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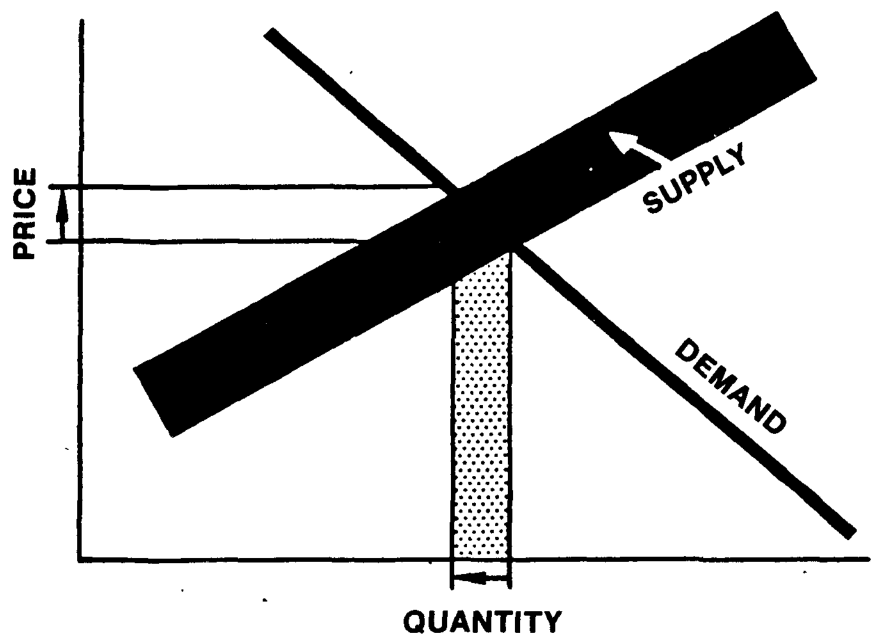
Economic Impact Analysis of Effluent Limitations and Standards for the Inorganic Chemicals Industry, Phase II



Economic Impact Analysis of Effluent Limitations Guidelines and Standards for the Inorganic Chemicals Industry--Phase II

Prepared for

U.S. Environmental Protection Agency
Office of Analysis and Evaluation
Office of Water Regulations and Standards
Washington, D.C. 20460

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

This document is an economic impact assessment of the recently promulgated effluent guidelines. The report is being distributed to EPA Regional Offices and state pollution control agencies and directed to the staff responsible for writing industrial discharge permits. The report includes detailed information on the costs and economic impacts of various treatment technologies. It should be helpful to the permit writer in evaluating the economic impacts on an industrial facility that must comply with BAT limitations or water quality standards.

A limited number of copies of this report are available from the Economic Analysis Staff in the Office of Water Regulations and Standards at EPA Headquarters:

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PREFACE

This document is a contractor's study prepared for the Office of Water Regulations and Standards of the Environmetal Protecton Agency (EPA). The purpose of the study is to analyze the economic impact which could result from the application of effluent standards and limitations guidelines issued under Sections 301, 304, 306, 307 and 501 of the Clean Water Act to the inorganic chemicals manufacturing industry.

This study supplements the technical study (EPA Development Document) supporting the issuance of these regulations. The Development Document surveys existing and potential waste treatment control methods and technologies within particular industrial source categories and supports certain standards and limitations based upon an analysis of the feasibility of these standards in accordance with the requirements of the Clean Water Act. Presented in the Development Document are the investment and operating costs associated with various control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the application of various control methods and technologies. This study investigates the effect in terms of product price increases, effects upon production and the continued viability of affected plants, effects upon foreign trade, and other competitive effects.

The study has been prepared with the supervision and review of the Office of Water Regulations and Standards of EPA. This report was submitted in fulfillment of Contract No. 68-01-6426 by Meta Systems Inc and completed in October 1983.

Section 1

Executive Summary

1.1 Introduction

This study presents the economic effects of the effluent limitations and standards on the inorganic chemicals manufacturing industry. The study was prepared under the supervision of the Office of Analysis and Evaluation, U.S. Environmental Protection Agency (the "Agency"). This section, the Executive Summary, presents brief descriptions of other sections of the report:

- Qualitative Economic Assessment
- Methodology
- Effluent Limitations Options and Compliance Costs
- Results
- Regulatory Flexibility Analysis
- Limits to the Analysis
- Sodium Sulfite Impact Analysis
- Sodium Chloride Impact Analysis (NSPS)

1.2 Qualitative Economic Assessment

The Agency is required by the Settlement Agreement and the Clean Water Act to issue effluent limitations for the Inorganic Chemicals Manufacturing Point Source Category. This category includes all products identified under Standard Industrial Classification (SIC) code numbers 2812, 2813, 2816, and 2819. Regulation of the Inorganic Chemicals Point Source Category was divided into two phases. Effluent limitations for Phase I were promulgated in June 1982; they addressed 60 subcategories and covered 85 percent of the toxic pollutant discharges from the industry. Phase II includes six subcategories that consolidate 17 chemicals.

The six subcategories (and 17 chemicals) in Phase II are analyzed here as nine separate chemical groups:

1. Cadmium Pigments
2. Cadmium Salts
   - cadmium chloride
   - cadmium nitrate
   - cadmium sulfate
3. Cobalt Salts
   - cobalt chloride
   - cobalt nitrate
   - cobalt sulfate

4. Copper Carbonate
5. Copper Salts
    - copper chloride
    - copper iodide
    - copper nitrate
6. Nickel Carbonate
7. Nickel Salts
    - nickel chloride
    - nickel fluoborate
    - nickel nitrate
8. Sodium Chlorate
9. Zinc Chloride

These chemicals represent a very small portion of the inorganic chemicals produced in the U.S. Thirty-six firms operate the 46 plants that produce these chemicals. Both the firms and the plants range in size from very small to very large. Virtually all of the plants also produce chemicals other than those examined in this study.

In addition we analyze the economic impacts of the current regulations in the sodium sulfite and sodium chloride subcategories.

The summary statistics of the subcategories are presented in Table 1-1. Sodium chlorate has by far the largest production of the nine groups. It has experienced significant growth in recent years. Growth of the other chemicals has varied, but has generally been stagnant.

1.3 Methodology

The economic impact assessment methodology consists of a baseline analysis and a subsequent impact analysis. The initial baseline analysis provides a basis against which potential impacts are assessed. Baseline values are calculated for manufacturing costs, profitability, and product price without additional treatment costs.

The extent to which treatment costs have an impact on plants and subcategories is determined in a series of steps. First, costs of treatment are estimated for each plant. The changes in manufacturing costs and profitability are estimated for each plant and aggregated for each subcategory. Price increases and production decreases are also calculated.

A plant closure analysis is performed for those plants with large changes in profitability (i.e., greater than 10 percent). A liquidity test compares annual treatment costs to annual cash flow (before treatment) at each plant. Where treatment costs exceed cash flow, a potential plant closure is projected. The second step of plant closure analysis is a solvency test. The test compares the magnitude of a plant's salvage value to the present value of the cash flow. If the discounted cash flow is less than salvage value, it is worth more to the operator to sell the facilities than to continue production. Hence, a potential closure is projected.

Table 1-1. Summary Statistics for Phase II Inorganic Chemicals

Subcategory	Average Price (1982 $/kg)	Major End Uses	Number of Plants	Estimated Demand Elasticity	Baseline Production (Metric ton/yr)
Cadmium Pigments	9.71	Plastics, paint, glass colorant	5	-0.1	2,860
Cadmium Salts	5.71	Printing, battery electrolyte, metal finishing	7	-0.3	618
Cobalt Salts	18.26	Electroplating, glazes, inks, pigments, dyes	9	-0.4	871
Copper Carbonate	2.62	Agricultural, textiles, paints	6	-0.2	4,365
Copper Salts	2.99	Colorant, battery electrolyte, feed additive	10	-0.3	1,980
Nickel Carbonate	6.67	Pigments, electroplating	7	-0.15	924
Nickel Salts	2.77	Electroplating, batteries, glass colorant	12	-0.2	7,443
Sodium Chlorate	0.46	Pulp bleach, chlorate intermediate, herbicide	13	-0.15	312,300
Zinc Chloride	0.91	Deodorant, disinfectant, fabric sizing	7	-0.2	39,714

Employment and foreign trade impacts are assessed by further interpretation of the closure analysis. The possibility of disproportionate impacts on small business is assessed in a separate small business analysis. Impacts on new sources are analyzed by examining model plants with proposed treatment options.

1.4 Effluent Limitations Options and Compliance Costs

Section 4 discusses the effluent regulations, the wastewater treatment options that were analyzed, and the costs associated with those options.

The treatment technologies for all subcategories except sodium chlorate are:

Level 1: Alkaline precipitation, clarification, sludge dewatering, pH adjustment.

Level 2: Filtration of clarified wastewater from Level 1.

For sodium chlorate plants, the treatment technologies are:

Level 1: Chromium reduction followed by lime precipitation and clarification. Reduction follows to destroy residual chlorine.

Level 2: Filtration of clarified wastewater from Level 1.

Plant level treatment costs are estimated from model plant costs and from available production, wastewater flow, and existing treatment-in-place data except where plant-specific costs are provided by EPA. The wastewater treatment costs are summarized in Table 1-2.

1.5 Results

The results of the impact analysis are presented under the subheadings of plant level impacts, product level impacts, closure, employment impacts, foreign trade impacts, and new source performance standards. A summary of results is presented in Table 1-2.

1.5.1 Plant Level Impacts

The plant level impacts examined are 1) the ratio of treatment costs to manufacturing costs and 2) the ratio of treatment costs to net revenue (i.e., the change in profitability). At both Level 1 and Level 2 costs, five plants have treatment costs in excess of 2 percent of manufacturing costs. At Level 2, the average change in profitability is 4.4 percent for direct dischargers and 1.7 percent for indirect dischargers. Six plants have treatment costs greater than 10 percent of net revenues. These six plants are examined further in the closure analysis.

Table 1-2. Summary of Impacts

	Direct Dischargers		Indirect Dischargers	
	Level 1	Level 2	Level 1	Level 2
Total number of plants	21	21	8	8
Number of Plants Incurring Cost	8	12	5	6
Investment Cost ($000)	3,917	4,799	868	1,116
Total Annual Cost ($000)	1,974	2,337	410	501
Change in Return on Investment (%)	3.75	4.44	1.37	1.67
Price Increase (%)	0.81	0.96	0.81	0.96
Closures	0	0	0	0

1.5.2 Product Level Impacts

Impacts to products are measured in terms of changes in price and production volume. Price increases range from 0.01 to 2.40 percent for Level 2 controls; the average for all subcategories is 0.96 percent. The prices for nickel carbonate show the greatest change and those for cobalt salts show the smallest change. Production decreases are small, ranging from 0.003 to 0.414 percent for Level 2.

1.5.3 Closure

Closure potential is identified with a liquidity test and a solvency test. In neither case is a closure predicted.

1.5.4 Employment

No loss of jobs is expected to result from compliance with these treatment requirements.

1.5.5 Foreign Trade Impacts

No negative foreign trade impacts are expected to result from compliance with these treatment requirements.

1.5.6 New Source Standards

The analysis of new source standards (new source performance standards, NSPS, and pretreatment standards for new sources, PSNS) considers that all new sources will have treatment requirements equal to the BAT/PSES treatment option for existing sources. An analysis of these costs has been performed for the model plants in each subcategory. The analysis covers both greenfield sites and major modifications to existing facilities. The exception is sodium chloride where alternative technologies are considered.

As found in the analysis of existing plants, the impacts are generally quite small. They are not predicted to present barriers to entry for new plants in any of the subcategories.

As part of the proposed regulations, pretreatment standards for new sources (PSNS) are being proposed for twelve additional subcategories. The PSNS requirement is zero discharge of process wastewater. In each of these subcategories, existing dischargers are subject to, and meeting zero discharge effluent limitations. No cost disadvantages or other impacts are expected from these new PSNS.

1.6 Regulatory Flexibility Analysis

The differential impact on small businesses is analyzed at Level 2 for direct and indirect dischargers. Small businesses are defined as corporations employing less than 1,000 persons. No closures are predicted in this group. No disproportional burden is detected.

1.7 Limits to the Analysis

The analysis of the economic impact of treatment costs on the inorganic chemicals industry is limited by the data. Many plant level economic characteristics are not available, and model plant information is necessary to supplement the actual plant data. The resulting plant level estimates of manufacturing costs, treatment costs, and the various financial ratios that use these values may not be accurate. To protect against the failure to identify significant impacts, conservative (i.e., worst-case scenarios) assumptions are made and sensitivity analyses are performed.

The sensitivity analyses test alternative assumptions for interest rates, cost pass-through, manufacturing costs, and treatment costs. The results of the impact analysis are not sensitive to reasonable variations in the critical assumptions. No reasonable variation in interest rates, cost pass-through or treatment costs causes major changes to the report's original conclusions.

1.8 Sodium Sulfite Impact Analysis

As part of the rulemaking for Inorganic Chemicals, Phase II, the Agency is including revisions to existing BAT and NSPS limitations in the sodium sulfite subcategory. Section 8 of this report addresses the impact of compliance costs for existing and new dischargers in this subcategory. Results of the cost analysis suggest that the existing zero discharge limitations are not economically achievable. The results support revision of the existing requirements to allow discharge of process wastewater.

1.9 Sodium Chloride Impact Analysis

In conjunction with the Phase II rulemaking EPA reexamined the zero discharge effluent limitations and performance standards in the sodium chloride subcategory. The agency is revising the BAT limitations because of the lack of toxic pollutants in the BPT discharge. Section 9 of this report addresses the impact of compliance costs for new dischargers in this subcategory. Several alternative treatment technologies are examined which achieve zero discharge of new sources. The analysis suggests that zero discharge limitations do not result in any barriers to entry for new sources.

Section 2

Qualitative Economic Assessment

2.1 Introduction

The Agency is required by the Settlement Agreement and the Clean Water Act to issue effluent limitations for the Inorganic Chemicals Manufacturing Point Source category. This category includes all products identified under Standard Industrial Classification (SIC) code numbers 2812, 2813, 2816, and 2819. Regulation of the Inorganic Chemicals Point Source category was divided into two phases. Effluent limitations for Phase I were promulgated in June 1982 1/. They addressed 60 subcategories and covered 85 percent of the toxic pollutant discharges from the industry. Phase II initially included 124 subcategories, many of which are excluded from further national regulation development under the provisions of Paragraph 8 of the Settlement Agreement. The remaining 17 chemicals are the focus of the Phase II study.

This section presents an industrial and economic profile of the inorganic chemicals included in the Phase II economic impact analysis. The 17 chemical products are grouped into six subcategories, with three subcategories--Cadmium Compounds, Copper Salts and Nickel Salts--further divided. In this report, the 17 chemicals are divided into nine chemical groups:

1. Cadmium Pigments
2. Cadmium Salts
   - cadmium chloride
   - cadmium nitrate
   - cadmium sulfate
3. Cobalt Salts
   - cobalt chloride
   - cobalt nitrate
   - cobalt sulfate
4. Copper Carbonate
5. Copper Salts
   - copper chloride
   - copper iodide
   - copper nitrate
6. Nickel Carbonate

1/ 47 FR 28260.

7. Nickel Salts
    nickel chloride
    nickel fluoborate
    nickel nitrate

8. Sodium Chlorate

9. Zinc Chloride

In addition we analyze the economic impacts of the current regulations in the sodium sulfite and sodium chloride subcategories.

2.2 Plants and Producers

In terms of both value added and number of plants, Phase II chemicals represent a very small portion of the inorganic chemical industry. For example, according to the Annual Survey of Manufacturers in 1980, inorganic pigments represent 0.95 percent of the total inorganic chemical market, and the inorganic pigments included in Phase II are a small portion of this 0.95 percent market. The SIC category for inorganic chemicals not elsewhere classified (2819) includes some of the Phase II chemicals and represents about 7.9 percent of the value added in the inorganic chemical industry. There are 564 establishments included in the SIC 2819 category. This analysis concerns 46 plants, or about 8 percent of the establishments in the SIC 2819 category.

Table 2-1 lists the producers of Phase II compounds. The majority of these plants produce a variety of chemicals, only some of which fall into Phase II subcategories. Table 2-2 gives chemical-specific information on producers and also indicates the relative importance of Phase II chemicals to the plants. In many cases the Phase II chemical production is not the major production activity at the plant.

Thirty-six firms operate the 46 plants which produce the compounds included in this analysis. The Richardson-Merrell plant in Phillipsburg, New Jersey produces 13 of the 17 Phase II chemicals. These 13 chemicals are 11 percent of the roughly 120 chemicals produced at that plant. Gulf Oil's Cleveland, Ohio plant produces 10 compounds, which account for one-third of the 30 chemicals produced at that plant. The plant operated by The Shepard Chemical Company in Cincinnati, Ohio produces 9 of the Phase II chemicals, and McGean Chemicals in Cleveland, Ohio produces seven. Cadmium pigments and sodium chlorate are manufactured exclusively by plants that produce no other Phase II inorganic chemicals. As Table 2-2 and Chart 2-1 indicate, most plants produce several chemical compounds.

Table 2-1 Plants Producing Phase II Inorganic Chemicals

SUBCATEGORY	PLANTS
Cadmium Pigments	ASARCO Inc., Denver, CO Ciba-Geigy Corp., Glens Falls, NY H. Kohnstamm & Co., Inc., Newark, NJ Gulf Oil (Harshaw), Louisville, KY SCM Corp., Baltimore, MD
Cadmium Salts	C.P. Chemicals, Sumter, SC Hall Chemical Co., Arab, AL Gulf Oil (Harshaw), Cleveland, OH Richardson-Merrell, Phillipsburg, NJ Shepard Chemical Co., Cincinnati, OH United Catalysts Inc., Louisville, KY W.A. Cleary Corp., Somerset, NJ
Cobalt Salts	Alfa Products, Danvers, MA C.P. Chemicals, Sewaren, NJ Gulf Oil (Harshaw), Cleveland, OH Hall Chemical Co., Arab, AL Richardson-Merrell (J.T. Baker), Phillipsburg NJ Hall Chemical Co., Wickliffe, OH McGean Chem., Cleveland, OH Mooney Chems., Franklin, PA The Shephard Chem. Co., Cincinnati, OH United Catalysts Inc., Louisville, KY
Copper Carbonate	C.P Chemicals, Inc., Sewaren, NJ Cities Services, Copperhill, TN Kocide Chemical Co., Houston, TX Mineral Research Development, Concord, NC North American Philips, Brea, CA Richardson-Merrell, Philipsburg, NJ The Shepard Chemical Co., Cincinnati, OH United Catalysts, Louisville, KY

Table 2-1 Plants Producing Phase II Inorganic Chemicals (continued)

SUBCATEGORY	PLANTS
Copper Salts	Ajay Chemical Co., Powder Springs, GA C.P. Chemicals, Powder Springs, GA Chemetals Corp., Curtis Bay, MD Deepwater Chem. Co., Irvine CA Gulf Oil (Harshaw), Cleveland, OH McGean Chemical Co., Cleveland, OH Mineral R & D Corp., Concord, NC Richardson-Merrell (J.T. Baker), Phillipsburg, NJ The Shepard Chem., Co., Cincinnati, OH Southern California Chemical Co., Garland, TX United Catalysts, Louisville, KY
Nickel Carbonate	C.P. Chemicals, Inc., Sewaren, NJ Gulf Oil, Cleveland, OH Hall Chemical Co., Wickliffe, OH McGean Chemical Co., Cleveland, OH Richardson-Merrell, Phillipsburg, NJ The Shepard Chemical Co., Cincinnati, OH United Catalysts, Inc., Louisville, KY
Nickel Salts	Alfa Products, Danvers, MA Allied Chemical, Claymont, DE C.P. Chems., Inc., Sewaren, NJ C.P. Chems., Sumter, SC Gulf Oil (Harshaw), Cleveland, OH Hall Chemical Co., Arab, AL Hall Chemicals, Wickliffe, OH Harstan Chemicals, Brooklyn, NY McGean Chemical Co., Cleveland, OH Richardson-Merrell (J.T. Baker), Philipsburg, NJ The Shepard Chem., Co., Cincinnati, OH United Catalysts Inc., Louisville, KY

Table 2-1 Plants Producing Phase II Inorganic Chemicals (continued)

SUBCATEGORY	PLANTS
Sodium Chlorate	Brunswick Pulp & Paper, Brunswick, GA ERCO Industries, Monroe, LA Georgia-Pacific Corp., Plaquemine, LA Huron Chems. of Am., Ridgewood, NC Kerr-McGee Corp., Hamilton, MS Kerr-McGee Corp., Henderson, NV Occidental Chemical Corp. (Hooker Chem), Columbus, MS Occidental Chemicals Corp., Taft, LA Olin Corp., McIntosh, AL Pacific Eng. & Production, Henderson, NV Pennwalt Corp., Calvert City, KY Pennwalt Corp., Portland, OR Pennwalt Corp, Tacoma, WA
Zinc Chloride	C.P. Chemicals, Sewaren, NJ C.P. Chemicals, Sumter, NJ DuPont, Cleveland, OH Madison Indust., Inc., Old Bridge, NJ Mallinckrodt, Inc., St. Louis, MO Mineral Res. & Dev. Corp., Freeport, TX Richardson-Merrell (J.T. Baker), Philipsburg, NJ.

Source: SRI 1979 Directory of Chemical Producers, EPA.

Table 2-2. Phase II Inorganic Chemicals by Producer

FIRM AND PLANT	PHASE II CHEMICALS	TOTAL PHASE II CHEMICALS PRODUCED	TOTAL CHEMICALS PRODUCED (Approximate)
Ajay Chemical Co., Powder Springs, GA	Copper Iodide	1	5
Alfa Products, Danvers, MA	Nickel Fluoborate		
	Cobalt Chloride	2	95
Allied Chemical Co., Claymont, DE	Nickel Chloride		
	Nickel Fluoborate	2	10
Asarco, Inc., Denver, CO	Cadmium Pigments	1	19
Brunswick Pulp and Paper, Brunswick, GA	Sodium Chlorate	1	3
Ciba-Giegy Corp., Glens Falls, NY	Cadmium Pigments	1	NA
Chemetals Corp., Curtis Bay, MD	Copper Chloride	1	15
Cities Services, Copperhill, TN	Copper Carbonate	1	14
Cleary Corp., Somerset, NJ	Cadmium Chloride	1	1
C.P. Chemicals, Inc., Powder Springs, GA	Copper Chloride	1	8
C.P. Chemicals, Inc., Sewaren, NJ	Cobalt Chloride		
	Cobalt Nitrate		
	Cobalt Sulfate		
	Copper Carbonate		
	Nickel Carbonate		
	Nickel Chloride		
	Zinc Chloride	7	41
C.P. Chemicals, Sumter, SC	Cadmium Nitrate		
	Nickel Nitrate		
	Zinc Chloride	3	4
Deepwater Chemicals, Carson, CA	Copper Iodide	1	22
DuPont, Cleveland, OH	Zinc Chloride	1	17
ERCO Industries, Monroe, LA	Sodium Chlorate	1	1
Georgia Pacific, Plaquemine, LA	Sodium Chlorate	1	10
Gulf Oil, Cleveland, OH	Cadmium Chloride		
(Harshaw)	Cadmium Sulfate		
	Cobalt Chloride		
	Cobalt Nitrate		
	Cobalt Sulfate		
	Copper Chloride		
	Nickel Carbonate		
	Nickel Chloride		
	Nickel Fluoborate		
	Nickel Nitrate	10	30
Gulf Oil, Elyria, OH	Copper Nitrate	1	31
Gulf Oil, Louisville,KY	Cadmium Pigments	1	30

Table 2-2. Phase II Inorganic Chemicals by Producer

(continued)

FIRM AND PLANT	PHASE II CHEMICALS	TOTAL PHASE II CHEMICALS PRODUCED	TOTAL CHEMICALS PRODUCED (Approximate)
Hall Chemical Co., Arab, AL	Cadmium Nitrate Cobalt Nitrate Cobalt Sulfate Nickel Nitrate	4	NA
Hall Chemical Co., Wickliffe, OH	Cobalt Chloride Cobalt Sulfate Nickel Carbonate Nickel Chloride Nickel Nitrate	5	NA
Harstan Chemicals, Brooklyn, NY	Nickel Chloride Nickel Fluoborate	2	30
Huron Chemicals, Ridgewood, NC	Sodium Chlorate	1	1
Kerr-McGee, Hamilton, MS	Sodium Chlorate	1	6
Kerr-McGee, Henderson, NV	Sodium Chlorate	1	9
Kocide Chemical Co., Houston,, TX	Copper Carbonate	1	17
H. Kohnstamm & Co., Inc., Newark, NJ	Cadmium Pigments	2	3
Madison Industries, Old Bridge, NJ	Zinc Chloride	1	6
Mallinckrodt, Inc., St. Louis, MO	Zinc Chloride	1	100
McGean Chemical Co., Cleveland, OH	Cobalt Chloride Cobalt Nitrate Cobalt Sulfate Copper Chloride Nickel Carbonate Nickel Chloride Nickel Nitrate	7	28
Mineral Research & Development, Concord, NC	Copper Carbonate Copper Nitrate	2	30
Mineral Research & Development, Freeport, TX	Zinc Chloride	1	3
Mooney Chemicals, Inc., Franklin,, PA	Cobalt Sulfate	1	70
North American Philips, Brea, CA	Copper Carbonate	1	10
Occidental Chemical Co., Columbus, MS	Sodium Chlorate	1	NA
Occidental Chemical Co., Taft, LA	Sodium Chlorate	1	6
Olin Corp., McIntosh, AL	Sodium Chlorate	1	5
Pacific Engineering & Production Co., Henderson, NV	Sodium Chlorate	1	3
Pennwalt Corp., Calvert City, KY	Sodium Chlorate	1	15
Pennwalt Corp., Portland, OR	Sodium Chlorate	1	9
Pennwalt Corp., Tacoma, WA	Sodium Chlorate	1	7

Table 2-2. Phase II Inorganic Chemicals by Producer

(continued)

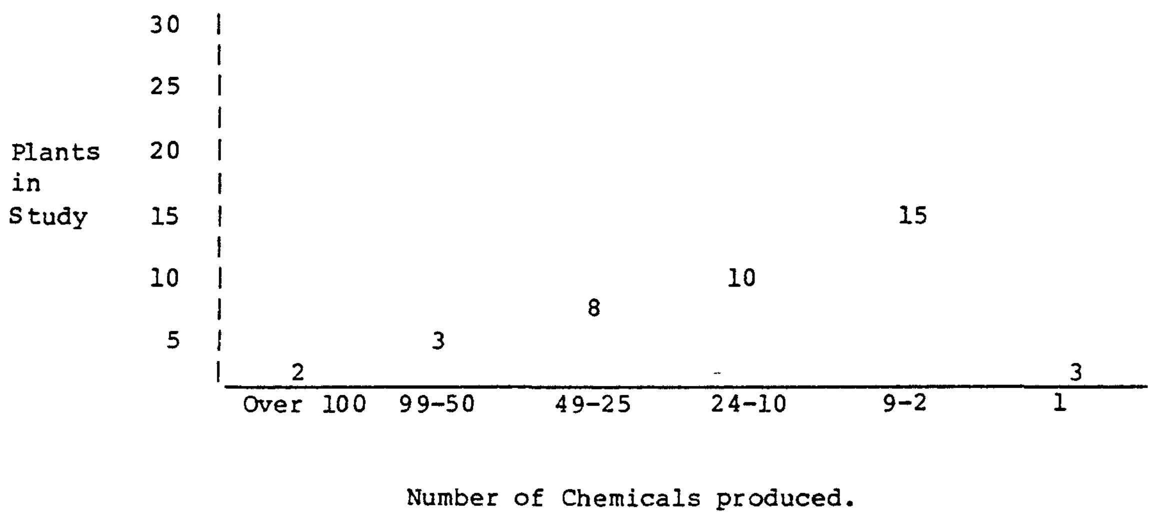
FIRM AND PLANT	PHASE II CHEMICALS	TOTAL PHASE II CHEMICALS PRODUCED	TOTAL CHEMICALS PRODUCED (Approximate)
Richardson-Merrell, Phillipsburg, NJ	Cadmium Chloride		
(J. T. Baker)	Cadmium Nitrate		
	Cadmium Sulfate		
	Cobalt Chloride		
	Cobalt Nitrate		
	Cobalt Sulfate		
	Copper Carbonate		
	Copper Chloride		
	Copper Nitrate		
	Nickel Carbonate		
	Nickel Chloride		
	Nickel Nitrate		
	Zinc Chloride	13	100
SCM Corp., Baltimore, MD	Cadmium Pigments	2	4
Shepard Chemical Co., Cincinnati, OH	Cadmium Nitrate		
	Cobalt Chloride		
	Cobalt Nitrate		
	Cobalt Sulfate		
	Copper Carbonate		
	Copper Iodide		
	Copper Nitrate		
	Nickel Carbonate		
	Nickel Nitrate	9	80
So. Cal. Chemicals Co. Inc., Garland, TX	Copper Chloride	1	NA
United Catalysts Inc., Louisville, KY	Cadmium Nitrate		
	Cobalt Nitrate		
	Copper Carbonate		
	Copper Nitrate		
	Nickel Carbonate		
	Nickel Nitrate	6	40

NA: Information not available.

Source: SRI 1979 Directory of Chemical Producers, EPA.

Chart 2-1

Number of Chemicals Produced by Plants (1979)



Source: SRI 1979 Directory of Chemical Producers

2.3 Economic Profile and Future Trends

The economic profile and future trends for each chemical were determined through public documents. In the following sections, baseline prices are expressed in second quarter 1983 dollars ($1983 Q2). Appendix 2A provides a brief description of the chemical processes by which the chemicals are produced.

2.3.1 Cadmium Salts and Pigments

There are at least eight commercially important cadmium compounds including the oxide, chloride, sulfate, nitrate, hydroxide, red pigments, yellow pigments, and various organic cadmium salts. Five of these for which there is economic data--chloride, nitrate, sulfate, cadmium red and cadmium yellow--are included in the present study.

There are many other inorganic chemicals that can substitute for cadmium salts in the various end-use markets. However, in the paints and pigments end-uses, other inorganics lack the heat stability of cadmium and, in most cases, the brilliance in colors. Zinc can be substituted for cadmium in electroplating, except when the plate must be exceptionally thin, or when solderability is important. Lead-acid batteries are the lowest cost substitute for cadmium batteries, but they lack dependability and longevity; therefore the demand for cadmium for batteries should remain strong. For low-melting point alloys, a number of other metals can be used.

2.3.1.1 Cadmium Chloride

Three firms are known to produce cadmium chloride. The major uses include: metal finishing, photo copying, printing, dyeing and catalysis. The price of cadmium chloride, as reported by The Chemical Marketing Reporter between 1978 and 1982 averaged about \$5.65/kg (in second quarter 1983 dollars). The cadmium chloride metal finishing bath, because it can be used in place of cyanide-based baths, is expected to increase its share of the metal finishing market in the next 20 years.

2.3.1.2 Cadmium Nitrate

Five firms are known to produce cadmium nitrate. Cadmium nitrate is the preferred starting material for the active material in nickel-cadmium and silver-cadmium alkaline storage batteries. It is also used in colorants for the ceramics industry and in combination with magnesium as a flash powder. The median CMR price was \$4.80/kg. The demand for cadmium compound batteries is expected to be strong in coming years and the demand for cadmium nitrate is thus expected to increase.

2.3.1.3 Cadmium Red

Cadmium red is produced by at least two firms. The pure red pigment, cadmium selenide, is produced by reacting cadmium sulfate with selenium. It is used in various pigments ranging from orange through maroon. The median price reported in CMR between 1978 and 1982 was \$9.70/kg but the many different grades in color shades vary in price. Cadmium red's market is tied directly to the markets of the products that it colors. It is expected to grow over time because of cadmium red's superior qualities as a colorant.

2.3.1.4 Cadmium Sulfate

Cadmium sulfate is produced by several firms as intermediate to cadmium pigments. Two other firms are known to produce cadmium sulfate as a final product. Cadmium sulfate solution is the electrolyte in standard cells such as the Weston cell and is used industrially as an alternative to the cadmium cyanide solution used in electroplating baths. It is also used in pigments, medicine vacuum tubes and flourescent screens. The median CMR price was \$7.00/kg. That cadmium sulfate can replace cyanide electroplating baths implies growth over the next few decades.

2.3.1.5 Cadmium Yellow

Cadmium yellow (cadmium sulfide) occurs naturally but is also made commercially by passing hydrogen sulfide gas into a solution of cadmium salt acidified with hydrochloric acid. An estimated four firms produce cadmium sulfide, and most of this is used for pigments. The main use for these pigments is in the plastics industry where over 1,000 tons (measured by cadmium content) were used in 1976. This amount represents 75 percent of all cadmium pigments used in that year. Additional colorant uses include: paints, soaps, rubber, paper, glass, printing inks, ceramic glazes, textiles and the blue color in fireworks.

Although Table 2-3 shows that production of cadmium sulfide declined over 65 percent between 1973 and 1981, a recent entry into the market is a sign that this trend has changed. The outlook for cadmium yellow is, therefore, stable.

Table 2-3. U.S. Cadmium Sulfide Production
(Metric Tons, Cadmium Content)

Year	Production	Year	Production
1971	1,230	1977	774
1972	1,493	1978	698
1973	1,555	1979	813
1974	1,194	1980	801
1975	1,086	1981	527
1976	884		

Source: U.S. Bureau of Mines: Mineral Facts and Problems, 1980.

2.3.1.6 Cadmium Salts and Pigments Summary Discussion.

Table 2-4 presents the summary statistics for the cadmium compounds subcategory. Production of cadmium salts and pigments is currently light and utilizes only 25 percent of subcategory capacity. The chemical groups are expected to grow over the next decade. The baseline prices for the subcategory range from $4.80/kg to $9.70/kg. The demand elasticities for these chemicals and the other chemicals in this analysis have been estimated from information on market growth and competition in the different end-use sectors.

Table 2-4. Subcategory Summary: Cadmium Salts and Pigments
Total Subcategory Production: 3,478 metric tons/year
Subcategory Capacity Utilization: 25%

Chemical	Baseline Price ($1983 Q2)	Major End-Uses	Number of Plants	Demand Elasticity
Cadmium Pigments	$9.70/kg	plastics paint glass colorant	5	-.1
Cadmium Chloride	$5.65/kg	metal finishing printing photo copying	3	-.3
Cadmium Nitrate	$4.80/kg	alkaline storage batteries ceramic colorant	5	-.1
Cadmium Sulfate	$7.00/kg	electroplating battery electrolyte	2	-.2

Sources: Chemical Marketing Reporter, 1978-82.
Effluent Guidelines Division, EPA, 1983.
Meta Systems, Inc.

2.3.2 Cobalt Salts

Reported domestic consumption of cobalt decreased 12 percent overall between 1977 and 1980. The decline in consumption can be attributed to cobalt's rapidly rising price which has encouraged substitution, and conservation by consumers. Table 2-5 shows cobalt's price increase from $7.63/kg in 1974 to $55/kg in February 1980.

Table 2-5. Average Annual Producer Price for Cobalt 1/

(dollars per kg)

Year	Price	Based on Constant 1978 Dollars
1974	7.63	9.98
1975	8.77	10.49
1976	9.79	11.13
1977	12.30	13.20
1978	25.41	25.41
1979	54.17	49.79
1980	55.00	46.46

1/ Prices are weighted averages based on African Metals Corporation price list.

Source: U.S. Bureau of Mines: Mineral Facts and Problems, 1980.

The SRI Chemical Economics Handbook for 1981 estimates that demand for superalloys and cobalt-rare earth magnets in the auto industry should keep cobalt salt demand strong in these end-uses. Demand for cobalt salts is projected to be generally constant. However, it will be stronger for ceramics and glass uses with a probable growth from 1.63 million pounds in 1978 to 5 million pounds in the year 2000.

The major cobalt salts included in this study are cobalt chloride, cobalt nitrate and cobalt sulfate.

2.3.2.1 Cobalt Chloride

Cobalt chloride is produced by seven firms. End-uses for cobalt chloride include: electroplating, inks and dyes, animal feed supplements, catalysis, and numerous laboratory uses. The median CMR price was $25.40/kg (in second quarter 1983 dollars). Prices have fluctuated quite widely over the past few years.

2.3.2.2 Cobalt Nitrate

Cobalt nitrate is produced by seven firms: The most common end-uses are in glass and porcelain coloring and as a laboratory reagent. The median CMR price was $15.90/kg.

2.3.2.3 Cobalt Sulfate

Eight firms produce this compound. The most common end-uses are similar to the other cobalt salts: pigments and glazes, additives for soil and animal feeds, and as a catalyst. The median CMR price was $16.80/kg.

2.3.2.4 Cobalt Salts Summary Discussion

Table 2-6 presents the summary statistics for this subcategory. Cobalt salts are produced in very small quantities, less than 1,400 metric tons annually. All three of the Phase II cobalt salts are used largely as pigments and are expected to maintain their current level of production. These three salts are very expensive with prices ranging from $15.9/kg to $25.4/kg.

Table 2-6. Subcategory Summary: Cobalt Salts
Total Subcategory Production: 871 metric tons/year
Subcategory Capacity Utilization: Not Available

Chemical	Baseline Price ($1983 Q2)	Major End-Uses	Number of Plants	Demand Elasticity
Cobalt Chloride	$25.40/kg	electroplating inks dyes	7	-.4
Cobalt Nitrate	$15.90/kg	glass and porcelain colorant	7	-.4
Cobalt Sulfate	$16.80/kg	pigments glazes	8	-.3

Sources: Chemical Marketing Reporter 1978-82.
Effluent Guidelines Division, EPA, 1983.
Meta Systems, Inc.

2.3.3 Copper Salts

Copper is widely distributed through the world and is one of the trace metals essential to life. In sufficiently large quantities, however, copper can be poisonous and for many generations copper salts have been used as fungicides.

Industrially important copper compounds number in the hundreds. Copper salts, however, are a minor part of total production compared to other copper compounds. The four copper salts included in this study are copper carbonate, copper chloride, copper iodide, and copper nitrate.

2.3.3.1 Copper Carbonate

Copper carbonate is produced by eight firms. The major uses of copper carbonate are diverse and include: agricultural uses, paints, catalysts for curing rubber, corrosion inhibitors, textiles and organic reactors. The median CMR price between 1978 and 1982 was $2.60/kg (in second quarter 1983 dollars).

2.3.3.2 Copper Chloride

Copper chloride is produced by five domestic firms and has a wide range of uses: as a battery electrolyte, lubricant, ceramic decolorizer, stabilizer in nylon manufacture, catalyst in olefins manufacture, flame-proofing agent and wood preservative. It is also used in textile bleach, soldering fluxes and pigments and dyes. The median CMR price was $2.20/kg.

2.3.3.3 Copper Iodide

Copper iodide is produced by three firms and is used in the manufacture of photographic emulsions and conductive transparent films, as a catalyst with olefins, as a promoter in cloud seedings and as an additive in animal feeds and table salt. Its price, quoted by a producer, is roughly $21.00/kg.

2.3.3.4 Copper Nitrate

Copper nitrate is produced by five firms. It has wide applications in ceramic color, as a mordant in dyeing, as a catalyst in solid rocket fuels, as a drilling mud disperant, as an agent to reduce carcinogenic gases in tobacco smoke, and as a corrosion inhibitor. CMR reports indicated a baseline price of $1.04/kg.

2.3.3.5 Copper Salts Summary Discussion

Table 2-7 presents the summary statistics for copper salts. The Phase II copper salts make up a very small portion of overall copper demand end-uses and their demand is expected to grow very little over the next two decades. Prices within the subcategory range from $1.04/kg to $21.00/kg. Production capacity is utilized at about 30 percent.

Table 2-7. Subcategory Summary: Copper Salts
Total Subcategory Production: 6,345 metric tons/year
Subcategory Capacity Utilization: 30%

Chemical	Baseline Price ($1983 Q2)	Major End-Uses	Number of Plants	Demand Elasticity
Copper Carbonate	$2.60/kg	agricultural textiles paints	8	-.2
Copper Chloride	$2.20/kg	battery electrolyte pigment dye textile bleach	5	-.2
Copper Iodide	$21.00/kg	photographic emulsions olefin catalyst feed additive	3	-.3
Copper Nitrate	$1.04/kg	ceramic colorant dye mordant rocket fuel	5	-.2

Sources: Chemical Marketing Reporter, 1978-82.
Effluent Guidelines Division, EPA, 1983.
Meta Systems, Inc.

2.3.4 Nickel Salts

There are at least 10 commercially important nickel compounds including the oxide, sulfate, nitrate, carbonate, hydroxide, and fluoborate of nickel. Four of these for which there is economic data are included as Phase II chemicals: the nitrate, chloride, carbonate, and fluoborate.

Nickel salts are primarily used in nickel electroplating and as an intermediate in the manufacture of nickel catalysts. Nickel salts can also be used as an alternative to cadmium and cobalt salts for petrochemical hydrogenation, desulfurization, and as denitrogenation catalysts. Nickel is sometimes used as a catalyst with other elements (primarily tungsten and molybdenum) when high concentrations of nitrogen and sulfur are present in petroleum fractions and distillates.

2.3.4.1 Nickel Carbonate

Seven firms produce nickel carbonate. It is used in the manufacture of catalysts, in the preparation of colored glass, in pigments, and as a neutralizing compound in nickel electroplating solutions. It also is used in the preparation of many specialty nickel compounds. The CMR median price is $6.70/kg.

2.3.4.2 Nickel Chloride

Seven firms produce nickel chloride. Nickel chloride is used as a reagent in a variety of reactions used to form compounds of nickel and in the electroplating industry. The median CMR price is $3.30/kg.

2.3.4.3. Nickel Fluoborate

Four firms produce nickel fluoborate. It is used as an electrolyte in specialty high speed nickel plating. The median CMR price is $3.00/kg.

2.3.4.4 Nickel Nitrate

Eight firms produce nickel nitrate. Nickel nitrate is an intermediate in the manufacture of nickel catalysts. It is important in the manufacture of nickel-cadmium batteries. It is also used as a glass colorant and in nickel plating. The median CMR price is $2.20/kg. Because of its use in nickel-cadmium batteries, a growing commodity, the production of nickel nitrate can be expected to increase over the next decade.

2.3.4.5 Nickel Salts Summary Discussion

Table 2-8 presents the summary statistics for this subcategory. Nickel salts are generally used in electroplating, as catalysts in the refining business and in batteries. The prices within the subcategory range from $2.20/kg to $6.70/kg. To the extent that nickel salts can replace cadmium and cobalt (the former quite toxic and the latter expensive) as catalysts, their demand can be expected to grow. The production of nickel nitrate, because of its use in nickel-cadmium batteries, will also increase over the next decade.

Table 2-8. Subcategory Summary: Nickel Salts
Total Subcategory Production: 8,367 metric tons/year
Subcategory Capacity Utilization: 20%

Chemical	Baseline Price ($1983 Q2)	Major End-Uses	Number of Plants	Demand Elasticity
Nickel Carbonate	$6.70/kg	pigments electroplating	7	-.15
Nickel Chloride	$3.30/kg	electroplating	7	-.2
Nickel Fluoborate	$3.00/kg	electroplating	4	-.2
Nickel Nitrate	$2.20/kg	batteries glass colorant	8	-.15

Sources: Chemical Marketing Reporter, 1978-82.
Effluent Guidelines Division, EPA, 1983.
Meta Systems, Inc.

2.3.5 Sodium Chlorate

Sodium chlorate is one of two important salts of chloric acid (the other is potassium chlorate). It is produced by nine firms that operate thirteen plants. Through the 1960's and 1970's, the manufacture of sodium chlorate was one of the most rapidly growing segments of the heavy chemical industry. Table 2-9 shows production to have been 157,000 metric tons in 1975 and about 316,000 metric tons in 1982. In January 1980, capacity was 357,000 metric tons resulting in capacity utilization of close to 80 percent.

The major use of sodium chlorate is as a pulp bleach. Most industry analysts expect declining demand for U.S. produced sodium chlorate over the next decade in large part due to increasing competition from the Canadian and Japanese pulp and paper industries.

Table 2-9. U.S. Sodium Chlorate: Capacity and Production
(Thousands of Metric Tons)

Year	Capacity	Production	Capacity Utilization
1970	269	180	.861
1975	246	157	.638
1976	246	181	.736
1977	280	228	.814
1978	342	240	.702
1979	380	244	.642
1980	357	280	.784
1982	357	316	.880

Sources: SRI, Chemical Economic Handbook, 1981, the technical 308 survey and Meta Systems' estimates.

The second largest use of sodium chlorate is as an intermediate in the production of other chlorates and perchlorates.

The use of sodium chlorate as an herbicide accounted for about 4,550 metric tons in 1975. Other agricultural uses for sodium chlorate are as a defoliant for cotton and as a desiccant for soybeans. The median CMR price for sodium chlorate was \$0.20/lb which is \$0.46/kg in second quarter 1983 dollars.

2.3.5.1 Sodium Chlorate Summary Discussion

The summary statistics for this subcategory are presented in Table 2-10. Sodium chlorate production utilizes close to 90 percent of its capacity. Over 80 percent of the chemical is consumed by the pulp and paper industry, and projections for its growth are directly tied to this industry's health.

Table 2-10. Subcategory Summary: Sodium Chlorate
Total Subcategory Production: 312,300 metric tons/year
Subcategory Capacity Utilization: 88%

Chemical	Baseline Price (\$1983 Q2)	Major End-Uses	Number of Plants	Demand Elasticity
Sodium Chlorate	\$0.46/kg	pulp bleach chlorate intermediate herbicide	13	-.15

Sources: *Chemical Marketing Reporter*, 1978-82.
Effluent Guidelines Division, EPA, 1983.
Meta Systems, Inc.

2.3.6 Zinc Chloride

Zinc chloride is one of the more industrially important zinc compounds. It has been called the "butter of zinc" because upon evaporation it forms a white semi-solid which is similar in consistency to common table butter. Zinc chloride production accounted for about 1.1 percent of total zinc demand in 1979 (1,090 metric tons) and 7.0 percent of zinc's non-metal end-uses (185 metric tons). Zinc chloride is used in deodorants, disinfectants, embalming fluids and wood preservatives. It is also used for fireproofing, etching and galvanizing. Other end-uses of zinc are in the manufacture of dyes, parchment paper, and fabric sizing. The median CMR price is $1.06/kg.

There are six firms producing zinc chloride in seven different locations. Production levels have declined in recent years. Given that no new end-uses for zinc chloride have been developed, this decline in production can be expected to continue.

2.3.6.1 Zinc Chloride Summary Discussion

The summary statistics for this subcategory are presented in Table 2-11. The zinc chloride industry currently utilizes its capacity at about 60 percent. The average price of the chemical is $1.06/kg. This varies according to the manner in which it is formulated. Production of zinc chloride has been declining over the past decade and this trend can be expected to continue.

Table 2-11. Subcategory Summary: Zinc Chloride
Total Subcategory Production: 39,714 metric tons/year
Subcategory Capacity Utilization: 60%

Chemical	Baseline Price ($1983 Q2)	Major End-Uses	Number of Plants	Demand Elasticity
Zinc Chloride	$1.06/kg	soldering flux deodorant disinfectant fabric sizing	7	-.2

Sources: Chemical Marketing Reporter, 1978-82.
Effluent Guidelines Division, EPA, 1983.
Meta Systems, Inc.

2.4 The Cyclic Behavior of the Inorganic Chemical Industry

2.4.1 Trends in the Inorganic Chemicals Industry

The chemicals examined in this study are produced in small volume and thus have incomplete statistics regarding price and production over the years. Examination of chemical specific information reveals that prices generally rise with materials costs and that annual production trends vary widely from chemical to chemical. Aggregate information from the Census of Manufactures provides some further insights into industry behavior and is the basis of most of the analysis of this section.

Price and production time series information that is available for individual chemicals is presented in Table 2-12. Table 2-13 presents similar data for SIC groups 2816 (inorganic pigments) and 2819 (inorganic chemicals, not elsewhere classified) and also the macroeconomic indicators used in this analysis: the U.S. industrial production index, GNP, the price index for inorganic chemicals (SIC 281), and the price index for metal and metal products (SIC 33).

Table 2-12. Selected Inorganic Chemicals Price and Production Data

	Zinc Chloride	Cadmium Sulfide	Cobalt Salts and Dyes	Sodium Chlorate
	Price (¢/lb.)	Production (Metric Tons, Cadmium Content)	Consumption (Metric Tons, Cobalt Content)	Production (Metric Tons x 1000)
1960				
1965	12.45			
1970	14.15	1,187	180	
1971		969		
1972	14.15	1,231		
1973	14.45	1,281		
1974	14.45	984	817.5	
1975	33.95	895	1,303	157
1976	33.95	729	1,992.5	181
1977	33.95	639	2,449	228
1978	38.4	699		240
1979	38.4			244
1980	41.5			280 (est.)
1981				
1982				

Source: SRI Chemical Economics Handbook, 1980.

Table 2-13.

Inorganic Chemicals Industry Data

Year	Inorganic Chemicals Price Index	Value Added	Value of Shipments	Payroll (MM$)	Value Added	Value of Industry Shipments	Payroll (MM$)	Industrial Production Index	GNP	Metals Price Index
1965		331.3	553.6	88.5				89.8	925.9	96.4
1966		339.9	581.8	96.2				97.7	981	98.8
1967		316.3	549.3	97.2				100	1,007.7	100
1968		356.1	624.0	105				106.3	1,051.8	102.5
1969		367.4	647.7	116.8				111.2	1,078.8	108.4
1970		337.0	646.3	126				107.8	1,075.3	116.5
1971		332.3	666.0	131.4				109.6	1,107.5	118.9
1972		382.6	796.9	134.6	2,038.2	3,833.3	704.7	119.7	1,171.1	123.3
1973		419.3	890.2	150.5	2,334.9	4,233.8	761.0	129.7	1,235.0	132.6
1974	121.5	590.9	1,188.6	184.7	2,904.4	5,534.9	897.0	129.3	1,217.9	171.5
1975	170.5	468.4	988.9	164.1	3,260.5	6,053.4	1,061.2	117.8	1,202.3	185.3
1976	183.6	584.9	1,292.5	181.1	3,974.7	7,388.5	1,186.8	130.5	1,273.0	195.9
1977	189.5	567.9	1,259.9	179.8	4,333.1	8,615.7	1,326.7	138.2	1,340.5	209.0
1978	196.1	564.9	1,366.4	198.1	4,878.0	9,801.4	1,519.8	146.1		227.1
1979	206.6	667.5	1,486.8	208.4	5,583.5	10,623.3	1,614.3	152.2		259.3
1980	240.7	709.0	1,556.9	239.6	6,590.6	12,095.5	1,894.0	147.0		286.4
1981	289.9	789.0	1,745.1	261.6	6,754.8	12,790.2	2,068.4	151.0		300.4
1982	311.0							139.1		301.6

Source: Census of Manufacturers, and the U.S. Federal Reserve Board, 1982.

Figure 2-1 compares inorganic compounds prices to the price of their major feedstocks and shows the two to be highly correlated. In both examples presented, the price of the inorganic chemicals follows the price of the major feedstock at a lag of one year. Accounting for this time relationship, the price of zinc chloride and zinc have a correlation coefficient of 0.91. Similarly, the price indices for SIC group 281 (inorganic chemicals) and the metal products (SIC class 33) have a correlation coefficient of 0.88, allowing for the time lag.

The production trends of several inorganic chemicals are compared with the overall industrial production index 2/ (IPI) in Figure 2-2. The figure illustrates a weak correlation between most of the chemical products and the IPI. Only sodium chlorate appears to follow the IPI trends.

Production data are not available at the 4-digit SIC level, but a proxy for production was created by dividing value of shipments for SIC groups 2816 and 2819 by the Metals Price Index 2/ lagged by one year. The production proxies for SIC groups 2816 and 2819, are compared to the IPI in Figure 2-3. Their correlations with IPI are indicated by correlated coefficients of 0.29 and 0.90, respectively.

Profitability at the 4-digit SIC level is measured by a cash flow to sales ratio (CFR). This is obtained from the Census of Manufactures according to the following formula:

$$\text{CFR} = \frac{\text{Value Added - Payroll}}{\text{Value of Shipments}}$$

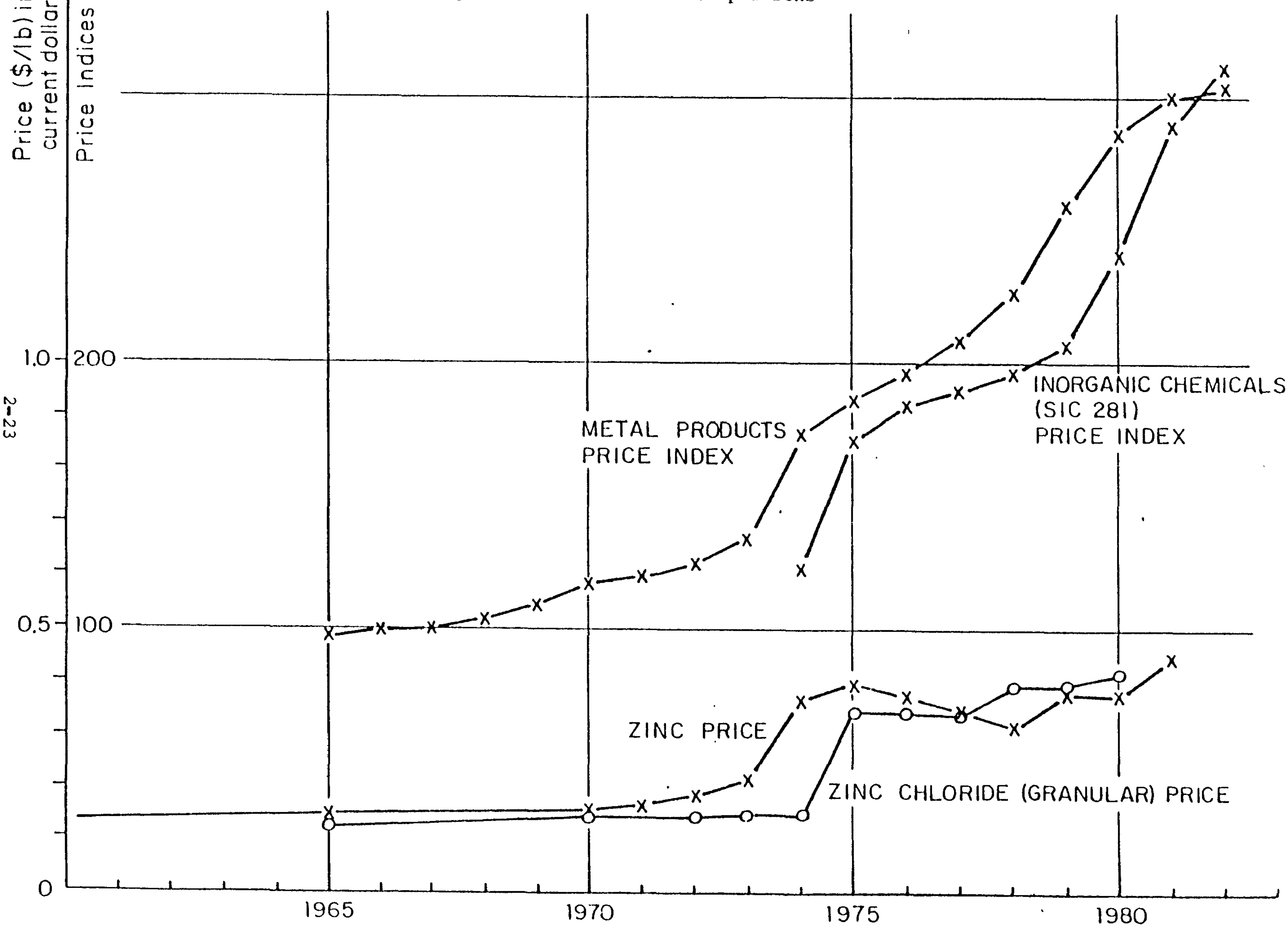
Figure 2-4 compares the CFR for SIC groups 2816 and 2819 to the IPI and Metal Price indices. The cash flows for the two variables were regressed against the IPI, the Metals Price Index (in constant dollars) and Time. The model for SIC class 2816 showed a good fit, with IPI the least important of the three independent variables. The CFR for SIC 2819 correlates very weakly to these variables. Details of these regression analyses are explained in Appendix 2B.

2.4.2 Forecasts of Inorganic Industry Variables

The examination of industry trends indicates that the performance characteristics (e.g., price, profitability) of most inorganic chemicals in this study cannot be forecasted with a high level of confidence. Production can sometimes be extrapolated since some of the chemicals have demonstrated recent trends of increasing or decreasing production. Profitability is less predictable. The cash flow ratios for the 2816 industry sector show weak correlations to overall industrial production and strongest correlation to the unidentified phenomena represented by the Time variable.

2/ These indices are developed by the Federal Reserve Board.

Figure 2-1. Price-Cost Comparisons



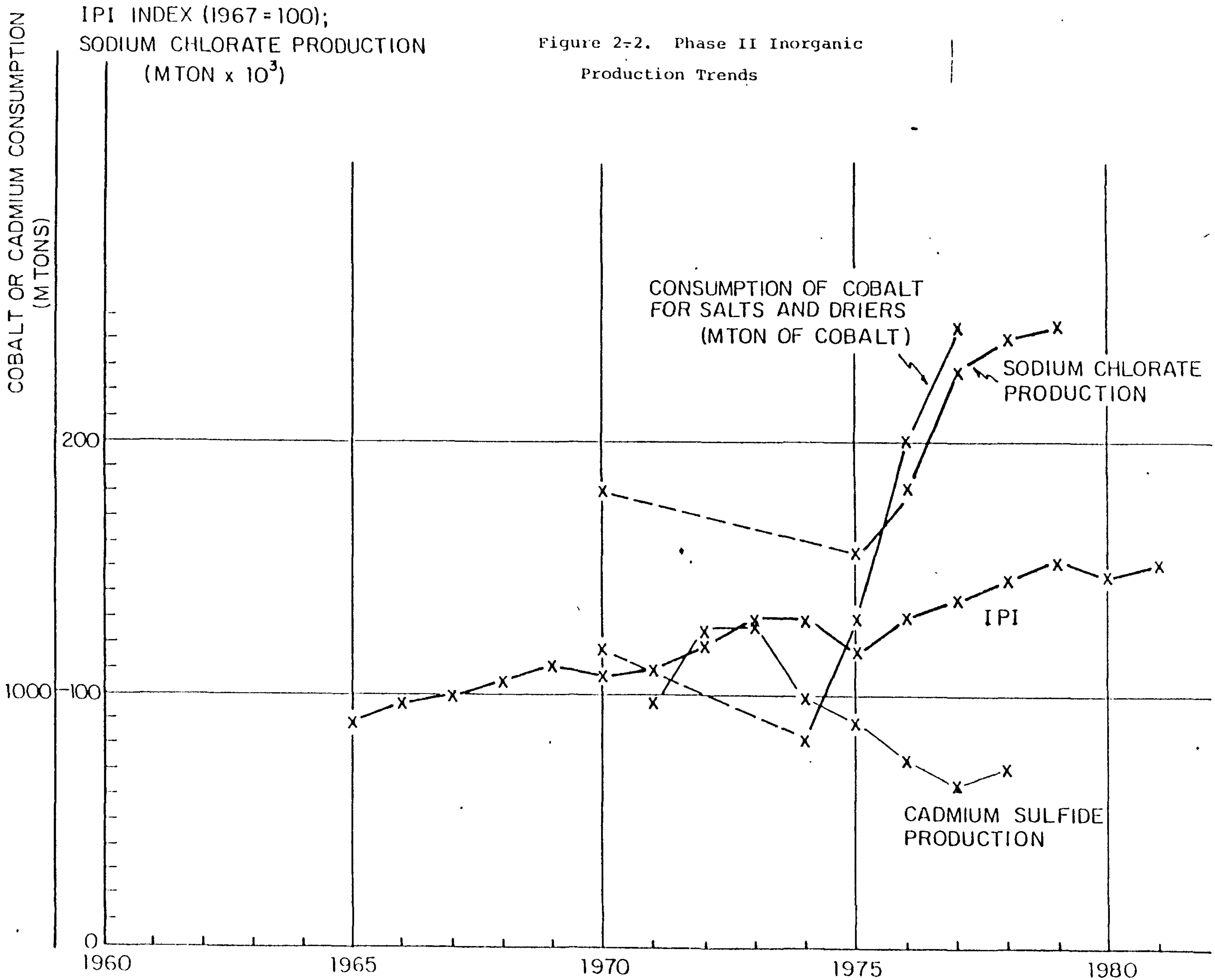


Figure 2-2. Phase II Inorganic Production Trends

Figure 2-3. Inorganics Shipments Compared to U.S. Industrial Production

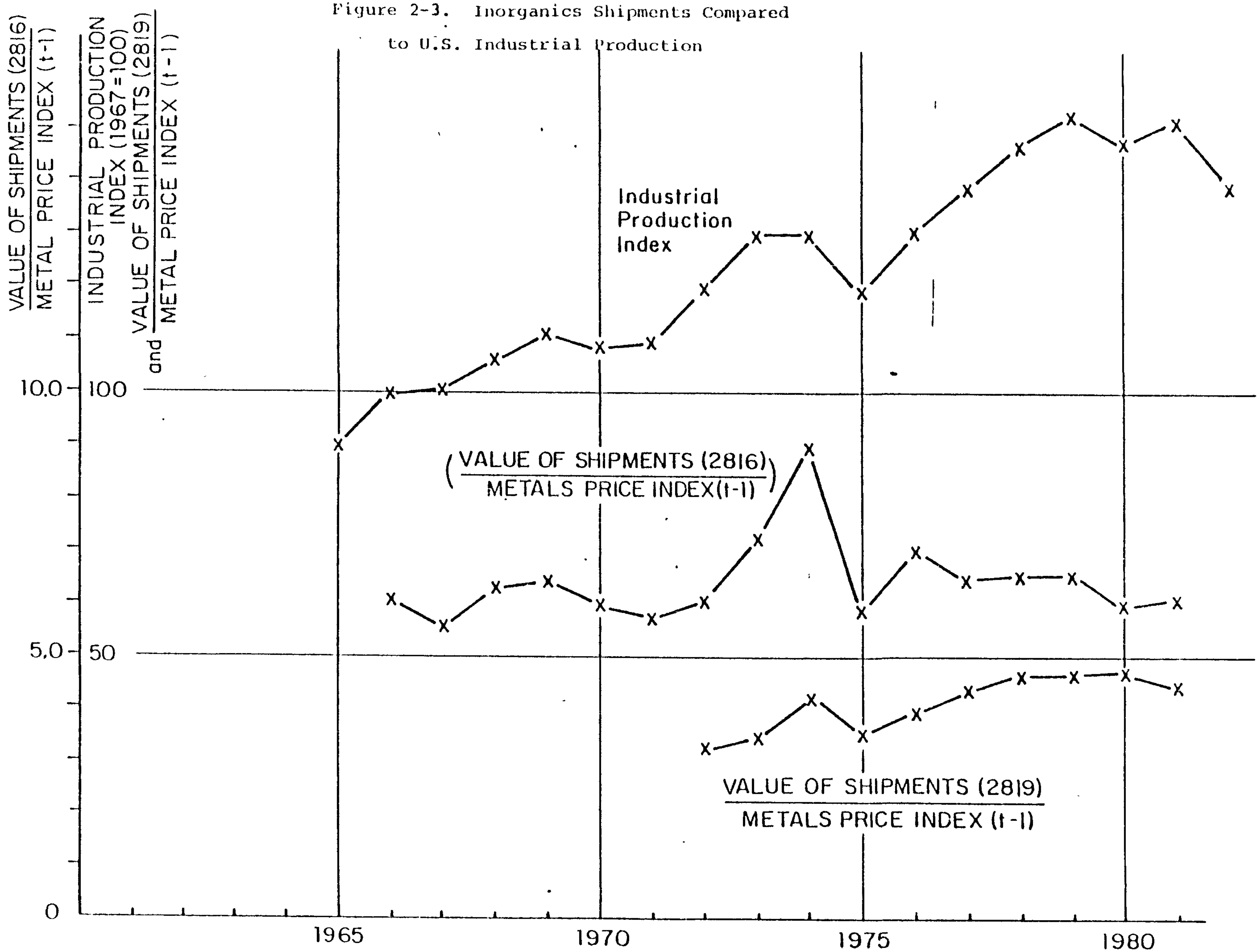
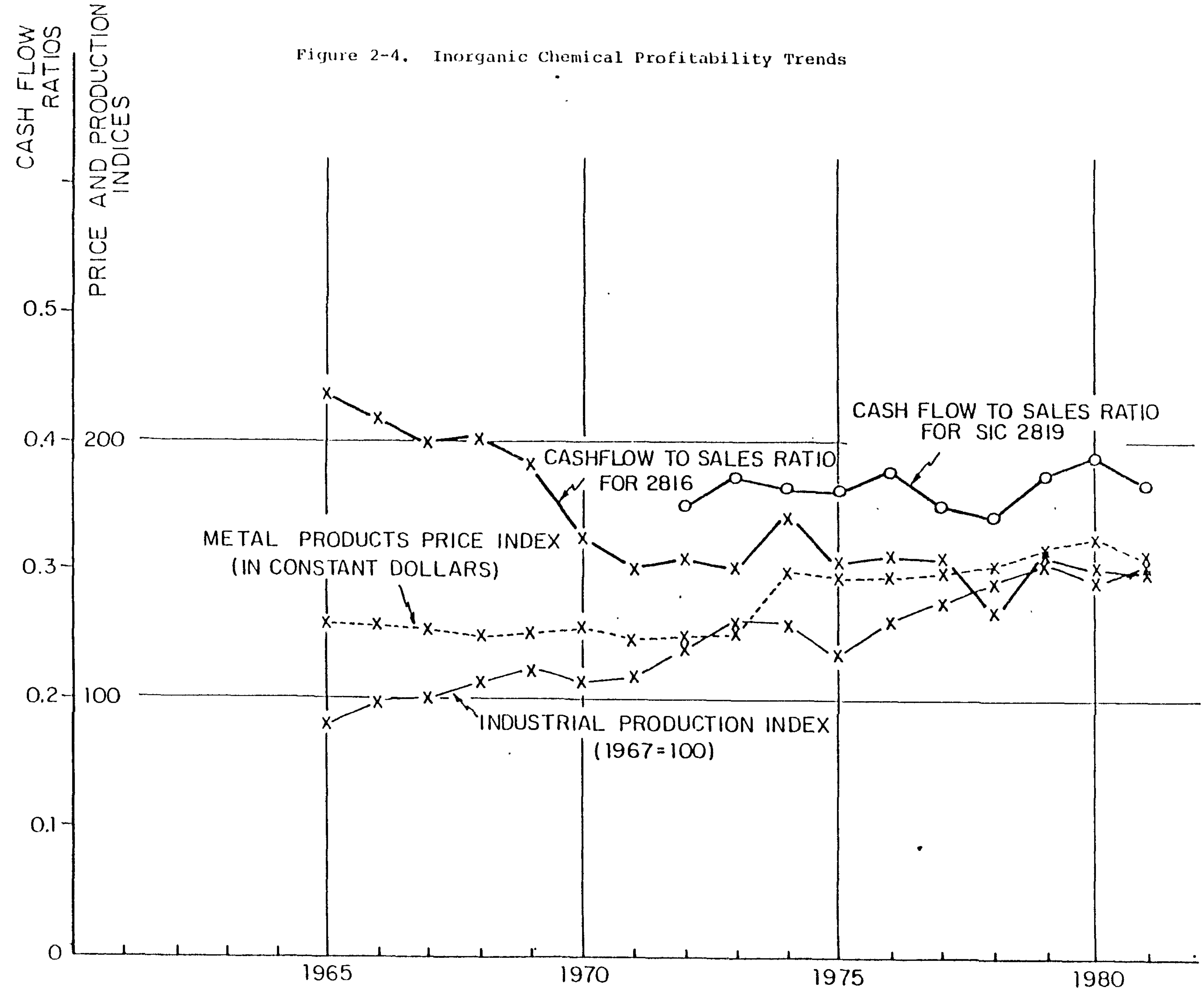


Figure 2-4. Inorganic Chemical Profitability Trends



2.4.3 Conclusions

The Business Cycle Analysis attempts to predict the price, production levels and profitability of a set of small volume chemicals produced at various sites in the country.

The results of this trend analysis are used to estimate the business conditions which will exist when the regulation is promulgated. Due to the incomplete information available for these chemicals, this task is extremely difficult. Consequently, the impact analysis section of this study assumes that the profitability, price and production levels of the different chemicals will remain at the 1981 levels. The sensivitity of the results to reasonable variations to this assumption is examined in Section 7 of this report.

Section 3

Economic Impact Methodology

3.1 Introduction

The economic impact methodology consists of a baseline analysis and a subsequent impact analysis. The initial baseline analysis provides a basis against which potential impacts are assessed. Baseline values are calculated for manufacturing costs, profitability, and product price before treatment costs.

The extent to which treatment costs have an impact on specific plants is determined in a series of steps. First, costs of treatment are estimated for each plant and any price increases and subsequent production decreases caused by those costs are determined. Second, the profitability reduction, calculated as the ratio of plant specific treatment costs to net revenues, is developed. For plants with large profitability reduction, further analysis is undertaken to predict closure. Plant closure analysis consists of a liquidity test and a solvency test. Employment and foreign trade impacts are determined from the closure analysis. Final sections of the methodology assess the effects of the treatment costs on new sources and small businesses.

Many sources of information and data have been used in developing this analysis. They include publicly available data (text books, government publications, 10K Reports) and plant specific data gathered by EPA through a technical survey of the industry. (Such surveys are authorized by Section 308 of the Clean Water Act.)

3.2 Baseline Calculations

Manufacturing costs, production values (in dollars) and quantities, and indices of profitability--without regulation--serve as a baseline against which the impacts from regulatory action are estimated. The economic variables used in baseline calculations assume median values observed between 1978 and 1982. Manufacturing costs are composed of fixed and variable costs. The analysis of profitability uses return on investment to provide a basis of comparison of profitability across plants. All monetary quantities are expressed in second quarter 1983 dollars.

3.2.1 Manufacturing Costs

Manufacturing costs are an important factor in determining economic impacts. Actual plant specific manufacturing costs are not available because this type of financial/economic information was not part of the Agency's survey of the industry. In the absence of detailed knowledge about the costs for each plant, EPA has estimated manufacturing costs for model plants in each subcategory. Appendix 3A summarizes these model plant manufacturing cost estimates and outlines the method by which they are developed. These model plant costs and plant specific information (such as a facility's capacity, production rate, and operating time) are then used to estimate manufacturing costs at the actual plants. Appendix 3B outlines the procedure by which model plant costs are used to estimate the actual plant costs.

For the purposes of this analysis, manufacturing costs are calculated as the sum of variable costs and 13 percent of fixed costs, where 13 percent represents the annuity factor associated with 10 percent interest rate over 15 years.

3.2.2 Profitability

The index of profitability is return on investment as defined by the ratio of a plant's net revenues (in this case defined as sales minus the variable costs of manufacturing) to the fixed cost. The net revenues reflect the conditions of a typical base year and are appropriate for estimating net revenues for the year when the regulation is implemented.

3.2.3 Price and Production

Baseline prices of individual chemicals are based on median prices reported in the Chemical Marketing Reporter (CMR) between 1978 and 1982 and have been adjusted to second quarter 1983 dollars. Production weighted averages were taken to derive subcategory prices.

3.2.4 Interest Rates

This analysis assumes an 8 percent return on equity and a 13 percent interest rate on borrowed capital. This return on equity is comparable to observed values of return in this industry, and the estimated rate for capital is based on forecasts of industrial bond rates. According to FINSTAT 1/ data, the industry generally funds 30 percent of its capital expenditures from loans and 70 percent from equity. Therefore, the appropriate interest rate for capital expenditures is a weighted average of the two--(.3)(.13) +(.7)(.08) = 0.095 or roughly 10 percent. The 10 percent interest rate is used to amortize treatment and manufacturing costs. The 8 percent return of equity assumption is used in the solvency test, which is described in Section 3.3.3.2. Treatment facilities are amortized over 10 years and production facilities are amortized over 15 years.

1/ U.S. Small Business Administration, 1982.

3.3 Impact Projections

The addition of treatment costs affects the cost of production and can have an impact on production levels, price, profitability, plant closures and employment.

3.3.1 Product Level Impacts

3.3.1.1 Price and Production

Price increase is estimated as the product of the average unit treatment cost for the subcategory (weighted by the annual production of each plant) and the cost pass-through factor, which depends on the elasticities of supply and demand. Because the price increase is based on the average treatment costs in a subcategory, the profitability of a plant may rise or fall due to treatment, depending on the treatment costs incurred by the plant. The elasticities of supply and demand and cost pass-through values calculated in the baseline analysis are used to estimate the effects of treatment costs on product prices and volume. Price increases will cause production to decline in proportion to the elasticity of demand (i.e., percent production change is calculated as the product of demand elasticity and percent price change).

3.3.1.2 Cost Pass-Through

The pass-through of treatment costs is estimated as a function of supply elasticity and demand elasticity for the different subcategories in this study. Where the data permit, the supply elasticities (e_s) are estimated by construction of supply curves and measurement of the slopes in the relevant production range. The demand elasticities (e_d) are estimated from market observation and are presented in Section 2 of this report. For subcategories with several chemicals that have different demand elasticities, the most elastic is used for the subcategory value.

The amount of cost pass-through is defined as the ratio of the increase in product price (P) to the unit treatment costs (t), or dP/t. If the supply curve is horizontal there is full (dP/t = 100 percent) pass-through--all treatment costs are passed on in the form of higher price. If the supply curve is vertical all additional treatment costs are absorbed by the plants and prices do not change (dP/t = 0). 2/ In industries with excess production capacity, as is found in this sector of the

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2/ Since the elasticity of supply measures the slope of the supply curve, the large values of e_s indicate a high cost pass-through. This is shown in by the formula used to estimate dP/t; i.e., $dP/t = e_s/(e_s-e_d)$.

inorganic chemicals industry, the cost of producing an additional unit will not exceed that of the previous unit; hence, the supply curves are close to horizontal.

The product level impact analysis assumes a 100 percent pass-through on the grounds that: 1) a horizontal supply curve is a reasonable approximation of industry conditions; and 2) demand in this industry is inelastic. The assumption of 100 percent pass-through implies the worst case for the product level impact analysis. With this assumption the maximum price increase and production decrease are examined. Section 7 presents an analysis of the sensitivity of the impact analysis results to this assumption. Appendix 3C details the development of supply curves and the derivation of elasticities and cost pass-through factors. Treatment costs and the methodology for their derivation are presented in Section 4.

3.3.2 Plant Level Impacts

The analysis of plant level economic impacts draws on plant specific data such as production, wastewater flow, and treatment-in-place. The projected impact for an individual plant depends on the values of these variables for the plant in question and for other plants manufacturing the same product. Other plants have an effect because the product price increases are expected to be uniform and depend on such factors as average treatment costs for a subcategory. The methodology focuses on two measures: change in manufacturing costs and changes in profitability.

3.3.2.1 Manufacturing Cost Increases

Manufacturing costs increases are calculated for each subcategory and for each discharge status. The increase is calculated as treatment costs divided by manufacturing costs.

3.3.2.2 Profitability

Change in profitability due to treatment costs is reflected by the change in return on investment (ROI) resulting from the treatment costs. When a zero cost pass-through is assumed, the change in ROI is represented by the ratio of plant specific treatment costs to net revenues.[3/] The ratio represents the maximum reduction in profits due to treatment; that is, the reduction in profits that would result if the cost pass-through is zero and all costs are absorbed by the plant. The costs used are for those plants upgrading from the current treatment-in-place to more stringent levels of control. Twenty (20) percent of the plants have treatment

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3/ Return on investment is estimated as (PQ-VC)/FC where: PQ = price x production quantity (= sales); VC = variable costs; and FC = fixed cost. With treatment costs (T) added to the variable costs, and no change in price (i.e., a zero cost pass-through), the change in ROI is equal to T/(PQ-VC).

costs greater than 10 percent of net revenues, which is taken as a reasonable criterion of potentially significant impact. Plants with smaller ratios are unlikely to have high impacts, especially in view of the supply curve analysis, which indicates that cost pass-through is nearly full.

3.3.3 Closure

3.3.3.1 Liquidity Test

The liquidity test is applied to plants that have a treatment cost to net revenues ratio greater than 10 percent. The purpose of the test is to determine a plant's ability to finance wastewater treatment from their current cash flow. The test estimates cash flow before treatment costs and assumes that a cash flow greater than treatment costs enables a plant to cover treatment costs. A cash flow less than treatment costs in a particular year does not necessarily mean a plant is unable to handle treatment costs (it is not uncommon for plants to have negative cash flow years from time to time), but it can be an indication of stress that the plant experiences from incurring treatment costs.

The method for deriving cash flow requires factoring in the consequences of taxes on net revenues. Therefore:

Cash Flow = Net revenues - Taxes

where:

Net revenues = Sales - Variable Costs

Taxes = net revenue x 0.4

Tax assumption: plant is in a 40 percent corporate income tax bracket.

3.3.3.2 Solvency Test

To determine whether or not a plant remains open, the present value of the plant's cash flow after treatment (CF) is compared to the salvage value of the equity of the plant. Present value of CF is the estimated time stream of cash flow over the life of the plant (assuming there is no change in production levels or discounted price) plus the present value of salvage at the end of the time period. It is calculated as follows:

$$\text{Present Value (CF)} = \sum_{i=1}^{N} CF/(1+r)^{i} = CF \times [1-(1+r)^{-N}]/r + SV\ 1 + R)^{-T}$$

where N is the life of the investment (assumed to be 15 years in accordance with the general investment practices in the industry), and r represents the return on investment required for equity assets. An 8 percent value of r is used because it is the return on equity that has prevailed for the inorganic chemicals industry for the past two years and can be expected to continue to prevail for the base period. The interest rate assumptions made in this analysis are discussed in Section 3.2.4 of this report. Section 7 of this report presents a sensitivity analysis of the 8 percent figure by comparing it with r values of 7, 10 and 12 percent.

If the present value of cash flow is greater than the salvage value of the plant, then the plant is worth more open and operating than it would be closed. If, on the other hand, the salvage value of the plant is greater than the net present value of cash flow, the plant is worth the salvage value and, discounting the possibility of extenuating circumstances (like captive consumption or subsidization), should be sold for that amount. In the event that a plant's present value of cash flow is nearly equal to its salvage value, other factors must be taken into account to form a clear judgment on closure.

Accurate salvage value estimation requires detailed financial data that have not been collected for this study. A reasonable surrogate, however, can be derived from the Small Business Administration's FINSTAT data. These data consist of balance sheet items for plants in the Dun and Bradstreet financial records for SIC 2816 (Inorganic Pigments) and SIC 2819 (Inorganic Chemicals, not elsewhere classified). In order to estimate salvage value for the plants in this study, two ratios are calculated from the FINSTAT data. The first ratio is total assets to sales; the second ratio is current liabilities to total assets. The ratios, found in the FINSTAT data, are ranked from smallest to largest and the value at the 75^{th} percentile (.78) is used to represent the industry-wide assets to sales ratio. The current liabilities to assets ratios are also ranked from smallest to largest, and in this case, the median value (.30) is used to represent the industry-wide value. Taking these values (75^{th} percentile of one and median value of the other) overestimates both the salvage value and the salvage value of equity thus tending to make the solvency test less likely to miss potential impacts.

Using these general, industry-wide ratios, plant specific salvage values are calculated in the following manner:

$$S = .78 \times \text{sales} \times .60$$

where:

S	=	salvage value
.78	=	75th percentile of industry wide assets/sales ratios

sales = plant specific sales

.60 = factor to reflect the assumption that a plant is 60 percent convertible to another use.

Salvage value of equity is then:

$$S_e = S - [(.78 \times \text{sales}) \times .30]$$

where:

S_e = salvage value of equity

.30 = median of industry-wide liabilities/assets ratios

S, .78, and sales are the same as in the previous equation.

3.4 Employment

Unemployment resulting from plant closures is estimated directly from the plant closure analysis.

3.5 Foreign Trade Impacts

Foreign trade impacts are estimated using the data presented in the Industry Profile (Section 2) and the results of the impact analysis.

3.6 New Source Analysis

The purpose of the New Source Analysis is to assess the impacts of New Source Performance Standards and Pretreatment Standards for New Sources on entry to the industry. This analysis uses the model plant data detailed in Appendix 3A and the industry trend information developed in Section 2. Industry trend information makes it possible to forecast growth for the various subcategories and thus to predict the possible need for capacity expansion in the future.

The analysis uses model plant treatment costs to perform the new source analysis. Treatment costs are estimated for each model plant and projections are made concerning possible impacts for both newly constructed facilities and major modifications to existing facilities.

3.7 Small Business Analysis

The Regulatory Flexibility Act (Public Law 96-354) of 1980 requires a Regulatory Flexibility Analysis for all regulations that have a significant impact on a substantial number of "small entities." This Act also requires that alternative regulatory options be considered to mitigate any significant impact on small businesses. "Small businesses" are defined by employment. This analysis evaluates the differential impacts of the proposed regulations on small businesses, relative to larger businesses.

Section 4

Effluent Limitations Options and Compliance Costs

4.1 Introduction

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101(a)). To implement the Act, EPA was to issue effluent limitations guidelines, pretreatment standards, and new source performance standards for industrial dischargers. The Act included a timetable for issuing these standards. However, EPA was unable to meet many of the deadlines and, as a result, in 1976, it was sued by several environmental groups. In settling this lawsuit, EPA and the plaintiffs executed a court approved "Settlement Agreement" which required EPA to develop a program and to adhere to a schedule in promulgating effluent limitations guidelines, new source performance standards, and pretreatment standards for 65 "priority" or toxic pollutants and classes of pollutants for 21 major industries (see Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified, 12 ERC 1833 (D.D.C. 1979)).

Many of the basic elements of this Settlement Agreement program were incorporated into the Clean Water Act of 1977. Under the Act, the EPA program is to set a number of different kinds of effluent limitations and standards. The following is a brief summary:

4.1.1 Best Practicable Control Technology Currently Available (BPT)

BPT applies to existing direct dischargers. The limitations are generally based on the average of the best existing performance at plants of various sizes, ages and unit processes.

4.1.2 Best Available Technology Economically Achievable (BAT)

BAT also applies to existing direct dischargers. These limitations, in general, represent the best existing performance in the industrial subcategory or category.

4.1.3 Best Conventional Pollutant Control Technology (BCT)

BCT replaced BAT for the control of conventional pollutants (BOD_5, TSS, oil and grease, and pH). The Clean Water Act requires that BCT limitations be assessed in light of a two part "cost-reasonableness" test.

4.1.4 New Source Performance Standards (NSPS)

NSPS apply to new facilities that discharge directly into the Nation's waterways and are based on the best available demonstrated technology.

4.1.5 Pretreatment Standards for Existing Sources (PSES) and New Sources (PSNS)

PSES and PSNS control the discharge of pollutants which pass-through, interfere with, or are otherwise incompatible with the operation of a publicly owned treatment works (POTW). These limitations are to be technology-based, with PSES analogous to BAT and PSNS analogous to NSPS.

4.2 Treatment Technology Options

This report analyzes the economic impact of wastewater treatment costs on six subcategories of the inorganic chemicals industry: cadmium compounds, cobalt salts, copper salts, nickel salts, sodium chlorate, and zinc chloride. For purposes of this analysis, some of these subcategories have been further subdivided. Detailed descriptions of the treatment technology options are included in the technical Development Document. The options are summarized below and are expressed in terms of different levels of treatment. Higher level numbers indicate more stringent control.

All subcategories except sodium chlorate have the following options:

Level 1: Alkaline precipitation, clarification, sludge dewatering, pH adjustment.

Level 2: Filtration of clarified wastewater from Level 1.

The options for sodium chlorate are:

Level 1: Hexavalent chromium reduction followed by lime precipitation and clarification. Reduction will serve the added purpose of destroying residual chlorine.

Level 2: Filtration of clarified wastewater from Level 1.

4.3 Current Treatment and Treatment Costs

4.3.1 Current Treatment

EPA conducted a technical survey of plants in this industry. In addition, EPA contacted or visited many of the plants in the six subcategories. Table 4-1 summarizes the treatment-in-place determinations. Among 29 discharging plants (21 direct and 8 indirect), most of the direct dischargers have some level of treatment. Only one-third of the indirect dischargers, however, pretreat their effluent.

4.3.2 Treatment Costing

The costs used in this report are based on engineering estimates of treatment costs for model plants, except where plant-specific costs are provided by EPA. The development of these model plant costs is detailed in the technical Development Document. These costs are then adjusted on the basis of current treatment-in-place, wastewater flow rate, and annual operating time in order to estimate plant-specific costs.

4.3.2.1 Treatment Costs for Model Plants

The model plant costs derived in the technical Development Document are summarized in Table 4-2. The total annual costs are the sum of amortized capital costs (assuming an interest rate of 10 percent and an equipment life of 10 years, as discussed in Section 3.2.4), operation and maintenance costs, and sludge disposal costs. Sludge disposal costs are listed separately and the sludge is assumed to be disposed of in compliance with applicable federal and state hazardous waste regulations.

4.3.2.2 Plant Specific Treatment Costs

The analysis of potential economic impacts requires plant specific treatment costs. EPA provided treatment costs for all multiproduct plants and for all plants in the copper salts, copper carbonate, and zinc chloride subcategories. For all other plants treatment costs are obtained by adjusting the model plant costs. EPA has gathered data for each plant on the wastewater flow and the annual operating time, the variables that most affect plant specific costs. The procedure for calculating plant specific costs is explained for two cases: single product plants and multi-product plants.

Consider first the plants which produce chemicals in only one subcategory.

The capital costs for treatment (CAP) are:

$$CAP = CAP_m(F/F_m)^d$$

where F is the daily wastewater flow rate, the subscript m refers to the model plant values, and d is the scaling factor--set equal to 0.6 (economy of scale factors in the range 0.5 - 0.7 are commonly used to reflect the decline in unit costs with increasing size). The variable treatment costs are comprised of operation and maintenance costs (OM) and sludge disposal

Table 4-1. Current Treatment-in-Place by Option for Existing Sources

Subcategory	Number of Plants	No Treatment	Level 1	Level 2
Cadmium Pigments	5	2	0	2
Direct	2	1	0	1
Indirect	2	1	0	1
Zero	1	-	-	-
Cadmium Salts	7	1	2	3
Direct	4	0	1	3
Indirect	2	1	1	0
Zero	1	-	-	-
Cobalt Salts	10	2	2	4
Direct	5	0	1	4
Indirect	3	2	1	0
Zero	2	-	-	-
Copper Carbonate	7	1	2	3
Direct	4	0	1	3
Indirect	2	1	1	0
Zero	1	-	-	-
Copper Salts	10	2	1	2
Direct	1	0	0	1
Indirect	4	2	1	1
Zero	5	-	-	-
Nickel Carbonate	7			
Direct	4	0	1	3
Indirect	3	2	1	0
Zero	0	-	-	-
Nickel Salts	12	2	3	4
Direct	6	0	2	4
Indirect	3	2	1	0
Zero	3	-	-	-
Sodium Chlorate	13	7	0	2
Direct	9	7	0	2
Indirect	0	0	0	0
Zero	4	-	-	-
Zinc Chloride	7	1	4	1
Direct	5	0	4	1
Indirect	1	1	0	0
Zero	1	-	-	-

Source: Effluent Guidelines Division, EPA, 1984.

Table 4-2. Wastewater Treatment Cost by Model Plant[1]

	Annual Production (metric tons)	Daily Flow (cubic meters)	Capital Cost	O&M Cost	Sludge Disposal	Total Annual Cost
Cadmium Pigments	711	262				
Level 1			303.1	117.2	2.8	169.3
Level 2			349.7	126.4	3.1	186.4
Cadmium Salts	169	0.07				
Level 1			3.0	4.3	0.1	4.9
Level 2			3.2	4.4	0.1	5.0
Cobalt Salts	358	0.26				
Level 1			10.4	6.2	1.0	8.9
Level 2			11.1	6.4	1.0	9.2
Copper Carbonate	155	291				
Level 1			299.1	81.6	0.90	131.2
Level 2			349.2	91.3	1.0	149.1
Copper Salts	85.2	0.8				
Level 1			11.6	7.6	0.7	10.2
Level 2			12.3	7.8	0.8	10.6
Nickel Carbonate	142	94.8				
Level 1			212.9	59.2	0.3	94.1
Level 2			248.6	67.0	0.3	107.7
Nickel Salts	429	1.67				
Level 1			21.1	7.7	0.5	11.6
Level 2			21.8	7.9	0.5	11.9
Sodium Chlorate	32,000	237				
Level 1			335.9	113.6	0.4	168.7
Level 2			379.3	123.8	0.4	185.9
Zinc Chloride (Small)	5,700	260				
Level 1			260.0	101.8	0.0	144.1
Level 2			329.6	120.7	0.0	174.3
Zinc Chloride (Large)	26,000	3,785				
Level 1			1,358.0	345.9	0.0	566.8
Level 2			1,524.3	393.9	0.0	641.3

[1]in thousands of 1983 dollars

Source: Effluent Guidelines Division, EPA, 1984.

costs (SLUDGE). Both of these costs depend on the number of days of operation per year and on the flow:

$$OM = OM_m (F/F_m)^e (D/D_m) \text{ with } e = 0.6 \text{ to reflect economies of scale}$$

and

$$SLUDGE = SLUDGE_m (F/F_m)(D/D_m)$$

No economy of scale is assumed for sludge disposal because there is frequently a fixed cost per ton for hauling. Since model plant costs are based on an operating time of D_m days/year, the operating time D, other than D_m days is accounted for by the factor D/D_m.

The values of CAP_m, OM_m, and $SLUDGE_m$ for each model plant are summarized in Table 4-2.

Annual treatment cost (T) is:

$$T = OM + SLUDGE + 0.1627\ CAP$$

where 0.1627 is the capital recovery factor for an interest rate of 10 percent and a time horizon of 10 years.

For plants producing chemicals in more than one subcategory, we assume that the different products are manufactured at different times of the year and that the associated wastewater streams are treated with the same pollution control equipment. The Agency provides overall treatment costs for each of these multiproduct plants. These costs are allocated among the several products at each plant on the basis of the wastewater flow associated with each product. Table 4-3 shows an example of the allocation procedure for a plant whose capital costs are $100,000, annual O&M costs are $50,000, and annual sludge disposal costs are $10,000.

Table 4-3
Example of Treatment Cost Allocation at a
Hypothetical Multi-Product Plant

	Cobalt Salts	Copper Salts	Nickel Salts	Total
Total Plant Costs				
- Capital ($ x 10^3)	-	-	-	100
- O&M ($ x 10^3/yr)	-	-	-	50
- Sludge ($ x 10^3/yr)	-	-	-	10
Flow (m^3/day)	70	20	10	100
Allocated Costs				
- Capital ($ x 10^3)	70	20	10	100
- O&M ($ x 10^3/yr)	35	10	5	50
- Sludge ($ x 10^3yr)	7	2	1	10

Treatment cost estimates for each subcategory are shown in Table 4-4a for Level 1 and in Table 4-4b for Level 2. The sodium chlorate subcategory has no indirect dischargers, but dominates costs for direct dischargers. The cobalt salts subcategory has the smallest costs for direct dischargers. Among the indirect dischargers, the cadmium pigment subcategory has the largest treatment costs and the cadmium salts subcategory has the smallest treatment costs. Total investment for direct dischargers at Level 2 is $4.8 million and for indirect dischargers, $1.1 million. Total annual costs are $2.3 million for direct dischargers and $0.5 million for indirect dischargers.

Table 4-4a.

Level 1 Treatment Costs[1/]

Subcategory	Capital Costs: Direct Dischargers	Capital Costs: Indirect Dischargers	Capital Costs: Total	Total Annual Costs: Direct Dischargers	Total Annual Costs: Indirect Dischargers	Total Annual Costs: Total
Cadmium Pigments	153.17	267.69	420.86	85.03	159.88	244.91
Cadmium Salts	0.00	4.27	4.27	0.00	1.81	1.81
Cobalt Salts	0.00	6.45	6.45	0.00	2.73	2.73
Copper Carbonate	0.00	86.09	86.09	0.00	18.07	18.07
Copper Salts	0.00	5.81	5.81	0.00	2.46	2.46
Nickel Carbonate	0.0	282.44	282.44	0.00	120.19	120.19
Nickel Salts	0.00	14.87	14.87	0.00	6.32	6.32
Sodium Chlorate	3,764.07	--	3,764.07	1,889.29	--	1,889.29
Zinc Chloride	0.00	200.02	200.02	0.00	98.52	98.52
Total	3,917.24	867.64	4,784.88	1,974.32	409.98	2,384.30

[1/]thousands of 1983 dollars

Source: Meta Systems Inc. estimates.

Table 4-4b. Level 2 Treatment Costs[1/]

Subcategory	Capital Costs: Direct Dischargers	Capital Costs: Indirect Dischargers	Capital Costs: Total	Total Annual Costs: Direct Dischargers	Total Annual Costs: Indirect Dischargers	Total Annual Costs: Total
Cadmium Pigments	176.71	308.84	485.55	93.65	175.87	269.52
Cadmium Salts	0.79	4.34	5.12	0.31	1.82	2.13
Cobalt Salts	0.02	7.28	7.30	0.01	3.01	3.01
Copper Carbonate	13.00	164.44	177.44	5.21	44.96	50.17
Copper Salts	0.00	9.73	9.73	0.00	3.82	3.82
Nickel Carbonate	26.84	363.85	390.69	10.76	149.28	160.04
Nickel Salts	1.01	18.52	19.54	0.40	7.61	8.01
Sodium Chlorate	4,249.91	--	4,249.91	2,081.97	0.00	2,081.97
Zinc Chloride	330.86	238.58	569.45	144.39	115.01	259.40
Total	4,779.14	1,115.58	5,914.72	2,336.70	501.38	2,838.07

[1/]thousands of 1983 dollars

Source: Meta Systems Inc. estimates.

Section 5

Results

5.1 Introduction

The economic analysis of the effects of effluent regulations on the inorganic chemicals industry is conducted in the manner described in Section 3. The results presented in this section are organized under the headings of plant level impacts, product level impacts, closure, employment impacts, foreign trade impacts and new source analysis.

5.2 Plant Level Impacts

Plant level impacts are measured by manufacturing cost increases and profitability changes. Of the 46 plants presented in Section 2, two are not presently producing any of the inorganic chemicals examined here. The results in this section consider only the 44 plants that presently produce chemicals in the subcategories.

5.2.1 Manufacturing Cost Increases

Table 5-1 shows increases in manufacturing costs, by subcategory, for each discharge status and level of control. Cost increases range from 0 to 4.8 percent. Indirect dischargers tend to have higher cost increases than direct dischargers. Eight plants have increases over two percent. The largest plant level cost increase, 15.1 percent, is found in the nickel carbonate subcategory.

Several of the plants with treatments costs greater than 2 percent of manufacturing costs actually belong to a multi-product plant. By comparing total plant treatment costs with total plant manufacturing costs, only five plants have treatment costs greater than 2 percent of manufacturing costs.

5.2.2 Profitability

The reduction in profitability is measured as the ratio of treatment cost to net revenue. This ratio is equal to the change in return on investment, assuming that none of the treatment cost is passed on as a price increase.

Table 5-2 summarizes profitability changes by subcategory, control level and discharge status. These changes range from zero for several of these categories to 24 percent for indirect discharging copper carbonate plants.

The number of plants with profitability reductions greater than 10 percent at Level 2 costs are presented in the last column of Table 5-2. By considering multiple product plants on the basis of their aggregate treatment costs and net revenues, six plants are shown to have profitability reductions greater than 10 percent. These six plants are further examined in the closure analysis.

5.3 Product Level Impacts

Product level impacts are measured by price increases and production changes by subcategory.

5.3.1 Price Increases

Price increases have been calculated assuming a 100 percent cost pass-through, i.e., the change in the price of a product is assumed to be equal to the average treatment cost for all plants producing that product.

The impact of treatment costs on prices is small. As shown in Table 5-3, subcategory price increases range from 0.01 to 2.40 percent. Level 1 increases range from 0.01 for cobalt salts to 1.81 percent for nickel carbonate. Level 2 increases range from 0.01 for cobalt salts to 2.40 percent for nickel carbonate. At roughly 2 percent, the estimated price increases for nickel carbonate and copper carbonate are high, compared to other products. However, these price increases do not indicate negative impacts.

5.3.2 Production Change

Production changes are estimated as a function of the change in price and the demand elasticity in each subcategory. The estimated production changes for each subcategory are shown in Table 5-4. Production changes are low because demand for all of the chemicals is inelastic and thus relatively unresponsive to price changes. At Level 1, production changes by subcategory range from 0.003 for cobalt salts to 0.27 percent for nickel carbonate. At Level 2, the changes range from 0.003 for cadmium salts to 0.41 percent for copper carbonate. All of these production changes are considered small.

Table 5-1. Manufacturing Cost Increases by Control Level

Subcategory	Discharge Status 1/	Manufacturing Cost Increase (Percent) Level 1	Level 2
Cadmium Pigments	D	0.75	0.82
	I	1.77	1.94
Cadmium Salts	D	0	negl.
	I	0.05	0.05
Cobalt Salts	D	0	0
	I	0.04	0.04
Copper Carbonate	D	0	0.19
	I	1.60	3.99
Copper Salts	D	0	0
	I	0.05	0.07
Nickel Carbonate	D	0	0.49
	I	3.86	4.79
Nickel Salts	D	0	negl.
	I	0.10	0.12
Sodium Chlorate	D	1.41	1.55
Zinc Chloride	D	0	0.70
	I	2.01	2.35
Total	D	1.07	1.27
	I	0.99	1.21

1/ D = direct discharge; I = indirect discharge.

Source: Meta Systems Inc. estimates.

Table 5-2. Profitability Reduction by Control Level

Subcategory	Discharge Status 1/	Profitability Reduction (%) Level 1	Level 2	Number of Plants with Level 2 Profitability Reductions ≥ 10%
Cadmium Pigments	D	1.55	1.71	0
	I	3.84	4.22	1
Cadmium Salts	D	0	0.03	0
	I	0.06	0.06	0
Cobalt Salts	D	0	0	0
	I	0.01	0.02	0
Copper Carbonate	D	0	1.24	0
	I	9.63	23.96	2
Copper Salts	D	0	0	0
	I	0.64	0.98	0
Nickel Carbonate	D	0	1.75	0
	I	10.80	13.42	2
Nickel Salts	D	0	0.02	0
	I	0.35	0.42	1
Sodium Chlorate	D	9.42	10.39	3
Zinc Chloride	D	0	0.88	1
	I	5.03	5.87	0
Total 2/	D	3.75	4.44	4
	I	1.36	1.67	6

1/ D = direct discharge; I = indirect discharge

2/ Total reflects individual product lines. The number of plants overstates the impacts to some multiple product plants.

Source: Meta Systems Inc. estimates.

Table 5-3. Price Increases by Subcategory

Subcategory	Price Increase (Percent) Level 1	Level 2
Cadmium Pigments	0.85	0.93
Cadmium Salts	0.02	0.02
Cobalt Salts	0.01	0.01
Copper Carbonate	0.74	2.07
Copper Salts	0.03	0.05
Nickel Carbonate	1.81	2.40
Nickel Salts	0.04	0.05
Sodium Chlorate	1.25	1.38
Zinc Chloride	0.26	0.69
**AVERAGE	0.81	0.96

Source: Meta Systems Inc. estimates

Table 5-4. Production Decreases by Subcategory

Subcategory	Production Decrease (Percent)	
	Level 1	Level 2
Cadmium Pigments	0.085	0.093
Cadmium Salts	0.005	0.006
Cobalt Salts	0.003	0.003
Copper Carbonate	0.149	0.414
Copper Salts	0.009	0.014
Nickel Carbonate	0.271	0.361
Nickel Salts	0.009	0.011
Sodium Chlorate	0.188	0.207
Zinc Chloride	0.053	0.139
**AVERAGE	0.167	0.194

Source: Meta Systems Inc. estimates

5.4 Closure

The six plants that have profitability changes greater than 10 percent are analyzed for potential closure with a liquidity test and a solvency test. A full cost pass-through is assumed for both of these tests.

5.4.1 Liquidity Test

The liquidity test compares the treatment cost to cash flow. Where treatment cost exceeds cash flow, it is possible that the plant will have difficulty covering the cost of treatment with internally generated cash flow. None of the six plants indicates liquidity problems resulting from Level 1 or Level 2 treatment costs.

5.4.2 Solvency Test

In the test for solvency, salvage value is compared to net present value of cash flow. In theory, where the salvage value exceeds the present value of cash flow, a company should consider selling the production facility. None of the plants exhibits a salvage value exceeding the net present value of cash flow. Therefore, no closures are predicted by this test.

Neither of the closure tests yielded any plants which came close to meeting the closure conditions. Thus, none of the compliance costs associated with either treatment level are expected to result in plant closures.

5.5 Employment

No loss of jobs is expected to result from compliance with these treatment levels.

5.6 Foreign Trade Impacts

The sodium chlorate industry has recently seen increasing competition from Canadian producers. Many of these producers locate their plants near the northwest U.S. border to meet the demands of U.S. pulp mills in that region.

Since roughly 10 percent of U.S. sodium chlorate demand is met by Canadian imports, and since the sodium chlorate price is expected to increase by 1.4 percent following the promulgation of this regulation, some foreign trade impacts might be expected. However, sodium chlorate is produced for regional markets (due to high transportation costs) and none of the U.S. producers in this region are expected to bear any additional treatment costs with this regulation. Thus, the impact of these price changes on foreign trade is expected to be small.

5.7 New Source Analysis

The examination of new source standards considers that all new sources will have treatment requirements equal to the Level 2 treatment for existing sources. This analysis is performed for the model plants in each subcategory. The treatment costs are compared to manufacturing costs and net revenues to determine their potential impact as barriers to entry into the market.

The results of this analysis are presented in Table 5-5. Manufacturing cost increases range from 0.37 percent for cobalt salts to 19.78 percent for copper carbonate. At Level 2, these increases exceed 10 percent in two of the nine subcategories: copper carbonate (19.78), and nickel carbonate (11.66). Profitability changes, measured here as treatment costs divided by net revenues, range from 0.2 to 87.3 percent.1/ They exceed 10 percent in 3 of the 9 subcategories. The affected subcategories are nickel salts (10.5 percent), nickel carbonate (46.3 percent), and copper carbonate (87.3 percent).

Judging from the analysis of existing plants, the impacts of these costs on new sources are regarded as small. The Level 2 treatment costs were shown to be economically achievable for existing plants and given that the estimated cost ratios for new plants fall in the same range, they should not present barriers to entry for new plants.

As part of the proposed regulations, pretreatment standards for new sources (PSNS) are being proposed for twelve additional subcategories. The PSNS requirement is zero discharge of process wastewater. In each of these subcategories, existing dischargers are subject to, and meeting zero discharge effluent limitations. No cost disadvantages or other impacts are expected from these new PSNS.

1/ Though a profitability decline of 87 percent for new sources appears high, it is important to note that existing copper carbonate producers are operating with only a 10 percent profit margin. New sources, as represented by the model plant, should attain a 40 percent profit margin before regulation. After the regulation, and its resultant 87 percent profit decline, the new sources should still have a profit margin of 5 to 6 percent. For this reason, the regulation is not expected to present any barrier to entry into the copper carbonate subcategory.

Table 5-5.

Impact Analysis for New Source Performance Standards[1]

Subcategory	Annual Production	Fixed Cost	Annual Variable Cost	Annual Sales	Net Revenue / Fixed Cost (Percent)	Annual Treatment Cost	Manuf. Cost Increase %	Reduction in Profitability %
Cadmium Pigments	711	4,052	4,662	7,197	62.55	186.5	3.59	7.36
Cadmium Salts	169	2,566	723	1006	11.04	5.0	0.47	1.77
Cobalt Salts	358	4,755	1,870	6,814	103.99	9.3	0.37	0.19
Copper Carbonate	155	3,859	252	423	4.43	149.2	19.78	87.30
Copper Salts	85	1,292	394	266	-9.89	10.7	1.90	8.34
Nickel Carbonate	142	1,309	754	987	17.79	107.8	11.66	46.26
Nickel Salts	429	3,167	1,124	1,239	3.62	12.0	0.78	10.47
Sodium Chlorate	32,000	35,250	12,675	15,443	7.85	186.0	1.08	6.72
Zinc Chloride								
(L)	26,000	18,021	11,317	24,769	74.65	641.3	4.69	4.77
(S)	5,700	11,461	3,566	5,430	16.33	174.3	3.45	9.35

1/costs are in thousands of 1983 dollars

Sources: Effluent Guidelines Division (EPA) and Meta Systems, Inc. estimates.

5-9

Section 6

Regulatory Flexibility Analysis

6.1 Introduction

Under the Regulatory Flexibility Act of 1980, the EPA and other regulatory agencies are required to consider the effects of environmental regulations on small entities. This section reviews the potential impacts of the environmental regulations on small businesses within the inorganic chemicals industry.

6.2 Definition of a Small Firm

The Act directs agencies to the Small Business Administration's (SBA) definitions for small firms. The Small Business Act, Section 3, defines a small business in the following statement:

> " ... a small business concern shall be deemed to be one which is independently owned and operated and which is not dominant in its field of operation. In addition to the foregoing criteria, the Administration (of the SBA), in making a detailed definition may use these criteria, among others: Number of employees and dollar volume of business."

In addition, the SBA published specific employee-based guidelines by SIC code for various business activities including manufacturing. For the plants included in this analysis (SIC groups 2816 and 2819), the Small Business Administration defines a small firm as one with not more than 1,000 employees.[1] Within the context of this industry's analysis, even firms with 1,000 employees may be considered large by the Regulatory Flexibility Act's definition of small businesses as being those firms having limited resources with which to comply with regulatory requirements or those encountering regulation-imposed barriers to entry into the industry.

The plants in this analysis have been ranked by number of employees in the parent corporation, and divided into five sets of eight plants each. Firms designated by the SBA as small businesses (those with 1,000 employees or less) make up the first and second size rankings. Thus, small businesses account for a total of 16 of the 39 ranked plants in this analysis.

1/ Code of Federal Regulations, Title 13, Section 121.3-16.

6.3 Results

The number of plants with potentially significant effects appearing in each firm employee size range has been identified in order to determine whether a relationship exists between business size and level of impact. Those plants incurring Level 2 treatment costs greater than 10 percent of net plant revenue have been designated as having potential significant effects. Results are shown in Table 6-1. Corporate data are unavailable for six plants. These plants have not been ranked, and are included in group six in Table 6-1.

Two of the 16 plants designated as small businesses are found to have treatment cost to net revenue ratios greater than 10 percent. However, as demonstrated in Section 5 of this report, none of these plants is expected to close. Of the remaining 23 ranked plants, three (13.0 percent) are identified as having treatment costs greater than 10 percent of net revenues. Judging from the similar ratios of treatment costs to net revenues in the small and large business groups, there appears to be no significant relationship between business size and degree of impact due to treatment costs.

Table 6-1.

Distribution of High Impact Plants by Firm Employment Size

Plants by Firm's Number of Employees (From Smallest)	Firm Employment Range	Number of Plants Where Treatment Costs Exceed 10 Percent of Revenues
First Fifth	0-125	0
Second Fifth	126-1000	2
Third Fifth	1001-12,500	1
Fourth Fifth	12,501-45,000	0
Fifth Fifth	45,501-175,000	2
6 Other Plants 1/	NA	1

1/ Number of employees is not known.

Source: Meta Systems Inc. estimates.

The Level 2 treatment costs for these 16 plants owned by small businesses are summarized in Table 6-2. This table indicates that the largest costs at this level are borne by indirect dischargers.

Table 6-2. Small Business Level 2 Treatment Cost Summary 1/

Parameter	Zero Discharge	Direct Discharge	Indirect Discharge
Number of Plants	4	7	5
Total Investment Costs	0.0	372.5	1,027.6
Total Annual Costs	0.0	161.4	482.8

1/ All costs are in thousands of 1983, second quarter dollars.

Source: Meta Systems, Inc. estimates.

In conclusion, small businesses do not appear to bear a disproportionate share of Level 2 treatment costs relative to their net revenues.

Section 7

Limits to the Analysis

7.1 Introduction

The basic task of this study is a difficult one--to assess the effects of a regulation on a set of small volume chemicals produced at various sites in the country. Little information is available about these chemicals, and more importantly, little is known about the facilities that produce the chemicals. Some specific economies of producing the chemicals and treating the wastes are therefore overlooked.

The analysis uses the available information in such a way that the closure results are very conservative (i.e., they represent a "worst case" scenario). The analysis clearly has some limitations in both the available data and methodological approach. Limitations are discussed in parts 7.2 and 7.3 of this section. Those assumptions that may be critical to the results of the analysis are examined closely in 7.4, the sensitivity analysis portion of this section.

7.2 Data Limitations

Some of the technical and economic data used in this analysis are plant specific but are not comprehensive enough to address many economic problems. The limitations imposed by data affect the choice of methodology as well as the reliability of the results.

The plant level data used in this analysis are described in Section 3. The principal source of these data is the Data Collection Portfolio for specific plants. The technical Development Document details the data collection effort. These data are from static observations, though, and may not be a true representation of the industry. The SRI Directory of Chemical Producers supplements this by identifying other products manufactured at these sites. Since there is no financial survey of the plants, there is little data available on depreciation, equity to assets ratio, or discount rate for the individual plants. This imposes a limit to plant level manufacturing cost and profitability estimates.

Plant level production costs are known to vary according to many factors, including plant age, production process, product grade, vertical integration and scale. Of these, only scale is known well enough to be considered in the cost estimates in this analysis. Here, the lack of financial and marketing information limits the degree to which non-merchant market producers can be identified.

The plant level data limitations pose a particular problem for plants that employ small batch processes. Where several products are produced with a single piece of equipment, the capital costs of that equipment are shared. To the extent that these products are Phase II chemicals, the effect of the shared investment can be estimated. However, most of the product lines sharing these facilities are not in Phase II and are therefore not considered. In those cases, the Phase II product lines studied are assumed to carry the capital costs of the equipment, and the costs will be disproportionately high.

Product level data limitations present other problems to the analysis. Since the chemicals and subcategories are generally small volume, production and price data and demand information are scarce. The absence of this information hinders accurate estimation of demand elasticity and profitability for the subcategories.

7.3 Methodological Limitations

The methodology used in this analysis has been chosen as the best means of utilizing the limited information to estimate the effects of this regulation on the inorganic chemicals industry. The principal limitations are: estimation of plant level manufacturing costs from model plant process economics; estimation of manufacturing capital costs for small batch processes; and interpretation of impacts in subcategories that are composed of several chemical products.

Plant level manufacturing costs are estimated by scaling the fixed costs and variable cost components from model plant production costs. The scale factors chosen for this extrapolation are intended to capture the effects of scale economies. However, when the actual plants are much smaller or much larger than the model plant, the scale factors may produce poor cost estimates. Many of the plant specific attributes (e.g., age, joint products) are overlooked.

The model plants in multiple-product subcategories represent the average process economics and treatment costs for the subcategory. By ignoring chemical specific costs, the model plant procedure may fail to identify plants where the chemicals have profitability or treatment cost characteristics very different than the model plant. Four of the six subcategories include more than one chemical.

7.4 Sensitivity Analyses

Sensitivity analyses have been performed on four of the major assumptions in this study. These assumptions concern the interest rate used to determine the present value of cash flow, the cost pass-through factor, the manufacturing costs and the treatment costs. These sensitivity analyses are presented in terms of the liquidity and solvency test results shown in Section 5.

The set of plants investigated in the sensitivity analysis consists of all plants that would sustain some treatment costs at the most stringent level of treatment (Level 2). Plants producing in multiple subcategories are considered as single aggregate plants. In this manner, the sensitivity analysis examines 19 plants.

7.4.1 Interest Rate

The solvency test assumes that the appropriate interest rate (r) for discounting future cash flow is 8 percent over a period (N) of 15 years, where eight percent is the assumed return on equity. Algebraically, the standard formula for the present value factor (PVF) is:

$$PVF = \frac{1 - (1 + r)^{-N}}{r} \qquad (7\text{-}1)$$

An eight percent interest rate results in a factor of 8.56. Considered over the same period for 7, 10 and 12 percent, the factor becomes 9.11, 7.61 and 6.81 percent, respectively. None of these interest rate assumptions raise any solvency ratios over 1. Hence, the interest rate assumption does not affect the results. Other interest rate and investment life assumptions have been used elsewhere in the report to determine the cost of capital for investment in manufacturing facilities (10 percent, 15 years) and treatment facilities (10 percent, 10 years). The sensitivity of the results to these assumptions is not examined separately because the manufacturing and treatment cost assumptions are themselves examined.

7.4.2 Cost Pass-Through

The cost pass-through factor assumed in Section 5 is 100 percent for all subcategories. This factor implies a horizontal supply curve or a market situation in which a change in production does not affect the price. That condition is generally true for situations in which capacity utilization is low, as is the case in these segments of the inorganic chemicals industry. (See Section 2 for specifics on capacity utilization.)

To test the sensitivity of the results to this assumption, a zero percent pass-through and a 50 percent pass-through are examined. Neither of these assumptions causes a change in the liquidity or solvency test results. Thus, while the 100 percent pass-through assumption is extreme, the consequences of any possible error are unimportant.

Other measures that are affected by this assumption are price change, production change, and profitability. The effects on price and production are tautological; a 50 percent pass-through reduces all of these changes shown in Section 5 by 50 percent. A zero percent pass-through results in no price or production change. The profitability test is only performed for the zero percent pass-through, since that is the most extreme situation. Alternative pass-through assumptions would simply reduce the impacts shown by that test.

7.4.3 Manufacturing Costs

The manufacturing cost assumption has been varied as a means of testing the sensitivity of the results both to plant level cost and to plant level profitability changes. Profitability is defined in Section 3 of this report as return on investment (ROI) where ROI = (PQ-VC)/FC. An increase in fixed and variable manufacturing costs, (FC) and (VC) respectively, will cause a profitability decrease. The effects of a 20 percent cost decrease and 20 and 40 percent cost increases were examined.

Most subcategories are unaffected by any of these cost changes. All multiple product plants and all single product plants producing cadmium salts, cobalt salts, copper salts, nickel salts and zinc chloride have liquidity and solvency ratios under 25 percent for all these cost assumptions.

With costs increased by 20 percent, two sodium chlorate plants and one cadmium pigment plant showed closure conditions. With a cost increase of 40 percent, six of the seven sodium chlorate plants and one of the two cadmium pigment plants became potential closures.

The sensitivity analysis of profitability shows that the baseline profitability assumptions are extremely important to the results of this analysis. Variations in costs affect the baseline closure conditions as well as impacts due to the regulation. Since virtually all of the treatment costs are small, the conditions for closure often are that a plant be only marginally profitable prior to assuming treatment costs. By increasing manufacturing costs until the plant is marginally profitable, any plant with treatment costs can be shown to exhibit closure conditions due to treatment. Of the 19 plants with treatment costs at Level 2, three would show closure conditions with cost increases of 20 percent and eight would exhibit these conditions with a 40 percent increase. These numbers are not alarming, particularly since six of the eight plants, which in the 40 percent cost increase scenario would close, produce sodium chlorate--which is judged to have the most reliable manufacturing cost estimates of all the subcategories.

7.4.4 Treatment Costs

The development of a model plant treatment costs is detailed in the technical Development Document. These model plants costs were adjusted to provide treatment costs for individual plants. In order to address possible errors in the model plant costs or in the adjustment procedure, we performed sensitivity analyses on the treatment costs. Sensitivity to variations in treatment costs is estimated by raising and lowering the treatment costs values used in the solvency test by 30 percent. Neither raising nor lowering the costs by 30 percent has a significant impact on solvency ratios. It is determined that in order to raise any of the plant solvency ratios to greater than 1, a 100 percent increase in treatment costs would have to occur. This sensitivity analysis shows that even if our estimation is off by 30 (or more) percent, the treatment costs do not have a significant impact on these plants (our conclusion in Chapter 5).

7.5 Conclusion

The analysis of the economic impacts of treatment costs on this segment of the inorganic chemicals industry is limited by data. Many of the plant level economic characteristics that would allow a reliable forecast of impacts are not available. Model plant information has been used to supplement the actual plant level economic data.

The results of the analysis are tested for sensitivity to variations in some of the critical assumptions. Overall, the results of the analysis are not sensitive to reasonable variations in these assumptions. The most critical assumptions are found to be the manufacturing costs; cost increases of 20 percent result in closure conditions in some plants. There would be several additional baseline closures were manufacturing costs to be increased (for reasons other than wastewater treatment) by 20 percent. There would not, however, be additional plant impacts due to the regulation.

In summation, the data and methodological limitations to the analysis are accommodated with conservative assumptions throughout the analysis. The sensitivity analysis that are performed support the conclusions in Section 5 of the report--that the treatment costs are not expected to cause any plant closures.

Section 8

Sodium Sulfite Impact Analysis

8.1 Introduction

Effluent limitations guidelines and standards for sodium sulfite were promulgated in 1974. The technology basis for BAT, NSPS, and PSNS limitations was evaporation of the treated wastewater to achieve zero discharge of process water. In 1981, the sodium chloride industry requested reconsideration of BAT guidelines for sodium chloride (solution brine-mining process) because they believed the costs of compliance with zero discharge were too large in comparison to the effluent reductions achieved. In the course of the review for sodium chloride, the Agency also reconsidered the zero discharge requirement for the sodium sulfite subcategory.

In its review, the Agency acquired additional data on the cost of the technology and developed current estimates of costs that existing dischargers would incur to meet the existing BAT requirements. Evaporation of wastewater for the sodium sulfite subcategory is considerably more expensive than originally estimated, in large part due to the greatly increased cost of fuel. Fuel prices increased approximately 500 percent (on a constant dollar basis) from the assumptions used to evaluate the 1974 regulation. Operating and maintenance costs, including the costs of energy, represented approximately 40 percent of the total estimated cost of compliance in 1974. Following the revisions to compliance cost estimates, the comparable cost component represents almost 90 percent of the total estimated cost of compliance.

The analysis in this section addresses the economic achievability of the zero discharge BAT regulation, using the updated treatment costs.

8.2 Qualitative Information

There are three plants currently producing sodium sulfite by the soda ash-sulfur dioxide process which defines this subcategory. The annual production capacity is approximately 69,840 metric tons and the estimated price (in second quarter 1983 dollars) is $475 per metric ton. Since the promulgation of the regulation in 1974, four plants in this subcategory have shut down, leaving the three plants examined in this analysis.

The soda ash-sulfur dioxide process remains the dominant means of producing both sodium bisulfite and sodium sulfite. The only other commercial production is as a by-product of phenol production through the reaction of sodium benzene sulfonate with sodium hydroxide.

Sodium sulfite is used primarily for deicing, dust control, in the pulp and paper industry, and other industrial uses. Sodium sulfite has a diversity of uses and shares many segments with sodium chlorate, for which the demand elasticity has been estimated to be -0.15.[1/] For this reason the demand elasticity for sodium sulfite is also expected to be low (i.e. -.20).

8.3 Methodology

The methodology employed to analyze the impacts of the effluent limitations of sodium sulfite is essentially the same as that used to analyze the Phase II inorganic chemicals. The description in this section, therefore, deals with departures from the methodology described in Section 3 of this report.

Model plant manufacturing costs were assumed to be four percent larger for sodium sulfite than those for sodium bisulfite, which was analyzed in the economic analysis for the Phase I inorganic chemicals. The four percent adjustment accounts for the price difference between the two products.

Plant level manufacturing costs are estimated using the procedures presented in Section 3 and described further in Appendix 3B. A 62 percent capacity utilization estimate reported for sodium bisulfite is used with the reported sodium sulfite production levels to estimate the size of the capital facility. Plant level treatment costs are discussed in Section 8.4.

The impact analyses include changes in manufacturing costs, profitability, price, and production and tests for liquidity and solvency. These analyses are performed in the manner described in Section 3. The plants are treated here as single product facilities.

8.4 Compliance Costs

The effluent limitations costs examined in this section pertain to BAT and NSPS limitations, only. The effluent limitation for BAT and NSPS is zero discharge except for excess water produced from wastewater impoundments designed to contain a 25 year-24 hour storm. The recommended treatment to achieve this is evaporation via a multiple effect evaporation system plus, if necessary, an agitated falling film evaporator.

Plant level production and treatment costs are outlined in the technical Development Document. The treatment cost estimates are updated to reflect current cost assumptions and reflect the costs attributable to the sodium sulfite flow at the plants. These treatment costs are summarized as follows. (All figures are in thousands of 1983 dollars.)

Total Capital Investment	=	2,425
Annual O&M Costs	=	2,285
Residual Waste	=	884
Capital Recovery	=	394
Total Annual Costs	=	3,564

1/ see Section 2 of this report.

8.5 Results

8.5.1 Plant Level Impacts

The plant level impacts are measured by manufacturing cost increases and profitability changes.

Table 8-1 shows plant level impacts, summed across the sodium sulfite subcategory. The plant level cost increases are all relatively high, ranging from 4.5 to 37.8 percent. The average manufacturing cost increase, shown in Table 8-1, is 23.3 percent.

Table 8-1. Plant Level Impacts--Sodium Sulfite Subcategory[1]

Annual Production (Metric tons)	43,300
Annual Manufacturing Costs	15,310
Annual Treatment Costs	3,563
Annual Sales	17,060
Annual Variable Costs	12,847
Manufacturing Cost Increase (%)	23.3
Profitability Reduction (%)	84.6

[1]Dollar values in thousand of second quarter 1983 dollars.

Source: Effluent Guidelines Division (EPA) and Meta Systems, Inc. 1983.

Profitability for plants is measured as the ratio of treatment costs to net revenues, assuming zero percent cost pass-through. These values are all quite high, averaging 84.6 percent. At this level of reduced profitability, continued manufacturing operations are unlikely.

8.5.2 Product Level Impacts

Product level impacts on sodium sulfite are measured by price increases and production changes. There are no price or production changes with a zero percent cost pass-through. With the 100 percent cost pass-through assumption, the price increase is 20.9 percent and the production decrease is 4.2 percent. These values are both high.

8.5.3 Closure

Closure is predicted if a plant fails to pass either the liquidity test or the solvency test. The liquidity of a plant is tested by comparing treatment costs to cash flow. Where treatment costs exceed cash flow, it is possible that the plant will not have access to sufficient cash to cover the cost of treatment. Two of the three plants fail this test and therefore would be expected to close.

In the test for solvency, salvage value is compared to net present value. Where the salvage value exceeds the present value of the estimated cash flow, a company might consider closing the production facility. The ratios of salvage value to the present value of cash flow range from 11.4 percent to 77.4 percent, but none of the plants are identified as closures on the basis of this test.

8.5.4 Employment

The closure of these plants would result in the estimated loss of 38 jobs.

8.5.5 New Source Standards

New source standards are assumed to be equal to the BAT standards. The treatment costs examined here, therefore, represent significant barriers to new plants entering the sodium sulfite manufacturing industry.

Section 9
Sodium Chloride NSPS Analysis

9.1 Introduction

This section presents an analysis of the impact of the existing no discharge regulations upon new sources within the sodium chloride subcategory. Four alternatives for control of effluents are discussed. The first alternative involves the use of a surface condenser in place of a barometric condenser. Using a surface condenser of equal size forces a plant to produce about 10 percent less than if a barometric condenser were used. The second alternative involves the use of a surface condenser which is scaled such that there is no difference in the production rate. The third and fourth alternatives involve the use of cooling ponds and cooling towers, respectively. The fifth alternative represents the additional costs of installing a surface condenser with costs 50 percent greater than those of the second alternative described above (this estimate was provided by Morton Salts). Total annual cost of treatment is total capital cost times the capital recovery factor, 0.1627, plus annual O&M plus annual sludge disposal costs.

The costs for the three alternatives involving surface condensers (1A, 1B, and 1E) are the additional costs of installing a surface condenser instead of a barometric condenser, which is required for normal operation of a sodium chloride plant. The model plant is assumed to produce 397,226 metric tons of sodium chloride per year with a wasteflow rate of 12 million gallons per day.

9.2 Methodology

The analysis described here conforms to that of other subcategories which is presented in Section 5.7 of this report. The treatment costs are compared to manufacturing costs and to net revenues to determine their potential impact as barriers to entry into the market.

Manufacturing costs (i.e., fixed cost and variable costs) are estimated using data available from the Census of Manufactures for 1977. The following data are taken from the Census of Manufactures for the 5-digit SIC code 28991, Evaporated Salt. The figures are expressed in millions of 1977 dollars.

Value of Shipments	247.6
Cost of Materials	92.8
Total Wages-Production Workers	41.9
Capital Expenditures-new	25.2

Table 9-1. Sodium Chloride Model Plant Treatment Costs[1]

Description	Level	Treatment Cost Capital	OM	Sludge
Small Surface Condenser[2]	1A	190.3	23.9	0.0
Large Surface Condenser[2]	1B	1566.4	230.2	0.0
Cooling Pond	1C	648.0	128.1	0.0
Cooling Tower	1D	683.5	231.4	0.0
Surface Condenser with costs 150% of large surface condenser above[2]	1E	2426.5	364.7	0.0

[1]/thousands of 1983 dollars, using factor of 1.04 to convert 1982 dollars to 1983 dollars.

[2]/Additional costs of installing a surface condenser instead of a barometric condenser.

Source: Effluent Guidelines Division, EPA, 1984.

The annual variable cost of manufacturing is estimated as the cost of materials plus production worker wages, or 134.7 million dollars. Annual fixed cost is assumed to be equal to new capital expenditures, or 25.2 million dollars. Total fixed cost is estimated to be 193.8 million dollars, using a capital recovery factor of 0.13. Since total industry variable costs represent 54 percent of the total value of shipments, the estimate of variable cost for a particular plant is estimated as 54 percent of sales at the plant. Likewise, total fixed cost is estimated to be 78 percent of plant sales.

Plant sales is calculated as model plant production times a sodium chloride price of 57.3 dollars per metric ton.1/ Model plant compliance costs are provided by EPA for the five alternatives and are presented in Table 9-1.

9.3 Results

The results of the analysis for the five alternatives are summarized in Table 9-2. Note that the production under Level 1A (small surface condenser) is 10 percent lower than the others.

The use of a large surface condenser (Level IE) has the largest impact on production cost and profit. For this alternative treatment costs represent 7.3 percent of the profit and 5.2 percent of production cost. None of the alternatives presents any barrier to market entry.

1/ Chemical Marketing Reporter, December 6, 1982--$50 per short ton, converted to 1983 dollars using factor of 1.04.

Table 9-2. NSPS Impact Analysis
Sodium Chloride[1]

Level	Annual Production	Fixed Cost	Ann. Var. Cost	Annual Sales	Net Rev. as % of Fixed Cost	Tot. Ann. Trtmt. Cost	Prod. Cost Change, %	Profit Decline, %
1A	357.6	17747	12286	20477	46.2%	54.9	0.38%	0.67%
1B	397.3	17747	12286	22752	57.2	485.1	3.32	4.63
1C	397.3	17747	12286	22752	57.2	233.6	1.60	2.23
1D	397.3	17747	12286	22752	57.2	342.6	2.35	3.27
IE	397.3	17747	12286	22752	57.2	759.5	5.20	7.26

[1]/thousands of 1983 dollars, using factor of 1.04 to convert 1982 dollars to 1983 dollars.

Source: Meta Systems, Inc. estimates.

Appendix 2A

Process Descriptions

Cadmium Pigments

Yellow cadmium pigments are made by precipitating a cadmium sulfate solution with a sodium sulfide solution. Red tones are produced by first dissolving selenium in the sulfide solution in a ratio to cadmium that may vary from 1:9 to 3:7. Zinc compounds may be added to obtain some lighter yellow and red tones and barium salts are used for lithopones, but the model plant manufacturing costs are based on selenium and cadmium only in a ratio of 2:8. The precipitate is dewatered, calcined, ground, washed, dried and mechanically processed.

Cadmium Salts

Cadmium chloride, nitrate and sulfate are made by dissolving metallic cadmium in the respective acid. The solution is filtered and the salt concentrated by evaporation. Cadmium chloride is crystallized. The solid salts are separated from the mother liquor and dried.

Cobalt Salts

Cobalt chloride, nitrate and sulfate are made by dissolving the metal or oxide in the respective acid. The raw solution is a marketable product. Alternatively, it is purified, and the salt subsequently evaporated, crystallized, separated and dried.

Copper Salts

Copper carbonate is made by precipitating a copper sulfate solution with carbon dioxide or aqueous sodium carbonate.

Copper chlorides are produced either by the chlorination of copper in a gas-liquid-solid system, or by interaction of copper sulfate and barium chloride solutions. In the former case, both cuprous and cupric chlorides will form in various proportions depending on the operating conditions. The cuprous salt crystallizes first and cupric chloride is then concentrated by evaporation. In the barium route, a cupric chloride solution is obtained after the insoluble barium sulfate is separated. The cupric ions may then be reduced to the cuprous form by metallic copper. Both salts are ultimately concentrated by evaporation.

Copper iodide is synthesized in molten form from its elements, molded and ground. It can also be produced by precipitation.

Copper nitrate is made by dissolving the metal or oxide in nitric acid (a saleable product) and purifying and evaporating the resulting solution. The present estimates are based on the production of the dry salt.

Nickel Salts

Nickel chloride and nitrate are made by dissolving metallic nickel or the oxide in the respective acid. The solution is a marketable product but this study assumes further purification, evaporation, crystallization, salt separation and drying.

Nickel carbonate is produced from the nitrate solution by precipitation with a sodium carbonate solution. The precipitate is separated and dried.

Nickel fluoborate is sold in an aqueous solution obtained by dissolving the carbonate in concentrated fluoboric acid and purifying the resulting liquid if necessary.

Sodium Chlorate

Sodium chlorate is made by the electrolysis of a purified sodium chloride brine in the presence of sodium dichromate and hydrochloric acid. The resulting solution is evaporated and filtered. The salt is then crystallized, dried and ground.

Zinc Chloride

Zinc Chloride is produced by dissolving the metal or oxide in hydrochloric acid. After removing iron impurities (if necessary) and decolorizing, the solution is concentrated by evaporation and sold. Alternatively, the solution is purified, if necessary, and evaporated to a higher degree (5 percent water). The solid "butter of zinc," as the product is known, then solidifies on cooling.

Appendix 2B

Regression Equations for Business Cycle Analysis

The Business Cycle Analysis of Section 2 evaluated certain ratios in an attempt to estimate changes in profitability over time. Regressions were run and discussed briefly in Section 2. This appendix provides technical back-up for the information presented in Section 2.

Cash flow ratios (defined as value added - payroll/value of shipment) for the two principal SIC groups, 2816 and 2819, were regressed against various macroeconomic variables. The variables were the Industrial Production Index, the Metals Products Price Index, and a trend variable. SIC 2819 exhibited poor correlation with all of the variables examined. SIC 2816 showed a high correlation to several of the variables.

The assumption of the following model is that profits are related to capacity utilization, price, and some (unidentified) time related phenomena. Profit is represented by the cash flow ratio described above, capacity utilization is represented by total industrial production (IPI), and price is represented by the metals price index (in constant dollars) lagged one year.

The estimated equation for SIC group 2816 is presented below with the t-statistics for each coefficient noted in parentheses. A t-statistic close to 2 or -2 indicates that there is a 90 percent probability that the variable associated with that t-statistic has some impact on the dependent variable (in this case Log CFR).

$$\text{Log}(CFR_{2816}) = \underset{(-2.69)}{-10.169} + \underset{(1.75)}{0.939}\ \text{Log}(IPI) + \underset{(2.69)}{1.06}\ \text{Log}\ (DMPI) - \underset{(-3.26)}{0.069}\ TIME$$

$$R^2 = 0.781$$

where:

CFR_{2816}	=	the ratio of cash flow to value of industry shipments for SIC group 2816
IPI	=	Industrial Production Index
DMPI	=	the Metal products (SIC33) price index, lagged one year, in constant 1972 dollars
TIME	=	trend variable with 1=1965, 2=1966, etc. . . . .

Two of the three coefficients are highly significant and the fit is good. The cost variable, DMPI, has a coefficient significant at the 0.02 level. A value of 1.06 indicates that increases in metal prices are reflected in even greater increases in CFR. The IPI variable is significant only at the 0.11 level. The coefficient of log (IPI) is 0.939, indicating that the CFR is slightly less sensitive to changes in IPI. For practical purposes, the coefficients of IPI and DMPI are both close to 1.0, indicating that the rate of change of cash flow is close to proportional with respect to either of these variables. The trend variable TIME is significant at the 0.02 level. It has been specified here as a logistic decay function (i.e., the incremental effect of TIME on CFR will dampen the growth of CFR as TIME increases).

Considering the anticipated values of IPI, DMPI and TIME over the next several years, TIME has by far the greatest influence on changes in CFR. This suggests that some time-related conditions other than metals price and industrial production have more influence on the CFR than the IPI or the Metal Price Indices.

Appendix 3A

Calculation of Manufacturing Costs

Manufacturing costs are developed for model inorganic chemical plants producing cadmium pigments, cadmium salts, cobalt salts, copper carbonate, copper salts, nickel carbonate, nickel salts, sodium chlorate, and zinc chloride. Table 3A-1 summarizes the characteristics and process economics for the model plants used in this analysis. The production rates were chosen to represent typically-sized facilities in order to estimate treatment costs.

The process economics were developed for this study based on literature review and the application of engineering principles. The process economics consist of capital investment and the different operating costs--materials, utilities, operating labor, maintenance labor, supervision, other fixed costs such as taxes and insurance. Capital investment estimation requires information regarding the production units used in these plants, scale, and the specific heat and pressure requirements of the process. Labor requirements were estimated using empirical relationships between labor requirements and production units. Materials requirements are estimated by stoichiometry and estimated reaction efficiencies, and the other costs are estimated using standard cost estimation techniques and these estimates of fixed cost, labor and materials.

Process economics for specific plants were estimated from these model plant process economics following the procedures described in Appendix 3B.

Table 3A-1. Summary of Model Plant Costs

Subcategory	Annual Production (Metric Tons)	Daily Flow (Cubic Meters)	Fixed Cost ($X1,000)	Variable Costs ($X1,000)						
				Materials & Utilities Costs	Operating Labor Costs	Maintenance Labor	Supervision	Plant Overhead	Other Fixed Costs	Total Variable Costs
Cadmium Pigments	711	262	3,888	3,634	497	117	99.4	245	194	4,787
Cadmium Salts	169	0.07	2,132	395	210	64	42	110	107	927
Cobalt Salts	358	0.26	3,459	1,308	437	103	87	216	172	2,325
Copper Carbonate	155	291	4,298	105	74	129	15	81	215	619
Copper Salts	85.2	0.8	2,610	138	62	78	12	56	130	477
Nickel Carbonate	142	94.8	1,063	398	287	32	57	128	53	955
Nickel Salts	429	1.67	2,542	574	399	76	80	190	127	1,446
Sodium Chlorate	32,000	237	34,396	8,083	733	1,032	147	706	1,720	12,420
Zinc Chloride	5,700	260	10,953	2,073	290	329	58	247	548	3,545
	26,000	1,000	17,290	8,658	519	519	104	415	864	11,079

Source: Meta Systems estimates

Appendix 3B

Actual Plant Manufacturing Cost Adjustments

Manufacturing costs for a specific plant are estimated by using model plant costs with adjustments for production capacity and operating time. Assuming equal capacity utilization rate, the ratio of real plant capacity to the model plant capacity is $(Q/Q_m)(D_m/D)$, where Q is annual production, D is the number of operating days per year and the subscript m denotes model plant values. Fixed costs (FC) for the actual plant are then estimated as:

$$FC = [(Q/Q_m)\ (D_m/D)]^a\ FC_m$$

where a = 0.5 for small plants (Q less than 10,000 metric tons/year) and a = 0.6 for large plants. The use of a smaller exponent for small plants is based on the fact that, because of the fixed startup costs applicable to even the smallest plants, unit costs rapidly decrease with size. The costs for materials and utilities (MU) are assumed directly proportional to production:

$$MU = (Q/Q_m)\ MU_m.$$

Operating labor costs (OL) are estimated by scaling according to both capacity and operating time:

$$OL = [(Q/Q_m)\ (D_m/D)]^b\ OL_m\ (D/D_m)$$

where b = 0.3 (small value to represent the weak dependence on production).

Other variable manufacturing costs, including maintenance labor (ML), supervision (SUP) and overhead (OV), are calculated as follows:

$$ML = 0.03\ FC\ (D/D_m)$$
$$SUP = 0.2\ OL$$
$$OV = 0.4\ (OL + ML)$$
$$OFC = 0.05\ FC.$$

The preceding equations are variations of cost estimations used widely in the chemicals industry. These calculations are adequate for plants producing a single chemical. For plants producing more than one chemical, an additional assumption is that the same equipment is used for different products at different times of year, thus making capital for the product requiring the largest investment sufficient for the other products. Therefore, the fixed costs for manufacturing are the largest of the single product costs. Variable costs that are independent of fixed costs are summed over individual products, while total maintenance, overhead, and "other fixed costs" (OFC) are calculated directly from the fixed costs and denote maintenance materials and supplies, operating supplies, property taxes, and insurance. An example of the calculation of manufacturing costs for a hypothetical multi-product plant is shown in Table 3B-1.

Table 3B-1.

Hypothetical Calculation of Manufacturing Costs
for a Multi-Product Plant

	Cobalt Salts	Copper Salts	Nickel Salts	Entire Plant
Q(MT/yr)	35	90	440	565 1/
D(days/yr)	40	25	160	225 1/
FC(x10^3$)	2,500	6,800	4,700	6,800 2/
MU(x10^3$/yr)	100	130	620	850 1/
OL(x10^3$/yr)	50	15	200	265 1/
ML(x10^3$/yr)				132
SUP(x10^3$/yr)	10	3	40	53 1/
OV(x10^3$/yr)				160
OFC(x10^3$/yr)				221
VC(x10^3$/yr)				1,681
P($/MT)	8,527	3,193	3,237	

1/ Sum of values for individual products.

2/ Maximum of values for individual products.

Table 3B-1 shows the figures for a hypothetical multi-product plant that produces cobalt, copper and nickel salts. Copper salt manufacturing has the highest fixed costs of the three and thus the fixed costs for the entire plant are assumed to be $6,800 x 10^3. Variable costs that are independent of fixed costs (maintenance and utilities - MU, operating labor - OL, and supervision - SUP) are summed across the products. Variable costs that depend on fixed costs (maintenance and labor--ML, and other fixed costs--OFC) are calculated as a fraction of $6,800 x 10^3.

For all plants (single or multi-product), the total variable costs (VC) are:

$$VC = MU + OL + ML + SUP + OV + OFC$$

The amortized fixed costs (AFC) are calculated based on a 10 percent interest rate and a time horizon of 15 years.

Appendix 3C

Estimation of Supply Curves, Elasticities and Cost Pass-Through Factors

This appendix addresses the estimation of the portion of treatment costs which are passed through to consumers as higher prices. The estimation of cost pass-through factors requires information on supply elasticities which, in turn, requires the construction of supply curves. This appendix will discuss, in turn, supply curve construction, supply elasticity estimation, and cost pass-through factor estimation.

Supply Curve Construction

The information necessary for a precise supply curve--marginal costs as a function of quantity produced--is not available. However, the following method serves as a reasonable surrogate. The unit manufacturing costs for all plants in a subcategory are estimated and ranked from smallest to largest. Let C_i be the i^{th} smallest unit cost and q_j be the production of the corresponding plant. If the price P is at least C_i, then plants 1 through i would each produce an amount leading to an output of

$$Q_i = \sum_{j=1}^{i} q_j.$$

The points (Q_i, C_i) then define the supply curve. The supply curve can be "calibrated" to fit a subcategory by adjusting the return on investment (ROI) portion of the plant costs, C_i, until a horizontal line passing through the price for that subcategory intersects the curve near (what is judged to be) the marginal plant in that subcategory.

For subcategories with adequate data, the supply curve is expressed algebraically by fitting a cubic equation to the point (Q_i, C_i) where C, the cost, translates into P, the price in the following equation:

$$P = a + bQ + cQ^2 + dQ^3$$

For other subcategories, this curve is expressed graphically by fitting a smooth curve to the observed points.

The representation of the different plants in an industry segment with a supply curve implies, among other things, that those plants produce the same product and sell it to a single market. Of the seven industry subsectors considered 1/, sodium chlorate comes closest to this description. Zinc chloride plants produce several grades of zinc chloride for

1/ For this analysis, copper salts have been combined with copper carbonate and nickel salts have been combined with nickel carbonate.

both captive and merchant markets. The other subcategories are aggregates of several chemicals and therefore depart even further from the one product, one market paradigm. Sodium chlorate is therefore the only subcategory to be represented algebraically. The fitted equation is:

$$P = 0.256 + (1.487 \times 10^{-6})Q - (8.713 \times 10^{-12}) Q^2 + (1.855 \times 10^{-17})Q^3$$

The other subcategories were fitted graphically.

Supply Elasticity Estimation

The elasticity of supply (e_s) is the slope of the supply curve at the current price P_o and production Q_o. It is estimated by:

$$e_s = (P_o/Q_o)\ (dQ/dP)_o$$

Supply elasticity is estimated in the sodium chlorate subcategory to be 1.03. Supply elasticities in other subcategories range from 0.24 to 3.15, but they are based on less reliable supply curve information. These values are presented in Table 3C-1. These supply elasticities are used in the following estimation of the cost pass-through factor.

Cost Pass-Through

The cost pass-through (the ratio of price increase to the unit cost of treatment) is

$$dP/t = e_s/(e_s - e_d)$$

where e_s and e_d are the elasticities of supply and demand, respectively, and t is a uniform unit cost of treatment. The elasticity of demand (e_d) is estimated on the basis of the qualitative assessment in Section 2. Where the different chemicals in a subcategory had different estimates of demand elasticity, the most elastic value was chosen. The cost pass-through estimates shown may therefore be low. Estimated values of e_s, e_d and dP/t are presented in Table 3C-1.

The cost pass-through estimates shown in Table 3C-1 range from 44 percent to 95 percent. The values of e_s have been estimated at the average unit price for each of the subcategories. The curves for sodium chlorate and zinc chloride represent single products. Each of the other subcategories includes two or more chemicals. The curves measured in these other subcategories are therefore aggregate supply curves. This additional step away from the theoretical construct indicates that the cost pass-through estimates for these aggregate subcategories are less reliable.

Table 3C-1.

Supply Elasticity and Cost Pass-Through Estimates
By Subcategory

Subcategory	e_s	e_d	Cost Pass-Through dP/t (%)*
Cadmium Pigments	3.15	-0.1	95
Cadmium Salts	0.81	-0.3	73
Cobalt Salts	0.78	-0.4	66
Copper Salts (including Copper Carbonate)	0.24	-0.3	44
Nickel Salts (including Nickel Carbonate)	0.19	-0.2	49
Sodium Chlorate	1.03	-0.15	87
Zinc Chloride	0.161	-0.2	45

* $dP/t = e_s/(e_s-e_d)$, with e_d estimates as described in Section 2 of the report.

The actual pass-through of treatment costs is more complicated than this estimation technique can capture. In the case of sodium chlorate, there are several plants of similar size selling to a merchant market, and the results of the supply curve analysis suggest that a high proportion of the costs will be passed through. With zinc chloride, various product grades are produced and the plant sizes range from less than 5,000 to almost 30,000 tons per year, suggesting that captive markets exist and that a single supply curve is a less appropriate tool for this purpose. The supply curves in the other subcategories are composites of plants with different scales, markets and products, and are therefore even less likely to respond to treatment costs in a manner shown by this graphical procedure.

In theory, since this sector of the inorganic chemicals industry produces at significantly less than productive capacity, the supply curve should be close to horizontal, the supply elasticity should be high and the cost pass-through should be close to 100 percent. The results of the sodium chlorate analysis support this theory. Since that analysis is the most valid and assuming that pricing behavior for the other chemicals is similar, the 100 percent cost pass-through has been used for all of the subcategories. Accordingly, section 5 of the report assumes that the cost pass-through is 100 percent. Section 7 tests the sensitivity of the results of the analysis to this assumption.