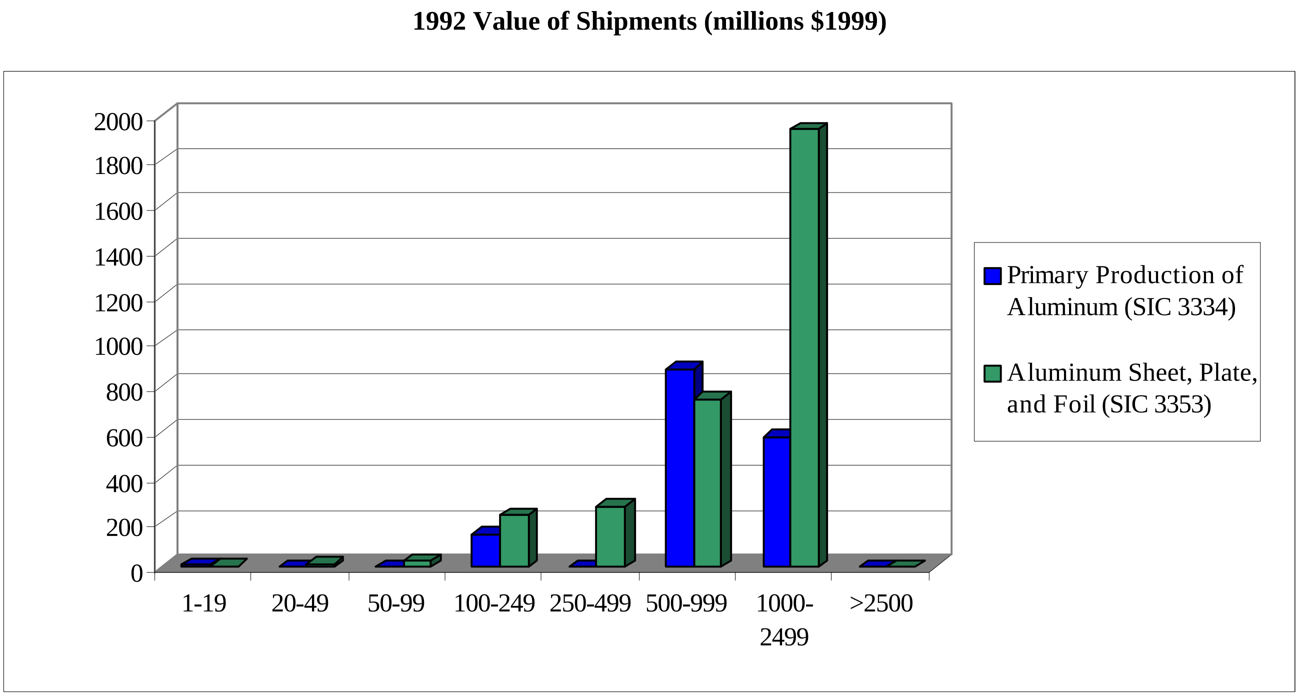
Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

b. Facility Size

The primary aluminum production and aluminum sheet, plate, and foil industries are both characterized by large facilities, with 59 percent and 37 percent of all establishments employing 250 or more employees, respectively. Figure 4E-6 shows that 93 percent of the value of shipments for the primary aluminum production industry is produced by establishments with more than 250 employees. Approximately 88 percent of value of shipments for the aluminum sheet, plate, and foil industry is produced by establishments with more than 250 employees. Establishments in the primary aluminum production and aluminum sheet, plate, and foil sectors with more than 1,000 employees are responsible for approximately 37 and 53 percent of all industry shipments, respectively.

Figure 4E-6: Value of Shipments and Number of Facilities by Employment Size Category for Profiled Aluminum Sectors





Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

c. Firm Size

The Small Business Administration (SBA) defines a small firm for SIC codes 3334 and 3353 as a firm with 1,000 or fewer and 750 or fewer employees, respectively. The size categories reported in the Statistics of U.S. Businesses (SUSB) do not provide data for firms with more and fewer than 750 and 1,000 employees, and it is therefore not possible to apply the SBA size threshold precisely.

- 27 of the 40 firms in the *Primary Aluminum Production* sector had less than 500 employees. Therefore, at least 68 percent of firms are classified as small. These small firms owned 51 facilities, or 53 percent of all facilities in the sector.
- 41 of the 56 firms in the Aluminum Sheet, Plate and Foil sector had less than 500 employees. Therefore, at least 73 percent of firms are classified as small. These small firms owned 41 facilities, or 51 percent of all facilities in the sector.

Table 4E-7 below shows the distribution of firms, facilities, and receipts in SIC 3334 and 3353 by the employment size of the parent firm. While there are some very small firms in each four-digit SIC code, it is unlikely that these small firms operate the facilities that are most likely to be affected the §316(b) requirements.

Table 4E-7: Number of Firms, Establishments and Estimated Receipts by Employment Size Category for the Profiled Aluminum Sectors, 1996

Employment Size Category	Primary Aluminum Production (SIC 3334)			Aluminum Sheet, Plate, and Foil (SIC 3353)		
	Number of Firms	Number of Facilities	Estimated Receipts ($1999 millions)	Number of Firms	Number of Facilities	Estimated Receipts ($1999 millions)
0-19	20	20	(D)	24	24	33
20-99	4	4		9	9	125
100-499	3	3		8	8	484
500-2,499	5	6	814	2	4	(D)
2,500+	8	18	4,120	13	36	
Total	40	51	4,934	56	81	11,331

(D) Withheld by SBA to avoid disclosure of information on individual operations.

Source: Small Business Administration, Statistics of U.S. Businesses.

d. Concentration and Specialization Ratios

Concentration is the degree to which industry output is concentrated in a few large firms. Concentration is closely related to entry and exit barriers with more concentrated industries generally having higher barriers.

The four-firm ***concentration ratio*** (CR4) and the ***Herfindahl-Hirschman Index*** (HHI) are common measures of industry concentration. The CR4 indicates the market share of the four largest firms. For example, a CR4 of 72 percent means that the four largest firms in the industry account for 72 percent of the industry's total value of shipments. The higher the concentration ratio, the less competition there is in the industry, other things being equal.[2] An industry with a CR4 of more than 50 percent is generally considered concentrated. The HHI indicates concentration based on the largest 50 firms in the industry. It is equal to the sum of the squares of the market shares for the largest 50 firms in the industry. For example, if an industry consists of only three firms with market shares of 60, 30, and 10 percent, respectively, the HHI of this industry would be equal to 4,600 ($60^2 + 30^2 + 10^2$). The higher the index, the fewer the number of firms supplying the industry and the

[2] Note that the measured concentration ratio and the HHF are very sensitive to how the industry is defined. An industry with a high concentration in domestic production may nonetheless be subject to significant competitive pressures if it competes with foreign producers or if it competes with products produced by other industries (e.g., plastics vs. aluminum in beverage containers). Concentration ratios are therefore only one indicator of the extent of competition in an industry.

more concentrated the industry. An industry is considered concentrated if the HHI exceeds 1,000.

The four largest firms in primary aluminum production accounted for 59 percent of total U.S. primary capacity in 1992.

The ***specialization ratio*** is the percentage of the industry's production accounted for by primary product shipments. The ***coverage ratio*** is the percentage of the industry's product shipments coming from facilities from the same primary industry. The coverage ratio provides an indication of how much of the production/product of interest is captured by the facilities classified in an SIC code.

Table 4E-8: Selected Ratios for the Profiled Aluminum Sectors

SIC Code	Year	Total Number of Firms	Concentration Ratios					Specialization Ratio	Coverage Ratio
			4 Firm (CR4)	8 Firm (CR8)	20 Firm (CR20)	50 Firm (CR50)	Herfindahl-Hirschman Index		
3334	1987	34	74%	95%	99%	100%	1934	95%	100%
	1992	30	59%	82%	99%	100%	1456	n/a	99%
3353	1987	39	74%	91%	99%	100%	1719	96%	98%
	1992	45	68%	86%	99%	100%	1633	96%	98%

Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

e. Foreign Trade

U.S. aluminum companies have a large overseas presence, which makes it difficult to analyze import data. Reported import data may reflect shipments from an overseas facility owned by a U.S. firm. The import data therefore do not provide a completely accurate picture of the extent to which foreign companies have penetrated the domestic market for aluminum.

The International Trade Administration also does not report the value of imports and exports for the two SIC codes of interest. Instead, data are reported for aluminum and bauxite combined (for imports) and for aluminum and alumina combined (for exports). Table 4E-9 provides the value of imports and exports for these categories. The table shows that while exports remained relatively steady over the nine year period, imports have been increasing.

Table 4E-9: Trade Statistics for Aluminum

Year	Value of imports ($1999 millions)	Value of exports ($1999 millions)
1991	2,708	3,516
1992	3,354	2,922
1993	4,087	2,443
1994	5,769	2,882
1995	5,237	3,143
1996	4,767	3,068
1997	5,830	3,592
1998	6,210	3,450
1999	6,400	3,382
Average Annual Growth Rate	*10%*	*-2%*

Source: U.S. Dept. of Commerce, Bureau of the Census; Foreign Trade Statistics.

4E.3 Financial Condition and Performance

The production of primary aluminum is an electrometallurgical process, which is extremely energy intensive. The aluminum industry is therefore a major industrial user of electricity, spending more than $2 billion annually. Electricity accounts for approximately 30 percent of total production costs for primary aluminum smelting. The industry has therefore pursued opportunities to reduce its use of electricity as a means of lowering costs. In the last 50 years, the average amount of electricity needed to make a pound of aluminum has declined from 12 kilowatt hours to approximately 7 kilowatt hours. (Aluminum Association, undated).

Like integrated steel mills, aluminum manufacturers require massive capital investments to transform raw material into finished product. Because of the high fixed costs of production, earnings can be very sensitive to production levels, with high output levels relative to capacity needed for plants to remain profitable.

Operating margin is a measure of how efficiently companies in an industry manage their costs. Relatively small changes in output or prices can have large positive or negative impacts on operating margins (S&P, 2000). Operating margins do not reflect the recovery of capital costs, however, and therefore are only a limited measure of profitability.

Table 4E-10 below shows trends in operating margins for the primary aluminum and aluminum plate, sheet, and foil sectors between 1987 and 1996. The table shows considerable volatility in the trends for each sector. Operating margins for the primary aluminum sector decreased between 1989 and 1993, reflecting the conditions of oversupply in the market which led to decreasing shipments from U.S. producers (McGraw-Hill, 1998). Those same conditions of oversupply in the market for aluminum led to a steady decrease in prices. Lower prices for aluminum were responsible for lower material costs for the aluminum plate, sheet, and foil sector and a modest increase in operating margins between 1989 and 1992.

Table 4E-10: Operating Margins for the Profiled Aluminum Sectors (Millions $1999)

Year	Primary Aluminum Production (SIC 3334)				Aluminum Sheet, Plate, and Foil (SIC 3353)			
	Value of Shipments	Cost of Materials	Payroll (all employees)	Operating Margin	Value of Shipments	Cost of Materials	Payroll (all employees)	Operating Margin
1987	4,583	2,792	521	28%	12,499	10,320	1,201	8%
1988	5,452	2,913	467	38%	12,537	10,683	1,037	7%
1989	5,545	3,434	520	29%	12,224	9,997	1,027	10%
1990	6,114	4,211	652	20%	11,971	9,345	1,099	13%
1991	6,355	4,656	796	14%	12,110	8,795	1,124	18%
1992	6,538	4,725	901	14%	11,970	8,176	1,140	22%
1993	6,100	4,737	859	8%	11,015	7,847	1,166	18%
1994	5,448	3,710	690	19%	11,600	9,006	1,076	13%
1995	4,909	2,865	548	30%	11,721	9,192	868	14%
1996	5,178	3,347	655	23%	11,883	8,491	1,014	20%

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

4E.4 Facilities Operating CWISs

In 1982, the Primary Metals industries withdrew 1,312 billion gallons of cooling water, accounting for approximately 1.7 percent of total industrial cooling water intake in the United States. The industry ranked 3rd in industrial cooling water use, behind the electric power generation industry, and the chemical industry (1982 Census of Manufactures).

This section presents information from EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* on existing facilities with the following characteristics:

- they withdraw from a water of the United States;
- they hold an NPDES permit;
- they have an intake flow of more than two MGD;
- they use at least 25 percent of that flow for cooling purposes.

These facilities are not "new facilities" as defined by the proposed §316(b) New Facility Rule and are therefore not subject to this regulation. However, they meet the criteria of the proposed rule except that they are already in operation. These existing facilities therefore provide a good indication of what new facilities in these sectors may look like. The remainder of this section refers to existing facilities with the above characteristics as "§316(b) facilities."

a. Cooling Water Uses and Systems

Information collected in EPA's *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* found that an estimated 11 out of 31 primary aluminum producers (34 percent) and 6 out of 57 aluminum sheet, plate, and foil manufacturers (11 percent) meet the characteristics of a §316(b) facility. Most §316(b) facilities in the profiled Aluminum sectors use cooling water for contact and non-contact production line or process cooling, electricity generation, and air conditioning:

- All §316(b) primary aluminum producers use cooling water for production line (or process) contact or noncontact cooling. Another 60 percent use cooling water for air conditioning, 11 percent use cooling water for electricity, and 30 percent have other uses for cooling water.

- All §316(b) aluminum sheet, plate, and foil manufacturers use cooling water for production line (or process) contact and noncontact cooling. Thirty-three percent also use cooling water for air conditioning.

Nine of the 10 §316(b) primary aluminum producers obtain their cooling water from a freshwater stream or river. The other §316(b) primary producer draws from a lake or reservoir. Half of the §316(b) aluminum sheet, plate, and foil manufacturers obtain their cooling water from either a freshwater stream or river, and the other half draw from both lakes or reservoirs and freshwater streams or rivers.

Table 4E-11: Number of §316(b) Facilities by Water Body Type and Cooling System Type for the Profiled Aluminum Sectors

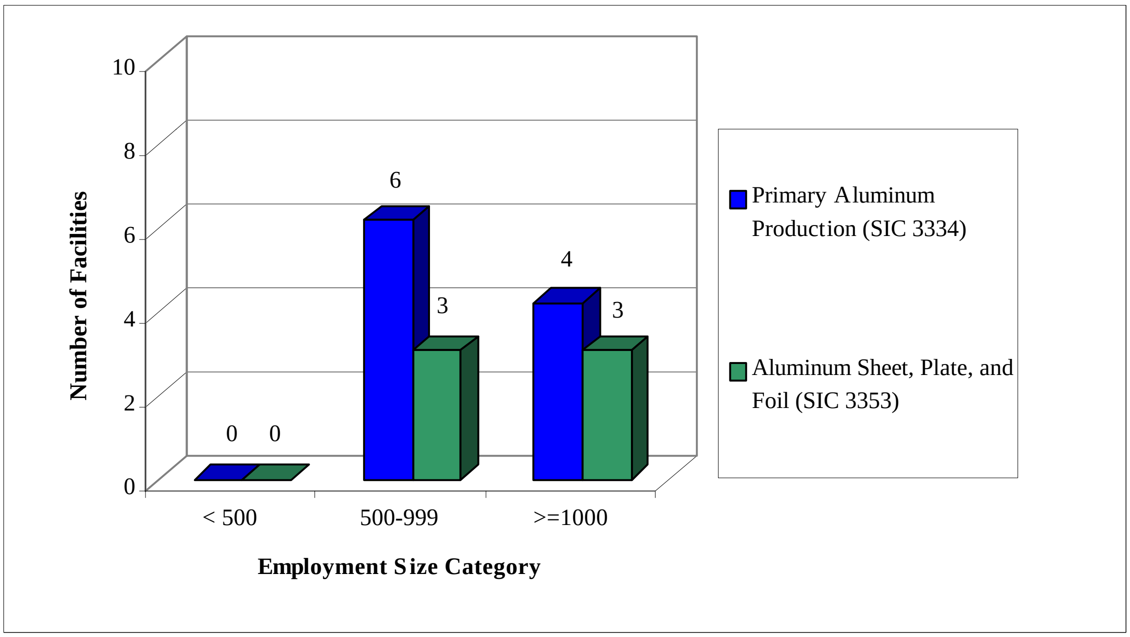
Water Body Type	Cooling System						
	Closed Cycle		Combination		Once Through		Total
	Number	% of Total	Number	% of Total	Number	% of Total	
Primary Production of Aluminum (SIC 3334)							
Freshwater Stream or River	3	33%	3	33%	3	33%	9
Lake or Reservoir	1	100%	0	0%	0	0%	1
Total	***4***	***40%***	***3***	***30%***	***3***	***30%***	***10***
Aluminum Sheet, Plate, and Foil (SIC 3353)							
Freshwater Stream or River	0	0%	0	0%	3	100%	3
Lake and Reservoir and Freshwater Stream and River	3	100%	0	0%	0	0%	3
Total	***3***	***50%***	***0***	***0%***	***3***	***50%***	***6***
Total for Profiled Aluminum Facilities (SIC 3334, 3353)							
Freshwater Stream or River	3	25%	3	25%	6	50%	12
Lake or Reservoir	1	100%	0	0%	0	0%	1
Lake and Reservoir and Freshwater Stream and River	3	100%	0	0%	0	0%	3
Total	**7**	**44%**	**3**	**19%**	**6**	**38%**	**16**

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

b. Facility Size

Both primary §316(b) aluminum producers and §316(b) aluminum sheet, plate, and foil manufacturers are large facilities, measured by employment size. All of the establishments employ over 500 people and 40 percent of primary aluminum producers and 50 percent aluminum sheet, plate, and foil manufacturers employ over 1,000 employees. Figure 4E-7 shows the number of §316(b) facilities by employment size category.

Figure 4E-7: Number of §316(b) Facilities by Employment Size for the Profiled Aluminum Sectors



Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999.

d. Firm Size

EPA used the Small Business Administration (SBA) small entity size standards to determine the number of existing §316(b) profiled aluminum industry facilities owned by small firms. Table 4E-12 shows that three of the ten §316(b) primary aluminum producers are owned by small firms. Another 3 are owned by a firm of unknown size which may qualify as a small firm. None of the §316(b) aluminum sheet, plate, and foil facilities are owned by a small firm. One-half of these facilities, however, are owned by firm of unknown size which may qualify as small firms.

Table 4E-12: Number of §316(b) Facilities by Firm Size for the Profiled Aluminum Sectors

SIC Code	Large		Small		Unknown		Total
	Number	% of SIC	Number	% of SIC	Number	% of SIC	
3334	4	40%	3	30%	3	30%	10
3353	3	50%	0	0%	3	50%	6
Total	**7**	**44%**	**3**	**19%**	**6**	**38%**	**16**

Source: EPA, Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, 1999; D&B Database.

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GLOSSARY

Capital expenditures: As reported in the Economic Censuses, reflects permanent additions and major alterations, as well as replacements and additions to capacity, for which depreciation, depletion, or Office of Minerals Exploration accounts are ordinarily maintained. Reported capital expenditures include work done on contract, as well as by the mine forces. Totals for expenditures include the costs of assets leased from other concerns through capital leases. Excluded are expenditures for land and cost of maintenance and repairs charged as current operating expenses. Also excluded are capital expenditures for mineral land and rights which are shown as a separate item.

Capacity utilization: Indicates the extent to which plant capacity is being used and shows potential excess or insufficient capacity. This profile reports capacity utilization as published by the U.S. Bureau of Census in the Survey of Plant Capacity published in the Current Industrial Reports. The utilization rate is equal to an output index divided by a capacity index. Output is measured by seasonally adjusted indexes of industrial production, and is based on actual output in 1992. The capacity indexes attempt to capture the concept of sustainable practical capacity, which is defined as the greatest level of output that a plant can maintain within the framework of a realistic work schedule, taking account of normal downtime, and assuming sufficient availability of inputs to operate the machinery and equipment in place.

Concentration ratio: The combined percentage of total industry output accounted for by the largest producers in the industry. For example, the four-firm concentration ratio (CR4) refers to the market share of the four largest firms. The higher the concentration ratio, the more concentrated the industry. A market is generally considered highly concentrated if the CR4 is greater than 50 percent.

Coverage ratio: The ratio of primary products shipped by the establishments classified in the industry to the total shipments of such products that are shipped by all manufacturing establishments, wherever classified. An industry with a high coverage ratio accounts for most of the value of shipments of its primary products, whereas an industry with a low coverage ratio produces a smaller portion of the total value of shipments of its primary products produced by all sources.

Employment: Total number of full-time equivalent employees, including production workers and non-production workers.

Export dependence: The share of shipments by domestic producers that is exported; calculated by dividing the value of exports by the value of domestic shipments.

Herfindahl-Hirschman index (HHI): An alternative measure of concentration. Equal to the sum of the squares of the market shares for the largest 50 firms in the industry. The higher the index, the more concentrated the industry. The Department of Justice uses the HHI for antitrust enforcement purposes. The benchmark used by DOJ is 1,000, where any industry with an HHI less than 1,000 is considered to be unconcentrated. The advantage of the HHI over the concentration ratio is that the former gives information about the dispersion of market share among all the firms in the industry, not just the largest firms (Arnold, 1989).

Import penetration: The share of all consumption in the U.S. that is provided by imports; calculated by dividing imports by reported or apparent domestic consumption (the latter calculated as domestic value of shipments minus exports plus imports).

Labor productivity: Amount of output produced per unit of labor input on average. Calculated in this profile as real value added divided by production hours. This measure indicates how an industry uses labor as an input in the production process. Changes over time in labor productivity may reflect changes in the relative use of labor versus other inputs to produce output, due to technological changes or cost-cutting efforts. Changing patterns of labor utilization relative to output are particularly important in understanding how regulatory requirements may translate into job losses, both in aggregate and at the community level.

Nominal values: Dollar values expressed in current dollars.

Operating margin: Measure of the relationship between input costs and the value of production, as an indicator of financial performance and condition. Everything else being equal, industries and firms with lower operating margins will generally have less flexibility to absorb the costs associated with a regulation than those with higher operating margins.

Operating margins were calculated in this profile by subtracting the cost of materials and total payroll from the value of shipments. Operating margin is only an approximate measure of profitability, since it does not consider capital costs and other costs. It is used to examine trends in revenues compared with production costs within an industry; it should not be used for cross-industry comparisons of financial performance.

Primary product shipments: An establishment is classified in a particular industry (4-digit SIC codes) if its shipments of the primary products of that industry exceed in value its shipments of the products of any other single industry. An establishment's primary product shipments are those products considered primary to its industry.

Producer production indexes (PPI): A family of indexes that measures the average change over time in selling prices received by domestic producers of goods and services (Bureau of Labor Statistics, PPI Overview). Used in this profile to convert nominal values into real 1997 dollar values.

Real values: Nominal values normalized using a price index to express values in a single year's dollars. Removes the effects of price inflation when evaluating trends in dollar measures.

Secondary product shipments: An establishment's products that are considered secondary to the industry in which the establishment is classified and primary to other industries. For example, a petroleum refinery classified in SIC code 2911 would produce petroleum products as primary products, but might produce organic chemicals as secondary products.

Specialization ratio: The ratio of primary product shipments to total product shipments (primary and secondary, excluding miscellaneous receipts) for the establishments classified in a particular industry (4-digit SIC code). An industry with a specialization ratio of 100 percent would, by definition, produce only its primary products. In contrast, a low specialization ratio indicates that much of an industry's output consists of secondary products.

Value added: A measure of manufacturing activity, derived by subtracting the cost of purchased inputs (materials, supplies, containers, fuel, purchased electricity, contract work, and contract labor) from the value of shipments (products manufactured plus receipts for services rendered), and adjusted by the addition of value added by merchandising operations (i.e., the difference between the sales value and the cost of merchandise sold without further manufacture, processing, or assembly) plus the net change in finished goods and work-in-process between the beginning-and end-of-year inventories. Value added avoids the duplication in value of shipments as a measure of economic activity that results from the use of products of some establishments as materials by others. Value added is considered to be the best value measure available for comparing the relative economic importance of manufacturing among industries and geographic areas.

Value of shipments: Net selling values of all products shipped as well as miscellaneous receipts. Includes all items made by or for an establishments from materials owned by it, whether sold, transferred to other plants of the same company, or shipped on consignment. Value of shipments is a measure of the dollar value of production, and is often used as a proxy for revenues. This profile uses value of shipments to indicate the size of a market and how the size differs from year to year, and to calculate operating margins.

Chapter 5: Baseline Projections of New Facilities

INTRODUCTION

Facilities regulated under the §316(b) New Facility Rule are new greenfield manufacturing facilities and electric generators that operate a cooling water intake structure (CWIS), require a National Pollutant Discharge Elimination System (NPDES) permit, have a design intake flow of greater than two million gallons per day (MGD), and use at least 25 percent of their intake water for cooling purposes. The overall costs and economic impacts of the proposed rule depend on the number of new facilities subject to the rule, and on the proposed construction, design, location, and capacity of their CWISs.

This chapter presents forecasts of the number of new electric generators and manufacturing facilities subject to the proposed §316(b) New Facility Rule that will begin operating between 2001 and 2020. The chapter consists of three sections. The first section presents estimates of the number and characteristics of new electric generating facilities. The second section presents estimates of the number of new manufacturing facilities. Each section discusses uncertainties about the estimated number and type of facilities that will be constructed in the future. The third section summarizes the results of the new facilities forecasts.

CHAPTER CONTENTS

5.1 NEW ELECTRIC GENERATORS

EPA used two data sources to estimate the number of new electric generators subject to the proposed §316(b) New Facility Rule: capacity forecasts from the Energy Information Administration's (EIA) *Annual Energy Outlook 2000* (AEO2000) and a database of planned new generating capacity (the *NEWGen database* created and maintained by RDI Consulting). The analysis involved two steps in estimating the number and characteristics of new generators for the first ten years (2001 to 2010) and for the second ten years (2011 to 2020) of the forecast period.

5.1.1 Forecast for 2001 to 2010

EPA used the NEWGen database to identify specific new electric generators that would be affected by the proposed rule, based on their cooling water source and their CWIS location and characteristics. Since the NEWGen database only covers a portion of the 10-year forecasting period, EPA supplemented this facility-specific information with macro-level electric capacity forecasts from EIA's AEO2000.[1]

a. NEWGen Sample Facilities

The NEWGen database is created and maintained by Resource Data International's (RDI) Energy Industry Consulting Practice. EPA used this database (beta version as of January 2000) to identify planned utility and nonutility electric generators that are subject to the proposed §316(b) New Facility Rule.

[1] According to RDI, the lead time for permitting and construction of a new electric generating facility is approximately three years. Projects that might be constructed substantially beyond three years in the future are therefore not likely to be reflected in this data set. The NEWGen database alone therefore cannot provide a complete forecast of new electric generating facilities for the entire analysis period.

The database provides facility-level data on 466 electric generation projects, including new (greenfield) facilities and additions and modifications to existing facilities, proposed over the next several years. Information in the NEWGen database includes: generating technology, fuel type, generation capacity, owner and holding company, electric interconnection, project status, on-line dates, and other operational details. The majority of the information contained in this database is obtained from trade journals, developers, local authorities, siting boards, and state environmental agencies.

The 466 facilities contained in the NEWGen database include new facilities in Canada and Mexico and existing facilities in the U.S. These facilities are irrelevant to the proposed §316(b) New Facility Rule and were therefore excluded from the analysis. The Agency evaluated each of the remaining 331 facilities to assess whether they would be subject to the proposed rule, based on the following factors:

- ***Project status:*** EPA included only projects that are in "Early Development," "Advanced Development," or "Under Construction." The analysis did not include projects that were listed as "Canceled" or "Tabled" because those projects are unlikely to be completed.

- ***Date of initial commercial operation:*** The rule only covers facilities that will begin commercial operation on or subsequent to the assumed promulgation date of August 13, 2001.[2] The analysis therefore excluded facilities with an operation date before August 13, 2001.

- ***Facility type:*** The analysis focuses on the subset of facilities that uses steam as a prime mover. Therefore, EPA included only those new facilities that will use steam electric generators (including steam turbine and combined-cycle prime movers).[3] The analysis excluded facilities using internal combustion turbines, hydroelectric turbines, combustion turbines, and wind or solar technologies, because they generally do not require cooling water and will therefore not be subject to this proposed regulation.

- ***Availability of CWIS information:*** EPA analyzed only those facilities that have filed sufficient information with their permitting authorities to determine their proposed cooling water source.[4]

A total of 56 facilities in the NEWGen database met these criteria. The following discussion refers to this subset of 56 facilities as the "NEWGen sample facilities."

The steam electric facilities in the NEWGen database reflect a strong trend toward combined-cycle generation technologies. Figure 5-1 shows that the large majority of the new facilities, 88 percent, are proposed with a combined-cycle prime mover. This trend is of significance to the proposed §316(b) New Facility Rule because combined-cycle technologies require less cooling water per unit of output than do other steam electric generating technologies. Analyses show that a combined-cycle facility uses approximately one third of the cooling water compared to a facility of the same size using steam turbines. Combined-cycle/cogeneration facilities are the second most common type of new facility in the NEWGen sample, representing approximately five percent of the new steam electric facilities.[5] Two facilities are planned with a combustion turbine/cogeneration technology. Only one coal facility and one geothermal facility are among the 56 sample facilities. The 56 sample facilities account for over 40,000 megawatts (MW) of new capacity. The combined-cycle facilities represent over 91 percent of these new capacity additions, the three combined-cycle/cogeneration facilities account for approximately five percent of the sample facility capacity, and the other three facility types represent less than three percent each of the sample facility capacity.

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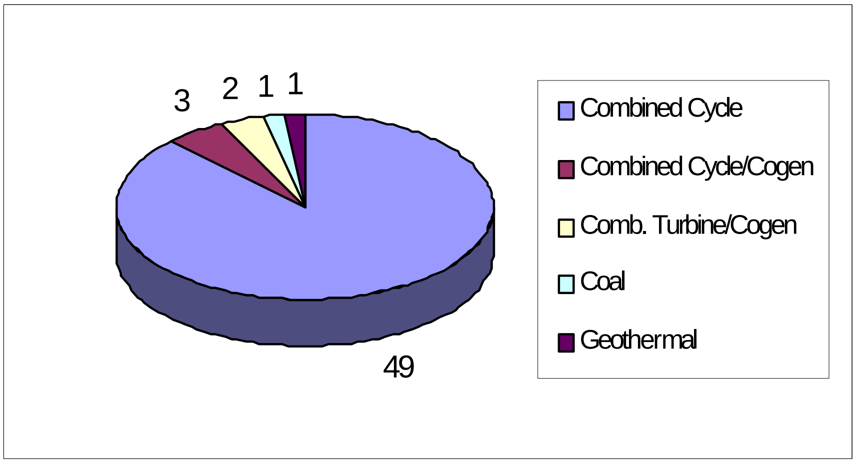
[2]EPA also included facilities for which no date of commercial operation was reported.

[3]A combined-cycle prime mover is an electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines.

[4]Information on a facility's permitting status and proposed cooling water source was obtained from state permitting authorities. Facilities for which cooling water source information is not available will not be disregarded when determining overall impacts from the proposed rule. The extrapolation methodology presented in subsection 5.1.1.c accounts for these facilities by including sufficient new facilities to account for the total projected growth in steam electric generating capacity.

[5]Cogeneration is the combined production of electricity and another form of useful thermal energy (such as heat or steam) which is used for industrial, commercial, heating, or cooling purposes.

Figure 5-1: Number of NEWGen Sample Facilities by Facility Type



Source: RDI, 2000.

b. Regulated Facilities in the NEWGen Sample

Not all 56 new steam electric facilities identified from the NEWGen database will be subject to the rule. EPA obtained information on the CWIS characteristics of the 56 electric generators, to determine the number of new facilities that would fall within the scope of the regulation. Facilities subject to the proposed rule must:

- withdraw from a water of the United States through a new CWIS;
- hold or require an NPDES permit;
- have a design intake flow of more than two million gallons per day (MGD); and
- use at least 25 percent of the total intake flow for cooling purposes.

An analysis of permit applications for the 56 sample facilities showed that only seven of the 56 facilities meet all of these criteria, and thus fall within the scope of the proposed §316(b) New Facility Rule. Table 5-1 indicates why 49 of the 56 NEWGen sample facilities are not in scope and hence will not incur any regulatory costs.

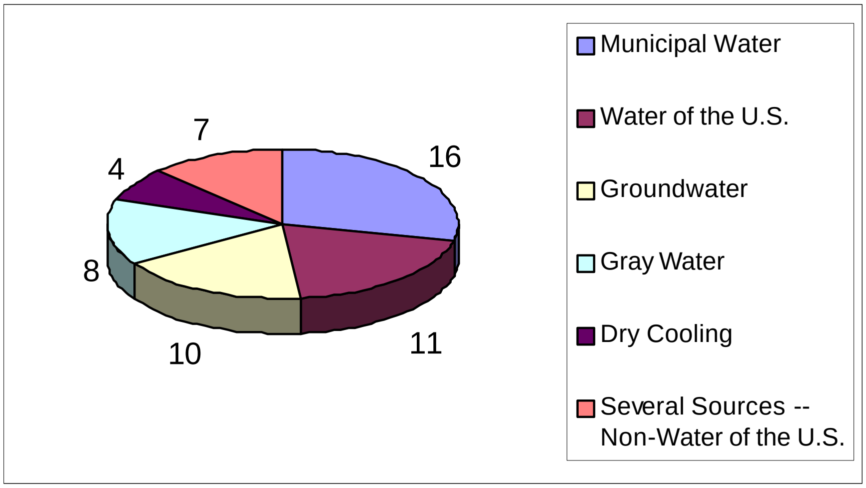
Table 5-1: In Scope Status of NEWGen Sample Facilities

In Scope Status	Number of Facilities	Percent of Sample Facilities
In Scope	7	12.5%
Out of Scope	49	87.5%
Does not withdraw from waters of the U.S.	*45*	*80.4%*
Existing CWIS	*3*	*5.4%*
No NPDES permit	*1*	*1.8%*
Design intake flow less than 2 MGD	*0*	*0.0%*
Less than 25% of intake water used for cooling purposes	*0*	*0.0%*

Source: EPA analysis of information from state permitting authorities, 2000.

The majority of the sample facilities (80 percent) fall outside the scope of the proposed rule because they do not withdraw from a water of the U.S. As shown in Figure 5-2, municipal water, groundwater, and gray water (treated effluent from sewage systems) are the most common alternative sources of cooling water. Four of the 56 new facilities are planning to use a dry cooling system.

Figure 5-2: Number of NEWGen Sample Facilities by Cooling Water Source



Source: EPA analysis of information from state permitting authorities, 2000.

Table 5-2 describes the operational characteristics of the seven in scope sample facilities.

Table 5-2: Operational Characteristics of In Scope NEWGen Sample Facilities

Facility Name	NERC Region	Facility Type	Fuel Source	Capacity (MW)	Projected On-Line Date
GenA	NPCC	CC	Natural Gas	750	2002
GenB	MAIN	CC	Natural Gas	1,100	2001 -2003
GenC	ERCOT	CC	Natural Gas	510	2001 - 2003
GenD	NPCC	CC	Natural Gas	525	2001
GenE	NPCC	CT/Cogen	Natural Gas	475	2002
GenF	NPCC	CC	Natural Gas	544	2001
GenG†	SERC	CC/Cogen	Natural Gas	650	2002
		CT	Natural Gas	150	2002

† GenG is proposing to begin operation of its units in two phases.

Source: RDI, 2000.

The majority of the in scope facilities are concentrated in the Northeast: four of the seven facilities, or 57 percent, will be built in the Northeast Power Coordinating Council (NPCC). The remaining three facilities will be located in three different regions: the Mid-America Interconnect Network (MAIN), the Electric Reliability Council of Texas (ERCOT), and the Southeastern Electric Reliability Council (SERC).

The seven in scope facilities range in capacity from 475 to 1,100 MW. All seven will use natural gas as their primary fuel source. Five facilities (GenA, GenB, GenC, GenD, and

GenF) plan on using combined-cycle (CC) technologies to generate electricity. GenE will use a combined-cycle/cogeneration technology, and GenG plans to use two units, one combined-cycle/cogeneration unit and one smaller combustion turbine.

c. Extrapolation of NEWGen Data to 10 Years

The NEWGen database only covers a portion of the 10-year forecasting period. EPA therefore used the U.S. Department of Energy capacity forecast described in EIA's AEO2000 to estimate the total number of new facilities for the period between 2001 and 2010. EIA's National Energy Modeling System (NEMS) projects future market conditions using a range of assumptions about overall economic growth, global fuel prices, and legislation and regulation affecting energy markets. NEMS forecasts are based on modeled equilibrium of supply and demand for electricity (EIA, 1999b).

The NEMS "Reference Case" forecasts for steam electric capacity provided the basis for estimating the number of new steam electric generating facilities constructed over the next ten years. The total number of new steam electric facilities is calculated by dividing the projected capacity, 73,591 MW, by the average capacity of the 56 NEWGen facilities, 723 MW.[6] Based on this methodology, EPA estimates that a total of 102 new steam electric facilities will be constructed over the next 10 years. Assuming that the proportion of these 102 facilities that will be in scope of this regulation is the same as for the NEWGen 56 facilities results in a forecast of 13 new in scope facilities (Table 5-3). This approach assumes that all new projected steam electric capacity will come from new greenfield facilities and may overestimate the number of new electric generators potentially affected by this rule, since some of the capacity growth may come from expansions or repowering of existing facilities.

[6] Steam electric capacity additions include planned and unplanned additions of coal steam and combined-cycle. EIA does not project any additions from nuclear power or other fossil steam (including oil-, gas-, and dual-fired capacity) over the next 20 years (AEO, 2000).

Table 5-3: Projection of New and Affected Electric Generators over 10 Years

	Sample Facilities (NEWGen)	10-Year Projection
Number of Facilities	56	102
Number of In Scope Facilities Incurring Compliance Costs	7	13†

† (7/56 * 102)

Source: EPA analysis based on RDI, NEWGen Database, January 2000; AEO 2000.

The electric power industry is currently experiencing a rapid expansion due the transition from a highly regulated monopolistic industry to a more competitive industry. This expansion has contributed to a surge in the number of generating plants being planned or under construction. As discussed earlier, only steam electric facilities use substantial amounts of cooling water and were considered for this analysis. The NEWGen sample data for new steam electric facilities show a trend toward combined-cycle generating technologies. This trend may reflect the transition toward competitive pricing for electricity. In competitive markets, prices will reflect the interaction of supply and demand for electricity. During most time periods, the price of electricity will be set by the generating unit with the highest operating costs needed to meet spot market generation demand (i.e., the "marginal cost" of production). The lower capital and operating cost usually associated with gas generation technologies may be one reason for the trend toward combined-cycle generating units in new facilities.

The NEWGen sample data also show a trend away from the use of a water of the U.S. as cooling water. Table 5-1 shows that 80 percent of the sample facilities use alternative sources of cooling water. EPA believes this trend reflects the increased competition for water and an increasing awareness of the need for water conservation.

Taken together, the trend toward combined-cycle generating technologies, which have small cooling water requirements per unit of output, and the trend away from the use of waters of the U.S. as cooling water result in a low projected number of regulated facilities, despite the expected expansion in new generating capacity.

5.1.2 Forecast for 2011 to 2020

For the second 10 years of the analysis, 2011 to 2020, no facility-specific information on new electric generators and their CWIS characteristics is available. EPA therefore relied on EIA's capacity forecasts in the AEO2000 and assumptions about the size, location, and operational characteristics of facilities projected to begin operation between 2011 and 2020.

The AEO2000 forecasts additions of 17,190 MW of coal steam capacity and 61,584 MW of combined-cycle capacity between 2011 and 2020. No new capacity additions are expected for other types of steam electric power, including nuclear power and other fossil steam. EPA made the following assumptions about the number of new facilities that will provide this additional capacity and their projected in scope status with respect to this proposed rule:

Coal steam capacity

- 82 percent of projected capacity additions will come from new facilities;[7] 18 percent will come from repowering or additions to existing facilities which are not covered under this proposed rule. Of the 17,190 MW of coal steam capacity additions, new facilities will therefore account for approximately 14,100 MW.
- New coal steam facilities will have a generating capacity of 800 MW. Eighteen new coal-fired facilities of 800 MW each will be required to provide the 14,100 MW of new capacity.
- Ten percent of new coal steam facilities will not be in scope of this regulation. This assumption results in a total of 16 new coal facilities that are expected to begin operation between 2011 and 2020 and be subject to this regulation.

Combined-cycle capacity

- New facilities will account for all combined-cycle capacity additions projected to come on-line between 2011 and 2020.

[7] This estimate is based on the share of coal capacity additions from new facilities reported in the NEWGen database.

- The average size of a new combined-cycle facility is the same as the average size of the 56 sample NEWGen facilities, i.e., 723 MW. Eighty-five facilities of 723 MW each will be required to provide the forecasted 61,584 MW of additional combined-cycle capacity.

- The in scope rate of new combined-cycle facilities is the same as that of the 56 NEWGen facilities, 12.5 percent. Based on this assumption, a total of 11 new combined-cycle facilities are expected to begin operation between 2011 and 2020 and be subject to this regulation

5.1.3 Summary of Forecasts for New Electric Generators

EPA estimates that a total of 205 new steam electric generators will begin operation between 2001 and 2020. 102 new facilities are expected to begin operation in the first ten years and 103 in the second ten years. Of the total number of new plants, EPA projects that 40 will be in scope of the proposed §316(b) New Facility Rule. Sixteen are expected to be coal-fired facilities and 24 combined-cycle facilities.

Table 5-4 summarizes the results of the analysis.

Table 5-4: Number of Projected New Electric Generators (2001 to 2020)

Year of Initial Operation	Total Number of New Facilities			Facilities In Scope of the Proposed Rule		
	Coal	Combined-Cycle	Total	Coal	Combined-Cycle	Total
2001 - 2010	0	102	102	0	13	13
2011 - 2020	18	85	103	16	11	27
Total	18	187	205	16	24	40

Source: EPA Analysis, 2000.

5.1.4 Uncertainties and Limitations

There are substantial uncertainties in EPA's projections of the number of new electric generators that will be subject to the proposed §316(b) New Facility Rule. EPA used two main data sources to derive the estimates: RDI's NEWGen database and EIA's AEO2000. While EPA has a high degree of confidence in the projection of total new steam electric capacity over the next ten years, there is more uncertainty about the number of new facilities over the second ten years. In addition, there is uncertainty about the portion of new capacity that will be provided by new in scope facilities. The projected number of new facilities for 2001 to 2010 assumes that the mix in new generating capacity over the next ten years will be identical to the mix planned over the next few years, as reflected in the NEWGen database. This assumption is realistic only if there are no significant changes in the relative efficiency and cost of constructing and employing the various steam electric generating technologies.

In addition, the electric power industry is in the middle of a major restructuring as the result of industry deregulation. While predictions about economic and technological trends 20 years into the future are always challenging, this is particularly the case for an industry undergoing substantial structural changes.

EPA believes that the trend toward closed-cycle cooling and the use of alternative cooling water sources, as observed in the NEWGen sample data, stems from an increasing consciousness in many parts of the country of the value of aquatic resources and the need to conserve water. As a result, EPA expects that the characteristics observed in the NEWGen database are not short-term phenomena that are tied to economic conditions but represent developments that are likely to continue beyond the current business cycle. The Agency therefore believes that the projected aggregate number of new in scope facilities is realistic, although there are uncertainties about specific characteristics of the new facilities.

5.2 New Manufacturing Facilities

Data on industrial water use presented in Chapter 2 showed that the Paper and Allied Products (SIC 26), Chemicals and Allied Products (SIC 28), Petroleum and Coal Products (SIC 29), and Primary Metals (SIC 33) industries account for more than the 90 percent of the water used for cooling purposes in the manufacturing sector. The economic analysis for manufacturing facilities therefore focuses on these industries. Other industrial sectors draw relatively small volumes of water for cooling purposes, and it is unlikely that significant numbers of facilities in these industries will exceed the two MGD threshold. The forecasts of new in scope facilities presented in this section cover the same 20-year time frame used for the projections of electric generation facilities.

5.2.1 Methodology

Forecasts of the number of new greenfield facilities that will be built in the various industrial sectors are generally not available over the 20-year time period required for this analysis. Information on the likely design and location characteristics of new facilities that will determine their status under the proposed rule is also not generally available for planned manufacturing facilities. EPA therefore estimated the number of new facilities based on general industry growth forecasts and other information for each industry, and used information on the characteristics of existing facilities in each industry to project the portion of these new facilities that will be subject to the proposed rule.

Information on existing facilities from the §316(b) *Industry Screener Questionnaire* provided a starting point for the forecast. The screener questionnaire results include information on the number and characteristics of existing facilities in the four industry sectors of interest. The Agency reviewed these facilities to determine how many of the screener facilities in each industry have NPDES permits, use CWISs that draw from a water of the U.S., have an intake flow of more than two MGD, and use at least 25 percent of that flow for cooling purposes.

Projected growth rates for value of shipments in each industry were used to project future growth in capacity. A number of sources provide forecasts, including the annual *U.S. Industry Trade & Industry Outlook*, USGS industry profiles for metals industries, and other sources specific to each industry.[8] EPA assumed that the growth in capacity will equal growth in the value of shipments, except where industry-specific information supported alternative assumptions. This assumption will overstate the growth in capacity to the extent that some growth in shipments will be provided by underutilized existing capacity. Some of the projected growth in capacity may also result from increasing efficiency or expansions in capacity at existing facilities rather than building new facilities. Information from industry sources provided a basis for estimating the potential for construction of new greenfield facilities for some industries. In other cases, EPA assumed as a default that 50 percent of the projected growth in capacity will be attributed to new greenfield facilities.

EPA also assumed that new greenfield plants will be the same size on average as the existing screener plants in the same industry. Therefore, the projected capacity growth rate multiplied by the percentage of capacity growth that is expected to come from new facilities is applied to the number of screener plants in each industry to calculate the total number of new plants.

Not all of the projected new facilities will be subject to requirements under the proposed rule. EPA assumed that the characteristics of new facilities will be similar to the characteristics of existing screener facilities (i.e., the same proportion of new as existing facilities would have NPDES permits, would draw cooling water from a water of the U.S., and would have specific intake volumes and types of CWIS). Therefore, the number of new in scope facilities is calculated by applying the percentage of screener facilities that have NPDES permits, draw from a water of the U.S., have an intake flow of more than two MGD, and use 25 percent of intake flow for cooling purposes to the total number of projected new plants. This approach most likely overstates the number of new facilities that will incur regulatory costs, because new facilities may be more likely than existing ones to recycle water and use cooling water sources other than a water of the U.S.

Section 5.2.2 below presents EPA's projection of the number of new facilities over the first *ten* years of the rule (2001 to 2010). EPA made the simplifying assumption that the same number of facilities would begin operation during the second ten years (2011 to 2020), and that these facilities would have characteristics similar to the facilities that will begin operation during the first ten years.[9]

5.2.2 Projected Number of New Manufacturing Facilities

a. Paper and Allied Products (SIC 26)

The §316(b) Industry Screener Questionnaire identified four 4-digit SIC codes in the Paper and Allied Products Industry (SIC 26) which are likely to be relevant to the proposed rule:

2611 – Pulp Mills
2621 – Paper Mills
2631 – Paperboard Mills
2676 – Sanitary Paper Products

EPA analyzed these industry segments to estimate the number of new in scope facilities in the Paper and Allied Products Industry.

[8] A complete list of data sources used can be found in the References at the end of this chapter.

[9] The Summary of Baseline Projections presented in Section 5.3 shows the estimated number of new facilities for the entire forecasting period.

❖ ***Projected growth in shipments***

Shipments of pulp and paper products are closely tied to the overall state of the U.S. and world economies (McGraw-Hill, 1999). Product exports are expected to increase as barriers to foreign market access are reduced through the North American Free Trade Agreement (NAFTA) and the General Agreement on Tariffs and Trade (GATT) (Stanley, 2000). Industry sources project the following growth rates for different segments of the market (Stanley, 2000):

- Pulp mill shipments (SIC 2611) are expected to increase by 1.75 percent annually over the 5-year period 2000 through 2004, with most of the growth representing increased exports.

- Shipments from the paper and paperboard mills sector (SICs 2621, 2631) are expected to increase about 1.8 percent annually from 2000 through 2004.

- No specific forecasts for sanitary paper products (SIC 2676) are available. EPA therefore assumed that between 1999 and 2003 shipments from these facilities will grow at the same rate as the overall U.S. GDP, or 2.5 percent annually (U.S. DOE, 2000).

❖ ***Projected number of new facilities***

Most sectors of the paper industry have been consolidating, with slower growth in capacity than in the past. According to the S&P Paper and Forest Products Industry Survey (S&P, 1999a), most companies that have increased operating capacity in recent years have taken over existing mills rather than constructing new mills. Those firms which cannot find a merger partner or an acquirable mill are often modernizing existing facilities rather than constructing a major new facility.

New capacity additions in 1999 in the pulp and paper industry were at their lowest level in the past 10 years, and the same is expected for 2000. According to the 40th annual Capacity Survey by the American Forest & Paper Association (AF&PA), U.S. capacity to produce paper and paperboard will increase by an annual average of 0.9 percent over the period 1999 to 2001 (pponline.com, 1999). This represents the lowest level of extended capacity additions in almost 40 years. The AF&PA survey cites several factors to explain the slow growth in capacity, including a highly competitive trade environment for some grades, competing demands for the industry's capital, and mill and machine shutdowns. Although most conditions influencing the industry are conducive to some growth, certain grades are experiencing reduced demand. Several pulp mills closed during the second half of 1998, and additional market pulp capacity was closed during 1999. According the AF&PA survey, 577,000 tons of paper and paperboard capacity was removed in 1998 and 2.5 million tons in 1999, mostly in the containerboard grades. Standard and Poor's (S&P) estimates that 6 percent of U.S. containerboard capacity was shut down between late 1998 and early 1999 (S&P, 1999). The recent reduced investment in new capacity is likely to continue. Any growth in production in the pulp, paper, and paperboard mill sectors (SICs 2611, 2621, and 2631) will likely result from increased efficiency at existing facilities, reopening of capacity that is currently idle, or perhaps rebuilding or expanding existing facilities (Stanley, 2000; Jensen, 2000). Therefore, EPA assumed that none of the projected growth in these industries would result from new greenfield facilities.

Substantial growth has occurred in the secondary fiber deink sector since 1990. The number of deink facilities has grown from 43 (1990) to about 77 over the past ten years. The sanitary paper products sector (SIC 2676) potentially includes deink facilities and may therefore experience construction of new greenfield facilities. EPA does not expect these new deink facilities to be in scope, however, because evidence suggests that cooling water intake flows of stand-alone deink facilities are well below the 2 MGD minimum flow threshold of the proposed §316(b) New Facility Rule (Environmental Assessment for Wisconsin Tissues, Weldon, N.C.). The existing facilities in SIC 2676 identified in the screener questionnaire all have intake flows substantially above two MGD, and are therefore likely to be in the non-deink part of SIC 2676. No growth is projected for new non-deink facilities in SIC 2676.

Table 5-5 presents the number of existing facilities in the four analyzed SIC codes and the projected industry growth (both the annual growth rate and the compounded growth rate over ten years) but shows that none of the growth in SIC 26 is expected to result from new facilities.

Table 5-5: Projected Number of New Pulp and Paper Facilities (SIC 26)							
SIC	Number of Existing Facilities[1]		Projected Industry Growth			Estimated Number of New Facilities	
	Total Screener Facilities (1998)	With CWIS, NPDES Permit, Flow > 2 MGD, and 25% for Cooling	Annual	Over 10 Years[2]	Share of Growth from New Facilities	Total[3]	In Scope[4]
2611	66.1	43.2	1.75%	18.94%	0.0%	0	0
2621	285.5	127.5	1.80%	19.53%	0.0%	0	0
2631	185.9	44.8	1.80%	19.53%	0.0%	0	0
2676[5]	3.8	3.8	2.50%	28.01%	0.0%	0	0
Total	541	219				0	0

[1] From screener survey results.
[2] Total percentage growth over 10 years, based on the forecasted annual growth rate $[(1 + \text{annual rate})^{10} - 1]$.
[3] Equal to total number of screener facilities * (1 + 10-year growth rate) * share of growth from new facilities.
[4] Equal to estimated total number of new facilities * ratio of number of screener facilities with CWIS, NPDES permit, flow > 2 MGD, and at least 25% use for cooling to the total number of screener facilities.
[5] Screener respondents in this SIC code are assumed to be facilities other than deink facilities.

Source: §316(b) Industry Screener Questionnaire and various industry sources.

b. Chemicals Manufacturing (SIC 28)

The §316(b) Industry Screener Questionnaire identified sixteen 4-digit SIC codes in the Chemicals Manufacturing Industry (SIC 28) that include facilities with NPDES permits, that use a CWIS, draw from a water of the U.S., and use at least 25 percent of the intake for cooling purposes:

2812 – Alkalies and Chlorine
2813 – Industrial Gases
2616 – Inorganic Pigments
2819 – Industrial Inorganic Chemicals, NEC
2821 – Plastics Material and Synthetic Resins, and Nonvulcanizable Elastomers
2823 – Cellulosic Manmade Fibers
2824 – Manmade Organic Fibers, Except Cellulosic
2833 – Medicinal Chemicals and Botanical Products
2834 – Pharmaceutical Preparations
2841 – Soaps and Other Detergents, Except Speciality Cleaners
2865 – Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments
2869 – Industrial Organic Chemicals, NEC
2873 – Nitrogenous Fertilizers
2874 – Phosphatic Fertilizers
2892 – Explosives
2899 – Chemicals and Chemical Preparations, NEC

EPA analyzed each of these sixteen industry segments to estimate the number of new in scope facilities in the Chemicals Manufacturing Industry.

❖ *Projected growth in shipments*

The Kline *Guide to the U.S. Chemical Industry* projects that shipments of the products from the chemical industry will generally follow the pattern of overall industrial growth over the next decade (Kline, 1999). The Chemical Manufacturers Association (CMA) reported that most chemical companies have been experiencing tough competition, with strong downward pressure on pricing, the loss of some export markets, and growing over-capacity. In response to an uncertain outlook for global chemical demand, firms are accelerating the pace of restructuring, joint venture, de-merger, and merger. Industry consolidation, competition, and continuing globalization has led to high capacity in many products and generally lower profitability than in the past (S&P, 2000). Industry employment will decline slightly during the next few years as a result of continued downsizing and outsourcing efforts. Some of the uncertainties facing the U.S. chemical industry include rising oil prices and global over-capacity in petrochemicals (Swift, 1999). More specifically, industry sources project the following growth rates for value of shipments in different chemicals market segments (Kline, 1999, except where noted):

- Shipments of industrial gases (SIC 2813) are projected to grow at a rate of 2.8 percent annually through 2003, while the rest of the inorganic chemicals sector (SIC 281) will grow at a rate of 1.9 percent annually.

- Shipments in the plastics industry (SIC 2821) are forecasted to grow more than 4 percent annually through 2003 (McGraw-Hill, 1999; Kline, 1999).

- Man-made fibers production (SICs 2823 and 2824) is expected to grow 1.9 percent annually through 2000. EPA assumed that this trend will continue in the near future.

- Medicinal chemicals shipments (SIC 2833) are expected to grow by 2.8 percent per year through 2003. The growth will be fueled by new products and increased demand for pharmaceuticals (McGraw-Hill, 1999). Growth in shipments of U.S. pharmaceutical products (SIC 2834) are projected to average "in the mid-single digits" for five years (McGraw-Hill, 1999). EPA assumed an annual growth rate of 5 percent for SIC 2834.

- Shipments of soaps and detergents (SIC 2841) are projected to increase by 2.4 percent per year through 2003.

- Basic petrochemical shipments (SIC 2865) are expected to grow by 3.3 annually through 2003 (Kline, 1999). There have been supply shortages for the largest volume organic chemical (ethylene), and capacity is expected to expand over the next year to ease the tightness in supply. Two facilities in Texas, each with annual capacity of about 1.8 billion pounds of ethylene, are expected to be completed by late 2000 (S&P, 2000).

- Shipments of industrial organic chemicals not elsewhere classified (SIC 2869) are projected to increase by 3 percent annually through 2003 (McGraw-Hill, 1999).

- Shipments of fertilizers are projected to increase by 2.4 percent annually through 2003 (Kline, 1999). The fertilizer industry (SICs 2873 and 2874) reflects a modest projected growth in the underlying American farm economy. The industry has undergone significant consolidation in recent years (McGraw-Hill, 1999).

- Shipments of explosives (SIC 2892) are expected to grow 4.1 percent per year.

- Shipments of miscellaneous chemicals (SIC 2899) are expected to increase by 3 percent annually through 2003 (McGraw-Hill, 1999).

❖ ***Projected number of new facilities***

EPA estimates that 284 new facilities may be constructed over the next ten years in the relevant SIC 28 segments, as shown in Table 5-6. Of these, 24 are expected to be in scope of the proposed §316(b) New Facility Rule. Nine of the in scope facilities are expected to produce industrial organics (SIC 2869), and three are plastics manufacturing facilities (SIC 2821).

Table 5-6: Projected Number of New Chemical Manufacturing Facilities (SIC 28)

SIC	Number of Existing Facilities[1]		Projected Industry Growth			Estimated Number of New Facilities	
	Total Screener Facilities (1998)	With CWIS, NPDES Permit, Flow > 2 MGD, and 25% for Cooling	Annual	Over 10 Years[2]	Share of Growth from New Facilities	Total[3]	In Scope[4]
2812	28.1	9.7	1.9%	20.7%	50.0%	3	1
2813	109.8	4.1	2.8%	31.8%	50.0%	17	1
2816	25.3	4.1	1.9%	20.7%	50.0%	3	0
2819	270.8	16.7	1.9%	20.7%	50.0%	28	2
2821	305.1	14.5	4.0%	48.0%	50.0%	73	3
2823	6.7	2.2	1.9%	20.7%	50.0%	1	0
2824	31.3	6.3	1.9%	20.7%	50.0%	3	1
2833	33.3	3.4	2.8%	31.8%	50.0%	5	1
2834	91.4	4.1	5.0%	62.9%	50.0%	29	1
2841	35.9	4.1	2.4%	26.8%	50.0%	5	1
2865	59.3	5.2	3.3%	38.4%	50.0%	11	1
2869	367.9	52.6	3.0%	34.4%	50.0%	63	9
2873	59.7	8.2	2.4%	26.8%	50.0%	8	1
2874	37.8	4.5	2.4%	26.8%	50.0%	5	1
2892	9.7	1.1	4.1%	49.5%	50.0%	2	0
2899	163.1	5.2	3.0%	34.4%	50.0%	28	1
Total	1,635	146				284	24

[1] From screener survey results.
[2] Total percentage growth over 10 years, based on the forecasted annual growth rate [$(1 + \text{annual rate})^{10}$ - 1].
[3] Equal to total number of screener facilities * (1 + 10-year growth rate) * share of growth from new facilities.
[4] Equal to estimated total number of new facilities * ratio of number of screener facilities with CWIS, NPDES permit, flow > 2 MGD, and at least 25% use for cooling to the total number of screener facilities.

Source: §316(b) Industry Screener Questionnaire and various industry sources.

c. Petroleum and Coal Products (SIC 29)

Responses to the industry screener survey indicate that two Petroleum and Coal Product sectors, SIC 2911 – Petroleum Refining; and SIC 2999 – Products of Petroleum and Coal, Not Elsewhere Classified, are likely to be relevant to the proposed regulation. These two industry segments are analyzed to determine the number of new in scope facilities in the Petroleum and Coal Products Industry.

❖ ***Projected growth in shipments***

EIA forecasts that U.S. petroleum consumption will increase by 6.2 million barrels (bbl) a day between 1998 and 2020. More than 90 percent of the projected demand growth results from increased consumption of "light products," including gasoline, diesel, heating oil, jet fuel, and liquified petroleum gases. Expansions at existing refineries (SIC 2911) are expected to meet only half of the projected increase in demand. The remainder is expected to result from increased imports of petroleum product (U.S. DOE, 1999a).

No forecasts of shipments specific to Miscellaneous Products of Coal and Petroleum (SIC 299) are available. Therefore, EPA assumed that shipments from this industry will grow at the same 2.5 percent annual rate as forecast for overall GDP.

❖ ***Projected number of new facilities***

EIA projects that domestic refinery capacity (SIC 2911) will grow from 16.3 million bbl per day in 1998 to between 17.6 million bbl per day (low economic growth case) and 18.3 million bbl per day (high economic growth case) in 2020. This expansion will result from expanded capacity at existing refineries. No new refineries are likely to be constructed in the U.S. due to financial and legal constraints (U.S. DOE, 1999a). For the purpose of this analysis, EPA therefore assumed that there will be no new petroleum refineries constructed in the U.S. over the next 10 years.

No information on expected capacity growth specific to SIC 2999 was identified. EPA therefore assumed that one-half of the projected growth in shipments will result from new facilities in these industries. Table 5-7 shows that one new facility is expected in SIC 2999. However, given the low numbers of screener facilities with in scope characteristics in that industry sector, EPA's forecast methodology results in a projection that no new in scope facilities will be constructed in SIC code 2999 over the next 10 years.

Table 5-7: Projected Number of New Petroleum and Coal Products Facilities (SIC 29)

SIC	Number of Existing Facilities[1]		Projected Industry Growth			Estimated Number of New Facilities	
	Total Screener Facilities (1998)	With CWIS, NPDES Permit, Flow > 2 MGD, and 25% for Cooling	Annual	Over 10 Years[2]	Share of Growth from New Facilities	Total[3]	In Scope[4]
2911	162.8	27.9	2.5%	28.0%	0.0%	0	0
2999	7.8	1.1	2.5%	28.0%	50.0%	1	0
Total	171	29				1	0

[1] From screener survey results.
[2] Total percentage growth over 10 years, based on the forecasted annual growth rate [(1 + annual rate)^{10} - 1].
[3] Equal to total number of screener facilities * (1 + 10-year growth rate) * share of growth from new facilities.
[4] Equal to estimated total number of new facilities * ratio of number of screener facilities with CWIS, NPDES permit, flow > 2 MGD, and at least 25% use for cooling to the total number of screener facilities.

Source: §316(b) Industry Screener Questionnaire and various industry sources.

d. Steel (SIC 331)

The §316(b) Industry Screener Questionnaire identified five 4-digit SIC codes in the Steel Industry (SIC 331) that are most likely to be most relevant to the proposed §316(b) New Facility Rule:

3312 – Steel Works, Blast Furnaces (Including Coke Ovens), and Rolling Mills
3313 – Electrometallurgical Products, Except Steel
3315 – Steel Wiredrawing and Steel Nails and Spikes
3316 – Cold-Rolled Steel Sheet, Strip, and Bars
3317 – Steel Pipe and Tubes

EPA analyzed each of these five industry segments to determine the number of new in scope facilities in the Steel Industry.

❖ *Projected growth in shipments*

Demand for North American steel is expected to increase over the long term. Domestic demand for steel mill products, which dropped precipitously during the 1980's, rebounded sharply during the 1990's. This increase in demand is attributed to overall growth in steel-consuming industries and increased steel use in some areas such as construction. The U.S. steel industry is considerably smaller, internationally competitive, and more innovative, after a decade of restructuring in the 1990's (McGraw-Hill, 1999). Steel shipments are expected to rise at a 1 to 2 percent annual rate through 2003, assuming continued moderate economic growth (McGraw-Hill, 1999).

❖ *Projected number of new facilities*

Recent growth in new steelmaking capacity has been in minimills. The success of the thin slab caster/flat rolling mill has resulted in construction of as much as 11 million tons of new minimill steel capacity in the U.S. between 1997 and 2000. Table 5-8 provides information on six new EAF minimill projects planned between late 1998 and early 2001. Higher demand is expected to absorb some of the new capacity from these mills. Imports are also likely to be displaced and exports will increase (McGraw-Hill, 1998). While new low-cost minimills have been starting up, some antiquated, less efficient integrated mills have been shut down and other integrated producers have increased output efficiencies at their existing blast furnaces (McGraw-Hill, 1999).

Table 5-8: Major New Minimill Projects 1998-2001

Company	Project	Location	Completion	Cost
Nucor	Structural mill	Berkeley County, S.C.	Late 1998	$150 million
Nucor	Cold mill	Hickman, AR	Early 1999	$120 million
Chapparal	Structural mill	Dinwiddie County, VA	Mid-1999	$400 million
Nucor	Plate mill	Hertford County, NC	Early 2000	$300 million
Steel Dynamics	Structural mill	Whitley County, IN	Early 2000	$285 million
Ipsco	Plate mill	Mobile County, AL	Early 2001	$425 million

Source: Metal Center News Online, 2000.

EPA assumed that one-half of the projected growth in shipments in all potentially-affected steel industries will result from new facilities, and that all of the new facilities in the basic steel sector (SIC 3312) will be new minimills rather than new integrated facilities. Table 5-9 shows the projected number of new in scope facilities in this sector. EPA estimates that 39 new facilities will be constructed over the next 10 years, of which four will be in scope of the proposed §316(b) New Facility Rule.

Table 5-9: Projected Number of New Iron and Steel Facilities (SIC 331)

SIC	Number of Existing Facilities[1]		Projected Industry Growth			Estimated Number of New Facilities	
	Total Screener Facilities (1998)	With CWIS, NPDES Permit, Flow > 2 MGD, and 25% for Cooling	Annual	Over 10 Years[2]	Share of Growth from New Facilities	Total[3]	In Scope[4]
3312[5]	156.6	37.7	1.5%	16.1%	50.0%	13	3
3313	5.6	1.1	2.5%	28.0%	50.0%	1	0
3315	121.9	3.1	1.5%	16.1%	50.0%	10	0
3316	59.8	9.3	1.5%	16.1%	50.0%	5	1
3317	129.6	1.1	1.5%	16.1%	50.0%	10	0
Total	474	52				39	4

[1] From screener survey results.
[2] Total percentage growth over 10 years, based on the forecasted annual growth rate [(1 + annual rate)^{10} - 1].
[3] Equal to total number of screener facilities * (1 + 10-year growth rate) * share of growth from new facilities.
[4] Equal to estimated total number of new facilities * ratio of number of screener facilities with CWIS, NPDES permit, flow > 2 MGD, and at least 25% use for cooling to the total number of screener facilities. All new facilities in SIC 3312 are assumed to be minimills rather than integrated steel mills.

Source: §316(b) Industry Screener Questionnaire and various industry sources.

e. Aluminum and Other Nonferrous Metals (SICs 333, 335)

The §316(b) Industry Screener Questionnaire identified three 4-digit SIC codes in the Aluminum and Other Nonferrous Metals Industry (SICs 333 and 335) that are potentially relevant to the proposed §316(b) New Facility Rule:

3334 – Primary Production of Aluminum
3339 – Primary Smelting and Refining of Nonferrous Metals, Except Copper and Aluminum
3353 – Aluminum Sheet, Plate, and Foil

EPA analyzed each of these three industry segments to determine the number of new in scope facilities in the Aluminum and Other Nonferrous Metals Industry.

❖ ***Projected growth in shipments***

Total shipments for all sectors of the aluminum industry are expected to increase 3 percent annually from 1999 through 2003 (McGraw-Hill, 1999). EPA therefore assumed that shipments of primary aluminum smelters (SIC 3334) and aluminum sheet, plate, and foil (SIC 3353) will increase at an annual rate of 3 percent. No information is available on the specific products produced by the screener facilities in SIC code 3339. EPA therefore assumed that shipments for this industry sector will grow at the same rate as overall GDP (2.5 percent annually).

❖ ***Projected number of new facilities***

There is a substantial amount of idled aluminum capacity in the U.S. that could be brought on-line as demand improves (McGraw-Hill, 1999). This idle capacity is likely to limit construction of new capacity and to limit price increases for aluminum (S&P, 2000). The 1997 capacity utilization rate of 86 percent was well below the 1987 rate of approximately 97 percent. Domestic production has increased since 1995, bringing some idled capacity back on-line, and domestic smelters are now operating at about 90 percent of rated or engineered capacity (USGS, 2000). These conditions make it likely that any capacity increases will involve using existing capacity or expansions at existing facilities, rather than construction of new greenfield facilities (Plunkert, 2000). No new primary smelters have been constructed in the U.S. since 1980 (McGraw-Hill, 1999). According to Standard & Poor's, construction of new minimill capacity is also unlikely given the potential that added capacity would drive down prices in the face of slow growth in the markets for minimill products (S&P, 2000). EPA therefore assumed that all projected growth in primary aluminum shipments (SIC 3334) will result from using the currently-idled capacity or from expansions at existing facilities.

In the absence of specific information for SIC codes 3339 and 3357, EPA assumed that half of the growth in shipments would result from new facilities, rather than from idled capacity or expansions at existing facilities.

Table 5-10 shows that 11 new facilities could be constructed over the next ten years with one new in scope Aluminum Sheet, Plate and Foil facilities (SIC 3353).

Table 5-10: Projected Number of New Aluminum and Other Nonferrous Metal Facilities (SIC 333,335)

SIC	Number of Existing Facilities[1]		Projected Industry Growth			Estimated Number of New Facilities	
	Total Screener Facilities (1998)	With CWIS, NPDES Permit, Flow > 2 MGD, and 25% for Cooling	Annual	Over 10 Years[2]	Share of Growth from New Facilities	Total[3]	In Scope[4]
3334	30.7	10.5	3.0%	34.4%	0.0%	0	0
3339	5.2	1.1	2.5%	28.0%	50.0%	1	0
3353	56.9	6.2	3.0%	34.4%	50.0%	10	1
Total	93	18				11	1

[1] From screener survey results.
[2] Total percentage growth over 10 years, based on the forecasted annual growth rate $[(1 + \text{annual rate})^{10} - 1]$.
[3] Equal to total number of screener facilities * (1 + 10-year growth rate) * share of growth from new facilities.
[4] Equal to estimated total number of new facilities * ratio of number of screener facilities with CWIS, NPDES permit, flow > 2 MGD, and at least 25% use for cooling to the total number of screener facilities.

Source: §316(b) Industry Screener Questionnaire and various industry sources.

5.2.3 Uncertainties and Limitations

There are substantial uncertainties in EPA's projections of the number of new manufacturing facilities that will be subject to the proposed §316(b) New Facility Rule. While 3-to-5 year forecasts of industry shipments are available for most of the relevant industries, forecasts of the likely growth in capacity and numbers of new facilities are less readily available and those that are available generally apply only for the next few years.

To account for the 20-year time frame of this analysis, EPA assumed that the projected growth for the next three to five years will continue over the next 20 years. This assumption increases the uncertainty about the projected number of new facilities. In addition, it is often not clear how much of any new growth in capacity will result from expansions at existing facilities as opposed to construction of new greenfield facilities. EPA relied on general information about trends in each industry for assumptions about the relationship between growth in shipments and growth in domestic capacity, and about the portion of new capacity that will be in new greenfield facilities.

EPA's forecasts assume that the characteristics of new facilities that determine their regulatory status under the proposed rule are the same as those of the screener facilities in the same industries. A variety of factors may lead new facilities to use municipal or ground water instead of a water of the U.S. or to recycle the process water more often than do existing facilities, however. Thus, this assumption may overstate the number of new facilities.

5.3 Summary of Baseline Projections

EPA estimates that over the next 20 years a total of 875 new greenfield facilities will be built in the industry sectors analyzed for this proposed regulation. Two hundred and five of these new facilities will be steam electric generating facilities and 670 will be manufacturing facilities. As Table 5-11 shows, only 98 of the 875 new facilities are projected to be in scope of the proposed §316(b) New Facility Rule, including 40 electric generators, 48 chemical facilities, and 10 primary metals facilities. No new in scope pulp and paper or petroleum facilities are projected over the next 20 years.

Table 5-11: Projected Number of In Scope Facilities (2001 to 2020)

SIC	SIC Description	Projected Number of New Facilities Over 20 Years	
		Total	**With Costs**
Electric Generators			
SIC 49	Electric Generators	205	40
Manufacturing Facilities [†]			
SIC 26	Paper and Allied Products	0	0
SIC 28	Chemicals and Allied Products	570	48
SIC 29	Petroleum Refining And Related Industries	2	0
SIC 33	Primary Metals Industries		
SIC 331	Blast Furnaces and Basic Steel Products	77	8
SIC 333 SIC 335	Primary Aluminum, Aluminum Rolling, and Drawing and Other Nonferrous Metals	21	2
Total Manufacturing		*670*	*58*
Total		**875**	**98**

† The number of new manufacturing presented in this table is *twice* the 10-year forecast presented in Section 5.2.

Source: EPA Analysis, 2000.

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Chapter 6: Facility Compliance Costs

INTRODUCTION

This chapter presents the estimated costs to facilities of complying with the proposed §316(b) New Facility Rule. EPA developed costs at three levels: (1) unit costs of complying with the various requirements of this regulation, including costs of §316(b) technologies and administrative costs; (2) facility-level costs for each projected in scope facility; and (3) total facility compliance costs aggregated to the national level. This chapter also presents cost estimates for eight additional case study facilities. The last section of this chapter discusses uncertainties and limitations in EPA's compliance cost estimates.

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Facilities generally have several alternatives for complying with the proposed rule's requirements.[1] Alternative compliance responses include:

- ***Compliance Response 1: Change the cooling system design so the facility would no longer be subject to regulation under the proposed §316(b) New Facility Rule:*** A facility may choose to use an alternative (a water other than those of the U.S.) cooling source, e.g., gray water or dry cooling, or to redesign its cooling water system to withdraw less than two million gallons per day (MGD). Under both scenarios, a facility would no longer be in scope of this regulation but might incur costs associated with these design changes.

- ***Compliance Response 2: Change the source water body type and make alterations to meet requirements based on the new water body type and the distance from the littoral zone:*** A facility may choose to locate on a different type of water body to reduce the stringency of its compliance requirements (e.g., locate on a lake or river instead of an estuary). This alternative may involve costs of redesigning the facility or acquiring land near the substitute water body as well as the cost of any requirements associated with the new water body type and distance from the littoral zone.

- ***Compliance Response 3: Change the distance from the littoral zone and make alterations to meet requirements based on water body type and the new distance from the littoral zone:*** A facility may choose to relocate the entrance of its intake structure within the water body to reduce the stringency of its compliance requirements (i.e., locate the intake outside of the littoral zone or more than 50 meters away from the littoral zone). This alternative may involve additional capital costs to extend the facility's intake pipe or to dredge an intake canal to make the intake deeper, as well as the cost of any requirements based on the new distance from the littoral zone.

- ***Compliance Response 4: Make alterations to meet requirements based on the baseline water body type and distance from littoral zone:*** A facility may choose to retain its planned location (water body type and distance from the littoral zone) and implement all measures required by the regulation. This alternative may involve costs of widening the intake structure or installing a velocity cap or passive screens to reduce velocity; and switching to a recirculating system to reduce intake flow;

[1] Compliance requirements vary with water body type and distance from the water body's littoral zone. See *Chapter 1: Introduction and Overview* for a summary of this rule's requirements.

implementing additional technologies to reduce impingement and entrainment (I&E).

The remainder of this chapter presents the estimated costs of compliance and the methodology and unit costs used to develop the estimates. The chapter is organized as follows:

- Section 6.1 presents the unit costs associated with various compliance actions that facilities may take as part of the compliance alternatives described above. The unit costs include average costs of implementing specific changes to a facility's cooling water intake structure (CWIS) or its cooling water system and are based on certain facility characteristics such as volume of flow. Unit costs are also estimated for administrative activities.

- Section 6.2 discusses the development of compliance cost estimates for the 98 projected new in scope facilities and presents the estimated costs.

- Section 6.3 presents the estimated facility compliance costs aggregated to the national level.

- Section 6.4 presents an estimate of facility costs for eight additional case study facilities.

- The final Section 6.5 discusses the limitations and uncertainties in EPA's compliance cost estimates.

6.1 UNIT COSTS

Unit costs are estimated costs of certain activities or actions, expressed on a uniform basis (i.e., using the same units), that a facility may take to comply with the regulatory requirements. Unit costs are developed to facilitate comparison of the costs of different actions. For this analysis, the unit basis is dollars per gallon per minute ($/gpm) of cooling water intake flow. All capital and operating and maintenance (O&M) costs were estimated in those units. These unit costs are the building blocks for developing costs at the facility and national levels. Individual facilities will incur only a subset of the unit costs, depending on the extent to which they would already comply with the requirements as originally designed (in the baseline) and on the compliance response they select. The unit costs presented in this section are engineering cost estimates, expressed in 1999 dollars. More detail on the development of these unit costs is provided in the appendices.

6.1.1 §316(b) Technology Costs

New facilities that in their original design do not comply with the §316(b) New Facility Rule framework would have to implement one or more technologies to reduce I&E. These technologies reduce I&E through one of four general methods:

- changing the location of the CWIS in a water body;
- reducing the design intake flow;
- reducing the design intake velocity; or
- implementing other design and construction technologies (referred to as other technologies) to reduce damage from I&E.

The remainder of Section 6.1.1 discusses specific §316(b) technologies and their respective costs.

a. Changing the Location of the CWIS in a Water Body

EPA analyzed two options for altering the location of a planned facility's CWIS: extending the intake pipe to increase the distance from the littoral zone, and deepening the intake canal to withdraw water from below the littoral zone.

❖ ***Extending the intake pipe***

There are a number of different methods for underwater pipe laying, including use of conventional pipe laying vessels, bottom-pulling, and micro-tunneling.[2] Each of these methods requires the use of skilled labor and specialized equipment and materials. The following general assumptions were used to estimate costs associated with extending an intake pipe:

- The littoral zone ends approximately 25 meters from the shoreline.[3] If a pipe extends 75 meters from the shoreline it would be 50 meters outside the littoral zone. The maximum necessary extension of the intake pipe to be at least 50 meters outside of the littoral zone therefore is 75 meters.

- The source water body is wide enough so that a pipe extending 75 meters from one shore/river bank will also be at least 75 meters from the opposite shore/bank. The intake structure would therefore meet the requirement of being at least 50 meters outside of the littoral zone on both sides of the source water body.

Table 6-1 presents a summary of the estimated costs associated with installing intake pipes of 25 meters and 125 meters in length using each method of installation. The table shows that for the pipe-laying vessel and bottom-pull

[2] See Appendix A for a more detailed discussion on the pipe extension technologies.

[3] The littoral zone may extend for more or less than 25 meters, depending on site-specific characteristics of the water body. The assumption of 25 meters is used for costing purposes only.

methods, the length of the pipe has a minimal impact on the total cost (the main cost components being the equipment and labor costs). The total cost associated with the micro-tunneling technique, on the other hand, does vary with the length of the pipeline. For micro-tunneling, to develop cost curves and equations based on flow, EPA assumed a pipe extension distance of 125 meters. Further details on the development of cost estimates are provided in Appendix A.

Table 6-1: Costs of Extending the Intake Pipe ($1999)

Method of Installation	Cost		Necessary Days to Complete Work		Total Cost	
	Rent Equipment / Labor	Pipe / Materials	25 meters	125 meters††	25 meters	125 meters††
Pipe Laying Vessel	$90,000 - $110,000 per day (all inclusive)	minimal	1	1	$90,000 - $110,000	$90,000 - $110,000
Bottom-Pull Method	$20,000 per day for a barge and labor	minimal	1	1	$25,200-$27,000	$25,200-$27,000
	$2,000 - $4,000 per day for a crane		1	1		
	$500 per day for welders		1	1		
	$1,350 per day for a bulldozer		2	2		
Micro-Tunneling	$1,000 - $2,000 per foot of piping (includes installation and material costs)		n/a	n/a	$82,000-$164,000	$410,000-$820,000

† See Appendix A for cost curves and further details on the development of cost estimates.
†† The costs presented in this table are based on extending the pipe for 125 meters rather than 75 meters. The cost for extending the pipe for only 75 meters may be as much as 30 to 40 percent lower, depending on the pipe extension method used. This potential decrease in costs would have minimal impact on the overall estimated cost of the proposed rule.

❖ ***Deepening the intake canal***

Shoreline intakes often have a dredged canal with a baffle or skimmer wall and withdraw water from below the surface. Deepening the canal such that the intake opening is below the littoral zone may require additional dredging.[4] For the smallest size canal, EPA assumed that an additional 10,000 cubic yards (CY) of sediments will be removed using a dredger.[5] For large size canals, EPA assumed that increasing the depth below the littoral zone entails the dredging of an area of 10 by 40 by 100 yards. Widening, dredging, and dumping operations are assumed to be accomplished using a 2,000 gallons per CY dredger at a cost of $12.25 per CY. Based on these estimates, the costs associated with deepening an intake canal to comply with the proposed §316(b) New Facility Rule range between $122,500 for a small canal to $490,000 for a large canal. A cost curve is included in Appendix A.

These costs apply to situations where sediments are disposed of onsite with no preparation costs. If sediments are contaminated, the permitting authority may require transport to and disposal at an offsite facility, which may double or triple the operational costs and may also delay construction of the new facility.

b. Reducing Design Intake Flow

New facilities that do not comply with the flow criteria established by the proposed §316(b) regulatory framework have a number of alternatives for reducing their intake flow to meet the rule's requirements. EPA analyzed two options for reducing the design intake flow and developed cost estimates for these two options: switching to a recirculating system and using a water other than those of the U.S.

By switching to a recirculating system or using an alternative cooling water source, it is possible for a new facility to reduce its intake flow to less than two MGD and

[4] The same assumptions were made here for the dimension of the littoral zone as in the section on extending the intake pipe.

[5] This estimate assumes that the canal dimensions are 10 by 100 yards and the canal will be deepened by an additional 10 yards.

therefore be exempt from the proposed §316(b) New Facility Rule. For some facilities, the cost of reducing the intake flow such that they are exempt from regulation under §316(b) may be lower than that of any other compliance response.

❖ ***Switching to a recirculating system***

Switching to a recirculating system involves redesigning the proposed facility to replace the planned once-through cooling system. Cooling towers are by far the most common type of recirculating system. EPA therefore assumed that all planned facilities switching to recirculating systems will use cooling towers.

Cooling tower configurations differ with respect to design characteristics such as the type of air flow (either natural or mechanical draft), the materials used in tower construction (wood, fiberglass, steel, and/or concrete), and whether water is recirculated or discharged to a receiving water body after cooling (only configurations that involve recirculating will be useful in meeting the regulatory requirements). The cost of installing cooling towers and their associated intakes and equipment is largely determined by the volume of cooling water needed, the material used to construct the tower (e.g., redwood, steel), and the special features of the tower (e.g., plume abatement). The volume of water needed for cooling depends on the following factors: source water temperature and quality; the type of cooling tower installed (i.e., whether it is natural or mechanical draft); type and make of equipment to be cooled (e.g., coal fired equipment, natural gas powered equipment); and the plant size/generating capacity (e.g., 50 megawatt vs. 200 megawatt).

Table 6-2 presents estimated capital and installation costs for different types of basic cooling towers and associated equipment, broken down by the volume of water used. Based on conversations with industry experts, installation costs are assumed to be 80 percent of the cooling tower equipment cost. The costs presented in Table 6-2 are the installation costs for a "basic" cooling tower (i.e., standard fill without special features) and associated equipment. For costing purposes, EPA assumed that a red-wood, splash-filled cooling tower would be installed because this type of tower has typical average costs. Site-specific conditions may require the installation of additional equipment to mitigate environmental impacts, such as drift, plume, and noise controls, at additional cost.

Table 6-2: Capital and Installation Costs for Cooling Towers ($1999)

Flow (gpm)	Douglas Fir Cooling Tower	Redwood Tower	Concrete Tower	Steel Tower	Fiberglass-Reinforced Plastic Tower
2,000-18,000	$108,000-$972,000	$121,000-$1,089,000	$151,000-$1,361,000	$146,000-$1,312,000	$157,000-$1,409,000
22,000-36,000	$1,148,400-$1,879,200	$1,286,000-$2,105,000	$1,608,000-$2,631,000	$1,550,000-$2,537,000	$1,665,000-$2,725,000
45,000-67,000	$2,268,000-$3,3768,00	$2,540,000-$3,782,000	$3,175,000-$4,728,000	$3,062,000-$4,559,000	$3,289,000-$4,896,000
73,000-102,000	$3,679,200-$4,957,200	$4,121,000-$5,552,000	$5,151,000-$6,940,000	$4,967,000-$6,692,000	$5,335,000-$7,188,000
112,000- 204,000	$5,443,200-$9,180,000	$6,096,000-$10,282,000	$7,620,000-$12,852,000	$7,348,000-$12,393,000	$7,893,000-$13,311,000

† See Appendix A for cost curves and further details on the development of cost estimates.

EPA also estimated O&M costs for cooling towers. These O&M costs tend to be driven by factors such as:

- the size of the cooling tower,
- the material from which the cooling tower is built,
- various features of the cooling tower,
- the source of make-up water,
- the disposition of blowdown water, and
- the tower's remaining useful life (maintenance costs increase as useful life diminishes).

To calculate estimated annual O&M costs, EPA made the following assumptions:

- For small cooling towers, five percent of capital costs is attributed to chemical costs and routine maintenance. To account for economies of scale, that percentage is gradually decreased to two percent for the largest cooling tower. This assumption is based on discussion with industry representatives.

- Two percent of tower flow is lost to evaporation and/or blowdown and/or drift, based on discussions with industry representatives.

- Make-up water was assumed to come from a water of the U.S., and disposal of blowdown was assumed to be to either a pond or back to the original water source, at a combined cost of $0.50/1000 gallons.

- Maintenance costs are 15 percent of capital costs, averaged over a 20 year period, based on discussions with industry representatives.

Cost curves developed based on the above assumptions and used to estimate costs are included in Appendix A, along with further details on the development of estimated costs.

❖ *Using a water other than those of the U.S.*

The use of a recirculating cooling water system does not eliminate the need for a supply of water. Facilities using cooling towers need a supply of cooling water to "make-up" for the water that is lost from the cooling process because of evaporation, blow down, and drift. This make-up water can come from a water of the U.S., ground water, a municipal domestic water supply, or the treated wastewater that is discharged from municipal wastewater treatment plants (gray water). Data from various existing utility databases, the §316(b) Screener Questionnaire, and the NEWGen database indicate a trend toward increased use of cooling towers and waters other than those of the U.S. for make-up water for power generation units coming on-line in recent years or planned to come on-line in the near future. Make-up water obtained from a domestic water supply or treated wastewater must be purchased.

EPA contacted several water and wastewater treatment plants in the Washington, DC area to develop cost estimates for using gray water as cooling tower make-up water. Cost data from power plant siting applications submitted to siting boards by utilities were also obtained. The cost for gray water varies greatly from one geographic area to another based on the availability of alternative sources of cooling water. Rate schedules for gray water supply are typically set such that costs per gallon increase with consumption. A review of cost estimates from wastewater treatment plants and siting applications indicates that the cost of gray water ranges from approximately $1.5 to $3 per 1,000 gallons for a facility with daily flows typical of electric generating facilities with recirculating cooling towers. Based on this review, EPA estimated a unit cost of $3/1000 gallons for the purchase of make-up gray water from a wastewater treatment plant. These costs do not include treatment or discharge costs. However, if on-site treatment is necessary, EPA estimates that the cost would be approximately $0.5/1000 gallons.

EPA also contacted the Washington Suburban Sanitary Commission to gather cost estimates for municipal domestic water for use as cooling water. A facility using municipal sources for clean make-up water and disposing of the blow down water into a publicly-owned treatment works (POTW) sewer line would incur a combined cost of $4/1000 gallons.

c. Reducing Design Intake Velocity

A facility not in compliance with the velocity criteria established by the proposed §316(b) regulatory framework may need to alter its CWIS to reduce the design intake velocity. This reduction can be achieved by branching the intake into a greater number of openings/pipes, installing velocity caps, or constructing a passive screen system. Each of these options is discussed below.

❖ *Passive screens*

Passive intake systems are those devices which screen-out debris and biota with little or no mechanical activity required. Most of these systems are based on the principle of achieving very low withdrawal velocities at the screening media. Passive screens reduce velocity by exploiting hydrodynamics. Hydrodynamic exclusion results from maintenance of a low through-slot velocity which allows organisms to escape the flow field. The physical shape and dimension (width and depth) of passive screens are determined by the application and site-specific conditions. See Appendix A for a more detailed description of the screen technologies.

Estimated capital costs for passive screens are shown in Table 6-3. These costs are based on discussions with industry representatives. The table presents costs for basic passive screens, made of carbon steel with a coating of epoxy paint. Passive screens larger than those presented in Table 6-3 will correspond to flows greater than 50,000 gallons per minute (gpm). Intake structures with flows in excess of 50,000 gpm are typically very large and the network fanning required for the total number of intake points and screens generally make passive screen systems infeasible.

Table 6-3: Capital Costs for Passive Screens - Stainless Steel ($1999)

Well Depth (ft)††	Screen Panel Width (ft)†††			
	2	5	10	14
10	$34,200	$56,100	$91,800	$128,700
25	$49,800	$84,900	$140,400	N/A
50	$74,400	$122,700	N/A	N/A
75	$99,000	N/A	N/A	N/A
100	$135,600	N/A	N/A	N/A

† See Appendix A for cost curves and further details on cost estimate development.
†† Well depth includes the height of the structure above the water line.
††† N/A indicates that costs were not estimated because passive screen systems of this size are not feasible.

Generally, there are no appreciable O&M costs for passive screens. In situations with biofouling problems or zebra mussels in the environment, special materials for the screens and periodic mechanical cleaning may be needed. Air backwash systems require periodic maintenance. These costs, however, are minimal.

❖ ***Velocity caps***

A velocity cap is used on vertical intakes located offshore. The velocity cap is a cover placed over the intake which converts vertical flow into horizontal flow at the entrance into the intake. The device works on the premise that fish will avoid rapid changes in horizontal flow. These devices have shown good performance for the protection of aquatic organisms. The primary cost driver for velocity caps is the installation costs. Installation is carried out underwater where the water intake mouth is modified to fit the velocity cap over the intake. Costs for installing velocity caps were estimated based on the following assumptions:

- Four velocity caps can be installed per day.
- Cost of the installation crew is similar to the cost of water screen installation crews (see Appendix A).
- To account for the difficulty of deep water installations, an additional work day is assumed for every increase in depth category.
- Equipment cost for a velocity cap is assumed to be 25 percent of the velocity cap installation cost.

Table 6-4 presents the estimated capital and installation costs for installing velocity caps at various depths. The number of velocity caps needed for various flow sizes is estimated based on a flow velocity of 0.5 ft/sec and assumes that the intake area to be covered by the velocity cap is 20 square feet.

Table 6-4: Capital and Installation Costs for Velocity Caps ($1999)

Flow (gpm) (No. of velocity caps)	Water Depth (feet)				
	8	20	30	50	65
Up to 18,000 (4 VC)	$10,000	$15,625	$21,250	$26,875	$32,500
18,000 < flow < 35,000 (9 VC)	$15,625	$21,250	$26,875	$32,500	$38,125
35,000 < flow < 70,000 (15 VC)	$26,875	$32,500	$38,125	$43,750	$49,375
70,000 < flow < 100,000 (23 VC)	$38,125	$43,750	$49,375	$55,000	$60,625
157,000 (35 VC)	$55,000	$60,625	$66,250	$71,875	$77,500
204,000 (46 VC)	$71,875	$77,500	$83,125	$88,750	$94,375

† See Appendix A for cost curves and further details on cost estimate development.

❖ ***Branching the intake pipe to increase the number of openings or widening the intake pipe***

Facilities can reduce the intake velocity to meet the requirements of the proposed §316(b) New Facility Rule by branching their intake pipe using a Tee to withdraw water from a greater number of openings or widening the pipe opening using an enlarger. For costing purposes, EPA assumed that the intake pipes were originally designed to withdraw water at a 3 ft/sec velocity (a reasonable low velocity at which silt will not settle in the pipe) and that a Tee or an enlarger will be fitted at the pipe opening to achieve the desired 0.5 ft/sec velocity. The cost of fittings for branching an intake pipe to reduce intake flow velocity is assumed to be 15 percent of pipe capital cost.[6] These estimated costs are given by the cost curves in Appendix A.

d. Implementing Other Design and Construction Technologies to Reduce Damage from I&E

Facilities may also have to employ additional technologies that reduce the extent of I&E, depending on their CWIS location and velocity. EPA considered adding traveling screens with fish baskets or adding fish baskets to existing screens, as ways to limit I&E.

❖ ***Installation of traveling screens with fish baskets***

Vertical traveling screens contain a series of wire mesh screen panels that are mounted end to end on a band to form a vertical loop. As water flows through the panels, debris and fish that are larger than the screen openings are caught on the screen or at the base of each panel in a basket. As the screen rotates, each panel passes through a series of spray wash systems which remove debris and fish from the basket. The first system is a low pressure spray wash which is used to release fish to a bypass/return trough. Once the fish have been removed, a high pressure jet spray wash system is used to remove debris. As the screen continues to rotate, the clean panels move down and back into the water to screen intake flow.

Two components were analyzed in estimating total capital costs associated with the installation of traveling screens with fish baskets: equipment costs and installation costs. Equipment costs for a basic traveling screen with fish baskets include costs for screens constructed of carbon steel coated with epoxy paint, a spray system, a fish trough, housings and transitions, continuous operating features, a drive unit, frame seals, and engineering. Installation costs include costs for site preparation and earthwork, clearing the site, excavation, paving and surfacing, and structural concrete work and underwater installation (personnel, equipment, and mobilization, including their cost of a barge equipped with a crane and the crew to operate it.

Table 6-5 presents the total capital costs associated with the installation of traveling screens with fish baskets. Costs are presented for screen panels of various widths and for selected well depths. Well depth includes the height of the structure above the water line and can exceed water depth by a few to tens of feet. Costs are calculated based on vendor estimates and information from *Heavy Construction Cost Data 1998* (R.S. Means, 1997) and Paroby (1999).

O&M costs for traveling screens vary by type, size, and mode of operation of the screen. Based on discussions with industry representatives, EPA estimated that the annual O&M cost factor ranges between eight percent of total capital cost for the smallest traveling screen (with and without fish baskets) and five percent for the largest

[6] This cost estimate is based on best professional judgement and was verified with costs reported in R.S. Means (1997).

traveling screen since O&M costs do not increase proportionateley with screen size. See Appendix A for further information on O&M costs.

Table 6-5: Capital Costs for Traveling Screens with Fish Baskets ($1999)				
Well Depth (ft)	**Screening Basket Panel Width (ft)**			
	2	**5**	**10**	**14**
10	$90,500	$132,000	$202,000	$285,000
25	$129,250	$194,000	$307,000	$453,000
50	$191,500	$287,000	$458,000	$647,000
75	$253,750	$381,500	$589,000	$831,000
100	$336,000	$477,000	$720,000	$1,010,000

† See Appendix A for cost curves and further detail on the development of cost curves.

❖ ***Adding fish baskets to existing traveling screens***

The costs associated with adding fish baskets to existing traveling screens were assumed to include equipment costs, installation costs, and costs associated with upgrading existing control systems from intermittent to continuous operation. Equipment costs include the cost of a spray system, a fish trough, housings and transitions, a drive unit, frame seals, and engineering. EPA assumed that installation costs would be 75 percent of the underwater portion of the installation costs of a traveling screen (based on best professional judgement). The use of a barge and crane would generally not be needed, and site preparation costs would be minimal.

Table 6-6 presents the total estimated capital costs for adding fish baskets to an existing traveling screen. Costs are presented for screen panels of various widths and for selected well depths. Costs are calculated based on vendor estimates from *Heavy Construction Cost Data 1998* (R.S. Means, 1997), Paroby (1999), and best professional judgement.

Table 6-6: Capital Costs for Adding Fish Baskets to Existing Traveling Screens ($1999)				
Well Depth (ft)	**Screening Basket Panel Width (ft)**			
	2	**5**	**10**	**14**
10	$46,200	$55,575	$71,550	$100,725
25	$68,250	$79,125	$107,100	$154,275
50	$100,500	$121,875	$161,850	$239,025
75	$132,750	$161,625	$216,600	$323,775
100	$165,000	$201,375	$271,350	$408,525

† See Appendix A for cost curves and further detail on the development of cost curves.

The additional O&M costs incurred as a result of adding fish baskets to existing traveling screens were estimated by taking the difference between estimated O&M costs for traveling screens *with* fish handling features and the estimated O&M costs for traveling screens *without* fish handling features.

6.1.2 Administrative Costs

Compliance with the proposed §316(b) New Facility Rule requires facilities to carry out certain administrative functions. These are either one-time requirements (compilation of information for the initial NPDES permit) or recurring requirements (compilation of information for NPDES permit renewal, and monitoring and record keeping). This section describes each of these administrative requirements and their estimated costs.

❖ *Initial NPDES permit application*

The proposed §316(b) New Facility Rule requires all new facilities subject to this regulation to submit information regarding the location, construction, design, and capacity of their proposed CWIS as part of their initial NPDES permit application. Activities and costs associated with the initial permit application include:

- ***start-up activities:*** reading and understanding the rule; mobilizing and planning; and training staff;
- ***general permit application activities:*** developing drawings that show the physical characteristics of the source water; documenting the littoral zone; developing a description of the CWIS's configuration; developing a facility water balance diagram; developing a narrative of operational characteristics; submitting materials for review by the Director; and keeping records;
- ***source water baseline characterization activities:*** developing a sampling plan; biweekly sampling; profiling the source water biota; identifying critical species; submitting the study for review by the Director; record keeping; and developing a final study based on review by the Director;
- ***source water baseline monitoring capital and O&M costs:*** laboratory analysis of samples;
- ***CWIS flow standard activities:*** developing information characterizing flow; performing engineering calculations; submitting data and analysis for review; and keeping records;
- ***CWIS velocity standard activities:*** developing a narrative description; performing engineering calculations; submitting data and analysis for review; revising analysis based on state review; and keeping records;
- ***CWIS 100 percent recirculation standard activities:*** developing a narrative description; performing engineering calculations; documenting blowdown minimization; submitting data and analysis for review; and keeping records;
- ***additional design and construction technology implementation plan:*** developing a narrative description; performing engineering calculations; submitting data and analysis for review; and keeping records.

Table 6-7 lists the estimated costs of each of the initial NPDES permit application activities described above. The specific activities that a facility will have to undertake depend on the facility's source water body type and the location of its CWIS relative to the water body's littoral zone. The typical cost a facility that is required to implement all the activities would incur for its initial NPDES permit application is estimated to be $53,382.

Table 6-7: Cost of Initial NPDES Permit Application Activities ($1999)

Activity	Estimated Cost
Start-up activities†	$1,380
General permit application activities†	$7,012
Source water baseline characterization activities†	$12,405
Source water baseline monitoring capital and O&M costs†	$20,000
CWIS flow standard activities	$2,595
CWIS velocity standard activities	$4,690
CWIS 100 percent recirculation standard activities	$2,878
Additional design and construction technology implementation plan	$2,422
Typical Initial NPDES Permit Application Cost	$53,382

† The costs for these activities are incurred in the year prior to the permit application.

Source: U.S. EPA, Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

❖ *NPDES permit renewal*

Each new facility operating a CWIS will have to renew its NPDES permit every 5 years. Permit renewal requires collecting and submitting the same type of information as required for the initial permit application. EPA expects that facilities can use some of the information from the initial permit. Building upon existing information is expected to require less effort than developing the data the first time.

Table 6-8 lists the estimated costs of each of the NPDES repermit application activities. The typical cost a facility that is required to implement all the renewal activities would incur for its NPDES permit renewal is estimated to be $44,230.

Table 6-8: Cost of NPDES Repermit Application Activities ($1999)

Activity	Estimated Cost
Start-up activities†	$471
General permit application activities†	$3,287
Source water baseline characterization activities†	$11,319
Source water baseline monitoring capital and O&M costs†	$20,000
CWIS flow standard activities	$2,595
CWIS velocity standard activities	$3,425
CWIS 100 percent recirculation standard activities	$2,151
Additional design and construction technology implementation plan	$982
Typical Initial NPDES Permit Application Cost	$44,230

† The costs for these activities are incurred in the year prior to the application for a permit renewal.

Source: U.S. EPA, Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

❖ *Monitoring, record keeping, and reporting*

All new facilities subject to the proposed §316(b) New Facility Rule are required to monitor to show compliance with the standards set forth in the rule. Facilities must keep records of their monitoring activities and report the results in a yearly status report. Monitoring, record keeping, and reporting activities and costs include:

- ***biological monitoring (impingement):*** collecting monthly samples; identifying and enumerating organisms; performing statistical analyses; and record keeping;
- ***biological monitoring (entrainment):*** collecting biweekly samples; identifying and enumerating organisms; performing statistical analyses; and record keeping;
- ***velocity monitoring:*** monitoring average through-technology velocity; analyzing data; and record keeping;
- ***weekly visual inspections:*** visually inspecting all installed technologies; and record keeping;
- ***yearly status report activities:*** reporting on inspection and maintenance; detailing velocity monitoring results; detailing biological monitoring results; compiling and submitting the report; and record keeping;

Table 6-9 lists the estimated costs of each of the monitoring, record keeping, and reporting activities described above. The specific activities that a facility will have to undertake depend on the facility's source water body type and the location of its CWIS relative to the water body's littoral zone. The typical cost a facility will incur for its monitoring, record keeping, and reporting activities is estimated to be $79,245.

Table 6-9: Cost of Annual Monitoring, Record Keeping, and Reporting Activities ($1999)

Activity	Estimated Cost
Biological monitoring (impingement)	$17,986
Biological monitoring (entrainment)	$38,675
Velocity monitoring	$4,269
Weekly visual inspections	$6,931
Yearly status report activities	$11,384
Typical Monitoring, Record Keeping, and Reporting Cost	$79,245

Source: U.S. EPA, Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

6.2 Facility-Level Costs

The cost estimates presented in this section are based on the unit costs presented in the previous section and assume that a facility will always choose the least-cost response among the feasible compliance responses. Some compliance responses may not be feasible for certain facilities because of facility-specific characteristics or conditions. EPA developed unit costs and evaluated facility-level costs associated with Compliance Response 1 (reconfiguring cooling water systems from once-through to recirculating or switching to a water other than those of the U.S.), Compliance Response 3 (changing the distance from the littoral zone and implementing requirements based on the new distance from the littoral zone), and Compliance Response 4 (implementing requirements based on water body type and distance from littoral zone). The feasibility of some methods of changing the cooling system design so that the facility would no longer be subject to the proposed §316(b) New Facility Rule (part of Compliance Response 1) or changing the source water body type (Compliance Response 2) could not be evaluated and costed with the information publicly available for new facilities. The estimated facility-level and national-level costs may be overstated, if these excluded responses are less expensive than the assumed response for some facilities.

6.2.1 New Electric Generators

EPA used the unit cost estimates discussed in Section 6.1 to estimate potential compliance costs of the 40 projected in scope electric generators.[7] Facility-specific information on proposed CWIS characteristics was available for the seven facilities identified from the NEWGen database. For these facilities, EPA determined the likely requirements to comply with the proposed §316(b) New Facility Rule. Six of the remaining 33 facilities are assumed to have characteristics similar to the seven analyzed facilities. These are assumed to be combined-cycle facilities projected to begin operation between 2004 and 2009. The Agency calculated the average cost for the seven facilities and applied this average to the remaining six facilities. Costs for the additional 27 facilities projected to begin operation between 2011 and 2020 were calculated based on the characteristics of five model plants.

The following sections present brief profiles of the characteristics of the seven NEWGen electric generating facilities, their compliance requirements and costs, and a summary of the assumptions used to cost the 27 facilities projected to begin operation between 2011 and 2020.

❖ *GenA*

The GenA facility proposes to withdraw water from a freshwater stream or river for its planned 750 MW plant. The facility plans to use an infiltration gallery or a radial well (Ranney collector) which would be located at the bottom of the river in a pool between two dams and is assumed to be adequately below/outside the littoral zone to be considered to be in the category of at least 50 meters outside the littoral zone. Based on the information provided by the state siting board, EPA estimates that the facility will not need to make any alterations to meet the criteria of the proposed §316(b) New Facility Rule. The facility's estimated water withdrawal needs of 1.9 to 4.4 MGD (average annual flow expected to be 2.6 MGD) for its cooling tower make-up water are less than 25 percent of the source water 7Q10 and less than 5 percent of the source water mean annual flow. The facility estimates that its intake velocity will be less than 0.1 fps under maximum sustained withdrawal conditions.

❖ *GenB*

The GenB facility proposes to withdraw cooling water from either a freshwater stream or river or from shallow ground wells for its planned 1,100 MW plant. The facility plans to use a multiple cell evaporative cooling tower, so the cooling water will serve as make-up water for the tower. EPA estimates that the facility meets all the technological and locational criteria for the proposed §316(b) New Facility Rule based on the information in its NPDES permit application on (1) the length of its proposed intake pipeline (about 300 feet from the shoreline which is assumed to be more than 50 meters outside the littoral zone); (2) the estimated volume of cooling water needed (19.4 MGD, which is less than 25 percent of the 7Q10 flow; this flow volume is also less than 5 percent of the 7Q10 flow and therefore is assumed to be less than 5 percent of the mean annual flow since waterbody 7Q10 flow is lower than average flow); (3) that the facility will use a recirculating system; and (4) the expected intake velocity of less than 0.5 fps (a wedge wire screen will be used).

❖ *GenC*

For the GenC facility, EPA only had access to limited facility and intake information from its raw water supply contract. The facility plans to withdraw cooling water from a lake or reservoir for its planned 510 MW plant. Based on the volume of available water the agreement specifies, EPA used an estimated intake flow of 10 MGD (6944 gpm). From the site map attached to the agreement, EPA surmised that the facility uses either two canals or a canal and an intake pipe to draw water from the lake. Based on the diversion point and site maps, EPA estimated that the facility would need to increase the depth of both intake canals or extend its intake pipe and increase the depth of its one canal to locate its intake outside the littoral zone. Dredging and widening the canals is estimated to cost $236,000. If the total design intake flow alters the natural stratification of the lake, the facility may incur additional costs to further alter the intake. This seems unlikely given the size of the lake.

❖ *GenD*

The GenD facility plans to withdraw cooling water from an estuary or tidal river for use in the cooling towers of its planned 525 MW plant. Based on its application to the state site evaluation committee, the facility's estimated design intake flow of 6.5 MGD will be less than 1 percent of the tidal prism volume. The facility will use cooling towers for a recirculating cooling system. The intake will incorporate a modified, Ristroph type traveling screen with an intake velocity of less than or equal to 0.5 fps. The relatively low intake flow and velocity, and the facility's plans to use a traveling screen equipped with fish baskets, a spray wash system, and a fish return channel to return impinged marine life back to the river is likely to meet the requirement for implementing technologies that maximize survival of impinged fish and minimize entrainment of eggs and larvae. EPA believes that the facility meets all the technological and locational criteria for the proposed §316(b) New Facility Rule.

❖ *GenE*

GenE proposes to withdraw cooling water from a freshwater stream or river for use in the wet/dry cooling tower of its planned 475 MW plant. EPA assumed that the intake pipe would be within the littoral zone, in the absence of

[7] See *Chapter 5: Baseline Projections of New Facilities* for detailed information on EPA's methodology for determining the number of new facilities.

information on intake location. Since the source water is a sizable river and the facility will use a recirculating system with a relatively small flow of 6.9 to 10.4 MGD, EPA assumed that the facility would meet the requirements for design intake flow and recirculation. The facility plans to use Johnson screens or the equivalent, which should meet the criteria for a design intake flow of no more than 0.5 fps. Using Johnson screens and a relatively small intake flow and velocity, the facility is likely to meet the requirement for implementing technologies that maximize survival of impinged fish and minimize entrainment of eggs and larvae. Therefore, the facility is expected to meet all the technological and vocational criteria for the proposed §316(b) New Facility Rule.

❖ *GenF*

Only limited information is available for the GenF facility, including a drawing of the planned collector well (radial well) cooling water intake system. The facility plans to withdraw up to 3.5 MGD of cooling water from a freshwater stream or river through collector laterals that appear to lie 20 feet below the river bottom. EPA assumed that the lateral wells are adequately below/outside the littoral zone to be considered to be in the category of at least 50 meters outside the littoral zone. Based on the relatively small flow, which the facility information indicates is less than 0.5 percent of the lowest flow recorded in the river, the facility's total design intake flow meets the flow requirements. A radial well is highly likely to withdraw water at a rate of less than 0.5 fps, so the Agency assumed that the facility would meet the intake velocity criteria.

❖ *GenG*

The GenG facility plans to withdraw cooling water from a system of reservoirs for its planned 1,016 MW plant. The intake pipes appear to be nearly 75 meters from shore and about 15 feet below the surface of the water at normal water level. Based on this estimated location, EPA assumed that the CWIS would be located less than 50 meters outside the littoral zone. The facility is likely planning to use a recirculating system since the design intake flow of 8.8 MGD is relatively small. The facility plans to use Johnson screens on its intakes, which provide an intake velocity of no more than 0.5 fps. Using Johnson screens and a relatively small intake flow and velocity, the facility is likely to meet the requirement for not altering the natural stratification of the source water. The facility is projected to extend its intake pipes in order to move the location to 50 meters outside the littoral zone and therefore no longer be subject to the technology criteria (Compliance Response 3). Extending its intake piping is estimated to cost $162,000. The facility may also incur costs related to the criteria for design intake flow not to alter the natural stratification of the source water.

❖ *2011 to 2020 facilities*

EPA used five model plants to develop the costs for the 27 facilities projected to begin operation between 2011 and 2020. The first three model plants are coal-fired facilities with 800 MW capacity and the following characteristics:

- once though system on an estuary (Coal1, 9, and 13);
- recirculating system on an estuary (Coal 2-4, 6-8, 10-12, and 14-16); and
- once through system on a nontidal river (Coal5).

The other two model facilities are 723 MW combined-cycle facilities with the following characteristics:

- once through system on an estuary (CC1, 5, and 9); and
- recirculating system on a nontidal river (CC2-4, 6-8, and 10-11).

EPA assumed that these facilities would continue the trend of offshore submerged intakes with screens systems.

Table 6-10 summarizes the expected compliance response and the associated costs for each facility. Appendix B provides more detailed information on each facility, including its water body type, the expected compliance response of each facility, and the capital costs, if any, associated with the expected action.

Table 6-10: Estimated Compliance Costs for Specific Electric Generator Facilities ($1999)

Facility	Category (Source Water)	Projected Compliance Response	Estimated Cost
GenA	Freshwater stream or river	None	$0
GenB	Freshwater stream or river	None	$0
GenC	Lake or reservoir	Deepen two canals	one-time: $236,000
GenD	Estuary or tidal river	None	$0
GenE	Freshwater stream or river	None	$0
GenF	Freshwater stream or river	None	$0
GenG	Lake or reservoir	Extend piping	one-time: $162,000
Gen1-6	n/a	n/a	one-time: $56,856
Coal1, 9, 13	Estuary or tidal river	Install a cooling tower; widen the intake; add traveling screens with fish handling equipment	one-time: $15,227,000 annual: $3,378,000
Coal2-4, 6-8, 10-12, 14-16	Estuary or tidal river	Add fish handling equipment	one-time: $33,000 annual: $5,700
Coal5	Freshwater stream or river	Widen the intake; extend the pipe	one-time: $5,364,200
CC1, 5, 9	Estuary or tidal river	Install a cooling tower; add fish handling equipment	one-time: $2,940,000 annual: $697,400
CC2-4, 6-8, 10-11	Freshwater stream or river	Extend the pipe	one-time: $162,000

† Not including administrative costs.

Source: Summary information from Appendix B.

Each facility subject to the proposed §316(b) New Facility Rule will incur administrative costs in addition to the estimated capital costs. These costs include one-time costs (initial permit application) and recurring costs (permit renewal, and monitoring, record keeping, and reporting), and depend on the facility's water body type and the location of its CWIS relative to the water body's littoral zone. Table 6-11 presents the costs for the administrative activities and the estimated capital, and operation and maintenance costs for the 40 new electric generators.

Table 6-11: Cost Estimates for Electric Generating Facilities (unit costs, $1999)

Facility Name	No. of Facilities	One-Time Costs		Recurring Costs		
		Capital Technology	Initial Permit Application	O&M	Permit Renewal	Monitoring, Record Keeping, & Reporting
GenA	1	$0	$48,082	$0	$41,098	$72,314
GenB	1	$0	$50,960	$0	$43,250	$72,314
GenC	1	$236,000	$43,392	$0	$37,673	$68,045
GenD	1	$0	$53,382	$0	$44,232	$79,245
GenE	1	$0	$53,382	$0	$44,232	$79,245
GenF	1	$0	$48,082	$0	$41,098	$72,314
GenG	1	$162,000	$53,382	$0	$44,232	$79,245
Gen1-6	6	$56,857	$50,095	$0	$42,259	$74,675
Coal1, 9, 13	3	$15,227,000	$53,382	$3,378,000	$44,232	$79,245
Coal2-4, 6-8, 10-12, 14-16	12	$33,000	$53,382	$5,700	$44,232	$79,245
Coal5	1	$5,364,200	$48,082	$0	$41,098	$72,314
CC1, 5, 9	3	$2,940,000	$53,382	$697,400	$44,232	$79,245
CC2-4, 6-8, 10-11	8	$162,000	$53,382	$0	$44,232	$79,245

Source: *Summary information from Appendix B and the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.*

6.2.2 New Manufacturing Facilities

EPA used the following process to develop cost estimates for new manufacturing facilities affected by the proposed §316(b) New Facility Rule:

- Project the likely characteristics of new in scope manufacturing facilities.
- Assess whether each facility is likely to be in compliance with the requirements of the proposed §316(b) New Facility Rule. If a facility is projected to be out of compliance, determine likely compliance responses.
- Estimate costs for the likely compliance responses at each facility.

❖ ***Projected characteristics of new facilities***

As described in Chapter 5, EPA projected the number of new manufacturing facilities for each SIC code in the manufacturing categories that typically use the greatest amount of cooling water and therefore are the most likely facilities to be subject to the proposed §316(b) New Facility Rule. To determine if these facilities must take compliance actions to meet the proposed requirements, EPA needed to estimate the likely characteristics of these new facilities. Important characteristics in assessing facility compliance with the rule's requirements and determining estimated compliance costs include: source water body type, intake flow volume, use of once-through or recirculating cooling systems, intake location (e.g., shoreline, offshore submerged), and intake control technologies already in place. Since facilities with the same SIC code generally have similar operations and generate similar products, EPA assumed that the characteristics of new facilities in a given SIC code will be similar to the characteristics of existing facilities in that same SIC code. EPA also considered current trends in facilities that have begun operation in more recent years. For example, a review of available data for facilities starting up in the last ten years indicates that newer facilities are much more likely to have at least partially recirculating cooling systems than older facilities. Therefore, EPA projected that a higher percentage of the new facilities would be recirculating than was indicated by existing facility data. EPA used available data from existing manufacturing facilities that responded to the §316(b) Screener Questionnaire.

EPA evaluated the characteristics listed above for all the existing facilities in each SIC code, and used those characteristics to project the characteristics for the one or more projected new facilities. If only one new facility was projected for a given SIC code, EPA generally used the following conventions:

- ***source water type:*** most common water body among the existing facilities;
- ***flow:*** median of the flows for existing facilities;
- ***intake location:*** most common intake location among existing facilities;
- ***control technology type:*** most common technologies in use at existing facilities; and
- ***cooling system type:*** most common type, with a bias toward recirculating or combined recirculating and once-through when the type of system among existing facilities was very mixed.

When more than one new facility was projected for a given SIC code, EPA generally split the existing facilities by waterbody type or by recirculating versus once-through and determined one new projected facility's characteristics based on one set of existing facilities and another new projected facility's characteristics based on the other set of existing facilities. Based on trends, EPA used a bias toward certain characteristics such as recirculating cooling systems, offshore intakes, and passive screens. Since the trend for new facilities is toward the use of cooling towers, flows used may be lower than those for the existing facilities in some cases.

❖ *Projected baseline compliance*

Based on the new manufacturing facility characteristics, determined as described above, EPA assessed whether a facility is likely to comply with the requirements of the proposed §316(b) New Facility Rule for its particular type of water body and intake location. Assumptions made in this assessment include the following:

- A facility with a shoreline, canal, or bay/cove intake was assumed to be in the littoral zone. A facility with an offshore intake was assumed to be less than 50 meters outside the littoral zone.[8]
- A facility with a passive screen was assumed to meet the 0.5 fps velocity criteria.
- A facility with a recirculating system is assumed to meet the intake flow criteria since most existing facilities (e.g., more than 90 percent of utilities) with recirculating systems would meet the intake flow criteria. Most once-through facilities were also assumed to meet the intake flow criteria since manufacturing facilities typically have much lower intake flows than utilities. If a once-through facility was projected to not meet the intake flow criteria, it was projected to switch to a recirculating system and then meet the criteria.
- All facilities were assumed to have one intake, which seems reasonable for manufacturers since most utilities have one or two intakes and typically have much higher flows.

❖ *Estimated costs*

The unit costs discussed in Section 6.1 were used to develop cost estimates for each of the new projected manufacturing facilities that needs to take compliance actions to meet the requirements of the proposed §316(b) New Facility Rule. Unit costs were based on flow. Costing assumptions related to flow include the following:

- If a facility has a once-through system only and is projected to switch to a 100 percent recirculating system as a compliance response, the flow used for costing the recirculating cooling tower is 15 percent of the original flow since the flow will be reduced in the new recirculating system.
- If a facility is planned as a combined once-through and recirculating system, the facility is assumed to have 10 percent of the initial flow attributed to recirculating and 90 percent to the once-through part of the system.
- If a facility is planned as a combined once-through and recirculating system and is projected to switch to a 100 percent recirculating system as part of its compliance response, the estimated cost of a cooling tower is based on the 90 percent of the original flow that was attributed to the once-through portion of the system. This 90 percent portion of the original flow is reduced to 15 percent of its original value and then added to the other 10

[8] The majority of the intakes of units in the EIA-767 database that are likely to use a water of the U.S. are less than 75 meters from shore, with a median distance of about 15 meters.

percent of the original flow to calculate the estimated flow once the system becomes 100 percent recirculating. This new flow is then used to calculate the estimated cost of any other technology compliance actions.

Estimated costs were calculated for all projected compliance responses, including adding technologies (for example, cooling towers to switch to a recirculating system), and administrative costs such as monitoring and permitting. Other technology costs (e.g., passive screens, cooling towers, widening intakes) include a capital cost for the equipment itself and associated installation costs. Some of these technologies also include an annual O&M cost, since these costs were significant for some technologies (e.g., cooling towers and traveling screens with fish baskets). O&M costs are negligible for some other technologies. Administrative costs were estimated as either annual costs or periodic costs based on the frequency of the activity. For example, monitoring and reporting occurs annually while applying for a permit occurs once every five years. For comparison purposes, all costs are annualized over a 30 year period using a seven percent discount rate.

Table 6-12 shows the estimated compliance costs for the projected new manufacturing facilities. The table only shows the 29 facilities projected for the forecasting period 2001 to 2010. As explained in *Chapter 5: Baseline Projections of New Facilities*, the 29 facilities projected to begin operation between 2011 and 2020 are assumed to be identical to the first 29 facilities. Therefore, each manufacturing facility presented in Table 6-12 represents two future facilities. Appendix B provides more detailed information on the estimated cost for each facility, including its water body type, whether the facility's baseline design meets compliance requirements, the expected compliance response of each facility and the capital costs, if any, associated with the expected action.

Table 6-12: Cost Estimates for Manufacturing Facilities (unit costs, $1999)

Facility ID	One-Time Costs		Recurring Costs		
	Capital Technology	Initial Permit Application	O&M	Permit Renewal	Monitoring, Record Keeping, & Reporting
new 2812-1	$24,000	$50,960	$0	$43,249	$72,314
new2813-1	$1,752,000	$53,382	$419,300	$44,231	$79,245
new2819-1	$320,000	$7,194	$89,000	$4,654	$0
new2819-2	$1,512,000	$53,382	$357,000	$44,231	$79,245
new2821-1	$170,000	$48,082	$0	$41,098	$72,314
new2821-2	$300,000	$43,392	$0	$37,673	$72,314
new2821-3	$47,000	$50,504	$0	$42,080	$79,245
new2824-1	$0	$53,382	$0	$44,231	$79,245
new2833-1	$0	$48,082	$0	$41,098	$72,314
new2834-1	$410,000	$7,194	$111,000	$4,654	$0
new2841-1	$375,000	$7,194	$102,000	$4,654	$0
new2865-1	$0	$48,082	$0	$41,098	$72,314
new2869-1	$605,000	$7,194	$157,000	$4,654	$0
new2869-2	$605,000	$7,194	$157,000	$4,654	$0
new2869-3	$21,000	$50,960	$0	$43,249	$72,314
new2869-4	$21,000	$50,960	$0	$43,249	$72,314
new2869-5	$21,000	$50,960	$0	$43,249	$72,314

Table 6-12: Cost Estimates for Manufacturing Facilities (unit costs, $1999)

Facility ID	One-Time Costs		Recurring Costs		
	Capital Technology	Initial Permit Application	O&M	Permit Renewal	Monitoring, Record Keeping, & Reporting
new2869-6	$400,000	$48,082	$0	$41,098	$72,314
new2869-7	$481,000	$48,082	$483,700	$41,098	$72,314
new2869-8	$481,000	$48,082	$483,700	$41,098	$72,314
new2869-9	$0	$53,382	$0	$44,231	$79,245
new2873-1	$91,000	$53,382	$5,200	$44,231	$79,245
new2874-1	$44,000	$50,960	$0	$43,249	$72,314
new2899-1	$299,000	$7,194	$84,000	$4,654	$0
new3312-1	$1,450,000	$50,504	$342,000	$42,080	$79,245
new3312-2	$21,000	$50,960	$0	$43,249	$72,314
new3312-3	$700,000	$43,392	$0	$37,673	$72,314
new3316-1	$0	$53,382	$0	$44,231	$79,245
new3353-1	$3,000	$50,960	$0	$43,249	$72,314

Source: Summary information from Appendix B and the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

6.3 Total Facility Compliance Costs

EPA estimated the national compliance costs for the proposed §316(b) New Facility Rule based on the facility-level costs discussed in Section 6.2. The costs developed in this section represent the total compliance costs for new facilities expected to begin operation between 2001 and 2020.[9] EPA estimated total compliance costs over the first 30 years of the proposed regulation (i.e., 2001 to 2030). Accordingly, the Agency considered all compliance costs incurred by each of the 98 facilities over this 30-year time period.[10]

The analysis assumes the following distribution of new facilities over the 20-year forecasting period:

- The seven NEWGen facilities will begin operation in the "projected on-line year" reported in the RDI database. For these facilities, the dates of initial commercial operation range between 2001 and 2003.
- The six extrapolated generators will begin operation between 2004 and 2009.
- The on-line dates of the 33 generators expected to begin operation between 2011 and 2020 are based on the relative magnitude of forecasted capacity additions over that time period.
- The years of initial operation for the 58 projected manufacturing facilities are assumed to be evenly distributed over the 20-year forecasting period.

[9] The national cost estimate presented in this chapter only accounts for *private costs* directly incurred by facilities. It does not represent total *social cost* of the proposed §316(b) New Facility Rule.

[10] This approach does not account for all compliance costs incurred by the 98 projected facilities because the analysis disregards costs incurred after 2030. For example, for a facility estimated to begin operation in 2015, the analysis would only include the first 16 years of costs in the national aggregate.

EPA calculated the present value of each cost category using a seven percent discount rate. The following formula was used to calculate the present value of each year's cost:[11]

$$Present\ Value_x = \frac{Cost_{x,t}}{(1 + r)^t}$$

where:

$Cost_{x,t}$	=	Costs in category x and year t
x	=	Cost category
r	=	Discount rate (7% in this analysis)
t	=	Year in which cost is incurred (2001 to 2030)

Total present value for each cost component was derived by summing the present value of each year's cost. Finally, EPA calculated annualized costs using the following formula:

$$Annualized\ Cost_x = PV_x \times \frac{r \times (1 + r)^n}{(1 + r)^n - 1}$$

where:

x	=	Cost category
PV_x	=	Present value of compliance costs in category x
r	=	Discount rate (7% in this analysis)
n	=	Amortization period (30 years)

Table 6-13 presents the estimated national aggregate of facility compliance costs of the proposed §316(b) New Facility Rule by cost category. The table shows that the present value of total facility compliance costs is estimated to be $150.5 million. The 40 electric generators account for $79.7 million of this total, and the 58 manufacturing facilities for $70.7 million. Total annualized cost for the 98 facilities is estimated to be $12.1 million. Of this, $6.4 million will be incurred by electric generators and $5.7 million by manufacturing facilities.

[11] Calculation of the present value assumes that the cost is incurred at the end of the year.

Table 6-13: Total Facility Costs of Compliance with the Proposed §316(b) New Facility Rule (in millions $1999)

Industry Category (Number of Facilities Affected)	One-Time Costs		Recurring Costs			Total
	Capital Technology	Initial Permit Application	O&M	Permit Renewal	Monitoring, Record Keeping & Reporting	
Total Compliance Costs (present value)						
Electric Generators (40)	$22.45	$1.05	$39.33	$1.53	$15.38	$79.74
Manufacturing Facilities (58)	$12.22	$1.38	$34.26	$2.14	$20.74	$70.74
Total (98)	**$34.67**	**$2.43**	**$73.60**	**$3.67**	**$36.12**	**$150.49**
Annualized Compliance Costs						
Electric Generators (40)	$1.81	$0.08	$3.17	$0.12	$1.24	$6.43
Manufacturing Facilities (58)	$0.98	$0.11	$2.76	$0.17	$1.67	$5.70
Total (98)	**$2.79**	**$0.20**	**$5.93**	**$0.30**	**$2.91**	**$12.12**

Source: *Summary information from Appendix B and the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.*

6.4 Case Study Facility Costs

Estimating compliance costs for the §316(b) New Facility Rule requires projecting the types of facilities that will be built in the future. EPA's projections do not include some facility types that could incur higher costs than estimated here or more significant impacts, if these types of plants were constructed. EPA estimated compliance costs for eight additional case studies. These are four high flow "worst case" electric generators and four manufacturing facilities in industries not covered in the previous sections. The costs for these case study facilities are not included in the estimated national costs of the rule, because EPA has no information to indicate that these types of facility are being planned.

EPA determined the worst case scenario for new electric generators would be a large nuclear or coal-fired power plant located on an estuary. Therefore, the Agency estimated costs for hypothetical large nuclear and coal-fired electricity generating plants. These plants' characteristics were defined as follows:

- ***source water type:*** estuary, no specific location (state or region) is assumed;
- ***flow:*** maximum flow for a recirculating system and the average flow for the highest third of the once-through systems based on the EIA 767 database for both coal-fired and nuclear plants;
- ***intake location:*** shoreline intake;
- ***control technology type:*** minimal control technologies were assumed (i.e., fixed screen);
- ***cooling system type:*** recirculating and once-through systems based on EIA 767 database.

Based on the power plant characteristics, determined as described above, EPA assessed the modifications these plants would have to make to comply with this rule's requirements. Assumptions made in this assessment include the following:

- Plants with a shoreline intake were assumed to be in the littoral zone.
- Plants with these high flows would not meet the velocity requirement.

- Each plant was assumed to have one intake, which seems reasonable since most power plants have one or two intakes.

Based on these initial basic assumptions, EPA assumed that, in the baseline, plants with recirculating systems would meet only the 100 percent recirculating requirement for estuaries in the proposed rule and plants with once-through systems would not meet any of the requirements. Therefore, all the new plants would need to make modifications to their original design in order to comply.

EPA used the same assumptions for the new manufacturers in these analyses as it did for the analyses of new manufacturers performed in Section 6.2.

The unit costs discussed in Section 6.1 were used to develop cost estimates for these hypothetical plants. Unit costs for technologies were based on flow, so the estimated flow for a plant was important in calculating the estimated cost for a given technology. Two of the plants were assumed to be once-through only and are projected to switch to a 100 percent recirculating system as a compliance action. The flow used for costing the recirculating cooling tower is 10 percent of the original flow since the flow will be reduced in the new recirculating system.

For the new manufacturing facilities flows were estimated using the following assumptions:

- If a facility is once-through only and is projected to switch to a 100 percent recirculating system as a compliance response, the flow used for costing the recirculating cooling tower is 15 percent of the original flow since the flow will be reduced in the new recirculating system.

- If a facility is planned as a combined once-through and recirculating system, the facility is assumed to have 10 percent of the initial flow attributed to recirculating and 90 percent to the once-through part of the system.

- If a facility is planned as a combined once-through and recirculating system and is projected to switch to a 100 percent recirculating system as part of its compliance response, the estimated cost of a cooling tower is based on the 90 percent of the original flow that was attributed to the once-through portion of the system. This 90 percent portion of the original flow is reduced to 15 percent of its original value and then added to the other 10 percent of the original flow to calculate the estimated flow once the system becomes 100 percent recirculating. This new flow is then used to calculate the estimated cost of any other technology compliance actions.

Estimated costs were calculated for all projected compliance actions, including adding technologies and for administrative costs. Technology costs (e.g., traveling screens with fish baskets, cooling towers, or widening intakes) always include a capital cost portion for the equipment itself and associated installation. Some of these technologies also include an annual O&M cost since these costs were significant for some technologies (e.g., cooling towers or traveling screens with fish baskets). Administrative costs were estimated as either annual costs (monitoring) or periodic costs (permit renewal) based on the frequency of the activity.

Table 6-14 presents the estimated facility compliance costs for the eight hypothetical case study facilities:

- two coal-fired electricity generating plants, one with the maximum flow for a recirculating system ("CoalMax") and the other with the average flow for the highest third of the once-through systems ("CoalAvg") based on the 1995 Form EIA-767 database;

- two nuclear electricity generating plants, one with the maximum flow for a recirculating system ("NucMax") and the other with the average flow for the highest third of the once-through systems ("NucAvg") based on the 1995 Form EIA-767 database; and

- four manufacturing facilities, one each in four of the two-digit SICs for which existing in scope facilities were reported in the screener database ("New SIC xx HF"). These are SIC codes 20 (Food and Kindred Products), 26 (Pulp and Paper), 29 (Petroleum Refining), and 32 (Stone, Clay, Glass and Concrete).

Table 6-14: Case Study Facility Compliance Costs (unit costs, $1999)

Facility	One-Time Costs		Recurring Costs		
	Capital Technology	Initial Permit Application	O&M	Permit Renewal	Monitoring, Record Keeping & Reporting
CoalMax	$13,291,000	$53,382	$400,000	$44,232	$79,245
CoalAvg	$23,471,000	$53,382	$5,275,000	$44,232	$79,245
NucMax	$27,812,000	$53,382	$900,000	$44,232	$79,245
NucAvg	$57,450,000	$53,382	$15,690,000	$44,232	$79,245
New SIC 20	$1,076,000	$48,082	$220,000	$41,098	$72,314
New SIC 26	$124,000	$48,082	$0	$41,098	$72,314
New SIC 29	$217,000	$50,960	$0	$43,250	$72,314
New SIC 32	$4,970,000	$50,960	$1,100,000	$43,250	$72,314

Source: Summary information from Appendix B and the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

Capital costs for the case study facilities range from $13.3 million to $57.5 million for electric generating plants, and from $124,000 to $5.0 million for manufacturing plants. Except for CoalMax, the costs for electricity generators are substantially higher than the corresponding costs estimated for the 33 projected electric generators. The estimated costs for the additional manufacturing facilities, on the other hand, fall within the range of capital costs estimated for the 58 projected manufacturing plant characteristics. The exception is NewSIC32, which has a total capital cost almost three times that of the highest cost facility among the 58 projected manufacturers.

The results for these case study scenarios show that compliance costs can be sensitive to the specific characteristics of each regulated plant, and that the rule could discourage the construction of very high flow electric generating plants in the future. Given the lack of evidence that such plants are likely to be constructed in the future, however, EPA does not consider the disincentives to construct such very high flow plants as a significant cost of the rule.

6.5 Limitations and Uncertainties

EPA's estimates of the compliance costs associated with the proposed §316(b) New Facility Rule are subject to limitations because of uncertainties about the number and characteristics of the new plants that will be subject to the rule. Projecting the number of new plants in different industries is subject to uncertainties about future industry growth rates and about the portion of new capacity that will come from new greenfield facilities as opposed to expansions at existing plants. This is especially the case when extending forecasts 20 years into the future.

To the extent possible, EPA used information on the characteristics of plants that are now being planned to project the baseline characteristics of facilities affected by the rule. Information on these planned plants and on the characteristics of existing plants that have CWIS provided a basis for projecting the characteristics of new plants beyond those for which plans are available. The estimated national facility compliance costs may be over- or understated if the projected number of new plants is incorrect or if the characteristics of new plants are different from those assumed in the analysis. In particular, the analysis may overestimate the number of plants that will withdraw from a water of the U.S. and thus be subject to the proposed rule, given observed trends toward greater use of recirculating systems and away from the use of water of the U.S. to provide cooling water.

Limitations in EPA's ability to consider a full range of compliance responses may result in an overestimate of facility compliance costs. The Agency was not able to consider certain compliance responses, including the costs of relocating the plant to use a different source water body type and the cost of some methods of changing the cooling system design. Costs will be overstated if these excluded compliance responses are less expensive than the projected compliance response for some facilities.

The estimated costs may be overstated if some compliance responses result in savings in facility construction or operating costs compared with the baseline plant design. Savings such as reduced water pumping costs, smaller pipes, smaller pumping station housing, and smaller size screens due to reduced water use have not been included in the cost estimates. For example, the costs for installing a recirculating cooling tower do not reflect the reduced cost of pumping water that will result from the use of less cooling water. EPA's facility-level and national-level cost estimates also exclude these potential savings to facilities from their compliance responses, and therefore overstate the costs associated with the rule for facilities that choose compliance responses that result in such savings. Finally, estimated costs do not account for reduced energy efficiencies that may result from switching to the use of cooling towers from a once-through cooling system. This energy "penalty" may be considerable and is dependent on specific site characteristics, such as plant type.

REFERENCES

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Chapter 7: Economic Impact Analysis

Introduction

The proposed §316(b) New Facility Rule applies to a number of industries, but only affects a small number of facilities in each industry. EPA conducted a screening analysis to assess whether it is likely that the proposed rule will have a significant economic impact on any of the 98 projected new facilities. This chapter presents EPA's analysis of economic impacts for the affected new facilities. Later chapters consider impacts on small entities (Chapter 8) and on governments (Chapter 9) as special cases.

The economic impact analysis is conducted at the facility-level. EPA would be concerned about potential firm- and industry-level impacts only if facility-level results indicated the potential for significant impacts or if one firm owned multiple facilities. The facility-level analysis showed that eight of the 98 projected new facilities would have annual compliance costs of more than one percent of revenues. Only one of these eight facilities is expected to have a cost-to-revenue ratio of more than five percent. EPA therefore concludes that compliance with this regulation is both economically practicable and achievable at the facility-, firm-, and national levels.

The remainder of this chapter is organized as follows:

- Section 7.1 discusses the methodology used to assess economic impacts for the 40 new electric generators, including the data sources and approach for estimating the economic characteristics of the regulated facilities, the specific economic impact measures used, and the results of the analysis.
- Section 7.2 presents the economic impact analysis for the 58 new manufacturing facilities. This section discusses the same information as Section 7.1 for electric generators.
- Section 7.3 provides a summary of the economic impact analysis at the facility-level.
- Section 7.4 discusses the potential for firm- and industry-level impacts as a result of the proposed §316(b) New Facility Rule.
- The final Section 7.5 presents the impact analysis for the eight case study facilities for which costs were developed in *Chapter 6: Facility Compliance Costs*.

Chapter Contents

7.1 New Steam Electric Generators

EPA projected that 40 new steam electric generators in scope of the proposed §316(b) New Facility Rule will begin commercial operation within the next 20 years (see *Chapter 5: Baseline Projections of New Facilities*). Seven of the 40 facilities are "real" facilities identified from a database of planned new electric generation facilities (the NEWGen database; RDI, 2000). For these facilities, some actual data on capacity, location, and technical characteristics were available. The remaining 33 facilities are projected facilities that are estimated to begin operation between 2004 and 2010. These are hypothetical, or "extrapolated," facilities for which no actual information is available.

EPA used the following measures to assess economic impacts for new electric generators:

- annualized compliance costs as a percent of expected annual revenues; and

- initial compliance costs as a percent of plant construction cost.[1]

7.1.1 Economic Characteristics

Calculating the two economic impact measures requires the following information for each new in-scope steam electric generator:

- total annualized compliance cost,
- expected annual revenues,
- initial compliance cost, and
- construction cost of the plant.

Chapter 6: Facility Compliance Costs summarized the methodology and results of EPA's cost estimation. The remainder of this section will therefore focus on the estimation of revenues and the total cost of the plant.

a. Expected Annual Revenues

EPA estimated expected annual revenues by making assumptions about future electricity sales for each facility. This calculation used the following formula:

$$Rev_x = GenCap_x * ESF_y * Price_y$$

where:

Rev_x	=	Annual revenues of facility x
$GenCap_x$	=	Generation capacity of facility x (in MW)
ESF_y	=	Projected electricity sales factor in NERC region y (in MWh/MW)
$Price_y$	=	Projected electricity price in NERC region y (in $1999)

Each component of this calculation is further explained below.

❖ *Generating capacity*

The NEWGen database provided information on the planned capacity (in MW) of the seven electric generators found to be in scope of this regulation. Total planned capacity for the seven facilities ranges between 475 MW and 1,100 MW. The generating capacity of the six extrapolated generators projected to begin operation between 2004 and 2009 is assumed to be equal to the average capacity for the seven NEWGen facilities, or 672 MW each. The capacities for the 16 coal and 11 combined-cycle plants expected to begin operation between 2011 and 2020 are assumed to be 800 MW and 723 MW, respectively.[2]

❖ *Electricity sales factor*

EPA estimated the average amount of electricity sold per MW of generating capacity for each NERC region using forecasts from the Energy Information Administration's (EIA) *Annual Energy Outlook 2000* (DOE, 1999a). The calculation was made by dividing the NERC region's projected annual electricity sales between 2001 and 2010 by the region's projected capacity over the same time period, using the following formula:

$$ESF_y = \frac{\sum_{t=2001}^{2010} Electricity\ Sold_y}{\sum_{t=2001}^{2010} GenCap_y}$$

where:

ESF_y	=	Projected electricity sales factor in NERC region y
$Electricity\ Sold_y$	=	Projected annual electricity sales in NERC region y (in MWh)
$GenCap_y$	=	Projected annual generating capacity in NERC region y (in MW)
t	=	Year of forecast (from 2001 to 2010)

Table 7-1 presents the calculated average electricity sales per MW of capacity for each NERC region and the U.S. average.

[1] Initial compliance costs include the compliance costs of the proposed §316(b) New Facility Rule that will be incurred before a new facility can begin operation. These are capital technology costs and initial permit application costs.

[2] The combined-cycle plants' capacity is the average of the 56 analyzed NEWGen facilities. Fifty-five of these 56 facilities are combined-cycle facilities.

Table 7-1: Estimated Average Electricity Sales Factors by NERC Region

NERC Region	Projected Electricity Sales per (2001 - 2010) in MWh/MW
ECAR – East Central Area Reliability Coordination Agreement	5,230
ERCOT – Electric Reliability Council of Texas	4,351
FRCC – Florida Reliability Coordinating Council	4,079
MAAC – Mid-Atlantic Area Council	4,427
MAIN – Mid-America Interconnected Network	4,225
MAPP – Mid-Continent Area Power Pool	4,882
NPCC/NE – Northeast Power Coordinating Council/New England	4,140
NPCC/NY – Northeast Power Coordinating Council/New York	3,644
SERC – Southeastern Electric Reliability Council/Excl. Florida	5,139
SPP – Southwest Power Pool	4,119
WSCC/CNV – Western Systems Coordinating Council/California-Southern Nevada Power	3,304
WSCC/NWP – Western Systems Coordinating Council/N.W. Power Pool Area	5,157
WSCC/RMPA – Western Systems Coordinating Council/Rocky Mountain Power Area & Arizona	5,116
U.S. Average	4,575

Source: U.S. DOE, 1999a.

EPA applied the NERC region-specific average sales per MW of capacity to the seven NEWGen facilities to calculate total annual electricity sales (in MWh). The national average was used for the 33 extrapolated facilities that do not have a known NERC region.

The actual amount of electricity that is generated and sold by a facility depends on how often the facility's units are dispatched. Using the calculated average factors may therefore over- or underestimate actual facility sales. The factors would *overestimate* electricity sales, and therefore estimated revenues, if the 40 electric generators were dispatched *less* than the average facility; they would *underestimate* sales and revenues if the 40 facilities were dispatched *more* than the average.

Dispatch frequencies are often correlated with the type of prime mover used at the facility.[3] Estimating the sales per MW of capacity by prime mover would require information on both sales and capacity by prime mover type. Published electricity generation and sales estimates are only available by fuel type and not by prime mover, however, while capacity is only available by prime mover.

EPA believes that using the calculated average factors by NERC region will generally provide a robust estimate of plant-level generation and sales, and therefore impacts, for the projected new facilities. Twenty-four of the 40 facilities are expected to be combined-cycle facilities, which are primarily designed to supply peak and intermediate capacity but can also be used to meet baseload requirements (U.S. DOE, 1999a, p. 65), and are therefore likely to have dispatch frequencies close to the average for all facilities.

[3] For example, gas turbines are generally peaking units that are dispatched less frequently than the average facility while coal or nuclear plants are generally baseload units that are dispatched more frequently than the average.

The estimated average factor may underestimate generation and sales for the projected 16 coal plants because these are relatively large facilities that can be expected to operated as baseload units. Using the average electricity sales factor may therefore understate revenues relative to compliance costs and would provide a conservative estimate of economic impacts for these facilities.

❖ ***Electricity price***

The final component needed to calculate annual revenues is the price of electricity. EPA used a regional price of generation, excluding transmission and distribution charges, forecasted by the U.S. Department of Energy's *Policy Office Electricity Modeling System* (POEMS). The generation price reflects the amount of revenue plants are likely to receive in a deregulated electricity market in which transmission and distribution services are separated from the generation function. POEMS forecasts electricity prices for several years into the future under a reference case and a competitive case. For this analysis, EPA considered the forecasted prices under the competitive case for 2000 and 2005. To provide a conservative estimate of revenues, EPA used the lower of the reported prices in each NERC region (U.S. DOE, 1999b).[4]

Table 7-2 presents the forecasted electricity prices per MWh for each NERC region and the U.S. average.[5]

[4] EPA also considered using the EIA's *National Energy Modeling System* (NEMS) forecasts, but the available NEMS results do not distinguish the price of generation from the distribution and transmission charges.

[5] Prices were adjusted from 1998 to 1999 dollars using the electric power Producer Price Index (PPI).

Table 7-2: Minimum Forecasted Electricity Prices by NERC Region

NERC Region	Electricity Price (Minimum of 2000 and 2005) in $/MWh
ECAR – East Central Area Reliability Coordination Agreement	21.0
ERCOT – Electric Reliability Council of Texas	29.7
FRCC – Florida Reliability Coordinating Council	30.7
MAAC – Mid-Atlantic Area Council	29.7
MAIN – Mid-America Interconnected Network	23.5
MAPP – Mid-Continent Area Power Pool	17.1
NPCC/NE – Northeast Power Coordinating Council/New England	34.3
NPCC/NY – Northeast Power Coordinating Council/New York	31.3
SERC – Southeastern Electric Reliability Council/Excl. Florida	24.9
SPP – Southwest Power Pool	24.7
WSCC – Western Systems Coordinating Council	27.2
U.S. Average	26.7

Source: U.S. DOE, 1999b.

EPA applied the NERC region-specific electricity prices to the projected electricity sales (in MWh) of the seven NEWGen facilities to calculate total annual revenues. The national average was used for the 33 extrapolated facilities that do not have a known NERC region. Projected annual facility revenues range from approximately $54 million to $109 million, or from $99,000 to $142,000 per MW of generating capacity.

b. Plant Construction Costs

EPA used two data sources to estimate the total construction cost of the new electric generating facilities. The NEWGen database contains "Total Plant Cost" among its data on facility financing. This information is available for most but not all facilities in the database.[6] According to RDI, however, these data may not provide a good basis for analysis because of uncertainty about which specific cost components are included by facilities when reporting this plant cost. EPA therefore used a second source, the *Assumptions to the Annual Energy Outlook 2000* (U.S. DOE, 2000), to estimate plant construction cost. Table 37 of the *Assumptions* presents the cost and performance characteristics of new generating technologies assumed in EIA's electricity forecasts. The following technology-specific overnight capital costs were used in the analysis:[7]

- Advanced Gas/Oil Combined Cycle $594/kW
- Scrubbed Coal New $1,128/kW
- Advanced Nuclear $2,447/kW

Overnight capital costs are the base costs estimated to build a plant in a hypothetical *Middletown, USA*. Regional multipliers for new construction, reported in Table 38 of the *Assumptions*, were applied to these base costs to account for construction cost differences between the various NERC regions.[8]

EPA used the smaller plant cost of the two data sources to

[6] EPA supplemented missing plant costs with information from permit applications and facility websites, where available.

[7] Overnight capital costs were adjusted from 1998 to 1999 dollars using the Engineering News-Record Construction Cost Index. The analysis of the 44 new electric generators presented in this section used the overnight capital costs for advanced gas/oil combined cycle and scrubbed new coal facilities. The costs for scrubbed new coal and advanced nuclear were used in the analysis of worst case electric generator impacts in Section 7.5.

[8] The regional multipliers used in this analysis are calculated as the average of reported multipliers for factory equipment, site labor, and site material.

estimate the ratio of initial compliance costs to plant construction costs. This approach provides a conservative measure of potential economic impacts on new electric generators.

Table 7-3 presents EPA's estimates of the economic and financial characteristics of the 40 new in scope electric generators.

Table 7-3: Economic and Financial Characteristics of New In Scope Electric Generators ($1999 thousands)

Facility Name	No. of Facilities	NERC Region	Planned Capacity (MW)	Electricity Sales Factor	Annual Electricity Sales (MWh)	Price ($/MWh)	Expected Annual Revenues	Plant Construction Cost	
								RDI	EIA
GenA	1	NPCC/NE	750	4,140	3,104,815	34.3	$106,639	$300,000	$519,502
GenB	1	MAIN	1,100	4,225	4,647,151	23.5	$109,137	n/a	$661,796
GenC	1	ERCOT	510	4,351	2,218,769	29.7	$66,002	$170,000	$291,693
GenD	1	NPCC/NE	525	4,140	2,173,371	34.3	$74,647	$175,000	$363,651
GenE	1	NPCC/NY	475	3,644	1,730,765	31.3	$54,195	$680,000	n/a
GenF	1	NPCC/NE	544	4,140	2,252,026	34.3	$77,349	$340,000	$376,812
GenG	1	SERC	800	5,139	4,111,273	24.9	$102,184	$397,000	$406,894
Gen1 - Gen6†	6	n/a	672	4,575	3,074,119	26.7	$82,226	$343,667	$436,724
Coal1, 9, 13	3	n/a	800	4,575	3,659,665	26.7	$97,888	n/a	$902,449
Coal2-4, 6-8, 10-12, 14-16	12	n/a	800	4,575	3,659,665	26.7	$97,888	n/a	$902,449
Coal5	1	n/a	800	4,575	3,659,665	26.7	$97,888	n/a	$902,449
CC1, 5, 9	3	n/a	723	4,575	3,307,422	26.7	$88,467	n/a	$429,257
CC2-4, 6-8, 10-11	8	n/a	723	4,575	3,307,422	26.7	$88,467	n/a	$429,257

† Gen1 through Gen6 are the six extrapolated facilities. Their characteristics represent the national average for the electricity sales factor and the electricity price, and the average of the seven NewGen facilities for capacity and plant construction cost.

Source: Analysis based on RDI, 2000; U.S. DOE, 1999a; U.S. DOE, 1999b.

7.1.2 Economic Impact Analysis Results

EPA used two economic impact measures for the 40 new electric generators: (1) the ratio of total annualized compliance cost to estimated revenues ("cost-to-revenue ratio") and (2) the ratio of initial compliance costs to the construction cost of the plant ("initial cost-to-plant construction cost ratio"). Estimating these ratios required discounting costs that occur in the future. For the cost-to-revenue ratio, EPA first calculated the present value of the streams of compliance costs over the first 30 years of each plant's life.[9] The present value was then annualized over 30 years to derive the constant annual value of the stream of

[9] The impact analysis presented in this chapter considers the first 30 years *of each facility's life*. This is different from the total cost estimate presented in Chapter 6 which only considered costs over the first 30 years *of the rule*, i.e., 2001 to 2030. EPA believes that including 30 years of compliance costs for each facility is a better indicator of potential facility-level impact than limiting costs to the first 30 years of the rule.

future compliance costs, using a seven percent discount rate (see formulas in *Chapter 6: Facility Compliance Costs*, Section 6.3).

Estimation of the initial cost-to-plant construction cost ratio involved dividing initial compliance costs, including capital technology and initial permit application costs, by the smaller of the two plant construction cost values.

Table 7-4 presents the results of the economic impact analysis for the 40 new electric generators. The table shows that the cost-to-revenue ratio for the new electric generators ranges between 0.07 and 4.16 percent. The initial cost-to-plant cost ratio ranges between 0.01 and 1.48 percent. Based on the low values of these impact measures, EPA believes that the economic impacts of the proposed §316(b) New Facility Rule on new electric generators will be minimal.

Table 7-4: Economic Impacts for New Electric Generators

Facility Name	No. of Facilities	Total Annualized Compl. Cost	Expected Annualized Revenues	Total Annualized Compl. Cost/ Expected Annualized Revenues	Net Present Value of Initial Compl. Cost†	Minimum Plant Construction Cost	NPV of Initial Compl. Cost/ Minimum Plant Construction Cost
GenA	1	$72,638	$106,638,872	**0.07%**	$44,491	$300,000,000	**0.01%**
GenB	1	$73,147	$109,136,681	**0.07%**	$47,004	$662,000,000	**0.01%**
GenC	1	$84,742	$66,002,195	**0.13%**	$246,526	$170,000,000	**0.15%**
GenD	1	$84,794	$74,647,211	**0.11%**	$49,889	$175,000,000	**0.03%**
GenE	1	$79,448	$54,195,202	**0.15%**	$49,120	$680,000,000	**0.01%**
GenF	1	$77,508	$77,348,729	**0.10%**	$44,936	$340,000,000	**0.01%**
GenG	1	$90,850	$102,183,962	**0.09%**	$190,617	$397,000,000	**0.05%**
Gen1-6	6	$78,987	$82,226,151	**0.10%**	$95,910	$344,000,000	**0.03%**
Coal1, 9, 13	3	$4,070,476	$97,888,275	**4.16%**	$13,348,971	$902,000,000	**1.48%**
Coal2-4, 6-8, 10-12, 14-16	12	$86,696	$97,888,275	**0.09%**	$77,943	$902,000,000	**0.01%**
Coal5	1	$450,210	$97,888,275	**0.46%**	$4,729,791	$902,000,000	**0.52%**
CC1, 5, 9	3	$889,074	$88,466,529	**1.01%**	$2,617,030	$429,000,000	**0.61%**
CC2-4, 6-8, 10-11	8	$90,850	$88,466,529	**0.10%**	$190,617	$429,000,000	**0.04%**

† Initial compliance cost includes the one-time costs presented in Table 6-11, i.e., capital and initial permit application costs.

Source: EPA Analysis, 2000.

7.2 New Manufacturing Facilities

EPA projected that 58 new manufacturing facilities in scope of the proposed §316(b) New Facility Rule will begin commercial operation within the next 20 years (see *Chapter 5: Baseline Projections of New Facilities*). Forty-eight of the 58 facilities are chemical facilities and ten are primary metals facilities. All 58 facilities are hypothetical facilities for which no actual information on capacity, location, technical, or economic characteristics are available.

EPA used annualized compliance costs as a percent of expected annual revenues ("cost-to-revenue ratio") as a measure of economic impacts. The comparison of initial compliance costs to plant construction costs used for electric generators could not be estimated for manufacturing facilities because information on facility construction cost is not readily available for the manufacturing SIC codes of interest.

7.2.1 Economic Characteristics

Estimation of the cost-to-revenue ratio requires the following information for each new in scope manufacturing facility:

- total annualized compliance cost, and
- expected annual revenues.

EPA estimated facility-level employment and revenues and firm-level employment for the 29 projected facilities expected to begin operation between 2001 and 2010, using information for existing facilities in the relevant industries.[10] The Agency used results from the §316(b) *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* (January 1999) to project employment and revenues, using the following methodology:

- ***Identify existing facilities from the Screener Questionnaire that serve as "model facilities" for the proposed new facilities:*** EPA analyzed screener respondents in each 4-digit SIC code that has at least one projected new facility. Only those screener respondents that meet the "in scope" characteristics of the proposed §316(b) New Facility Rule were used as model facilities.[11]

- ***Assign economic characteristics to each new in scope facility:*** EPA grouped the screener model facilities by SIC code and sorted them by their reported facility employment. EPA then selected one screener model facility to represent the economic characteristics of the projected new facility. Where only one new in scope facility is projected in an SIC code, the screener facility with the median facility employment served as the representative facility. In SIC codes where EPA projects more than one new in scope facility, all screener model facilities in that SIC code were evenly divided into as many groups as there are projected new facilities. The model facility with the median facility employment in each group served as the representative facility.[12] EPA assumed that the facility- and firm-level employment and revenues of the projected new facilities is the same as the facility- and firm-level employment and revenues of these representative screener facilities.

- ***Supplement missing data, where necessary:*** Some of the representative facilities identified among the screener model facilities did not report facility revenues or firm employment in the screener questionnaire. The missing information for these facilities was supplemented by data from the 1992 Census of Manufactures and the Dun and Bradstreet (D&B) database. EPA supplemented missing facility revenues by using average facility-level revenues by employment size category from the Census of Manufactures.[13] EPA supplemented missing firm-level information by identifying the DUNS numbers of the firms owning the screener model facilities and by retrieving each firm's employment data from the D&B database.

Table 7-5 presents the economic characteristics of the projected new in scope facilities using model facilities developed from the Industry Screener database and supplemented with facility revenue data from the Bureau of the Census and the D&B database.

[10] This section only presents information for the 29 facilities expected to begin operation in the first ten years of the rule. The characteristics, both revenues and compliance costs, of the 29 facilities projected to begin operation in the second ten years are assumed to be identical to the first 29 facilities. Facilities beginning operation between 2011 and 2020 would therefore experience the same impacts as the 29 facilities discussed in this section.

[11] Screener respondents that meet the in scope characteristics of the proposed §316(b) New Facility Rule (1) operate a CWIS; (2) hold an NPDES permit;(3) have a design intake flow of greater than two million gallons per day (MGD); and (4) use at least 25 percent of the water withdrawn for cooling purposes. Information on the percentage of intake water for cooling purposes was not available for all screener respondents. Where this information was unavailable, EPA assumed that the facility would meet this criterion.

[12] For example, an SIC code may have 45 screener model facilities and three projected in scope facilities. The 45 screener model facilities would be sorted in ascending order by their facility employment and divided into three groups of 15 facilities each. The first group would contain the 15 facilities with the fewest employees; the second group would contain the 15 facilities with middle employment levels; the third group would contain the 15 facilities with the most employees. Within each group, EPA assigned the median employment level of the model facilities to the new facility. The median facilities in this case are the facilities that rank eighth, 23rd, and 38th in employment.

[13] For example, a projected new facility in SIC code 2824 with an employment level of 1,200 employees would be assigned average facility revenues reported in the Census for the employment size category from 1,000 to 2,499 employees.

Table 7-5: Projected Economic Characteristics of New Manufacturing Facilities (2001 to 2010) (Revenues in $1999 thousands)

Facility ID	SIC	SIC Description	Number of New Facilities	Facility FTEs	Facility Annual Revenue†	Firm FTEs
Chemical and Allied Product Facilities (SIC 28)						
new 2812-1	2812	Alkalies and Chlorine	1	650	$125,271	12,380
new 2813-1	2813	Industrial Gases	1	18	$24,951	25,388
new 2819-1	2819	Industrial Inorganic Chemicals, N.E.C.	2	75	$26,345	81,600
new 2819-2				140	$94,502	5,500
new 2821-1	2821	Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers	3	567	$113,521	10,500
new 2821-2				1,000	$455,816	70,400
new 2821-3				1,610	$1,142,768	290,000
new 2824-1	2824	Manmade Organic Fibers, Except Cellulosic	1	1,446	$472,593	98,000
new 2833-1	2833	Medicinal Chemicals and Botanical Products	1	600	$605,178	53,800
new 2834-1	2834	Pharmaceutical Preparations	1	273	$228,029	40,000
new 2841-1	2841	Soaps and Other Detergents, Except Speciality Cleaners	1	460	$283,962	26,946
new 2865-1	2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments	1	139	$874,267	39,362
new 2869-1	2869	Industrial Organic Chemicals, N.E.C.	9	170	$68,898	17,000
new 2869-2				200	$97,698	17,000
new 2869-3				200	$107,064	98,000
new 2869-4				240	$67,566	260
new 2869-5				452	$334,647	39,362
new 2869-6				1,160	$615,280	98,000
new 2869-7				1,290	$1,214,590	13,300
new 2869-8				1,290	$1,214,590	13,300
new 2869-9				1,780	$1,214,590	15,000
new 2873-1	2873	Nitrogenous Fertilizers	1	170	$46,543	8,390
new 2874-1	2874	Phosphatic Fertilizers	1	350	$268,721	9,000
new 2899-1	2899	Chemicals and Chemical Preparations, NEC	1	135	$30,360	135

Table 7-5: Projected Economic Characteristics of New Manufacturing Facilities (2001 to 2010) (Revenues in $1999 thousands)

Facility ID	SIC	SIC Description	Number of New Facilities	Facility FTEs	Facility Annual Revenue†	Firm FTEs
Primary Metals Industries (SIC 33)						
new 3312-1	3312	Steel Works, Blast Furnaces (Including Coke Ovens), and Rolling Mills	3	260	$5,828	14,880
new 3312-2				1,000	$225,286	41,620
new 3312-3				5,000	$1,503,693	16,400
new 3316-1	3316	Cold-Rolled Steel Sheet, Strip, and Bars	1	240	$28,871	4,580
new 3353-1	3353	Aluminum Sheet, Plate, and Foil	1	690	$404,434	690

† Facility revenues from the screener were updated from 1997 to 1999 using Producer Price Indexes (PPI) compiled at the four-digit SIC level; revenues from the Census of Manufacturers were updated from 1992 to 1999 using the PPIs.

†† Facility annual revenues are based on Census data for the employment range from 100 to 249 employees.

Source: §316(b) Industry Screener Questionnaire, 1999; Bureau of the Census, 1992; D&B, 1999.

7.2.2 Economic Impact Analysis Results

EPA used the ratio of total annualized compliance cost to estimated revenues ("cost-to-revenue ratio") to determine facility-level impacts from the proposed §316(b) New Facility Rule. Estimating this ratio required discounting compliance costs that occur in the future. EPA first calculated the present value of the stream of costs over the first 30 years of each facility's life.[14] This present value was then annualized over 30 years to derive the constant annual value of the stream of future costs. This calculation used a seven percent discount rate (see formulas in *Chapter 6: Facility Compliance Costs*, Section 6.3).

Table 7-6 presents the results of the economic impact analysis for the 29 new manufacturing facilities projected to begin operation between 2001 and 2010. The table shows that the cost-to-revenue ratio for the 29 facilities ranges between 0.01 percent and 8.75 percent. Only two facilities are expected to have a cost-to-revenue ratio of greater than one percent, and only one facility is expected to have a ratio of greater than three percent. Based on the low values of this impact measure, EPA believes that the economic impacts of the proposed §316(b) New Facility Rule on new manufacturing facilities will be minimal.

[14] The impact analysis presented in this chapter considers the first 30 years *of each facility's life*. This is different from the total cost estimate presented in Chapter 6 which only considered costs over the first 30 years *of the rule*, i.e., 2001 to 2030. EPA believes that including 30 years of compliance costs for each facility is a better indicator of potential facility-level impact than limiting costs to the first 30 years of the rule.

Table 7-6: Economic Impacts for New Manufacturing Facilities

Facility ID	Total Annualized Compl. Cost	Expected Annual Revenues	Total Annualized Compl. Cost/ Expected Annualized Revenues
Chemical and Allied Product Facilities (SIC 28)			
new 2812-1	$79,860	$125,270,979	**0.06%**
new 2813-1	$604,465	$24,951,488	**2.42%**
new 2819-1	$100,678	$26,345,174	**0.38%**
new 2819-2	$494,390	$94,502,418	**0.52%**
new 2821-1	$84,604	$113,521,036	**0.07%**
new 2821-2	$92,936	$455,815,465	**0.02%**
new 2821-3	$82,246	$1,142,767,830	**0.01%**
new 2824-1	$79,448	$472,593,447	**0.02%**
new 2833-1	$72,638	$605,177,537	**0.01%**
new 2834-1	$126,025	$228,029,293	**0.06%**
new 2841-1	$115,784	$283,961,823	**0.04%**
new 2865-1	$72,638	$874,267,070	**0.01%**
new 2869-1	$179,504	$68,897,959	**0.26%**
new 2869-2	$179,504	$97,698,290	**0.18%**
new 2869-3	$74,626	$107,063,884	**0.07%**
new 2869-4	$74,626	$67,565,540	**0.11%**
new 2869-5	$74,626	$334,647,230	**0.02%**
new 2869-6	$100,793	$615,279,734	**0.02%**
new 2869-7	$524,504	$1,214,590,376	**0.04%**
new 2869-8	$524,504	$1,214,590,376	**0.04%**
new 2869-9	$79,448	$1,214,590,376	**0.01%**
new 2873-1	$90,347	$46,543,017	**0.19%**
new 2874-1	$76,245	$268,721,097	**0.03%**
new 2899-1	$94,879	$30,360,360	**0.31%**
Primary Metals Industries (SIC 33)			
new 3312-1	$509,697	$5,827,925	**8.75%**
new 3312-2	$74,626	$225,285,745	**0.03%**
new 3312-3	$121,090	$1,503,693,468	**0.01%**
new 3316-1	$74,250	$28,870,812	**0.26%**
new 3353-1	$73,359	$404,433,726	**0.02%**

Source: EPA Analysis, 2000.

7.3 Summary of Facility-Level Impacts

The economic impact analysis for the proposed §316(b) New Facility Rule shows that the requirements of this regulation would have minimal impacts on projected new electric generators and manufacturing facilities. Of the 98 projected facilities, only eight facilities are expected to incur annualized costs greater than one percent of revenues. Initial compliance costs compared to the plant construction cost are also expected to be small for electric generators. Table 7-7 summarizes the results of the impact analysis by industry sector.

Table 7-7: Compliance Costs and Economic Impacts by Sector

Sector	Number of Projected New In Scope Facilities	Total Annualized Compliance Costs ($mill 1999)†	Total Annualized Compl. Cost/ Annual Revenues		NPV of Initial Compl. Cost/ Plant Construction Cost	
			Lowest	Highest	Lowest	Highest
SIC 49 Steam Electric Generating	40	$18.1	0.07%	4.2%	0.01%	1.48%
SIC 26 Pulp & Paper	0	$0.0	n/a	n/a		
SIC 28 Chemicals	48	$8.2	0.01%	2.4%		
SIC 29 Petroleum	0	$0.0	n/a	n/a		
SIC 331 Steel	8	$1.6	0.01%	8.75%		
SIC 333/335 Aluminum	2	$0.1	0.02%	0.02%		
Total	98	$28.0				

† Total Annualized costs represent the costs for the first 30 years of each facility's life. These costs therefore do not match the compliance costs for the first 30 years of this rule presented in Chapter 6.

Source: EPA Analysis, 2000.

7.4 Potential for Firm- and Industry-Level Impacts

The previous section presented EPA's estimate of facility-level impacts as a result of the proposed §316(b) New Facility Rule. Given the insignificant impacts on the facility-level, EPA did not conduct a formal impact analysis at the firm- or industry-levels. Based on the analysis presented in this chapter, EPA concludes that the proposed §316(b) New Facility Rule will not cause impacts on the firms owning the impacted facilities or on their industries, for reasons discussed in this section.

The proposed rule is expected to increase the cost of the projected new in scope facilities relative to other new facilities and to existing facilities. Annualized compliance costs as a percentage of revenues at the facility-level ranged from 0.07 to 4.2 percent for new electric generators and from 0.01 to 8.8 percent for new manufacturing facilities. Since firm revenues are always equal to or greater than facility-level revenues, the cost-to-revenue ratio at the firm-level cannot be higher than at the facility-level. In most cases, this ratio would be lower. EPA therefore concluded that significant firm-level impacts as a result of the proposed §316(b) New Facility Rule are unlikely.

A rule that substantially increases the cost of new facilities could present a barrier to new entry, and constrain capacity growth in the affected industries. Barriers to new entry result in higher product prices in the long run and can retard valuable technological innovation. EPA concluded that the proposed rule is unlikely to discourage new entry, because the compliance costs associated with the proposed rule are small compared with the expected revenues of the projected facilities. However, the rule may influence the location, design, and choice of water sources of new facilities planning to use cooling water.

Given the small number of affected in scope facilities relative to the size of the affected industries, EPA also concluded that impacts at the industry-level are very unlikely. The maximum costs incurred in any one year represent a very small percentage of total industry revenues at the 4-digit SIC level. The rule affects too small a portion of any industry to have observable impacts at the industry level. EPA therefore does not expect any impacts on industry productivity, competition, prices, output, foreign trade, or employment. EPA concluded that a detailed market analysis is not required for any of the affected industries, given the screening analysis results.

7.5 Case Study Facility Impacts

EPA also estimated economic impacts for the eight case study facilities costed in Section 6.4 of *Chapter 6: Facility Compliance Costs*. These eight facilities include four worst case hypothetical electric generators (two large coal-fired power plants and two large nuclear plants) and four manufacturing facilities in industries in which EPA does not expect construction of new in scope facilities in the near future: SIC 20 (Food and Kindred Products), SIC 26 (Pulp and Paper), SIC 29 (Petroleum Refining), and SIC 32 (Stone, Clay, Glass and Concrete).

EPA used the same methodologies to estimate economic characteristics and impacts for the eight case study facilities as were used for the 98 projected new facilities discussed in Sections 7.1 and 7.2 above.

The following two subsections present the economic characteristics and impacts for the worst case electric generators and the case study manufacturing facilities, respectively.

a. Worst Case Electric Generators

The four worst case electric generators are hypothetical facilities with no actual economic or technical information. EPA made the following assumptions to project economic characteristics and estimate impacts:

- ***Waterbody type:*** All four plants will be located on an estuary. This assumption will result in the highest potential compliance costs because facilities drawing water from estuaries are subject to the most stringent compliance requirements under the proposed §316(b) New Facility Rule.

- ***NERC region:*** All four facilities will be located in the Southwest Power Pool (SPP) NERC region. The SPP region has the lowest electricity price of any coastal regions and one of the lowest electricity sales factors. The analysis will therefore provide a conservative estimate of projected facility revenues and is likely to overstate economic impacts.

- ***Capacity:*** The capacity of two of the four electric generators (CoalMax and NucMax) is the capacity of the facility with the maximum flow for a recirculating system among existing coal plants and nuclear plants, respectively. EPA identified these two high-flow plants from the 1995 EIA-767 database. The capacity of the two other generators (CoalAvg and NucAvg) is the average capacity of facilities with a flow among the highest third of once-through systems for existing coal plants and nuclear plants, respectively. This information is also based on the 1995 EIA-767 database.

Table 7-8 presents the assumed economic characteristics of the four worst case electric generators.

Table 7-8: Economic and Financial Characteristics of Worst Case Electric Generators ($1999 thousands)

Facility Name	NERC Region	Planned Capacity (MW)	Electricity Sales Factor	Annual Electricity Sales (MWh)	Price ($/MWh)	Estimated Annual Revenues	Plant Construction Cost	
							RDI	EIA
CoalMax	SPP	2,558	4,119	10,535,816	24.7	$260,145	n/a	$1,523,789
CoalAvg	SPP	1,200	4,119	4,942,525	24.7	$122,038	n/a	$714,834
NucMax	SPP	2,708	4,119	11,153,632	24.7	$275,400	n/a	$1,613,143
NucAvg	SPP	2,666	4,119	10,980,643	24.7	$271,129	n/a	$1,588,124

Source: Analysis based on U.S. DOE, 1999a; U.S. DOE, 1999b.

EPA applied the same measures used for the 40 projected new electric generators to assess economic impacts on the four worst case facilities:

- annualized compliance costs as a percent of expected annual revenues; and
- initial compliance costs as a percent of the construction cost of the plant.

Table 7-9 presents the economic impact results for the four worst case electric generators.

Table 7-9: Economic Impacts for Worst Case Electric Generators

Facility Name	Total Annualized Compl. Cost	Expected Annualized Revenues	Total Annualized Compl. Cost/ Expected Annualized Revenues	Net Present Value of Initial Compl. Cost†	Plant Construction Cost	NPV of Initial Compl. Cost/ Plant Construction Cost
CoalMax	$1,353,428	$260,145,006	**0.5%**	$12,444,249	$1,523,788,501	**0.8%**
CoalAvg	$6,234,675	$122,038,314	**5.1%**	$21,958,268	$714,834,324	**3.1%**
NucMax	$2,802,671	$275,399,795	**1.0%**	$26,015,277	$1,613,142,792	**1.6%**
NucAvg	$17,523,882	$271,128,454	**6.5%**	$53,714,343	$1,588,123,591	**3.4%**

† Initial compliance cost includes the one-time costs presented in Table 6-14, i.e., capital, and initial permit application costs.

Source: EPA Analysis, 2000.

Table 7-9 shows that the cost-to-revenue ratio for the four hypothetical worst case electric generators ranges between 0.5 and 6.5 percent. The initial cost-to-plant construction cost ratio ranges between 0.8 and 3.4 percent.

These results show that, if facilities with the characteristics of the four hypothetical worst case generators were being built in the future, such facilities could experience economic impacts that are higher than those estimated for the projected 40 electric generators. However, EPA believes that it is extremely unlikely that many facilities with worst case characteristics will be constructed in the future. The EIA does not project construction of any new nuclear facilities over the next 20 years.

In addition, the regulatory framework provides considerable flexibility for facilities to meet the requirements of the proposed §316(b) New Facility Rule. Facilities that are proposing to withdraw from estuaries and would as a result incur high compliance costs may choose to locate on a different type of water body and at a greater distance from biologically sensitive areas. By relocating their CWISs, facilities similar to the four worst case facilities can avoid some of the compliance requirements and would therefore face lower compliance costs and economic impacts.

EPA believes that, based on current technology and resource conservation trends, significant economic impacts on the electricity generation sector are unlikely. However, the Agency recognizes that in a few worst case instances, high flow electric generators could incur high costs to comply with the requirements of the proposed §316(b) New Facility Rule.

b. Case Study Manufacturing Facilities

The four case study manufacturing facilities are hypothetical facilities for which no actual economic or technical information exists. EPA estimated economic characteristics for these facilities using responses to the §316(b) Screener Questionnaire, as described in Section 7.2 for the 58 projected new manufacturing facilities.

Table 7-10 presents the economic characteristics of the four case study manufacturing facilities.

Table 7-10: Projected Economic Characteristics of Case Study Manufacturing Facilities (Revenues in $1999 thousands)

Facility ID	SIC	SIC Description	Facility FTEs	Facility Annual Revenue†
New SIC 20 HF	20	Food And Kindred Products	689	$1,826,719
New SIC 26 HF	26	Paper And Allied Products	331	$164,273
New SIC 29 HF	29	Petroleum Refining	570	$151,681
New SIC 32 HF	32	Stone, Clay, Glass, And Concrete Products	260	$64,581

† Facility revenues from the screener were updated from 1997 to 1999 using Producer Price Indexes (PPI) compiled at the four-digit SIC level; revenues from the Census of Manufacturers were updated from 1992 to 1999 using the PPIs.

Source: §316(b) Screener Questionnaire, 1999; Bureau of the Census, 1992.

EPA used the ratio of total annualized compliance cost to estimated revenues ("cost-to-revenue ratio") to determine facility-level impacts for the four case study manufacturing facilities.

Table 7-11 presents the economic impact results for these facilities. The table shows that the cost-to-revenue ratio for the four facilities ranges between 0.02 and 2.1 percent. The Agency therefore concludes that new manufacturing facilities in other industries are not expected to incur significant economic impacts as a result of the proposed §316(b) New Facility Rule.

Table 7-11: Economic Impacts for Case Study Manufacturing Facilities

Facility ID	Total Annualized Compl. Cost	Expected Annualized Revenues	Total Annualized Compl. Cost/ Expected Annualized Revenues
New SIC 20 HF	$333,460	$1,826,718,783	**0.02%**
New SIC 26 HF	$77,780	$164,273,163	**0.05%**
New SIC 29 HF	$84,326	$151,680,887	**0.06%**
New SIC 32 HF	$1,367,874	$64,581,082	**2.12%**

Source: EPA Analysis, 2000.

References

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Chapter 8: Regulatory Flexibility Analysis/SBREFA

Chapter Contents

Introduction

The Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), requires EPA to consider the economic impacts a rule will have on small entities. RFA/SBREFA requires an agency to prepare a regulatory flexibility analysis for any notice-and-comment rule it issues, unless the Agency certifies that the rule "will not, if promulgated, have a significant economic impact on a substantial number of small entities" (Small Business Regulation Enforcement Fairness Act of 1996, P.L. 104-121, Section 243).

EPA conducted a screening analysis to determine the potential impact of the proposed §316(b) New Facility Rule on small entities. The screening analysis showed that this regulation will not have a significant economic impact on a substantial number of small entities (SISNOSE). This finding is based on the limited number of small entities expected to incur compliance costs and the insignificant magnitude of compliance costs as a percentage of sales revenues.

The analysis used the definitions of small businesses established by the Small Business Administration (SBA) in the screening analysis.[1] The SBA defines small businesses based on Standard Industrial Classification (SIC) codes and size standards expressed by the number of employees, annual receipts, or electric output (13 CFR §121.20). The small business determination is made at the level of the parent firm.

To evaluate the economic impact on small entities, EPA analyzed each of the new facilities projected to incur costs under this regulation. These are electric generating facilities (SIC 49), chemical facilities (SIC 28), steel facilities (SIC 331), and aluminum facilities (SIC 335).[2]

A "sales test" is used to determine the potential severity of economic impacts on electric generators and manufacturing facilities owned by small firms. The test calculates annualized compliance cost as a percentage of total sales revenues. This screening analysis conducts the sales test at the facility-level.

8.1 Electric Generation Sector

EPA's analysis in Chapter 5 identified 40 new electric generators expected to incur costs under the proposed §316(b) New Facility Rule. Seven of the 40 facilities are "actual" planned facilities for which real information, including data on the parent firm, was available. The remaining 33 facilities are projected facilities expected to begin operation between 2004 and 2009 (six facilities) and 2011 and 2020 (27 facilities). No actual information on parent firms was available for these 33 facilities.

EPA used the NEWGen database to identify the parent firms of the seven actual facilities. Two of these facilities are owned by more than one firm. Therefore, the total number of firms that own a share in the seven facilities is nine. The Dun & Bradstreet (D&B) database was used to obtain each parent firm's SIC code, employment, and

[1] The SBA definitions only apply to private businesses, not governments or non-profit organizations. All small entities affected by the proposed §316(b) New Facility Rule are private businesses.

[2] New facilities in other industry sectors are assumed not to be impacted by the rule based on their low overall intake flows. They are therefore not included in this SBREFA analysis. See *Chapter 5: Baseline Projections of New Facilities* for further information on how new facilities expected to incur costs were identified.

revenues. Table 8-1 shows that eight parent firms are private businesses and one is a State government. For the purposes of the RFA/SBREFA analysis, States and tribal governments are not considered small governments but rather as independent sovereigns (U.S. EPA, 1999). Therefore, this facility is excluded from the SBREFA analysis.

Table 8-1 also shows the SIC codes of the parent firms. SBA's definition of small business for firms with SIC code 4911 (Electric Services) is different from the definition for other industrial categories. The small business standard for SIC code 4911 is electric output of less than 4 million megawatt hours, rather than an employment or revenue standard. EPA used the Energy Information Administration (EIA) Form 861 database to determine electric output of firms with SIC code 4911.

Table 8-1: Parent Firm and Facility Information for New In Scope Electric Generators

Parent Firm			Facility	
Name	**Type**	**SIC Code**	**Name**	**Share in Facility**
ParentA	private business	4924	GenA	100%
ParentB	private business	8741	GenB	100%
ParentC	private business	4911	GenC	100%
ParentD	private business	4911	GenD	100%
ParentE1	private business	4911	GenE†††	50%
ParentE2	private business	unknown††		50%
ParentF1	private business	4922	GenF†††	50%
ParentF2	private business	unknown††		50%
ParentG	state government†	n/a	GenG	100%

† For the purposes of the RFA/SBREFA analysis, States and tribal governments are not considered small governments but rather as independent sovereigns (U.S. EPA, 1999). This entity is therefore not considered in the small entity analysis.
†† No DUNS number could be identified for this entity. The SIC code is therefore unknown.
††† GenE and GenF are both owned by two parent firms.

Source: EPA analysis based on RDI, 2000; D&B, 1999.

EPA determined the size of each of the nine parent firms by comparing their electric output, revenues, or employment to the SBA small entity size standard for the entity's SIC code. Table 8-2 presents the comparison of the SBA small entity size standard with economic data for each parent firm. Based on data from the Dun & Bradstreet database and Form EIA-861, EPA determined that three parent firms are large, two are small, and the other three are of undetermined size. Since no further information could be retrieved for the firms of undetermined size, EPA assumed that these firms are also small entities. This assumption is both reasonable and conservative because, data are generally more readily available for larger entities, and the lack of data may be the result of a smaller entity size. By assuming that the parent firms of unknown size are small, EPA may overestimate the potential impacts on small entities.

Table 8 2: Parent Firm Information for New In Scope Electric Generators

Parent Firm Name	Parent Firm SIC Code	SBA Small Entity Size Standard	Parent Firm Value	Parent Firm Size
ParentA	4924	500 emp	62 emp	**small**
ParentB	8741	$5,000,000	$660,000	**small**
ParentC	4911	4,000,000 MWh	78,552,062 MWh	large
ParentD	4911	4,000,000 MWh	5,059,220 MWh	large
ParentE1	4911	4,000,000 MWh	unknown	**undetermined**
ParentE2	unknown	unknown	unknown	**undetermined**
ParentF1	4922	$5,000,000	$5,781,999,616	large
ParentF2	unknown	unknown	unknown	**undetermined**
ParentG	n/a	n/a	n/a	n/a

Source: EPA Analysis based on NEWGen Database; D&B Database.

No information was available on the entity size of the 27 electric generators projected to begin operation between 2011 and 2020. EPA made the following assumptions for these facilities:

- ***Four of the six extrapolated facilities projected to begin operation between 2004 and 2009 will be owned by small entities.*** This is based on the assumption that the projected facilities have the same characteristics as the seven NEWGen facilities for which actual data are available. Four of the seven NEWGen facilities, or 57 percent, were determined to be owned by a small entity or an entity of unknown size. Applying this factor to the projected six facilities, EPA determined that an additional four projected facilities may be owned by a small entity.

- ***None of the 16 coal facilities projected to begin operation between 2011 and 2020 will be owned by a small entity.*** The 16 coal plants are assumed to have a generating capacity of 800 MW. Using the average electricity sales factors presented in *Chapter 7: Economic Impact Analysis*, each facility would generate more than 3.6 million MWh per year. This amount almost qualifies the facility as a large entity *at the facility-level*. EPA believes that coal plants of 800 MW would actually generate more than the average across all technologies. In addition, it is unlikely that a small firm would plan to construct a large coal plant. Based on these factors, EPA assumes that the 16 new coal facilities will not be owned by a small entity.

- ***Six of the 11 extrapolated combined-cycle facilities projected to begin operation between 2011 and 2020 will be owned by small entities.*** This estimate is based on the assumption that the projected combined-cycle facilities have the same characteristics as the seven NEWGen facilities for which data are available. Fifty-seven percent of the NEWGen facilities were determined to be owned by a small entity or an entity of unknown size. Applying this factor to the projected 11 facilities, EPA determined that an additional six projected facilities would be owned by a small entity

Table 8-3 lists the 14 new electric generators expected to be owned by a small entity. Sales revenues required for the sales test were not available for all parent firms. The test to determine significant economic impacts was therefore applied at the facility-level instead of the parent firm-level.[3] As facility-level revenues are equal to or smaller than the parent firm revenues, this approach may overstate the economic impacts of this rule.

[3] Facility-level revenues were estimated using expected annual electricity generation and expected future prices of electricity. Compliance costs include all costs incurred during the first 30 years of each facility's life. *Chapter 7: Economic Impact Analysis* provides details on the estimation of expected annual compliance costs and expected annual revenues for this screening analysis.

Table 8-3: Economic Impact Condition of New In Scope Electric Generators					
Facility Name	No. of Facilities	Parent Name	Facility Information		
			Estimated Annual Compliance Cost ($1999)	Estimated Annual Revenues ($1999)	Ann. Compl. Cost/ Ann. Revenues
GenA	1	ParentA	$72,638	$106,638,872	0.07%
GenB	1	ParentB	$73,147	$109,136,681	0.07%
GenE	1	ParentE1	$79,448	$54,195,202	0.15%
		ParentE2			
GenF	1	ParentF2	$77,508	$77,348,729	0.10%
Gen1-Gen6	4	N/A	$78,987	$82,226,151	0.10%
CC1-CC11	6	N/A	$90,850	$88,466,529	0.10%

Source: EPA Analysis, 2000.

Table 8-3 shows that the ratio of estimated annual compliance costs to estimated annual revenues for the 14 in scope facilities owned by a small firm ranges from 0.07 percent to 0.15 percent. None of these facilities are expected to incur compliance costs in excess of one percent of revenues.

8.2 MANUFACTURING SECTOR

The analysis in *Chapter 5: Baseline Projections of New Facilities* determined that 58 new manufacturing facilities are expected to incur compliance costs under the proposed §316(b) New Facility Rule. Since EPA's estimate of new manufacturing facilities is based on industry growth forecasts and not on specific planned facilities, actual parent firm information was not available. EPA therefore developed representative facilities based on the characteristics of existing facilities identified in the §316(b) Industry Screener Questionnaire.[4]

Table 8-4 presents the comparison of parent firm employment with the SBA small entity size standard for the 29 new manufacturing facilities projected to begin operation between 2001 and 2010.[5] The SBA standard is based on the firm's SIC code. The table shows that only three of the 29 new manufacturing facilities are projected to be owned by a small parent firm. Two of the three facilities are in the chemicals sector and one is in the metals sector. None of the three small firms are expected to own more than one new facility with costs under the proposed §316(b) New Facility Rule.

[4] For each SIC code with a projected new facility, EPA sorted screener respondents in that SIC code by their facility employment. EPA selected the facility with the median employment value as the representative facility and used that facility's reported firm employment for this SBREFA analysis. Data from the Dun & Bradstreet database were used where information on the firm was not available in the screener. In cases where more than one new facility is projected in an SIC code, EPA divided the screener respondents in as many ranges as there are new facilities and identified the median-employment facility in each range. *Chapter 7: Economic Impact Analysis* provides more detailed information on how facility and firm characteristics for the 58 new manufacturing facilities were determined.

[5] This section only presents information for the 29 facilities expected to begin operation during the first ten years of the rule. EPA's analysis assumed that facilities beginning operation between 2011 and 2020 would have characteristics identical to facilities beginning operation during the first ten years of the forecasting period. Each facility presented in table 8-4 therefore represents two new facilities.

Table 8-4: Parent Firm Size of New In Scope Manufacturing Facilities

Facility ID	SIC Code	SIC Code Description	SBA Small Entity Size Standard (Employees)	Estimated Parent Firm Employment	Parent Firm Size
new 2812-1	2812	Alkalies and Chlorine	1,000	12,380	large
new 2813-1	2813	Industrial Gases	1,000	25,388	large
new 2819-1	2819	Industrial Inorganic Chemicals, N.E.C.	1,000	81,600	large
new 2819-2				5,500	large
new 2821-1	2821	Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers	750	10,500	large
new 2821-2				70,400	large
new 2821-3				290,000	large
new 2824-1	2824	Manmade Organic Fibers, Except Cellulosic	1,000	98,000	large
new 2833-1	2833	Medicinal Chemicals and Botanical Products	750	53,800	large
new 2834-1	2834	Pharmaceutical Preparations	750	40,000	large
new 2841-1	2841	Soaps and Other Detergents, Except Speciality Cleaners	750	26,946	large
new 2865-1	2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments	750	39,362	large
new 2869-1	2869	Industrial Organic Chemicals, N.E.C.	1,000	17,000	large
new 2869-2				17,000	large
new 2869-3				98,000	large
new 2869-4				260	**small**
new 2869-5				39,362	large
new 2869-6				98,000	large
new 2869-7				13,300	large
new 2869-8				13,300	large
new 2869-9				15,000	large
new 2873-1	2873	Nitrogenous Fertilizers	1,000	8,390	large
new 2874-1	2874	Phosphatic Fertilizers	500	9,000	large
new 2899-1	2899	Chemicals and Chemical Preparations, NEC	500	135	**small**
new 3312-1	3312	Steel Works, Blast Furnaces (Including Coke Ovens), and Rolling Mills	1,000	14,800	large
new 3312-2				41,620	large
new 3312-3				16,400	large
new 3316-1	3316	Cold-Rolled Steel Sheet, Strip, and Bars	1,000	4,580	large
new 3353-1	3353	Aluminum Sheet, Plate, and Foil	750	690	**small**

Source: EPA analysis based on §316(b) Industry Screener Questionnaire, 1999; D&B, 1999.

Each of the three facilities owned by a small parent firm was further analyzed to determine if it will experience a significant economic impact as a result of this regulation. The analysis is based on the ratio of estimated annual compliance cost to estimated annual revenues. As with electric generators, this analysis was conducted at the facility-level rather than the firm-level, and includes all compliance costs incurred during the first 30 years of each facility's life.. (See *Chapter 7: Economic Impact Analysis* for details on the estimation of expected annual compliance costs and expected annual revenues for this screening analysis.)

Table 8-5: Economic Impact Condition of New In Scope Manufacturing Facilities

Facility ID	Facility SIC	Facility Information		
		Estimated Annual Compliance Cost ($1999)	Estimated Annual Revenues ($1999)	Annual Compliance Cost/ Annual Revenues
new 2869-4	2869	$74,626	$67,565,540	0.11%
new 2899-1	2899	$94,879	$30,360,360	0.31%
new 3353-1	3353	$73,359	$404,433,726	0.02%

Source: EPA Analysis, 2000.

The results in Table 8-5 show that none of the facilities owned by a small firm would have a compliance cost-to-revenue ratio of greater than one percent. Based on this screening analysis EPA determined that no small firm in the analyzed manufacturing industries would experience significant impacts from the compliance cost of this rule.[6]

[6] The estimated ratio of annual compliance costs to annual revenues is likely to overestimate impacts because it is based on facility revenues rather than firm revenues. Firm revenues are always greater than or equal to facility revenues. In addition, the number of facilities owned by small entities may be overstated because it is based on the firm's *current employment*. Once the employment of the new facility is added to the firm's employment, the firm may no longer be considered small.

8.3 Summary of Results

The RFA/SBREFA analysis for this proposed regulation shows that only 20 facilities owned by a small entity would be impacted by the proposed §316(b) New Facility Rule. This number is well below the SBREFA threshold of 100 small entities suggested by EPA's SBREFA guidance. In addition, none of the small entities are expected to experience a significant economic impact as a result of this regulation. Therefore, EPA certifies that the proposed §316(b) New Facility Rule will not have a significant economic impact on a substantial number of small entities.

Table 8-6 summarizes the results of the SBREFA screening analysis.

Table 8-6: Projected Number of New Facilities Owned by a Small Entity

SIC Code	Facilities Owned by Small Entities	Compliance Cost as a Percent of Revenue	Number of Facilities Owned by a Small Entity With Significant Impact
Electric Generators			
49, 87	***14***	***0.07% to 0.15%***	***0***
Manufacturing Facilities			
26 – Pulp & Paper	0	n/a	0
28 – Chemicals	4	0.11% to 0.31%	0
29 – Petroleum	0	n/a	0
33 – Metals	2	0.02%	0
Total Manufacturing	***6***	***0.02% to 0.31%***	***0***
Total	**20**	**0.02% to 0.29%**	**0**

Source: EPA Analysis, 2000.

REFERENCES

Dun and Bradstreet (D&B). 1999. Data as of April 1999.

Research Data International (RDI). 2000. NEWGen Database.

U.S. Environmental Protection Agency (EPA). 1999. *Revised Interim Guidance for EPA Rulewriters: Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act. March 29, 1999.*

Chapter 9: UMRA and Other Economic Analyses

Introduction

This chapter addresses the requirements of the Unfunded Mandates Reform Act (UMRA) and the related requirements of Executive Order 13132 on "Federalism" and the Paperwork Reduction Act (PRA). To demonstrate compliance with these mandates, EPA analyzed the costs and impacts of the proposed rule for government and private sector entities, including the administrative costs imposed by the regulation.

Section 9.1 of this chapter presents an analysis which supports EPA's compliance with the requirements of UMRA. Section 9.2 presents the total social costs of the proposed rule. Section 9.3 addresses Executive Order 13132 and the Paperwork Reduction Act.

Chapter Contents

9.1 The Unfunded Mandates Reform Act (UMRA) of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires that Federal agencies assess the effects of their regulatory actions on state, local, and tribal governments and the private sector. Agencies must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with "Federal mandates" that may result in expenditures by state, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more in any one year (Section 202 of UMRA).[1]

Before promulgating a rule for which a written statement is needed, agencies must identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule (Section 205). The provisions of Section 205 do not apply when they are inconsistent with applicable law. Agencies may adopt an alternative other than the least costly, most cost-effective, or least burdensome alternative if they publish with the final rule an explanation why that alternative was not adopted (Section 205). Before establishing any regulatory requirements that may significantly or uniquely affect small governments, including tribal governments, agencies must develop a small government agency plan (Section 203). The plan must provide for notifying potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of EPA regulatory proposals with significant Federal intergovernmental mandates, and informing, educating, and advising small governments on compliance with the regulatory requirements.

UMRA specifies that a written statement is needed if either (1) the cost of a regulation to *state, local, and tribal governments* exceeds $100 million in any one year, or (2) the cost of a regulation to the *private sector* exceeds $100 million in any one year.[2] The following two subsections, 9.1.1 and 9.1.2, present the costs of the proposed §316(b) New Facility Rule to the government and the private sector,

[1] Federal mandates include Federal regulations that impose enforceable duties on state, local, and tribal governments, or on the private sector, excluding those related to conditions of Federal assistance and participation in voluntary Federal programs.

[2] The $100 million test is applied separately to governments and the private sector. The term "in any one year" refers to the maximum cost in a single year, not the annualized cost over the analysis period.

respectively. Subsection 9.1.3 presents a summary of the results of the UMRA analysis.

9.1.1 Compliance Costs for Governments

Governments may incur two types of costs as a result of the proposed rule: (1) costs to comply with the rule for in scope facilities owned by government entities; and (2) costs to implement the rule, borne by the responsible regulatory authorities. Both types of costs are discussed below.

a. Compliance Costs for Government-Owned Entities

Of the 98 new in scope facilities subject to the proposed rule, only three are expected to be owned by a government entity. All three are electric generators projected to be owned by a state government or municipality.[3]

Compliance costs for individual facilities were presented in *Chapter 6: Facility Compliance Costs*. The maximum aggregate costs for the three government-owned facilities in any one year is estimated to be $189,000.[4]

b. Implementation Costs for Regulatory Authorities

The requirements of §316(b) are implemented through the NPDES permit program. Forty-four states and territories currently have NPDES permitting authority under Section 402(b) of the Clean Water Act (CWA). EPA estimates that states and territories will incur four types of costs associated with implementing the requirements of the proposed §316(b) New Facility Rule: (1) start-up activities; (2) issuing an initial NPDES permit for each new facility; (3) reviewing and reissuing a permit for each new facility every five years; and (4) annual activities.

Each state's actual burden associated with the administrative functions required by the proposed §316(b) New Facility Rule will depend on the number of new in scope facilities that will be built in the state during the ten year analysis period. The incremental burden will also depend on the extent of each state's current practices for regulating CWISs.[5]

[3] Based on EPA's research of the NEWGen database, one new in scope facility, GenG, is owned by a state government. EPA extrapolated information from the NEWGen database to account for the 20-year forecasting period of this analysis. Based on this extrapolation, EPA estimated that an additional two government-owned facilities, Gen1 and CC6, would be subject to this proposed regulation. (See *Chapter 5: Baseline Projections of New Facilities* and *Chapter 7: Economic Impact Analysis* for more information on how EPA estimated the number and the type and characteristics of facilities subject to this rule.)

[4] Annualized at seven percent, this cost is estimated to be $186,000.

[5] States that currently require relatively modest analysis, monitoring, and reporting of impacts from CWISs in NPDES permits may require more permitting resources to implement the proposed rule than are required under their current programs. For states that are actively implementing §316(b) requirements now, the proposed rule may actually reduce the burden on permit writers, by clarifying key concepts in the rule and by providing easily-applied criteria for some regulatory determinations. The available information on current implementation of the §316(b) requirements by different regulatory authorities is insufficient to allow EPA to estimate the costs of the proposed rule to the regulatory authorities with precision. EPA therefore made the conservative assumption that permitting authorities currently do not incur administrative costs of implementing §316(b) requirements and that all costs for new facilities under the proposed §316(b) New Facility Rule are incremental costs.

❖ ***Start-up activities***

All 44 states and territories with NPDES permitting authority are expected to undergo start-up activities to prepare for administering the provisions of the proposed §316(b) New Facility Rule. Start-up activities include reading and understanding the rule, mobilization and planning of the resources required to address the rule's requirements, and training technical staff on how to review materials submitted by facilities and make determinations on the§316(b) requirements for each facility's NPDES permit. In addition, permitting authorities are expected to incur other direct costs, e.g., for copying and the purchase of supplies. Table 9-1 shows that total start-up costs of $3,054 are expected to be incurred by each of the 44 states and territories with NPDES permitting authority.

Table 9-1: Government Costs of Start-Up Activities (per Regulatory Authority)

Activity	Costs
Read and Understand Rule	$758
Mobilization/Planning	$1,326
Training	$919
Other Direct Costs	$50
Total†	**$3,054**

† Individual numbers may not add up to total due to independent rounding.

Source: *U.S. EPA, Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.*

❖ ***Issue initial NPDES permit***

The permitting authorities will have to include the requirements of the proposed §316(b) New Facility Rule in the initial NPDES permit issued to each new in scope facility. The activities required to make determinations of §316(b) requirements include reviewing submitted documents and supporting materials, verifying data sources, consulting with facilities and the interested public, determining specific permit requirements, and writing the actual permit.

Table 9-2 below shows the activities that EPA anticipates will be necessary for initial permit issuance and the estimated cost of each activity. Permits that require all of the components listed in Table 9-2 are expected to impose a cost of $3,482 per permit.

Table 9-2: Government Costs of Initial NPDES Permit Issuance (per Permit)

Activity	Costs
Review Source Water Baseline Characterization Study	$443
Review Littoral Zone and CWIS Location Data	$443
Review CWIS Design Data	$443
Review Additional Technology Implementation Plan	$222
Determine Compliance with CWIS Standards	$665
Determine Monitoring Frequency	$222
Determine Record Keeping and Reporting Frequency	$222
Consider Public Comments	$222
Issue Permit	$201
Keep Permit Record	$100
Other Direct Costs	$300
Total[††]	**$3,482**

† Actual per permit costs may be lower than the total cost because some facilities will not have to submit information on all compliance requirements.

†† Individual numbers may not add up to total due to independent rounding.

Source: U.S. EPA, Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

❖ ***Review and reissue permit every five years***

NPDES permits are issued for five years. The permitting authority therefore has to reissue the permits for the new in scope facilities every five years following issuance of the initial permit. Before reissuing a facility's permit, the regulatory authority must determine if there have been any changes in the facility's operations or in the physical or biological attributes of the source water body. Any changes should be evaluated to determine the need for additional, or more stringent, conditions in the permit.

The proposed §316(b) New Facility Rule requires facilities to submit the same type of information for their permit renewal application as was required for the initial permit. The permitting authorities will therefore have to carry out the same type of administrative activities as during the initial permitting process. The burden of these activities is expected to be smaller for permit reissuance, however, because the permitting authority is already familiar with the facility's case and the type of information the facility will provide. The reduction in costs is expected to vary by the specific repermitting activities.

Table 9-3 shows the activities that EPA anticipates will be necessary for permit reissuance and the estimated cost of each activity. Permits that require all of the components listed in Table 9-3 are expected to impose a cost of $2,861 per permit.

Table 9-3: Government Costs of Repermitting (per Permit)

Activity	Costs
Review Source Water Baseline Characterization Study	$443
Review Littoral Zone and CWIS Location Data	$133
Review CWIS Design Data	$133
Review Additional Technology Implementation Plan	$222
Determine Compliance with CWIS Standards	$665
Determine Monitoring Frequency	$222
Determine Record Keeping and Reporting Frequency	$222
Consider Public Comments	$222
Issue Permit	$201
Keep Permit Record	$100
Other Direct Costs	$300
Total	**$2,861**

† Actual per permit costs may be lower than the total cost because some facilities will not have to submit information on all compliance requirements.

†† Individual numbers may not add up to total due to independent rounding.

Source: U.S. EPA, Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

❖ ***Annual activities***

In addition to the start-up and permitting activities discussed above, permitting authorities will have to carry out certain annual activities to ensure the continued implementation of the requirements of the proposed §316(b) New Facility Rule. These annual activities include reviewing yearly status reports, tracking compliance, determining monitoring scope reduction, and record keeping.

Table 9-4 below shows the annual activities that will be necessary for each permit following the year of initial permitting and the estimated cost of each activity. A total cost of $1,469 is estimated for each permit per year.

Table 9-4: Government Costs for Annual Activities (per Permit)

Activity	Costs
Review of Yearly Report	$522
Track Compliance	$443
Determine Monitoring Scope Reduction	$348
Keep Records	$106
Other Direct Costs	$50
Total†	**$1,469**

†† Individual numbers may not add up to total due to independent rounding.

Source: Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

EPA calculated total government costs for implementing the proposed §316(b) New Facility Rule by aggregating the unit costs presented in Tables 9-1 to 9-4 based on the specific permitting requirements for each of the 98 new in scope facilities. Table 9-5 presents the rule's estimated government implementation costs for 2001 to 2030. The table shows that the highest one-year implementation costs, $159,319, will be incurred in 2001, the first year of the final §316(b) New Facility Rule. This cost is mainly the result of start-up activities for the 44 states and territories with NPDES permitting authority. The total net present value of government implementation costs is estimated to be $953,700 or $76,860 per year when annualized over 30 years at a seven percent rate.[6]

[6] Calculation of the present value assumes that costs are incurred at the end of the year.

Table 9-5: Total Government Implementation Costs by Year and Activity

Year	Start-Up Activities	Initial Permitting	Repermitting	Annual Activities	Total Costs
2001	$134,376	$24,943	$0	$0	$159,319
2002	$0	$18,832	$0	$7,344	$26,175
2003	$0	$12,977	$0	$17,624	$30,601
2004	$0	$11,679	$3,546	$24,968	$40,193
2005	$0	$10,571	$14,262	$30,843	$55,676
2006	$0	$12,280	$16,040	$36,718	$65,037
2007	$0	$13,009	$10,805	$44,061	$67,875
2008	$0	$12,344	$9,507	$49,936	$71,787
2009	$0	$6,425	$12,255	$55,811	$74,491
2010	$0	$5,255	$24,060	$60,217	$89,531
2011	$0	$9,116	$26,567	$61,685	$97,367
2012	$0	$6,963	$21,287	$61,685	$89,936
2013	$0	$6,963	$15,622	$61,685	$84,271
2014	$0	$6,963	$13,521	$61,685	$82,170
2015	$0	$6,520	$24,060	$61,685	$92,266
2016	$0	$8,293	$26,567	$61,685	$96,545
2017	$0	$11,775	$21,287	$61,685	$94,747
2018	$0	$12,597	$15,622	$61,685	$89,904
2019	$0	$11,775	$13,521	$61,685	$86,981
2020	$0	$8,608	$24,060	$61,685	$94,354
2021	$0	$0	$26,567	$61,685	$88,252
2022	$0	$0	$21,287	$61,685	$82,973
2023	$0	$0	$15,622	$61,685	$77,307
2024	$0	$0	$13,521	$61,685	$75,206
2025	$0	$0	$24,060	$61,685	$85,745
2026	$0	$0	$26,567	$61,685	$88,252
2027	$0	$0	$21,287	$61,685	$82,973
2028	$0	$0	$15,622	$61,685	$77,307
2029	$0	$0	$13,521	$61,685	$75,206
2030	$0	$0	$24,060	$61,685	$85,745
Net Present Value @7%	**$125,585**	**$127,553**	**$164,583**	**$535,980**	**$953,701**
Annualized @7%	**$10,120**	**$10,280**	**$13,260**	**$43,190**	**$76,860**

Source: Summary information from the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

9.1.2 Compliance Costs for the Private Sector

The private sector incurs costs under the proposed §316(b) New Facility Rule to comply with the requirements for in scope facilities. Of the 98 new in scope facilities subject to the proposed rule, 95 are estimated to be owned by a private entity. The privately-owned facilities include all 58 manufacturing facilities and 37 of the 40 electric generators.

Compliance costs for individual facilities were presented in *Chapter 6: Facility Compliance Costs*. Total annualized compliance costs for the 95 privately-owned facilities are estimated to be $11.9 million, discounted at seven percent. The maximum aggregate costs for all 95 facilities in any one year is estimated to be $36.2 million. This is well below the UMRA $100 million cost threshold for private sector costs in any one year.

9.1.3 Summary of the UMRA Analysis

EPA has determined that the proposed rule, if promulgated, would not contain a Federal mandate that will result in expenditures of $100 million or more for state, local and tribal governments, in the aggregate, or for the private sector in any one year.

Table 9-6 summarizes the costs to comply with the rule for the 98 in scope facilities and the costs to implement the rule, borne by the responsible regulatory authorities.

Table 9-6: Summary of Total Costs

Sector	Total Annualized Cost			Maximum One-Year Cost		
	Facility Compliance Costs	Government Implement-ation Costs	Total	Facility Compliance Costs	Government Implement-ation Costs	Total
Government Sector	$185,950	$76,860	$262,810	$189,000	$97,370	$286,370
Private Sector	$11,941,130	n/a	$11,941,130	$36,182,530	n/a	$36,182,530
Total	$12,127,080	$76,860	$12,203,940	$36,371,530	$97,370	$36,468,900

Source: Summary information from Appendix B and the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

Table 9-6 shows that total annualized costs of the §316(b) New Facility Rule borne by governments is $0.26 million per year. The maximum one-year costs that will be incurred by government entities is expected to be $0.29 million ($0.19 million in compliance costs for the three projected government-owned facilities and $0.1 million in implementation costs). Total annualized costs and maximum one-year costs borne by the private sector are $11.9 million and $36.2 million, respectively. Both of these maximum costs are well below the $100 million UMRA threshold. EPA therefore concludes that the proposed §316(b) New Facility Rule is not subject to the requirements of Sections 202 and 205 of UMRA.

9.2 Social Costs of the Proposed Rule

The social costs of regulatory actions are the opportunity costs to society of employing scarce resources to reduce environmental damage. The largest component of economic costs to society generally is the estimated costs incurred by facilities for the labor, equipment, material, and other economic resources needed to comply with the proposed rule. Social costs also include the value of resources used by governments to implement the rule, including the costs of permitting, compliance monitoring, and enforcement activities. Finally, social costs include lost producers' and consumers' surplus that result when the quantity of goods and services produced decreases as a result of the rule.

The estimated total social cost of the proposed §316(b) New Facility Rule is the sum of three cost components: (1) direct compliance costs to facilities subject to the regulation; (2) costs to permitting authorities of implementing the rule; and (3) costs to the federal government of overseeing rule implementation.

- ***Facility compliance costs*** are discussed in *Chapter 6: Facility Compliance Costs* and include technology costs, operating and maintenance costs, and permitting and monitoring costs.[7]

- ***State permitting costs*** are presented in Section 9.1.1(b) of this chapter and include start-up costs, costs for initial permit application review and permit development, repermitting costs, and costs for annual activities.

- ***Federal costs*** include the same types of costs as are incurred by states but are associated with reviewing the states' permitting actions.

Given the small number of new facilities that would incur costs under the proposed §316(b) New Facility Rule, EPA does not expect a reduction in output in the affected industries due to the proposed rule (see discussion in *Chapter 7: Economic Impact Analysis*). Therefore, social costs are fully accounted for by the compliance costs incurred by the regulated facilities and the costs incurred by governments to implement the rule.

The total estimated social cost of the proposed §316(b) New Facility Rule is approximately $12.2 million annually (using a seven percent discount rate and a 30 year discounting period). Direct facility compliance costs account for $12.1 million, or 99.2 percent, of the total. Annual state and federal implementation costs account for approximately $76,860 and $3,250, respectively. The net present value of total social costs is $151.5 million, with facility compliance costs accounting for $150.5 million, state implementation costs for $0.95 million, and federal costs for $0.04 million.

[7] Direct compliance costs to facilities are often calculated differently for the economic impact analysis and the social cost estimation. Economic impact analyses often take into account the tax deductability of compliance costs to private businesses and differences between social and private opportunity costs of capital. The facility compliance costs estimated in Chapter 6, however, were not adjusted for tax effects. In addition, a single discount rate of seven percent is used in all parts of the analysis. Therefore, the costs presented in Chapter 6 represent both, the costs used in the impact analysis and the value to society of the resources used by facilities in compliance activities.

Table 9-7: Social Cost of the Proposed §316(b) New Facility Rule ($1999)		
	NPV	**Annualized**
Facility Compliance Costs	$150,485,380	$12,127,080
State Implementation Costs	$953,700	$76,860
Federal Costs	$40,320	$3,250
Total	**$151,479,400**	**$12,207,190**

Source: Summary information from Appendix B and the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

9.3 Other Economic Analyses

9.3.1 Executive Order 13132 (Federalism)

Executive Order 13132 on "Federalism" (64 FR 43255, August 10, 1999) requires EPA to develop an accountable process to ensure "meaningful and timely input by state and local officials in the development of regulatory policies that have federalism implications." "Policies that have federalism implications" is defined in the Executive Order to include regulations that have "substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government."

Under Section 6 of Executive Order 13132, EPA may not issue a regulation that has federalism implications, that imposes substantial direct compliance costs, and that is not required by statute, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by state and local governments, or EPA consults with state and local officials early in the process of developing the proposed regulation. EPA also may not issue a regulation that has federalism implications and that preempts state law, unless the Agency consults with state and local officials early in the process of developing the proposed regulation.

EPA determined that the proposed §316(b) New Facility Rule does not have federalism implications. It will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. The rule will not impose substantial costs on states and localities. In addition, the rule is required by §316(b) of the Clean Water Act. For these reasons, the requirements of Section 6 of the Executive Order do not apply to this rule.

9.3.2 The Paperwork Reduction Act of 1995

The Paperwork Reduction Act of 1995 (PRA) (superseding the PRA of 1980) is implemented by the Office of Management and Budget (OMB) and requires that agencies submit a supporting statement to OMB for any information collection that solicits the same data from more than nine parties. The PRA seeks to ensure that Federal agencies balance their need to collect information with the paperwork burden imposed on the public by the collection.

The definition of "information collection" includes activities required by regulations, such as permit development, monitoring, recordkeeping, and reporting. The term "burden" refers to the "time, effort, or financial resources" the public expends to provide information to or for a Federal agency, or otherwise fulfill statutory or regulatory requirements. PRA paperwork burden is measured in terms of annual time and financial resources the public devotes to meet one-time and recurring information requests (44 U.S.C. 3502(2); 5 C.F.R. 1320.3(b)).

Information collection activities may include:

- reviewing instructions;
- using technology to collect, process, and disclose information;
- adjusting existing practices to comply with requirements;

- searching data sources;
- completing and reviewing the response; and
- transmitting or disclosing information.

Agencies must provide information to OMB on the parties affected, the annual reporting burden, the annualized cost of responding to the information collection, and whether the request significantly impacts a substantial number of small entities. An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a currently valid OMB control number.

EPA's estimate of the information collection requirements imposed by the proposed §316(b) New Facility Rule are documented in the Information Collection Request (ICR) which accompanies this regulation.

REFERENCES

U.S. Environmental Protection Agency. 2000. Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

Chapter 10: Alternative Regulatory Options

INTRODUCTION

EPA defined and evaluated a number of alternative Best Technology Available (BTA) options for facilities subject to the proposed §316(b) New Facility Rule. This chapter presents two alternative options that EPA considered for proposal and their costs.

CHAPTER CONTENTS

10.1 ALTERNATIVE OPTION 1: UNIFORM STANDARDS OPTION

The first alternative option that EPA considered would apply the BTA requirements proposed for estuaries and tidal rivers to all facilities, regardless of location. Under this option, the definition and number of new facilities subject to the rule would not change, but some facilities would incur more stringent compliance requirements. Application of these requirements would ensure that stringent controls, based on the capabilities of closed-cycle recirculating systems, are the nationally applicable minimum for all new CWISs on all water body types. The specific standards under this option would include:

- reducing total design intake flow to no more than one percent of annual flow or volume of the source water body;
- reducing maximum design intake velocity to no more than 0.5 feet per second;
- reducing intake flow to a level commensurate with that which could be attained by a closed-cycle recirculating cooling water system;
- implementing additional technologies that minimize I&E of fish eggs and larvae and maximize survival of impinged adult and juvenile fish;
- implementing other requirements as defined by the Director.

EPA used the same process to develop the estimates for the Uniform Standards Option as was used for the proposed rule. Based on the new facility characteristics, EPA assessed whether a facility is likely to comply with the Uniform Standards Option requirements in the baseline. Assumptions made in this assessment include the following:

- A facility with a passive screen was assumed to meet the 0.5 fps velocity criteria.
- A facility using an intake screen only was assumed have a traveling screen without fish handling equipment.
- A facility with a recirculating system is assumed to meet the one percent intake flow criteria, since most existing facilities (e.g., more than 90 percent of utilities) with recirculating systems would meet the intake flow criteria. Most once-through facilities were also assumed to meet the intake flow criteria since manufacturing facilities typically have much lower intake flows than utilities.
- All facilities were assumed to have one intake, which seems reasonable for manufacturers since most utilities have one or two intakes and typically use much higher flows.

The unit costs discussed in *Chapter 6: Facility Compliance Costs*, Section 6.1 also were used to develop cost estimates for the Uniform Standards Option requirements. The estimated flow for a facility was important in calculating the cost for a given technology because unit costs for technologies are based on flow. Costing assumptions related to flow for this option are the same as used to estimate the costs of the proposed rule.

Table 10-1 shows the estimated compliance costs under the Uniform Standards Option.

Table 10-1: National Costs of Compliance with the Uniform Standards Option						
Industry Category (Number of Facilities Affected)	One-Time Costs		Recurring Costs			Total
	Capital Technology	Initial Permit Application	O&M	Permit Renewal	Monitoring, Record Keeping & Reporting	
Total Compliance Costs (present value, in millions $1999)						
Electric Generators (40)	$25.87	$1.08	$50.60	$1.57	$15.93	$95.05
Manufacturing Facilities (58)	$23.49	$1.47	$59.48	$2.23	$21.95	$108.62
Total (98)	**$49.36**	**$2.55**	**$110.08**	**$3.80**	**$37.88**	**$203.67**
Annualized Compliance Costs (in millions $1999)						
Electric Generators (40)	$2.08	$0.09	$4.08	$0.13	$1.28	$7.66
Manufacturing Facilities (58)	$1.89	$0.12	$4.79	$0.18	$1.77	$8.75
Total (98)	**$3.97**	**$0.21**	**$8.87**	**$0.31**	**$3.05**	**$16.41**

Source: Summary information from Appendix B and the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

Under the Uniform Standards Option, the present value of total compliance costs is estimated to be $203.7 million. The 40 electric generators account for $108.6 million of this total, and the 58 manufacturing facilities for $95.1 million. Total annualized cost for the 98 facilities is estimated to be $16.4 million. Of this, $7.7 million will be incurred by electric generators and $8.8 million by manufacturing facilities.

10.2 Alternative Option 2: Dry Cooling Option

The second alternative option considered by EPA would impose more stringent compliance requirements on the electric generating segment of the industry. It is based in whole or in part on a zero intake-flow (or nearly zero, extremely low-flow) requirement commensurate with levels achievable through the use of dry cooling systems. New manufacturing facilities would not be subject to these stricter requirements but would have to comply with the standards of the proposed rule.

EPA developed cost equations and curves for dry cooling towers similarly to those for wet cooling towers, relating tower capital and operating and maintenance (O&M) costs to the system's cooling water flow requirement. EPA used the same flow volume used for developing cost estimates for the other options to develop the costs for the Dry Cooling Option.

Table 10-2 shows the estimated compliance costs under the Dry Cooling Option.

Table 10-2: National Costs of Compliance with the Dry Cooling Option

Industry Category (Number of Facilities Affected)	One-Time Costs		Recurring Costs			Total
	Capital Technology	Initial Permit Application	O&M	Permit Renewal	Monitoring, Record Keeping & Reporting	
Total Compliance Costs (present value, in millions $1999)						
Electric Generators (40)	$657.50	$0.09	$1,665.52	$0.09	$0.00	$2,323.20
Manufacturing Facilities (58)	$12.22	$1.38	$34.26	$2.14	$20.74	$70.74
Total (98)	**$669.72**	**$1.47**	**$1,699.78**	**$2.23**	**$20.74**	**$2,393.94**
Annualized Compliance Costs (in millions $1999)						
Electric Generators (40)	$52.99	$0.01	$134.22	$0.01	$0.00	$187.23
Manufacturing Facilities (58)	$0.98	$0.11	$2.76	$0.17	$1.67	$5.70
Total (98)	**$53.97**	**$0.12**	**$136.98**	**$0.18**	**$1.67**	**$192.93**

Source: Summary information from Appendix B and the Information Collection Request for Cooling Water Intake Structures, New Facility Proposed Rule, July 2000.

The Dry Cooling Option would be the most expensive of the three regulatory frameworks considered by EPA. Under this option, the present value of total compliance costs is estimated to be almost $2.4 billion. Total annualized cost for the 98 facilities is estimated to be $193 million.

Manufacturing facilities would incur the same compliance costs as under the proposed rule,$5.7 million. The 40 electric generators, however, would face considerably higher costs with approximately $187 million annually.

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Chapter 11: CWIS Impacts and Potential Benefits

INTRODUCTION

In this chapter, we discuss impacts of CWIS by waterbody type and potential benefits of the proposed §316(b) regulation. EPA was unable to conduct a detailed, quantitative analysis of the proposed rule because much of the information needed to quantify and value potential reductions in I&E at new facilities was unavailable. At the time of proposal, there was only general information about the location of proposed new facilities, and in most cases details of facility and environmental characteristics were unknown. To overcome these limitations, this chapter presents examples of impacts and potential regulatory benefits based on a subset of existing facilities for which information was readily available. The focus is on fish species because very large numbers of fish are impinged and entrained compared to other aquatic organisms such as phytoplankton and benthic invertebrates.

The chapter

- summarizes factors related to intake location, design, and capacity that influence the magnitude of I&E,
- discusses CWIS impacts for different waterbody types (rivers, lakes and reservoirs, the Great Lakes, oceans, and estuaries), and
- provides examples of potential benefits from previous studies of existing facilities.

CHAPTER CONTENTS

11.1 CWIS CHARACTERISTICS THAT INFLUENCE THE MAGNITUDE OF I&E

11.1.1 Intake Location

Two major components of a CWIS's location that influence the relative magnitude of I&E are (1) the type of waterbody from which a CWIS is withdrawing water, and (2) the placement of the CWIS relative to sensitive biological areas within the waterbody. EPA's proposed regulatory framework is designed to take both of these factors into account.

Considerations in siting an intake to reduce the potential for I&E include intake depth and distance from the shoreline in relation to the physical, chemical, and biological characteristics of the source waterbody. In general, intakes located in nearshore areas (riparian or littoral zones) will have greater ecological impacts than intakes located offshore because nearshore areas are more biologically productive and have higher concentrations of organisms.

Critical physical and chemical factors related to siting of an intake include the direction and rate of waterbody flow, tidal influences, currents, salinity, dissolved oxygen levels, thermal stratification, and the presence of pollutants. The withdrawal of water by an intake can change ambient flows, velocities, and currents within the source waterbody, which may cause organisms to concentrate in the vicinity of an intake or reduce their ability to escape a current. Effects vary according to the type of waterbody and species present.

In large rivers, withdrawal of water may have little effect on flows because of the strong, unidirectional nature of ambient currents. In contrast, lakes and reservoirs have small ambient flows and currents, and therefore a large intake flow can significantly alter current patterns. Tidal currents in estuaries or tidally influenced sections of rivers can carry organisms past intakes multiple times, thereby increasing their probability of entrainment. If intake withdrawal and discharge are in close proximity, entrained organisms released in the discharge can become re-entrained.

The magnitude of I&E in relation to intake location also depends on biological factors such as species' distributions and the presence of critical habitats within an intake's zone of influence. In general, intakes located in nearshore areas have greater impacts than intakes located offshore because nearshore areas are typically more biologically productive and have higher concentrations of organisms. Also, species with planktonic (free-floating) early life stages have higher rates of entrainment because they are unable to actively avoid being drawn into the intake flow.

11.1.2 Intake Design

Intake design refers to the design and configuration of various components of the intake structure, including screening systems (trash racks, pumps, pressure washes), passive intake systems, and fish diversion and avoidance technologies (U.S. EPA, 1976). After entering the CWIS, water must pass through a screening device before entering the power plant. The screen is designed to prevent debris from entering and clogging the condenser tubes. Screen mesh size and velocity characteristics are two important design features of the screening system that influence the potential for impingement and entrainment of aquatic organisms that are withdrawn with the cooling water (U.S. EPA, 1976).

Design intake velocity has a significant influence on the potential for impingement (Boreman, 1977). The biological significance of design intake velocity depends on species-specific characteristics such as fish swimming ability and endurance. These characteristics are a function of the size of the organism and the temperature and oxygen levels of water in the area of the intake (U.S. EPA, 1976). The maximum velocity protecting most small fish is 0.5 ft/s, but lower velocities will still impinge some fish and entrain eggs and larvae and other small organisms (Boreman, 1977).

Conventional traveling screens have been modified to improve fish survival of screen impingement and spray wash removal (Taft, 1999). However, a review of steam electric utilities indicated that alternative screen technologies are usually not much more effective at reducing impingement than the conventional vertical traveling screens used by most steam electric facilities (SAIC, 1994). An exception may be traveling screens modified with fish collection systems (e.g., Ristroph screens). Studies of improved fish collection baskets at Salem Generating Station showed increased survival of impinged fish (Ronafalvy et al., 1999).

Passive intake systems (physical exclusion devices) screen out debris and aquatic organisms with minimal mechanical activity and low withdrawal velocities (Taft, 1999). The most effective passive intake systems are wedge-wire screens and radial wells (SAIC, 1994). A new technology, the Gunderboom, which consists of polyester fiber strands pressed into a water-permeable fabric mat, has shown promise in reducing ichthyoplankton entrainment at the Lovett Generating Station on the Hudson River (Taft, 1999).

Fish diversion/avoidance systems (behavioral barriers) take advantage of natural behavioral characteristics of fish to guide them away from an intake structure or into a bypass system (SAIC, 1994, Taft, 1999). The most effective of these technologies are velocity caps, which divert fish away from intakes, and underwater strobe lights, which repel some species (Taft, 1999). Velocity caps are used mostly at offshore facilities and have proven effective in reducing impingement (e.g., California's San Onofre Nuclear Generating Station, SONGS).

Another important design consideration is the orientation of the intake in relation to the source waterbody (U.S. EPA, 1976). Conventional intake designs include shoreline, offshore, and approach channel intakes. In addition, intake operation can be modified to reduce the quantity of source water withdrawn or the timing, duration, and frequency of water withdrawal. This is an important way to reduce entrainment. For example, larval entrainment at the San Onofre facility was reduced by 50% by rescheduling the timing of high volume water withdrawals (SAIC, 1996).

11.1.3 Intake Capacity

Intake capacity is a measure of the volume or quantity of water withdrawn or flowing through a cooling water intake structure over a specified period of time. Intake capacity can be expressed as millions or billions of gallons per day (MGD or BGD), or as cubic feet per second (cfs). Capacity can be measured for the facility as a whole, for all of the intakes used by a single unit, or for the intake structure alone. In defining an intake's capacity it is important to distinguish between the *design* intake flow (the maximum possible) and the actual operational intake flow. For this regulation, EPA is regulating the total design intake flow of the facility.

The quantity of cooling water needed and the type of cooling system are the most important factors determining the quantity of intake flow (U.S. EPA, 1976). Once-through cooling systems withdraw water from a natural waterbody, circulate the water through condensers, and then discharge it back to the source waterbody. Closed-cycle cooling systems withdraw water from a natural waterbody, circulate the water through the condensers, and then send it to a cooling tower or cooling pond before recirculating it back through the condensers. Because cooling water is recirculated, closed-cycle systems generally reduce the water flow from 71.9% to 96.6%, thereby using only 3.4% to 28.8% of the water used by once-through systems (Kaplan, 2000).[1] It is generally assumed that this will result in a comparable reduction in I&E (Goodyear, 1977). Systems with helper towers reduce water usage much less. Plants with helper towers can operate in once-through or closed-cycle modes.

Circulating water intakes are used by once-through cooling systems to continuously withdraw water from the cooling water source. The typical circulating water intake is designed to use 0.03-0.1 m^3/s (1.06-3.53 cfs, or 500-1500 gallons per minute, gpm) per megawatt (MW) of electricity generated (U.S. EPA, 1976). Closed cycle systems use makeup water intakes to provide water lost by evaporation, blowdown, and drift. Although makeup quantities are only a fraction of the intake flows of once-through systems, quantities of water withdrawn can still be significant, especially by large facilities (U.S. EPA, 1976).

If the quantity of water withdrawn is large relative to the flow of the source waterbody, a larger number of organisms will potentially be affected by a facility's CWIS. Thus, the proportion of the source water flow supplied to a CWIS is often used to derive a conservative estimate of the potential for adverse impact (e.g., Goodyear, 1977). For example, withdrawal of 5% of the source water flow may be expected to result in a loss of 5% of planktonic organisms based on the assumption that organisms are uniformly distributed in the vicinity of an intake. Although the assumption of uniform distribution may not always be met, when data on actual distributions are unavailable, simple mathematical models based on this assumption provide a conservative and easily applied method for predicting potential losses (Goodyear, 1977).

In addition to the quantity of intake flow, the potential for aquatic organisms to be impinged or entrained also depends on physical, chemical, and biological characteristics of the surrounding ecosystem and species characteristics that influence the intensity, time, and spatial extent of contact of aquatic organisms with a facility's CWIS. Table 11-1 lists CWIS characteristics and ecosystem characteristics that influence when, how, and why aquatic organisms may become exposed to, and experience adverse effects of, CWIS.

[1] The difference in water usage in cooling towers results from differences in source water (salinity) and the temperature rise of the system.

11.2 Methods for Estimating Potential I&E Losses

11.2.1 Development of a Database of I&E Rates

To estimate the relative magnitude of I&E losses for different species and waterbody types, EPA compiled annual I&E data from 107 documents representing a variety of sources, including previous §316(b) studies, critical reviews of §316(b) studies, biomonitoring and aquatic ecology studies, technology implementation studies, and data compilations. In total, data were compiled from 98 steam electric facilities (36 riverine facilities, 9 lake/reservoir facilities, 19 facilities on the Great Lakes, 22 estuarine facilities, and 12 ocean facilities). Design intake flows at these facilities ranged from a low of 19.7 to a high of 3,315.6 MGD.

The data were aggregated in a series of steps to derive average annual impingement and entrainment rates, on a per facility basis, for different species and waterbody types. First, the data for each species were summed across all units of a facility and averaged across years (e.g., 1972 to 1976). Losses were then averaged by species for all facilities in the database on a given waterbody type to derive species-specific and waterbody-specific mean annual I&E rates. Finally, mean annual I&E rates were ranked, and rates for the top 15 species were used for subsequent data presentation.

11.2.2 Data Uncertainties and Potential Biases

A number of uncertainties and potential biases are associated with the annual I&E estimates that EPA developed. Most important, natural environmental variability makes it difficult to detect ecological impacts and identify cause-effect relationships even in cases where study methods are as accurate and reliable as possible. For example, I&E rates for any given population will vary with changes in environmental conditions that influence annual variation in recruitment. As a result, it can be difficult to determine the relative role of I&E mortality in population fluctuations.

Table 11-1: Partial List of CWIS, Ecosystem, and Species Characteristics Influencing Potential for I&E

CWIS Characteristics[†]	Ecosystem and Species Characteristics

Location
▸ Depth of intake
▸ Distance from shoreline
▸ Proximity of intake withdrawal and discharge
▸ Proximity to other industrial discharges or water withdrawals
▸ Proximity to an area of biological concern
 	
Design
▸ Type of intake structure (size, shape, configuration, orientation)
▸ Design intake velocity
▸ Presence/absence of intake control and fish protection technologies
  ▸ Intake Screen Systems
  ▸ Passive Intake Systems
  ▸ Fish Diversion/Avoidance Systems
▸ Water temperature in cooling system
▸ Temperature change during entrainment
▸ Duration of entrainment
▸ Use of intake biocides and ice removal technologies
▸ Scheduling of timing, duration, frequency, and quantity of water withdrawal.
 	
Construction
▸ Mortality of aquatic organisms
▸ Displacement of aquatic organisms
▸ Destruction of habitat (e.g., burial of eggs deposited in stream beds, increased turbidity of water column)
 	
Capacity
▸ Type of withdrawal — once through vs. recycled (cooling water volume and volume per unit time)
▸ Ratio of cooling water intake flow to source water flow
	Ecosystem Characteristics (abiotic environment)
	▸ Source waterbody type
	▸ Water temperatures
	▸ Ambient light conditions
	▸ Salinity levels
	▸ Dissolved oxygen levels
	▸ Tides/currents
	▸ Direction and rate of ambient flows
	
	Species Characteristics (physiology, behavior, life history)
	▸ Density in zone of influence of CWIS
	▸ Spatial and temporal distributions (e.g., daily, seasonal, annual migrations)
	▸ Habitat preferences (e.g., depth, substrate)
	▸ Ability to detect and avoid intake currents
	▸ Swimming speeds
	▸ Mobility
	▸ Body size
	▸ Age/developmental stage
	▸ Physiological tolerances (e.g., temperature, salinity, dissolved oxygen)
	▸ Feeding habits
	▸ Reproductive strategy
	▸ Mode of egg and larval dispersal
	▸ Generation time

† All of these CWIS characteristics can potentially be controlled to minimize adverse environmental impacts (I&E) of new facilities.

In addition to the influence of natural variability, data uncertainties result from measurement errors, some of which are unavoidable. There was also insufficient information in many of the source documents to determine potential variation in collection and analytical methods among studies and across years, or to account for changes at a facility over time, such as the number of units in operation or technologies in use.

Potential biases were also difficult to control. For example, many studies presented data for only a subset of "representative" species, which may lead to an underestimation of total I&E. On the other hand, the entrainment estimates obtained from EPA's database do not take into account the high natural mortality of egg and larval stages and therefore are likely to be biased upwards. However, this bias was unavoidable because most of the source documents from which the database was derived did not estimate losses of early life stages as an equivalent number of adults, or provide information for making such calculations[2]. In the absence of information for adjusting egg losses on this basis, EPA chose to include eggs and larvae in the entrainment estimates to avoid underestimating age 0 losses.

With these caveats in mind, the following sections present the results of EPA's data compilation. The data are grouped

[2] For species for which sufficient life history information is available, the Equivalent Adult Model (EAM) can be used to predict the number of individuals that would have survived to adulthood each year if entrainment at egg or larval stages had not occurred (Horst, 1975; Goodyear, C.P., 1978). The resulting estimate is known as the number of "equivalent adults."

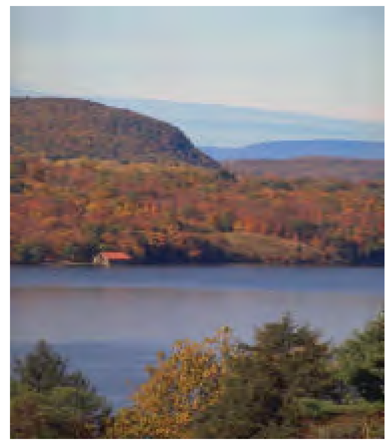
by waterbody type and are presented in summary tables that indicate the range of losses for the 15 species with the highest I&E rates based on the limited subset of data available to EPA. I&E losses are expressed as mean annual numbers on a per facility basis. Because the data do not represent a random sample of I&E losses, it was not appropriate to summarize the data statistically. It is also important to stress that because the data are not a statistical sample, the data presented here may not represent actual losses. Thus, the data should be viewed only as general indicators of the potential range of I&E losses.

11.3 CWIS Impacts in Rivers

Freshwater rivers and streams are free-flowing bodies of water that do not receive significant inflows of water from oceans or bays. Current is typically highest in the center of a river and rapidly drops toward the edges and at depth because of increased friction with river banks and the bottom (Hynes, 1970; Allan, 1995). Close to and at the bottom, the current can become minimal. The range of flow conditions in undammed rivers helps explain why fish with very different habitat requirements can co-exist within the same stretch of surface water (Matthews, 1998).

In general, the shoreline areas along river banks support the highest diversity of aquatic life. These are areas where light penetrates to the bottom and supports the growth of rooted vegetation. Suspended solids tend to settle along shorelines where the current slows, creating shallow, weedy areas that attract aquatic life. Riparian vegetation, if present, also provides cover and shade. Such areas represent important feeding, resting, spawning, and nursery habitats for many aquatic species. In temperate regions, the number of impingeable and entrainable organisms in the littoral zone of rivers increases during the spring and early summer when most riverine fish species reproduce. This concentration of aquatic organisms along river shorelines in turn attracts wading birds and other kinds of wildlife.

EPA's regulatory framework requires stricter compliance requirements for CWIS located in the sensitive littoral zones of rivers. A notable exception to the general rule of placing CWIS away from river banks is when the structure is to be located in a stretch of the river used by pelagic spawners such as alewife (*Alosa pseudoharengus*). During a few weeks in the spring or early summer, large numbers of eggs and larvae of such fish species can be entrained, even though entrainment may be minimal during the remainder of the year.



The data analyzed by EPA indicate that fish species such as common carp (*Cyprinus carpio*), yellow perch (*Perca flavescens*), white bass (*Morone chrysops*), freshwater drum (*Aplodinotus grunniens)*, gizzard shad (*Dorosoma cepedianum*), and alewife are the main fishes harmed by CWIS located in rivers (Tables 11-2 and 11-3). These species occur in nearshore areas and/or have pelagic early life stages, traits that greatly increase their susceptibility to I&E.

Table 11-2: Annual Entrainment of Eggs, Larvae and Juvenile Fish in Rivers

Common Name	Scientific Name	Number of Facilities	Mean Annual Entrainment per Facility (fish/year)	Range
common carp	*Cyprinus carpio*	7	20,500,000	859,000 - 79,400,000
yellow perch	*Perca flavescens*	4	13,100,000	434,000 - 50,400,000
white bass	*Morone chrysops*	4	12,800,000	69,400 - 49,600,000
freshwater drum	*Aplodinotus grunniens*	5	12,800,000	38,200 - 40,500,000
gizzard shad	*Dorosoma cepedianum*	4	7,680,000	45,800 - 24,700,000
shiner	*Notropis* spp.	4	3,540,000	191,000 - 13,000,000
channel catfish	*Ictalurus punctatus*	5	3,110,000	19,100 - 14,900,000
bluntnose minnow	*Pimephales notatus*	1	2,050,000	---
black bass	*Micropterus* spp.	1	1,900,000	---
rainbow smelt	*Osmerus mordax*	1	1,330,000	---
minnow	*Pimephales* spp.	1	1,040,000	---
sunfish	*Lepomis* spp.	5	976,000	4,230 - 4,660,000
emerald shiner	*Notropis atherinoides*	3	722,000	166,000 - 1,480,000
white sucker	*Catostomus commersoni*	5	704,000	20,700 - 2,860,000
mimic shiner	*Notropis volucellus*	2	406,000	30,100 - 781,000

Sources: Hicks, 1977; Cole, 1978; Geo-Marine Inc., 1978; Goodyear, C.D., 1978; Potter, 1978; Cincinnati Gas & Electric Company, 1979; Potter et al., 1979a, 1979b, 1979c, 1997d; Cherry and Currie, 1998; Lewis and Segart, 1998.

Table 11-3: Annual Impingement in the Rivers for All Age Classes

Common Name	Scientific Name	Number of Facilities	Mean Annual Impingement per Facility (fish/year)	Range
threadfin shad	*Dorosoma petenense*	3	1,030,000	199 - 3,050,000
gizzard shad	*Dorosoma cepedianum*	25	248,000	3,080 - 1,480,000
shiner	*Notropis* spp.	4	121,000	28 - 486,000
alewife	*Alosa pseudoharengus*	13	73,200	199 - 237,000
white perch	*Morone americana*	3	66,400	27,100 - 112,000
yellow perch	*Perca flavescens*	18	40,600	13 - 374,000
spottail shiner	*Notropis hudsonius*	10	28,500	10 - 117,000
freshwater drum	*Aplodinotus grunniens*	24	19,900	8 - 176,000
rainbow smelt	*Osmerus mordax*	11	19,700	7 - 119,000
skipjack herring	*Alosa chrysochons*	7	17,900	52 - 89,000
white bass	*Morone chrysops*	19	11,500	21 - 188,000
trout perch	*Percopsis omiscomaycus*	13	9,100	38 - 49,800
emerald shiner	*Notropis atherinoides*	17	7,600	109 - 36,100
blue catfish	*Ictalurus furcatus*	2	5,370	42 - 10,700
channel catfish	*Ictalurus punctatus*	23	3,130	3 - 25,600

Sources: Benda and Houtcooper, 1977; Freeman and Sharma, 1977; Hicks, 1977; Sharma and Freeman, 1977; Stupka and Sharma, 1977; Energy Impacts Associates Inc., 1978; Geo-Marine Inc., 1978; Goodyear, C.D., 1978; Potter, 1978; Cincinnati Gas & Electric Company, 1979; Potter et al., 1979a, 1979b, 1979c, 1979d; Van Winkle et al., 1980; EA Science and Technology, 1987; Cherry and Currie, 1998; Michaud, 1998; Lohner, 1999.

11.4 CWIS Impacts in Lakes and Reservoirs

Lakes are inland bodies of open water located in natural depressions (Goldman and Horne, 1983). Lakes are fed by rivers, streams, springs, and/or local precipitation. Water currents in lakes are small or negligible compared to rivers, and are most noticeable near lake inlets and outlets.

Larger lakes are divided into three general zones – the littoral zone (shoreline areas where light penetrates to the bottom), the limnetic zone (the surface layer where most photosynthesis takes place), and the profundal zone (relatively deeper and colder offshore area) (Goldman and Horne, 1983). Each zone differs in its biological productivity and species diversity and hence in the potential magnitude of CWIS impacts. The importance of these zones in the context of the §316(b) regulation are discussed below.

The littoral zone is the highly productive nearshore area where light penetration is just sufficient to allow rooted aquatic plants to grow (Goldman and Horne, 1983). The littoral zone extends farther and deeper in clear lakes than in turbid lakes. In small, shallow lakes, the littoral zone can be quite extensive and even include the entire waterbody. As along river banks, this zone supports high primary productivity and biological diversity. It is used by a host of fish species, benthic invertebrates, and zooplankton for feeding, resting, and reproduction, and as nursery habitat. Many fish species adapted to living in the colder profundal zone also move to shallower in-shore areas to spawn, e.g., lake trout (*Salmo namycush*) and various deep water sculpin species (*Cottus* spp.).

Many fish species spend most of their early development in and around the littoral zone of lakes. These shallow waters warm up rapidly in spring and summer, offer a variety of different habitats (submerged plants, boulders, logs, etc.) in which to hide or feed, and stay well-oxygenated throughout the year. Typically, the littoral zone is a major contributor to the total primary productivity of lakes (Goldman and Horne, 1983).

The limnetic zone is the surface layer of a lake. The vast majority of light that enters the water column is absorbed in this layer. In contrast to the high biological activity observed in the nearshore littoral zone, the offshore limnetic zone supports fewer species of fish and invertebrates. However, during certain times of year, some fish and invertebrate species spend the daylight hours hiding on the bottom and rise to the surface of the limnetic zone at night to feed and reproduce. Adult fish may migrate through the limnetic zone during seasonal spawning migrations. The juvenile stages of numerous aquatic insects – such as caddisflies, stoneflies, mayflies, dragonflies, and damselflies – develop in sediments at the bottom of lakes but move through the limnetic zone to reach the surface and fly away. This activity attracts foraging fish.

The profundal zone is the deeper, colder area of a lake. Rooted plants are absent because insufficient light penetrates at these depths. For the same reason, primary productivity by phytoplankton is minimal. A well-oxygenated profundal zone can support a variety of benthic invertebrates or cold-water fish, e.g., brown trout (*Salmo trutta*), lake trout, ciscoes (*Coregonus* spp.). With few exceptions (such as ciscos or whitefish), these species seek out shallower areas to spawn, either in littoral areas or in adjacent rivers and streams, where they may become susceptible to CWIS.

Most of the larger rivers in the United States have one or more dams that create artificial lakes or reservoirs. Reservoirs have some characteristics that mimic those of natural lakes, but large reservoirs differ from most lakes in that they obtain most of their water from a large river instead of from groundwater recharge or from smaller creeks and streams.

The fish species composition in reservoirs may or may not reflect the native assemblages found in the pre-dammed river. Dams create two significant changes to the local aquatic ecosystem that can alter the original species composition: (1) blockages that prevent anadromous species from migrating upstream, and (2) altered riverine habitat that can eliminate species that cannot readily adapt to the modified hydrologic conditions.

Reservoirs typically support littoral zones, limnetic zones, and profundal zones, and the same concepts outlined above for lakes apply to these bodies of water. For example, compared to the profundal zone, the littoral zone along the edges of reservoirs supports greater biological diversity and provides prime habitat for spawning, feeding, resting, and protection for numerous fish and zooplankton species. However, there are also several differences. Reservoirs often lack extensive shallow areas along their edges because their banks have been engineered or raised to contain extra water and prevent flooding. In mountainous areas, the banks of reservoirs may be quite steep and drop off precipitously with little or no littoral zone. As with lakes and rivers, however, CWIS located in shallower water have a higher probability of entraining or impinging organisms. Because the profundal zone supports less biological productivity than the littoral or limnetic zones of lakes and reservoirs, EPA believes that placing CWIS in these deeper areas represents the least potential for biological impact in these systems. Therefore, EPA's proposed regulation places no national §316(b) compliance requirements on CWIS located in the profundal zones of lakes and reservoirs.

Results of EPA's data compilation indicate that fish species most commonly affected by CWIS located on lakes and reservoirs are the same as the riverine species that are most susceptible, including alewife, drum (*Aplondinotus* spp.), and gizzard shad (*Dorsoma cepedianum*) (Tables 11-4 and 11-5).

Table 11-4: Annual Entrainment of Eggs, Larvae and Juvenile Fish in Reservoirs and Lakes (excluding the Great Lakes)

Common Name	Scientific Name	Number of Facilities	Mean Annual Entrainment per Facility (fish/year)
drum	*Aplondinotus* spp.	1	15,600,000
sunfish	*Lepomis* spp.	1	10,600,000
gizzard shad	*Dorosoma cepedianum*	1	9,550,000
crappie	*Pomoxis* spp.	1	8,500,000
alewife	*Alosa pseudoharengus*	1	1,730,000

Sources: Michaud, 1998; Spicer et al., 1998.

Table 11-5: Annual Impingement in Reservoirs and Lakes (excluding the Great Lakes) for All Age Classes Combined

Common Name	Scientific Name	Number of Facilities	Mean Annual Impingement per Facility (fish/year)	Range
threadfin shad	*Dorosoma petenense*	4	678,000	203,000 - 1,370,000
alewife	*Alosa pseudoharengus*	4	201,000	33,100 - 514,000
skipjack herring	*Alosa chrysochons*	1	115,000	---
bluegill	*Lepomis macrochirus*	6	48,600	468 - 277,000
gizzard shad	*Dorosoma cepedianum*	5	41,100	829 - 80,700
warmouth sunfish	*Lepomis gulosus*	4	39,400	31 - 157,000
yellow perch	*Perca flavescens*	2	38,900	502 - 114,000
freshwater drum	*Aplodinotus grunniens*	4	37,500	8 - 150,000
silver chub	*Hybopsis storeriana*	1	18,200	---
black bullhead	*Ictalurus melas*	3	10,300	171 - 30,300
trout perch	*Percopsis omiscomaycus*	2	8,750	691 - 16,800
northern pike	*Esox lucius*	2	7,180	154 - 14,200
blue catfish	*Ictalurus furcatus*	1	3,350	---
paddlefish	*Polyodon spathula*	2	3,160	1,940 - 4380
inland (tidewater) silverside	*Menidia beryllina*	1	3,100	---

Sources: Tennessee Division of Forestry, Fisheries, and Wildlife Development, 1976; Tennessee Valley Authority, 1976; Benda and Houtcooper, 1977; Freeman and Sharma, 1977; Sharma and Freeman, 1977; Tennessee Valley Authority, 1977; Spicer et al., 1998; Michaud, 1998.

11.5 CWIS Impacts in the Great Lakes

The Great Lakes were carved out by glaciers during the last ice age (Bailey and Smith, 1981). They contain nearly 20% of the earth's fresh water, or about 23,000 km^3 (5,500 cu. mi.) of water, covering a total area of 244,000 km^2 (94,000 sq. mi.). There are five Great Lakes: Lake Superior, Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario. Although part of a single system, each lake has distinct characteristics. Lake Superior is the largest by volume, with a retention time of 191 years, followed by Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario.

Water temperatures in the Great Lakes strongly influence the physiological processes of aquatic organisms, affecting growth, reproduction, survival, and species temporal and spatial distribution. During the spring, many fish species inhabit shallow, warmer waters where temperatures are closer to their thermal optimum. As water temperatures increase, these species migrate to deeper water. For species that are near the northern limit of their range, the availability of shallow, sheltered habitats that warm early in the spring is probably essential for survival (Lane et al., 1996a). For other species, using warmer littoral areas increases the growing season and may significantly increase production.

Some 80 percent of Great Lakes fishes use the littoral zone for at least part of the year (Lane et al.,1996a). Of 139 Great Lakes fish species reviewed by Lane et al. (1996b), all but the deepwater ciscoes (*Coregonus* spp.) and deepwater sculpin (*Myxocephalus thompsoni*) use waters less than 10 m deep as nursery habitat.

A large number of thermal-electric plants located on the Great Lakes draw their cooling water from the littoral zone, resulting in high I&E of several fish species of commercial, recreational, and ecological importance, including alewife, gizzard shad, yellow perch, rainbow smelt , and lake trout (Tables 11-6 to 11-9).

The I&E estimates of Kelso and Milburn (1979) presented in Tables 11-7 and 11-9 were derived using methods that differed in a number of ways from EPA's estimation methods, and therefore the data are not strictly comparable. First, the Kelso and Milburn (1979) data represent total annual losses per lake, whereas EPA's estimates are on a per facility basis. In addition, the estimates of Kelso and Milburn (1979) are based on extrapolation of losses to facilities for which data were unavailable using regression equations relating losses to plant size.

Despite the differences in estimation methods, when converted to an annual average per facility, the impingement estimates of Kelso and Milburn (1979) are within the range of EPA's estimates. For example, average annual impingement is 675,980 fish per facility based on Kelso and Milburn's (1979) data is comparable to EPA's high estimate of 1,470,000 for alewife.

On the other hand, EPA's entrainment estimates include egg losses and are therefore substantially larger than those of Kelso and Milburn (1979). Because of the high natural mortality of fish eggs, EPA's inclusion of all egg losses likely overestimates entrainment, as noted in Section 11.2.2. However, by omitting all egg losses, the entrainment estimates of Kelso and Milburn (1979) are likely to underestimate losses. Viewed together, the two types of estimates give an indication of the possible upper and lower bounds of annual entrainment losses per facility (e.g., an annual average of 8,018,657 fish based on Kelso and Milburn's data compared to EPA's highest estimate of 526,000,000 based on the average for alewife) .

Table 11-6: Annual Entrainment of Eggs, Larvae and Juvenile Fish in the Great Lakes

Common Name	Scientific Name	Number of Facilities	Mean Annual Entrainment per Facility (fish/year)	Range
alewife	*Alosa pseudoharengus*	5	526,000,000	3,930,000 - 1,360,000,000
rainbow smelt	*Osmerus mordax*	5	90,500,000	424,000 - 438,000,000
lake trout	*Salmo namaycush*	1	116,000	---

Sources: Texas Instruments Inc., 1978; Michaud, 1998.

Table 11-7: Annual Entrainment of Larval Fish in the Great Lakes by Lake

Lake	Number of Facilities	Total Annual Entrainment (fish/year)
Erie	16	255,348,164
Michigan	25	196,307,405
Ontario	11	176,285,758
Huron	6	81,462,440
Superior	14	4,256,707

Source: Kelso and Milburn, 1979.

Table 11-8: Annual Impingement in the Great Lakes for All Age Classes Combined

Common Name	Scientific Name	Number of Facilities	Mean Annual Impingement per Facility (fish/year)	Range
alewife	*Alosa pseudoharengus*	15	1,470,000	355 - 5,740,000
gizzard shad	*Dorosoma cepedianum*	6	185,000	25 - 946,000
rainbow smelt	*Osmerus mordax*	15	118,000	78 - 549,000
threespine stickleback	*Gasterosteus aculeatus*	3	60,600	23,200 - 86,200
yellow perch	*Perca flavescens*	9	29,900	58 - 127,000
spottail shiner	*Notropis hudsonius*	8	22,100	5 - 62,000
freshwater drum	*Aplodinotus grunniens*	4	18,700	2 - 74,800
emerald shiner	*Notropis atherinoides*	4	7,250	3 - 28,600
trout perch	*Percopsis omiscomaycus*	5	5,630	30 - 23,900
bloater	*Coregonus hoyi*	2	4,980	3,620 - 6,340
white bass	*Morone chrysops*	1	4,820	--
slimy sculpin	*Cottus cognatus*	4	3,330	795 - 5,800
goldfish	*Carassius auratus*	3	2,620	4 - 7,690
mottled sculpin	*Cottus bairdi*	3	1,970	625 - 3,450
common carp	*Cyprinus carpio*	4	1,110	16 - 4,180
pumpkinseed	*Lepomis gibbosus*	4	1,060	14 - 3,920

Sources: Benda and Houtcooper, 1977; Sharma and Freeman, 1977; Texas Instruments Inc., 1978; Thurber and Jude, 1985; Lawler Matusky & Skelly Engineers, 1993; Michaud, 1998.

Table 11-9: Annual Impingement of Fish in the Great Lakes

Lake	Number of Facilities	Total Annual Impingement (fish/year)
Erie	16	22,961,915
Michigan	25	15,377,339
Ontario	11	14,483,271
Huron	6	7,096,053
Superior	14	243,683

Source: Kelso and Milburn, 1979.

11.6 CWIS Impacts in Estuaries

Estuaries are semi-enclosed bodies of water that have a an unimpaired natural connection with the open ocean and within which sea water is diluted with fresh water derived from land. Estuaries are created and sustained by dynamic interactions among oceanic and freshwater environments, resulting in a rich array of habitats used by both terrestrial and aquatic species (Day et al., 1989). Because of the high biological productivity and sensitivity of estuaries, EPA's regulatory framework imposes more stringent compliance requirements on CWIS located in estuaries than on those located in other waterbody types.

Numerous commercially, recreationally, and ecologically important species of clams, crustaceans, and fish spend part or all of their life cycle within estuaries. Marine species that spawn offshore take advantage of prevailing inshore currents to transport their eggs, larvae, or juveniles into estuaries where they hatch or mature. Inshore areas along the edges of estuaries support high rates of primary productivity and are used by numerous aquatic and terrestrial species for nesting, feeding, and resting, or as nursery habitats or shelter. This high level of biological productivity makes these shallow littoral zone habitats highly susceptible to I&E impacts from CWIS.

Estuarine species that show the highest rates of I&E in the studies reviewed by EPA include bay anchovy (*Anchoa mitchilli*), tautog (*Tautoga onitis*), Atlantic menhaden (*Brevoortia tyrannus*), gulf menhaden (*Brevoortia patronus*), winter flounder (*Pleuronectes americanus*), and weakfish (*Cynoscion regalis*) (Tables 11-10 and 11-11).

During spring, summer and fall, various life stages of these and other estuarine fishes show considerable migratory activity. Adults move in from the ocean to spawn in the marine, brackish, or freshwater portions of estuaries or their associated rivers; the eggs and larvae can be planktonic and move about with prevailing currents or by using selective tidal transport; juveniles actively move upstream or downstream in search of optimal nursery habitat; and young adult anadromous fish move out into the ocean to reach sexual maturity.

Because of this high degree of migratory activity, a CWIS located in an estuary not only harms indigenous fish species and local food webs, but also directly affects adult or juvenile anadromous fish and indirectly affects marine food webs that depend on these fish. As a result, EPA's proposed regulatory framework seeks to discourage placement of a CWIS anywhere in an estuary.

Table 11-10: Annual Entrainment of Eggs, Larvae, and Juvenile Fish in Estuaries

Common Name	Scientific Name	Number of Facilities	Mean Annual Entrainment per Facility (fish/year)	Range
bay anchovy	*Anchoa mitchilli*	2	18,300,000,000	12,300,000,000 - 24,400,000,000
tautog	*Tautoga onitis*	1	6,100,000,000	---
Atlantic menhaden	*Brevoortia tyrannus*	2	3,160,000,000	50,400,000 - 6,260,000,000
winter flounder	*Pleuronectes americanus*	1	952,000,000	---
weakfish	*Cynoscion regalis*	2	339,000,000	99,100,000 - 579,000,000
hogchoker	*Trinectes maculatus*	1	241,000,000	---
Atlantic croaker	*Micropogonias undulatus*	1	48,500,000	---
striped bass	*Morone saxatilis*	4	19,200,000	111,00 - 74,800,000
white perch	*Morone americana*	4	16,600,000	87,700 - 65,700,000
spot	*Leiostomus xanthurus*	1	11,400,000	---
blueback herring	*Alosa aestivalis*	1	10,200,000	---
alewife	*Alosa pseudoharengus*	1	2,580,000	---
Atlantic tomcod	*Microgadus tomcod*	3	2,380,000	2,070 - 7,030,000
American shad	*Alosa sapidissima*	1	1,810,000	---

Sources: U.S. EPA, 1982; Lawler Matusky & Skelly Engineers, 1983; DeHart, 1994; PSE&G, 1999.

Table 11-11: Annual Impingement in Estuaries for All Age Classes Combined

Common Name	Scientific Name	Number of Facilities	Mean Annual Impingement per Facility (fish/year)	Range
gulf menhaden	*Brevoortia patronus*	2	76,000,000	2,990,000 - 149,000,000
smooth flounder	*Liopsetta putnami*	1	3,320,000	--
threespine stickleback	*Gasterosteus aculeatus*	4	866,000	123 - 3,460,000
Atlantic menhaden	*Brevoortia tyrannus*	12	628,000	114 - 4,610,000
rainbow smelt	*Osmerus mordax*	4	510,000	737 - 2,000,000
bay anchovy	*Anchoa mitchilli*	9	450,000	1,700 - 2,750,000
weakfish	*Cynoscion regalis*	4	320,000	357 - 1,210,000
Atlantic croaker	*Micropogonias undulatus*	8	311,000	13 - 1,500,000
spot	*Leiostomus xanthurus*	10	270,000	176 - 647,000
blueback herring	*Alosa aestivalis*	7	205,000	1,170 - 962,000
white perch	*Morone americana*	14	200,000	287 - 1,380,000
threadfin shad	*Dorosoma petenense*	1	185,000	---
lake trout	*Salmo namaycush*	1	162,000	---
gizzard shad	*Dorosoma cepedianum*	6	125,000	2,058 - 715,000
silvery minnow	*Hybognathus nuchalis*	1	73,400	---

Sources: Consolidated Edison Company of New York Inc., 1975; Lawler Matusky & Skelly Engineers, 1975, 1976; Stupka and Sharma, 1977; Lawler et al., 1980; Texas Instruments Inc., 1980; Van Winkle et al., 1980; Consolidated Edison Company of New York Inc. and New York Power Authority, 1983; Normandeau Associates Inc., 1984; EA Science and Technology, 1987; Lawler Matusky & Skelly Engineers, 1991; Richkus and McClean, 1998; PSE&G, 1999; New York State Department of Environmental Conservation, No Date.

11.7 CWIS Impacts in Oceans

Oceans are marine open coastal waters with salinity greater than or equal to 30 parts per thousand. CWIS in oceans are usually located over the continental shelf, a shallow shelf that slopes gently out from the coastline an average of 74 km (46 miles) to where the sea floor reaches a maximum depth of 200 m (660 ft) (Ross, 1995). The deep ocean extends beyond this region. The area over the continental shelf is known as the Neritic Province and the area over the deep ocean is the Oceanic Province (Meadows and Campbell, 1978).

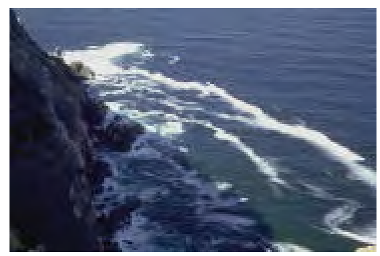
Vertically, the upper, sunlit epipelagic zone over the continental shelf averages about 100 m in depth (Meadows and Campbell, 1978). This zone has pronounced light and temperature gradients that vary seasonally and influence the temporal and spatial distribution of marine organisms.

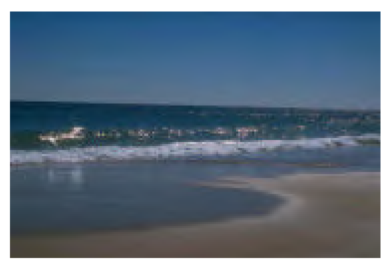
In oceans, the littoral zone encompasses the photic zone of the area over the continental shelf. As in other water body types, the littoral zone is where most marine organisms concentrate. The littoral zone of oceans is of particular concern in the context of §316(b) because this biologically productive zone is also where most coastal utilities withdraw cooling water. EPA's regulatory framework imposes more stringent standards for facilities with intakes located less than 100 m outside the coastal littoral zone.

The morphology of the continental shelf along the U.S. coastline is quite varied (NRC, 1993). Along the Pacific coast of the United States the continental shelf is relatively narrow, ranging from 5 to 20 km (3 to 12 miles), and is cut by several steep-sided submarine canyons. As a result, the littoral zone along this coast tends to be narrow, shallow, and steep. In contrast, along most of the Atlantic coast of the United States, there is a wide, thick, and wedge-shaped shelf that extends as much as 250 km (155 miles) from shore, with the greatest widths generally opposite large rivers. Along the Gulf coast, the shelf ranges from 20 to 50 km (12 to 31 miles).

Marine environments differ in several fundamental ways from freshwater environments. For example, they include much larger volumes of water, and pelagic life stages of aquatic organisms are more prevalent. Currents and tides play an important role in distributing pelagic organisms. One reproductive strategy used by marine fish and invertebrates species is to cast their offspring into the ocean currents to ensure wide geographic distribution. Planktonic life stages are therefore quite common. The abundance of plankton in temperate regions is seasonal, with greater numbers in spring and summer and fewer numbers in winter. The young of a number of invertebrate and fish species reproduce over the continental shelf. Prevailing currents and tides tend to carry these organisms back to nursery areas such as bays, estuaries, wetlands, or coastal rivers.

The potential for I&E can be high if CWIS are located in productive, shallow areas of oceans or in locations where tides bring in or aggregate plankton or migratory fish species. This effect is magnified because many marine species rely on drifting, planktonic life stages of their offspring to increase their dispersal potential over large volumes of water. An additional issue pertains to the presence of marine mammals and reptiles, including threatened and endangered species of sea turtles. These species are known to enter submerged offshore CWIS and can drown once inside the intake tunnel.





In addition to many of the species discussed in the section on estuaries, other fish species found in near coastal waters that are of commercial, recreational, or ecological importance and are particularly vulnerable to I&E include silver perch (*Bairdiella chrysura*), cunner (*Tautogolabrus adspersus*), several anchovy species, scaled sardine (*Harengula jaguana)*, and queenfish (*Seriphus politus*) (Tables 11-12 and 11-13).

Table 11-12: Annual Entrainment of Eggs, Larvae, and Juvenile Fish in Oceans

Common Name	Scientific Name	Number of Facilities	Mean Annual Entrainment per Facility (fish/year)	Range
bay anchovy	*Anchoa mitchilli*	2	44,300,000,000	9,230,000,000 - 79,300,000,000
silver perch	*Bairdiella chrysura*	2	26,400,000,000	8,630,000 - 52,800,000,000
striped anchovy	*Anchoa hepsetus*	1	6,650,000,000	---
cunner	*Tautogolabrus adspersus*	2	1,620,000,000	33,900,000 - 3,200,000,000
scaled sardine	*Harengula jaguana*	1	1,210,000,000	---
tautog	*Tautoga onitis*	2	911,000,000	300,000 - 1,820,000,000
clown goby	*Microgobius gulosus*	1	803,000,000	---
code goby	*Gobiosoma robustum*	1	680,000,000	---
sheepshead	*Archosargus probatocephalus*	1	602,000,000	---
kingfish	*Menticirrhus* spp.	1	542,000,000	---
pigfish	*Orthopristis chrysoptera*	2	459,000,000	755,000 - 918,000,000
sand sea trout	*Cynoscion arenarius*	1	325,000,000	---
northern kingfish	*Menticirrhus saxatilis*	1	322,000,000	---
Atlantic mackerel	*Scomber scombrus*	1	312,000,000	---
Atlantic bumper	*Chloroscombrus chrysurus*	1	298,000,000	---

Sources: Conservation Consultants Inc., 1977; Stone & Webster Engineering Corporation, 1980; Florida Power Corporation, 1985; Normandeau Associates, 1994; Jacobsen et al., 1998; Northeast Utilities Environmental Laboratory, 1999.

Table 11-13: Annual Impingement in Oceans for All Age Classes Combined

Common Name	Scientific Name	Number of Facilities	Mean Annual Impingement per Facility (fish/year)	Range
queenfish	*Seriphus politus*	2	201,000	19,800 - 382,000
polka-dot batfish	*Ogcocephalus radiatus*	1	74,500	---
bay anchovy	*Anchoa mitchilli*	2	49,500	11,000 - 87,900
northern anchovy	*Engraulis mordax*	2	36,900	26,600 - 47,200
deepbody anchovy	*Anchoa compressa*	2	35,300	34,200 - 36,400
spot	*Leiostomus xanthurus*	1	28,100	---
American sand lance	*Ammodytes americanus*	2	20,700	886 - 40,600
silver perch	*Bairdiella chrysura*	2	20,500	12,000 - 29,000
California grunion	*Caranx hippos*	1	18,300	---
topsmelt	*Atherinops affinis*	2	18,200	4,320 - 32,300
alewife	*Alosa pseudoharengus*	2	16,900	1,520 - 32,200
pinfish	*Lagodon rhomboides*	1	15,200	---
slough anchovy	*Anchoa delicatissima*	3	10,900	2,220 - 27,000
walleye surfperch	*Hyperprosopon argenteum*	1	10,200	---
Atlantic menhaden	*Brevoortia tyrannus*	3	7,500	861 - 20,400

Sources: Stone & Webster Engineering Corporation, 1977; Stupka and Sharma, 1977; Tetra Tech Inc., 1978; Stone and Webster Engineering Corporation, 1980; Florida Power Corporation, 1985; Southern California Edison Company, 1987; SAIC, 1993; EA Engineering, Science and Technology, 1997; Jacobsen et al., 1998.

11.8 Summary of I&E Data

The data evaluated by EPA indicate that fish species with free-floating, early life stages are those most susceptible to CWIS impacts. Such planktonic organisms lack the swimming ability to avoid being drawn into intake flows. Species that spawn in nearshore areas, have planktonic eggs and larvae, and are small as adults experience even greater impacts because both new recruits and the spawning adults are affected (e.g., bay anchovy in estuaries and oceans).

EPA's data review also indicates that fish species in estuaries and oceans experience the highest rates of I&E. These species tend to have planktonic eggs and larvae, and tidal currents carry planktonic organisms past intakes multiple times, increasing the probability of I&E. In addition, fish spawning and nursery areas are located throughout estuaries and near coastal waters, making it difficult to avoid locating intakes in areas where fish are present.

11.9 Potential Benefits of §316(b) Regulation

11.9.1 Introduction: Benefits Concepts, Categories, and Causal Links

Valuing the changes in environmental quality that arise from the §316(b) regulations for new facilities is a principal desired outcome for the Agency's policy assessment framework. However, time and data constraints do not permit a quantified assessment of the economic benefits of the proposed rule. Nonetheless, this section provides a qualitative description of the types of benefits that are expected.

As noted in previous sections of this chapter, changes in CWIS design, location, or capacity can reduce I&E rates. These changes in I&E can potentially yield significant ecosystem improvements in terms of the number of fish that avoid premature mortality. This in turn is expected to increase local and regional fishery populations, and ultimately contribute to the enhanced environmental functioning of affected water bodies (rivers, lakes, estuaries, and oceans). Finally, the economic welfare of human populations is expected to increase as a consequence of the improvements in fisheries and associated aquatic ecosystem functioning. Below, we identify potential ecological outcomes and related economic benefits from anticipated reductions in adverse effects of CWIS. We explain the basic economic concepts applicable to the economic benefits, including benefit categories and taxonomies, service flows, and market and nonmarket goods and services.

11.9.2 Economic Benefit Categories Applicable to the §316(b) Rule

To estimate the economic benefits of minimizing I&E at new CWIS, all the beneficial outcomes need to be identified and, where possible, quantified and assigned appropriate monetary values. Estimating economic benefits can be challenging because of the many steps that need to be analyzed to link a reduction in I&E to changes in impacted fisheries and other aspects of relevant aquatic ecosystems, and to then link these ecosystem changes to the resulting changes in quantities and values for the associated environmental goods and services that ultimately are linked to human welfare.

Key challenges in benefits assessment include uncertainties and data gaps, as well as the fact that many of the goods and services beneficially affected by the proposed change in new facility I&E are not traded in the marketplace. Thus there are numerous instances — including this proposed §316(b) rule for new facilities — when it is not feasible to confidently assign monetary values to some beneficial outcomes. In such instances, benefits need to be described and considered qualitatively. This is the case for the proposed rule for new facility CWIS. At this time, there is only general information about the location of most proposed new facilities, and in most cases details of facility and environmental characteristics are unknown. As a result, it is not possible to do a detailed analysis of potential monetary benefits associated with the proposed regulations.

11.9.3 Benefit Category Taxonomies

The term "economic benefits" here refers to the dollar value associated with all the expected positive impacts of the §316(b) regulation being proposed for new facilities. Conceptually, the monetary value of benefits is the sum of the predicted changes in "consumer and producer surplus." These surplus measures are standard and widely accepted terms of applied welfare economics, and reflect the degree of well-being derived by economic agents (e.g., people or firms) given different levels of goods and services, including those associated with environmental quality.[3]

The economic benefits of activities that improve environmental conditions can be categorized in many different ways. The various terms and categories offered by

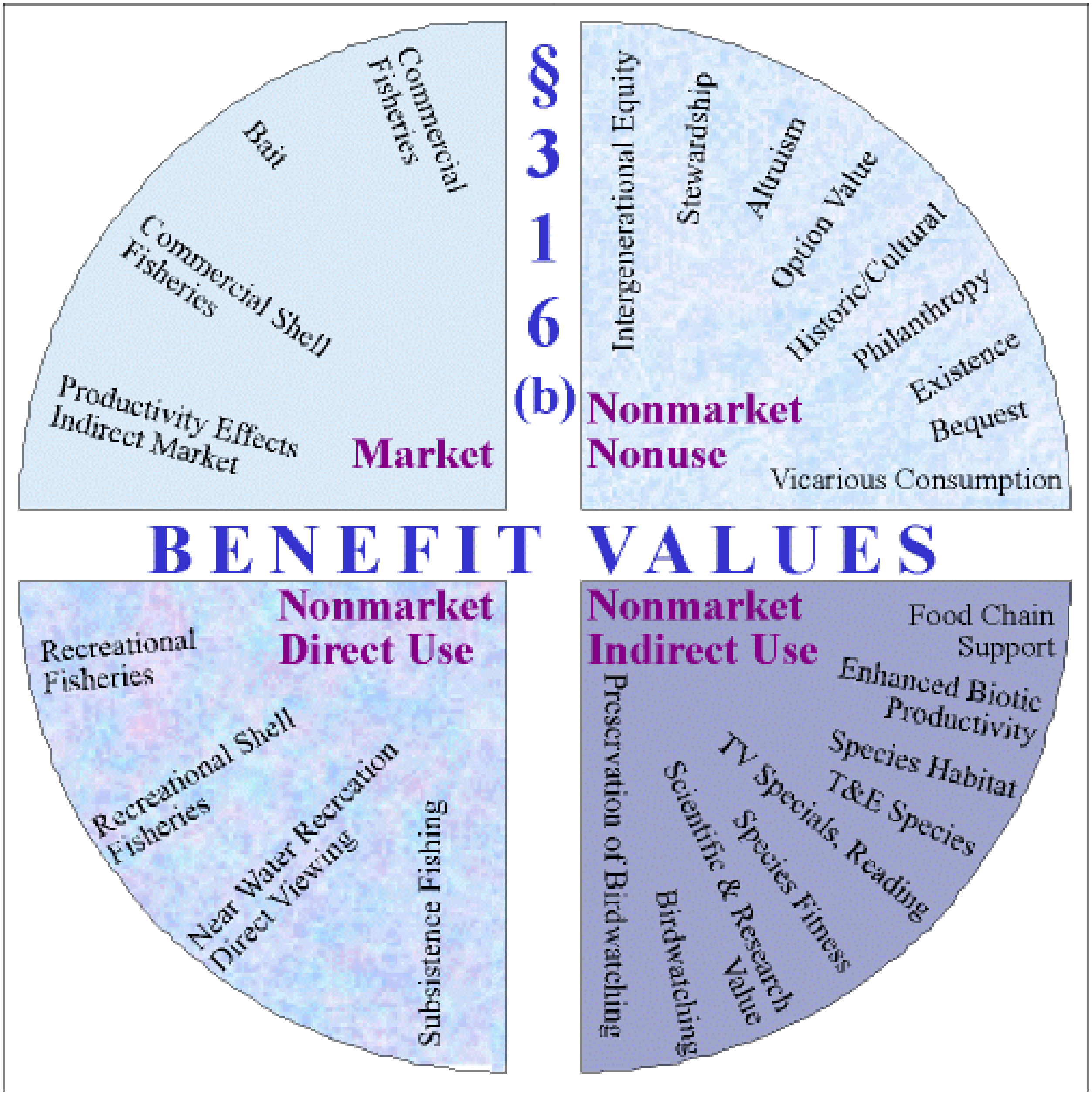
[3] Technically, consumer surplus reflects the difference between the "value" an individual places on a good or service (as reflected by the individual's "willingness to pay" for that unit of the good or service) and the "cost" incurred by that individual to acquire it (as reflected by the "price" of a commodity or service, if it is provided in the marketplace). Graphically, this is the area bounded from above by the demand curve and below by the market clearing price. Producer surplus is a similar concept, reflecting the difference between the market price a producer can obtain for a good or service and the actual cost of producing that unit of the commodity.

different authors can lead to some confusion with semantics. However, the most critical issue is to try not to omit any relevant benefit, and at the same time avoid potential double counting of benefits.

One common typology for benefits of environmental programs is to divide them into three main categories of (1) economic welfare (e.g., changes in the well-being of humans who derive use value from market or nonmarket goods and services such as fisheries); (2) human health (e.g., the value of reducing the risk of premature fatality due to changing exposure to environmental exposure); and (3) nonuse values (e.g., stewardship values for the desire to preserve threatened and endangered species). For the §316(b) regulation, however, this typology does not convey all the intricacies of how the rule might generate benefits. Further, human health benefits are not anticipated. Therefore, another categorization may be more informative.

Figure 11-1 outlines the most prominent categories of benefit values for the §316(b) rule. The four quadrants are divided by two principles: (1) whether the benefit can be tracked in a market (i.e., market goods and services) and (2) how the benefit of a nonmarket good is received by human beneficiaries (either from direct use of the resource, from indirect use, or from nonuse).

Figure 11-1: §316(b) Benefit Values



Market benefits are best typified by commercial fisheries, where a change in fishery conditions will manifest itself in the price, quantity, and/or quality of fish harvests. The fishery changes thus result in changes in the marketplace, and can be evaluated based on market exchanges.

Direct use benefits include the value of improved environmental goods and services used and valued by people (whether or not they are traded in markets). A typical nonmarket direct use would be recreational angling, in which participants enjoy a welfare gain when the fishery improvement results in a more enjoyable angling experience (e.g., higher catch rates).

Indirect use benefits refer to changes that contribute, through an indirect pathway, to an increase in welfare for users (or nonusers) of the resource. An example of an indirect benefit would be when the increase in the number of forage fish enables the population of valued predator species to improve (e.g., when the size and numbers of prized recreational or commercial fish increase because their food source has been improved). In such a context, the I&E impacts on a forage species will indirectly result in welfare gains for recreational or commercial anglers.

Nonuse benefits — also known as passive use values — reflect the values individuals assign to improved ecological conditions apart from any current, anticipated, or optional use by them. Some economists consider option values to be a part of nonuse values because the option value is not derived from actual current use, whereas other writers place it in a use category (because the option value is associated with preserving opportunity for a future use of the resource). For convenience, we place option value in the nonuse category.

11.9.4 Direct Use

Direct use benefits are the simplest to envision. The welfare of commercial, recreational, and subsistence fishermen is improved when fish stocks increase and their catch rates rise. This increase in stocks may be induced by reduced I&E of species sought by fishermen, or through reduced I&E of forage and bait fish, which leads to increases in populations of commercial and recreational species. For subsistence fishermen, the increase in fish stocks may reduce the amount of time spent fishing for their meals or increase the number of meals they are able to catch. For recreational anglers, more fish and higher catch rates may increase the enjoyment of a fishing trip and may also increase the number of fishing trips taken. For commercial fishermen, larger fish stocks may lead to increased revenues through increases in total landings and/or increases in the catch per unit of effort (i.e., lower costs per fish caught). Increases in catch may also lead to growth in related commercial enterprises, such as commercial fish cleaning/filleting, commercial fish markets, recreational charter fishing, and fishing equipment sales.

Evidence that these use benefits are valued by society can be seen in the market. For example, in 1996 about 35 million recreational anglers spent nearly $38 billion on equipment and fishing trip related expenditures (US DOI, 1997) and the 1996 GDP from fishing, forestry, and agricultural services (not including farms) was about $39 billion (BEA, 1998). Clearly, these data indicate that the fishery resource is very important. These baseline values do not give us a sense of how benefits change with changes in environmental quality such as reduced I&E and increased fish stocks. However, even a change of 0.1% would translate into potential benefits of $40 million per year.

Commercial fishermen. The benefits derived from increased landings by commercial fishermen can be valued by looking at the market in which the fish are sold. The ideal measure of commercial fishing benefits is the producer surplus generated by the marginal increase in landings, but often the data required to compute the producer surplus are unavailable. In this case, revenues may be used as a proxy for producer surplus, with some assumptions and an adjustment. The assumptions are that (1) there will be no change in harvesting behavior or effort, but existing commercial anglers will experience an increase in landings, and (2) there will be no change in price. Given these assumptions, benefits can be estimated by calculating the expected increase in the value of commercial landings, and then translating the landed values into estimated increases in producer surplus. The economic literature (Huppert, 1990) suggests that producer surplus values for commercial fishing have been estimated to be approximately 90% of total revenue (landings values are a close proxy for producer surplus because the commercial fishing sector has very high fixed costs relative to its variable costs). Therefore, the marginal benefit from an increase in commercial landings can be estimated to be approximately 90% of the anticipated change in revenue.

Recreational users. The benefits of recreational use cannot be tracked in the market. However, there is an extensive literature on valuing fishing trips and valuing increased catch rates on fishing trips. While it is likely that nearwater recreational users will gain benefits, It is unlikely that swimmers would perceive an important effect on their use of the ecosystem. Boaters may receive recreational value to the degree that enjoyment of their surroundings is an important part of their recreational pleasure or that fishing is a secondary reason for boating. Passive use values to these and other individuals are discussed below.

Primary studies of sites throughout the United States have shown that anglers value their fishing trips and that catch rates are one of the most important attributes contributing the quality of their trips.

Higher catch rates may translate into two components of recreational angling benefits: an increase in the value of existing recreational fishing trips, and an increase in recreational angling participation. The most promising approaches for quantifying and monetizing these two benefits components are benefits transfer (as a secondary method) and random utility modeling or RUM (as a primary research method).

To estimate the value of an improved recreational fishing experience, it is necessary to estimate the existing number of angling trips or days that are expected to be improved by reducing I&E. As with the commercial fishing benefits, it is important to identify the appropriate geographic scope when estimating these numbers. Once the existing angling numbers have been estimated, the economic value of an improvement (consumer surplus) can be estimated. The specific approach for estimating the value will depend on the economic literature that is most relevant to the specific characteristics of the study site. For example, some economic studies in the literature can be used to infer a factor (percentage increase) that can be applied to the baseline value of the fishery for specific changes in fishery conditions. Other primary studies simply provide an estimate of the incremental value attributable to an improvement in catch rate.

In some cases it may be reasonable to assume that increases in fish abundance (attributable to reducing I&E) will lead to an increase in recreational fishing participation. This would be particularly relevant in a location that has experienced such a severe impact to the fishery that the site is no longer an attractive location for recreational activity. Estimates of potential recreational activity post-regulation can be made based on similar sites with healthy fishery populations, on conservative estimates of the potential increase in participation (e.g., a 5% increase), or on recreational planning standards (densities or level of use per acre or stream mile). A participation model (as in a RUM application) could also be used to predict changes in the net addition to user levels from the improvement at an impacted site. The economic benefit of the increase in angling days then can be estimated using values from the economic literature for a similar type of fishery and angling experience.

Subsistence anglers. Subsistence use of fishery resources can be an important issue in areas where socioeconomic conditions (e.g., the number of low income households) or the mix of ethnic backgrounds make such angling economically or culturally important to a component of the community. In cases of Native American use of impacted fisheries, the value of an improvement can sometimes be inferred from settlements in similar legal cases (including natural resource damage assessments, or compensation agreements between impacted tribes and various government or other institutions in cases of resource acquisitions or resource use restrictions). For more general populations, the value of improved subsistence fisheries may be estimated from the costs saved in acquiring alternative food sources (assuming the meals are replaced rather than foregone).

11.9.5 Indirect Use Benefits

Indirect use benefits refer to welfare improvements that arise for those individuals whose activities are enhanced as an indirect consequence of the fishery or habitat improvements generated by the proposed new facility standards for CWIS. For example, the rule's positive impacts on local fisheries may, through the intricate linkages in ecologic systems, generate an improvement in the population levels and/or diversity of bird species in an area. This might occur, for example, if the impacted fishery is a desired source of food for an avian species of interest. Avid bird watchers might thus obtain greater enjoyment from their outings, as they are more likely to see a wider mix or greater numbers of birds. The increased welfare of the bird watchers is thus a legitimate but indirect consequence of the proposed rule's initial impact on fish.

There are many forms of potential indirect benefits. For example, a rule-induced improvement in the population of a forage fish species may not be of any direct consequence to recreational or commercial anglers. However, the increased presence of forage fish may well have an indirect affect on commercial and recreational fishing values because it enhances an important part of the food chain. Thus, direct improvements in forage species populations may well result in a greater number (and/or greater individual size) of those fish that are targeted by recreational or commercial anglers. In such an instance, the relevant recreational and commercial fishery benefits would be an indirect consequence of the proposed rule's initial impacts on lower levels of the aquatic ecosystem.

The data and methods available for estimating indirect use benefits depend on the specific activity that is enhanced. For example, an indirect improvement to recreational anglers would be measured in essentially the same manner discussed under the preceding discussion on direct use benefits (e.g., using a RUM model). However, the analysis requires one additional critical step — that of indicating the link between the direct impact of the proposed rule (e.g., improvements in forage species populations) and the indirect use that is ultimately enhanced (e.g., the recreationally targeted fish). Therefore, what is typically required for estimating indirect use benefits is ecologic modeling that captures the key linkages between the initial impact of the rule and its ultimate (albeit indirect) effect on use values. In the example of forage species, the change in forage fish populations would need to be analyzed in a manner that ultimately yields information on responses in recreationally targeted species (e.g., that can be linked to a RUM analysis).

11.9.6 Nonuse Benefits

Nonuse (passive use) benefits arise when individuals value improved environmental quality apart from any past, present, or anticipated future use of the resource in question. Such passive use values have been categorized in several ways in the economic literature, typically embracing the concepts of existence (stewardship) and bequest (intergenerational equity) motives. Passive use values also may include the concept that some ecological services are valuable apart from any human uses or motives. Examples of these ecological services may include improved reproductive success for aquatic and terrestrial wildlife, increased diversity of aquatic and terrestrial wildlife, and improved conditions for recovery of threatened and endangered species.

Passive values can only be estimated in primary research through the use of direct valuation techniques such as contingent valuation method (CVM) surveys and related techniques (e.g., conjoint analysis using surveys). In the case of the §316(b) proposed new facilities rule, benefits transfer is used, with appropriate care and caveats clearly recognized.

One typical approach for estimating passive values is to apply a ratio between certain use-related benefits estimates and the passive use values anticipated for the same site and resource change. Freeman (1979) applied a rule of thumb in which he inferred that national-level passive benefits of water quality improvements were 50% of the estimated recreational fishing benefits. This was based on his review of the literature in those instances where nonuse and use values had been estimated for the same resource and policy change. Fisher and Raucher (1984) undertook a more in-depth and expansive review of the literature, found a comparable relationship between recreational angling benefits and nonuse values, and concluded that since nonuse values were likely to be positive, applying the 50% "rule of thumb" was preferred over omitting nonuse values from a benefits analysis entirely.

The 50% rule has since been applied frequently in EPA water quality benefits analyses (e.g., effluent guidelines RIAs for the iron and steel and pulp and paper sectors, and the RIA for the Great Lakes Water Quality Guidance). At times the rule has been extended to ratios higher than 50% (based on specific studies in the literature). However, the overall reliability and credibility of this type of approach is, as for any benefits transfer approach, dependent on the credibility of the underlying study and the comparability in resources and changes in conditions between the research survey and the §316(b) rule's impacts at selected sites. The credibility of the nonuse value estimate also is contingent on the reliability of the recreational angling estimates to which the 50% rule is applied.

A second approach to deriving estimates for §316(b) passive use values is to use benefits transfer to apply an annual willingness-to-pay estimate per nonuser household (e.g., Mitchell and Carson, 1986; Carson and Mitchell, 1993) to all the households with passive use motives for the impacted waterbody. The challenges in this approach include defining the appropriate "market" for the impacted site (e.g., what are the boundaries for defining how many households apply), as well as matching the primary research scenario (e.g., "boatable to fishable") to the predicted improvements at the §316(b)-impacted site.

For specific species, some valuation may be deduced using restoration-based costs as a proxy for the value of the change in stocks (or for threatened and endangered species the value of preserving the species). Where a measure of the approximate cost per individual can be deduced, and the number of individuals spared via BTA can be estimated, this may be a viable approach.

Table 11-14: Summary of Benefit Categories, Data Needs, Potential Data Sources, and Approaches		
Benefits Category	**Basic Data Needs**	**Potential Data Sources/Approaches**
Direct Use, Marketed Goods		
Increased commercial landings (fishing, shellfishing, & aquaculture)	▸ Estimated change in landings ▸ Estimated producer surplus	▸ Based on ecological modeling ▸ Based on available literature or 50% rule
Direct Use, Nonmarket Goods		
Improved value of a recreational fishing experience	▸ Estimated number of affected anglers ▸ Value of an improvement in catch rate, and possibly, value of an angling day	▸ Site-specific studies, national or statewide surveys ▸ Based on available literature
Increase in recreational fishing participation	▸ Estimated number of affected anglers or estimate of potential anglers ▸ Value of an angling day	▸ Site-specific studies, national or statewide surveys ▸ Based on available literature
Increase in subsistence fishing	▸ Estimated number of affected anglers or estimate of potential anglers ▸ Value of an angling day	▸ Site-specific studies, national or statewide surveys ▸ Based on available literature
Nonuse and Indirect Use, Nonmarketed		
Increase in indirect values	▸ Estimated changes in ecological services (e.g., reproductive success of aquatic species) ▸ Restoration based on costs	▸ Based on ecological modeling ▸ Site-specific studies, national or statewide surveys
Increase in passive use values	▸ Apply 50% rule to recreational fishing values	▸ Or use site-specific studies, national or statewide surveys

11.9.7 Summary of Benefits Categories

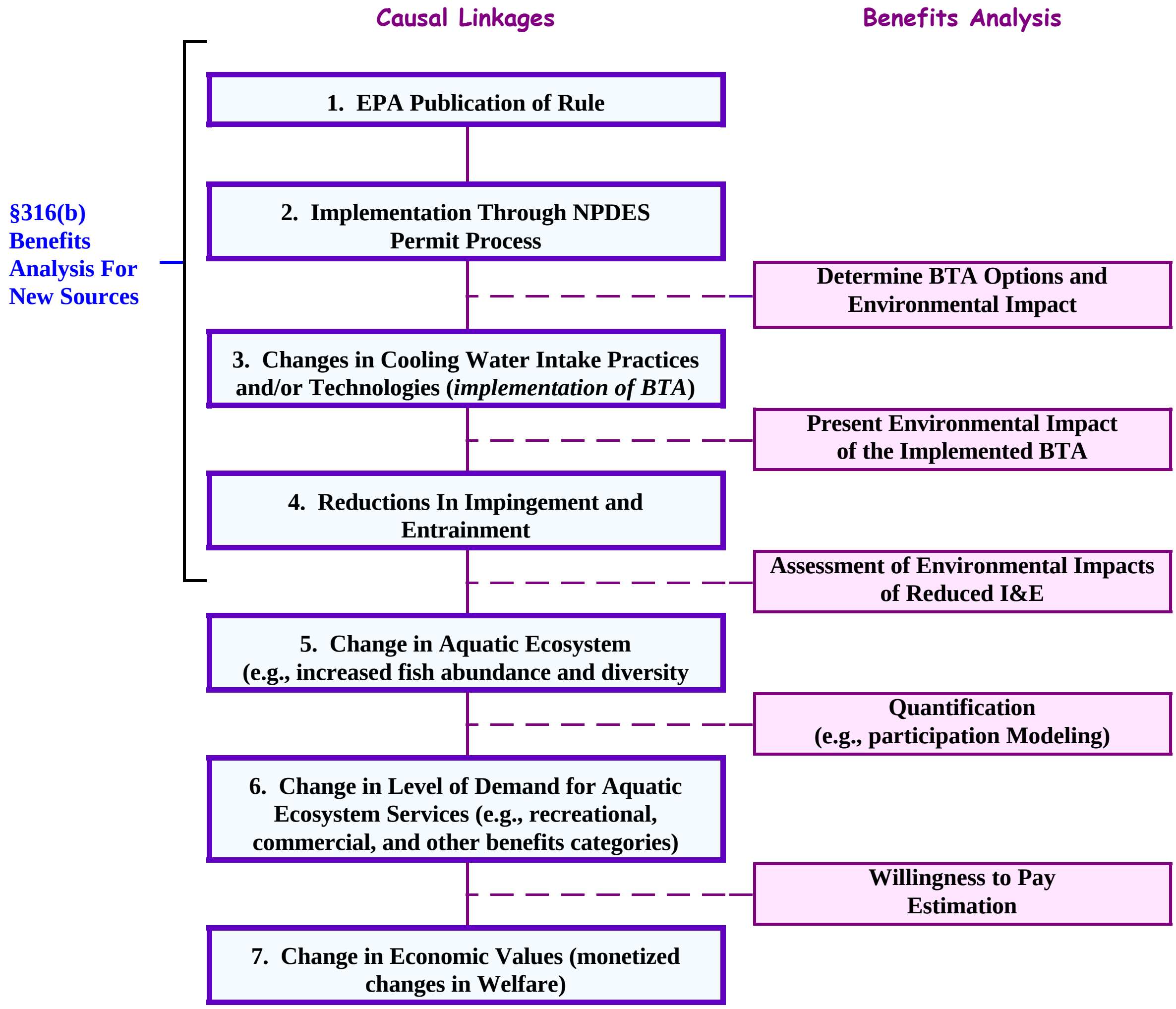
Table 11-4 displays the types of benefits categories expected to be affected by the §316(b) rule and the various data needs, data sources, and estimation approaches associated with each category. As described in sections 11.9.4 to 11.9.6, economic benefits can be broadly defined according to three categories: 1) direct use, 2) indirect use, and 3) nonuse (passive use) benefits. These benefits can be further categorized according to whether or not they are traded in the market. As indicated in Table 11-4 , "direct use" benefits include both "marketed" and "nonmarketed" goods, whereas "nonuse" and "indirect use" benefits include only "nonmarketed" goods.

11.9.8 Causality: Linking the §316(b) Rule to Beneficial Outcomes

Understanding the anticipated economic benefits arising from changes in I&E requires understanding a series of physical and socioeconomic relationships linking the installation of Best Technology Available (BTA) to changes in human behavior and values. As shown in Figure 11-2, these relationships span a broad spectrum, including institutional relationships to define BTA (from policy making to field implementation), the technical performance of BTA, the population dynamics of the aquatic ecosystems affected, and the human responses and values associated with these changes.

The first two steps in Figure 11-2 reflect the institutional aspects of implementing the §316(b) rule. In step 3, the anticipated applications of BTA (or a range of BTA options) must be determined for the regulated entities. This technology forms the basis for estimating the cost of compliance, and provides the basis for the initial physical impact of the rule (step 4). Hence, the analysis must predict how implementation of BTAs (as predicted in step 3) translates into changes in I&E at the regulated CWIS (step 4). These changes in I&E then serve as input for the ecosystem modeling (step 5).

Figure 11-2: Casual Linkages in the Benefits Analysis



In moving from step 4 to step 5, the selected ecosystem model (or models) are used to assess the change in the aquatic ecosystem from the preregulatory baseline (e.g., losses of aquatic organisms before BTA) to the postregulatory conditions (e.g., losses after BTA implementation). The potential output from these steps includes estimates of reductions in I&E rates, and changes in the abundance and diversity of aquatic organisms of commercial, recreational, ecological, or cultural value, including threatened and endangered species.

In step 6, the analysis involves estimating how the changes in the aquatic ecosystem (estimated in step 5) translate into changes in level of demand for goods and services. For example, the analysis needs to establish links between improved fishery abundance, potential increases in catch rates, and enhanced participation. Then, in step 7, as an example, the value of the increased enjoyment realized by recreational anglers is estimated. These last two steps typically are the focal points of the economic benefits portion of the analysis. However, because of data and time constraints, this benefits analysis is limited to only the first four steps of the process.

11.10 Empirical Indications of Potential Benefits

The following discussion provides examples from existing facilities that offer some indication of the relative magnitude of monetary benefits that may be expected to result from the proposed new facility regulations.

The potential benefits of lower intake flows and 100% recirculation of flow are illustrated by comparisons of once-through and closed-cycle cooling (e.g., Brayton Point and Hudson River facilities). The potential benefits of additional requirements defined by regional permit directors are demonstrated by operational changes implemented to reduce impingement and entrainment (e.g., Pittsburg and Contra Costa facilities). The potential benefits of reducing losses of forage species are demonstrated by analysis of the biological and economic relationships among forage species and commercial and recreational fishery species (e.g., Ludington facility on Lake Michigan). Finally, the potential benefits of implementing additional technologies to increase survival of organisms impinged or entrained are illustrated by the application of modified intake screens and fish return systems (e.g., Salem Nuclear Generating Facility). These cases are discussed below.

An example of the potential benefits of minimizing intake flow is provided by data for the Brayton Point facility, located on Mt. Hope Bay in Massachusetts (NEPMRI, 1981, 1995; U.S. EPA, 1982). In the mid-1980's, the operation of Unit 4 at Brayton Point was changed from closed-cycle to once-through cooling, increasing flow by 48% from an average of 703 MGD before conversion to an average of 1045 MGD for the first 6 years post-conversion (Lawler, Matusky, and Skelly Engineers, 1993). Although conversion to once-through cooling increased coolant flow and the associated heat load to Mt. Hope Bay, the facility requested the change because of electrical problems associated with Unit 4's saltwater spray cooling system (U.S. EPA, 1982). Comparison of I&E losses before and after the change provides a means of estimating the potential reduction in losses under closed cycle operation. Data on I&E losses following conversion of Unit 4 to once-through cooling are available in reports giving predicted (NEPMRI, 1981) or actual (Gibson, 1996) losses. Based on data for four species, EPA estimated that the annual reduction in entrainment losses of adult-equivalents of catchable fish under closed-cycle cooling would range from 7,250 for weakfish and 20,198 for tautog to 155,139 for winter flounder and 207,254 for Atlantic menhaden. Assuming that this would result in a proportional change in harvest, this represents an increase under closed cycle operation of 330,000 to 2 million pounds per year in commercial landings and from 42,000 to 128,000 pounds per year in recreational landings for these four species alone.

Another example of the potential benefits of low intake flow is provided by an analysis of I&E losses at five Hudson River power plants. Estimated fishery losses under once-through compared to closed-cycle cooling indicated that an average reduction in intake flow of about 95% at the three facilities responsible for the greatest impacts would result in a 30-80% reduction in fish losses, depending on the species involved (Boreman and Goodyear, 1988). An economic analysis estimated monetary damages under once-through cooling based on the assumption that annual percent reductions in year classes of fish result in proportional reductions in fish stocks and harvest rates (Rowe et al., 1995). A low estimate of per facility damages was based on losses at all five facilities and a high estimate was based on losses at the three facilities that account for most of the impacts. Damage estimates under once-through cooling ranged from about $1.3 million to $6.1 million annually in 1999 dollars.

Another example demonstrates how I&E losses of forage species can lead to reductions in economically valued species. Jones and Sung (1993) applied a RUM to estimate fishery impacts of I&E by the Ludington Pumped-Storage plant on Lake Michigan. This method estimates changes in demand as a function of changes in catch rates. The Ludington facility is responsible for the loss of about 1-3% of the total Lake Michigan production of alewives, a forage species that supports valuable trout and salmon fisheries. Jones and Sung (1993) estimated that losses of alewife result in a loss of nearly 6% of the angler catch of trout and salmon each year. Based on RUM analysis, they estimated that if Ludington operations ceased, catch rates of trout and salmon species would increase by 3.3 to 13.7 percent annually, amounting to an estimated recreational angling benefit of $0.95 million per year (in 1999 dollars) for these species alone.

Another example indicates the potential benefits of operational BTA that may be required by regional permit directors. Two plants in the San Francisco Bay/Delta, Pittsburg and Contra Costa, have made changes to their intake operations to reduce I&E of striped bass (*Morone saxatilis*). This also reduces incidental take of several threatened and endangered fish species, including the delta smelt (*Hypomesus transpacificus*) and several runs of chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*). According to technical reports by the facilities, operational BTA has reduced striped bass losses by 78-94%, representing an increase in striped bass recreational landings of about 15,000 fish each year. A local study estimated that the consumer surplus of an additional striped bass caught by a recreational angler is $8.87 to $13.77 in 1999 dollars (Huppert, 1989). This implies a benefit to the recreational fishery, from reduced I&E of striped bass alone, in the range of $131,000 to $204,000 annually.

A final example indicates the benefits of technologies that can be applied to maximize survival. At the Salem Nuclear Generating Station in Delaware Bay, the facility's original intake screens were replaced with modified screens and improved fish return baskets that reduce impingement stress and increase survival of impinged fish (Ronafalvy et al., 1999). The changes resulted in an estimated 51% reduction in losses of weakfish. Assuming similar reductions in losses of other recreational and commercial species, this represents an increase in recreational landings of 13,000 to 65,000 fish per year and an increase in angler consumer surplus of as much as $269,000 annually in 1999 dollars. The estimated increase in commercial landings of 700 to 28,000 pounds per year represents an increase in producer surplus of up to $25,000 annually. Assuming that nonuse benefits are at least 50% of recreational use benefits, nonuse benefits associated with the screens may be expected to amount to up to $134,000 per year.

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APPENDIX A

DETAILED INFORMATION ON TECHNOLOGIES AND THE DEVELOPMENT OF UNIT COSTS

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APPENDIX A

DETAILED INFORMATION ON TECHNOLOGIES AND THE DEVELOPMENT OF UNIT COSTS

This Appendix presents detailed information on the development of unit cost estimates for a set of technologies that may be used and actions that may be taken to meet requirements under the proposed §316(b) New Facility Rule. The Appendix provides additional description of many of the technologies and compliance actions to supplement the information presented in the main document.

Background

Facilities using cooling water may be subject to the proposed §316(b) New Facility Rule. A facility using cooling water can have either a once-through or a recirculating cooling system.

In a once-through system, the cooling water that is drawn in from a waterbody travels through the cooling system once to provide cooling and is then discharged, typically back to the waterbody from which it was withdrawn. The cooling water is withdrawn from a water source, typically a surface waterbody, through a cooling water intake structure (CWIS). Many facilities using cooling water (e.g., steam electric power generation facilities, chemical and allied products manufacturers, pulp and paper plants) need large volumes of cooling water, so the water is generally drawn in through one or more large CWIS, potentially at high velocities. Because of this, debris, tree limbs, and many fish and other aquatic organisms can be drawn toward or into the CWIS. Since a facility's cooling water system can be damaged or clogged by large debris, most facilities have protective devices such as trash racks, fixed screens, or traveling screens, on their CWIS. Some of these devices provide limited protection to fish and other aquatic organisms, but other measures such as the use of passive (e.g., wedgewire) screens, velocity caps, traveling screens with fish baskets, or the use of a recirculating cooling system may provide better protection and have greater capability to minimize adverse environmental impacts.[1]

In a recirculating system, the cooling water is used to cool equipment and steam, absorbing heat in the process, and is then cooled and recirculated to the beginning of the system to be used again for cooling. The heated cooling water is generally cooled in either a cooling tower or in a cooling lake/pond. In the process of being cooled, some of the water evaporates or escapes as steam. Flow lost through evaporation typically ranges from 0.5% to 1% of the total flow (Antaya, 1999). Also, because of the heating and cooling of recirculating water, mineral deposition occurs which necessitates some bleeding of water from the system. The water that is purged from the system to maintain chemical balance is called blow down. The amount of blow down is generally around 1% of the flow. Cooling towers may also have a small amount of drift, or windage loss, which occurs when some recirculating water is blown out of the tower by the wind or the velocity of the air flowing through the tower. The water lost to evaporation, blow down, and drift needs to be replaced by what is typically called makeup water. Overall, makeup water is generally 3% or less of the recirculating water flow.[2] Therefore, recirculating systems still need to draw in water and may have cooling water intakes. However, the volume of water drawn in is significantly less than in once-through systems so the likelihood of adverse environmental impacts as a result of the CWIS is much lower.[3] Also, some recirculating systems obtain their makeup water from ground water sources or public water supplies, and a small but growing number use treated wastewater from municipal wastewater treatment plants for makeup water.

[1]CWIS devices used in an effort to protect fish also include other fish diversion and avoidance systems (e.g., barrier nets, strobe lights, electric curtains), which may be effective in certain conditions and for certain species.

[2]In some salt water cooling towers, however, makeup water can be as much as 15%.

[3]Manufacturer Brackett Green notes that closed loop systems (i.e., recirculating systems) normally require one-sixth the number of traveling screens as a power plant of equal size that has a once-through cooling system.

A. GENERAL COST INFORMATION

The cost estimates presented in this analysis include both capital costs and operations and maintenance (O&M) costs and are for primary technologies such as traveling screens and cooling towers and for actions such as extending intake piping to locate a CWIS outside the littoral zone. Facilities may install these technologies or take these actions to meet requirements of the proposed §316(b) New Facility Rule. Cooling tower cost estimates are presented for various types of cooling towers including towers fitted with features such as plume reduction and noise reduction. Estimated costs for traveling screens were developed mainly from cost information provided by vendors. The cost of installing other CWIS technologies such as passive screens and velocity caps are calculated by applying a cost factor based on the cost of traveling screens. All of the base cost estimates are for new sources.

To provide a relative measurement of the differences in cost across technologies, costs need to be developed on a uniform basis. The cost for many of the CWIS and flow reduction technologies depends on many factors, including site-specific conditions, and the relative importance of many of these factors varies from technology to technology. The factor that is most relevant and that seems to most affect cost is the total intake flow. Therefore, EPA selected total intake flow as the factor on which to base unit costs and thus use for basic cost comparisons. EPA developed cost estimates, in $/gallons per minute (gpm), for each of the technologies for use at a range of different total intake flow volumes.

EPA assumed average values or typical situations for the other factors that also impact the cost components. For example, EPA assumed an average debris level and an intake flow velocity of 0.5 feet per second (fps); EPA also used 1.0 fps for cost comparison purposes. EPA separately assessed the cost effect of variations from these average conditions as add-on costs. For instance, if the water being drawn in has a high debris level, this would tend to increase cost by about 20%.

EPA determined the specifications for each factor based on a review of information about the characteristics most likely to be encountered at a typical facility withdrawing cooling water. Cost factors used in this analysis and the assumed values/scenarios are listed below in Table A-1.

EPA's unit cost estimates for the selected technologies are based on the information provided by vendors. Most of the cost information came from well-established firms and from industry representatives who have lengthy experience in the design, vending, and installation of CWIS and cooling towers. Although only a limited number of vendors provided cost information, EPA believes the information is sufficient for developing unit cost estimates.

Industry representatives often preferred to remain anonymous whether they were helpful and provided cost information or not. Some industry representatives who provided cost information wanted to be acknowledged for providing information but without being directly linked to specific technology costs. For these reasons and because information from several sources was combined during analysis, some of the cost information presented in this document is not attributed to a specific industry source.

Table A-1. Basis for Development of Costs

Base Factor for Developing Unit Costs	**Assumed Values of Other Factors for Base Costs**
Costs were developed for flows of: [1] < 10,000 gpm - 4 flows 10,000 to < 100,000 gpm - 20 flows 100,000 to 200,000 gpm - 4 flows > 200,000 gpm - 1 flow.	Intake flow velocity = 0.5 fps, and 1.0 fps for comparison Amount and type of debris = average/typical Water quality = fresh water Waterbody flow velocity = moderate flow Accessability to intake = average/typical (no dredging needed, use of crane possible)
Cost Elements	
Cost estimates of screens include non-metallic fish handling panels, a spray system, a fish trough, housings and transitions, continuous operating features (intermittent operation feature for traveling screens without fish baskets), a drive unit, frame seals, engineering, and installation. EPA separately estimated costs for spray wash pumps, permitting, and pilot studies. Cost estimates do *not* include a differential control system. Cooling towers cost estimates are based on unit costs that include all costs associated with the design, construction, and commissioning of a standard fill cooling tower. Costs of cooling towers with various features, building materials, and types are calculated based on cost comparisons with standard cooling towers. O&M costs were estimated for each type of technology. These costs were estimated, in part, using a percent of capital costs as a basis and considering additional factors.	
Potential Add-Ons to Cost	
Amount and type of debris = high or need for smaller than typical openings Depth of waterbody = particularly shallow or deep Water quality = salt or brackish water (extra cost for non-corrosive material for device and shorter life expectancy/higher replacement cost) Waterbody flow velocity = stagnant or rapidly moving Accessability to intake = cost of difficult installation (extra cost for dredging, extra cost for unusual installation due to site-specific conditions) Existing intake structure = costs associated with retrofit and what existing structure(s) or conditions would cause the extra costs. For example, if an existing structure has an intake flow of 2.0 fps and the intake velocity will be reduced to 0.5 fps with a new device, additional equipment or changes to other equipment/structures of that part of the intake system may increase capital costs (albeit minimially) when compared to installing a new system.	
1) Cost estimates were developed for selected flows in each range (e.g., 4 different flows less than 10,000 gpm). 10,000 gpm = 14.4 MGD	

The costs estimated for fish protection equipment are linked to both flow rates and intake width and depth. Cooling towers costs are costed based on the flow rate, in and out temperature delta (defined later), and the type of cooling tower. Some industry representatives provided information on how they conduct preliminary cost estimates for cooling towers. This is considered to be the "rule of thumb" in costing cooling towers [i.e., $/gallons per minute (gpm)]). Regional variations in costs do exist. For example, the costs of cooling towers in New England are generally more than for comparable cooling towers in the Mid Atlantic and Southeast parts of the country. In addition to the costs presented below, cost curves and equations are provided at the end of this Appendix. The cost curves and equations can be used to estimate costs for implementing technologies or taking actions for facilities across a range of intake flows. Additional supporting information can be found in *Cost Research and Analysis of Cooling Water Technologies for 316(b) Regulatory Options* (SAIC, 2000).

A.I. Flow

EPA determined preliminary intake flow values for the base factor based on data from the ICR (Information Collection Request) for the §316(b) industry questionnaire, a sampling of responses to the §316(b) industry screener questionnaire, a Utility Data Institute database (UDI, 1995), and industry brochures and technology background papers.[4] Data from these sources represent utility and nonutility steam electric facilities and industrial facilities that could be subject to prospective §316(b) requirements and are provided in Table A-2. EPA used these data to determine the range of typical intake flows for these types of facilities to ensure that the flows included in the cost estimates were representative. Through conversations with industry representatives, EPA determined the flows typically handled by available CWIS equipment and cooling towers. Facilities with greater flows would generally either use multiple screens, towers, or other technologies, or use a special design. Considering this information together, EPA selected flows for various screen sizes, water depths, and intake velocities for use in collecting cost data directly from industry representatives.

Table A-2. Flow Data

ICR (average intake flows by utility/industry category)			
Steam electric utilities:	178 MGD (124,000 gpm) for 1,093 facilities		
Steam electric non-utilities:	2.8 MGD (1,944 gpm) for 1,158 facilities		
Chemicals & allied products:	0.339 MGD (235 gpm) for 22,579 facilities		
Primary metals:	0.327 MGD (227 gpm) for 10,999 facilities		
Petroleum & coal products:	0.461 MGD (320 gpm) for 3,509 facilities		
Paper & allied products:	0.148 MGD (103 gpm) for 9,881 facilities		
UDI Database (design intake flow for steam electric utilities) (UDI, 1995)			
Up to 11,219 gpm (16.15 MGD)	401 units		
11,220-44,877 gpm (16.16-64.62 MGD)	465 units		
44,878-134,630 gpm (64.63-193.9 MGD)	684 units		
134,631-448,766 gpm (194-646.2 MGD)	453 units		
More than 448,766 gpm (646.2 MGD)	68 units		
Sampling of Responses from Industry Screener Questionnaire (daily intake flow for non-utilities)			
Up to 0.5 MGD (347 gpm)	6 facilities	>20-30.0 MGD (13,890-20,833 gpm)	2 facilities
>0.5-1.0 MGD (348-694 gpm)	1 facilities	>30-40.0 MGD (20,834-27,778 gpm)	2 facilities
>1-5.0 MGD (695-3,472 gpm)	3 facilities	>40-50.0 MGD (27,779-34,722 gpm)	1 facility
>5.0-10.0 MGD (3,473-6,944 gpm)	8 facilities	>50-100.0 MGD (34,723-69,444 gpm)	0 facilities
>10-20.0 MGD (6,945-13,889 gpm)	2 facilities	>100 MGD (>69,444 gpm)	1 facility
US Filter/Johnson Screens Brochure (ranges for flow definitions) (US Filter, 1998)			
Low flow:	200 to 4,000 gpm (0.288 to 5.76 MGD)		
Intermediate flow:	1,500 to 15,000 gpm (2.16 to 21.6 MGD)		
High flow:	5,000 to 30,000 gpm (7.2 to 43.2 MGD)		
Background Technology Papers (SAIC, 1994; SAIC, 1996)			
"Relatively low intake flow":	1-30 MGD (694-20,833 gpm)		
"Relatively small quantities of water":	up to 50,000 gpm (70 MGD)		

[4] EPA sent the *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* to about 2,500 steam electric non-utility power producers and manufacturers. This sample included most of the non-utility power producers that were identified by EPA and a subset of the identified manufacturers in industry groups that EPA determined use relatively large quantities of cooling water.

A.II. Additional Cost Considerations Included in the Analysis

The cost estimates include costs, such as design/engineering, process equipment, and installation, that are clearly part of getting a CWIS structure or cooling tower in place and operational. However, there are additional associated capital costs that may be less apparent but may also be incurred by a facility and have been included in the cost estimates either as stand alone cost items or included in installation and construction costs. These costs include:

- Mobilization and demobilization,
- Architectural fees,
- Contractor's overhead and profit,
- Process engineering,
- Sitework and yard piping,
- Standby power,
- Electrical allowance,
- Instrumentation and controls, and
- Contingencies.

Following is a brief description of these miscellaneous capital cost items to provide an indication of their general effect on capital costs. These descriptions are intended to help economists adjust costs to account for regional variations within the U.S.

A.II.a. Mobilization and Demobilization

Mobilization and demobilization costs are costs incurred by the contractor to assemble crews and equipment on-site and to dismantle semi-permanent and temporary construction facilities once the job is completed. The equipment that may be needed includes backhoes, bulldozers, front-end loaders, self-propelled scrapers, pavers, pavement rollers, sheeps-foot rollers, rubber tire rollers, cranes, temporary generators, trucks (including water and fuel trucks), and trailers. Mobilization costs also include bonds and insurance. To account for mobilization and demobilization costs, 2% to 5% is generally added to the total capital cost.

A.II.b. Architectural Fees

Estimates need to include the cost of the building design, architectural drawings, building construction supervision, construction engineering, and travel.

A.II.c. Contractor's Overhead and Profit

This element includes field supervision, main office expenses, tools and minor equipment, workers' compensation and employer's liability, field office expenses, performance and payment bonds, unemployment tax, profit, Social Security and Medicare, builder's risk insurance, and public liability insurance.

A.II.d. Process Engineering

Costs for this category include treatment process engineering, unit operation construction supervision, travel, system start-up engineering, study, design, operation and maintenance (O&M) manuals, and record drawings. These costs are generally estimated by adding 10% to 20% to the estimated construction cost.

A.II.e. Sitework and Yard Piping

Cost estimates for sitework should include site preparation, excavation, backfilling, roads, walls, landscaping, parking lots, fencing, storm water control, yard structures, and yard piping (interconnecting piping between treatment units). These costs are generally estimated by adding 5% to 15% to the estimated construction cost for sitework and 3% to 7% for yard piping.

For installation of CWIS technologies (e.g., screens), a yard piping cost of 5% of the total capital cost is sometimes used based on site-specific conditions. Therefore, to cost a specific site that might require extensive yard piping, a facility would multiply the total capital cost by a factor of 1.05. Cooling towers are more likely to require a significant amount of piping (for both new facilities and retrofits to existing facilities); these costs are already included in the "rule of thumb" cost estimate for cooling towers so an additional 5% was not applied.

A.II.f. Standby Power

Standby generators may be needed to produce power to the treatment and distribution system during power outages and should be included in cost estimates. These costs are generally estimated by adding 2% to 5% to the estimated construction cost.

A.II.g. Electrical Allowance (including yard wiring)

An electrical allowance should be made for electric wiring, motors, duct banks, MCCs, relays, lighting, etc. These costs are generally estimated by adding 10% to 15% to the estimated construction cost.

A.II.h. Instrumentation and Controls

Instrumentation and control (I&C) costs may include a facility control system, software, etc. The cost depends on the degree of automation desired for the entire facility. These costs are generally estimated by adding 3% to 8% to the estimated construction cost.

A.II.i. Contingencies

Contingency cost estimates include compensation for uncertainty within the scope of labor, materials, equipment, and construction specifications. This uncertainty factor can range from 5% to 25% of all capital costs, with an average of 10%.

Contingency costs can range from 2% to 20% for construction projects. CWIS technology projects are not typical construction projects since most of the construction is done at the manufacturing facility and site work mainly involves installation. So some of the uncertainties that could occur in typical construction projects are less likely in CWIS projects. Design and manufacture of the technology can be around 90% of the total cost for a project that involves a straightforward installation (e.g., no dredging). The approach used in this cost estimate is conservative and is considered to cover contingencies for typical CWIS technology or cooling tower projects.

In its 1992 study of cooling tower retrofit costs, Stone and Webster (1992) included, in its line item costs, an allowance for indeterminates (e.g., contingencies) of 15% for future utility projects. The Stone and Webster study involved major retrofit work on existing plants (i.e., converting a once through cooling system plant to recirculating), so the contingencies allowance fell in the higher end of the typical range.

A.III. Replacement Costs

EPA assumed that the technologies should be in place and reasonably expected to be operational for at least a 20-year period (the typical financing period). Therefore, O&M costs should meet that criteria. Vendors estimated the life expectancy of their devices under the base cost scenario and identified the conditions that most alter life expectancy and to what degree. EPA cost estimates generally cover the financial life of a project and do not include the cost of replacing the equipment when it reaches the end of its useful life. For most of the technologies examined here, the useful life of major equipment is often beyond the financing period of 20 years. For these reasons, EPA has not included replacement costs in the cost estimates for most of the technologies. However, for cooling towers, industry sources indicated that replacement of some major equipment during the financing period is necessary for the upkeep of the cooling tower. These costs tend to increase over the useful life of the tower and constitute a major O&M expenditure that needs to be accounted for. Therefore, EPA factored these periodic equipment replacement costs into the O&M cost estimates presented herein.

A.IV. Site-Specific Costs that are Not Included

The cost estimates developed for various technologies are intended to represent a National "typical average" cost estimate. The cost estimates should not be used as a project pricing tool as they cannot account for all the site-specific conditions for a particular project. Some highly site-specific capital costs are discussed generally in Section B.V of this Appendix but are not included in the cost estimates. Site-specific costs that are not accounted for in the cost estimates include the following:

- Regulatory requirements (e.g., permitting costs) that vary from one region/area to another,
- Testing (e.g., costs for pilot studies),
- Geotechnical allowance,
- Land aquisition costs, and
- Costs associated with facility/plant personnel.

Refer to Section B.V of this Appendix for additional discussion.

B. SPECIFIC COST INFORMATION FOR TECHNOLOGIES AND ACTIONS

The following presents information on potential compliance actions that a facility might take, including the installation of certain technologies, in order to meet requirements under the §316(b) New Facility Rule. The information presented includes the cost curves and unit costs developed for each potential compliance action. Estimated costs are presented in 1999 dollars. The cost equations and cost curves can be used to estimate costs. The equations and cost curves generally use flow as the basis for determining estimated costs (i.e., unit costs are in $/gpm). For screens, since flow is dependent on the flow velocity through the screen, different equations and cost curves are included for the two velocities of 0.5 fps and 1.0 fps.

B.I. Changing the Location of the CWIS in a Water Body

B.I.a. Extending the intake pipe

As part of complying with §316(b) New Facility Rule requirements, a facility may extend its intake pipe further into a waterbody in order to move the intake outside or further from the littoral zone.

Assumptions:
1) Criteria involving measurement of the Secchi Depth, change in the percent slope of the waterbody bottom, and substrate composition are being considered to determine whether a particular location is within the littoral zone. This information was not available for the proposed new facilities and is very site-specific. For costing purposes, EPA assumed that the littoral zone would end approximately 25 meters from the shoreline, so if a pipe extends at least 75 meters from the shoreline it would be 50 meters outside the littoral zone.[5] In a given location, the littoral zone may extend more or less than 25 meters from the shoreline into the water body, but for National costing purposes this distance is assumed to be a realistic estimate of a typical situation.

2) To meet the 50-meter littoral zone requirement, an intake pipe will sometimes need to be extended less than 75 meters from its original water intake design point since some intakes are planned for offshore. The maximum would be converting a shoreline intake to an offshore intake, which would require a 75-meter extension.[5] A 75-meter extension is the equivalent of about 246 foot extension.[6]

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[5] EPA used a very conservative estimate of a pipe extension of 125 meters as a basis for estimating costs. Potentially the pipe extension length may be less and thus costs for a given facility taking this action could be lower, by as much as 30-40% depending on the pipe extension method used. This potential decrease in costs would have minimal impact on the overall estimated cost of the proposed Rule.

[6] 1 meter = 3.281 feet

EPA analyzed intake data from several databases to assess whether assuming a shoreline intake and therefore an intake pipe extension of 75 meters (to be outside the littoral zone) for estimating compliance costs is justified. The 1995 Utility Data Institute database (UDI, 1995) contains data compiled for 991 steam electric utility plants in the United States, on a unit by unit basis. In total, there are data records for 2,759 units (i.e., intakes) at these plants. For all units, the UDI database shows that 50% have shoreline intakes and 10% have offshore intakes, while 19% use a canal and 14% use a well. If only the newer units are considered (those brought online in the last 10 years before the 1995 UDI survey was completed), the percent of shoreline intakes decreases to 39% and the portion of offshore intakes increases to 16% (14% use canals and 17% use wells). This may indicate a trend toward greater use of offshore intakes, however shoreline intakes are still much more common.

EPA sent the *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures* to about 2,500 steam electric non-utility power producers and manufacturers. This sample included most of the non-utility power producers that were identified by EPA and a subset of the identified manufacturers in industry groups that EPA determined use relatively large quantities of cooling water. In total, 2,070 survey recipients filled out (at least in part) and returned a survey. Of these responses, EPA determined that 479 facilities were in-scope (i.e., facilities that have a point source as defined under the Clean Water Act, use cooling water, receive their cooling water supply from a surface water source, are currently in commercial service, and have an operating cooling water intake structure). Information on the type of CWIS configuration (e.g., shoreline-submerged intake, submerged offshore intake, intake canal) was requested on a facility-wide basis, so a respondent simply marked off all the configurations that applied, whether they were applicable at an individual CWIS or more than one CWIS. For the 479 in-scope facilities, the most common intake configuration is a submerged shoreline intake (183 facilities, or 38%). A significant number of in-scope facilities (147, or 31%) have at least one CWIS that is a submerged offshore intake. A smaller tier of facilities have intake canals or channels (102, or 21%) and/or surface shoreline intakes (81, or 17%).[7]

EPA also evaluated a database generated from data reported by utilities on U.S. Department of Energy *Form EIA-767 Steam Electric Plant Operation and Design Report 1997*. The database contains records for 1,537 units. Of the units likely to have cooling water intakes (e.g., they do not receive their water supply from a well or municipal source), approximately 60% have shoreline intakes (i.e., the intake is located 0 feet from the shore), and about 85% of the units have an intake that has a maximum distance from the shoreline of less than 410 feet (125 meters). These units represent 73% of all the intakes in the database. For the offshore intakes less than 410 feet from shore, the median distance for an intake is about 50 feet (15 meters) from the shoreline.

Since a majority of the units have intakes at the shoreline, and those with offshore intakes often extend only about 50 feet (about 15 meters) or less into the source water, it is reasonable to use a 75-meter (246-foot) extension as the estimated necessary extension length. Further, the underwater pipe laying costs will generally not change much for various lengths of pipe extension up to 75 meters since equipment rental, equipment and crew mobilization and demobilization, and onsite operations are the greatest costs and would be incurred regardless of the length of pipe laid for a distance less than 75 meters. Finally, because the cost estimates are assumed to be within 30 percent of the typical National average cost which would more than adequately account for variations due to changes in pipe distances. Therefore, the maximum distance is considered in these cost estimates.[8]

3) The source water (e.g., river) is wide enough so that a pipe extending 75 meters from one shore/river bank will also be at least 75 meters from the opposite shore/river bank and therefore meet the requirement on that side of the source water as well.

[7]These values will change slightly after they are scaled to account for the fact that the survey included only a portion of identified manufacturers.

[8]EPA used a very conservative estimate of a pipe extension of 125 meters as a basis for estimating costs. Potentially the pipe extension length may be less and thus costs for a given facility taking this action could be lower, by as much as 30-40% depending on the pipe extension method used. This potential decrease in costs would have minimal impact on the overall estimated cost of the proposed Rule.

4) Installation: Since these are new facilities, they will already be incurring some cost to construct/install an intake. Therefore, putting in a longer intake pipe than originally planned does not entail all new construction and installation costs. Some of the crew and equipment would already be onsite, roads would already need to be built, and some earthwork would be done for the facility as originally planned. For estimating costs due to the §316(b) New Facility Rule, we need to consider the additional costs for the longer intake pipe. For example, if a shoreline intake has to become an offshore intake, costs for dredging, an underwater dive crew, and barge rental may now be incurred.

Costs:
The installation of a pipeline underwater requires skilled labor and special equipment and material. Unlike screens installed at water intakes, pressure is an important factor in the design and installation of the pipeline. The difference is that screens are much lighter than pipes and are open to water flow on both sides allowing for equalization of pressure, while pipelines are subject to axial tension and bending tension at the bottom side of the pipe body and bending compression at the upper side of the pipe body during laying. Therefore, special barges designed and equipped with special tools to avoid pipe distortion are used in such operations. Very often these barges use robots for pipe laying, trenching, and covering. The internal diameter of underwater pipeline ranges from 3" to 48" (very few cases are reported in the literature where pipe diameters reach 72"; this is mainly for oil and gas underwater pipeline application). Steel pipes are often used in underwater applications. Pipes are coated on the inside by a cement lining and on the outside by epoxy with a concrete overcoat or fiberglass wrapping. Prestressed concrete cylinder pipe (PCCP) and reinforced concrete pipe are also used. Steel pipe sections are joined together by full-penetration welding or flanged connectors. PCCP pipe sections are connected underwater by means of a device that uses a pump that creates a vacuum at the joint causing the sections to snap and tightly connect.

Pipes can either be placed on the waterbody floor or in a trench that is dug through the water body floor. For pipelines laid on the floor, where outcrops and uneven floors exist installation must include placing protective blankets under the pipe. For both water body floor and subfloor placements, pipelines need to be buried to protect them from fishing trawl boards, anchors, and from fatigue due to waterbody current stresses. Burying pipelines can be accomplished by sand bags, back fill with soil and a rock layer on top of the soil, and in some cases natural processes of sedimentation can be used to help protect the pipe. For underwater pipe laying, and particularly for short-distance underwater pipe laying, there are several ways to extend an intake pipe to 125 meters off the shore line. These methods include the use of special pipe laying vessels, the application of the bottom-pull method, and the micro-tunnel drilling method (discussed further below).

Generally, for lake applications steel piping is used and may be installed using any of the three pipe laying methods. For riverine applications, both PCCP and steel piping are used. All three of the installation methods are used for steel piping, while conventional pipe laying and micro-tunneling techniques are typically used for PCCP (although the bottom-pull method can be used). In ocean applications, PCCP is typically used and is installed using conventional methods.

1) Use of Conventional Pipe Laying Vessels
Special pipe laying vessels are vessels that are specially designed and constructed for underwater works. They are equipped with features such as a pipe delivery, handling, and storage station, a welding station, and a pipeline tensioner. These vessels are capable of handling 12-meter to 20-meter pipe sections and carrying out underwater welding. In addition to the pipe laying vessel, a supply vessel and a tug boat may be needed. A tug boat is sometimes used to pull the pipe laying vessel away from the shoreline in confined, high traffic, or low wake areas. The onshore support needed includes a crane to transport the pipes to the pipe laying vessel. Loading the pipe laying vessel with pipes would take about 1 to 2 hours (based on about 10 minutes per pipe section, assuming a pipe section length of 12 meters). The new generation pipe laying vessel, with a skilled crew and automatic welding equipment, can lay one mile of pipes on a good day. Based on this estimate, it is realistic to assume that one day would be sufficient for installing the pipe for a situation where the intake pipe needs to be extended up to 125 meters offshore. Because equipment and crew rental and mobilization/demobilization account for most of the cost, the cost per day of installing pipe is almost the same whether or not any pipe is laid (i.e., the pipe cost can be assumed to be a minor cost driver) (Gerwick, 2000). In a closed water body (e.g., lake), the pipe laying vessel has to be assembled and disassembled onsite. For large pipes a 150-ton crane also needs to be transported to site. The cost of transporting equipment varies greatly from site to site. Factors that contribute to cost variability include accessability to site, labor rates (union or non-union), and environmental and seasonal conditions. Box A-1 provides further detail.

Box A-1. Hypothetical Scenario for Installation of Pipe

The pipe laying vessel costs are based on the following base scenario:

Installation of pipes underwater, zero to 1 foot underwater visibility, 60-70 degree water temperature, low current lake, river, or ocean. The installation is to take place from the shoreline out to 125 meters (410 feet) offshore and requires the use of a barge or vessel with 4-point anchor capability and crane.

Job description: position and connect pipes to inlet flange. Lift, lower, and position via crane anchored to barge or vessel. Connect pipe sections and fittings. It is estimated that 500 feet of pipe can be installed per day using conventional pipe laying techniques depending on favorable logistic and environmental conditions and that the 125 meters of pipe can easily be installed in one day.

Rental cost of the pipe laying vessel (for pipes with diameter less than 12") is estimated at $90,000 to $110,000 depending on location of the vessel at the time of its rental. Installations in the Great Lakes area are estimated to be 10% to 15% higher because according to industry sources there are only four such vessels operating in that area, the labor rates are union rates, and the demand is greater. The rental price includes barge/vessel personnel (captain, crew, etc), material needed, and equipment needed to lay the pipe underwater.

Other considerations: Uncontrollable factors like barge availability, weather, water temperature, water depth, underwater visibility, currents, and onshore support can affect the daily production of the installation team. These variables always have to be considered when a job is quoted on a daily rate.

2) Bottom-Pull Method for Underwater Pipe Laying
In this method the pipeline is assembled onshore over a launching pad with rollers. The welded or flange-connected pipeline is then pulled by a barge that is anchored offshore. The barge rental cost is estimated at $20,000 per day. This estimated cost includes equipment, labor (crew and divers), and material needed for barge operation and pipe pulling. Additional costs for the application of this method include the rental of a small crane for onshore operation at $2000/day for pipes up to 12" in diameter and a heavy duty crane at $4,000/day for pipes of a pipe diameter greater than 12". The labor cost for welders and pipe connectors is estimated at $500 per day. The cost of using this method varies greatly from one site to another because it is important to have a site that is suitable for laying a pipe flat and therefore some sites require much more site preparation earth work than other sites. For costing purposes, EPA estimated that a combination tractor-crawler equipped with a bulldozer of 410 HP will be rented for two days for site preparation at an estimated cost of $1350/day. Some sites may not require this equipment.

3) Micro-Tunneling Technique
For river applications, drilling is the method of choice for pipe laying. This technique is the least disturbing to a site. Using this technique a shaft is drilled near the shoreline into which a horizontal boring machine is placed. The horizontal boring machine drills a micro tunnel where the intake pipe is installed under the river bed, sea floor, or lake floor. According to industry sources, the cost of this method does not differ much between a small pipe (12" diameter) and a large pipe (84" diameter) because the main costs are in shaft construction and the mobilization and demobilization of the crew and equipment. The lump-sum cost ranges between $1000 and $2000 per linear foot, with a typical budgetary cost for a small project (300 to 400 feet) at $1500/ft for large pipes. To develop cost curves and unit costs based on flow for micro-tunneling, EPA assumed a 125 meter pipe extension. Costs for this length of pipe extension were calculated and then related to the flows that would be reasonable for pipes of various sizes. See the end of this Appendix for the cost curves and equations for pipe extension.

B.I.b. Dredging the intake canal

Relocating a proposed intake pipe so that it is outside the littoral zone can be accomplished by either extending the pipe (further) away from the shoreline or placing a shoreline intake deeper. For facilities using an intake canal or channel, the facility may need to dredge the canal or channel deeper so that the intake pipe is located outside the littoral zone. The size of the littoral zone is very site-specific. The extent of the littoral zone of a given water body depends on factors such as water depth, season, rain episodes (amounts, frequency, and intensity), the quantity and quality of runoff and other discharges, biota and biomass, sediment disturbance, and water quality in the area of interest. The littoral zone would be determined using a site-specific measurement of Secchi Depth.

Assumptions:
1) Moving a cooling water intake structure to outside the littoral zone may be done by relocating the pipe to a greater depth. This depth will depend on the quality of water in the lake. Based on the depth location required, the pipe would be extended a certain amount from the shoreline to reach the depth. Table A-3 shows the depths EPA estimates are needed to locate the pipe below the littoral zone for different categories of water quality. EPA then estimated the distance from the shoreline that a pipe would need to be extended to reach that water depth. These estimated depths are based on field experience, discussions with ecologists and biologists, and best professional judgement. Cost estimates for extending an intake pipe were presented in the previous section.

Table A-3. Estimated Pipe Placement to Reach Outside the Littoral Zone

Water Quality	Depth of Water to Reach Outside Littoral Zone (feet)	Distance from Shoreline to Reach the Depth (feet)
Pristine	15	150
Average	8	100
Turbid	4	10

2) Shoreline intakes often have a dredged channel with a baffle or skimmer wall and withdraw water from below the surface, possibly from the bottom. To retain this type of intake (instead of extending it offshore), the channel would have to be deep enough to pull in water from outside the littoral zone. To accomplish this, dredging of the canal at the mouth of the river and near the power plant pumping station would need to be done.

Costs:
1) Increasing the depth of the proposed intake to below the littoral zone is assumed to be achieved by further deepening the planned intake to a level below the littoral zone. For the smallest size deepening operation, it is assumed that 10,000 CY of sediments will be removed using a dredger for the small size canal (i.e., assuming that the dimensions are 10 by 10 by 100 yards). It is also assumed that increasing the depth below the littoral zone for the large size canal entails the dredging of an area of 10 by 40 by 100 yards. Widening, dredging, and dumping operations are assumed to be accomplished using a 2000 gallons per CY dredger at $12.25 per CY. These costs apply to situations where sediments are disposed of onsite. If sediments are contaminated, the permitting authority may require transport for offsite disposal which may double or triple the operational costs. See the end of this Appendix for costs curves.

B.II. Reducing Design Intake Flow

B.II.a. Switching to a recirculating system

As noted earlier, in a recirculating system cooling water is used to cool equipment and steam, and absorbs heat in the process. The cooling water is then cooled and recirculated to the beginning of the system to be used again for cooling. Recirculating the cooling water in a system vastly reduces the amount of cooling water needed. The method most frequently used to cool the water in a recirculating system is putting the cooling water through a cooling tower. Therefore, EPA chose to cost cooling towers as the technology used to switch a once through cooling system to a recirculating system.

Based on discussions with industry representatives, the factors that generally have the greatest impact on cost appear to be the flow desired by the facility, delta (the difference between cold water temperature and ambient wet bulb temperature), tower type, and environmental considerations. Physical site conditions (e.g., topographic conditions, soils and underground conditions, water quality) affect cost, but in most situations are secondary to the primary cost factors. Table A-4 presents relative capital and operation cost estimates for various cooling towers in comparison to the conventional, basic Douglas Fir cooling tower as a standard.

Table A-4. Relative Cost Factors for Various Cooling Tower Types[1]

Tower Type	Capital Cost Factor (%)	Operation Cost Factor (%)
Douglas Fir	100	100
Redwood	112[2]	100
Concrete	140	90
Steel	135	98
Fiberglass Reinforced Plastic	110	98
Splash Fill	120	150
Non-Fouling Film Fill	110	102
Mechanical draft	100	100
Natural draft (concrete)	175	35
Hybrid [Plume abatement (32DBT)]	250-300	125-150
Dry/wet	375	175
Air condenser (steel)	250-325	175-225
Noise reduction (10dBA)	130	107

1) Percent estimates are relative to the Douglas Fir cooling tower.
2) Redwood cooling tower costs may be higher because redwood trees are a protected species, particularly in the Northwest.

Sources: Mirsky et al. (1992), Mirsky and Bauthier (1997), and Mirsky (2000).

There are two general types of cooling towers, wet and dry. Wet cooling towers, which are the far more common type, reduce the temperature of the water by bringing it directly into contact with large amounts of air. Through this process, heat is transferred from the water to the air which is then discharged into the atmosphere. Part of the water evaporates through this process thereby having a cooling effect on the rest of the water. This water then exits the cooling tower at a temperature approaching the wet bulb temperature of the air. For dry cooling towers, the water does not come in direct contact with the air, but instead travels in closed pipes through the tower. Air going through the tower flows along the outside of the pipe walls and absorbs heat from the pipe walls which absorb heat from the water in the pipes. Dry cooling towers tend to be much larger and more costly than wet towers since the dry cooling process is less efficient. Also, the effluent water temperature is warmer since it only approaches the dry bulb temperature of the air (not the cooler wet bulb temperature). Hybrid wet-dry towers, which combine dry heat exchange surfaces with standard wet cooling towers, are plume abatement towers. These towers tend to be used most where plume abatement is required by local authorities. Technologies for achieving low noise and low drift can be fitted to all types of towers.

Other characteristics of cooling towers include:

- ***Air flow*:** Mechanical draft towers use fans to induce air flow, while natural draft (i.e., hyperbolic) towers induce natural air flow by the chimney effect produced by the height and shape of the tower. For towers of similar capacity, natural draft towers typically require significantly less land area and have lower power costs (i.e., fans to induce air flow are not needed) but have higher initial costs (particularly because they need to be taller) than mechanical draft towers. Both mechanical draft and natural draft towers can be designed for air to flow through the fill material using either a crossflow (air flows horizontally) or counterflow (air flows vertically upward) design, while the water flows vertically downward. Counterflow towers tend to be more efficient at achieving heat reduction but are generally more expensive to build and operate because clearance needed at the bottom of the tower means the tower needs to be taller.

- ***Mode of operation*:** Cooling towers can be either recirculating (water is returned to the condenser for reuse) or nonrecirculating (tower effluent is discharged to a receiving waterbody and not reused). Facilities using nonrecirculating types (i.e., "helper" towers) draw large flows for cooling and therefore do not provide fish protection for §316(b) purposes, so the information in this report is not intended to address non-recirculating towers.

- ***Construction materials*:** Towers can be made from concrete, steel, wood, and/or fiberglass.

Generally, all cooling towers with plume abatement features are hybrid towers. According to an industry source, attempts to modify towers with special designs and construction features to abate plumes was prohibitively expensive. Natural draft towers are concrete towers, although some old natural draft wood cooling towers do exist. Therefore, for costing purposes, concrete is assumed to be the material used for building natural draft cooling towers.

To collect data and cost estimates on cooling towers, EPA obtained a list of cooling tower manufacturers, suppliers and users from the Cooling Tower Institute (CTI). CTI members are local and international. Representatives of the cooling tower industry were contacted as part of an effort to get information on firms involved in the design, manufacture, and supply of cooling water intake structures and fish protection equipment. The CTI members contacted indicated that in general they rely on groundwater or treated municipal water sources for supplemental/makeup water for cooling. Other CTI members, though listed as manufacturers, indicated that they specialize in repairing cooling towers only and are not involved in repairing intake facilities. Many CTI members indicated that they specialize in recirculating systems that require little or no water (after initial startup). For example, GEA Integrated Cooling Technologies provided brochures of its latest line of cooling equipment that does not need cooling water. Based on discussions with GEA representatives and as reflected in its brochures, GEA specializes in dry cooling systems and in hybrid systems that use very little water from municipal or ground sources. The air cooled condensers provide cooling towers with plume abatement and water savings. GEA also provided information on a system that uses a hybrid cooling system because the facility had a discharge permit for half the flow generated at the facility.

Cooling tower industry representatives provided names and telephone numbers of persons and firms that are involved in the design and installation of cooling towers, CWIS technologies, and associated equipment, or represent firms that do. The representatives provided contacts at two prominent engineering firms, Bechtel and Black &Veatch, who were contacted to request information.

A Bechtel senior engineer indicated that the cost data that Bechtel has are confidential. However, he provided his personal experience on factors that drive the costs of cooling towers and their associated intake structures and screening equipment. Typically, and particularly based on the experience gained in power plants, the size of an intake structure is determined from the financial feasibility study of the project. The financial feasibility study determines the need for power, the expected power loads, and the ability of the community to pay. Based on that study, and on an environmental and socioeconomic study that follows the financial study, the project site (including the water intake site) is selected. The cost of the turnkey project is estimated based on the concepts outlined in the site selection study.[9] Typically, the cost of the project is determined based on the following factors: type of equipment to be cooled (e.g., coal fired equipment, natural gas powered equipment); location of the water intake (on a river, lake, or seashore); amount of power to-be-generated (e.g., 50 mega Watt vs. 200 mega Watt); and volume of water needed. The volume of water needed for cooling depends on the following critical parameters: water temperature, make of equipment to be used (e.g, G.E turbine vs. ABB turbine, turbine with heat recovery system and turbine without heat recovery system), discharge permit limits, water quality (particularly for wet cooling towers), and type of wet cooling tower (i.e., whether it is a natural draft or a mechanical draft).

To estimate costs specifically for installing and operating a particular cooling tower, important factors include:

[9] For a turnkey project, the engineering firm typically manages design, construction, and initial operation of the system, and then "turns the key" over to the facility for the facility to continue operating and maintaining the system.

- ***Condenser heat load and wet bulb temperature (or approach to wet bulb temperature)*****:** Largely determine the size needed. Size is also affected by climate conditions.

- ***Plant fuel type and age/efficiency*****:** Condenser discharge heat load per Mega watt varies greatly by plant type (nuclear thermal efficiency is about 33% to 35%, while newer oil-fired plants can have nearly 40% thermal efficiency, and newer coal-fired plants can have nearly 38% thermal efficiency).[10] Older plants typically have lower thermal efficiency than new plants.

- ***Topography*****:** May affect tower height and/or shape, and may increase construction costs due to subsurface conditions. For example, sites requiring significant blasting, use of piles, or a remote tower location will typically have greater installation/construction cost.

- ***Material used for tower construction*****:** Wood towers tend to be the least expensive, followed by fiberglass reinforced plastic, steel, and concrete. However, some industry sources claim that Redwood capital costs might be much higher compared to other wood cooling towers, particularly in the Northwest U.S., because Redwood trees are a protected species. Factors that affect the material used include chemical and mineral composition of the cooling water, cost, aesthetics, and local/regional availability of materials.

- ***Pollution control requirements*****:** Air pollution control facilities require electricity to operate. Local requirements to control drift, plume, fog, and noise and to consider aesthetics can also increase costs for a given site (e.g., different design specifications may be required).

Summaries of some EPRI research on dry cooling systems and wet-dry supplemental cooling systems note that dry cooling towers may cost as much as four times more than conventional wet towers (EPRI, 1986a and 1986b).

Capital Cost of Cooling Towers

Two cooling tower industry managers with extensive experience in selling and installing cooling towers to power plants and other industries provided information on how they estimate budget capital costs associated with a wet cooling tower. The rule of thumb they use is $30/gpm for a delta of 10 degrees and $50/gpm for a delta of 5 degrees.[11] This cost is for a "small" tower (flow less than 10,000 gpm) and equipment associated with the "basic" tower, and does not include installation. Above 10,000 gpm, to account for economy of scale, the unit cost was lowered by $5/gpm over the flow range up to 204,000 gpm. For flows greater than 204,000 gpm, a facility may need to use multiple towers or a custom design. Combining this with the variability in cost among various cooling tower types, costs for various tower types and features were calculated for the flows used in calculating screen capacities at 1 ft/sec and 0.5 ft/sec. Based on discussions with industry representatives, EPA estimated installation costs as 80% of cooling tower equipment cost. These estimates are presented in Table A-5. See the end of this Appendix for cost curves and equations.

[10]With a 33% efficiency, one-third of the heat is converted to electric energy and two-thirds goes to waste heat in the cooling water.

[11]The delta is the difference between the cold water (tower effluent) temperature and the tower wet bulb temperature. This is also referred to as the design approach. For example, at design conditions with a delta or design approach of 5 degrees, the tower effluent and blowdown would be 5 degrees warmer than the wet bulb temperature. A smaller delta (or lower tower effluent temperature) requires a larger cooling tower and thus is more expensive.

Table A-5. Estimated Capital Costs of Cooling Towers without Special Environmental Impact Mitigation Features (1999 Dollars)

Flow (gpm)	Basic Douglas Fir Cooling Tower Cost[1]	Redwood Tower	Concrete Tower	Steel Tower	Fiberglass Reinforced Plastic Tower
2000	$108,000	$121,000	$151,000	$146,000	$119,000
4000	$216,000	$242,000	$302,000	$ 292,000	$238,000
7000	$378,000	$423,000	$529,000	$ 510,000	$416,000
9000	$486,000	$544,000	$680,000	$ 656,000	$535,000
11,000	$594,000	$665,000	$832,000	$ 802,000	$653,000
13,000	$702,000	$786,000	$983,000	$ 948,000	$772,000
15,000	$810,000	$907,000	$1,134,000	$1,094,000	$891,000
17,000	$918,000	$1,028,000	$1,285,000	$1,239,000	$1,010,000
18,000	$972,000	$1,089,000	$1,361,000	$1,312,000	$1,069,000
22,000	$1,148,400	$1,286,000	$1,608,000	$1,550,000	$1,263,000
25,000	$1,305,000	$1,462,000	$1,827,000	$1,762,000	$1,436,000
28,000	$1,461,600	$1,637,000	$2,046,000	$1,973,000	$1,608,000
29,000	$1,513,800	$1,695,000	$2,119,000	$2,044,000	$1,665,000
31,000	$1,618,200	$1,812,000	$2,265,000	$2,185,000	$1,780,000
34,000	$1,774,800	$1,988,000	$2,485,000	$2,396,000	$1,952,000
36,000	$1,879,200	$2,105,000	$2,631,000	$2,537,000	$2,067,000
45,000	$2,268,000	$2,540,000	$3,175,000	$3,062,000	$2,495,000
47,000	$2,368,800	$2,653,000	$3,316,000	$3,198,000	$2,606,000
56,000	$2,822,400	$3,161,000	$3,951,000	$3,810,000	$3,105,000
63,000	$3,175,200	$3,556,000	$4,445,000	$4,287,000	$3,493,000
67,000	$3,376,800	$3,782,000	$4,728,000	$4,559,000	$3,714,000
73,000	$3,679,200	$4,121,000	$5,151,000	$4,967,000	$4,047,000
79,000	$3,839,400	$4,300,000	$5,375,000	$5,183,000	$4,223,000
94,000	$4,568,400	$5,117,000	$6,396,000	$6,167,000	$5,025,000
102,000	$4,957,200	$5,552,000	$6,940,000	$6,692,000	$5,453,000
112,000	$5,443,200	$6,096,000	$7,620,000	$7,348,000	$5,988,000
146,000	$7,095,600	$7,947,000	$9,934,000	$9,579,000	$7,805,000
157,000	$7,347,600	$8,229,000	$10,287,000	$9,919,000	$8,082,000
204,000	$9,180,000	$10,282,000	$12,852,000	$12,393,000	$10,098,000
1) Includes installation at 80% of equipment cost for a delta of 10 degrees.					

Using the estimated costs, EPA developed a cost equation using a polynomial curve fitting function. Table A-6 presents cost equations for basic tower types built with different building materials and assuming a delta of 10 degrees. The cost equations presented in Table A-6 include installation costs. The "x" in the presented cost equations is for flow in gpm and the "y" is in dollars.

Table A-6. Capital Cost Equations of Cooling Towers without Special Environmental Impact Mitigation Features (Delta 10 degrees)

Tower Type	Capital Cost Equation[1]	Correlation Coefficient
Douglas Fir	$y = -9E\text{-}11x^3 - 8E\text{-}06x^2 + 50.395x + 44058$	$R^2 = 0.9997$
Redwood	$y = -1E\text{-}10x^3 - 9E\text{-}06x^2 + 56.453x + 49125$	$R^2 = 0.9997$
Steel	$y = -1E\text{-}10x^3 - 1E\text{-}05x^2 + 68.039x + 59511$	$R^2 = 0.9997$
Concrete	$y = -1E\text{-}10x^3 - 1E\text{-}05x^2 + 70.552x + 61609$	$R^2 = 0.9997$
Fiberglass Reinforced Plastic	$y = -1E\text{-}10x^3 - 9E\text{-}06x^2 + 55.432x + 48575$	$R^2 = 0.9997$
1) x is for flow in gpm and y is cost in dollars.		

Using the cost comparison information published by Mirsky et al. (1992), EPA calculated the costs of cooling towers with various additional features. These costs are presented in Table A-7. Table A-7 presents capital costs of the Douglas Fir Tower with various features. The cost for other types of cooling towers are also calculated.

Table A-8 presents cost equations for cooling towers with special environmental mitigation features, built with different building materials and assuming a delta of 10 degrees. The cost equations presented in Table A-8 include installation costs. The “x” in the presented cost equations is for flow in gpm and the “y” is in dollars.

At the end of this Appendix, cost curves with equations are also presented for other types of cooling towers.

Operation and Maintenance (O&M) Cost of Cooling Towers

Estimating annual O&M costs for cooling towers is an involved process since the estimator has to account for many interrelated dependent and independent cost drivers. These cost drivers include:

- Size of the cooling tower,
- Material from which the cooling tower is built,
- Various features that the cooling tower may include,
- Source of make-up water,
- How blow down water is disposed, and
- Increase in maintenance costs as the tower useful life diminishes.

For example, if make-up water is obtained from a lesser quality source, additional treatment may be required to prevent biofouling in the tower.

Table A-7. Capital Costs of Douglas Fir Cooling Towers with Special Environmental Impact Mitigation Features (Delta 10 degrees) (1999 Dollars)

Flows (gpm)	Douglas Fir Cooling Tower	Splash Fill	Non-fouling Film Fill	Noise Reduction 10 dBA	Dry/wet	Hybrid Tower (32DBT Plume Abatement)
2000	$108,000	$130,000	$119,000	$140,000	$405,000	$324,000
4000	$216,000	$259,000	$238,000	$281,000	$810,000	$648,000
7000	$378,000	$454,000	$416,000	$491,000	$1,418,000	$1,134,000
9000	$486,000	$583,000	$535,000	$632,000	$1,823,000	$1,458,000
11,000	$594,000	$713,000	$653,000	$772,000	$2,228,000	$1,782,000
13,000	$702,000	$842,000	$772,000	$913,000	$2,633,000	$2,106,000
15,000	$810,000	$972,000	$891,000	$1,053,000	$3,038,000	$2,430,000
17,000	$918,000	$1,102,000	$1,010,000	$1,193,000	$3,443,000	$2,754,000
18,000	$972,000	$1,166,000	$1,069,000	$1,264,000	$3,645,000	$2,916,000
22,000	$1,148,400	$1,378,000	$1,263,000	$1,493,000	$4,307,000	$3,445,000
25,000	$1,305,000	$1,566,000	$1,436,000	$1,697,000	$4,894,000	$3,915,000
28,000	$1,461,600	$1,754,000	$1,608,000	$1,900,000	$5,481,000	$4,385,000
29,000	$1,513,800	$1,817,000	$1,665,000	$1,968,000	$5,677,000	$4,541,000
31,000	$1,618,200	$1,942,000	$1,780,000	$2,104,000	$6,068,000	$4,855,000
34,000	$1,774,800	$2,130,000	$1,952,000	$2,307,000	$6,656,000	$5,324,000
36,000	$1,879,200	$2,255,000	$2,067,000	$2,443,000	$7,047,000	$5,638,000
45,000	$2,268,000	$2,722,000	$2,495,000	$2,948,000	$8,505,000	$6,804,000
47,000	$2,368,800	$2,843,000	$2,606,000	$3,079,000	$8,883,000	$7,106,000
56,000	$2,822,400	$3,387,000	$3,105,000	$3,669,000	$10,584,000	$8,467,000
63,000	$3,175,200	$3,810,000	$3,493,000	$4,128,000	$11,907,000	$9,526,000
67,000	$3,376,800	$4,052,000	$3,714,000	$4,390,000	$12,663,000	$10,130,000
73,000	$3,679,200	$4,415,000	$4,047,000	$4,783,000	$13,797,000	$11,038,000
79,000	$3,839,400	$4,607,000	$4,223,000	$4,991,000	$14,398,000	$11,518,000
94,000	$4,568,400	$5,482,000	$5,025,000	$5,939,000	$17,132,000	$13,705,000
102,000	$4,957,200	$5,949,000	$5,453,000	$6,444,000	$18,590,000	$14,872,000
112,000	$5,443,200	$6,532,000	$5,988,000	$7,076,000	$20,412,000	$16,330,000
146,000	$7,095,600	$8,515,000	$7,805,000	$9,224,000	$26,609,000	$21,287,000
157,000	$7,347,600	$8,817,000	$8,082,000	$9,552,000	$27,554,000	$22,043,000
204,000	$9,180,000	$11,016,000	$10,098,000	$11,934,000	$34,425,000	$27,540,000

Table A-8. Capital Cost Equations of Douglas Fir Cooling Towers with Special Environmental Impact Mitigation Features (Delta 10 degrees)

Tower Type	Capital Cost Equation[1]	Correlation Coefficient
Douglas Fir	$y = -9E\text{-}11x^3 - 8E\text{-}06x^2 + 50.395x + 44058$	$R^2 = 0.9997$
Splash Fill	$y = -4E\text{-}05x^2 + 62.744x + 22836$	$R^2 = 0.9996$
Non-fouling Film Fill	$y = -1E\text{-}10x^3 - 9E\text{-}06x^2 + 55.432x + 48575$	$R^2 = 0.9997$
Noise Reduction 10 dBA	$y = -1E\text{-}10x^3 - 1E\text{-}05x^2 + 65.517x + 57246$	$R^2 = 0.9997$
Dry/Wet	$y = -0.0001x^2 + 196.07x + 71424$	$R^2 = 0.9996$
Hybrid Tower (Plume Abatement 32DBT)	$y = -3E\text{-}10x^3 - 2E\text{-}05x^2 + 151.18x + 132225$	$R^2 = 0.9997$
1) x is flow in gpm and y is cost in dollars.		

The estimated annual O&M costs presented below are for cooling towers designed at a delta of 10 degrees. Annual O&M costs for cooling towers designed at a delta of 5 degrees can be calculated using the procedure detailed below. To calculate annual O&M costs for various types of cooling towers, EPA made the following assumptions:

- For small cooling towers, 5% of capital costs is attributed to chemical costs and routine maintenance. To account for economy of scale, that percentage is gradually decreased to 2% for the largest size cooling tower. This assumption is based on discussions with industry representatives and information provided by them.

- Based on discussions with industry representatives, 2% of the tower flow is lost to evaporation and/or blow down.

- To account for the costs of makeup water and disposal of blow down water, EPA used three scenarios. The first scenario is based on the facility using surface water sources for makeup water and disposing of blow down water either to a pond or back to the surface water source at a combined cost of $0.5/1000 gallons. The second scenario is based on the facility using gray water (treated municipal wastewater) for makeup water and disposing of the blow down water into a POTW sewer line at a combined cost of $3/1000 gallons. The third scenario is based on the facility using municipal sources for clean makeup water and disposing of the blow down water into a POTW sewer line at a combined cost of $4/1000 gallons.

- Based on discussions with industry representatives, maintenance costs are 10% of capital costs for towers over 5 years old, 20% for towers over 10 years old, and 30% for towers more than 15 years old. Averaging these percentages over a period of 20 years yields a maintenance cost at 15% of capital cost [((5*0/100)+(5*10/100)+(5*20/100)+(5*30/100))/20)].

To account for the variation in maintenance costs among cooling tower types, a scaling factor is used. Douglas Fir is the type with the greatest maintenance cost, followed by Redwood, steel, concrete, and fiberglass. For additional cooling tower features, a scaling factor was used to account for the variations in maintenance (e.g., splash fill and non-fouling film fill are the features with the lowest maintenance costs).

Using the operation cost comparison information published by Mirsky et al. (1992) and maintenance cost assumptions set out above, EPA calculated estimated costs of O&M for various types of cooling towers with and without additional features. EPA then developed cost equations from the generated cost data points. The equations and costs are shown in Tables A-9 through A-14 for the first and second scenarios for different types of towers (i.e., various materials and features). Cost curves and equations for O&M costs for additional types of cooling towers are presented at the end of the Appendix.

Note that these cost estimates and equations are for total O&M costs. Stone and Webster (1992) presents a value for additional annual O&M costs equal to approximately 0.7% of the capital costs for a retrofit project. Stone and Webster's estimate is for the amount O&M costs are expected to *increase* when plants with once through cooling systems are retrofit with cooling towers to become recirculating systems, and therefore do not represent total O&M costs.

Table A-9. Total Annual O&M Cost Equations by Tower Type - 1st Scenario

Cooling Tower Material Type	Total Annual O&M Cost Equations[1]	Correlation Coefficient
Concrete	$y = -8E\text{-}06x^2 + 13.291x + 13850$	$R^2 = 0.9999$
Douglas Fir	$y = -8E\text{-}06x^2 + 14.524x + 11183$	$R^2 = 0.9999$
Redwood	$y = -8E\text{-}06x^2 + 13.938x + 11895$	$R^2 = 0.9999$
Steel	$y = -8E\text{-}06x^2 + 14.183x + 13605$	$R^2 = 0.9999$
Fiberglass Reinforced Plastic	$y = - 6E\text{-}06x^2 + 11.425x + 10854$	$R^2 = 0.9999$
1) x is flow in gpm and y is annual O&M cost in dollars.		

Table A-10. Total Estimated Annual O&M Costs by Tower Type-1st Scenario (1999 Dollars)

Flow (gpm)	Douglas Fir Tower	Redwood Tower	Concrete Tower	Steel Tower	Fiberglass Reinforced Plastic Tower
2000	$32,000	$31,000	$31,000	$32,000	$26,000
4000	$63,000	$61,000	$60,000	$63,000	$51,000
7000	$109,000	$106,000	$103,000	$109,000	$87,000
9000	$140,000	$135,000	$131,000	$139,000	$112,000
11,000	$170,000	$164,000	$159,000	$168,000	$135,000
13,000	$200,000	$193,000	$187,000	$198,000	$159,000
15,000	$230,000	$222,000	$214,000	$228,000	$183,000
17,000	$260,000	$251,000	$242,000	$257,000	$207,000
18,000	$275,000	$265,000	$256,000	$271,000	$218,000
22,000	$327,000	$316,000	$304,000	$323,000	$260,000
25,000	$371,000	$357,000	$344,000	$365,000	$295,000
28,000	$414,000	$399,000	$383,000	$408,000	$329,000
29,000	$429,000	$413,000	$396,000	$422,000	$340,000
31,000	$458,000	$441,000	$423,000	$450,000	$363,000
34,000	$501,000	$482,000	$462,000	$492,000	$397,000
36,000	$530,000	$510,000	$488,000	$520,000	$419,000
45,000	$644,000	$620,000	$593,000	$631,000	$510,000
47,000	$672,000	$646,000	$618,000	$659,000	$532,000
56,000	$798,000	$767,000	$732,000	$780,000	$631,000
63,000	$895,000	$860,000	$821,000	$875,000	$707,000
67,000	$951,000	$913,000	$871,000	$929,000	$750,000
73,000	$1,034,000	$992,000	$946,000	$1,009,000	$815,000
79,000	$1,092,000	$1,048,000	$999,000	$1,065,000	$863,000
94,000	$1,294,000	$1,241,000	$1,182,000	$1,260,000	$1,022,000
102,000	$1,401,000	$1,344,000	$1,279,000	$1,364,000	$1,106,000
112,000	$1,535,000	$1,472,000	$1,399,000	$1,494,000	$1,211,000
146,000	$1,989,000	$1,905,000	$1,807,000	$1,931,000	$1,565,000
157,000	$2,087,000	$1,999,000	$1,897,000	$2,026,000	$1,647,000
204,000	$2,633,000	$2,522,000	$2,389,000	$2,551,000	$2,082,000

Table A-11. Total Annual O&M Cost Equations - 1st scenario for Douglas Fir with Various Features

Type of Tower	O&M Cost Equations[1]	Correlation Coefficient
Non-Fouling Film Fill tower	$y = -8E-06x^2 + 14.619x + 12191$	$R^2 = 0.9999$
Noise reduction (10dBA)	$y = -1E-05x^2 + 17.434x + 15301$	$R^2 = 0.9998$
Hybrid tower (Plume Aabatement 32DBT)	$y = -3E-05x^2 + 35.199x + 46043$	$R^2 = 0.9997$
Splash Fill tower	$y = -1E-05x^2 + 15.351x + 17751$	$R^2 = 0.9998$
Dry/wet tower	$y = -4E-05x^2 + 44.021x + 65444$	$R^2 = 0.9997$
1) x is flow in gpm and y is annual O&M cost in dollars.		

Table A-12. Total Estimated Annual O&M Costs - 1st scenario for Douglas Fir with Various Features (1999 Dollars)

Flows (gpm)	Splash Fill Tower	Non-Fouling Film Fill Tower	Hybrid Tower (Plume abatement (32DBT	Dry/Wet Tower	Noise Reduction (10dBA)
2000	$36,000	$33,000	$83,000	$107,000	$39,000
4000	$70,000	$64,000	$162,000	$207,000	$77,000
7000	$120,000	$111,000	$278,000	$353,000	$132,000
9000	$152,000	$141,000	$354,000	$449,000	$169,000
11,000	$185,000	$172,000	$429,000	$542,000	$206,000
13,000	$217,000	$202,000	$504,000	$638,000	$242,000
15,000	$249,000	$233,000	$578,000	$731,000	$278,000
17,000	$281,000	$263,000	$652,000	$823,000	$314,000
18,000	$297,000	$278,000	$688,000	$869,000	$332,000
22,000	$352,000	$331,000	$810,000	$1,021,000	$395,000
25,000	$398,000	$374,000	$916,000	$1,153,000	$447,000
28,000	$444,000	$418,000	$1,021,000	$1,285,000	$499,000
29,000	$459,000	$433,000	$1,056,000	$1,328,000	$516,000
31,000	$490,000	$462,000	$1,126,000	$1,415,000	$551,000
34,000	$535,000	$505,000	$1,230,000	$1,545,000	$603,000
36,000	$566,000	$534,000	$1,299,000	$1,632,000	$637,000
45,000	$685,000	$649,000	$1,561,000	$1,956,000	$773,000
47,000	$714,000	$677,000	$1,628,000	$2,038,000	$806,000
56,000	$845,000	$803,000	$1,925,000	$2,408,000	$956,000
63,000	$946,000	$901,000	$2,155,000	$2,693,000	$1,072,000
67,000	$1,004,000	$957,000	$2,285,000	$2,855,000	$1,138,000
73,000	$1,090,000	$1,040,000	$2,481,000	$3,097,000	$1,238,000
79,000	$1,149,000	$1,098,000	$2,595,000	$3,234,000	$1,304,000
94,000	$1,358,000	$1,301,000	$3,064,000	$3,814,000	$1,544,000
102,000	$1,469,000	$1,408,000	$3,313,000	$4,121,000	$1,672,000
112,000	$1,607,000	$1,543,000	$3,623,000	$4,504,000	$1,831,000
146,000	$2,072,000	$1,997,000	$4,668,000	$5,791,000	$2,370,000
157,000	$2,170,000	$2,095,000	$4,849,000	$6,004,000	$2,480,000
204,000	$2,725,000	$2,641,000	$6,029,000	$7,440,000	$3,118,000

Table A-13. Total Annual O&M Cost - 2nd Scenario for Douglas Fir Tower[1]

Type of Tower	O&M Cost Equations	Correlation Coefficient
Douglas Fir	$y = -8E-06x^2 + 40.899x + 12191$	$R^2 = 1$
Non-Fouling Film Fill tower	$y = -8E-06x^2 + 40.899x + 12191$	$R^2 = 1$
Noise reduction (10dBA)	$y = -1E-05x^2 + 43.714x + 15301$	$R^2 = 1$
Hybrid tower (Plume abatement 32DBT)	$y = -3E-05x^2 + 61.479x + 46043$	$R^2 = 0.9999$
Splash Fill tower	$y = -8E-06x^2 + 40.899x + 12191$	$R^2 = 1$
Dry/wet tower	$y = -4E-05x^2 + 70.301x + 65444$	$R^2 = 0.9999$
1) x is flow in gpm and y is annual O&M cost in dollars.		

Table A-14. Total Estimated Annual O&M Costs - 2nd Scenario for Douglas Fir with Various Features (1999 Dollars)

Flow (gpm)	Douglas Fir Tower	Splash Fill Tower	Non-Fouling Film Fill Tower	Hybrid Tower (Plume Abatement 32DBT)	Dry/wet Tower	Noise Reduction (10dBA)
2000	$84,672	$88,421	$85,206	$135,970	$159,257	$91,561
4000	$168,372	$174,901	$169,319	$267,570	$312,140	$181,974
7000	$293,279	$303,745	$294,678	$462,072	$537,351	$316,399
9000	$376,280	$388,973	$378,007	$590,527	$685,646	$405,835
11,000	$459,125	$474,099	$460,986	$718,275	$832,912	$494,860
13,000	$541,841	$558,817	$543,995	$845,447	$979,338	$583,898
15,000	$624,449	$643,517	$626,883	$972,133	$1,125,053	$672,594
17,000	$706,964	$728,047	$709,666	$1,098,396	$1,270,154	$761,161
18,000	$748,190	$770,082	$750,936	$1,161,386	$1,342,391	$805,589
22,000	$905,604	$930,341	$908,666	$1,388,515	$1,599,431	$972,762
25,000	$1,028,013	$1,055,274	$1,031,492	$1,573,034	$1,810,366	$1,103,982
28,000	$1,150,300	$1,179,986	$1,154,011	$1,757,002	$2,020,500	$1,234,846
29,000	$1,191,038	$1,221,568	$1,194,766	$1,818,081	$2,090,451	$1,278,494
31,000	$1,272,478	$1,304,502	$1,276,408	$1,940,480	$2,229,919	$1,365,743
34,000	$1,394,558	$1,428,840	$1,398,694	$2,123,316	$2,438,898	$1,496,320
36,000	$1,475,894	$1,511,586	$1,480,218	$2,245,244	$2,577,681	$1,583,424
45,000	$1,826,903	$1,867,428	$1,831,779	$2,743,844	$3,138,384	$1,955,315
47,000	$1,907,431	$1,949,225	$1,912,460	$2,862,708	$3,273,483	$2,041,285
56,000	$2,269,476	$2,316,640	$2,275,073	$3,396,505	$3,879,269	$2,427,781
63,000	$2,550,734	$2,601,793	$2,556,715	$3,810,271	$4,348,257	$2,727,946
67,000	$2,711,337	$2,764,574	$2,717,406	$4,045,967	$4,615,488	$2,899,256
73,000	$2,952,096	$3,008,485	$2,958,525	$4,399,241	$5,015,381	$3,156,020
79,000	$3,167,646	$3,224,878	$3,174,080	$4,670,799	$5,309,877	$3,379,633
94,000	$3,763,946	$3,827,964	$3,770,999	$5,534,483	$6,284,310	$4,014,230
102,000	$4,081,655	$4,149,090	$4,089,043	$5,993,799	$6,801,899	$4,352,134
112,000	$4,478,515	$4,549,882	$4,486,287	$6,566,558	$7,446,974	$4,774,262
146,000	$5,825,861	$5,909,142	$5,834,379	$8,505,005	$9,627,677	$6,206,605
157,000	$6,212,680	$6,296,086	$6,221,047	$8,974,854	$10,130,255	$6,605,663
204,000	$7,993,887	$8,085,641	$8,002,509	$11,390,286	$12,801,592	$8,478,752

B.II.b. Using non-surface water sources

A facility may be able to obtain some of its cooling water from a source other than the surface water it is using (WWTP gray water, ground water, or municipal water supply) and thereby reduce the volume of its withdrawals from the surface water and meet the percent of flow requirements. Some facilities may only need to use this alternate source during low flow periods in the surface water source. To use this option, a facility would need to build a pond or basin for the supplemental cooling water.

A facility using gray water may need to install some water treatment equipment (e.g., sedimentation, filtration) to ensure that its discharge of the combined source water and gray water meets any applicable effluent limits. For costing purposes, EPA has assumed that a facility would only need to install treatment for gray water in situations where treatment would have been required for river intake water. Therefore, no additional (i.e., "new") costs are incurred for treatment of gray water after intake or before discharge.

See the end of this Appendix for cost curves and equations for estimating gray water and municipal water costs.

B.III. Reducing Design Intake Velocity

B.III.a. Passive screens

Passive screens, typically made of wedge wire, are screens that use little or no mechanical activity to prevent debris and aquatic organisms from entering a cooling water intake. The screens reduce impingement and entrainment by using a small mesh size for the wedge wire and a low through-slot velocity that is quickly dissipated. The main components of a passive screening system are typically the screen(s), framing, an air backwash system if needed, and possibly guide rails depending on the installation location.

Passive screens vary in shape and form and include flat panels, curved panels, tee screens, vee screens, and cylinder screens. Screen dimensions (width and depth) vary; they are generally made to order with sizing as required by site conditions. Panels can be of any size, while cylinders are generally in the 12" to 96" diameter range. According to industry sources, the main advantages of passive intake systems are:

- They are fish-friendly due to low slot velocities (peak <0.5 fps), and
- They have no moving parts and thus minimal O&M costs.

New passive intake screens have higher capacity (due to higher screen efficiency) than older versions of passive screens. Wedge wire screens are effective in reducing impingement and entrainment as long as a sufficiently small screen slot size is used and ambient currents have enough velocity to move aquatic organisms around the screen and flush debris away.

The key parameters and additional features that are considered in estimating the cost of passive/wedge wire screening systems on CWIS are:

- Size of screen and flow rate (i.e., volume of water used),
- Size of screen slots/openings,
- Screen material,
- Water depth,
- Water quality (debris, biological growth, salinity), and
- Air backwash systems.

The size and material of a screen most affect cost. For larger volumes of cooling water withdrawals, a facility will need to use larger and/or more intake screens. Branched intakes, with a screen on each branch, can be used for large flows. Screen slot size also impacts the size of a screen. A smaller slot opening will result in a larger screen being required to keep the peak slot velocity under 0.5 fps.

Site-specific conditions significantly affect costs of the screen(s). The water depth affects equipment and installation costs because structural reinforcement is required as depth increases, air backwash system capacities need to be increased due to the reduced air volume at greater depths, and installation is generally more difficult. The potential for clogging from debris and fouling from biogrowth are water quality concerns that affect costs. The amount and type of debris influence the size of openings in the screen, which affects water flow through the screen and thus screen size. Finer debris may require a smaller slot opening to prevent debris from entering and clogging the openings.

Generally, speed and flow of water do not affect the installation cost or the operation of passive intakes, however there must be adequate current in the source water to carry away debris that is backwashed from the screen so that it does not become (re)clogged. It is recommended as good engineering practice that the axis of the screen cylinder be oriented parallel with the water flow to minimize fish entrainment and to aid in removal of debris during air backwash. The effects of the presence of sensitive species or certain types of species affect the design of the screen and may increase screen cost. For example, the lesser strength of a local species could result in the need for a peak velocity less than 0.5 fps which would result in a larger screen. Biofouling from the attachment of zebra mussels and barnacles and the growth of algae may necessitate the use of a special screen material, periodic flushing with biocides, and in limited cases, manual cleaning by divers. For example, the presence of zebra mussels often requires the use of a special alloy material to prevent attachment to the screen assembly.

The level of debris in the water also affects whether an air backwash system is needed and how often it is used. Heavy debris loadings may dictate the need for more frequent air backwashing. If the air backwash frequency is high enough, a larger compressor may be required to recharge the accumulator tank more quickly.

Another water quality factor that affects screen cost is water corrosiveness (e.g., whether the intake water is seawater, freshwater, or brackish). Most passive screens are manufactured in either 304 or 316 stainless steel for freshwater installations. The 316L stainless steel can be used for some saltwater installations, but has limited life. Screens made of copper-nickel alloys (70/30 or 90/10) have shown excellent corrosion resistance in saltwater, however they are significantly more expensive than stainless steel (50% to 100% greater in cost, i.e., can be double the cost).

Installation

The screen installation cost is largely a function of site conditions. Costs are typically greater for deeper installations and larger screens (e.g., screens for larger volumes of flow). Site-specific conditions such as space constraints, environmental and license/permit requirements, and the location/accessibility of the intake may greatly affect installation cost. For instance, for a project requiring dredging the installation cost can be two to four more times the installation cost of a project that does not require dredging. However, for National cost estimates, atypical conditions will not be considered in the cost estimates.

Capital Costs

EPA assumed that the capital cost of passive screens will be 60% of the capital cost of a basic traveling screen of similar size (Table A-24a). This assumption is based on discussions with industry representatives. The lower capital cost is because passive screen systems have lower onshore site preparation and installation costs (no extensive mechanical equipment as in the traveling screens) and are easier to install in offshore situations. The estimated capital costs for passive screens are shown in Table A-15, corresponding to the flows shown in Table A-19b for a through screen velocity of 0.5 fps. Passive screens for sizes larger than those shown in Table A-15 will generate flows higher than 50,000 gpm. For flows greater than 50,000 gpm, particularly when water is drawn in from a river, the size of the CWIS site becomes very big and the necessary network fanning for intake points and screens generally makes passive screen systems unfeasible.

Table A-15. Estimated Capital Costs for a Through Flow Passive Water Screen Stainless Steel 304 - Standard Design[1] (1999 Dollars)

Well Depth (ft)	Screen Panel Width (ft)			
	2	5	10	14
10	$34,200	$56,100	$91,800	$128,700
25	$49,800	$84,900	$140,400	(2)
50	$74,400	$122,700	(2)	(2)
75	$99,000	(2)	(2)	(2)
100	$135,600	(2)	(2)	(2)

1) Cost estimate includes stainless steel 304 structure.
2) Not estimated because passive screen systems of this size are not feasible.

As noted above, the capital costs for special screen materials (e.g., copper-nickel alloys) are typically 50% to 100% higher.

Table A-16 presents cost equations for estimating capital costs for passive screens. The "x" in the equation represents the flow volume in gpm and the "y" value is the passive screen total capital cost. Cost equations associated with a flow of 1 fps are provided for comparative purposes.

Table A-16. Capital Cost Equations for Passive Screens

Screen Width (ft)	Passive Screens Velocity 0.5 ft/sec		Passive Screens Velocity 1ft/sec	
	Equation[1]	Correlation Coefficient	Equation[1]	Correlation Coefficient
2	$y = 3E\text{-}08x^3 - 0.0008x^2 + 12.535x + 11263$	$R^2 = 0.9991$	$y = 2E\text{-}12x^4 - 1E\text{-}07x^3 + 0.0029x^2 - 18.885x + 71766$	$R^2 = 1$
5	$y = 0.0002x^2 + 1.5923x + 47041$	$R^2 = 1$	$y = 4E\text{-}05x^2 + 1.0565x + 43564$	$R^2 = 1$
10	$y = 3.7385x + 58154$	$R^2 = 1$	$y = 1.8x + 59400$	$R^2 = 1$

1) x is the flow in gpm y is the capital cost in dollars.

The typical useful life of a passive screen is greater than 20 years. See the end of this Appendix for cost curves and equations.

Operation and Maintenance (O&M) Costs for Passive Screens

Generally, there are no appreciable O&M costs for passive screens unless there are biofouling problems or zebra mussels in the environment. Biofouling problems can be remedied through the proper choice of materials and periodic mechanical cleaning. Screens equipped with air backwash systems require periodic compressor/motor/valve maintenance.

B.III.b. Velocity Caps

The cost driver of velocity caps is the installation cost. Installation is carried out underwater where the water intake mouth is modified to fit the velocity cap over the intake. EPA estimated capital costs for velocity caps based on the following assumptions:

- Four velocity caps can be installed in a day,
- Cost of the installation crew is similar to the cost of the water screen installation crew (see Box A-2),

- To account for the difficulty in installing in deep water, an additional work day is assumed for every increase in depth size category, and
- Equipment cost for a velocity cap is assumed to be 25% of the velocity cap installation cost. In our BPJ, this is a conservatively high estimate of the cost of velocity cap material and delivery to the installation site.

Based on these assumptions, EPA calculated estimated costs for velocity caps, which are shown in Tables A-17a and A-17b. EPA calculated the number of velocity caps needed for various flow sizes based on a flow velocity of 0.5ft/sec and assuming that the intake area to be covered by the velocity cap is 20 ft^2 which is the area comparable to a pipe diameter of about 5 feet. For flows requiring pipes larger than this, EPA assumed, for velocity cap costing purposes, that multiple intake pipes with a standard, easy-to-handle pipe diameter will be used rather than larger-diameter, custom made pipes (based on BPJ). Table A-17a presents the calculated velocity cap installation costs while Table A-17b presents the calculated total capital costs of velocity caps including installation and equipment. Cost equations for estimating the total capital costs of velocity caps are presented in Table A-18. Cost curves and equations are at the end of the Appendix.

Table A-17a. Estimated Velocity Cap Installation Costs (1999 Dollars)

Flow (gpm) (No. of velocity caps)	Water Depth (ft)				
	8	20	30	50	65
Up to 18,000 (4 VC)	$8000	$12,500	$17,000	$21,500	$26,000
18,000 ≤ flow <35,000 (9 VC)	$12,500	$17,000	$21,500	$26,000	$30,500
35,000≤ flow <70,000 (15 VC)	$21,500	$26,000	$30,500	$35,000	$39,500
70,000≤ flow <100,000 (23 VC)	$30,500	$35,000	$39,500	$44,000	$48,500
157,000 (35 VC)	$44,000	$48,500	$53,000	$57,500	$62,000
204,000 (46 VC)	$57,500	$62,000	$66,500	$71,000	$75,500

Table A-17b. Estimated Velocity Cap Equipment and Installation Costs (1999 Dollars)

Flow (gpm) (No. of velocity caps)	Water Depth (ft)				
	8	20	30	50	65
Up to 18,000 (4 VC)	$10,000	$15,625	$21,250	$26,875	$32,500
18,000 ≤ flow <35,000 (9 VC)	$15,625	$21,250	$26,875	$32,500	$38,125
35,000≤ flow <70,000 (15 VC)	$26,875	$32,500	$38,125	$43,750	$49,375
70,000≤ flow <100,000 (23 VC)	$38,125	$43,750	$49,375	$55,000	$60,625
157,000 (35 VC)	$55,000	$60,625	$66,250	$71,875	$77,500
204,000 (46 VC)	$71,875	$77,500	$83,125	$88,750	$94,375

Table A-18. Cost Equations for Velocity Cap Capital Costs

Flow (gpm) (No. of velocity caps)	Velocity Cap Capital Cost Equation	Correlation Coefficient
Up to 18,000 (4 VC)	$y = 0.071x^3 - 9.865x^2 + 775.03x + 4212.7$	$R^2 = 0.9962$
18,000 $\leq$ flow <35,000 (8 VC)	$y = 0.071x^3 - 9.865x^2 + 775.03x + 9837.7$	$R^2 = 0.9962$
35,000$\leq$ flow <70,000 (16 VC)	$y = 0.071x^3 - 9.865x^2 + 775.03x + 21088$	$R^2 = 0.9962$
70,000$\leq$ flow <100,000 (24 VC)	$y = 0.071x^3 - 9.865x^2 + 775.03x + 32338$	$R^2 = 0.9962$
157,000 (35 VC)	$y = 0.071x^3 - 9.865x^2 + 775.03x + 49213$	$R^2 = 0.9962$
204,000 (46 VC)	$y = 0.071x^3 - 9.865x^2 + 775.03x + 66088$	$R^2 = 0.9962$
1) x represents the water depth in feet and y is the capital cost in dollars.		

B.III.c. Branching the intake pipe to increase the number of openings or widening the intake pipe

Branching an intake pipe involves the use of fittings to attach the separate pipe sections. See the end of this Appendix for costs curves and equations.

B.IV. Implementing Other Design and Construction Technologies to Reduce Damage from I&E

B.IV.a. Installation of traveling screens with fish baskets

Single-entry, single-exit vertical traveling screens (conventional traveling screens) contain a series of wire mesh screen panels that are mounted end to end on a band to form a vertical loop. As water flows through the panels, debris and fish that are larger than the screen openings are caught on the screen or at the base of each panel in a basket. As the screen rotates around, each panel in turn reaches a top area where a high-pressure jet spray wash pushes debris and fish from the basket into a trash trough for disposal. As the screen rotates over time, the clean panels move down, back into the water to screen the intake flow.

Conventional traveling screens can be operated continuously or intermittently. However, when these screens are fitted with fish baskets (also called modified conventional traveling screens or Ristroph screens), the screens must be operated continuously so that fish that are collected in the fish baskets can be released to a bypass/return using a low pressure spray wash when the basket reaches the top of the screen. Once the fish have been removed, a high pressure jet spray wash is typically used to remove debris from the screen. In recent years, the design of fish baskets has been refined (e.g., deeper baskets, smoother mesh, better balance) to decrease chances of injury and mortality and to better retain fish (i.e., prevent them from flopping out and potentially being injured). Methods used to protect fish include the Stabilized Integral Marine Protective Lifting Environment (S.I.M.P.L.E.) developed by Brackett Green and the Modified Ristroph design by U.S. Filter.

U.S. Filter's conventional (through flow) traveling screens are typically manufactured in widths ranging from two feet to at least 14 feet, for channel depths of up to 100 feet, although custom design is possible to fit other dimensions.

Flow

To calculate the flow through a screen panel, the width of the screen panel is multiplied by the water depth and, using the desired flow velocities (1 foot per second and 0.5 foot per second), is converted to gallons per minute assuming a screen efficiency of 50%. The calculated flows for selected screen widths, water depths, and well depths are presented in Tables A-19a and A-19b. For flows greater than this, a facility would generally install multiple screens or use a custom design.

Well depth includes the height of the structure above the water line. The well depth can be more than the water depth by a few to tens of feet. The flow velocities used are representative of a flow speed that is generally considered to be fish friendly particularly for sensitive species (0.5 fps), and a flow speed that may be more practical for some facilities to achieve but typically provides less fish protection. The water depths and well depths are approximate and may vary based on actual site conditions.

Table A-19a. Average Flow Through A Traveling Water Screen (gpm) for a Flow Velocity of 1.0 fps

Well Depth (ft)	Water Depth (ft)	Basket Panel Screening Width (ft)			
		2	5	10	14
10	8	4000	9000	18,000	25,000
25	20	9000	22,000	45,000	63,000
50	30	13,000	34,000	67,000	94,000
75	50	22,000	56,000	112,000	157,000
100	65	29,000	73,000	146,000	204,000

Table A-19b. Average Flow Through A Traveling Water Screen (gpm) for a Flow Velocity of 0.5 fps

Well Depth (ft)	Water Depth (ft)	Basket Screening Panel Width			
		2	5	10	14
10	8	2000	4000	9000	13,000
25	20	4000	11,000	22,000	31,000
50	30	7000	17,000	34,000	47,000
75	50	11,000	28,000	56,000	79,000
100	65	15,000	36,000	73,000	102,000

Capital Costs

Equipment Cost

Basic costs for screens with flows comparable to those shown in the above tables are presented in Tables A-20a and A-20b. Table A-20a contains estimated costs for basic traveling screens without fish handling features, that have a carbon steel structure coated with epoxy paint. The cost of similar size screens using 316 stainless steel is generally twice as expensive. The advantages of using 316 stainless steel are its longer useful life and its resistance to harsh water quality conditions. The costs presented in Table A-20b are for traveling screens with fish handling features including a spray system, a fish trough, housings and transitions, continuous operating features, a drive unit, frame seals, and engineering. Installation costs and spray pump costs are presented separately below.

Table A-20a. Estimated Equipment Cost for Traveling Water Screens Without Fish Handling Features[1] (1999 Dollars)

Well Depth (ft)	Basket Screening Panel Width (ft)			
	2	5	10	14
10	$30,000	$35,000	$45,000	$65,000
25	$35,000	$45,000	$60,000	$105,000
50	$55,000	$70,000	$105,000	$145,000
75	$75,000	$100,000	$130,000	$175,000
100	$115,000	$130,000	$155,000	$200,000

1) Cost includes carbon steel structure coated with epoxy paint and non-metallic trash baskets with Type 304 stainless mesh and intermittent operation components.

Source: Vendor estimates.

Table A-20b. Estimated Equipment Cost for Traveling Water Screens With Fish Handling Features[1] (1999 Dollars)

Well depth (ft)	Basket Screening Panel Width (ft)			
	2	5	10	14
10	$63,500	$73,500	$94,000	$135,500
25	$81,250	$97,500	$133,000	$214,000
50	$122,500	$152,000	$218,000	$319,500
75	$163,750	$210,000	$283,000	$414,500
100	$225,000	$267,500	$348,000	$504,500

1) Cost includes carbon steel screen structure coated with epoxy paint and non-metallic fish handling panels, spray systems, fish trough, housings and transitions, continuous operating features, drive unit, frame seals, and engineering (averaged over 5 units). Costs do *not* include differential control system, installation, and spray wash pumps.

Source: Vendor estimates.

Installation Cost

Installation costs of traveling screens are based on the following assumptions of a typical average installation requirement for a hypothetical scenario. Site preparation and earth work are calculated based on the following assumptions:

- ***Clearing and grubbing*:** Clearing light to medium brush up to 4" diameter with a bulldozer.
- ***Earthwork*:** Excavation of heavy soils. Quantity is based on the assumption that earthwork increases with screen width.
- ***Paving and surfacing*:** Using concrete 8" thick and assuming that the cost of pavement attributed to screen installation is 6x3 yards for the smallest screen and 25x6 yards for the largest screen.
- ***Structural concrete*:** The structural concrete work attributed to screen installation is four 12"x12" reinforced concrete columns with depths varying between 1.5 yards and 3 yards. There is more structural concrete work for a water intake structure, however, for new source screens and retrofit screens, only a portion of the intake structural cost can be justifiably attributed to the screen costs. For new screens, most of the concrete structure work is for developing the site to make it accessible for equipment and protect it from hydraulic elements, which are necessary for constructing the intake itself. For retrofits, some of the structural concrete will already exist and some of it will not be needed since the intake is already in place and only the screen needs to be installed. All unit costs used in

calculating on-shore site preparation were obtained from *Heavy Construction Cost Data 1998* (R. S. Means, 1997b).

Table A-21a presents site preparation installation costs that apply to traveling screens both with and without fish handling features. The total onshore construction costs presented in Table A-21a are for a screen to be installed in a 10-foot well depth. Screens to be installed in deeper water are assumed to require additional site preparation work. Hence for costing purposes it is assumed that site preparation costs increase at a rate of an additional 25% per depth factor (calculated as the ratio of the well depth to the base well depth of 10 feet) for well depths greater than 10 feet. Table A-21b presents the estimated costs of site preparation for four sizes of screen widths and various well depths.

Table A-21a. Estimated Installation (Site Preparation) Costs for Traveling Water Screens Installed at a 10-foot Well Depth (1999 Dollars)

Screen Width (ft)	Clearing and Grabbing (acre)	Clearing Cost[1]	Earth Work (cy)	Earth Work Cost[1]	Paving and Surfacing Using Concrete (sy)	Paving Cost[1]	Structural Concrete (cy)	Structural Cost	Total Onshore Construction Costs
2	0.1	$250	200	$17,400	18	$250	0.54	$680	$19,000
5	0.35	$875	500	$43,500	40	$560	0.63	$790	$46,000
10	0.7	$1,750	1000	$87,000	75	$1,050	0.72	$900	$91,000
14	1	$2,500	1400	$121,800	150	$2,100	1.08	$1,350	$128,000

ft = feet, cy=cubic yard, sy=square yard
1) Clearing cost @ $2,500/acre, earth work cost @ $87/cubic yard, paving cost @ $14/square yard, structural cost @ $1,250/cubic yard.

Source of unit costs: *Heavy Construction Cost Data 1998* (R.S. Means, 1997b).

Table A-21b. Estimated Installation (Site Preparation, Construction, and Onshore Installation) Costs for Traveling Water Screens of Various Well Depths (1999 Dollars)

Well Depth (ft)	Screen Panel Width (ft)			
	2	5	10	14
10	$19,000	$46,000	$91,000	$128,000
25	$31,000	$75,000	$148,000	$208,000
50	$43,000	$104,000	$205,000	$288,000
75	$55,000	$132,000	$262,000	$368,000
100	$67,000	$161,000	$319,000	$448,000

Source: R.S. Means (1997b) and vendor estimates.

EPA developed a hypothetical scenario of a typical underwater installation to estimate an average cost for underwater installation costs. EPA estimated costs of personnel and equipment per day, as well as mobilization and demobilization. Personnel and equipment costs would increase proportionately based on the number of days of a project, however mobilization and demobilization costs would be relatively constant regardless of the number of days of a project since the cost of transporting personnel and equipment is largely independent of the length of a project. The hypothetical project scenario and estimated costs are presented in Box A-2. This scenario uses passive intake screens, but the estimated costs can be used to develop installation costs for traveling screens and velocity caps.

As shown in the hypothetical scenario in Box A-2, the estimated cost for a one-day installation project would be $8,000 ($4,500 for personnel and equipment, plus $3,500 for mobilization and demobilization). Using this one-day cost estimate as a basis, EPA generated estimated installation costs for various sizes of screens under different scenarios. These costs are presented in Table A-22. The baseline costs for underwater installation include the costs of a crew of divers and equipment including mobilization and demobilization, divers, a barge, and a crane. The number of days needed is based on a minimum of one day for a screen of less than 5 feet in width and up to 10 feet in well depth. Using best professional judgement (BPJ), EPA estimated the costs for larger jobs assuming an increase of two days for every increase in well depth size and of one day for every increase in screen width size.

Box A-2. Hypothetical Scenario for Underwater Installation of an Intake Screen System

This project involves the installation of 12, t-24 passive intake screens onto a manifold inlet system. Site conditions include a 20-foot water depth, zero to one-foot underwater visibility, 60-70 °F water temperature, and fresh water at an inland. The installation is assumed to be 75 yards offshore and requires the use of a barge or vessel with 4-point anchor capability and crane.

Job Description:
Position and connect water intake screens to inlet flange via 16 bolt/nut connectors. Lift, lower, and position intake screens via crane anchored to barge or vessel. Between 4 and 6 screens of the smallest size can be installed per day per dive team, depending on favorable environmental conditions.

Estimated Personnel Costs:
Each dive team consists of 5 people (1 supervisor, 2 surface tenders, and 2 divers), the assumed minimum number of personnel needed to operate safely and efficiently. The labor rates are based on a 12-hour work day. The day rate for the supervisor is $600. The day rate for each diver is $400. The day rate for each surface tender is $200. Total base day rate per dive team is $1,800.

Estimated Equipment Costs:
Use of hydraulic lifts, underwater impact tools, and other support equipment is $450 per day. Shallow water air packs and hoses cost $100 per day. The use of a crane sufficient to lift the 375 lb t-24 intakes is $300 per day. A barge or vessel with 4-point anchor capability can be provided by either a local contractor or the dive company for $1,800 per day (cost generally ranges from $1,500-$2,000 per day). This price includes barge/vessel personnel (captain, crew, etc) but the barge/vessel price does not include any land/waterway transportation needed to move barge/vessel to inland locations. Using land-based crane and dive operations can eliminate the barge/vessel costs. Thus total equipment cost is $2,650 per day.

Estimated Mobilization and Demobilization Expenses:
This includes transportation of all personnel and equipment to the job site via means necessary (air, land, sea), all hotels, meals, and ground transportation. An accurate estimate on travel can vary wildly depending on job location and travel mode. For this hypothetical scenario, costs are estimated for transportation with airfare, and boarding and freight and would be $3,500 for the team (costs generally range between $3,000 and $4,000 for a team).

Other Considerations:
Uncontrollable factors like weather, water temperature, water depth, underwater visibility, currents, and distance to shore can affect the daily production of the dive team. These variables always have to be considered when a job is quoted on a daily rate. Normally, the dive-company takes on the risks for these variables because the job is quoted on a "to completion" status. These types of jobs usually take a week or more for medium to large-size installations.

Total of Estimated Costs:
The final estimated total for this hypothetical job is nearly $4500 per day for personnel and equipment. For a three-day job, this would total about $13,500. Adding to this amount about $3,500 for mobilization and demobilization, the complete job is estimated at $17,000.

Note: Costs for a given project vary greatly depending on screen size, depth of water, and other site-specific conditions such as climate and site accessibility.

Source: Developed based on information from Paroby (1999).

Table A-22. Estimated Underwater Installation Costs for Various Screen Widths and Well Depths[1] (1999 Dollars)

Well Depth (ft)	Basket Screening Panel Width			
	2	5	10	14
10	$8,000	$12,500	$17,000	$21,500
25	$17,000	$21,500	$26,000	$30,500
50	$26,000	$30,500	$35,000	$39,500
75	$35,000	$39,500	$44,000	$48,500
100	$44,000	$48,500	$53,000	$57,500

1) Based on hypothetical scenario of crew and equipment costs of $4,500 per day and mobilization and demobilization costs of $3,500 (see Box A-2).

Table A-23 presents total estimated installation costs for traveling screens. These costs equal the total of the costs in Table A-21b and Table A-22. Installation costs for traveling screens with fish handling features and those without fish handling features are assumed to be similar.

Table A-23. Estimated Total Installation Costs for Traveling Water Screens[1] (1999 Dollars)

Well Depth (ft)	Basket Screening Panel Width (ft)			
	2	5	10	14
10	$27,000	$58,500	$108,000	$149,500
25	$48,000	$96,500	$174,000	$238,500
50	$69,000	$134,500	$240,000	$327,500
75	$90,000	$171,500	$306,000	$416,500
100	$111,000	$209,500	$372,000	$505,500

1) Includes site preparation, and onshore and underwater construction and installation costs.

Total Estimated Capital Costs

The installation costs in Table A-23 can be added to the equipment costs in Tables A-20a and A-20b to derive total equipment and installation costs for traveling screens with and without fish handling features. These estimated costs are presented in Tables A-24a and A-24b. The flow volume corresponding to each screen width and well depth combination varies based on the through screen flow velocity. These flow volumes were presented in Tables A-19a and A-19b for flow velocities of 1.0 fps and 0.5 fps, respectively.

Table A-24a. Estimated Total Capital Costs for Traveling Screens Without Fish Handling Features (Equipment and Installation)[1] (1999 Dollars)

Well Depth (ft)	Screening Basket Panel Width (ft)			
	2	5	10	14
10	$57,000	$93,500	$153,000	$214,500
25	$83,000	$141,500	$234,000	$343,500
50	$124,000	$204,500	$345,000	$472,500
75	$165,000	$271,500	$436,000	$591,500
100	$226,000	$339,500	$527,000	$705,500

1) Costs include carbon steel structure coated with an epoxy paint, non-metallic trash baskets with Type 304 stainless mesh, and intermittent operation components and installation.

Table A-24b. Estimated Total Capital Costs for Traveling Screens With Fish Handling Features (Equipment and Installation)[1] (1999 Dollars)

Well Depth (ft)	Screening Basket Panel Width (ft)			
	2	5	10	14
10	$90,500	$132,000	$202,000	$285,000
25	$129,250	$194,000	$307,000	$453,000
50	$191,500	$287,000	$458,000	$647,000
75	$253,750	$381,500	$589,000	$831,000
100	$336,000	$477,000	$720,000	$1,010,000

1) Costs include non-metallic fish handling panels, spray systems, fish trough, housings and transitions, continuous operating features, drive unit, frame seals, engineering (averaged over 5 units), and installation. Costs do *not* include differential control system and spray wash pumps.

Tables A-25a and A-25b present equations that can be used to estimate costs for traveling screens at 0.5 fps and 1.0 fps, respectively. See the end of this Appendix for cost curves and equations.

Table A-25a. Capital Cost Equations for Traveling Screens for Velocity of 0.5 fps

Screen Width (ft)	Traveling Screens with Fish Handling Equipment		Traveling Screens without Fish Handling Equipment	
	Equation[1]	Correlation Coefficient	Equation[1]	Correlation Coefficient
2	$y = 2E\text{-}11x^4 - 6E\text{-}07x^3 + 0.0053x^2 + 1.0283x + 71506$	$R^2 = 1$	$y = 1E\text{-}11x^4 - 4E\text{-}07x^3 + 0.0036x^2 + 0.8119x + 44000$	$R^2 = 1$
5	$y = 2E\text{-}12x^4 - 2E\text{-}07x^3 + 0.004x^2 - 27.772x + 187917$	$R^2 = 1$	$y = 1E\text{-}12x^4 - 9E\text{-}08x^3 + 0.0024x^2 - 14.878x + 120042$	$R^2 = 1$
10	$y = 2E\text{-}13x^4 - 3E\text{-}08x^3 + 0.0017x^2 - 22.739x + 293474$	$R^2 = 1$	$y = 1E\text{-}13x^4 - 2E\text{-}08x^3 + 0.0012x^2 - 15.939x + 214636$	$R^2 = 1$
14	$y = 6E\text{-}14x^4 - 1E\text{-}08x^3 + 0.001x^2 - 15.915x + 353385$	$R^2 = 1$	$y = 4E\text{-}14x^4 - 8E\text{-}09x^3 + 0.0006x^2 - 6.4565x + 222007$	$R^2 = 1$

1) x is the flow in gpm y is the capital cost in dollars.

Table A-25b. Capital Cost Equations for Traveling Screens for Velocity of 1 fps

Screen Width (ft)	Traveling Screens with Fish Handling Equipment		Traveling Screens without Fish Handling Equipment	
	Equation[1]	Correlation Coefficient	Equation[1]	Correlation Coefficient
2	$y = 5E\text{-}12x^4 - 3E\text{-}07x^3 + 0.0072x^2 - 47.584x + 185604$	$R^2 = 1$	$y = 4E\text{-}12x^4 - 2E\text{-}07x^3 + 0.0048x^2 - 31.475x + 119611$	$R^2 = 1$
5	$y = 1E\text{-}13x^4 - 2E\text{-}08x^3 + 0.001x^2 - 13.641x + 187644$	$R^2 = 1$	$y = 7E\text{-}14x^4 - 1E\text{-}08x^3 + 0.0006x^2 - 6.9771x + 117069$	$R^2 = 1$
10	$y = 2E\text{-}14x^4 - 5E\text{-}09x^3 + 0.0005x^2 - 15.877x + 344095$	$R^2 = 1$	$y = 1E\text{-}14x^4 - 4E\text{-}09x^3 + 0.0004x^2 - 11.291x + 251956$	$R^2 = 1$
14	$y = 4E\text{-}15x^4 - 2E\text{-}09x^3 + 0.0003x^2 - 9.9356x + 387337$	$R^2 = 1$	$y = 3E\text{-}15x^4 - 1E\text{-}09x^3 + 0.0002x^2 - 4.6948x + 248170$	$R^2 = 1$
1) x is the flow in gpm y is the capital cost in dollars.				

Potential Additional Capital Costs

Fish spray pumps are used to increase the survival rate of fish by directing the fish out of fish baskets and facilitating their return to the waterbody. In some instances, water used for spraying fish can be obtained by passing a portion of the water pumped for cooling to use in spraying fish. These pumps are an additional cost that is minimal compared to the other equipment and installation costs of a CWIS. They are presented separately to account for systems that must have a separate pumping facility for fish spraying. Assuming that a minimum of one percent of the flows used in cooling is used in spraying fish will yield a flow range from 20 gpm to 2250 gpm. Even if the one percent flow assumption varies for some systems, the flow range generated based on the one percent assumption is large enough to construct a cost curve for water pumps. Table A-26 presents the estimated costs of fish spray pumps, calculated based on the R.S. Means cost data for centrifugal water pumps (R.S. Means, 1997c). The costs in Table A-26 include labor, material, and equipment. See the end of this Appendix for cost curves and equations.

Table A-26. Estimated Total Capital Costs for Fish Spray Pumps (1999 Dollars)

Centrifugal Pump Flow (gpm)	Total Capital Costs for Centrifugal Pumps	Cost Equation[1]	Correlation Coefficient
10	$ 800	$y = -0.2394x^2 + 47.9x + 364.04$	$R^2 = 0.9907$
50	$ 2250		
75	$ 2500		
100	$ 2800		
500	$ 3700	$y = 2E\text{-}06x^3 - 0.0035x^2 + 3.8696x + 2446.8$	$R^2 = 1$
1000	$ 4400		
2000	$ 9000		
1) x is flow in gpm and y is cost in dollars.			

Operation and Maintenance (O&M) Costs for Traveling Screens

O&M costs for traveling screens vary by type, size, and mode of operation of the screen. Based on discussions with industry representatives, EPA estimated annual O&M cost as a percentage of total capital cost. The O&M cost factor ranges between 8% of total capital cost for the smallest size traveling screens with and without fish handling equipment and 5% for the largest traveling screen since O&M costs do not increase proportionately with screen size. Estimated annual O&M costs for traveling screens with and without fish handling features are presented in Tables A-27a and A-27b, respectively. As noted earlier, the flow volume corresponding to each screen width and well depth combination varies based on the through screen flow velocity. These flow volumes were presented in Tables A-19a and A-19b for flow velocities of 1.0 fps and 0.5 fps, respectively.

Table A-27a. Estimated Annual O&M Costs for Traveling Water Screens Without Fish Handling Features (Carbon Steel - Standard Design)[1] (1999 Dollars)

Well Depth (ft)	Screen Panel Width (ft)			
	2	5	10	14
10	$4560	$6545	$7650	$12,870
25	$5810	$9905	$14,040	$17,175
50	$8680	$12,270	$17,250	$23,625
75	$11,550	$16,290	$21,800	$29,575
100	$13,560	$16,975	$26,350	$35,275

1) Annual O&M costs range between 8% of total capital cost for the smallest size traveling screens with and without fish handling equipment and 5% for the largest traveling screen.

Table A-27b. Estimated Annual O&M Costs for Traveling Water Screens With Fish Handling Features (Carbon Steel Structure, Non-Metallic Fish Handling Screening Panel)[1] (1999 Dollars)

Well Depth (ft)	Screen Panel Width (ft)			
	2	5	10	14
10	$7240	$9240	$10,100	$17,100
25	$9048	$13,580	$18,420	$22,650
50	$13,405	$17,220	$22,900	$32,350
75	$17,763	$22,890	$29,450	$41,550
100	$20,160	$23,850	$36,000	$50,500

1) Annual O&M costs range between 8% of total capital cost for the smallest size traveling screens with and without fish handling equipment and 5% for the largest traveling screen.

Tables A-28a and A-28b present O&M cost equations generated from the above tables for various screen sizes and water depths at velocities of 0.5 fps and 1 fps, respectively. The “x” value of the equation is the flow and the ”y” value is the O&M cost in dollars.

Table A-28a. Annual O&M Cost Equations for Traveling Screens Velocity 0.5 fps

Screen Width (ft)	Traveling Screens with Fish Handling Equipment		Traveling Screens without Fish Handling Equipment	
	Equation[1]	Correlation Coefficient	Equation[1]	Correlation Coefficient
2	$y = -3E\text{-}05x^2 + 1.6179x + 3739.1$	$R^2 = 0.9943$	$y = -2E\text{-}05x^2 + 1.0121x + 2392.4$	$R^2 = 0.9965$
5	$y = -1E\text{-}05x^2 + 0.8563x + 5686.3$	$R^2 = 0.9943$	$y = -7E\text{-}06x^2 + 0.6204x + 4045.7$	$R^2 = 0.9956$
10	$y = -2E\text{-}06x^2 + 0.5703x + 5864.4$	$R^2 = 0.9907$	$y = 9E\text{-}11x^3 - 1E\text{-}05x^2 + 0.8216x + 1319.5$	$R^2 = 0.9997$
14	$y = 4E\text{-}15x^4 - 9E\text{-}10x^3 + 7E\text{-}05x^2 - 1.5031x + 26977$	$R^2 = 1$	$y = 2E\text{-}15x^4 - 6E\text{-}10x^3 + 4E\text{-}05x^2 - 0.8552x + 18106$	$R^2 = 1$
1) x is the flow in gpm and y is the annual O&M cost in dollars.				

Table A-28b. Annual O&M Cost Equations for Traveling Screens Velocity 1 fps

Screen Width (ft)	Traveling Screens with Fish Handling Equipment		Traveling Screens without Fish Handling Equipment	
	Equation[1]	Correlation Coefficient	Equation[1]	Correlation Coefficient
2	$y = -8E\text{-}06x^2 + 0.806x + 3646.7$	$R^2 = 0.982$	$y = -4E\text{-}06x^2 + 0.5035x + 2334$	$R^2 = 0.9853$
5	$y = -3E\text{-}06x^2 + 0.4585x + 5080.7$	$R^2 = 0.9954$	$y = -2E\text{-}06x^2 + 0.3312x + 3621.1$	$R^2 = 0.9963$
10	$y = -6E\text{-}07x^2 + 0.2895x + 5705.3$	$R^2 = 0.9915$	$y = 1E\text{-}11x^3 - 3E\text{-}06x^2 + 0.4047x + 1359.4$	$R^2 = 1$
14	$y = 3E\text{-}16x^4 - 1E\text{-}10x^3 + 2E\text{-}05x^2 - 0.8264x + 28092$	$R^2 = 1$	$y = 2E\text{-}16x^4 - 8E\text{-}11x^3 + 1E\text{-}05x^2 - 0.4829x + 18975$	$R^2 = 1$
1) x is the flow in gpm and y is the annual O&M cost in dollars.				

B.IV.b. Adding fish baskets to existing traveling screens

Capital Costs

Table A-29 presents estimated costs of fish handling equipment without installation costs. These estimated costs represent the difference between costs for equipment with fish handling features (Table A-20b) and costs for equipment without fish handling features (Table A-20a), plus a 20% add-on for upgrading existing equipment (mainly to convert traveling screens from intermittent operation to continuous operation).[12] These costs would be used to estimate equipment capital costs for upgrading an existing traveling water screen to add fish protection and fish return equipment.

[12]This 20% additional cost for upgrades to existing equipment was included based on recommendations from one of the equipment vendors supplying cost data for this research effort.

Table A-29. Estimated Capital Costs of Fish Handling Equipment (1999 Dollars)

Well Depth (ft)	Basket Screening Panel Width (ft)			
	2	5	10	14
10	$40,200	$46,200	$58,800	$84,600
25	$55,500	$63,000	$87,600	$131,400
50	$81,000	$99,000	$135,600	$209,400
75	$106,500	$132,000	$183,600	$287,400
100	$132,000	$165,000	$231,600	$365,400

Source: Vendor estimates.

Installation of Fish Handling Features to Existing Traveling Screens

As stated earlier, the basic equipment cost of fish handling features (presented in Table A-29) is calculated based on the difference in cost between screens with and without fish handling equipment, plus a cost factor of 20% for upgrading the existing system from intermittent to continuous operation. Although retrofitting existing screens with fish handling equipment will require upgrading some mechanical equipment, installing fish handling equipment generally will not require the use of a costly barge that is equipped with a crane and requires a minimum number of crew to operate it. EPA assumed that costs are 75% of the underwater installation cost (Table A-22) for a traveling screen (based on BPJ). Table A-30 shows total estimated costs (equipment and installation) for adding fish handling equipment to an existing traveling screen.

Table A-30. Estimated Capital Costs of Fish Handling Equipment and Installation[1] (1999 Dollars)

Well Depth (ft)	Basket Screening Panel Width (ft)			
	2	5	10	14
10	$46,200	$55,575	$71,550	$100,725
25	$68,250	$79,125	$107,100	$154,275
50	$100,500	$121,875	$161,850	$239,025
75	$132,750	$161,625	$216,600	$323,775
100	$165,000	$201,375	$271,350	$408,525

1) Installation portion of the costs estimated as 75% of the *underwater* installation cost for installing a traveling water screen.

The additional O&M costs due to the installation of fish baskets on existing traveling screens can be calculated by subtracting the O&M costs for basic traveling screens from the O&M costs for traveling screens with fish baskets. See the end of this Appendix for cost curves and equations.

B.V. Additional Cost Considerations

To account for other minor cost elements, EPA estimates that 5% may need to be added to the total cost for each alteration. Minor cost elements include:

- Permanent buoys for shallow waters to warn fishing boats and other boats against dropping anchor over the pipes. Temporary buoys and warning signs during construction.

- Additional permit costs. Permit costs may increase because of the trenching and dredging for pipe installation.

- Facility replanning/redesign costs may be incurred if the facility is far enough along in the facility planning and development process. This cost would likely be minimal to negligible for most of the alterations discussed above, but could be much higher for switching a facility to a recirculating cooling system.

- Monitoring costs (e.g., to test for contaminated sediments).

As noted earlier, if the intake structure installation involves disturbance of contaminated sediments, the permitting authority may require special construction procedures, including hauling the sediments to an appropriate disposal facility offsite. This may increase the cost of the project by more than two to three times the original cost estimate.

B.V.a Potential Additional Site-Specific Costs

There are some especially site-specific costs associated with the construction of cooling towers and water intake structures that represent potential additional expenditures a facility may incur to get a technology in place and operational. These costs can be considerable in some individual cases and in such cases would need to be added to cost estimates. The items described below were not included in the National cost estimates presented in this document. General ranges for these costs are provided in the descriptions below.[13]

These potential site-specific costs that need to be added where applicable are:

- Pilot studies,
- Geotechnical allowance,
- Land acquisition,
- Interest,
- Legal, fiscal, and administrative expenses, and
- Sales tax.

The following subsections describe each of these indirect cost elements in more detail.

Pilot Studies

Site-specific pilot tests are often required by regulatory agencies to better define design conditions and to ensure protection of public health by the proposed technology. Pilot tests can be run to determine appropriate loading rates, chemical feed rates or other process parameters, waste handling requirements, and whether a facility is likely to meet requirements for noise and air drift control (for cooling towers) and other emissions limits.

Requirements of predesign testing can be satisfied through several alternatives. Among these are full- or small-scale pilot studies, bench tests, and desktop feasibility studies. In addition, participating in cooperative studies between suppliers, associations, and users can sometimes reduce costs for such pre-design requirements.

The general costs for each type of study range from an inexpensive, small-scale pilot study to full-scale pilot studies that are warranted by site-specific conditions. Performing a full-scale pilot study with the actual process equipment, as installed on-site, can sometimes reduce equipment costs. Three variables affecting these costs are technology requirements, existing standard protocol requirements, and state requirements. Some states may determine test requirements on a case-by-case basis particularly where stringent fish protection, NPDES, and noise and plume abatement regulations exist.

The diversity of state requirements, along with the many options for pre-design testing, results in poorly defined requirements for pilot or bench scale studies. To determine costs, a strong definition of pilot scale testing requirements is necessary.

[13]Because these costs are so site-specific, an individual cost estimate would not be appropriate on a National basis. In addition, costs may vary substantially by region. For example, weighted unit cost averages for 689 cities range from 0.653 to 1.352, with a 30-city average index of 1.0 (R.S. Means, 1997a). City indices are available on the Internet on various sites and provide a tool for adjusting estimated costs to be more reflective of potential costs in specific geographic locations.

Table A-31 shows estimated hours and cost for a pilot test and is the result of a combination of available information, contacts with vendors for verification, and review of references.

Table A-31. Potential Pilot Test Costs for Screens and Cooling Towers (1999 Dollars)

Element	Hours	Cost	Assumptions
P.E./P.M.	12		1. A 2-week pilot study test is sufficient. 2. P.M./P.E. will arrange and coordinate test. 3. Selection of technology performed in the process design phase of the project. 4. A brief report will be prepared describing test, results and recommendations. 5. Other costs include power costs, chemical costs, sludge disposal, and one effluent sample per day for TSS, turbidity, and three volatile organic constituents.
Junior Engineer	40		
Word Processor	16		
Pilot System Rental		$10,000	
Other costs		$4,000	

Geotechnical Allowance

Cost estimates should include a geotechnical allowance for any unique subsurface conditions that require special construction techniques, such as piles or high ground water table dewatering. These costs are very site-specific.

Land Acquisition

Cost estimates for purchasing land for buildings, facility units, and conveyance should be included, if necessary. The amount of land required should include a 40-foot buffer on each side for emergency vehicle access. Typical costs per acre range from $4,000 to $350,000 for industrial sites and from $150 to $2,200 for rural sites. Average costs are $10,000 per industrial acre and $1,000 per rural acre. (EPA, 1996)

Interest

Cost estimates may need to include interest for the financing of the project. The interest rate depends on the funding source, subsidies, and the general economy, but generally ranges from 3% to 10%. The interest on capital expenses during construction generally ranges between 5% and 10% of capital costs.

Legal, Fiscal and Administrative Expenses

This category includes project management, accounting, and administrative activities related to the project, excluding permitting. The cost can range from 2% to 5% of the equipment, installation, construction, electrical, and standby power cost, with an average of 3%.

Sales Tax

Projects may be exempt from the sales tax, particularly those constructed with public funds. If not, the tax can be as high as 7.25% of the equipment and construction cost, with a National average of 4.75% (R.S. Means, 1997a).

C. REFERENCES

In addition to the references listed below, EPA would like to thank the following individuals for providing valuable information, comments and support: Russel Bellman and Brian Julius, Acting Chief, Gulf Coast Branch NOAA Damage Assessment Center, Silver Spring, MD, of the National Oceanic and Atmospheric Administration; Adnan Alsaffar, Arman Sanver, and John Gantnier, Bechtel Power Corporation, Fredrick, MD; Gary R. Mirsky Vice President, Hamon Cooling Towers, Somerville, NJ; Jim Prillaman, Prillaman Cooling Towers, Richmond, VA; Ken Campbell GEA Power Systems, Denver, CO and David Sanderlin, GEA Power Systems, San Diego, CA; Michael D. Quick, Manager - Marketing / Communications, U.S. Filter - Envirex Products, Waukesha, WI; Trent T. Gathright, Fish Handling Band Screen Specialist, Marketing Manager, Brackett Geiger USA, Inc., Houston, TX; Richard J. Sommers, U.S. Filter Intake Systems, Chalfont,

PA; Ken McKay, VP Sales/Marketing, USF Intake Products; and Larry Sloan, District Representative, Sloan Equipment Sales Co.,Inc., Owings Mills, MD.

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D. LIST OF COST CURVES AND EQUATIONS

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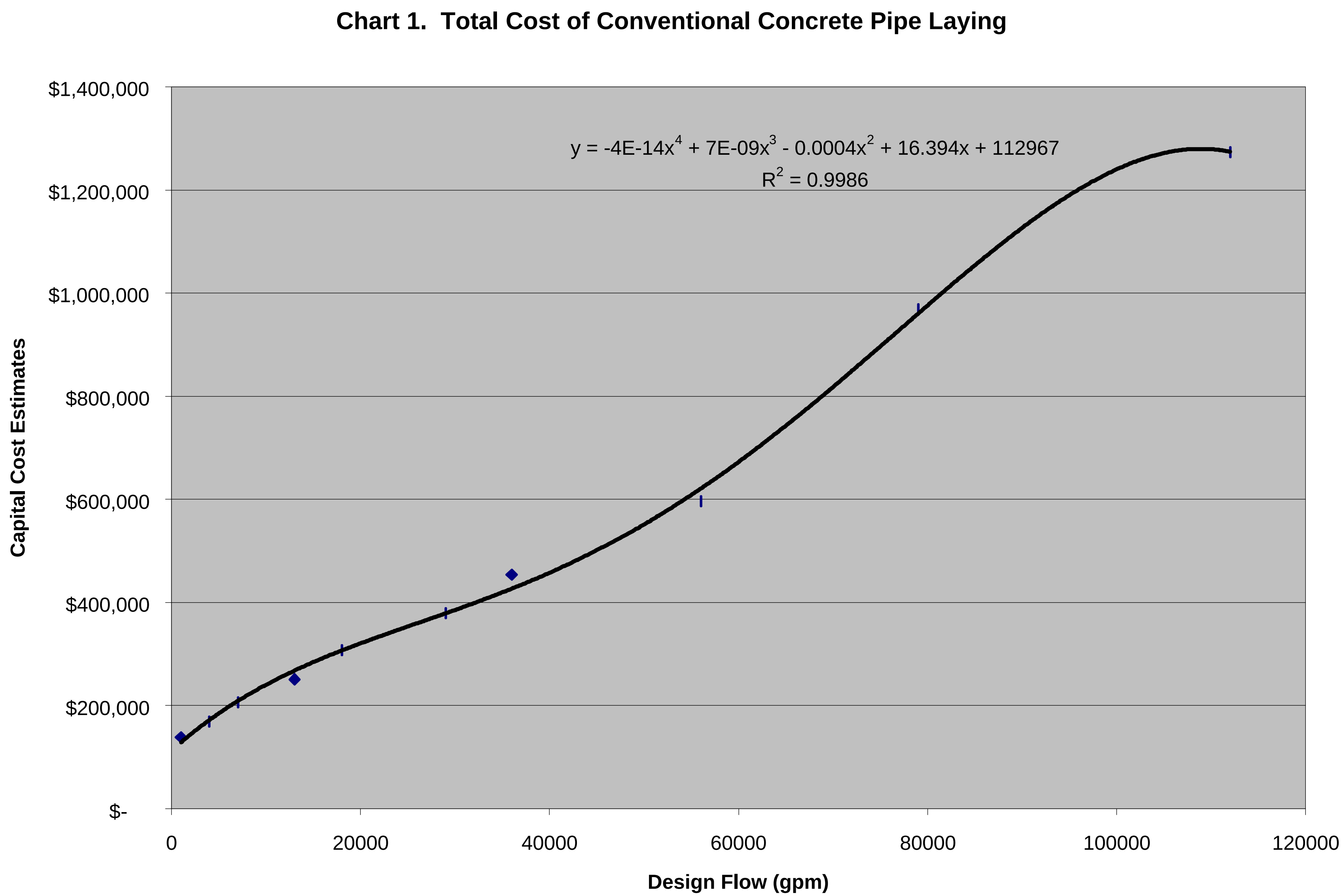


Chart 1. Total Cost of Conventional Concrete Pipe Laying
y = -4E-14x4 + 7E-09x3 - 0.0004x2 + 16.394x + 112967
R2 = 0.9986
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$-
0
20000
40000
60000
80000
100000
120000
Capital Cost Estimates
Design Flow (gpm)

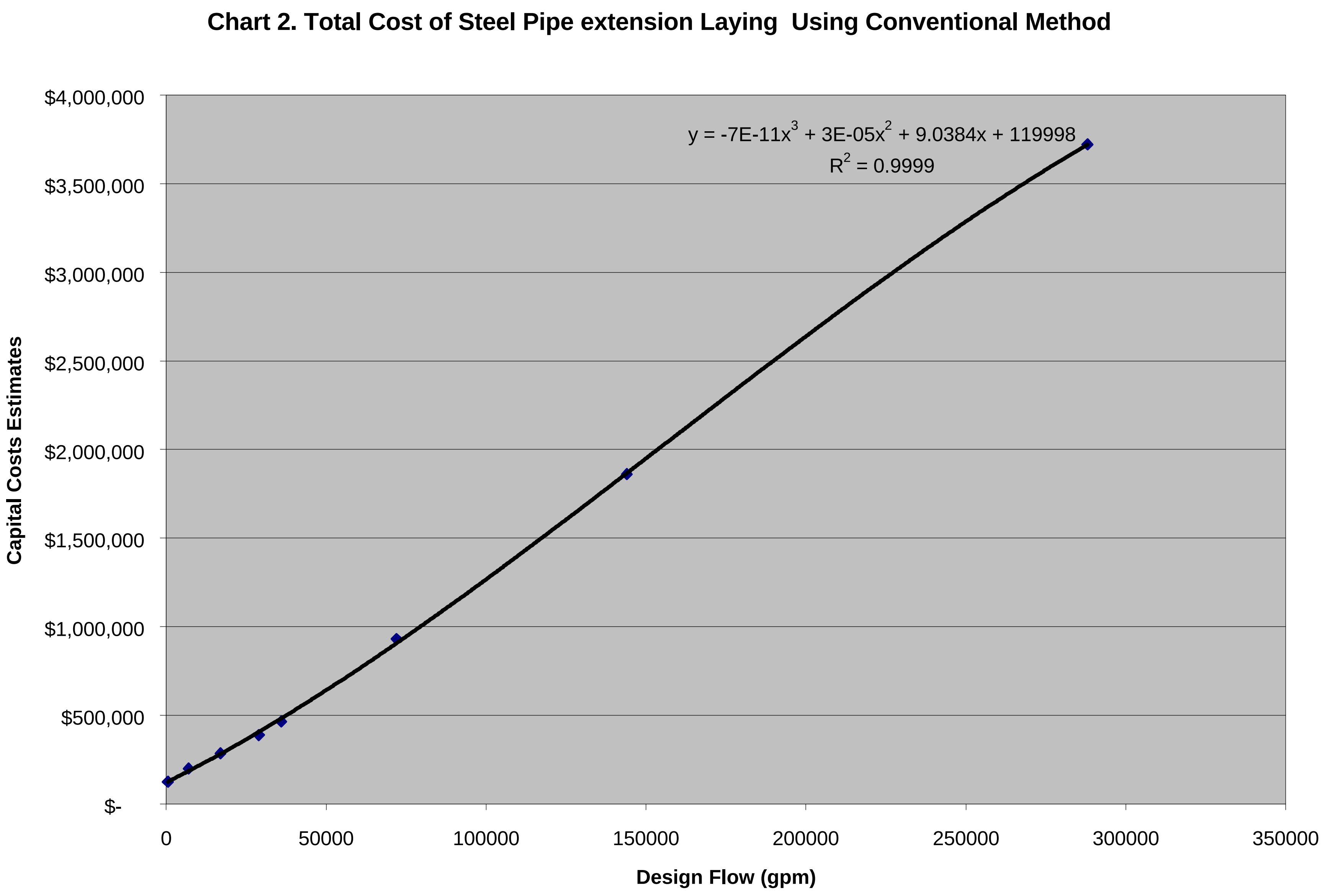


Chart 2. Total Cost of Steel Pipe extension Laying Using Conventional Method
y = -7E-11x3 + 3E-05x2 + 9.0384x + 119998
R2 = 0.9999
$4,000,000
$3,500,000
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$-
Capital Costs Estimates
0
50000
100000
150000
200000
250000
300000
350000
Design Flow (gpm)

Chart 3. Cost of Bottom-pull Concrete Pipe Laying

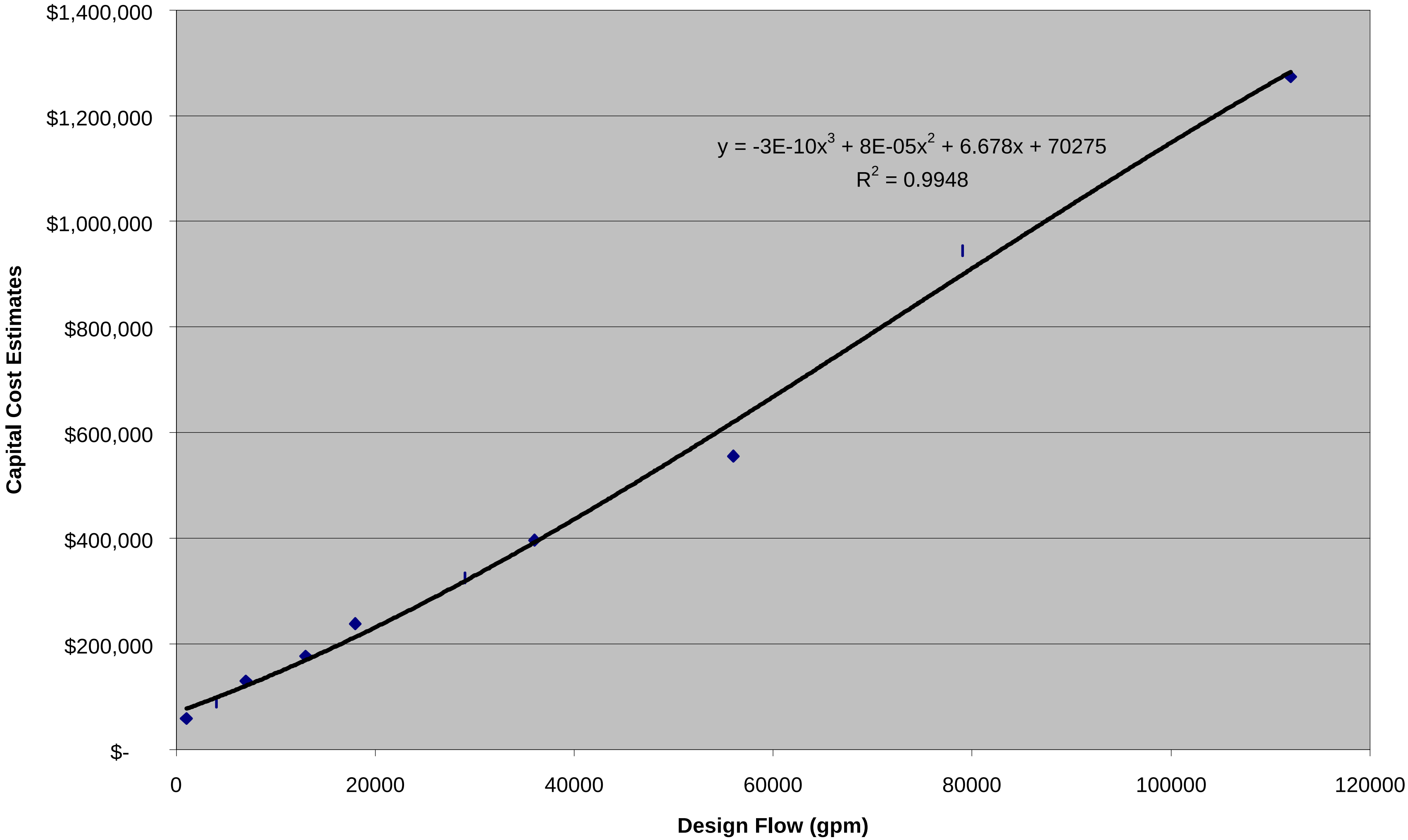


Chart 4. Total Cost of Steel Pipe Extension Using Bottom-pull Laying Method

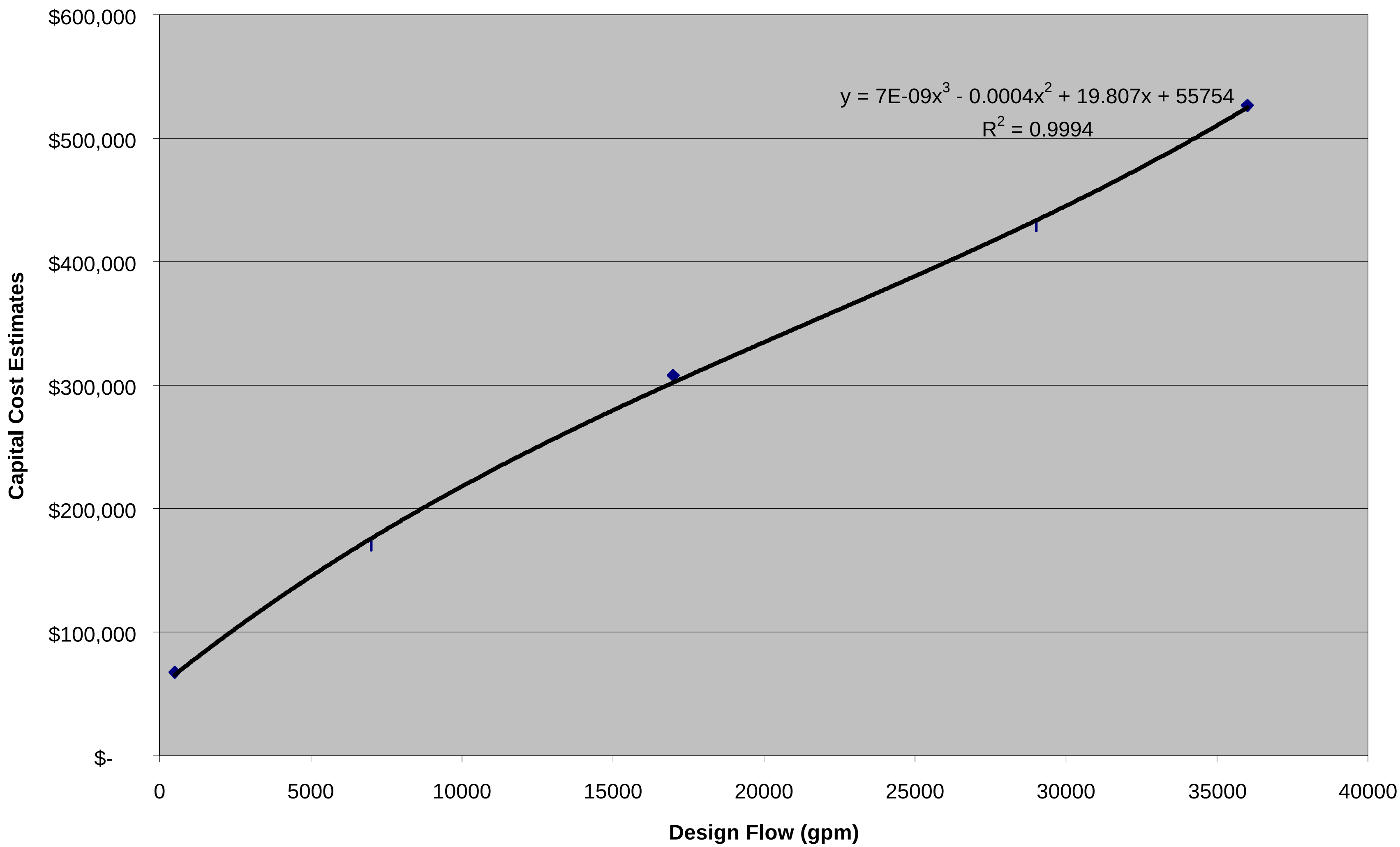


Chart 5. Capital Cost for Extending Intake Pipe 125 Meters Using Micro Tunneling Techniques - Steel Pipe

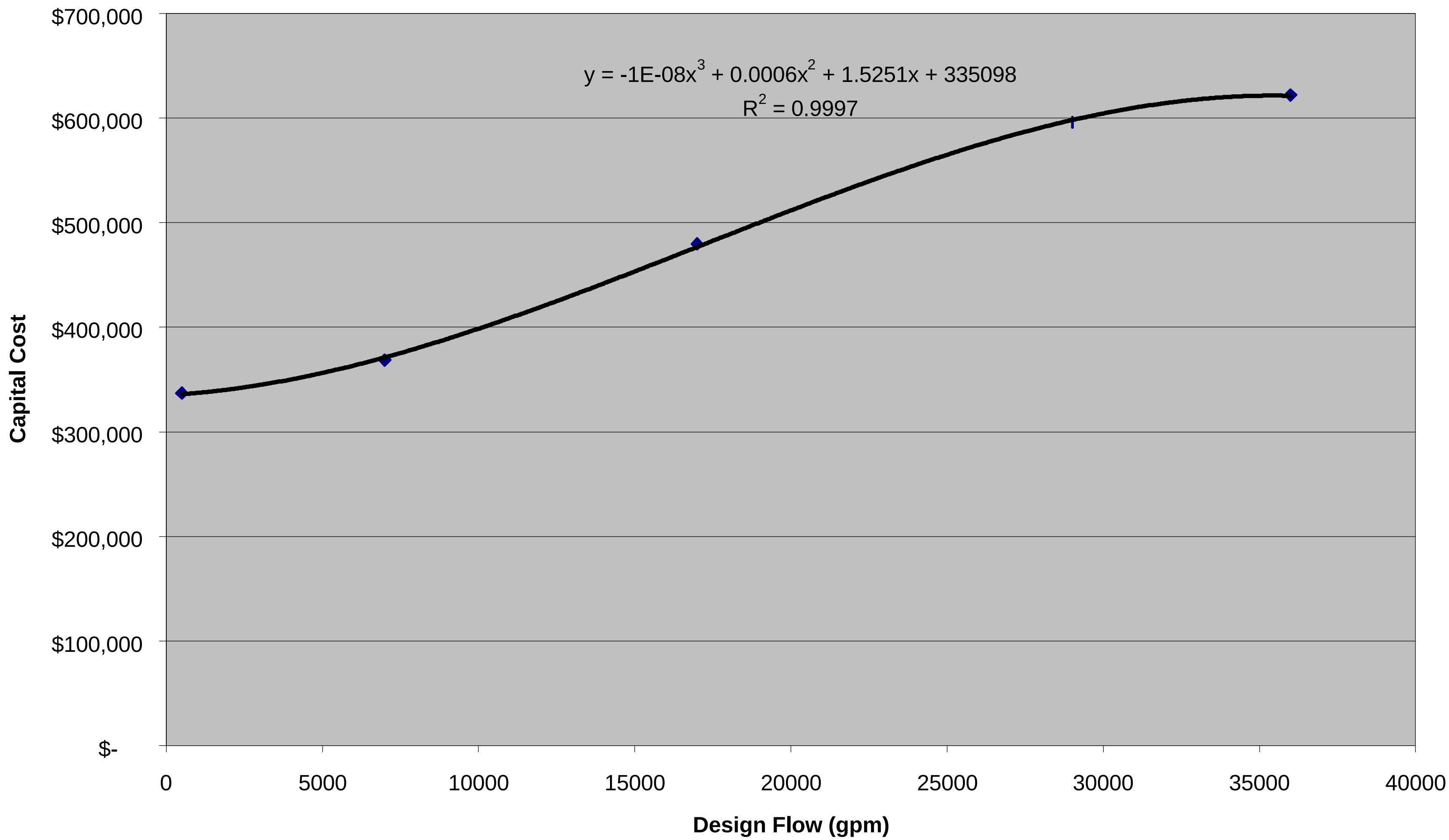


Chart 6. Microtunelling Technique
Capital Cost for 125 meter pipe extension - concrete pipe

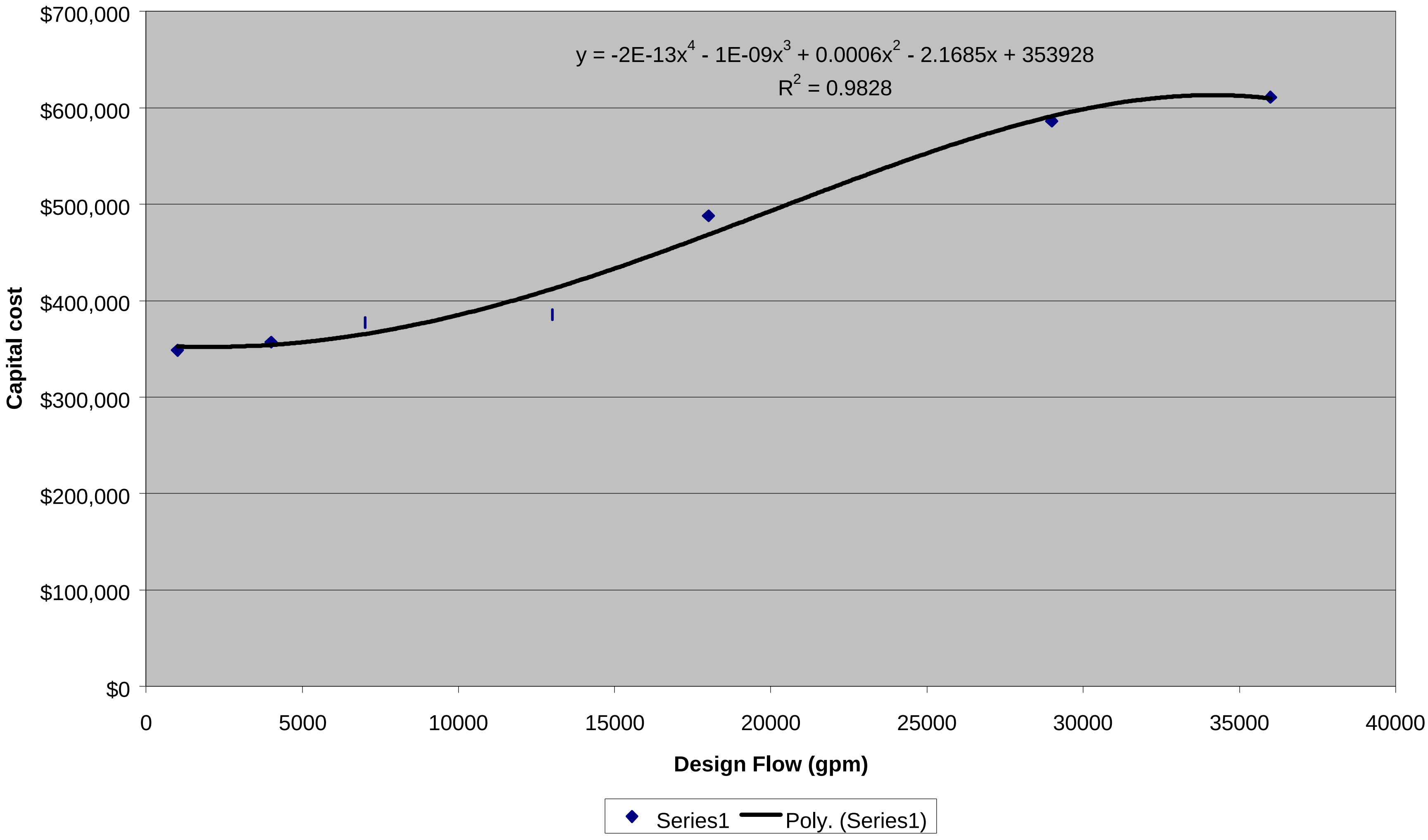


Chart 7. Canal Dredging and Widening Cost

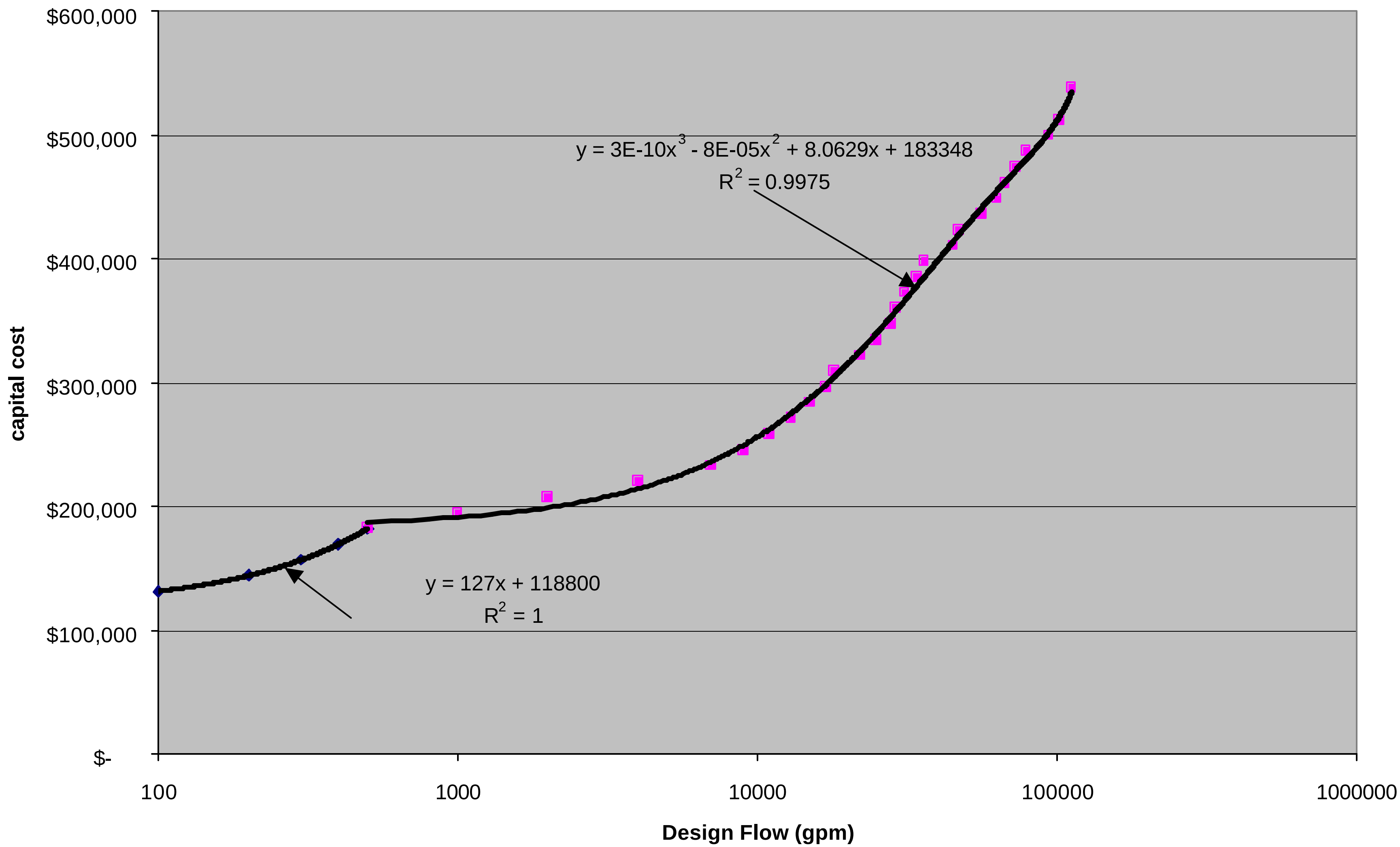
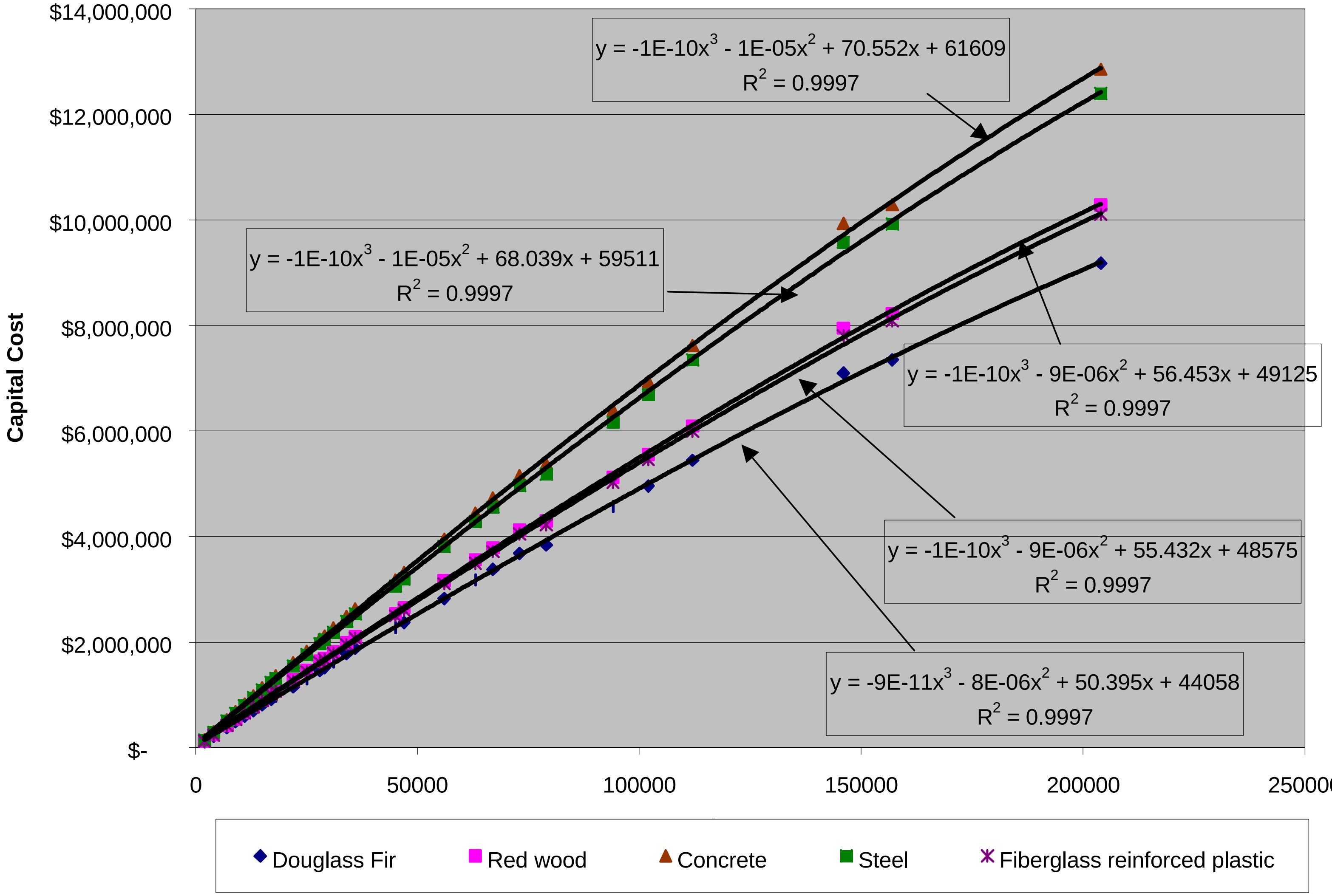


Chart 8. Capital Costs of Basic Cooling Towers with Various Building Material (Delta 10 Degrees)



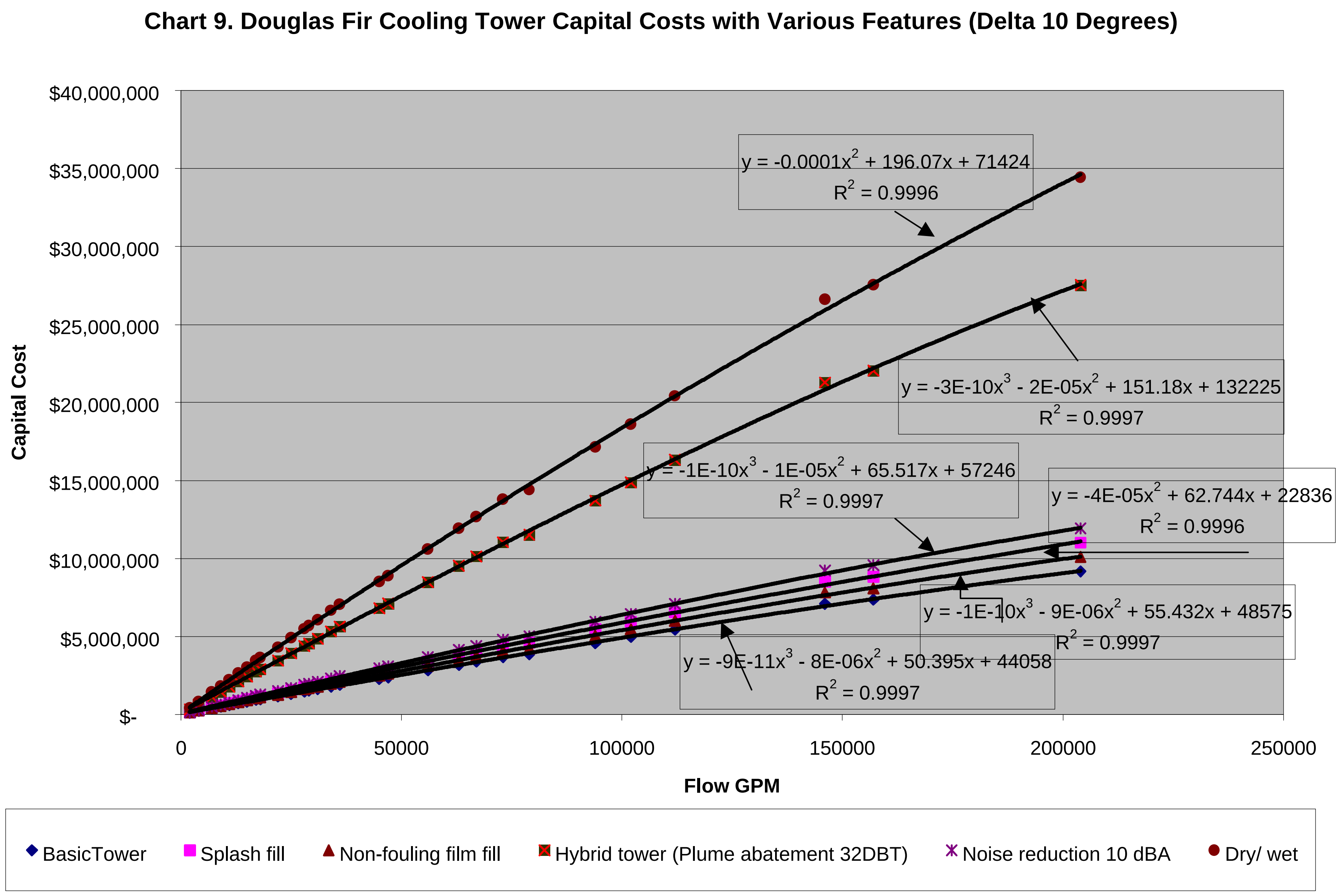


Chart 9. Douglas Fir Cooling Tower Capital Costs with Various Features (Delta 10 Degrees)
$40,000,000
$35,000,000
$30,000,000
$25,000,000
$20,000,000
$15,000,000
$10,000,000
$5,000,000
$-
Capital Cost
0
50000
100000
150000
200000
250000
Flow GPM
y = -0.0001x2 + 196.07x + 71424
R2 = 0.9996
y = -3E-10x3 - 2E-05x2 + 151.18x + 132225
R2 = 0.9997
y = -1E-10x3 - 1E-05x2 + 65.517x + 57246
R2 = 0.9997
y = -4E-05x2 + 62.744x + 22836
R2 = 0.9996
y = -1E-10x3 - 9E-06x2 + 55.432x + 48575
R2 = 0.9997
y = -9E-11x3 - 8E-06x2 + 50.395x + 44058
R2 = 0.9997
BasicTower
Splash fill
Non-fouling film fill
Hybrid tower (Plume abatement 32DBT)
Noise reduction 10 dBA
Dry/ wet

Chart 10. Red Wood Cooling Tower Capital Costs with Various Features (Delta 10 Degrees)

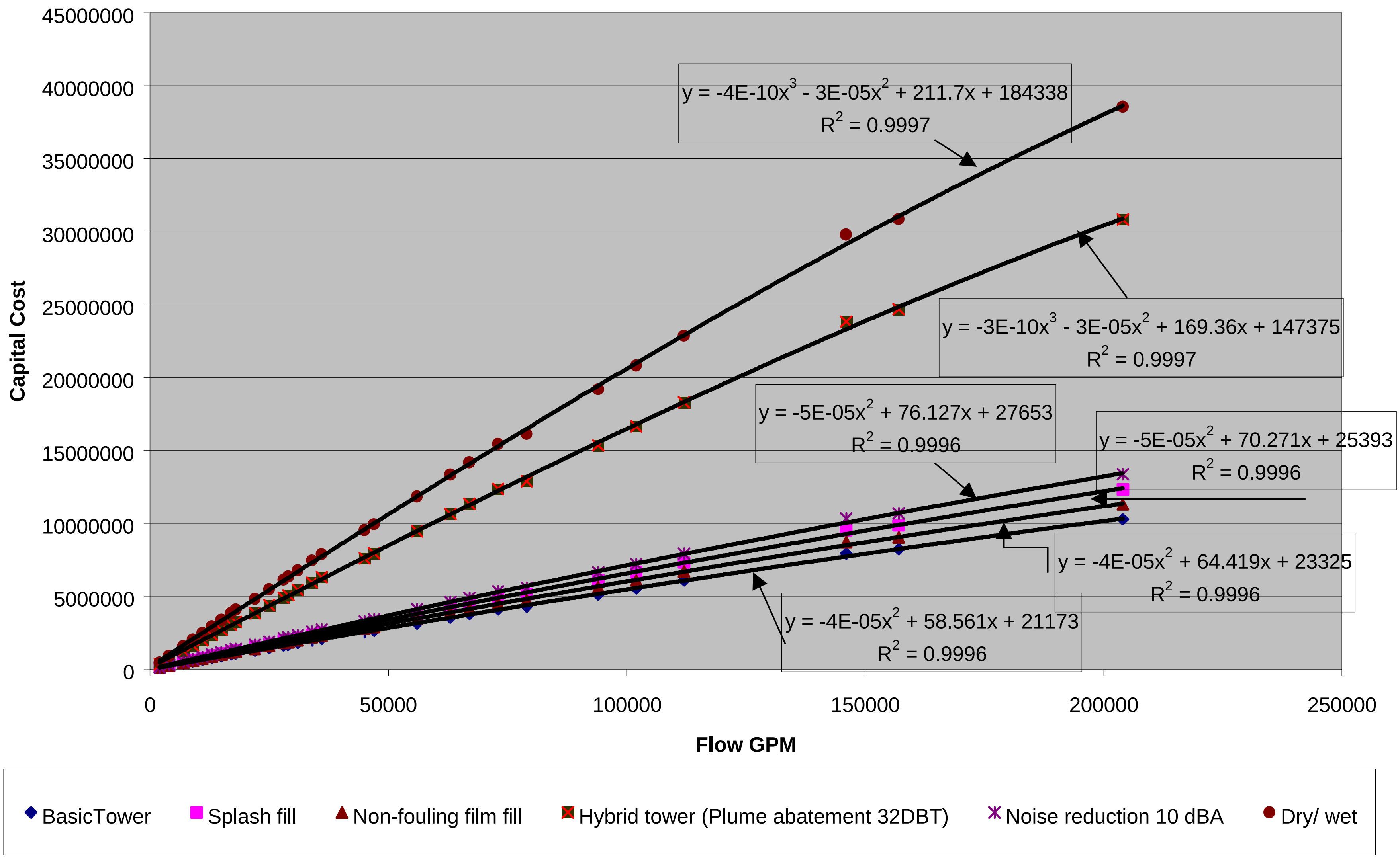


Chart 11. Concrete Cooling Tower Capital Costs with Various Features (Delta 10 Degrees)

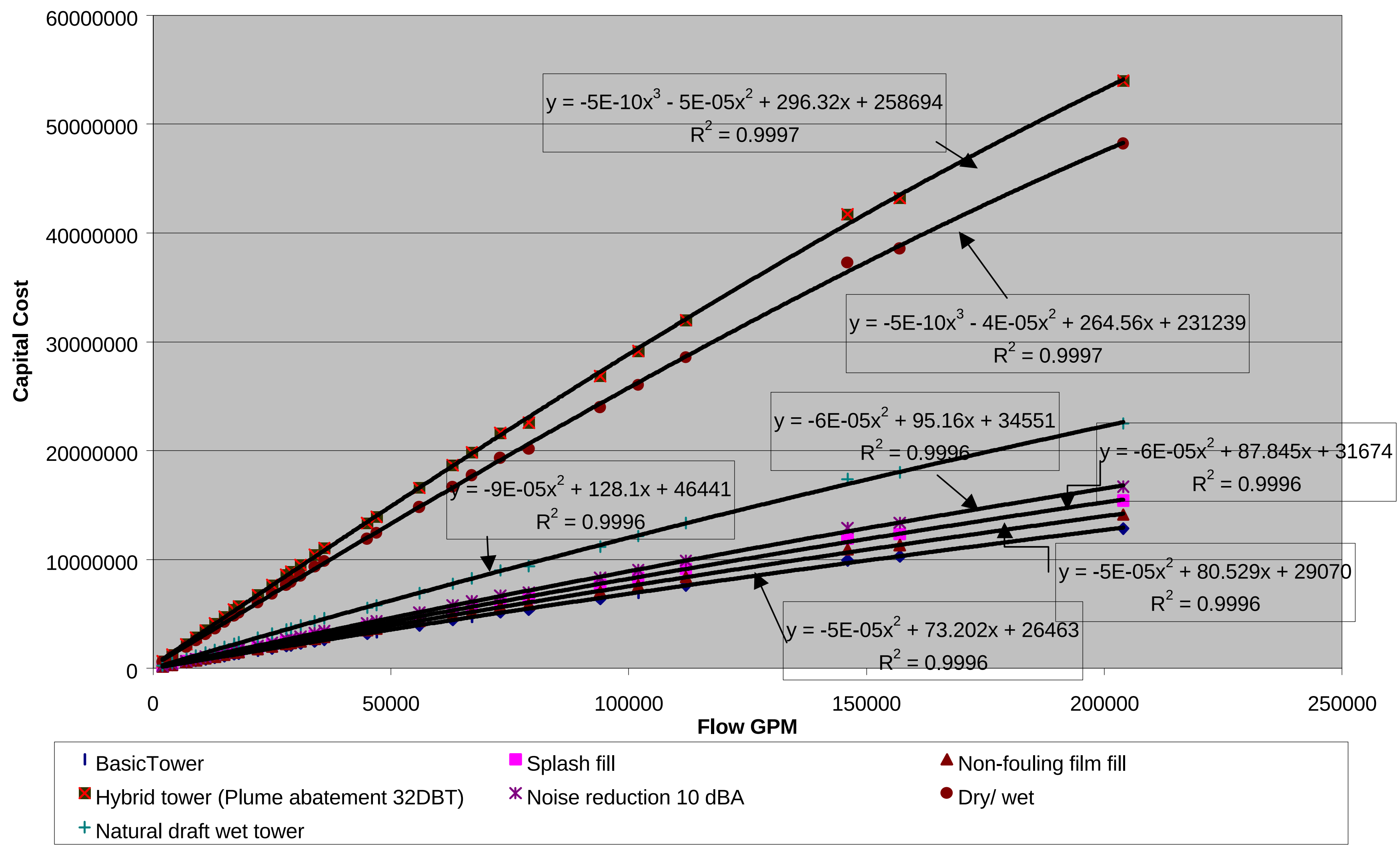


Chart 12. Steel Cooling Tower Capital Costs with Various Features (Delta 10 Degrees)

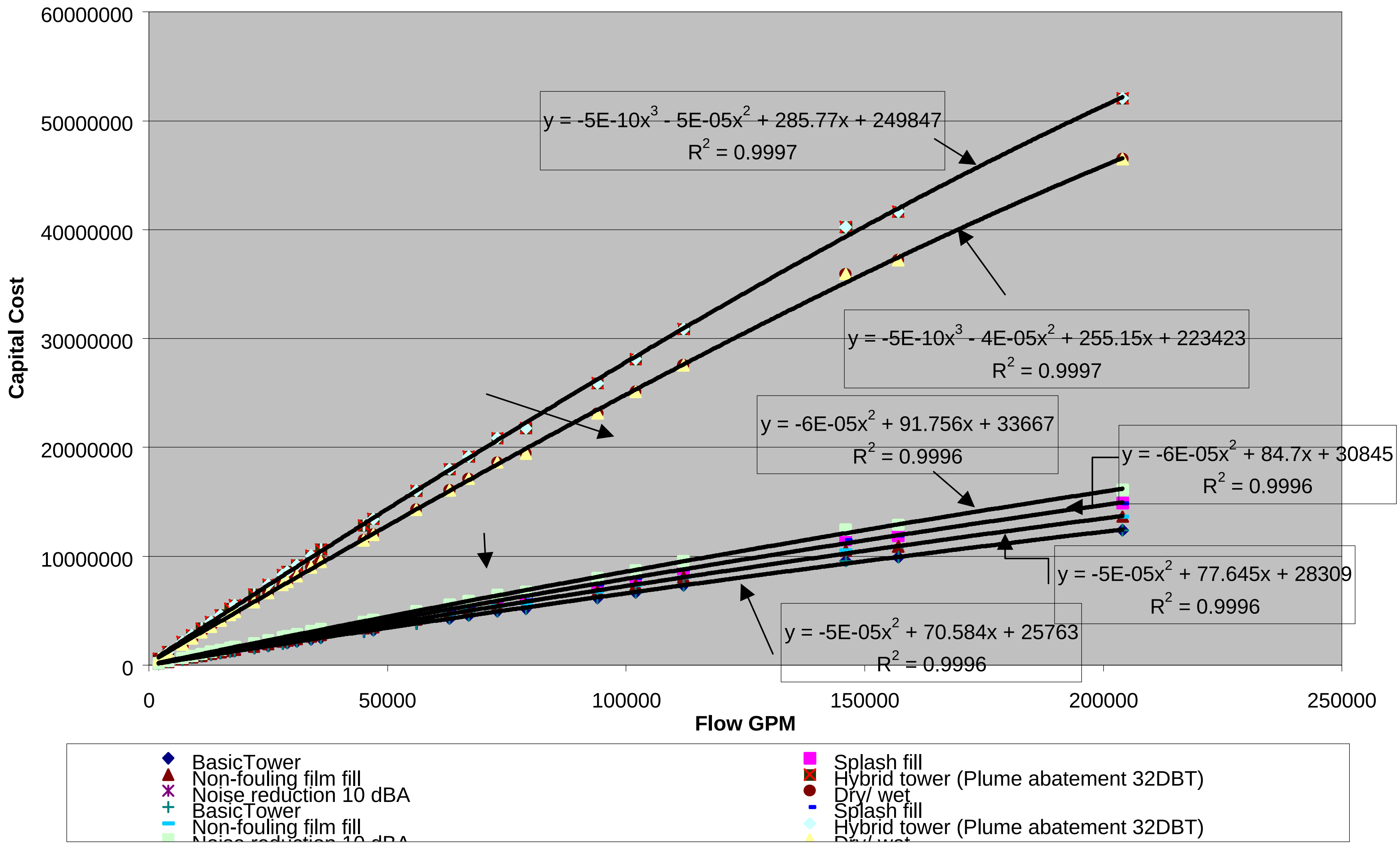
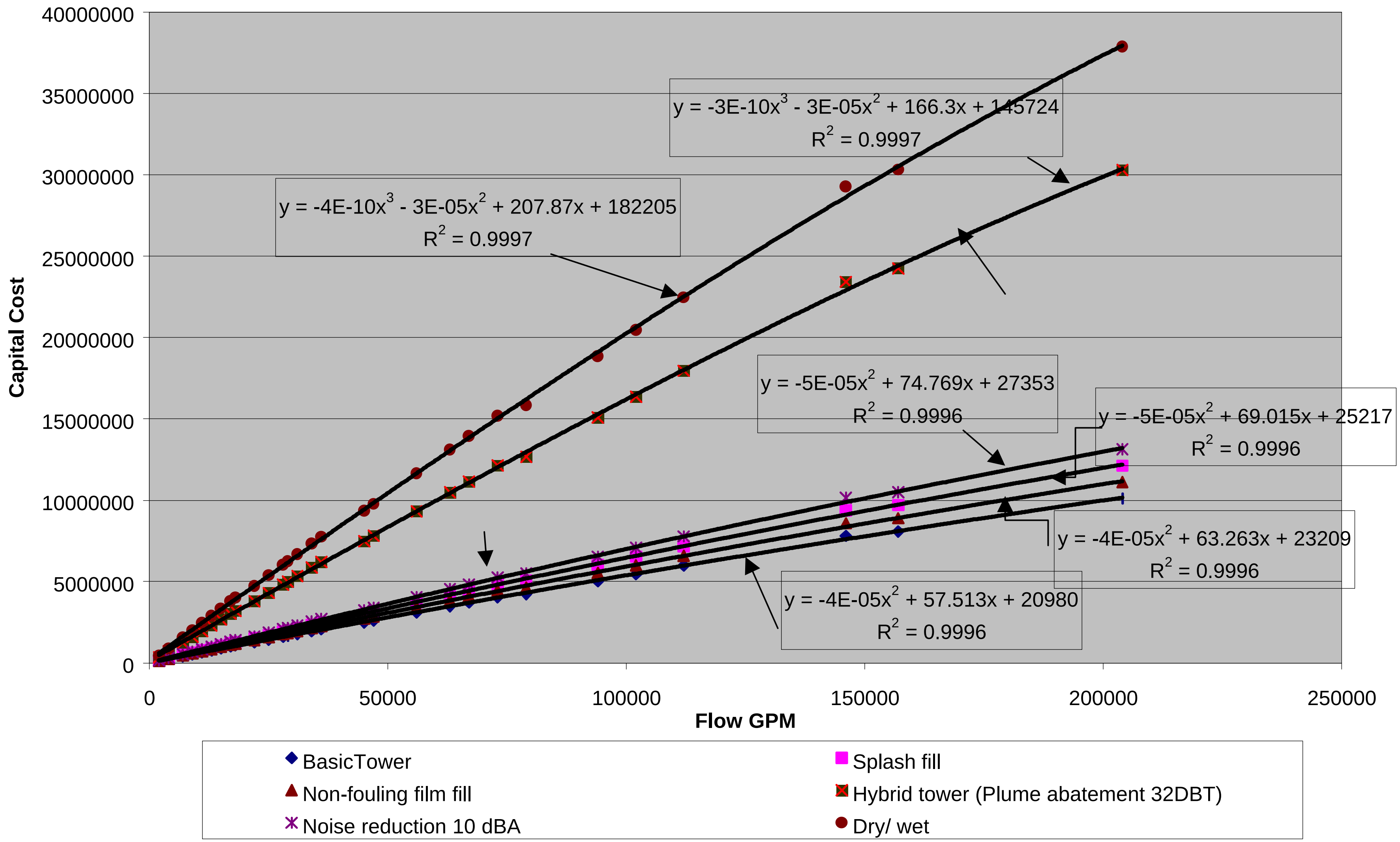


Chart 13. Fiberglass Cooling Tower Capital Costs with Various Features (Delta 10 Degrees)



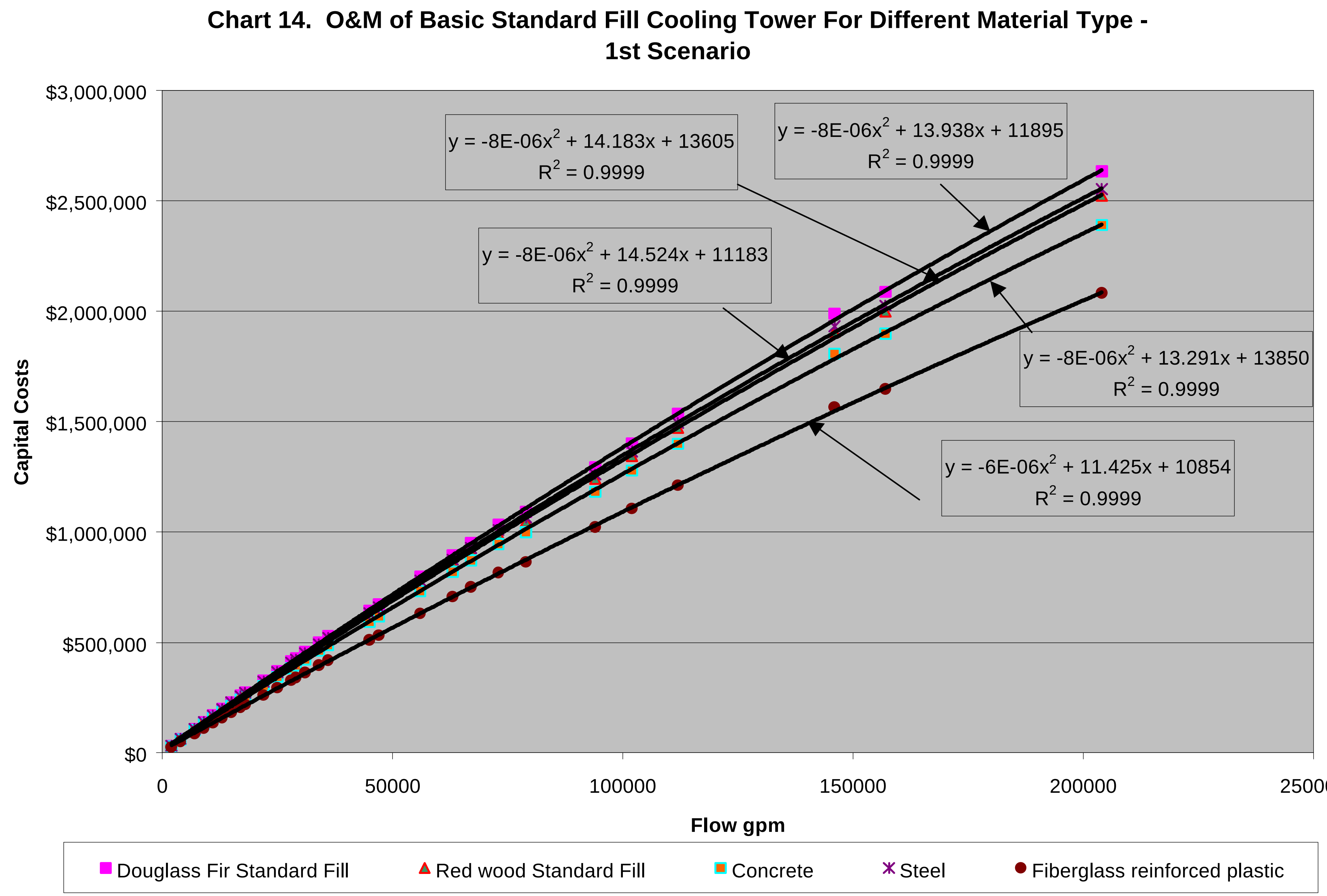


Chart 14. O&M of Basic Standard Fill Cooling Tower For Different Material Type - 1st Scenario
Capital Costs
Flow gpm
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0
0
50000
100000
150000
200000
250000
y = -8E-06x2 + 14.183x + 13605
R2 = 0.9999
y = -8E-06x2 + 13.938x + 11895
R2 = 0.9999
y = -8E-06x2 + 14.524x + 11183
R2 = 0.9999
y = -8E-06x2 + 13.291x + 13850
R2 = 0.9999
y = -6E-06x2 + 11.425x + 10854
R2 = 0.9999
Douglass Fir Standard Fill
Red wood Standard Fill
Concrete
Steel
Fiberglass reinforced plastic

Chart 15. O&M of Basic Standard Fill Cooling Tower For Different Material Type - 2nd Scenario

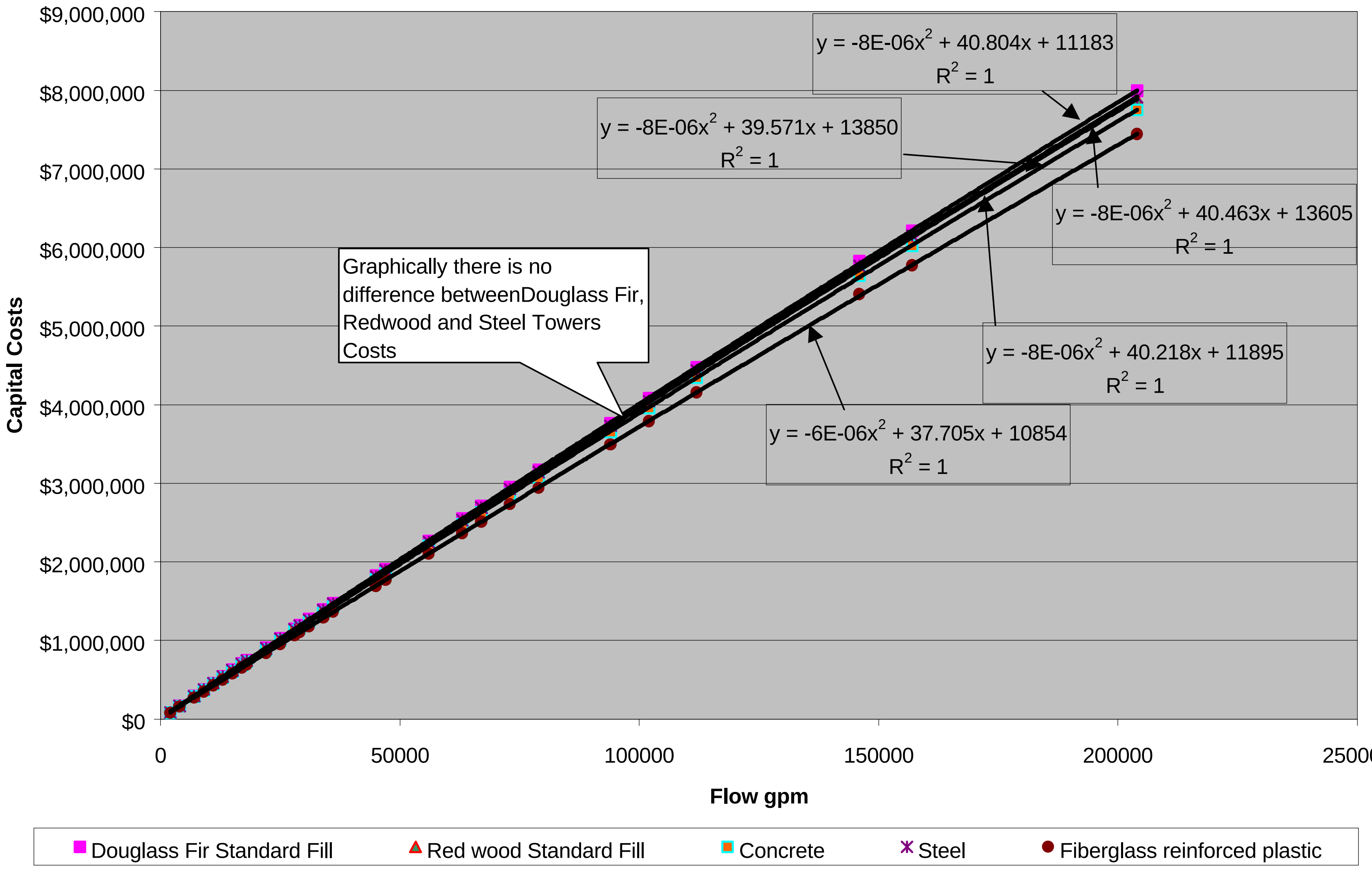
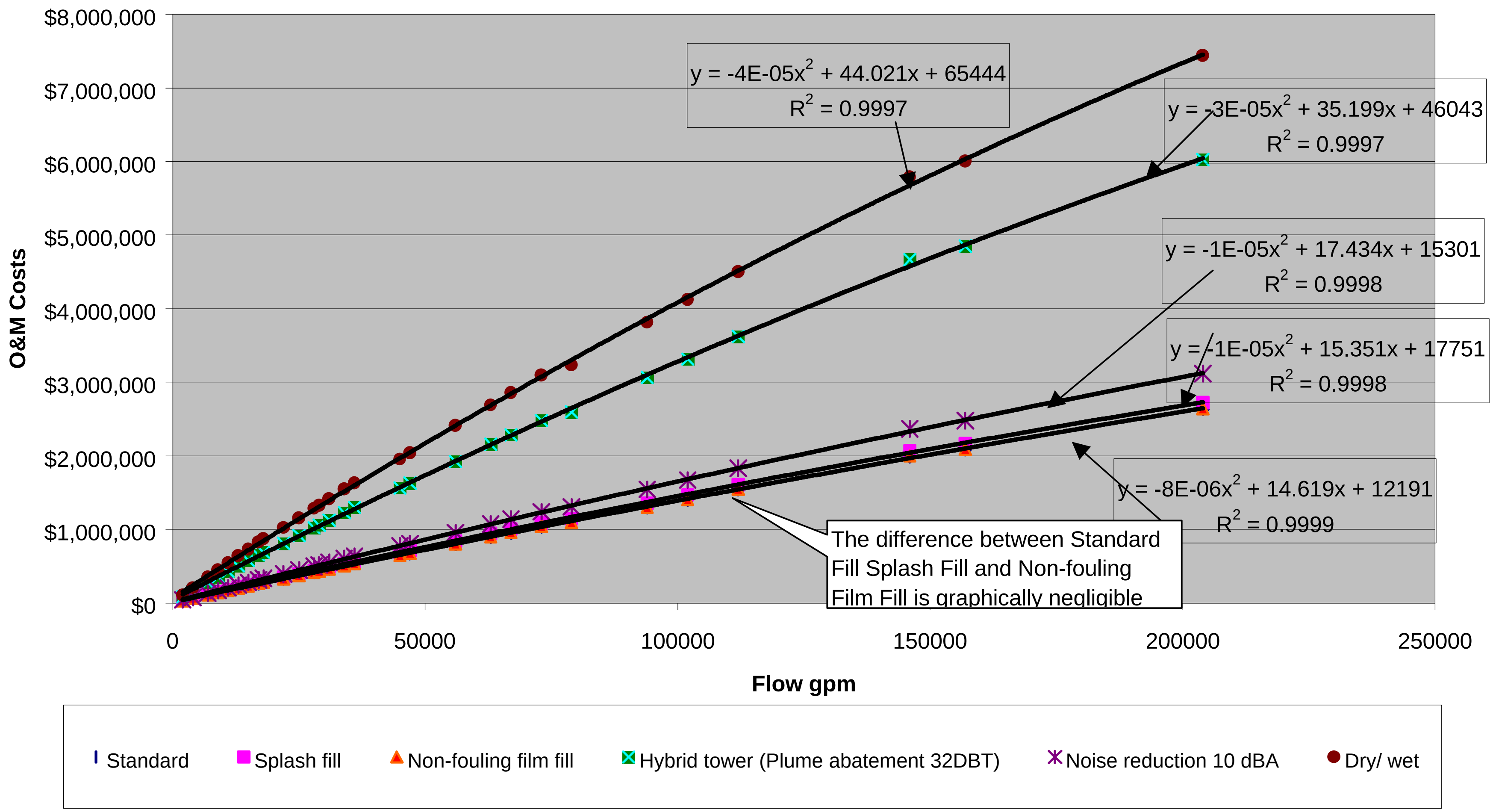


Chart 16. Total O&M Douglas Fir Tower Annual Cost - 1st Scenario



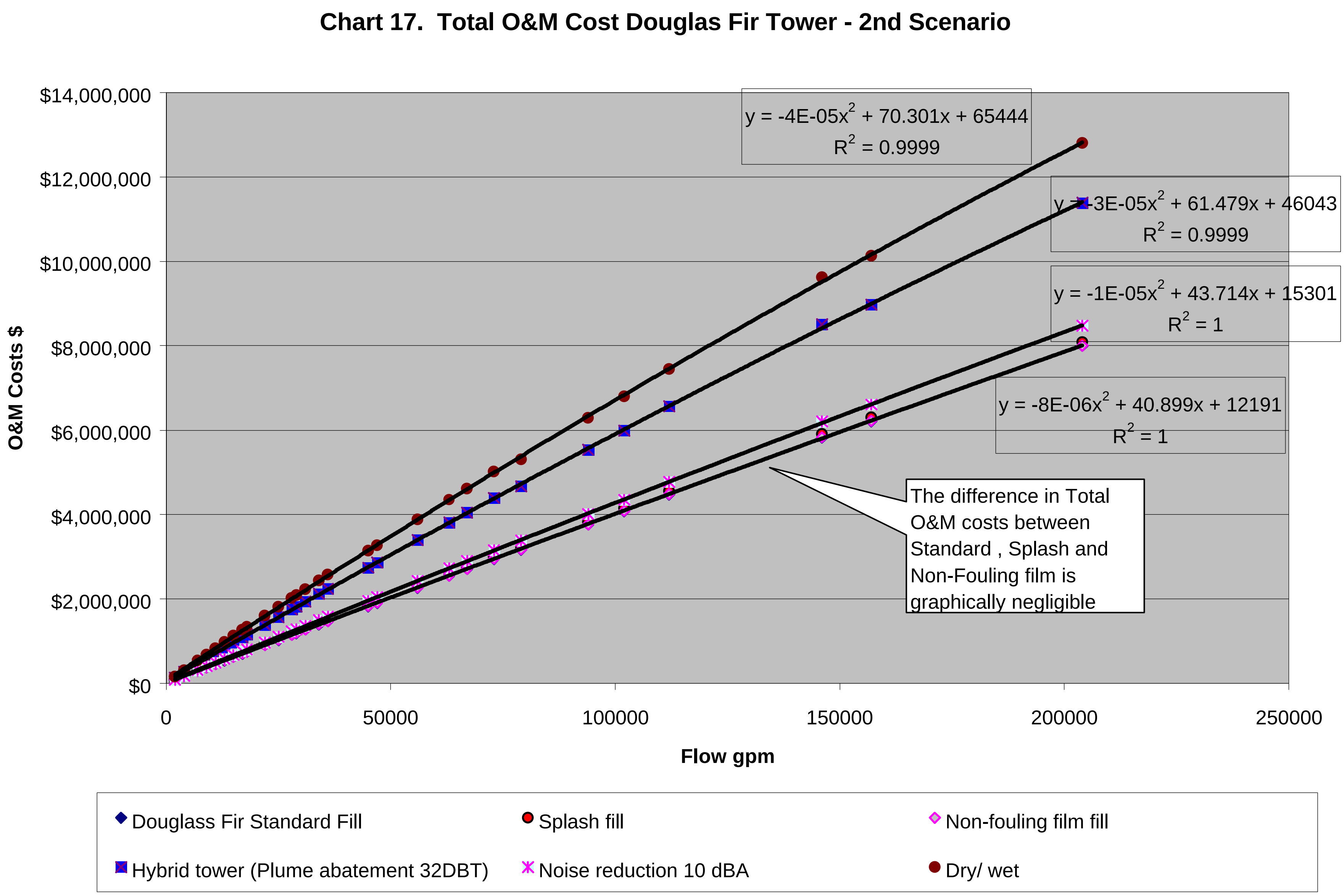


Chart 17. Total O&M Cost Douglas Fir Tower - 2nd Scenario
$14,000,000
$12,000,000
$10,000,000
$8,000,000
$6,000,000
$4,000,000
$2,000,000
$0
O&M Costs $
0
50000
100000
150000
200000
250000
Flow gpm
y = -4E-05x2 + 70.301x + 65444
R2 = 0.9999
y = -3E-05x2 + 61.479x + 46043
R2 = 0.9999
y = -1E-05x2 + 43.714x + 15301
R2 = 1
y = -8E-06x2 + 40.899x + 12191
R2 = 1
The difference in Total O&M costs between Standard , Splash and Non-Fouling film is graphically negligible
Douglass Fir Standard Fill
Splash fill
Non-fouling film fill
Hybrid tower (Plume abatement 32DBT)
Noise reduction 10 dBA
Dry/ wet

Chart 18. Total O&M Cost Douglas Fir Tower - 3rd Scenario

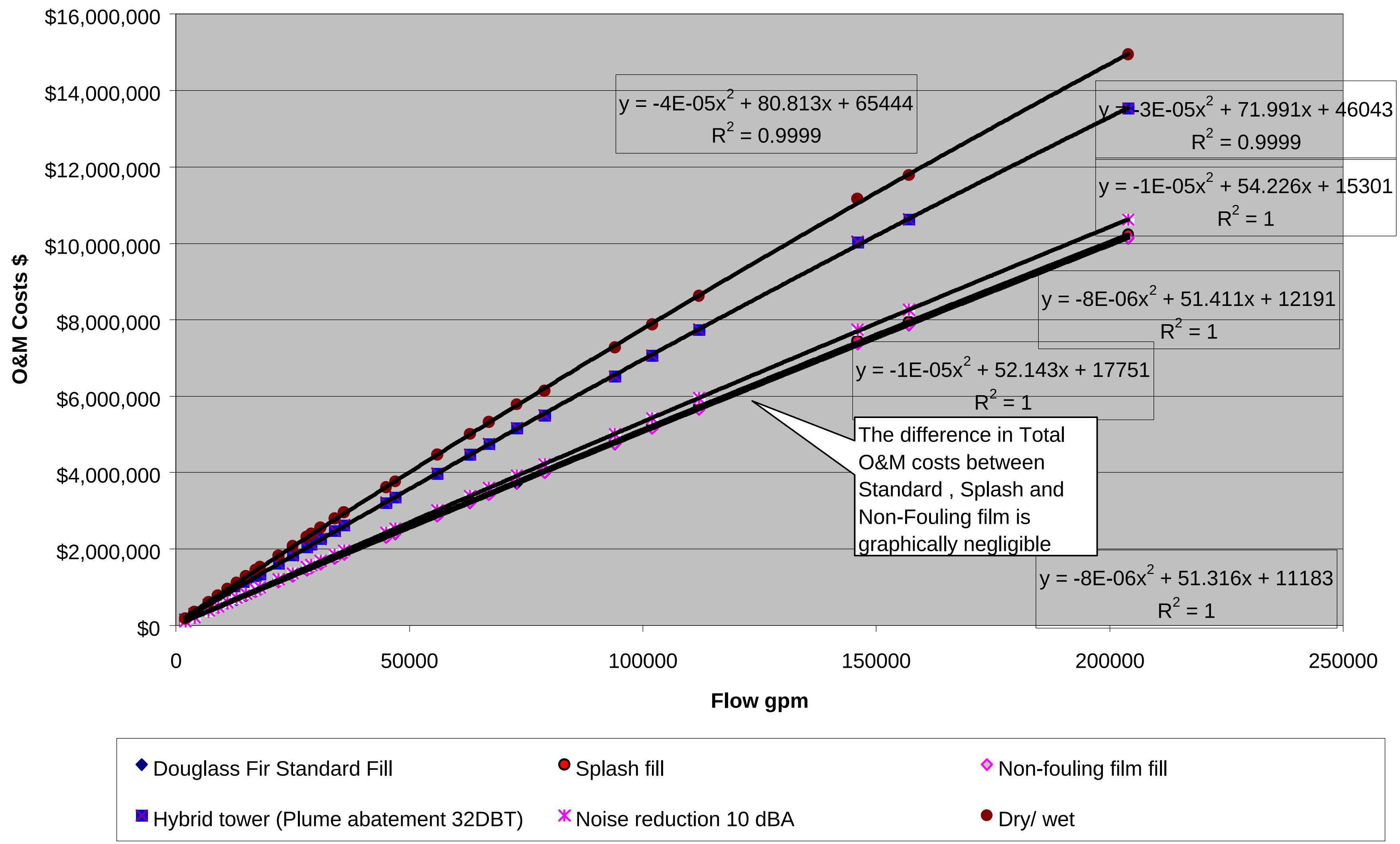


Chart 19. O&M Red Wood Tower Annual Costs - 1st Scenario

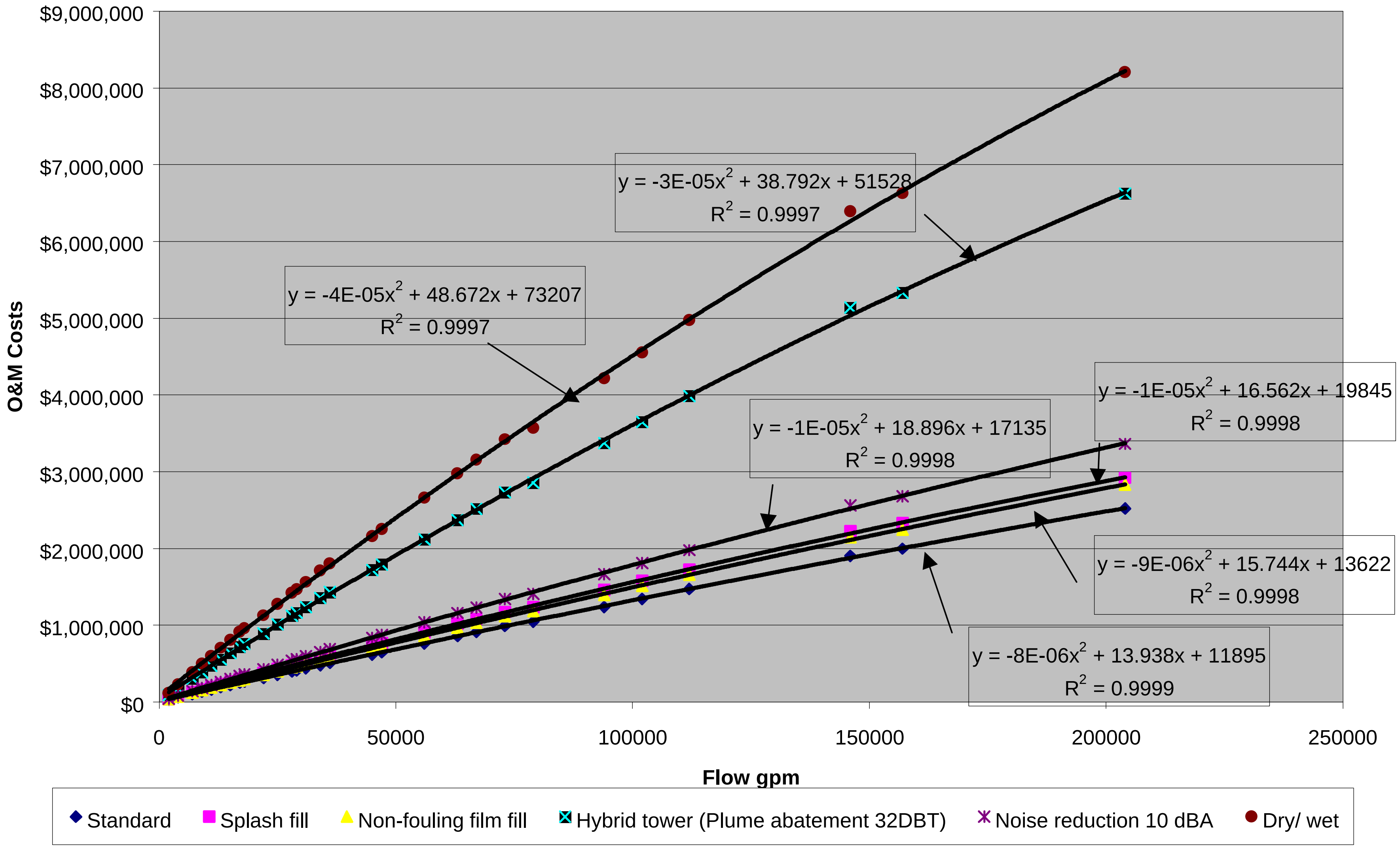


Chart 20. O&M Red Wood Tower Annual Costs - 2nd Scenario

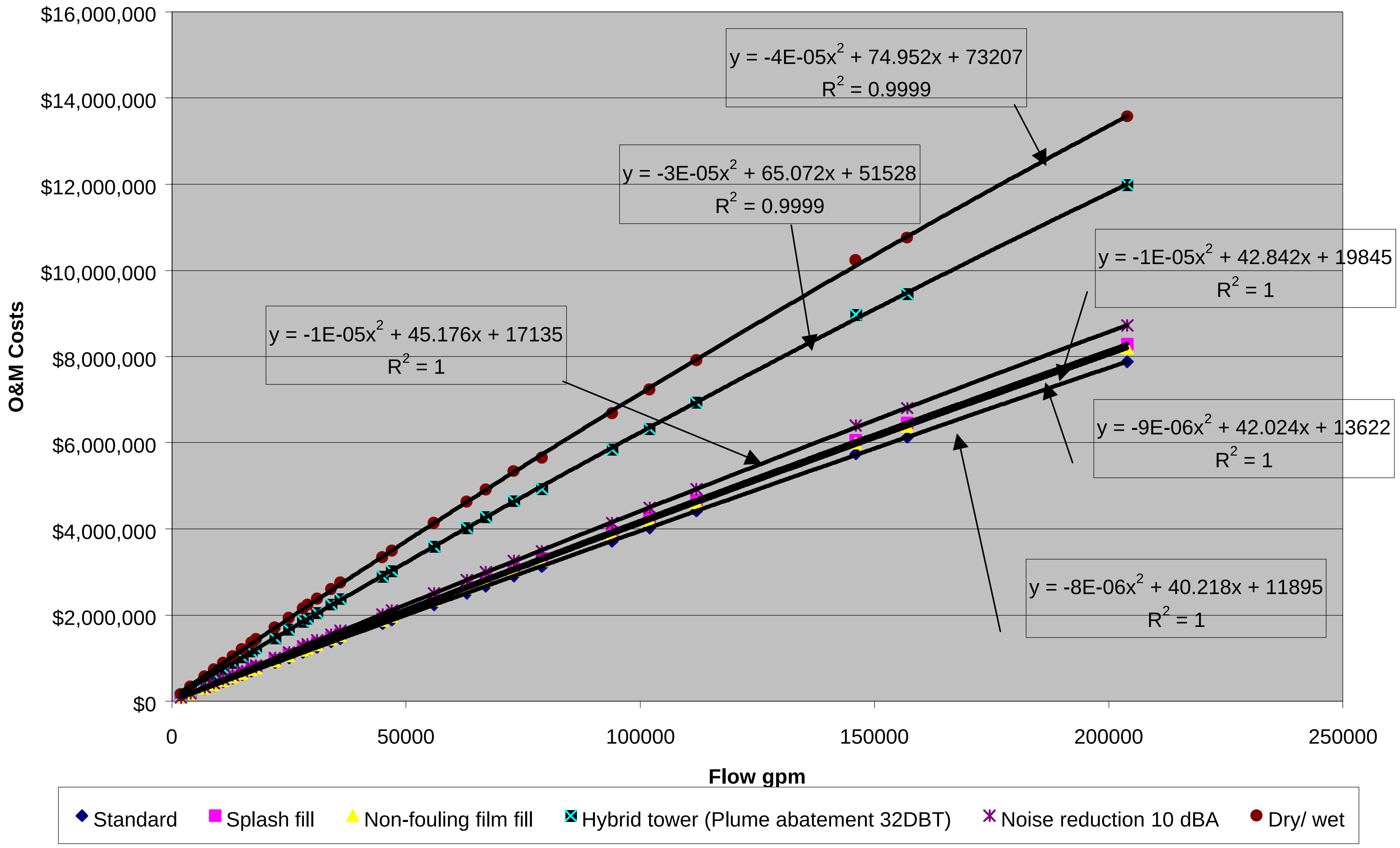


Chart 21. O&M Concrete Tower Annual Costs - 1st Scenario

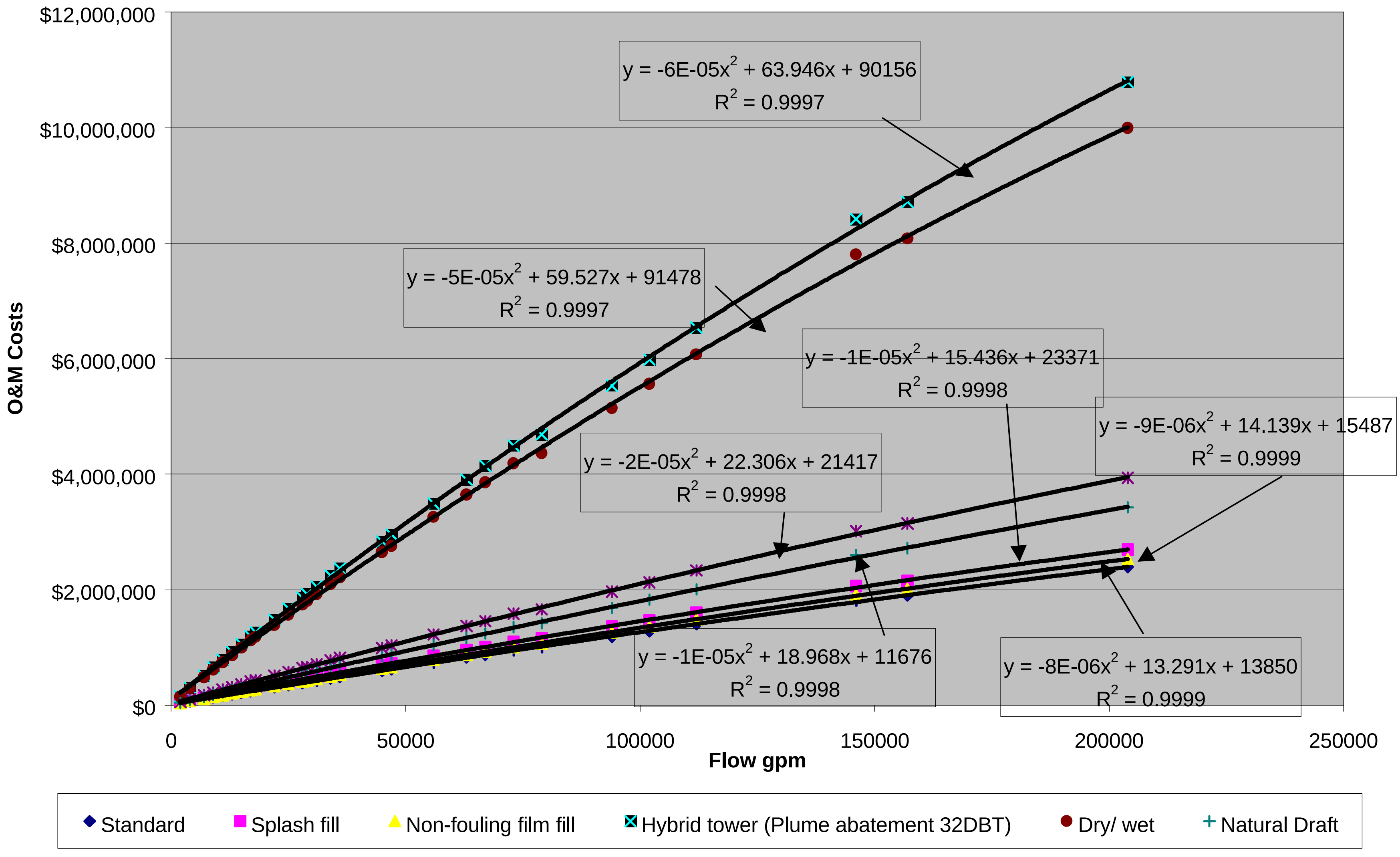


Chart 22. O&M Concrete Tower Annual Costs - 2nd Scenario

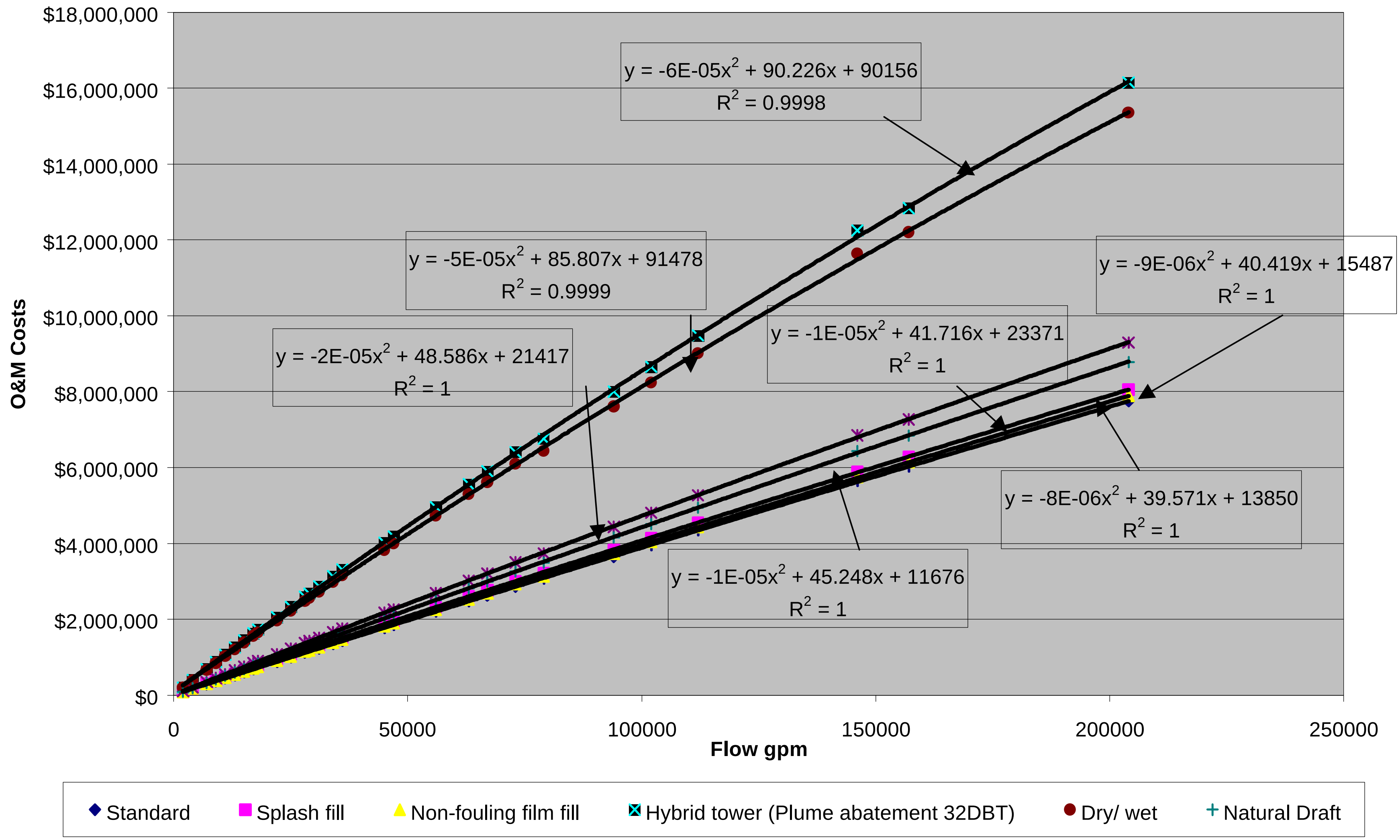


Chart 23. O&M Steel Tower Annual Costs - 1st Scenario

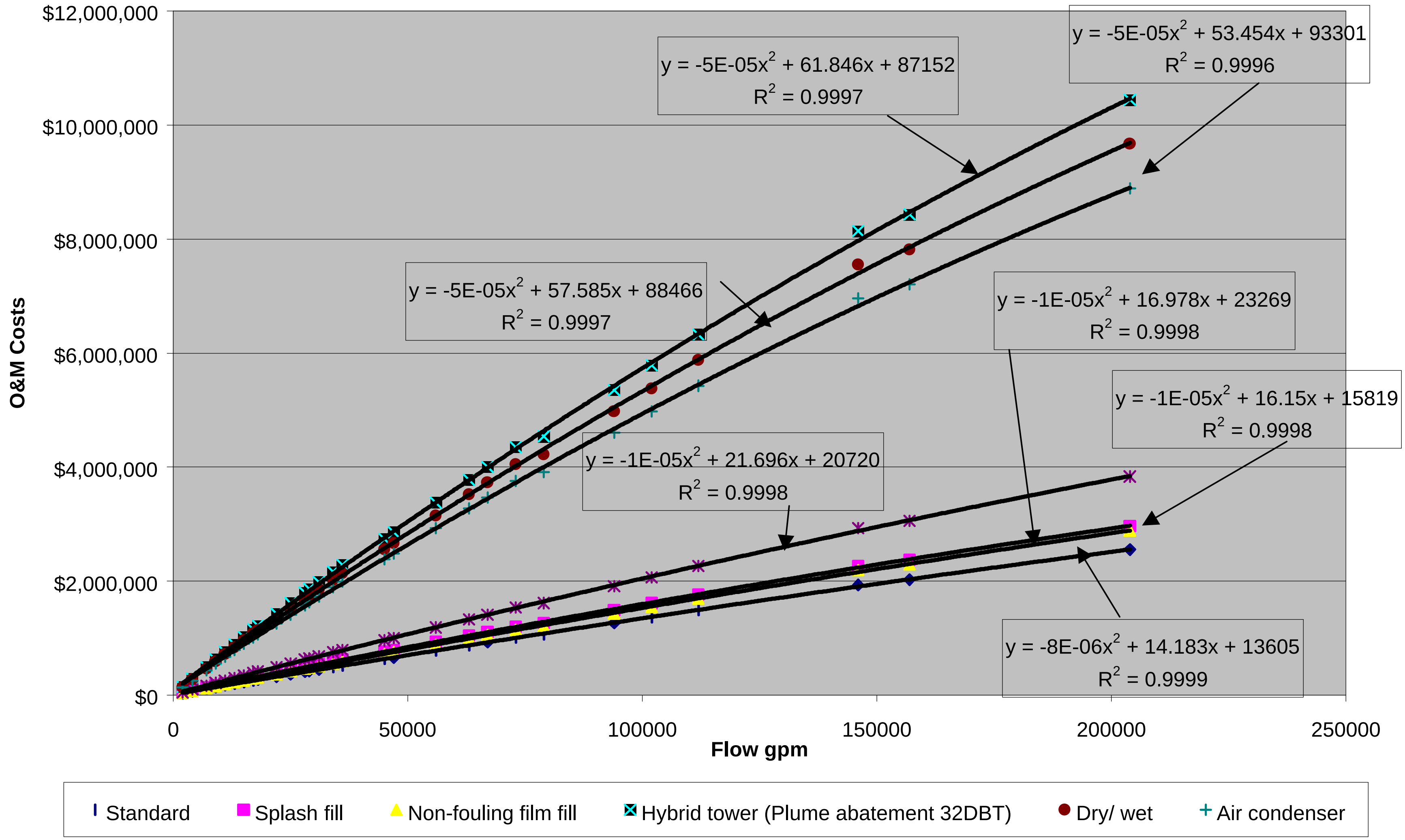
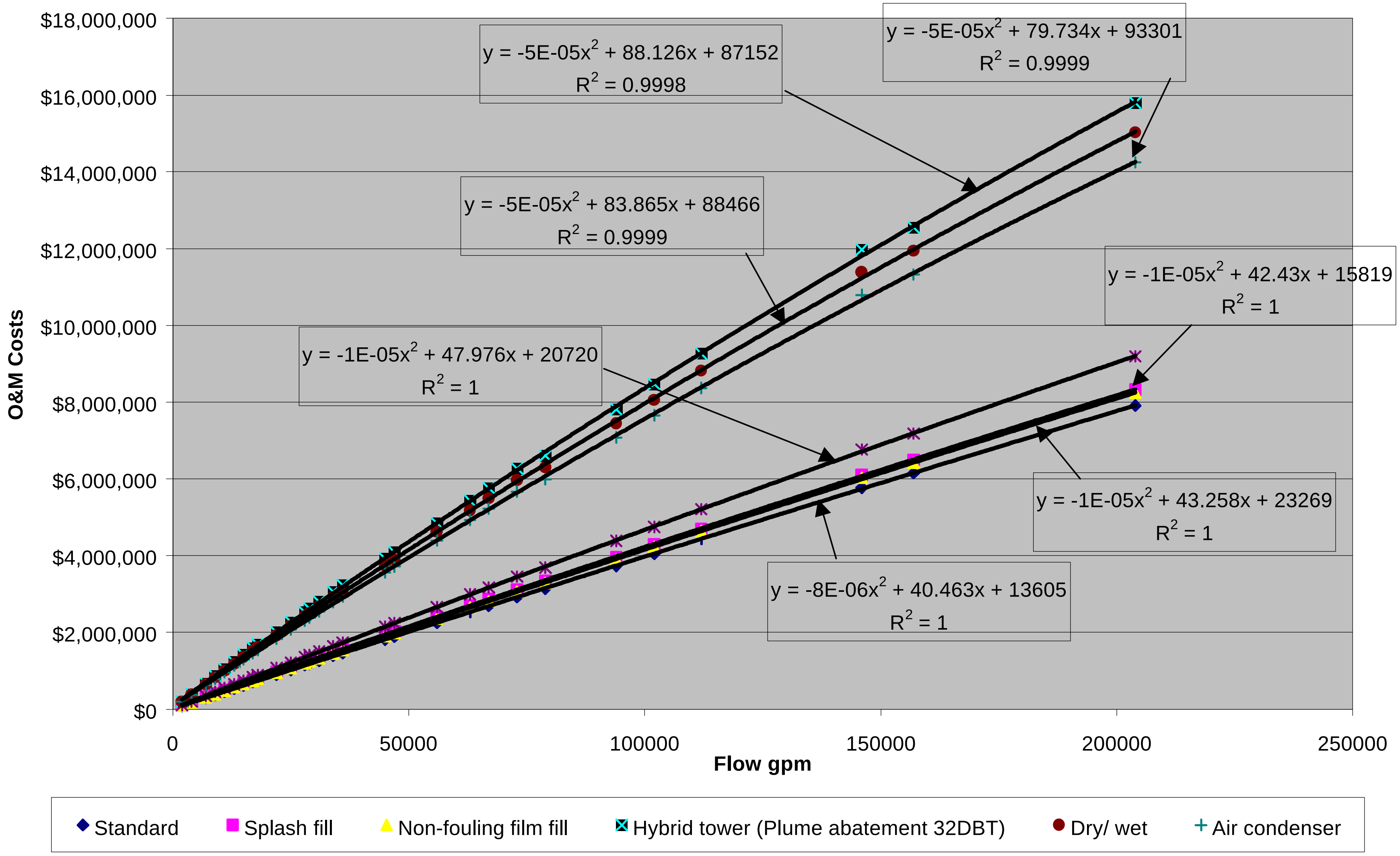


Chart 24. O&M Steel Tower Annual Costs - 2nd Scenario



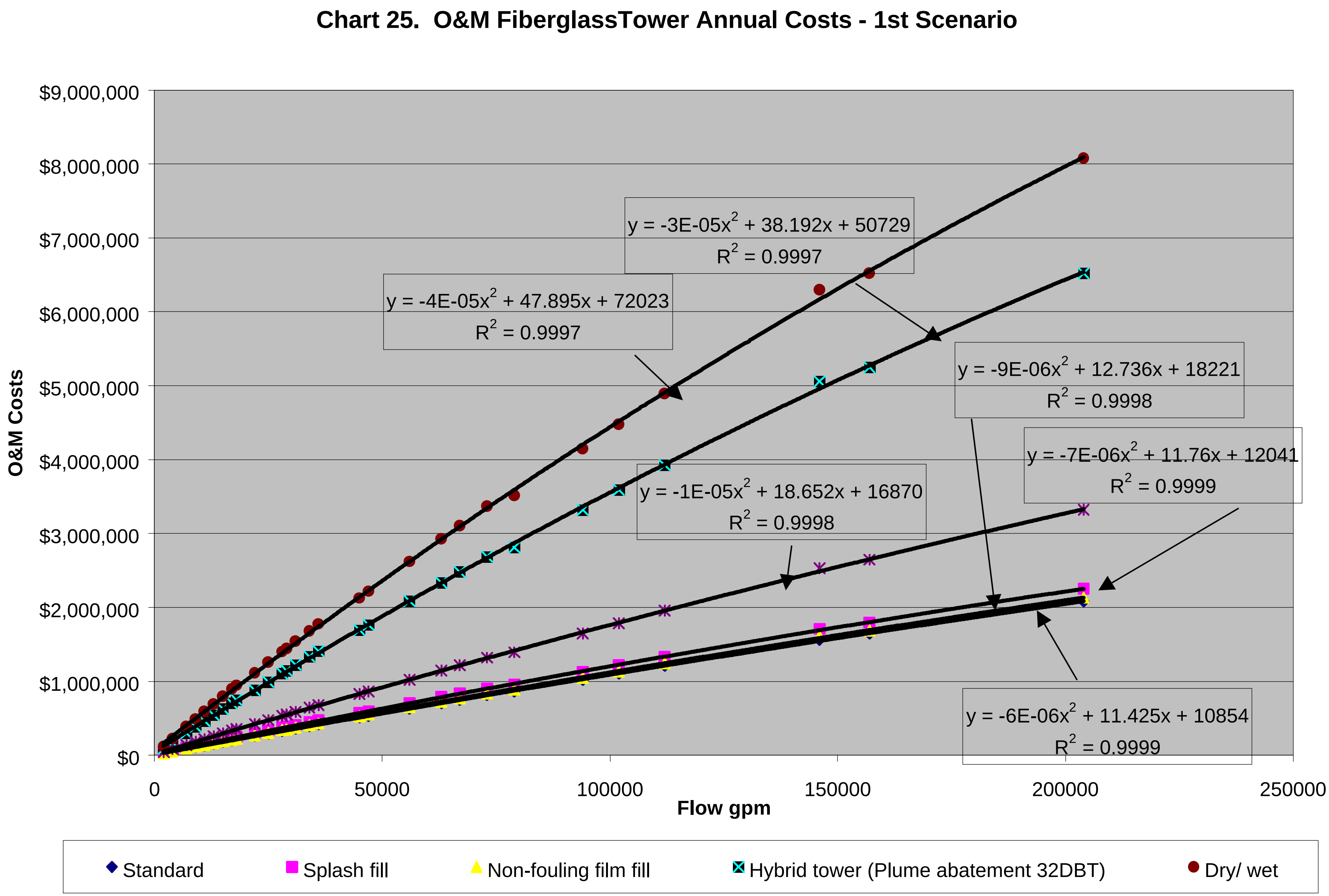
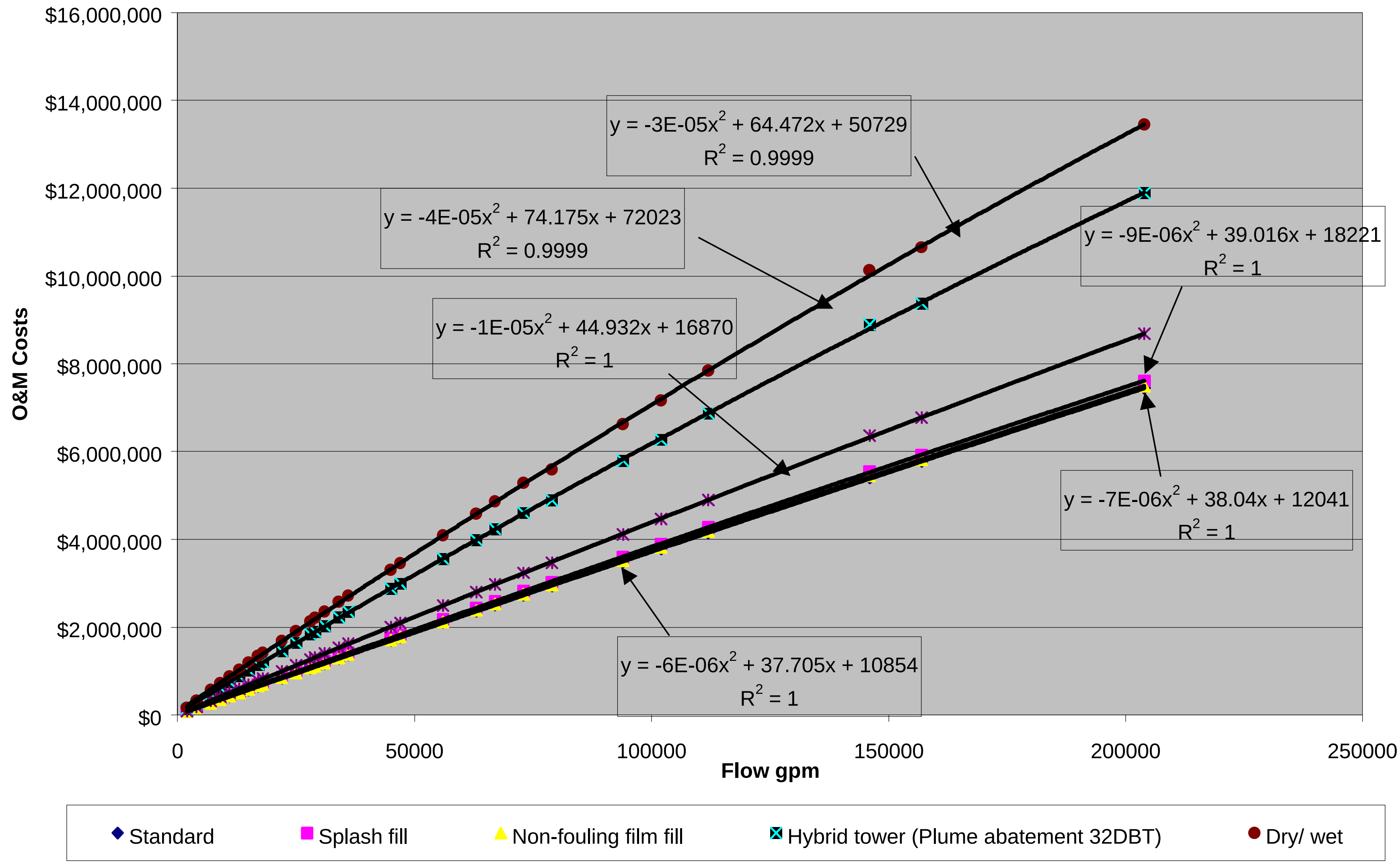


Chart 25. O&M FiberglassTower Annual Costs - 1st Scenario
O&M Costs
$9,000,000
$8,000,000
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
0
50000
100000
150000
200000
250000
Flow gpm
y = -3E-05x2 + 38.192x + 50729
R2 = 0.9997
y = -4E-05x2 + 47.895x + 72023
R2 = 0.9997
y = -9E-06x2 + 12.736x + 18221
R2 = 0.9998
y = -7E-06x2 + 11.76x + 12041
R2 = 0.9999
y = -1E-05x2 + 18.652x + 16870
R2 = 0.9998
y = -6E-06x2 + 11.425x + 10854
R2 = 0.9999
Standard
Splash fill
Non-fouling film fill
Hybrid tower (Plume abatement 32DBT)
Dry/ wet

Chart 26. O&M FiberglassTower Annual Costs - 2nd Scenario



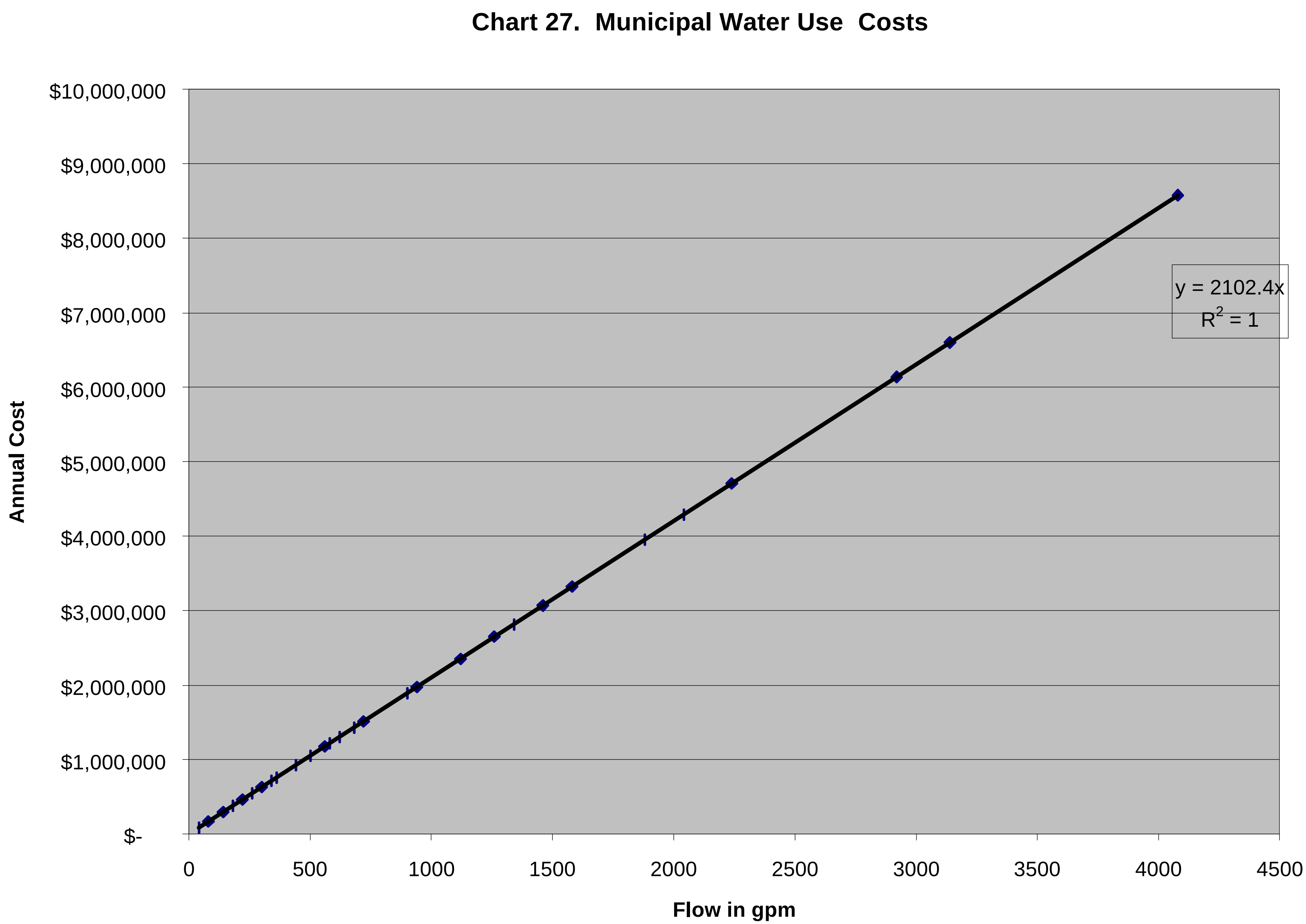


Chart 27. Municipal Water Use Costs
Annual Cost
$10,000,000
$9,000,000
$8,000,000
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$-
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Flow in gpm
y = 2102.4x
$R^2 = 1$

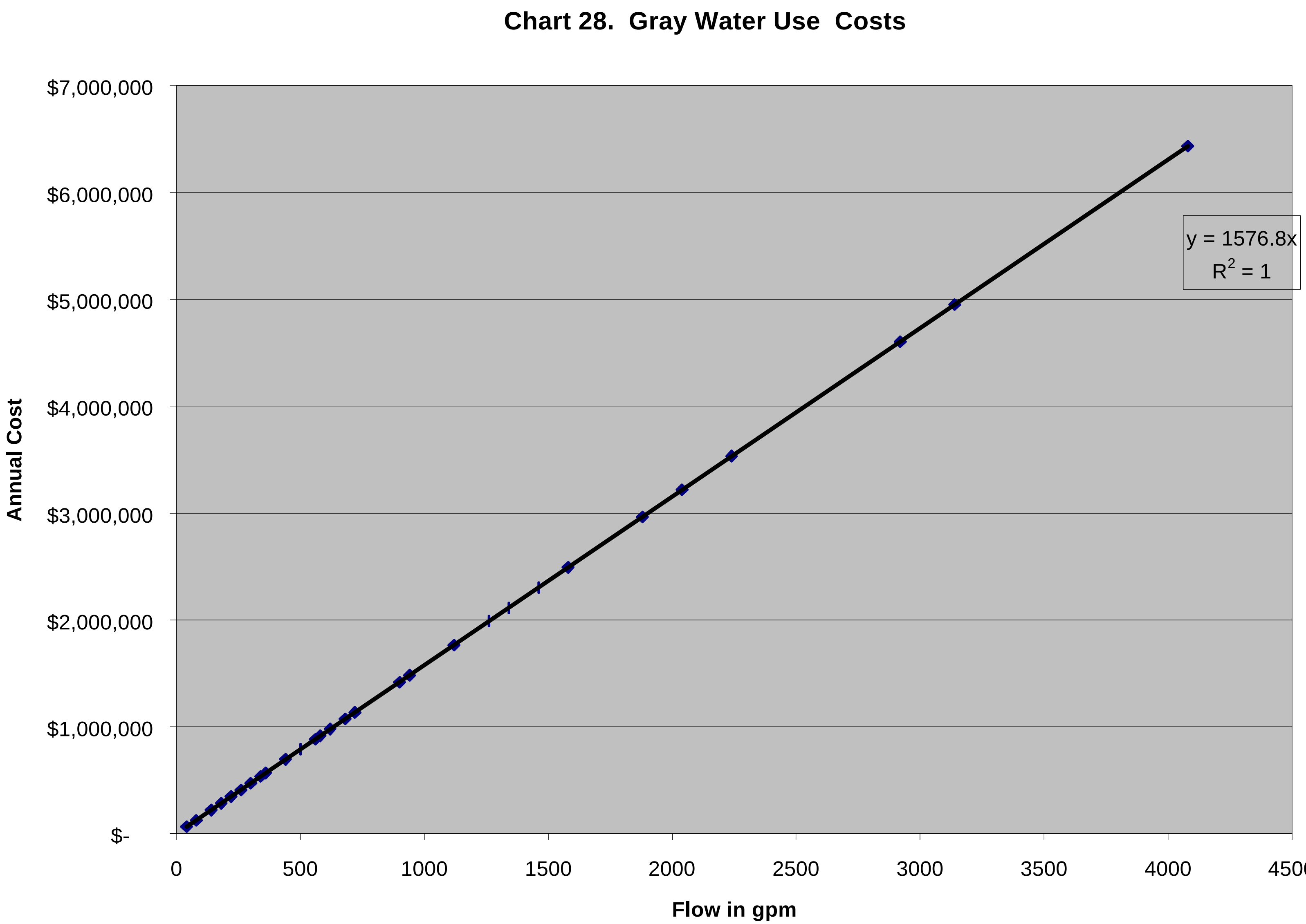


Chart 28. Gray Water Use Costs
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$-
Annual Cost
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Flow in gpm
y = 1576.8x
R2 = 1

Chart 29. Capital Costs of Passive Screens Based on Well Depth

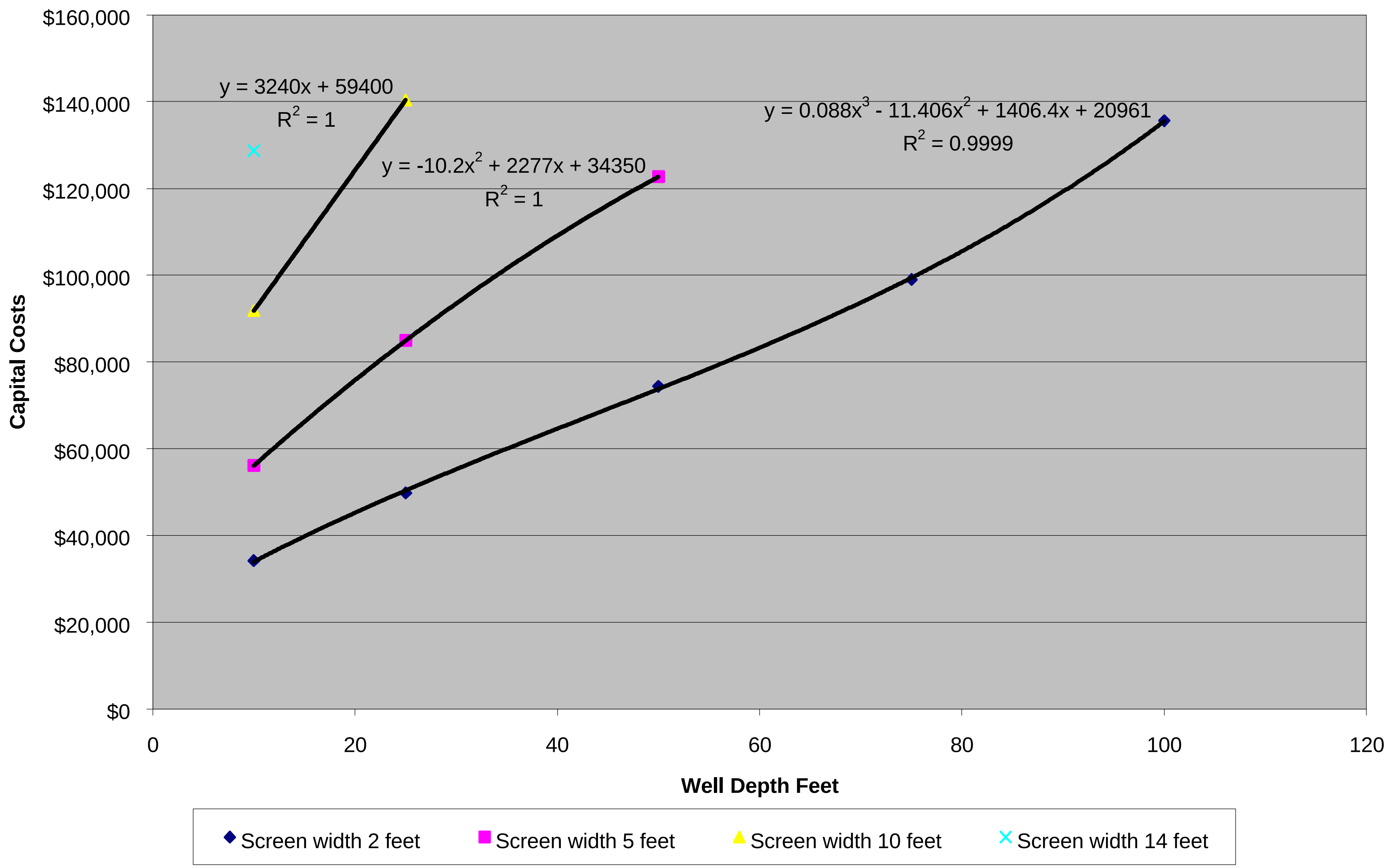


Chart 30. Capital Costs of Passive Screens for a Flow Velocity 0.5 ft/sec

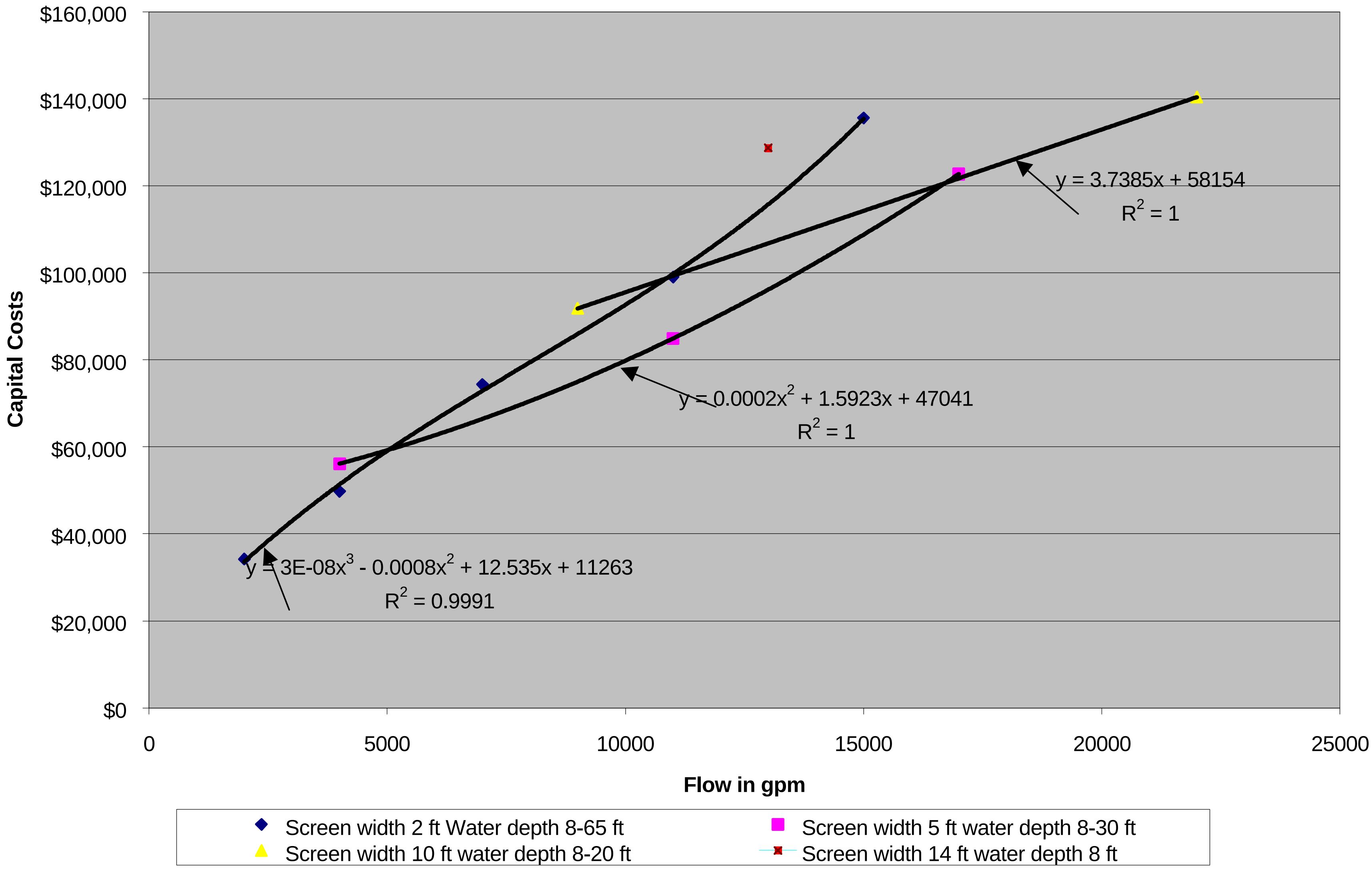


Chart 31. Capital Costs of Passive Screens for a Flow Velocity 1 ft/sec

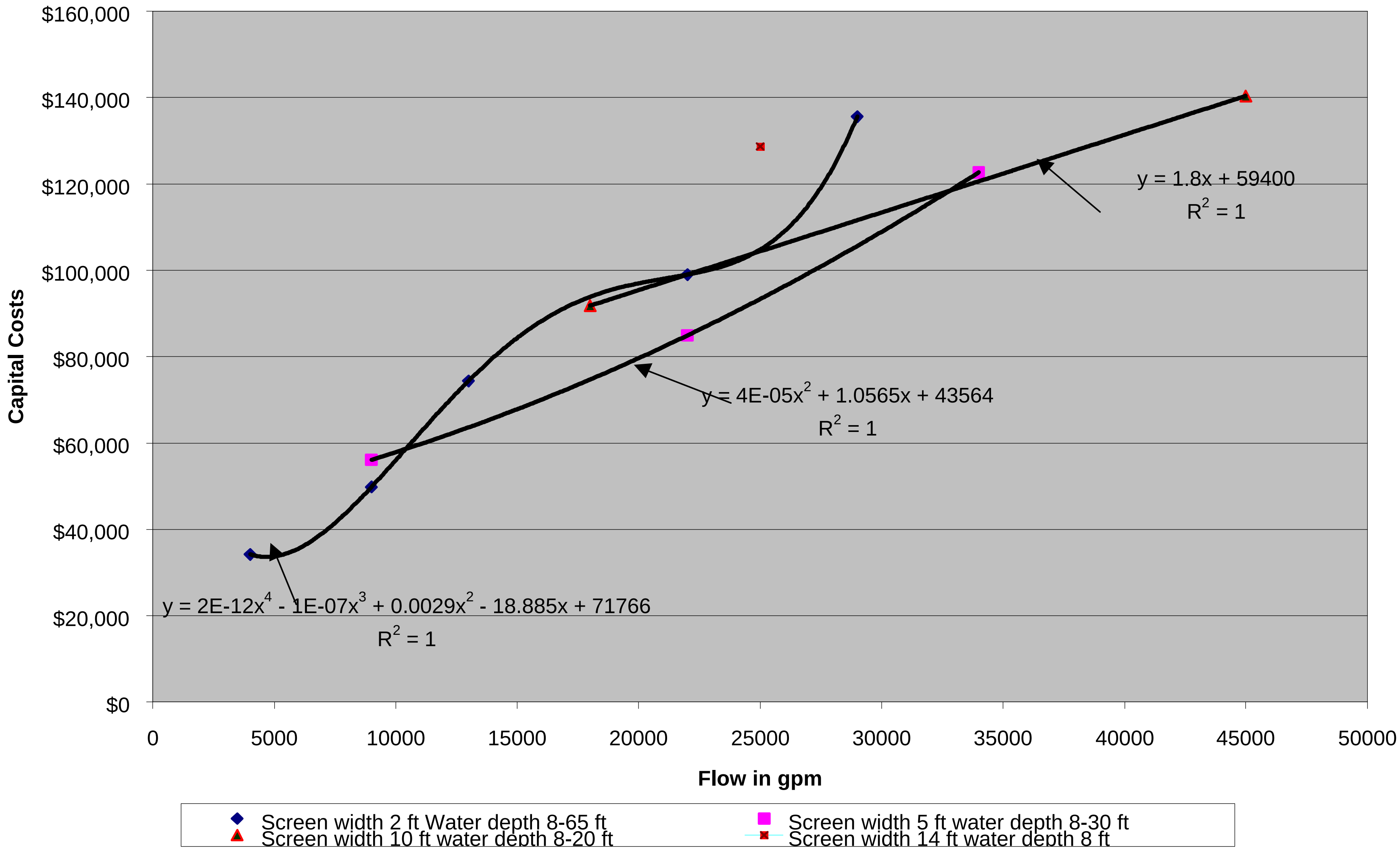


Chart 32. Velocity Caps Total Capital Costs

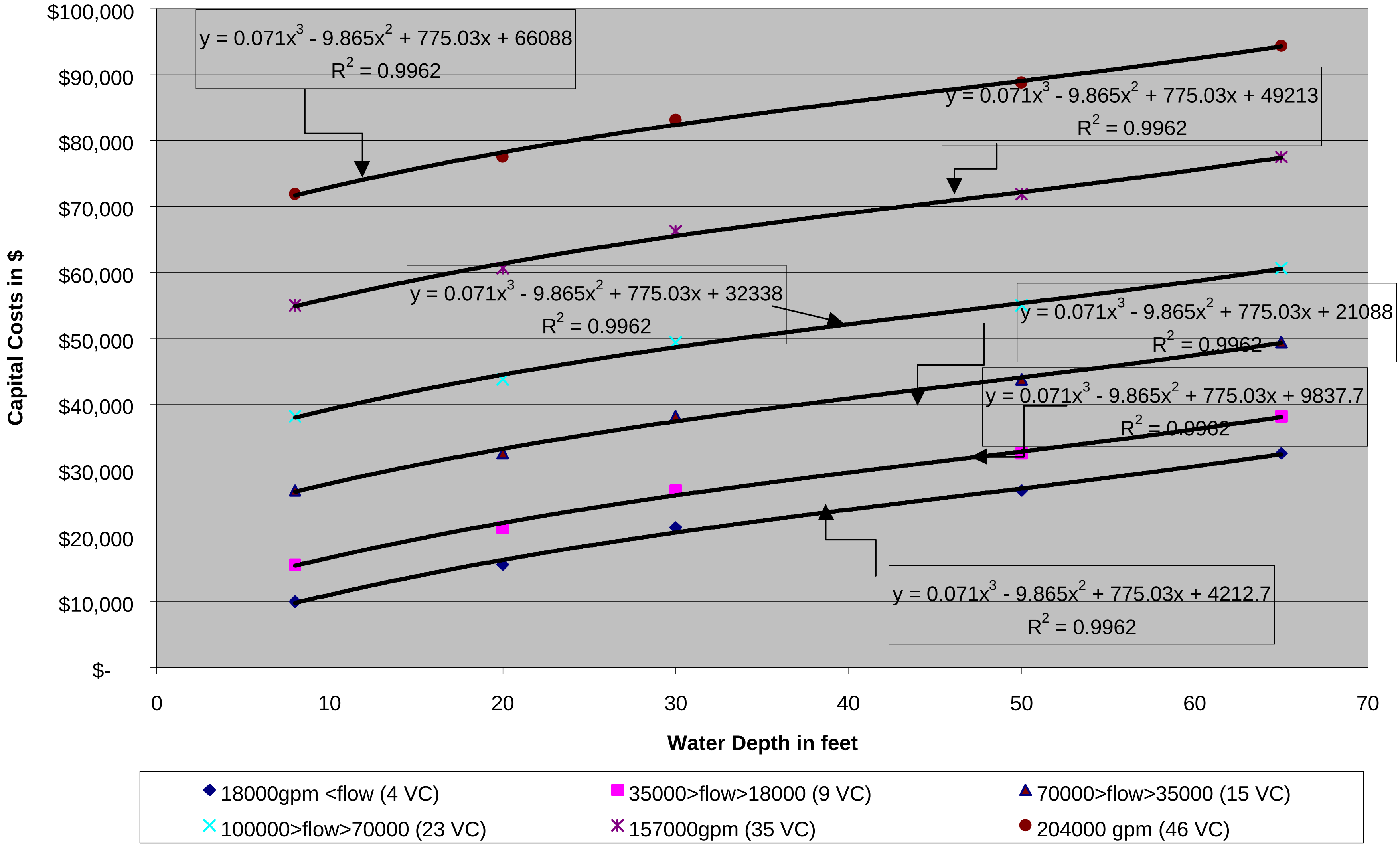
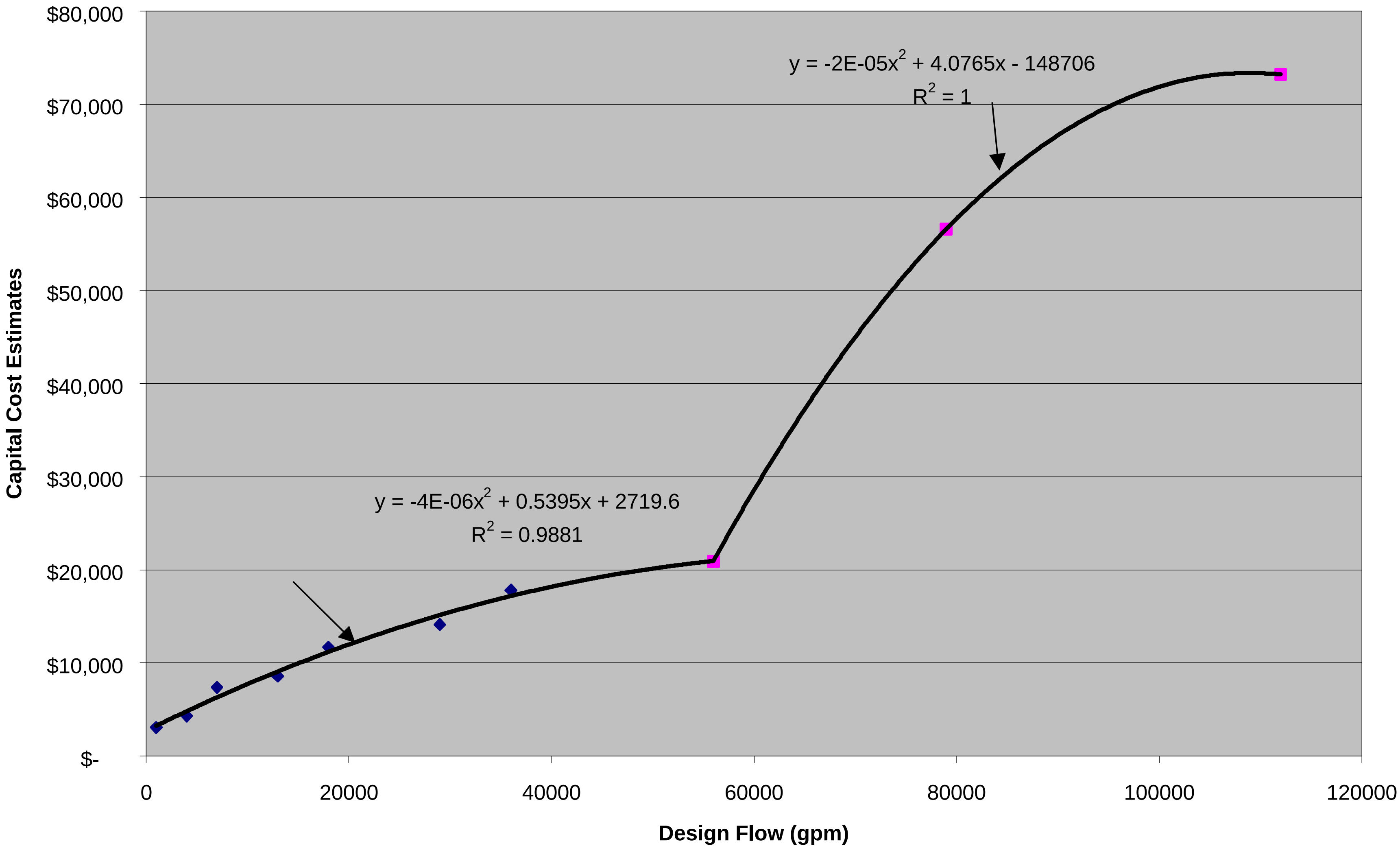


Chart 33. Concrete Fittings for Intake Flow Velocity Reduction



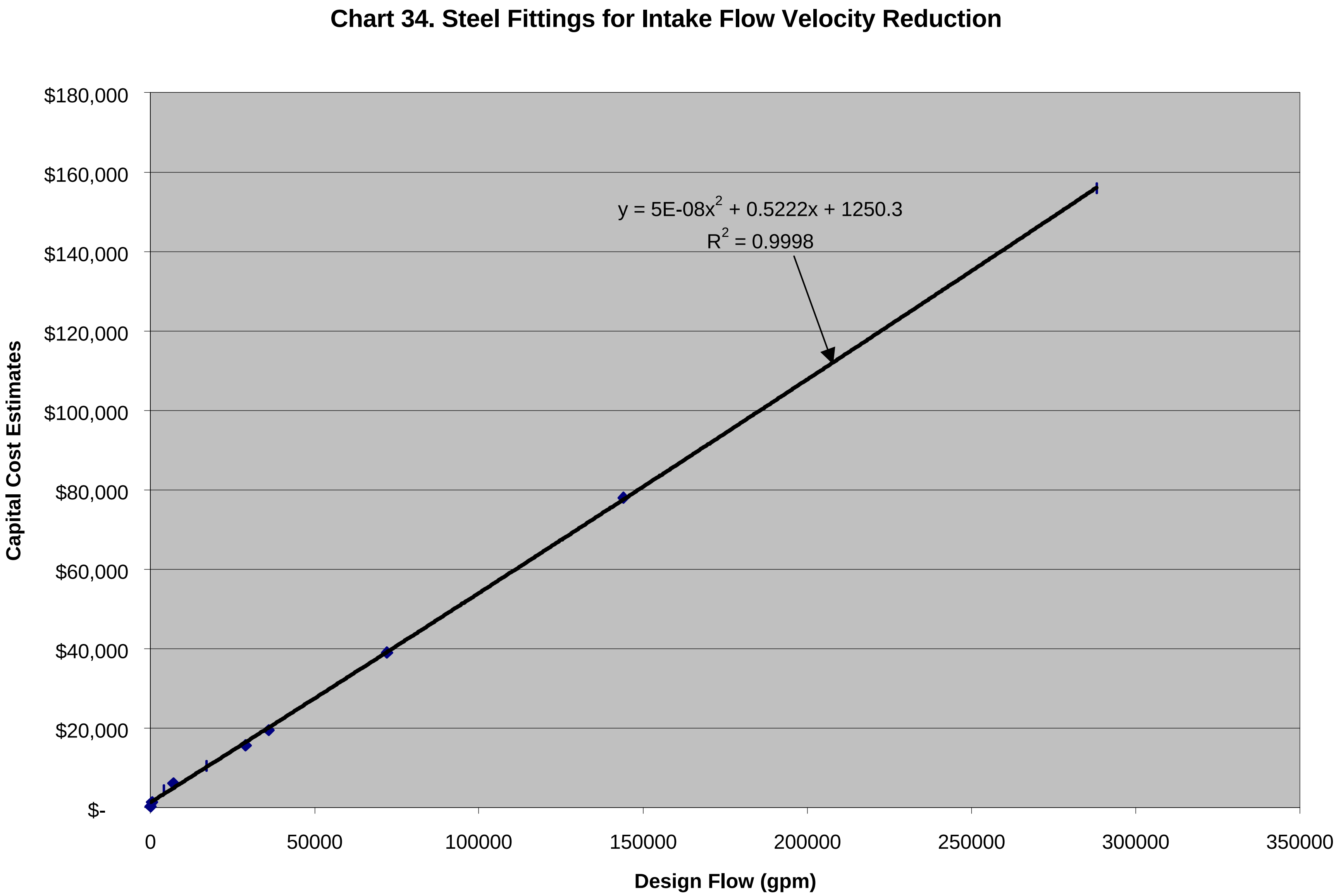


Chart 34. Steel Fittings for Intake Flow Velocity Reduction
$180,000
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$-
Capital Cost Estimates
0
50000
100000
150000
200000
250000
300000
350000
Design Flow (gpm)
y = 5E-08x2 + 0.5222x + 1250.3
R2 = 0.9998

Chart 35. Travel Screens Capital Cost Without Fish Handling Features Flow Velocity 0.5ft/sec

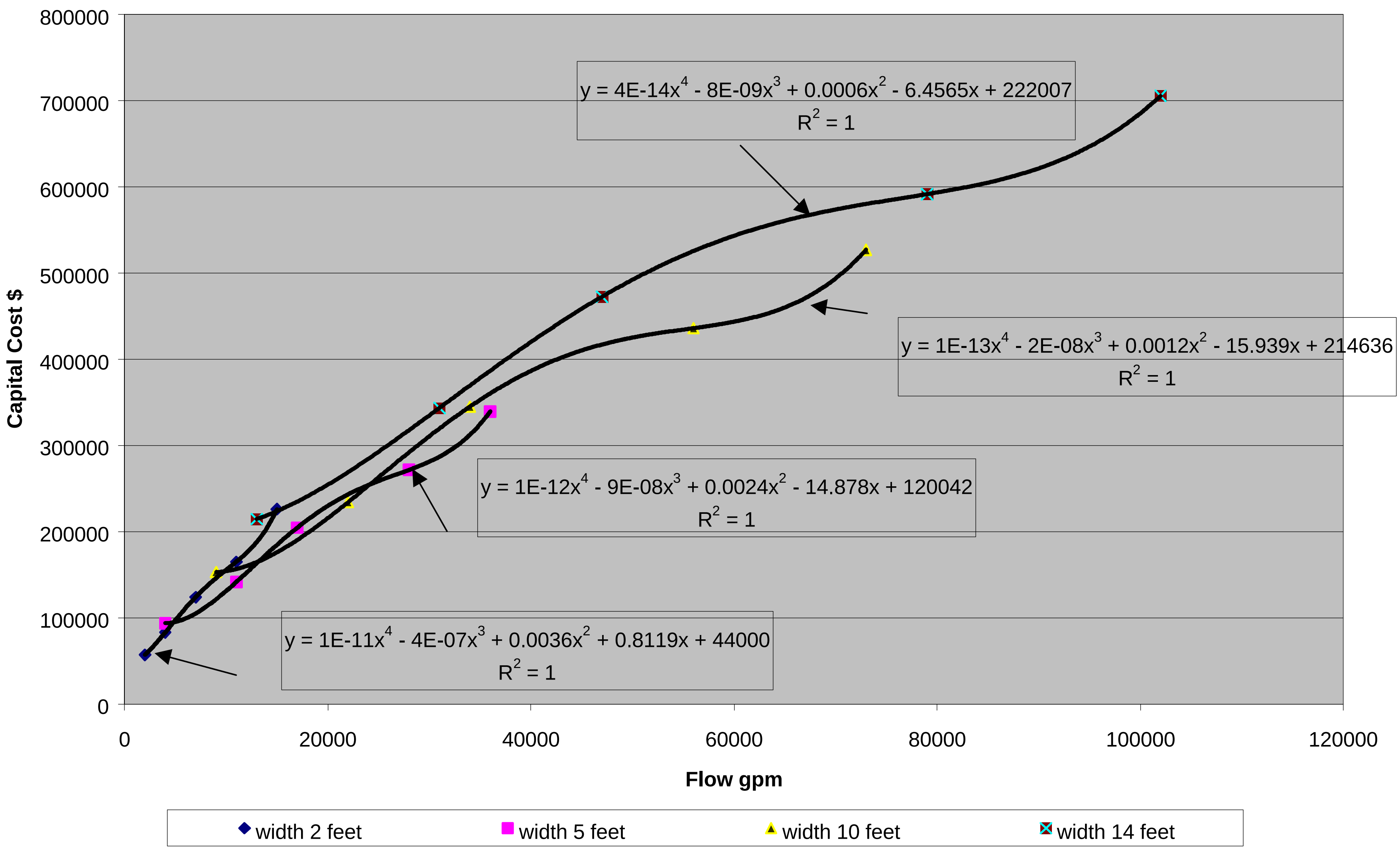


Chart 36. Travel Screens Capital Cost With Fish Handling Features Flow Velocity 0.5ft/sec

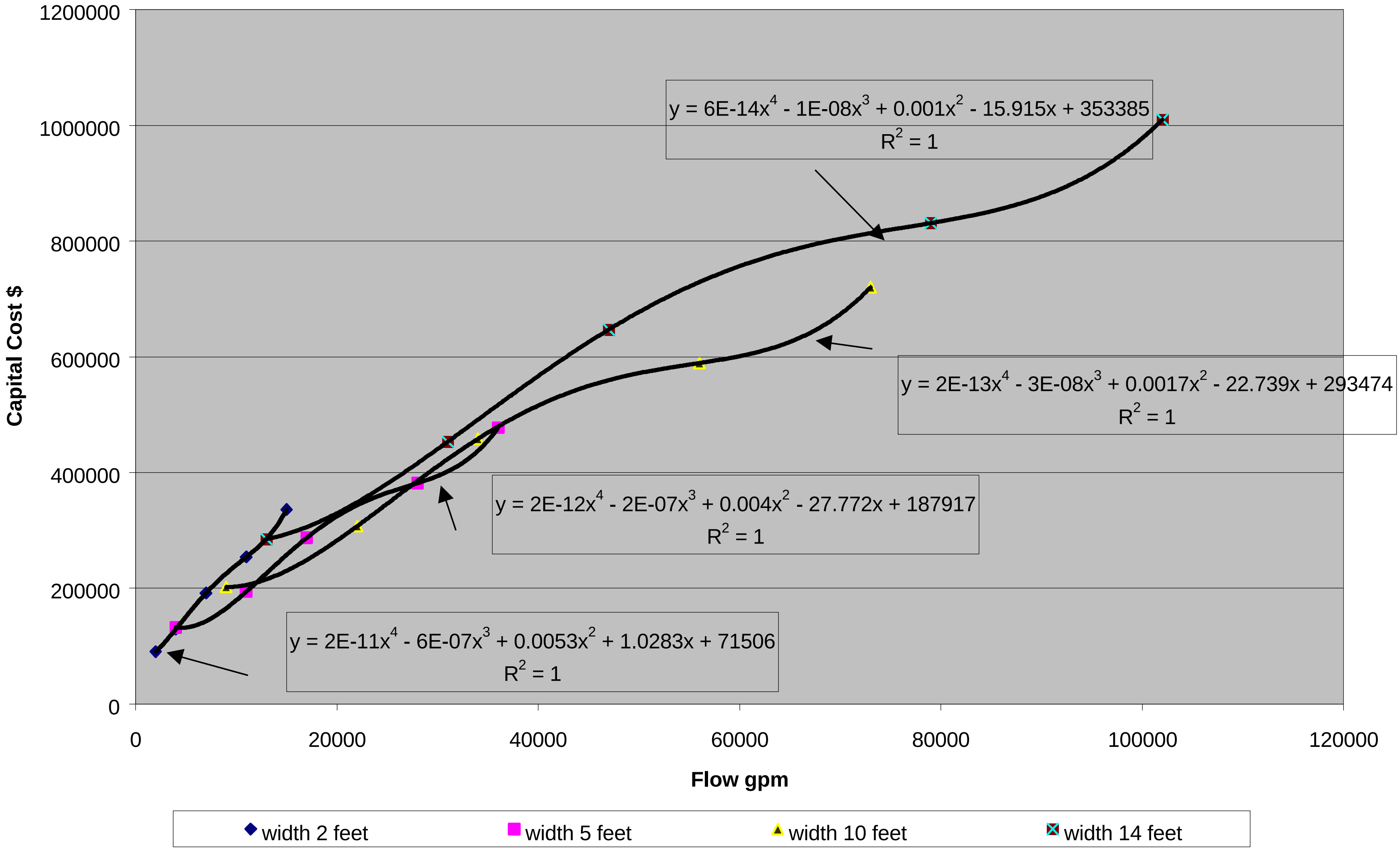


Chart 37. Travel Screens Capital Cost Without Fish Handling Features Flow Velocity 1 ft/sec

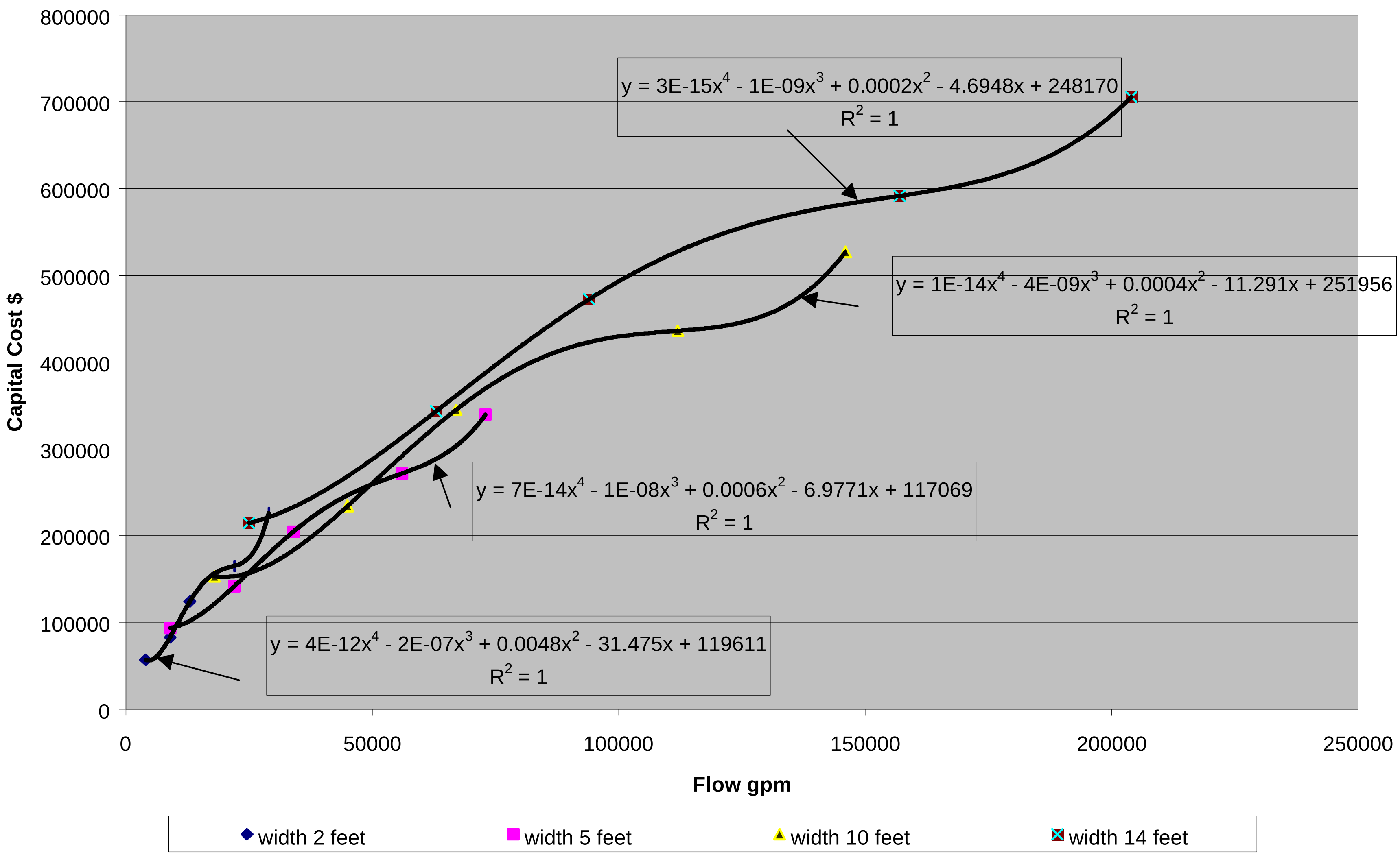
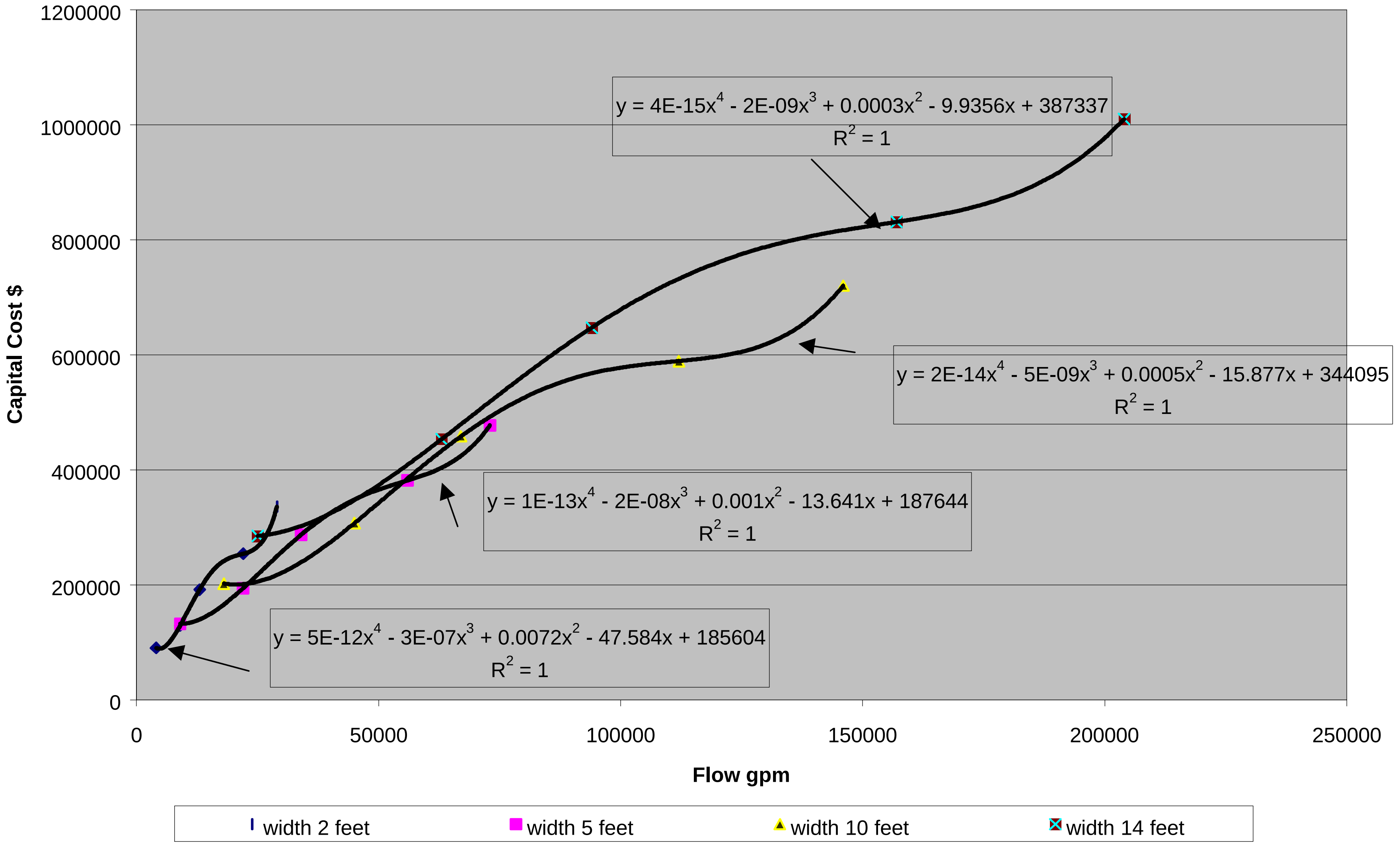


Chart 38. Travel Screens Capital Cost With Fish Handling Features Flow Velocity 1 ft/sec



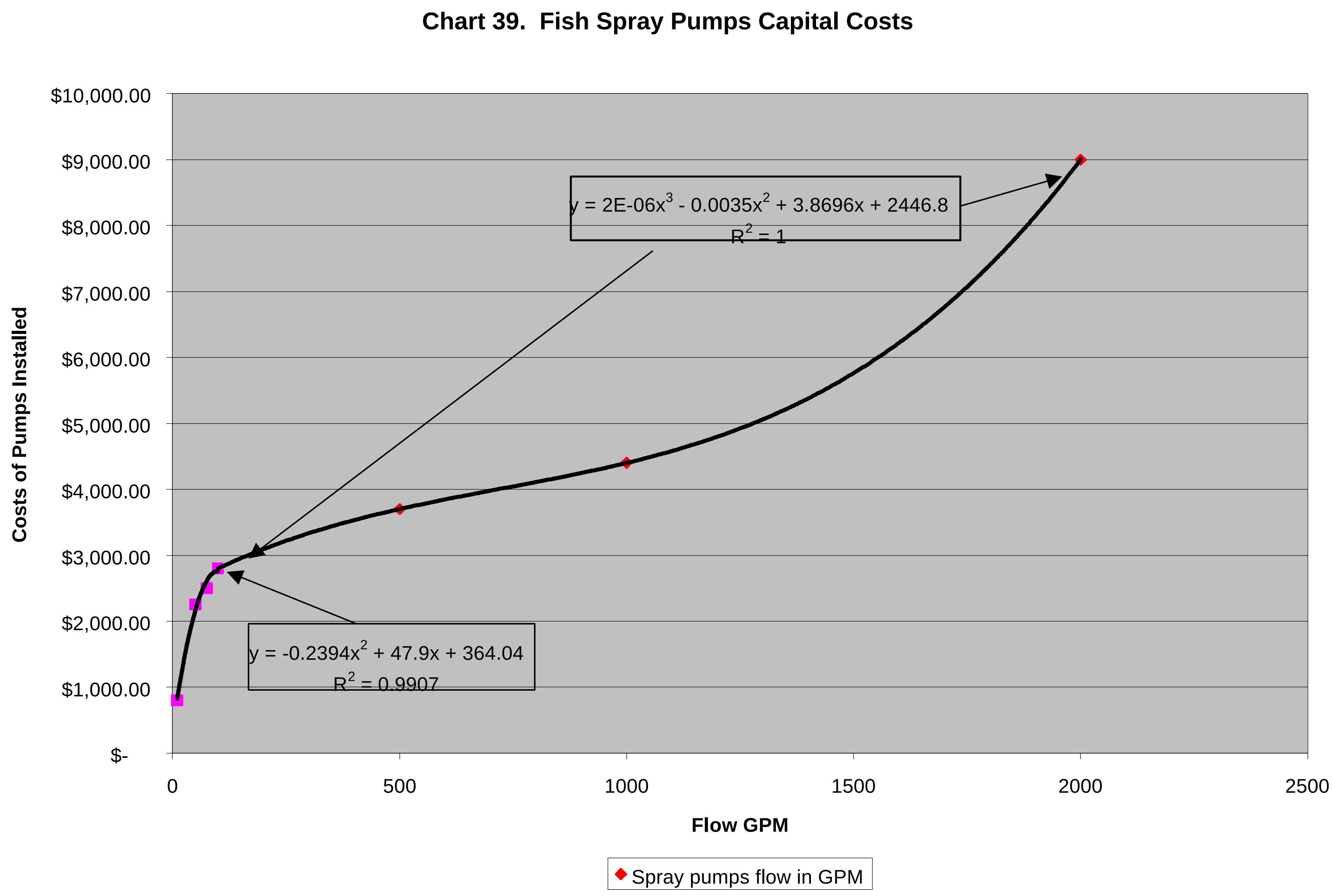


Chart 39. Fish Spray Pumps Capital Costs
Costs of Pumps Installed
$10,000.00
$9,000.00
$8,000.00
$7,000.00
$6,000.00
$5,000.00
$4,000.00
$3,000.00
$2,000.00
$1,000.00
$-
y = 2E-06x3 - 0.0035x2 + 3.8696x + 2446.8
R2 = 1
y = -0.2394x2 + 47.9x + 364.04
R2 = 0.9907
0
500
1000
1500
2000
2500
Flow GPM
Spray pumps flow in GPM

Chart 40. O&M Cost for Traveling Screens Without Fish Handling Features Flow Velocity 0.5ft/sec

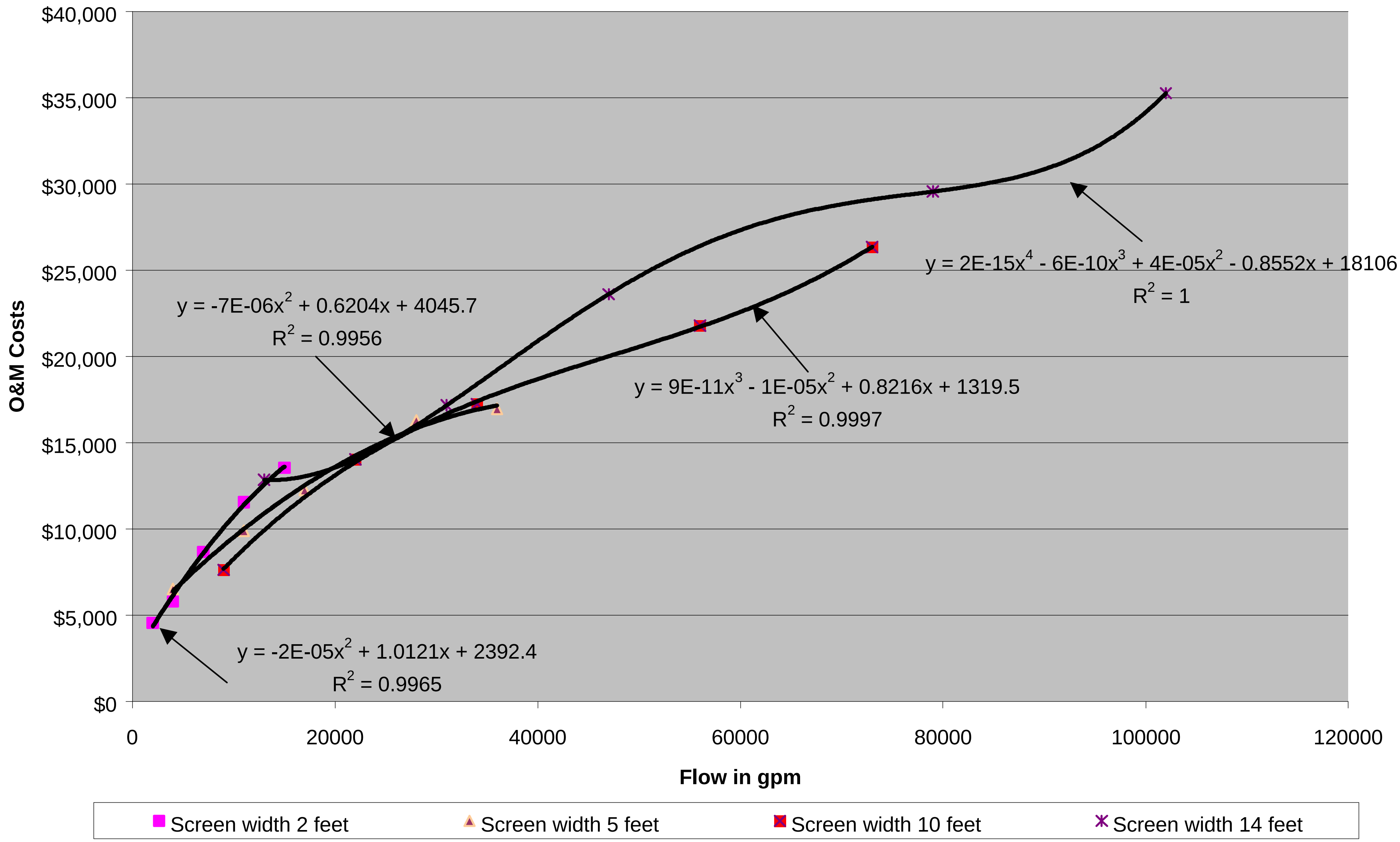


Chart 41. O&M Cost for Traveling Screens With Fish Handling Features Flow Velocity 0.5ft/sec

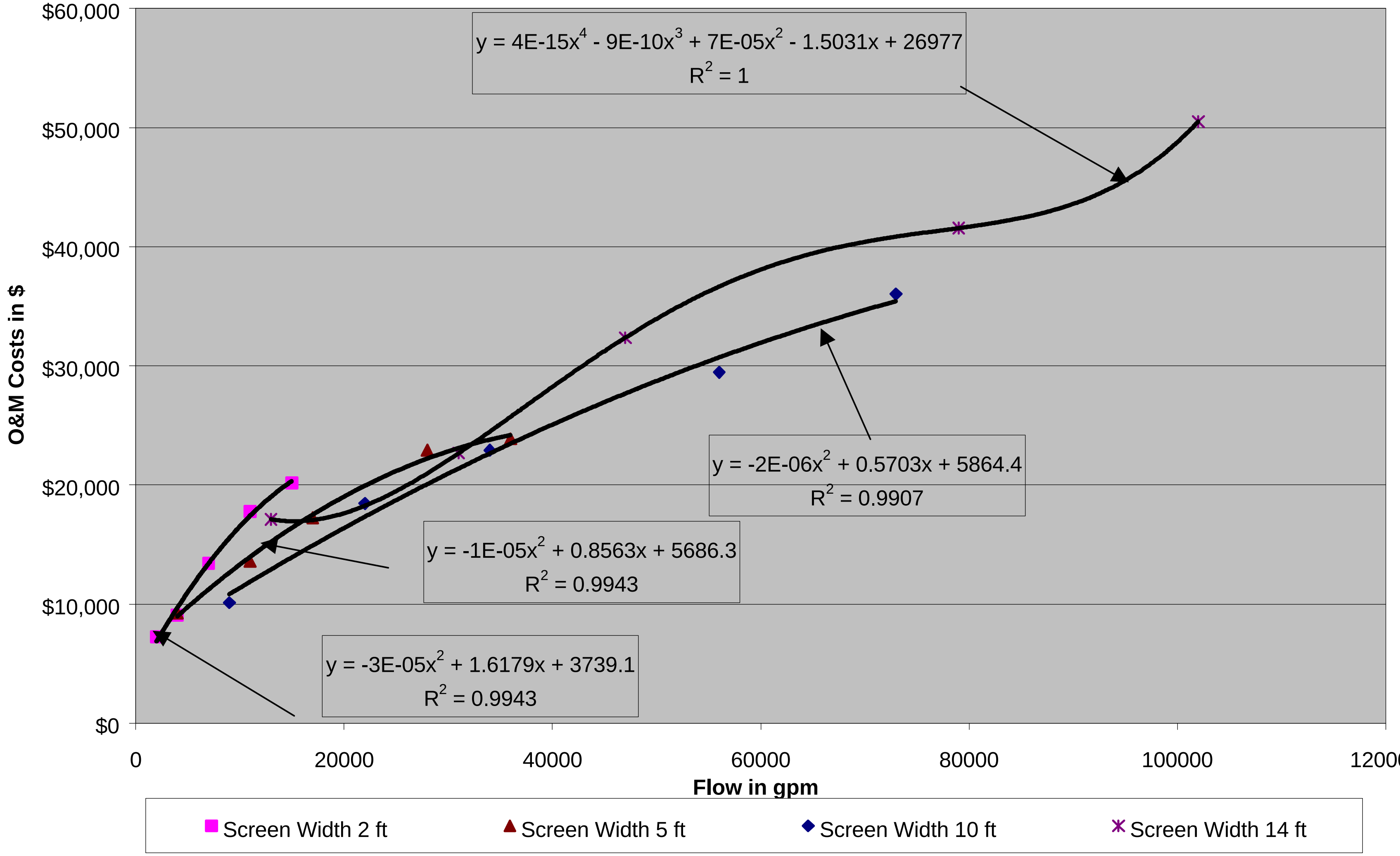


Chart 42. O&M Cost for Traveling Screens Without Fish Handling Features Flow Velocity 1 ft/sec

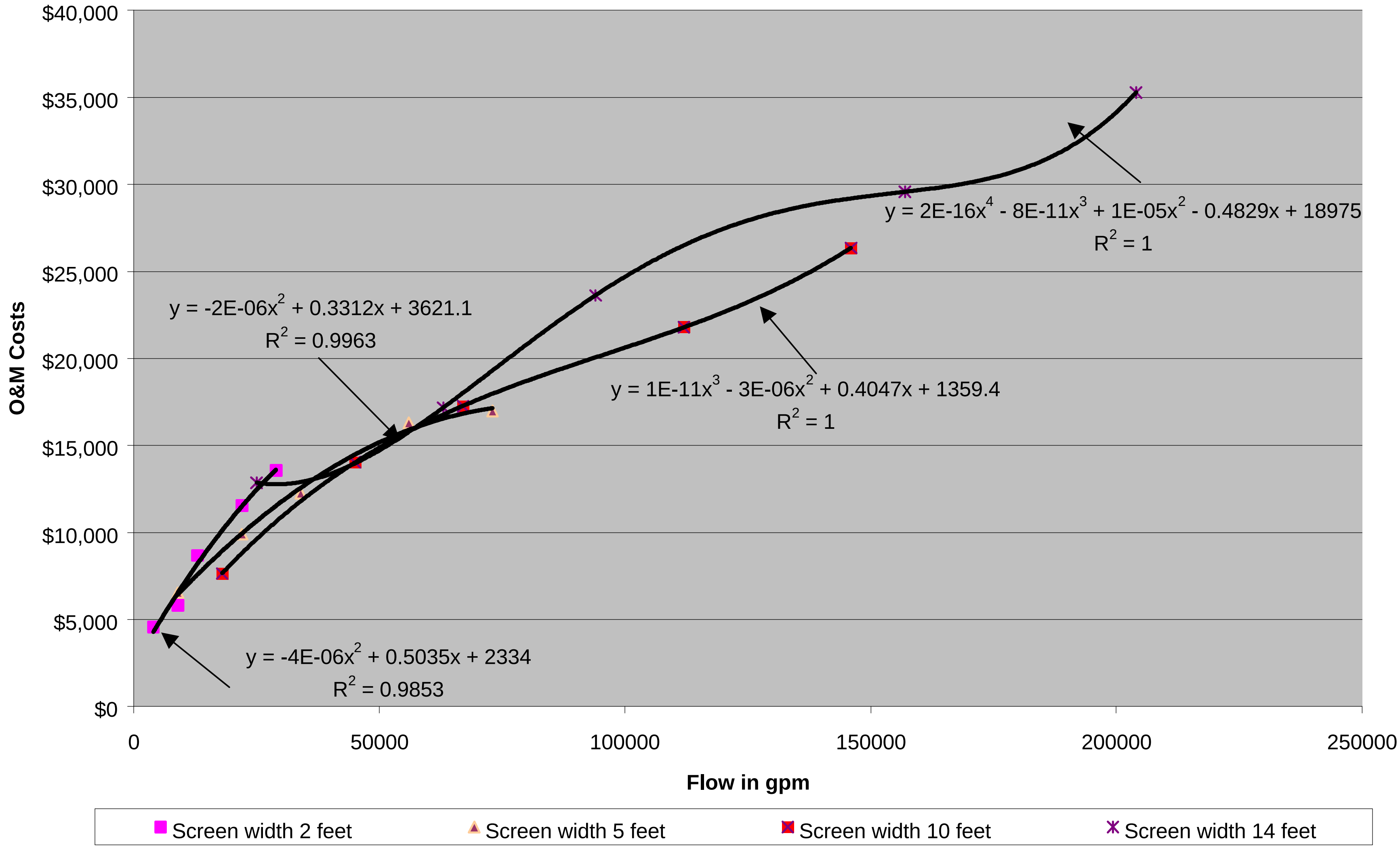


Chart 43. O&M Cost for Traveling Screens With Fish Handling Features Flow Velocity 1 ft/sec

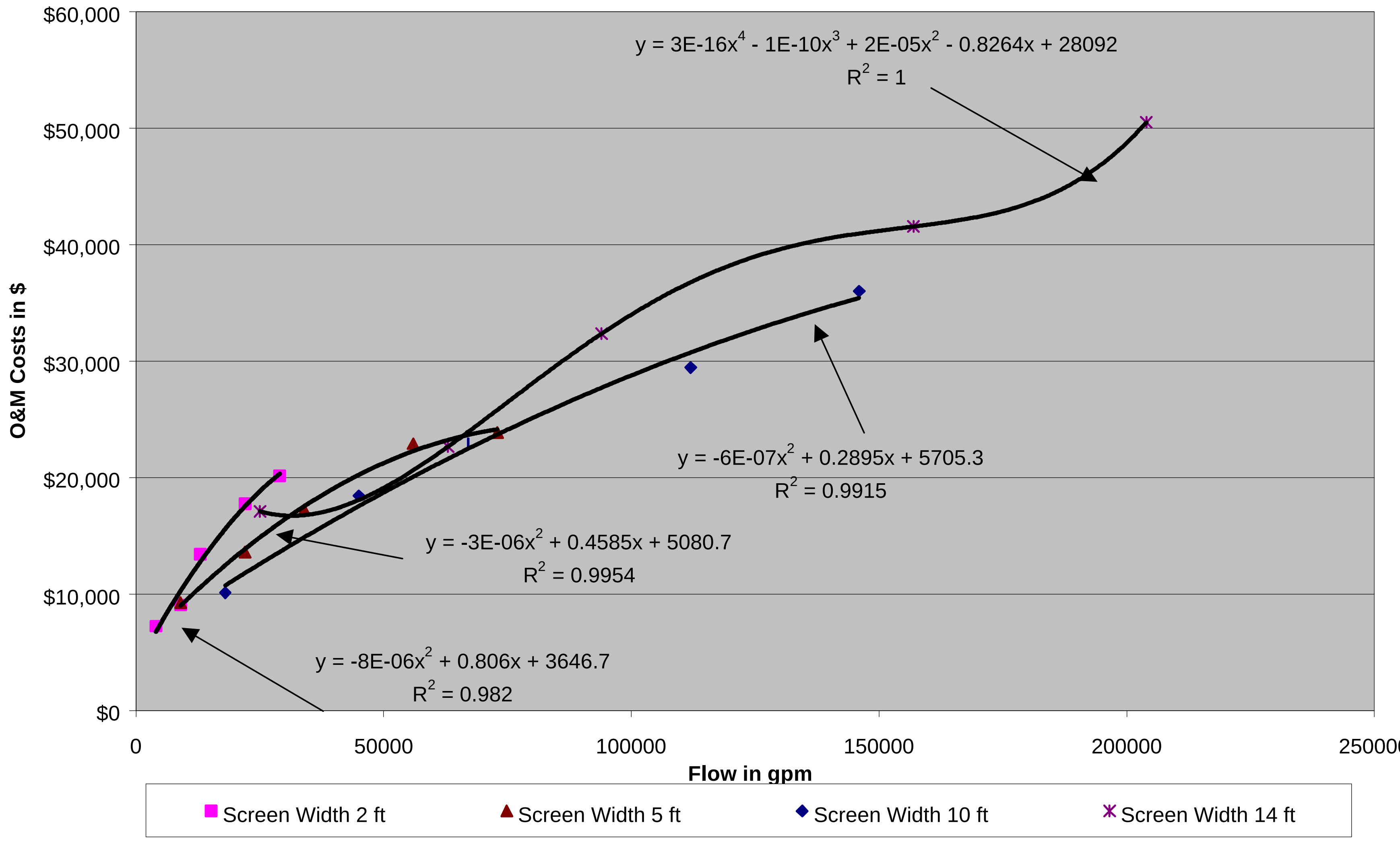


Chart 44. Capital Cost of Fish Handling Equipment Screen Flow Velocity 0.5 ft/sec

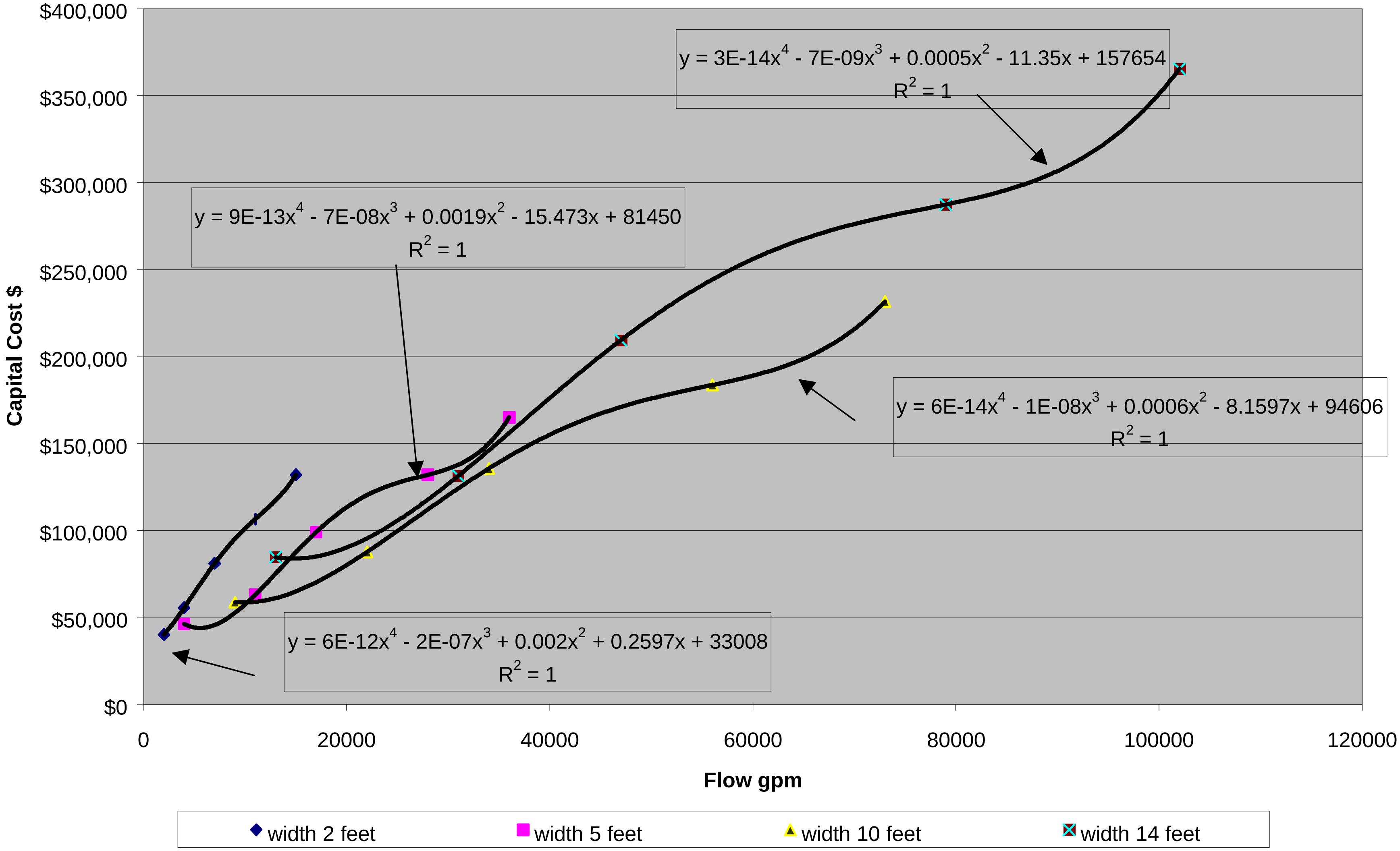
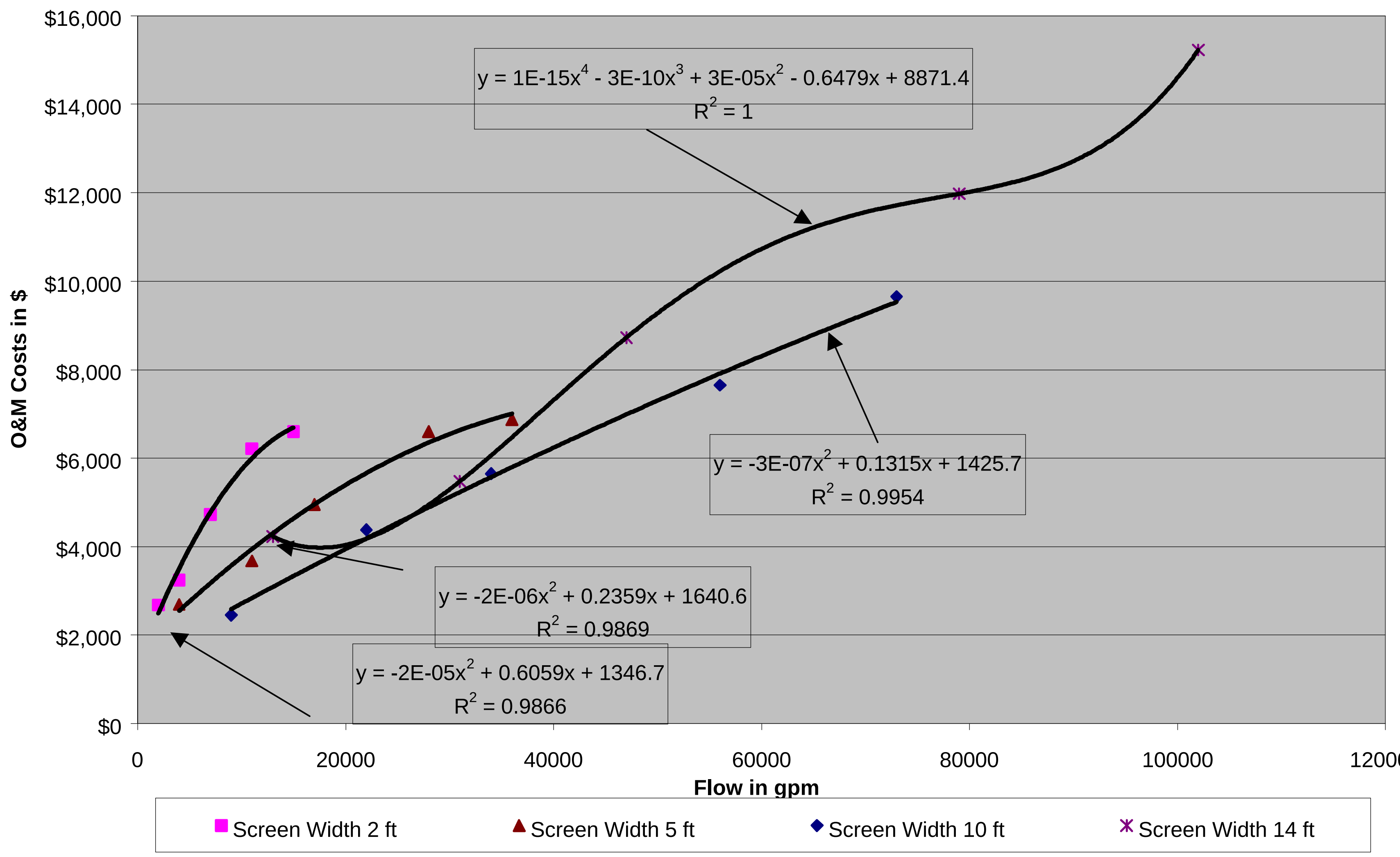


Chart 45. O&M Cost for Fish Handling Features Flow Velocity 0.5ft/sec



APPENDIX B

UNIT COST ANALYSES

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APPENDIX B

UNIT COST ANALYSES

EPA developed unit cost estimates for the new steam electric generators and new manufacturers expected to begin operation during the next 20 years. For a detailed discussion on how the new generators and the new manufacturing SIC codes were selected please refer to Chapter 5 of this document The characteristics of the new facilities were determined for the new steam electric database from the information provided in the NewGen database or for the new manufacturers by analyzing similar SIC code facility data from EPA Screener Survey database. The following provides a detailed discussion on how the characteristics of the projected manufacturers were determined and how unit costs were assigned.

To determine if these facilities must take compliance actions to meet the proposed requirements, EPA needed to estimate the likely characteristics of these new facilities. Important characteristics in assessing facility compliance with New Facility Rule requirements and determining estimated compliance costs include: source water body type, intake flow volume, use of once-through or recirculating cooling systems, intake location (e.g., shoreline, offshore submerged), and in-place intake control technologies.

In order to determine the characteristics of the new manufacturing facilities that are projected to come online over the next 20 years, EPA performed an analysis of the *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures*. In 1999, EPA administered a screener questionnaire to manufacturers and non-utilities. The screener questionnaire was intended to identify facilities that are subject to standards under Sections 301 or 306 and are point source dischargers under a number of industrial categories to identify the facilities that operate cooling water intake structures in surface waters and are therefore subject to Section 316(b). The survey requests information on whether the facility is a point source discharger; directly withdraws cooling water from surface water sources; the water body types upon which cooling water is being withdrawn; design intake flow for a typical operational year; type of cooling water systems in use; configuration of cooling water intake structures; technology types being used at cooling water intake structures; gross annual electricity generated; annual sales of electricity ownership type; number of full-time equivalent employees; and annual sales revenue.

Using the Screener data for a given SIC code, EPA determined the projected facility's characteristics such as originating surface water sources, flow rates, profile of cooling water systems, configuration of intake structures, and control technologies by analyzing the trends of an industry to have particular characteristics. Since facilities with the same SIC code generally have similar operations and generate similar products, EPA assumed that the characteristics of new facilities in a given SIC code will be the same as the characteristics of existing facilities in that same SIC code. EPA also considered current trends in facilities that have come online in more recent years. For example, a review of available data for facilities starting up in the last 10 years indicates that newer facilities are much more likely to have at least partially recirculating cooling systems than older facilities. In situations where a particular trend was not as definable, EPA assumed the national trends such as recirculating systems, use of screens, etc., would be the projected characteristic.

EPA evaluated the characteristics listed above for all the existing facilities in each SIC code, and used those characteristics to project the characteristics for the one or more projected new facilities. If only one new facility was projected for a given SIC code, EPA generally used the following conventions:

- Source water type: most common water body among the existing facilities;
- Flow[1]: weighted median[2] flow either by source water type, cooling system type or all flow for the SIC code;
- Intake location: most common intake location among existing facilities;

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[1]Several flow values are presented in the tables. They include: Flow in gallons per day (GPD) (from screener survey data), Flow in gallons per minute (gpm), Total Flow Requirement (the total water for a facility required to circulate through the cooling systems), Flow Needed for Recirculating Cooling Towers (this is the volume of water required to recirculate through the cooling towers used to cost the towers), and Flow Used for Costing Activities Other Than Cooling Tower (this is the volume of water through the intake structure used to cost intake technologies).

[2]The Screener Survey was sent to a sample of the manufacturing facilities that may be impacted by the rule. A statistical weight was applied to the responses to represent the impacted universe.

- Control technology type: most common technologies in use at existing facilities; and
- Cooling system type: most common type, with a bias toward recirculating or combined recirculating and once-through when the type of system among existing facilities was very mixed.

When more than one new facility was projected for a given SIC code, EPA generally split the existing facilities by waterbody type or by recirculating versus once-through and determined one new projected facility's characteristics based on one set of existing facilities and another new projected facility's characteristics based on the other set of existing facilities. Based on trends, EPA used a bias toward certain characteristics such as recirculating cooling systems, offshore intakes, and passive screens. Since the trend for new facilities is toward the use of cooling towers, flows used may be lower than those for the existing facilities in some cases.

EPA analyzed the characteristic data to assess with which of the New Source Rule's regulatory framework criteria a new facility would already be complying (current compliance assumptions) and what changes would need to be made to comply with all the criteria for their water body (projected compliance actions). Once the compliance actions were determined, EPA developed capital and operation and maintenance (O&M) unit cost estimates for each projected facility. For costing purposes, compliance actions were assumed to be the addition of a technology or a construction modification. The following provides the list of costed technologies or construction actions:

- Intake fanning or widening for velocity reduction
- Canal dredging
- Pipe extensions
- Traveling screen with fish handling devices
- Fish handling equipment
- Passive screens
- Velocity caps
- Cooling Towers

EPA developed cost estimates for three regulatory scenarios: the preferred regulatory framework option, the one standard option, and the dry cooling option. Refer to Chapter 10 of this document for the estimated costs for dry cooling for the other generating facilities. EPA assumed that since manufacturers reused much of their cooling water in their process they would not be able to switch to dry cooling and, therefore, did not develop cost estimates for that scenario. Cost estimates for each scenario are in separate tables provided at the end of this appendix. The costing scenarios are as follows:

- Table 1 - Unit costs for new steam electric generators expected to be built during 2001 to 2010. The cost was estimated based on the regulatory framework.

- Table 2 - Unit costs for new steam electric generators expected to be built during 2001 to 2010. The cost was estimated based on the one standard option (standards for estuaries).

- Table 3 - Unit costs for projected new manufacturers by SIC code projected to build new facilities during 2001 to 2010. The cost was estimated based on the regulatory framework. (To determine the costs for the second ten years, EPA doubled these costs.)

- Table 4 - Unit costs for projected new manufacturers by SIC code projected to build new facilities during 2001 to 2010. The cost was estimated based on the one standard option (standards for estuaries).

- Table 5 - Unit costs for manufacturing facilities in industries that are not projected to build new facilities during 2001 to 2010 but if such a facility were to be built the compliance costs were estimated. The cost was estimated based on the regulatory framework.

- Table 6 - Unit costs for large coal-fired or nuclear plants. EPA does not expect such facilities to be built. The cost was estimated based on the regulatory framework.

- Table 7 - Unit costs for new coal steam plants expected to be built during 2011 to 2020. The cost was estimated based on the regulatory framework.

- Table 8 - Unit costs for new coal steam plants expected to be built during 2011 to 2020. The cost was estimated based on the one standard option (standards for estuaries).

- Table 9 - Unit costs for new combined cycle plants expected to be built during 2011 to 2020. The cost was estimated based on the regulatory framework.

- Table 10 - Unit costs for new combined cycle plants expected to be built during 2011 to 2020. The cost was estimated based on the one standard option (standards for estuaries).

- Table 11 - Unit costs for both the coal-fired and combined cycle generating plants expected to be built during 2011 to 2020. The cost estimate was performed to determine the cost if all the facilities used dry cooling.

The following tables provide the unit costs for the new projected facilities for the compliance scenarios discussed above.

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Table 1. Projected New Generator Characteristics and Needed Compliance Action and Costs

New Gen	Water Body	Flow GPD	Total Water Requirement GPD	Configuration of Facility's CWIS						Technology Types Being Used				
				Canal	Submergec Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.
GenA	Nontidal River	3,600,000	129,000,000						X					X
GenB	Nontidal River	19,400,000	24,000,000					X					X	
GenC	Lake, Pond or Res.	10,000,000	23,000,000	X				X					X	
GenD	Tidal River	6,500,000	59,000,000					X				X	X	
GenE	Nontidal River	10,400,000	43,000,000										X	
GenF	Nontidal River	3,500,000	67,000,000						X					X
GenG	Lake, Pond or Res.	8,800,000	69,000,000					X					X	

0= Not applicable for this facility under these compliance scenarios

Table 1. Projected New Generator Characteristics and Needed Compliance Action and Costs

New Gen	Profile of Facility's Cooling Water System							Current Compliance Assumptions	Projected Compliance action(s)	Flow in gpm	Flow needed for Recirc Cooling Tower gpm	Flow Needed for activities Other Than Cooling Tower gpm
	Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other					
GenA						X		Infiltration gallery under river bed: Meets the flow, velocity, and recirc criteria	None	3,000	0	0
GenB						X		Meets the flow, velocity, and recirc criteria	None	13,000	0	0
GenC						X		Meets the flow, velocity, and recirc criteria	Dredge canal	7,000	0	0
GenD						X		Meets the flow, velocity, and recirc criteria	None	5,000	0	0
GenE						X		Meets the flow, velocity, and recirc criteria; assume in the littoral zone; assume Johnson screens maximize the survival of impinged and entrained	None	7,000	0	0
GenF						X		Raney wells under river bed: Meets the flow, velocity, and recirc criteria	None	2,000	0	0
GenG						X		Meets the flow, velocity, and recirc criteria	Extend the pipe	6,000	0	0

Table 1. Projected New Generator Characteristics and Needed Compliance Action and Costs

New Gen	Capital Costs									Annual O&M Costs			Total Cost	
	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 ft/Sec $	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
GenA	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenB	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenC	$0	$0	$0	$0	$0	$0	$236,000	$0	$236,000	$0	$0	$0	$0	$236,000
GenD	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenE	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenF	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenG	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000

Table 2. Projected New Generator Characteristics and Needed Compliance Action and Cost for Uniform Standards

				Configuration of Facility's CWIS						Technology Types Being Used				
New Gen	Water Body	Flow GPD	Total Water Requirement GPD	Canal	Submerge Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.
GenA	Nontidal River	3,600,000	129,000,000						X					X
GenB	Nontidal River	19,400,000	24,000,000					X					X	
GenC	Lake, Pond or Res.	10,000,000	23,000,000	X				X					X	
GenD	Tidal River	6,500,000	59,000,000					X				X	X	
GenE	Nontidal River	10,400,000	43,000,000										X	
GenF	Nontidal River	3,500,000	67,000,000						X					X
GenG	Lake, Pond or Res.	8,800,000	69,000,000					X					X	

0= Not applicable for this facility under these compliance scenarios

Table 2. Projected New Generator Characteristics and Needed Compliance Action and Cost for Uniform Standards

New Gen	Profile of Facility's Cooling Water System: Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other	Current Compliance Assumptions	Projected Complianc action(s)	Flow in gpm	Flow needed for Recirc Cooling Tower gpm	Flow Needed for activities Other Than Cooling Tower gpm
GenA						X		Infiltration gallery under river bed: Meets the flow, velocity, and recirc criteria	None	3,000	0	0
GenB						X		Meets the flow, velocity, and recirc criteria	None	13,000	0	0
GenC						X		Meets the flow, velocity, and recirc criteria	Dredge canal	7,000	0	0
GenD						X		Meets the flow, velocity, and recirc.criteria	None	5,000	0	0
GenE						X		Meets the flow, velocity, and recirc criteria; assume in the littoral zone; assume Johnson screens maximize the survival of impinged and entrained organisms	None	7,000	0	0
GenF						X		Raney wells under river bed: Meets the flow, velocity, and recirc criteria	None	2,000	0	0
GenG						X		Meets the flow, velocity, and recirc criteria	Extend the pipe	6,000	0	0

Table 2. Projected New Generator Characteristics and Needed Compliance Action and Cost for Uniform Standards

New Gen	Capital Costs									Annual O&M Costs			Total Cost	
	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 ft/Sec $	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
GenA	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenB	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenC	$0	$0	$0	$0	$0	$0	$236,000	$0	$236,000	$0	$0	$0	$0	$236,000
GenD	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenE	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenF	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GenG	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

Primary SIC code	Water Body	Flow GPD	Total Water Requirement GPD	Configuration of Facility's CWIS					
				Canal	Submerged Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other
new 2812-1	Nontidal River	72,400,000	482,666,667					X	
new 2813-1	[redacted]								
new 2819-1	Nontidal River	6,000,000	6,000,000		X				
new 2819-2	Tidal River	33,000,000	51,711,000					X	
new 2821-1	Nontidal River	9,500,000	14,886,500					X	
new 2821-2	Lake, Pond or Res.	26,640,000	26,640,000					X	
new 2821-3	Tidal River	5,000,000	33,333,333					X	
new 2824-1	[redacted]								
new 2833-1	Nontidal River	16,347,000	25,615,749					X	
new 2834-1	[redacted]								
new 2841-1	Lake, Pond or Res.	7,180,000	7,180,000					X	
new 2865-1	[redacted]								
new 2869-1	Nontidal River	12,000,000	12,000,000					X	
new 2869-2	Nontidal River	12,000,000	12,000,000					X	
new 2869-3	Nontidal River	2,400,000	16,000,000					X	
new 2869-4	Nontidal River	2,400,000	16,000,000					X	
new 2869-5	Nontidal River	2,400,000	16,000,000					X	
new 2869-6	Nontidal River	45,000,000	70,515,000		X				
new 2869-7	Nontidal River	45,000,000	70,515,000		X				

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

	Technology Types Being Used					Profile of Facility's Cooling Water System						
Primary SIC code	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.	Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other
new 2812-1				X							X	
new 2813-1	[redacted]											
new 2819-1		X		X		X						
new 2819-2				X		X					X	
new 2821-1		X		X		X					X	
new 2821-2		X		X			X					
new 2821-3				X							X	
new 2824-1	[redacted]											
new 2833-1				X		X					X	X
new 2834-1	[redacted]											
new 2841-1				X		X						
new 2865-1	[redacted]											
new 2869-1		X		X		X						
new 2869-2		X		X		X						
new 2869-3				X							X	
new 2869-4				X							X	
new 2869-5				X							X	
new 2869-6				X		X					X	
new 2869-7				X		X					X	

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

Primary SIC code	Current Compliance Assumptions	Projected Compliance Actions	Flow in gpm	Flow needed for Recirculating Cooling Tower gpm	Flow Needed for Activities Other Than Cooling Tower gpm
new 2812-1	Trend for recirculating & submerged offshore; Assume meets intake flow criteria & 100% recirc criteria	Enlarge intake pipe opening to achieve 0.5 fps velocity	50,300	0	50,300
new 2813-1	Assume meets intake flow criteria & velocity criteria; assume cannot extend 50 meters beyond littoral zone	Install cooling towers to make 100% recirc; Add fish baskets to maximize survival (for remaining flow)	[redacted]		
new 2819-1	Assume meets intake flow criteria & velocity criteria, & maximizes survival of impinged & minimizes entrainment because of passive screens; After switching to 100% recirc, facility flow is less than 2 MGD so no other action is required	Install cooling towers to make 100% recirc	4,200	4,200	600
new 2819-2	Trend for submerged & recirculating; Assume meets intake flow volume criteria after switching to 100% recirculating system	Install cooling towers to make 100% recirc; Install passive screens to achieve 0.5 fps velocity and maximize survival of impinged & minimize entrainment	22,900	20,600	5,400
new 2821-1	Trend is for recirculating & submerged; Assume meets intake flow criteria & velocity criteria	Extend pipe to be 50 meters outside littoral zone	6,600	5,900	1,600
new 2821-2	Assume does not alter natural stratification after pipe extension	Extend pipe to be 50 meters outside littoral zone	18,500	18,500	2,800
new 2821-3	Trend is for recirculating; Assume meets intake flow criteria	Install passive screens to achieve 0.5 fps velocity and maximize survival of impinged & minimize entrainment	3,500	0	3,500
new 2824-1	Trend for recirculating; Assume meets intake flow criteria, velocity criteria, & 100% recirc criteria; Assume maximizes survival & minimizes impingement because of passive screens and fish returns	None	[redacted]		
new 2833-1	Trend for recirculating; Assume meets intake flow criteria. Assume 50 meters outside littoral zone.	None	11,400	10,300	2,700
new 2834-1	Intake flow criteria not met, so switch to recirculating and then since flow is less than 2 MGD, no other action is required	Install cooling tower to make 100% recirc	[redacted]		
new 2841-1	Assume none of the criteria met.After switching to 100% recirc, facility flow is less than 2 MGD so no other action is required	Install cooling tower for 100% recirc.	5,000	5,000	800
new 2865-1	Trend for recirculating; Assume meets intake flow criteria, velocity criteria (passive screens) & 50 meters outside littoral zone	None	[redacted]		
new 2869-1	Once through only (based on 10 facilities); Assume meets intake flow criteria, velocity criteria (passive screen); After switching to 100% recirc, flow is less than 2 MGD so no other action is requried	Install cooling tower to make 100% recirc	8,300	8,300	1,200
new 2869-2	Once through only (based on 10 facilities); Assume meets intake flow criteria, velocity criteria (passive screen); After switching to 100% recirc, flow is less than 2 MGD so no other action is requried	Install cooling tower to make 100% recirc	8,300	8,300	1,200
new 2869-3	Recirc only (based on data for 7 facilities); Assume meets intake flow & recirc criteria	Install velocity caps to meet velocity criteria	1,700	0	1,700
new 2869-4	Recirc only (based on data for 7 facilities); Assume meets intake flow & recirc criteria	Install velocity caps to meet velocity criteria	1,700	0	1,700
new 2869-5	Recirc only (based on data for 7 facilities); Assume meets intake flow & recirc criteria	Install velocity caps to meet velocity criteria	1,700	0	1,700
new 2869-6	Recirc & once thru (based on 3 facilities); assume meets velocity criteria	Extend pipe to be 50 meters outside littoral zone	31,300	28,200	7,400
new 2869-7	Recirc & once thru (based on 3 facilities); assume meets velocity criteria	Extend pipe to be 50 meters outside littoral zone	31,300	28,200	7,400

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

	Capital Costs								
Primary SIC code	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 ft/Sec $	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $
new 2812-1	$24,000	$0	$0	$0	$0	$0	$0	$0	$24,000
new 2813-1	[redacted]								
new 2819-1	$0	$0	$0	$0	$0	$0	$0	$320,000	$320,000
new 2819-2	$0	$0	$60,000	$0	$0	$0	$0	$1,452,000	$1,512,000
new 2821-1	$0	$0	$0	$0	$170,000	$0	$0	$0	$170,000
new 2821-2	$0	$0	$0	$0	$300,000	$0	$0	$0	$300,000
new 2821-3	$0	$0	$47,000	$0	$0	$0	$0	$0	$47,000
new 2824-1	[redacted]								
new 2833-1	$0	$0	$0	$0	$0	$0	$0	$0	$0
new 2834-1	[redacted]								
new 2841-1	$0	$0	$0	$0	$0	$0	$0	$375,000	$375,000
new 2865-1	[redacted]								
new 2869-1	$0	$0	$0	$0	$0	$0	$0	$605,000	$605,000
new 2869-2	$0	$0	$0	$0	$0	$0	$0	$605,000	$605,000
new 2869-3	$0	$0	$0	$0	$0	$21,000	$0	$0	$21,000
new 2869-4	$0	$0	$0	$0	$0	$21,000	$0	$0	$21,000
new 2869-5	$0	$0	$0	$0	$0	$21,000	$0	$0	$21,000
new 2869-6	$0	$0	$0	$0	$400,000	$0	$0	$0	$400,000
new 2869-7	$0	$81,000	$0	$0	$400,000	$0	$0	$0	$481,000

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

	Annual O&M Costs			Total Costs	
Primary SIC code	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
new 2812-1	$0	$0	$0	$0	$24,000
new 2813-1	[redacted]	[redacted]	[redacted]	$419,300	$1,752,000
new 2819-1	$89,000	$0	$0	$89,000	$320,000
new 2819-2	$357,000	$0	$0	$357,000	$1,512,000
new 2821-1	$0	$0	$0	$0	$170,000
new 2821-2	$0	$0	$0	$0	$300,000
new 2821-3	$0	$0	$0	$0	$47,000
new 2824-1	[redacted]	[redacted]	[redacted]	$0	$0
new 2833-1	$0	$0	$0	$0	$0
new 2834-1	[redacted]	[redacted]	[redacted]	$111,000	$410,000
new 2841-1	$102,000	$0	$0	$102,000	$375,000
new 2865-1	[redacted]	[redacted]	[redacted]	$0	$0
new 2869-1	$157,000	$0	$0	$157,000	$605,000
new 2869-2	$157,000	$0	$0	$157,000	$605,000
new 2869-3	$0	$0	$0	$0	$21,000
new 2869-4	$0	$0	$0	$0	$21,000
new 2869-5	$0	$0	$0	$0	$21,000
new 2869-6	$0	$0	$0	$0	$400,000
new 2869-7	$479,000	$0	$4,700	$483,700	$481,000

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

Primary SIC code	Water Body	Flow GPD	Total Water Requirement GPD	Configuration of Facility's CWIS: Canal	Submerged Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other
new 2869-8	Nontidal River	45,000,000	70,515,000		X				
new 2869-9	Nontidal River	12,000,000	80,000,000	X					
new 2873-1	[redacted]								
new 2874-1	Lake, Pond or Res.	4,612,500	30,750,000					X	
new 2899-1	[redacted]								
new 3312-1	Tidal River	31,500,000	49,360,500					X	
new 3312-2	Nontidal River	16,700,000	111,333,333					X	
new 3312-3	Lake, Pond or Res.	76,000,000	119,092,000		X				
new 3316-1	[redacted]								
new 3353-1	[redacted]								

0= Not applicable for this facility under these compliance scenarios

[redacted] Contains Confidential Business Information

Notes/Assumptions for Facility Characteristics and Compliance Determination:

1) Facility with a passive screen is assumed to meet the 0.5 fps velocity criteria

2) Location: Facility with a shoreline, canal, or bay/cove intake is assumed to be in the littoral zone; Facility with an offshore intake is assumed to be less than 50 meters outside the littoral zone. As noted in the new source document, about 85% of the units in the EIA-767 database likely to have intakes have them less than 125 meters from shore, with a median distance of about 17 meters

3) Flow: Comments on flow are imbedded in the cells of the spreadsheet and can be viewed electronically; Since the trend for new facilities is toward the use of cooling towers, flows used may be lower than those for the existing facilities in some cases. All facilities that intake less than 2MGD were assumed to intake <1% of the source waterbody flow and thus are exempt.

4) All facilities assumed to have one intake, which seems reasonable for chemical and metals manufacturers since even most utilities have 1 or 2 intakes (verify) and typically use much higher flows.

Costing Assumptions:

5) If a facility is once through only and is projected to switch to a 100% recirculating system, the flow used for costing the cooling tower is 15% of the original flow since the flow will be reduced in the new system.

6) If a facility starts out as a combined once through and recirculating system, the facility is assumed to have 10% of the initial flow attributed to recirculating and 90% to the once through part of the system. The relative portions of the total flow are used for costing compliance actions.

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

	Technology Types Being Used					Profile of Facility's Cooling Water System						
Primary SIC code	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.	Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other
new 2869-8				X		X					X	
new 2869-9		X	X	X						X		
new 2873-1	[redacted]											
new 2874-1				X							X	
new 2899-1	[redacted]											
new 3312-1	X			X		X					X	
new 3312-2				X							X	
new 3312-3				X		X					X	
new 3316-1	[redacted]											
new 3353-1	[redacted]											

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

Primary SIC code	Current Compliance Assumptions	Projected Compliance Actions	Flow in gpm	Flow needed for Recirculating Cooling Tower gpm	Flow Needed for Activities Other Than Cooling Tower gpm
new 2869-8	Recirc & once thru (based on 3 facilities); assume meets velocity criteria	Extend pipe to be 50 meters outside littoral zone	31,300	28,200	7,400
new 2869-9	Due to trend for recirc (based on all data); Assume meets intake flow criteria, velocity criteria (passive screen), recirc criteria, maximizes survival of impinged & minimizes entrained because of passive screens & fish returns	None	8,300	0	8,300
new 2873-1	Assume meets intake flow criteria, meets recirc criteria	Install fish handling equipment to maximize survival of impinged fish & minimize entrainment	[redacted]	[redacted]	[redacted]
new 2874-1	Assume does not alter natural stratification of lake, meets recirc criteria; Assume cannot extend intake pipe to 50 meters outside littoral zone due to local geography	Install passive screens to meet 0.5 fps	3,200	0	3,200
new 2899-1	Once through only and recirc systems; Assume meets intake flow criteria, velocity criteria (passive screen); After switching to 100% recirc, flow is less than 2 MGD so no other action is required	Install cooling tower to make 100% recirc	[redacted]	[redacted]	[redacted]
new 3312-1	Assume meets intake flow criteria after switch to 100% recirculating system	Install cooling towers to switch rest of system to recirc; Install passive screens to meet 0.5 fps and maximize survival & minimize entrained	21,900	19,700	5,100
new 3312-2	Trend for recirculating; Assume meets intake flow criteria	Install velocity caps to meet 0.5 fps	11,600	0	11,600
new 3312-3	Trend for recirculating; Assume does not alter natural stratification of source water after switch to all recirc	Extend the pipe to 50 meters ouside the littoral zone	52,800	47,500	12,400
new 3316-1	Trend for recirculating; Assume meets intake flow criteria, velocity criteria, recirc criteria, maximize survival of impinged & minimize entrained because of passive screens & recirc system	None	[redacted]	[redacted]	[redacted]
new 3353-1	Assume meets intake flow criteria & recirc criteria; Assume cannot extend intake pipe to 50 meters outside littoral zone due to local geography	Enlarge intake pipe opening to meet 0.5 fps	[redacted]	[redacted]	[redacted]

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

	Capital Costs								
Primary SIC code	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 ft/Sec $	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $
new 2869-8	$0	$81,000	$0	$0	$400,000	$0	$0	$0	$481,000
new 2869-9	$0	$0	$0	$0	$0	$0	$0	$0	$0
new 2873-1	[redacted]								
new 2874-1	$0	$0	$44,000	$0	$0	$0	$0	$0	$44,000
new 2899-1	[redacted]								
new 3312-1	$0	$0	$60,000	$0	$0	$0	$0	$1,390,000	$1,450,000
new 3312-2	$0	$0	$0	$0	$0	$21,000	$0	$0	$21,000
new 3312-3	$0	$0	$0	$0	$700,000	$0	$0	$0	$700,000
new 3316-1	[redacted]								
new 3353-1	[redacted]								

Table 3. Projected New Manufacturing Facility Characteristics and Needed Compliance Action and Costs

	Annual O&M Costs			Total Costs	
Primary SIC code	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
new 2869-8	$479,000	$0	$4,700	$483,700	$481,000
new 2869-9	$0	$0	$0	$0	$0
new 2873-1	[redacted]	[redacted]	[redacted]	$5,200	$91,000
new 2874-1	$0	$0	NA	$0	$44,000
new 2899-1	[redacted]	[redacted]	[redacted]	$84,000	$299,000
new 3312-1	$342,000	$0	$0	$342,000	$1,450,000
new 3312-2	$0	$0	$0	$0	$21,000
new 3312-3	$0	$0	$0	$0	$700,000
new 3316-1	[redacted]	[redacted]	[redacted]	$0	$0
new 3353-1	[redacted]	[redacted]	[redacted]	$0	$3,000

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

Primary SIC code	Water Body	FLOW GPD	Total Water Requirement GPD	Flow needed for Recirculating Cooling Tower gpm	Flow Used for Costing Activities Other Than Cooling Tower gpm	Configuration of Facility's CWIS: Canal	Submerged Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other
new 2812-1	Nontidal River	72,400,000	482,666,667	-	50,300					X	
new 2813-1	[redacted]										
new 2819-1	Nontidal River	6,000,000	6,000,000	4,200	600		X				
new 2819-2	Tidal River	33,000,000	51,711,000	20,600	5,400					X	
new 2821-1	Nontidal River	9,500,000	14,886,500	5,900	1,600					X	
new 2821-2	Lake, Pond or Res.	26,640,000	26,640,000	18,500	2,800					X	
new 2821-3	Tidal River	5,000,000	33,333,333	-	3,500					X	
new 2824-1	[redacted]										
new 2833-1	Nontidal River	16,347,000	25,615,749	10,300	2,700					X	
new 2834-1	[redacted]										
new 2841-1	Lake, Pond or Res.	7,180,000	7,180,000	5,000	800					X	
new 2865-1	[redacted]										
new 2869-1	Nontidal River	12,000,000	12,000,000	8,300	1,200					X	
new 2869-2	Nontidal River	12,000,000	12,000,000	8,300	1,200					X	
new 2869-3	Nontidal River	2,400,000	16,000,000	-	1,700					X	
new 2869-4	Nontidal River	2,400,000	16,000,000	-	1,700					X	
new 2869-5	Nontidal River	2,400,000	16,000,000	-	1,700					X	
new 2869-6	Nontidal River	45,000,000	70,515,000	28,200	7,400		X				

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

	Technology Types Being Used					Profile of Facility's Cooling Water System						
Primary SIC code	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.	Once Through	Once through w/ ponds	Once through w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other
new 2812-1				X							X	
new 2813-1	[redacted]											
new 2819-1		X		X		X						
new 2819-2				X		X					X	
new 2821-1		X		X		X					X	
new 2821-2		X		X			X					
new 2821-3				X							X	
new 2824-1	[redacted]											
new 2833-1				X		X					X	X
new 2834-1	[redacted]											
new 2841-1				X		X						
new 2865-1	[redacted]											
new 2869-1		X		X		X						
new 2869-2		X		X		X						
new 2869-3				X							X	
new 2869-4				X							X	
new 2869-5				X							X	
new 2869-6				X		X					X	

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

Primary SIC code	Current Compliance Assumptions	Projected Compliance Action(s)
new 2812-1	Trend for recirculating & submerged offshore; Assume meets intake flow criteria & 100% recirc criteria	Enlarge intake pipe opening to achieve 0.5 fps velocity and install velocity cap; install fish handling and return equipment
new 2813-1	Passive and travel screens. Assume meets intake flow criteria & velocity criteria	Install cooling towers to make 100% recirc. Add fish baskets to maximize survival (for remaining flow)
new 2819-1	Assume meets intake flow criteria & velocity criteria, & maximizes survival of impinged & minimizes entrainment because of passive screens; After switching to 100% recirc, facility flow is less than 2 MGD so no other action is required	Install cooling towers to make 100% recirc
new 2819-2	Trend for submerged & recirculating; Assume meets intake flow volume and velocity criteria after switching to 100% recirculating system	Install cooling towers to make 100% recirc; Install fish handling equipment to maximize survival of impinged fish & minimize entrainment.
new 2821-1	Trend is for recirculating & submerged; Assume meets intake velocity criteria	Install cooling towers to make 100% recirc. Install fish handling equipment to maximize survival of impinged fish & minimize entrainment
new 2821-2	Trend for submerged; Passive screens and intake screens. Assume meets intake flow volume criteria after switching to 100% recirculating system	Install cooling towers to make 100% recirc. Install fish handling equipment to maximize survival of impinged fish & minimize entrainment
new 2821-3	Trend is for recirculating; Assume meets 100% recirc. flow criteria; estend the pipe to get outside of sensitive biological area	Install fish handling equipment to maximize survival of impinged fish & minimize entrainment; extend intake pipe
new 2824-1	Trend for recirculating; Assume meets intake flow criteria, velocity criteria, & 100% recirc criteria; Assume maximizes survival & minimizes impingement because of passive screens and fish returns	None
new 2833-1	Trend for recirculating; Assume meets intake flow and velocity criteria after switching to 100% recirculating	Add cooling tower for 100% recirc; install fish handling equipment for impingement and entrainment
new 2834-1	Intake flow criteria not met, so switch to recirculating and then since flow is less than 2 MGD, no other action is required	Install cooling tower to make 100% recirc
new 2841-1	Assume none of the criteria met.After switching to 100% recirc, facility flow is less than 2 MGD so no other action is required	Install cooling tower for 100% recirc.
new 2865-1	Trend for recirculating; Assume meets intake flow criteria, velocity criteria (passive screens) & 100% recirc criteria and passive screens minimize impingement and entrainment	None
new 2869-1	Once through only (based on 10 facilities); Assume meets intake flow criteria, velocity criteria (passive screen); After switching to 100% recirc, flow is less than 2 MGD so no other action is required	Install cooling tower to make 100% recirc
new 2869-2	Once through only (based on 10 facilities); Assume meets intake flow criteria, velocity criteria (passive screen); After switching to 100% recirc, flow is less than 2 MGD so no other action is required	Install cooling tower to make 100% recirc
new 2869-3	Recirc only (based on data for 7 facilities); Assume meets intake flow & recirc criteria	Install velocity caps and reduce velocity through fanning to meet velocity criteria; install fish handling equipment
new 2869-4	Recirc only (based on data for 7 facilities); Assume meets intake flow & recirc criteria	Install velocity caps and reduce velocity through fanning to meet velocity criteria; install fish handling equipment
new 2869-5	Recirc only (based on data for 7 facilities); Assume meets intake flow & recirc criteria	Install velocity caps and reduce velocity through fanning to meet velocity criteria; install fish handling equipment
new 2869-6	Recirc & once through (based on 3 facilities); Intake flow criteria not met before cooling towers	Install cooling tower for once through portion of flow to meet intake flow criteria, velocity criteria (same size intake but reduced flow now) & recirc criteria, & minimize entrainment (reduced velocity & flow); Add fish baskets to maximize survival of impinged fish

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

	Capital Costs										
Primary SIC code	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 fps $	Travel Screens with Fish Handling Equipment $	Area Restored ha	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Tech.. Capital Cost $
new 2812-1	$24,000	$153,000	$0	$0	$0	$0	$0	$37,000	$0	$0	$214,000
new 2813-1	[redacted]										
new 2819-1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$320,000	$320,000
new 2819-2	$0	$66,000	$0	$0	$0	$0	$0	$0	$0	$1,452,000	$1,518,000
new 2821-1	$0	$38,000	$0	$0	$0	$0	$0	$0	$0	$438,000	$476,000
new 2821-2	$0	$45,000	$0	$0	$0	$0	$0	$0	$0	$1,308,000	$1,353,000
new 2821-3	$0	$51,000	$0	$0	$0	$0	$130,000	$0	$0	$0	$181,000
new 2824-1	[redacted]										
new 2833-1	$0	$45,000	$0	$0	$0	$0	$0	$0	$0	$744,000	$789,000
new 2834-1	[redacted]										
new 2841-1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$375,000	$375,000
new 2865-1	[redacted]										
new 2869-1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$605,000	$605,000
new 2869-2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$605,000	$605,000
new 2869-3	$3,000	$38,000	$0	$0	$0	$0	$0	$21,000	$0	$0	$62,000
new 2869-4	$3,000	$38,000	$0	$0	$0	$0	$0	$21,000	$0	$0	$62,000
new 2869-5	$3,000	$38,000	$0	$0	$0	$0	$0	$21,000	$0	$0	$62,000
new 2869-6	$0	$81,000	$0	$0	$0	$0	$0	$0	$0	$1,967,000	$2,048,000

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

	Annual O&M Costs						Total Costs	
Primary SIC code	O&M Cost for cooling towers $	Number of Restocked Fish 1000	O&M Cost for Restoration $	Estimated Annual Cost for Gray water Purchase $	Annual O&M Costs for Travel Screens with Fish Handling Equipment $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
new 2812-1	$0	$0	$0	$0	$0	$21,000	$21,000	$214,000
new 2813-1	[redacted]						$423,300	$1,752,000
new 2819-1	$89,000	$0	$0	$0	$0	$0	$89,000	$320,000
new 2819-2	$357,000	$0	$0	$0	$0	$4,000	$361,000	$1,518,000
new 2821-1	$117,000	$0	$0	$0	$0	$2,300	$119,300	$476,000
new 2821-2	$323,000	$0	$0	$0	$0	$2,900	$325,900	$1,353,000
new 2821-3	$0	$0	$0	$0	$0	$3,200	$3,200	$181,000
new 2824-1	[redacted]						$0	$0
new 2833-1	$189,000	$0	$0	$0	$0	$2,800	$191,800	$789,000
new 2834-1	[redacted]						$111,000	$410,000
new 2841-1	$102,000	$0	$0	$0	$0	$0	$102,000	$375,000
new 2865-1	[redacted]						$0	$0
new 2869-1	$157,000	$0	$0	$0	$0	$0	$157,000	$605,000
new 2869-2	$157,000	$0	$0	$0	$0	$0	$157,000	$605,000
new 2869-3	$0	$0	$0	$0	$0	$2,300	$2,300	$62,000
new 2869-4	$0	$0	$0	$0	$0	$2,300	$2,300	$62,000
new 2869-5	$0	$0	$0	$0	$0	$2,300	$2,300	$62,000
new 2869-6	$479,000	$0	$0	$0	$0	$4,700	$483,700	$2,048,000

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

						Configuration of Facility's CWIS					
Primary SIC code	Water Body	FLOW GPD	Total Water Requirement GPD	Flow needed for Recirculating Cooling Tower gpm	Flow Used for Costing Activities Other Than Cooling Tower gpm	Canal	Submerged Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other
new 2869-7	Nontidal River	45,000,000	70,515,000	28,200	7,400		X				
new 2869-8	Nontidal River	45,000,000	70,515,000	28,200	7,400		X				
new 2869-9	Nontidal River	12,000,000	80,000,000	-	8,300	X					
new 2873-1	[redacted]										
new 2874-1	Lake, Pond or Res.	4,612,500	30,750,000	-	3,200					X	
new 2899-1	[redacted]										
new 3312-1	Tidal River	31,500,000	49,360,500	19,700	5,100					X	
new 3312-2	Nontidal River	16,700,000	111,333,333	-	11,600					X	
new 3312-3	Lake, Pond or Res.	76,000,000	119,092,000	47,500	12,400		X				
new 3316-1	[redacted]										
new 3353-1	[redacted]										

0= Not applicable for this facility under these compliance scenarios

Contains Confidential Business Information

Notes/Assumptions for Facility Characteristics and Compliance Determination:
1) Facility with a passive screen is assumed to meet the 0.5 fps velocity criteria
2) Location: Facility with a shoreline, canal, or bay/cove intake is assumed to be in the littoral zone; Facility with an offshore intake is assumed to be less than 50 meters outside the littoral zone. As noted in the new source document, about 85% of the units in the EIA-767 database likely to have intakes less than 75 meters from shore, with a median distance of about 17 meters

3) Flow: Comments on flow are imbedded in the cells of the spreadsheet and can be viewed electronically; Since the trend for new facilities is toward the use of cooling towers, flows used may be lower than those for the existing facilities in some cases. All facilities that intake less than 2MGD were assumed to intake <1% of the source waterbody flow and thus are exempt.
4) All facilities assumed to have one intake, which seems reasonable for chemical and metals manufacturers since even most utilities have 1 or 2 intakes (verify) and typically use much higher flows.

Costing Assumptions:
5) If a facility is once through only and is projected to switch to a 100% recirculating system, the flow used for costing the cooling tower is 15% of the original flow since the flow will be reduced in the new system.

6) If a facility starts out as a combined once through and recirculating system, the facility is assumed to have 10% of the initial flow attributed to recirculating and 90% to the once through part of the system. The relative portions of the total flow are used for costing compliance actions.

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

	Technology Types Being Used					Profile of Facility's Cooling Water System						
Primary SIC code	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.	Once Through	Once through w/ ponds	Once through w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other
new 2869-7				X		X					X	
new 2869-8				X		X					X	
new 2869-9		X	X	X						X		
new 2873-1	[redacted]											
new 2874-1				X							X	
new 2899-1	[redacted]											
new 3312-1	X			X		X					X	
new 3312-2				X							X	
new 3312-3				X		X					X	
new 3316-1	[redacted]											
new 3353-1	[redacted]											

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

Primary SIC code	Current Compliance Assumptions	Projected Compliance Action(s)
new 2869-7	Recirc & once through (based on 3 facilities); Intake flow criteria not met before cooling towers	Install cooling tower for once through portion of flow to meet intake flow criteria, velocity criteria (same size intake but reduced flow now) & recirc criteria, & minimize entrainment (reduced velocity & flow); Add fish baskets to maximize survival of impinged fish
new 2869-8	Recirc & once through (based on 3 facilities); Intake flow criteria not met before cooling towers	Install cooling tower for once through portion of flow to meet intake flow criteria, velocity criteria (same size intake but reduced flow now) & recirc criteria, & minimize entrainment (reduced velocity & flow); Add fish baskets to
new 2869-9	Due to trend for recirc (based on all data); Assume meets intake flow criteria, velocity criteria (passive screen), recirc criteria, maximizes survival of impinged & minimizes entrained because of passive screens & fish returns	None
new 2873-1	Assume meets intake flow criteria, meets recirc criteria	Install fish handling equipment for maximize survival of impinged & minimize entrainment
new 2874-1	Meets recirc criteria	Install fish handling equipment for maximize survival of impinged & minimize entrainment
new 2899-1	Once through only and recirc systems; Assume meets intake flow criteria, velocity criteria (passive screen); After switching to 100% recirc, flow is less than 2 MGD so no other action is required	Install cooling tower to make 100% recirc
new 3312-1	Assume meets intake flow criteria after switch to 100% recirculating system. Trend for fish diversion technology; travel screen	Install cooling towers to switch rest of system to recirc; Extend intake pipe
new 3312-2	Trend for recirculating; Assume meets 100% recirc criteria	Install velocity caps; install fish handling to maximize survival of entrained
new 3312-3	Trend for recirculating; Assume does not alter natural stratification of source water after switch to all recirc; Assume cannot extend intake pipe to 50 meters outside littoral zone due to local geography	Install cooling towers to switch rest of system to recirculating; install Travel screens with fish handling to maximize survival of impinged & minimize entrained
new 3316-1	Trend for recirculating; Assume meets intake flow criteria, velocity criteria, recirc criteria, maximize survival of impinged & minimize entrained because of passive screens & recirc system	None
new 3353-1	Assume meets intake flow criteria & 100% recirc criteria	Enlarge intake pipe opening to meet 0.5 fps; install fish handling equipment and fish baskets to maximize survival of impinged and entrained

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

Primary SIC code	Capital Costs										
	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 fps $	Travel Screens with Fish Handling Equipment $	Area Restored ha	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Tech.. Capital Cost $
new 2869-7	$0	$81,000	$0	$0	$0	$0	$0	$0	$0	$1,967,000	$2,048,000
new 2869-8	$0	$81,000	$0	$0	$0	$0	$0	$0	$0	$1,967,000	$2,048,000
new 2869-9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
new 2873-1	[redacted]										
new 2874-1	$0	$48,000	$0	$0	$0	$0	$0	$0	$0	$0	$48,000
new 2899-1	[redacted]										
new 3312-1	$0	$0	$0	$0	$0	$0	$150,000	$0	$0	$1,390,000	$1,540,000
new 3312-2	$0	$102,000	$0	$0	$0	$0	$0	$21,000	$0	$0	$123,000
new 3312-3	$0	$0	$0	$292,000	$0	$0	$0	$0	$0	$3,250,000	$3,542,000
new 3316-1	[redacted]										
new 3353-1	[redacted]										

Table 4. Projected New Manufacturer Characteristics, Needed Compliance Action and Costs for Uniform Standard

	Annual O&M Costs						Total Costs	
Primary SIC code	O&M Cost for cooling towers $	Number of Restocked Fish 1000	O&M Cost for Restoration $	Estimated Annual Cost for Gray water Purchase $	Annual O&M Costs for Travel Screens with Fish Handling Equipment $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
new 2869-7	$479,000	$0	$0	$0	$0	$4,700	$483,700	$2,048,000
new 2869-8	$479,000	$0	$0	$0	$0	$4,700	$483,700	$2,048,000
new 2869-9	$0	$0	$0	$0	$0	$0	$0	$0
new 2873-1	[redacted]						$5,200	$91,000
new 2874-1	$0	$0	$0	$0	$0	$3,100	$3,100	$48,000
new 2899-1	[redacted]						$84,000	$299,000
new 3312-1	$342,000	$0	$0	$0	$0	$0	$342,000	$1,540,000
new 3312-2	$0	$0	$0	$0	$0	$5,700	$5,700	$123,000
new 3312-3	$784,000	$0	$0	$0	$17,000	$0	$801,000	$3,542,000
new 3316-1	[redacted]						$0	$0
new 3353-1	[redacted]						$2,600	$45,000

Table 5. Case Study Manufacturer Characteristics and Needed Compliance Actions and Costs

Primary SIC code	Water Body	Flow GPD	Total Water Requirement GPD	Configuration of Facility's CWIS: Canal	Submerge Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other	Technology Types Being Used: Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.
NEW 2600 HF	Nontidal River	16,500,000	25,855,500		X						X		X	
NEW 2600 MF	Nontidal River	5,070,000	7,944,690		X						X		X	
NEW 2900 HF	Nontidal River	49,680,000	77,848,560		X								X	
NEW 2900 MF	Nontidal River	7,200,000	11,282,400		X								X	
NEW 2000 HF	Nontidal River	19,258,333	30,177,808	X							X		X	
NEW 2000 MF	Nontidal River	2,648,000	4,149,416	X							X		X	
NEW 2400 HF	Nontidal River	4,000,000	4,000,000	X									X	
NEW 2400 MF	Nontidal River	1,700,000	1,700,000	X									X	
NEW 3200	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

HF - High Flow
MF - Median Flow
[redacted] Contains Confidential Business Information
0= Not applicable for this facility under these compliance scenarios

Table 5. Case Study Manufacturer Characteristics and Needed Compliance Actions and Costs

Primary SIC code	Profile of Facility's Cooling Water System: Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other	Current Compliance Assumptions	Projected Compliance Actions	Flow in gpm	Flow needed for Recirculating Cooling Tower gpm	Flow Needed for Activities Other Than Cooling Tower gpm
NEW 2600 HF	X					X		Trend for recirc; Since shoreline intake assume in littoral zone; assume meets flow criteria	Extend pipe 50 meters out of littoral zone; fan the opening to decrease the velocity to meet criteria	11,500	1,600	2,700
NEW 2600 MF	X					X		Trend for recirc; Since shoreline intake assume in littoral zone; after switching to 100% recirc, under 2 MGD no further action required.	Install cooling tower to make 100% recirc.	3,500	500	800
NEW 2900 HF	X					X		Trend for recirc; Since shoreline intake assume in littoral zone; assume meets the flow criteria	Extend the pipe outside littoral zone; fanning to meet velocity criteria with velocity caps for additional fish protection.	34,500	4,700	8,100
NEW 2900 MF	X					X		Trend for recirc; Since shoreline intake assume in littoral zone; after switching to 100% recirc, under 2 MGD no further action required.	Install cooling tower to make 100% recirc.	5,000	700	1,200
NEW 2000 HF	X					X		Trend for recirc.; assume meets flow and velocity (passive screens) criteria; assume in littoral zone	Dredge canal below littoral zone; install cooling towers	13,400	1,800	3,100
NEW 2000 MF	X					X		Trend for recirc.; assume meets flow and velocity (passive screens) criteria; assume in littoral zone; after switching to 100% recirc., flow is less than 2 MGD no further action required	Install cooling towers	1,800	200	400
NEW 2400 HF	X							After switching to 100% recirc., flow is less than 2 MGD no further action required	Install cooling tower to make 100% recirc.	2,800	420	-
NEW 2400 MF	X							Meets the 2 MGD exemption, no action required	None	1,200	180	-
NEW 3200	[redacted]							Assume in littoral zone, meets the flow criteria, and does not alter the natural stratification of the lake	Install cooling tower for 100% recirc.; extend the pipe to get out of littoral zone but within 50 meters; fan intake pipe to meet velocity criteria with velocity caps for additional fish protection; and add passive screens to reduce impingement	[redacted]		

Table 5. Case Study Manufacturer Characteristics and Needed Compliance Actions and Costs

	Capital Costs									Annual O&M Costs			Total Costs	
Primary SIC code	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 ft/Sec $	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
NEW 2600 HF	$3,500	$0	$0	$0	$120,000	$0	$0	$0	$124,000	$0	$0	$0	$0	$124,000
NEW 2600 MF	$0	$0	$0	$0	$0	$0	$0	$246,000	$246,000	$70,000	$0	$0	$70,000	$246,000
NEW 2900 HF	$6,000	$0	$0	$0	$190,000	$21,000	$0	$0	$217,000	$0	$0	$0	$0	$217,000
NEW 2900 MF	$0	$0	$0	$0	$0	$0	$0	$341,000	$341,000	$90,000	$0	$0	$90,000	$341,000
NEW 2000 HF	$0	$0	$0	$0	$0	$0	$210,000	$866,000	$1,076,000	$220,000	$0	$0	$220,000	$1,076,000
NEW 2000 MF	$0	$0	$0	$0	$0	$0	$0	$139,000	$139,000	$50,000	$0	$0	$50,000	$139,000
NEW 2400 HF	$0	$0	$0	$0	$0	$0	$0	$202,000	$202,000	$60,000	$0	$0	$60,000	$202,000
NEW 2400 MF	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
NEW 3200	[redacted]												$1,110,000	$4,970,000

Table 6. Worst Case Costing Scenario for Steam Electric Plant

Base Plant	Water Body	FLOW GPD	Electricity Generation MW	Configuration of Facility's CWIS					Technology Types Being Used			
				Canal	Submerged Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens
Coal-fired- Max flow for recirc	Estuary	1,247,000,000	2,558			X						X
Coal-fired - Avg flow for Top 1/3 of once through systems	Estuary	1,080,000,000	1,200			X						X
Nuclear - Max flow for recirc	Estuary	2,611,000,000	2,708			X						X
Nuclear - Avg flow for Top 1/3 of once through systems	Estuary	2,931,000,000	2,666			X						X

Table 6. Worst Case Costing Scenario for Steam Electric Plant

Base Plant	Profile of Facility's Cooling Water System: Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Current Compliance Assumptions	Projected Compliance Action(s)	Flow needed for Recirculating Cooling Tower gpm	Flow Needed for Activities Other Than Cooling Tower gpm
Coal-fired- Max flow for recirc				X			Meets the recirculating criteria	Dredge canal to off the shoreline to get off the highly productive shoreline to a less productive area, and fan intake to decrease velocity; install traveling screens and fish handling to maximize survival of I&E fish	865,972	865,972
Coal-fired - Avg flow for Top 1/3 of once through systems	X						Assume meet none of the criteria for estuarine environment	Install cooling towers to meet 100% recirc.; Dredge canal to off the shoreline to get off the highly productive shoreline to a less productive area and fan intake to decrease velocity; install traveling screens and fish handling to maximize survival of I&E fish	75,000	75,000
Nuclear - Max flow for recirc	X			X			Meets the recirculating criteria	Dredge canal to off the shoreline to get off the highly productive shoreline to a less productive area and fan intake to decrease velocity; install traveling screens and fish handling to maximize survival of I&E fish	1,813,194	1,813,194
Nuclear - Avg flow for Top 1/3 of once through systems	X						Assume meet none of the criteria for estuarine environment	Install cooling towers to meet 100% recirc.; Dredge canal to off the shoreline to get off the highly productive shoreline to a less productive area and fan intake to decrease velocity; install traveling screens and fish handling to maximize survival of I&E fish	203,542	203,542

Table 6. Worst Case Costing Scenario for Steam Electric Plant

	Capital Costs						Annual O&M Costs			Total Cost	
Base Plant	Velocity reduction by Intake Fanning or Widening Cost $	Traveling Screen w/ fish handling equipment (0.5 fps) Cost $	Restoration Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Traveling Screens & Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
Coal-fired- Max flow for recirc	$491,000	$8,600,000	$0	$4,200,000	$0	$13,291,000	$0	$0	$400,000	$400,000	$13,291,000
Coal-fired - Avg flow for Top 1/3 of once through systems	$41,000	$970,000	$0	$460,000	$22,000,000	$23,471,000	$5,220,000	$0	$55,000	$5,275,000	$23,471,000
Nuclear - Max flow for recirc	$1,112,000	$18,000,000	$0	$8,700,000	$0	$27,812,000	$0	$0	$900,000	$900,000	$27,812,000
Nuclear - Avg flow for Top 1/3 of once through systems	$110,000	$2,000,000	$0	$1,040,000	$54,300,000	$57,450,000	$15,590,000	$0	$100,000	$15,690,000	$57,450,000

Table 7. Projected New 800 MW Coal-Fired Facilities Compliance Actions and Costs

Base Plant	Water Body	FLOW GPD	Electricity Generation MW	Configuration of Facility's CWIS				
				Canal	Submerged Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore
Coal1	Estuary	700,000,000	800					X
Coal2	Estuary	17,000,000	800					X
Coal3	Estuary	17,000,000	800					X
Coal4	Estuary	17,000,000	800					X
Coal5	Nontidal River	700,000,000	800					X
Coal6	Estuary	17,000,000	800					X
Coal7	Estuary	17,000,000	800					X
Coal8	Estuary	17,000,000	800					X
Coal9	Estuary	700,000,000	800					X
Coal10	Estuary	17,000,000	800					X
Coal11	Estuary	17,000,000	800					X
Coal12	Estuary	17,000,000	800					X
Coal13	Estuary	700,000,000	800					X
Coal14	Estuary	17,000,000	800					X
Coal15	Estuary	17,000,000	800					X
Coal16	Estuary	17,000,000	800					X

Table 7. Projected New 800 MW Coal-Fired Facilities Compliance Actions and Costs

	Technology Types Being Used				Profile of Facility's Cooling Water System					
Base Plant	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers
Coal1		X			X					
Coal2				X						X
Coal3				X						X
Coal4				X						X
Coal5				X	X					
Coal6				X						X
Coal7				X						X
Coal8				X						X
Coal9		X			X					
Coal10				X						X
Coal11				X						X
Coal12				X						X
Coal13		X			X					
Coal14				X						X
Coal15				X						X
Coal16				X						X

Table 7. Projected New 800 MW Coal-Fired Facilities Compliance Actions and Costs

Base Plant	Current Compliance Assumptions	Projected Compliance Action(s)	Flow in gpm	Flow needed for Recirculating Cooling Tower gpm	Flow Needed for Activities Other Than Cooling Tower gpm
Coal1	Assume meet none of the criteria for estuarine environment	Add cooling towers for 100% recirc, widen intake for velocity reduction, add traveling screens with fish handling equipment to reduce impingement and entrainment	486,111	48,611	48,611
Coal2	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal3	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal4	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal5	Assume within 50 meters of littoral zone, does not meet the velocity standard	Widen the intake to reduce velocity, extend the pipe to 50 meters outside the littoral zone	486,111	486,111	486,111
Coal6	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal7	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal8	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal9	Assume meet none of the criteria for estuarine environment	Add cooling towers for 100% recirc, widen intake for velocity reduction, add traveling screens with fish handling equipment to reduce impingement and entrainment	486,111	48,611	48,611
Coal10	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal11	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal12	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal13	Assume meet none of the criteria for estuarine environment	Add cooling towers for 100% recirc, widen intake for velocity reduction, add traveling screens with fish handling equipment to reduce impingement and entrainment	486,111	48,611	48,611
Coal14	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal15	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal16	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805

Table 7. Projected New 800 MW Coal-Fired Facilities Compliance Actions and Costs

	Capital Costs							
Base Plant	Velocity reduction by Intake Fanning or Widening Cost $	Traveling Screen w/ fish handling equipment (0.5 fps) Cost $	Fish Handling Equipment Cost $	Restoration Cost $	Pipe Extension Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $
Coal1	$27,000	$700,000	$0	$0	$0	$0	$14,500,000	$15,227,000
Coal2	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal3	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal4	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal5	$267,000	$0	$0	$0	$5,097,200	$0	$0	$5,364,200
Coal6	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal7	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal8	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal9	$27,000	$700,000	$0	$0	$0	$0	$14,500,000	$15,227,000
Coal10	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal11	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal12	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal13	$27,000	$700,000	$0	$0	$0	$0	$14,500,000	$15,227,000
Coal14	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal15	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal16	$0	$0	$33,000	$0	$0	$0	$0	$33,000

Table 7. Projected New 800 MW Coal-Fired Facilities Compliance Actions and Costs

	Annual O&M Costs				Total Cost	
Base Plant	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Annual O&M Costs for Traveling Screens & Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
Coal1	$3,340,000	$0	$0	$38,000	$3,378,000	$15,227,000
Coal2	N/A	$0	$5,700	$0	$5,700	$33,000
Coal3	N/A	$0	$5,700	$0	$5,700	$33,000
Coal4	N/A	$0	$5,700	$0	$5,700	$33,000
Coal5	$0	$0	$0	$0	$0	$5,364,200
Coal6	N/A	$0	$5,700	$0	$5,700	$33,000
Coal7	N/A	$0	$5,700	$0	$5,700	$33,000
Coal8	N/A	$0	$5,700	$0	$5,700	$33,000
Coal9	$3,340,000	$0	$0	$38,000	$3,378,000	$15,227,000
Coal10	N/A	$0	$5,700	$0	$5,700	$33,000
Coal11	N/A	$0	$5,700	$0	$5,700	$33,000
Coal12	N/A	$0	$5,700	$0	$5,700	$33,000
Coal13	$3,340,000	$0	$0	$38,000	$3,378,000	$15,227,000
Coal14	N/A	$0	$5,700	$0	$5,700	$33,000
Coal15	N/A	$0	$5,700	$0	$5,700	$33,000
Coal16	N/A	$0	$5,700	$0	$5,700	$33,000

Table 8. New 800 MW Coal-fired Plants Compliance Actions and Costs for Uniform Standard

Base Plant	Water Body	FLOW GPD	Electricity Generation MW	Configuration of Facility's CWIS: Canal	Submerged Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore
Coal1	Estuary	700,000,000	800					X
Coal2	Estuary	17,000,000	800					X
Coal3	Estuary	17,000,000	800					X
Coal4	Estuary	17,000,000	800					X
Coal5	Estuary	700,000,000	800					X
Coal6	Estuary	17,000,000	800					X
Coal7	Estuary	17,000,000	800					X
Coal8	Estuary	17,000,000	800					X
Coal9	Estuary	700,000,000	800					X
Coal10	Estuary	17,000,000	800					X
Coal11	Estuary	17,000,000	800					X
Coal12	Estuary	17,000,000	800					X
Coal13	Estuary	700,000,000	800					X
Coal14	Estuary	17,000,000	800					X
Coal15	Estuary	17,000,000	800					X
Coal16	Estuary	17,000,000	800					X

Table 8. New 800 MW Coal-fired Plants Compliance Actions and Costs for Uniform Standard

	Technology Types Being Used				Profile of Facility's Cooling Water System					
Base Plant	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers
Coal1		X			X					
Coal2				X						X
Coal3				X						X
Coal4				X						X
Coal5		X			X					
Coal6				X						X
Coal7				X						X
Coal8				X						X
Coal9		X			X					
Coal10				X						X
Coal11				X						X
Coal12				X						X
Coal13		X			X					
Coal14				X						X
Coal15				X						X
Coal16				X						X

Table 8. New 800 MW Coal-fired Plants Compliance Actions and Costs for Uniform Standard

Base Plant	Current Compliance Assumptions	Projected Compliance Action(s)	Flow in gpm	Flow needed for Recirculating Cooling Tower gpm	Flow Needed for Activities Other Than Cooling Tower gpm
Coal1	Assume meet none of the criteria for estuarine environment	Add cooling towers for 100% recirc, widen intake for velocity reduction, add traveling screens with fish handling equipment to reduce impingement and entrainment	486,111	48,611	48,611
Coal2	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal3	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal4	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal5	Assume meet none of the criteria for estuarine environment	Add cooling towers for 100% recirc, widen intake for velocity reduction, add traveling screens with fish handling equipment to reduce impingement and entrainment	486,111	48,611	48,611
Coal6	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal7	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal8	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal9	Assume meet none of the criteria for estuarine environment	Add cooling towers for 100% recirc, widen intake for velocity reduction, add traveling screens with fish handling equipment to reduce impingement and entrainment	486,111	48,611	48,611
Coal10	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal11	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal12	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal13	Assume meet none of the criteria for estuarine environment	Add cooling towers for 100% recirc, widen intake for velocity reduction, add traveling screens with fish handling equipment to reduce impingement and entrainment	486,111	48,611	48,611
Coal14	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal15	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805
Coal16	Trend for submerged offshore CWIS with screens. Meets the recirculating and velocity criteria.	Add fish handling technologies to reduce impingement and entrainment	11,805	11,805	11,805

Table 8. New 800 MW Coal-fired Plants Compliance Actions and Costs for Uniform Standard

	Capital Costs							
Base Plant	Velocity reduction by Intake Fanning or Widening Cost $	Traveling Screen w/ fish handling equipment (0.5 fps) Cost $	Fish Handling Equipment Cost $	Restoration Cost $	Pipe Extension Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $
Coal1	$27,000	$700,000	$0	$0	$0	$0	$14,500,000	$15,227,000
Coal2	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal3	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal4	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal5	$27,000	$700,000	$0	$0	$0	$0	$14,500,000	$15,227,000
Coal6	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal7	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal8	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal9	$27,000	$700,000	$0	$0	$0	$0	$14,500,000	$15,227,000
Coal10	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal11	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal12	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal13	$27,000	$700,000	$0	$0	$0	$0	$14,500,000	$15,227,000
Coal14	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal15	$0	$0	$33,000	$0	$0	$0	$0	$33,000
Coal16	$0	$0	$33,000	$0	$0	$0	$0	$33,000

Table 8. New 800 MW Coal-fired Plants Compliance Actions and Costs for Uniform Standard

	Annual O&M Costs				Total Cost	
Base Plant	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Annual O&M Costs for Traveling Screens & Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
Coal1	$3,340,000	$0	$0	$38,000	$3,378,000	$15,227,000
Coal2	$0	$0	$5,700	$0	$5,700	$33,000
Coal3	$0	$0	$5,700	$0	$5,700	$33,000
Coal4	$0	$0	$5,700	$0	$5,700	$33,000
Coal5	$3,340,000	$0	$0	$38,000	$3,378,000	$15,227,000
Coal6	$0	$0	$5,700	$0	$5,700	$33,000
Coal7	$0	$0	$5,700	$0	$5,700	$33,000
Coal8	$0	$0	$5,700	$0	$5,700	$33,000
Coal9	$3,340,000	$0	$0	$38,000	$3,378,000	$15,227,000
Coal10	$0	$0	$5,700	$0	$5,700	$33,000
Coal11	$0	$0	$5,700	$0	$5,700	$33,000
Coal12	$0	$0	$5,700	$0	$5,700	$33,000
Coal13	$3,340,000	$0	$0	$38,000	$3,378,000	$15,227,000
Coal14	$0	$0	$5,700	$0	$5,700	$33,000
Coal15	$0	$0	$5,700	$0	$5,700	$33,000
Coal16	$0	$0	$5,700	$0	$5,700	$33,000

Table 9. New Combined Cycle Facilities Compliance Actions and Costs

New Gen	Water Body	Flow GPD	Total Water Requirement GPD	Configuration of Facility's CWIS						Technology Types Being Used				
				Canal	Submergec Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.
CC1	Estuary	60,000,000	60,000,000					X					X	
CC2	Lake, Pond or Res.	9,000,000	60,000,000					X					X	
CC3	Lake, Pond or Res.	9,000,000	60,000,000					X					X	
CC4	Lake, Pond or Res.	9,000,000	60,000,000					X					X	
CC5	Estuary	60,000,000	60,000,000					X					X	
CC6	Lake, Pond or Res.	9,000,000	60,000,000					X					X	
CC7	Lake, Pond or Res.	9,000,000	60,000,000					X					X	
CC8	Lake, Pond or Res.	9,000,000	60,000,000					X					X	
CC9	Estuary	60,000,000	60,000,000					X					X	
CC10	Lake, Pond or Res.	9,000,000	60,000,000					X					X	
CC11	Lake, Pond or Res.	9,000,000	60,000,000					X					X	

Table 9. New Combined Cycle Facilities Compliance Actions and Costs

New Gen	Profile of Facility's Cooling Water System: Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other	Current Compliance Assumptions	Projected Compliance action(s)	Flow in gpm	Flow needed for Recirc Cooling Tower gpm	Flow Needed for activities Other Than Cooling Tower gpm
CC1	X							Meets flow requirement	Install cooling towers, and fish handling equipment.	41,666	41,666	6,250
CC2						X		Meets the flow, velocity, and recirc criteria;	Extend the pipe	6,000	-	-
CC3						X		Meets the flow, velocity, and recirc criteria;	Extend the pipe	6,000	-	-
CC4						X		Meets the flow, velocity, and recirc criteria;	Extend the pipe	6,000	-	-
CC5	X							Meets flow requirement	Install cooling towers, and fish handling equipment.	41,666	41,666	6,250
CC6						X		Meets the flow, velocity, and recirc criteria;	Extend the pipe	6,000	-	-
CC7						X		Meets the flow, velocity, and recirc criteria;	Extend the pipe	6,000	-	-
CC8						X		Meets the flow, velocity, and recirc criteria;	Extend the pipe	6,000	-	-
CC9	X							Meets flow requirement	Install cooling towers, and fish handling equipment.	41,666	41,666	6,250
CC10						X		Meets the flow, velocity, and recirc criteria;	Extend the pipe	6,000	-	-
CC11						X		Meets the flow, velocity, and recirc criteria;	Extend the pipe	6,000	-	-

Table 9. New Combined Cycle Facilities Compliance Actions and Costs

	Capital Costs									Annual O&M Costs			Total Cost	
New Gen	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 ft/Sec $	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
CC1	$0	$73,000	$0	$0	$0	$0	$0	$2,867,000	$2,940,000	$693,000	$0	$4,400	$697,400	$3,637,400
CC2	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000
CC3	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000
CC4	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000
CC5	$0	$73,000	$0	$0	$0	$0	$0	$2,867,000	$3,029,582	$693,000	$0	$4,400	$697,400	$3,726,982
CC6	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000
CC7	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000
CC8	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000
CC9	$0	$73,000	$0	$0	$0	$0	$0	$2,867,000	$3,029,582	$693,000	$0	$4,400	$697,400	$3,726,982
CC10	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000
CC11	$0	$0	$0	$0	$162,000	$0	$0	$0	$162,000	$0	$0	$0	$0	$162,000

Table 10. New Combined Cycle Plants Compliance Actions and Costs for the Uniform Standard

				Configuration of Facility's CWIS						Technology Types Being Used				
New Gen	Water Body	Flow GPD	Total Water Requirement GPD	Canal	Submergec Shoreline	Surface Shoreline	Bay-cove	Submerged Offshore	Other	Fish Diversion	Passive Intakes	Fish Returns	Intake Screens	Other Tech.
CC1	Estuary	60,000,000	60,000,000					X					X	
CC2	Estuary	9,000,000	60,000,000					X					X	
CC3	Estuary	9,000,000	60,000,000					X					X	
CC4	Estuary	9,000,000	60,000,000					X					X	
CC5	Estuary	60,000,000	60,000,000					X					X	
CC6	Estuary	9,000,000	60,000,000					X					X	
CC7	Estuary	9,000,000	60,000,000					X					X	
CC8	Estuary	9,000,000	60,000,000					X					X	
CC9	Estuary	60,000,000	60,000,000					X					X	
CC10	Estuary	9,000,000	60,000,000					X					X	
CC11	Estuary	9,000,000	60,000,000					X					X	

Table 10. New Combined Cycle Plants Compliance Actions and Costs for the Uniform Standard

	Profile of Facility's Cooling Water System											
New Gen	Once Through	Once thru w/ ponds	Once thru w/ towers	Recirc.	Recirc w/ ponds	Recirc w/ towers	Other	Current Compliance Assumptions	Projected Compliance action(s)	Flow in gpm	Flow needed for Recirc Cooling Tower gpm	Flow Needed for activities Other Than Cooling Tower gpm
CC1	X							Meets flow requirement	Install cooling towers, and fish handling equipment.	41,666	41,666	6,250
CC2						X		Meets the flow, velocity, and recirc criteria	Add fish handling technologies.	6,000	6,000	6,000
CC3						X		Meets the flow, velocity, and recirc criteria	Add fish handling technologies.	6,000	6,000	6,000
CC4						X		Meets the flow, velocity, and recirc criteria	Add fish handling technologies.	6,000	6,000	6,000
CC5	X							Meets flow requirement	Install cooling towers, and fish handling equipment.	41,666	41,666	6,250
CC6						X		Meets the flow, velocity, and recirc criteria	Add fish handling technologies.	6,000	6,000	6,000
CC7						X		Meets the flow, velocity, and recirc criteria	Add fish handling technologies.	6,000	6,000	6,000
CC8						X		Meets the flow, velocity, and recirc criteria	Add fish handling technologies.	6,000	6,000	6,000
CC9	X							Meets flow requirement	Install cooling towers, and fish handling equipment.	41,666	41,666	6,250
CC10						X		Meets the flow, velocity, and recirc criteria	Add fish handling technologies.	6,000	6,000	6,000
CC11						X		Meets the flow, velocity, and recirc criteria	Add fish handling technologies.	6,000	6,000	6,000

Table 10. New Combined Cycle Plants Compliance Actions and Costs for the Uniform Standard

	Capital Costs									Annual O&M Costs			Total Cost	
New Gen	Velocity Reduction by Intake Fanning or Widening Cost $	Fish Handling Equipment Cost $	Passive Screen 0.5 ft/Sec $	Restoration Cost $	Pipe Extension Cost $	Velocity Cap Cost $	Canal Dredging Cost $	Cooling Tower Cost $	Total Techn. Capital Cost $	O&M Cost for cooling towers $	O&M Cost for Restoration $	Annual O&M Costs for Fish Handling $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
CC1	$0	$73,000	$0	$0	$0	$0	$0	$2,867,000	$3,029,582	$693,000	$0	$4,400	$697,400	$3,726,982
CC2	$0	$71,000	$0	$0	$0	$0	$0	$0	$71,000	$0	$0	$4,300	$4,300	$71,000
CC3	$0	$71,000	$0	$0	$0	$0	$0	$0	$71,000	$0	$0	$4,300	$4,300	$71,000
CC4	$0	$71,000	$0	$0	$0	$0	$0	$0	$71,000	$0	$0	$4,300	$4,300	$71,000
CC5	$0	$73,000	$0	$0	$0	$0	$0	$2,867,000	$3,029,582	$693,000	$0	$4,400	$697,400	$3,726,982
CC6	$0	$71,000	$0	$0	$0	$0	$0	$0	$71,000	$0	$0	$4,300	$4,300	$71,000
CC7	$0	$71,000	$0	$0	$0	$0	$0	$0	$71,000	$0	$0	$4,300	$4,300	$71,000
CC8	$0	$71,000	$0	$0	$0	$0	$0	$0	$71,000	$0	$0	$4,300	$4,300	$71,000
CC9	$0	$73,000	$0	$0	$0	$0	$0	$2,867,000	$3,029,582	$693,000	$0	$4,400	$697,400	$3,726,982
CC10	$0	$71,000	$0	$0	$0	$0	$0	$0	$71,000	$0	$0	$4,300	$4,300	$71,000
CC11	$0	$71,000	$0	$0	$0	$0	$0	$0	$71,000	$0	$0	$4,300	$4,300	$71,000

Table 11. Dry cooling Tower Costs for New Coal-fired and Combined Cycle Plants

			Profile of Facility's Cooling Water					Capital Costs		Annual O&M Costs	Total Cost	
Base Plant	FLOW GPD	Electricity Generation MW	Once Through	Recirc w/ towers	Projected Compliance Action(s)	Flow in gpm	Total Water Requirement gpm	Dry Cooling Tower Cost $	Total Techn. Capital Cost $	O&M Cost for Dry Cooling Towers $	Total Estimated Annual Cost $	Total Estimated Capital Costs $
Coal1	700,000,000	800	X		Add dry cooling towers	486,111	486,111	$64,337,000	$64,337,000	$22,370,000	$22,370,000	$64,337,000
Coal2	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal3	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal4	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal5	700,000,000	800	X		Add dry cooling towers	486,111	486,111	$64,337,000	$64,337,000	$22,370,000	$22,370,000	$64,337,000
Coal6	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal7	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal8	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal9	700,000,000	800	X		Add dry cooling towers	486,111	486,111	$64,337,000	$64,337,000	$22,370,000	$22,370,000	$64,337,000
Coal10	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal11	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal12	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal13	700,000,000	800	X		Add dry cooling towers	486,111	486,111	$64,337,000	$64,337,000	$22,370,000	$22,370,000	$64,337,000
Coal14	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal15	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
Coal16	17,000,000	800		X	Add dry cooling towers	11,805	118,050	$24,377,000	$24,377,000	$7,624,000	$7,624,000	$24,377,000
CC1	60,000,000		X		Add dry cooling towers	41,666	41,666	$9,295,000	$9,295,000	$2,867,000	$2,867,000	$9,295,000
CC2	9,000,000			X	Add dry cooling towers	6,000	60,000	$13,128,000	$13,128,000	$4,062,000	$4,062,000	$13,128,000
CC3	9,000,000			X	Add dry cooling towers	6,000	60,000	$13,128,000	$13,128,000	$4,062,000	$4,062,000	$13,128,000
CC4	9,000,000			X	Add dry cooling towers	6,000	60,000	$13,128,000	$13,128,000	$4,062,000	$4,062,000	$13,128,000
CC5	60,000,000		X		Add dry cooling towers	41,666	41,666	$9,295,000	$9,295,000	$2,867,000	$2,867,000	$9,295,000
CC6	9,000,000			X	Add dry cooling towers	6,000	60,000	$13,128,000	$13,128,000	$4,062,000	$4,062,000	$13,128,000
CC7	9,000,000			X	Add dry cooling towers	6,000	60,000	$13,128,000	$13,128,000	$4,062,000	$4,062,000	$13,128,000
CC8	9,000,000			X	Add dry cooling towers	6,000	60,000	$13,128,000	$13,128,000	$4,062,000	$4,062,000	$13,128,000
CC9	60,000,000		X		Add dry cooling towers	41,666	41,666	$9,295,000	$9,295,000	$2,867,000	$2,867,000	$9,295,000
CC10	9,000,000			X	Add dry cooling towers	6,000	60,000	$13,128,000	$13,128,000	$4,062,000	$4,062,000	$13,128,000
CC11	9,000,000			X	Add dry cooling towers	6,000	60,000	$13,128,000	$13,128,000	$4,062,000	$4,062,000	$13,128,000