821R93002

# REGULATORY IMPACT ANALYSIS OF EFFLUENT LIMITATION GUIDELINES FOR OFFSHORE OIL AND GAS FACILITIES

*Final Report*

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68-C8-0084

January 14, 1993

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# EXECUTIVE SUMMARY

For all major rulemaking actions, Executive Order 12291 requires a Regulatory Impact Analysis (RIA), in which benefits of the regulation are compared to costs imposed by the regulation. This report presents the Environmental Protection Agency's (EPA, or the Agency) RIA of the final rule on the effluent limitations guidelines for the Offshore Subcategory of the Oil and Gas Extraction Industry.

The principal requirement of the Executive Order is that the Agency perform an analysis comparing the benefits of the regulation to the costs that the regulation imposes. Three types of benefits are analyzed in this RIA: quantified and monetized benefits; quantified and non-monetized benefits; and non-quantified and non-monetized benefits. Wherever possible, the costs and benefits are to be expressed in monetary terms; however, many of the benefits are not currently amenable to quantification or monetization. To address the analytical requirement of an RIA, this report is organized into five major sections:

- Background
- Need for the Regulation
- Evaluation of Alternatives and Technology Options
- Evaluation of Costs and Economic Impacts
- Evaluation of Benefits and Water Quality Impacts.

## Regulatory Background

The 1972 Federal Water Pollution Control Act, as amended by the 1977 Clean Water Act Amendments and the Water Quality Act of 1987 (Clean Water Act), authorizes EPA to develop technology-based effluent limitations guidelines and standards for categories of industries, including the oil and gas extraction category, of which offshore oil and gas activities are a subcategory. These effluent limitations guidelines and standards are defined based upon the following levels of pollution control:

- Best Conventional Pollutant Control Technology (BCT)
- Best Available Technology Economically Achievable (BAT)
- New Source Performance Standards (NSPS).

An estimated 2,549 structures develop or produce oil or gas in the offshore waters of the United States and are estimated to bear costs associated with the rule. This estimate includes all tracts leased offshore in the Gulf of Mexico, California, and Alaska. There are no development or production platforms in the Atlantic Ocean. In terms of development operations, offshore drilling varies from year to year, depending on such factors as the hydrocarbon economic market conditions, state and federal leasing programs and reservoir discoveries. The Agency estimates that between 1993 and the year 2007, an average of 759 wells/year will be drilled (based on an average oil price of $21/barrel). Of these 759 wells/year, 456 wells/year are projected to become producing wells drilled on new and existing structures, and the remaining 303 wells/year are projected to be dry holes. Between the years 1993 and 2007, an estimated 759 new platforms installed offshore will be producing oil or gas.

## Regulatory Options

For *drilling fluids and drill cuttings*, several regulatory options beyond baseline practices (BPJ, or "dirty" barite muds) were developed. While cost estimates were prepared for all regions, benefit estimates were prepared for Gulf of Mexico locations only. The options for which both costs and benefits were estimated include:

- 3 Mile Gulf/California. Zero discharge (i.e., the transport of muds and cuttings to shore for appropriate land-based waste management and disposal) for all platforms within three miles of shore. Under this option, Best Available Technology (BAT), consisting of using "clean" barite drilling fluids and other requirements, applies to all platforms beyond three miles of shore. Alaska is exempt from the zero discharge requirement.

- 8 Mile Gulf/3 Mile California. Zero discharge for platforms within eight miles of shore, and BAT for platforms beyond. California and Alaska must meet the same requirements as in the 3 Mile Gulf/California option.

- Zero Discharge Gulf/California. Zero discharge for all platforms. Alaska is exempt, but must meet the same requirements as in the 3 Mile Gulf/California option.

For *produced water* (BAT and NSPS), several regulatory options were evaluated. While cost estimates were prepared for all regions, benefit estimates were prepared for Gulf of Mexico locations only. The options for which both costs and benefits were estimated include:

- Flotation All. Improved gas flotation for all platforms.

- Zero 3 Miles Gulf and Alaska. Zero discharge (re-injection) at platforms within three miles of shore, and BAT for platforms beyond three miles. BAT required for California wells. Exclusion for Gulf single-well structures but no exclusion for Gulf NSPS structures.

- Zero Discharge Gulf and Alaska. Zero discharge for all platforms except California. BAT required for California wells.

**Estimate of Costs**

For drilling fluids and drill cuttings, total annual costs for all options considered range from $18.9 million for the selected option, 3 Mile Gulf/California, to $148.4 million for Zero Discharge Gulf/California. For the selected option, costs are approximately $26,000 per well in the Gulf of Mexico and $3,000 per well in the Pacific.[1]

For produced waters (BAT), the peak annual costs for all options considered range from $96.3 million ($108.4 million in 1991 dollars) for the selected option, Flotation All, to $654.2 million ($736.5 million in 1991 dollars) for Zero Discharge Gulf and Alaska. These costs do not represent average annual costs over the 15-year period evaluated; rather, they represent the peak costs that will be incurred in the first year of the regulation. By Year 15, these costs will decline to zero.

For produced waters (NSPS), total annual costs for all options considered range from $0.8 million ($0.9 million in 1991 dollars) for the selected option, Flotation All, to $23.1 million ($26 million in 1991 dollars) for Zero Discharge Gulf and Alaska.

Combined costs were calculated for two packages of selected regulatory options:

- Package A includes the selected options for drilling fluids and cuttings (3 Mile Gulf/California) and produced water (Flotation All).
- Package B contains the selected option for drilling fluids and cuttings, the Zero 3 Miles Gulf and Alaska option for BAT produced water, and the Zero 3 Miles Gulf and Alaska option for NSPS produced water.

Both packages include costs for regulation of workover fluids and produced sand (not presented in this RIA). For all regions, first-year annualized costs for Package A are $122 million ($134 million in 1991 dollars), and $144 million ($160 million in 1991 dollars) for Package B (workover fluids and produced sand comprise 4.5 percent and 3.8 percent of the package costs, respectively). Fifteen-year costs, the point at which all BAT projects will have reached the end of their economic lifetimes and NSPS costs are at their peak, are estimated at $36 million annually for Package A ($38 million in 1991 dollars), and $86 million per year for Package B ($94 million in 1991 dollars). Old projects anticipated to cease production are projected to outnumber new projects that

[1] Cost estimates, as developed by ERG (1993a), are in 1986 dollars. Because barite and barging costs have remained constant since that time, the 1991 price levels for costs related to drilling fluids and cuttings are not likely to have changed significantly and, therefore, are unchanged from the 1986 estimates (ERG, Memorandum of October 21, 1992 from Maureen Kaplan to Mahesh Podar).

begin production over the 15-year period. For the Gulf of Mexico only, the 1991 annualized costs of the proposed regulatory package are $127 million in Year 1 and $37 million in Year 15.

## Cost-Effectiveness and Economic Impacts

The incremental cost-effectiveness (1981 dollars) of the selected options is $44 per pound equivalent removed for drilling fluids and drill cuttings, $33 per pound equivalent removed for BAT produced water, and $17 per pound equivalent removed for NSPS produced water. The economic impacts of the pollution control options are minimal for a typical major oil company under any set of options. Impacts on a typical independent oil company are somewhat greater. Given a regulatory package including the 3 Mile Gulf/California option for drilling fluids and drill cuttings and the Flotation All option for produced water, working capital may decline by 5 percent in the event that an independent should choose to fund all expenditures out of working capital. All other ratios would change by no more than 0.4 percent.

## Estimate of Benefits

The benefit assessment for the effluent limitations guidelines includes: 1) assessment of benefits that can be quantified and monetized, consisting of estimates of health-related benefits anticipated from controlling pollutants in effluent discharges from drilling and production waste streams; 2) assessment of water quality improvements attributable to the guidelines that can be quantified but not easily monetized; and 3) compilation of case studies of documented environmental impacts from these discharges that, similar to water quality improvements, can be quantified but not easily monetized. Monetized results focus exclusively on the benefits associated with human health risk reduction through reduced concentration of platform-related pollutants in recreationally-caught finfish species and commercial shrimp. The monetized benefits assessment presented in this RIA is restricted to analysis of operations in the Gulf of Mexico. The vast majority of production platforms are located in the Gulf of Mexico (2,517 of 2,549 total U.S. offshore producing structures).

The estimated benefits of the effluent guidelines for drilling fluids and cuttings are predominantly derived from reducing the amount of lead in edible shrimp tissue harvested commercially from platform-impacted waters of the Gulf. Additionally, lead concentrations in edible fish tissue, based on water column concentrations (omitting uptake via sediment or food chain), were applied to estimates of recreationally-caught Gulf finfish to derive applicable health benefits. Finally, benefits associated with decreased carcinogenic risks from commercially-caught shrimp and recreationally-caught finfish were estimated.

The total monetized benefits of the options for drilling muds and cuttings are shown in Table ES-1, along with their associated costs. In addition to the lead-related benefits described above, the values also reflect modest reductions in cancer risk as associated with arsenic. These "total" benefits are understated due to the omission of several potentially significant benefits. Omitted benefits include, but are not limited to: (1) adverse health effects from lead in women (all ages) and in men below the age of 40 or over the age of 59; (2) adverse lead-related health effects other than the endpoints quantified; (3) lead-related exposure associated with shrimp or finfish uptake of lead through the sediments directly, or indirectly, through the food chain; (4) recreational and commercial fishery improvements; (5) ecologic benefits; and (6) nonuse values.

As shown in this table, most of the benefits are obtained at the 3-mile Gulf/California option, with small incremental benefits realized at more stringent options. All of the benefit levels shown in these tables are related to the use of a saltwater leach scenario for calculating the bioavailability of lead in the marine environment. An alternative scenario evaluated (using a pH-dependent leach rate to estimate fish tissue concentrations) would increase human intake of lead to a significant degree, and the resulting benefit levels would increase by more than a factor of six times greater than the values shown here.[2]

For produced water, the quantified and monetized benefits are based on reduced human health risks through exposure to selected carcinogens (e.g., arsenic, benzene, benzo(a)pyrene) and lead through the consumption of recreationally-harvested finfish.[3] The estimated benefit levels are relatively modest, as shown in Table ES-2 for existing platforms and NSPS. It is important to note, however, that these quantified and monetized values omit several potentially important benefits. These omitted benefits include (but are not limited to): (1) lead-related risk reductions for women (all ages) and for men other than those between the ages of 40 and 59; (2) lead-related health effects other than those evaluated; (3) lead-related exposure associated with shrimp or finfish uptake of lead through sediment or the food chain; (4) recreational and commercial fishery benefits; (5) ecologic benefits; (6) any nonuse values that may be associated with the regulatory options; and (7) benefits from reduced lead exposure via shrimp.

[2] While available data appear to support use of a weak acid extraction (pH 5.0-5.3), benefits summarized in this RIA are based on a saltwater leach scenario to avoid any potential overestimate of benefits. This issue is discussed on page 6-17 of the RIA, and a full discussion is found in Avanti, 1993, Appendix C.

[3] Shrimp impacts could not be estimated for produced water. Highly preliminary benefits estimates, based on a rough assessment of risk reductions associated with the potential for incidental removal of radium, also are developed.

**Table ES-1**
**Total Monetized Benefits and Costs**
**Drilling Fluids and Cuttings**
**Gulf of Mexico**
**(Salt Water Leach Scenario)**

| Regulatory Option | Annual Benefits [a,b,c] (millions 1991 dollars) | Annual Costs [c] (millions 1991 dollars) |
|---|---|---|
| Baseline - Current | -- | -- |
| 3 Mile Gulf/California | $28.1 - $103.6 | $18.8 |
| 8 Mile Gulf/3 Mile California | $28.5 - $104.7 | $33.1 |
| Zero Discharge Gulf/California | $30.0 - $110.5 | $142.4 |

a Health benefits primarily based on reduced lead exposure, only partially on reduced arsenic-related carcinogenic risks.

b Relative to baseline.

c For Gulf of Mexico only.

**Table ES-2**
**Total Monetized Benefits for Produced Waters**
**Gulf of Mexico**
**(Thousands of 1991 Dollars)**

| Regulatory Option | Existing Sources | NSPS |
|---|---|---|
| Baseline | -- | -- |
| Flotation All | $29.8 - $122.5 | $39.0 - $161.6 |
| Zero 3 Miles Gulf and Alaska | $278.7 - $1,417.5 | $298.7 - $1,464.3 |
| Zero Discharge Gulf and Alaska | $542.4 - $2,773.2 | $554.8 - $2,824.8 |

## Comparison of Benefits to Costs

The combined human health benefits of regulating drilling fluids and cuttings and produced water for the selected options (3 Mile Gulf/California and Flotation All) are between $28 and $104 million per year in 1991 dollars.[4] In addition, under an alternative, pH-dependent leach scenario, benefits of the selected options may amount to more than $600 million per year. The total annualized costs (1991 dollars) of the selected options are estimated to be $121.9 million for the Gulf region in Year 1 and $32.2 million in Year 15. Costs decline over time as existing projects, which must meet BAT requirements, reach the end of their economic lives. Assuming a straight-line decline in existing BAT projects over the 15-year time frame, benefits could begin to exceed costs as early as Year 9. Benefits and costs associated with the selected options are compared in Table ES-3.

**Table ES-3**
**Summary of Benefits and Costs**
**Selected Options**
**Gulf of Mexico Operations**

| Wastestream | Annual Benefits[a] (1991 dollars) | | Annual Costs (1991 dollars) | |
|---|---|---|---|---|
| | Low | High | Year 1 | Year 15 |
| Drilling Fluids and Drill Cuttings (3 Mile Gulf/California Option) | $28,100,000 | $103,600,000 | 18,800,000 | $18,800,000 |
| Produced Water (BAT) (Flotation All Option) | $30,000 | $123,000 | 102,200,000 | 0 |
| Produced Water (NSPS) (Flotation All Option) | $39,000 | $162,000 | 900,000 | $13,400,000 |
| Total | $28,174,000 | $103,885,000 | 121,900,000 | $32,200,000 |

[a] Monetized benefits are limited to the health-related benefits presented in Table ES-4.

[4] Benefits estimates are for the Gulf of Mexico only. Ninety-nine percent of existing oil and gas structures are located in the Gulf.

Monetized benefits reflect only a limited set of health-related benefits associated with the rule. These benefit categories, as well as the categories of non-monetized benefits evaluated in this RIA, are summarized in Table ES-4.

**Evaluation of Non-Monetized Benefits**

An assessment of quantified, non-monetized water quality benefits was developed to compare projected water column and sediment pore water pollutant concentrations, resulting from discharges at the current level of treatment and for evaluated options, to acute and chronic marine and human health (fish consumption only) criteria/toxic values. This benefits assessment projected exceedences of these values by drilling fluids, drill cuttings, and produced water discharges. The quantified, non-monetized benefits identified for the selected options include: (1) for drilling fluids and drill cuttings, elimination of the projected aquatic life and human health toxic values exceedences within 3 miles from the shore and reduction of projected impacts beyond 3 miles from shore; and (2) reduction of projected impacts for produced water.

The assessment of quantified, non-monetized impacts also reviewed and summarized case studies of localized impacts found near oil and gas drill sites and platforms located in the Gulf of Mexico, Southern California, and Alaska. Discharged drilling fluids and drill cuttings contaminate sediments with heavy metals and hydrocarbons. Documented biological effects include elimination and inhibited growth of seagrasses, declined abundance in benthic species, altered benthic community structure, decreased coral coverage, and bioaccumulation of heavy metals. Biological impacts from single wells occur from several hundred meters to several kilometers; chemical impacts have been noted from several to tens of kilometers. Produced water discharges contaminate sediments with polynuclear aromatic hydrocarbons (PAH), metals, and radionuclides, local elimination and depressed abundance of benthic species, and alteration of benthic communities. Studies do not indicate that larger-scale (more than several hundred to a thousand meters) impacts occur. However, these studies are not adequate to conclude that regional-scale impacts do not occur.

Federal water quality criteria or toxic benchmarks for marine organisms acute effects, marine organisms chronic effects, and human health for fish consumption (Versar, 1992) are compared to the projected incremental concentration of pollutants in the water column (for drilling fluids and produced water) and the sediment pore water (for the drilling fluids and drill cuttings).

For drilling fluids, using the selected option (3 Mile Gulf/California), the water quality exceedences in the water column in the 0-3 mile zone will drop to zero. In waters for which discharge is allowed, projected water quality exceedences in the water column are reduced to a maximum of 2 exceedences (1 marine chronic and 1 human health for fish

**Table ES-4**
**Benefits of Offshore Oil and Gas Effluent Guidelines**

**Monetized Benefits**

**Human Health Risk Reductions:**

**Contaminants**
- carcinogens with Agency-established risk slope factors
- lead

**Environmental Pathway**
- water column concentrations (finfish)
- sediment pore water concentrations (shrimp)

**Exposure Route**
- commercially harvested shrimp in Gulf of Mexico (drilling fluids and cuttings only)
- offshore rig recreational angling catch in Gulf of Mexico

**Populations**
- carcinogens: all shrimp consumers and offshore Gulf recreational anglers
- lead--from among shrimp and recreational finfish consumers: children (5 year old-cohort), males (40 to 59 years old), pregnant women (infant mortality)

**Non-Monetized Benefits**

**Human Health Risk Reductions Associated With:**

- carcinogens without Agency-established risk slope factors
- systemics other than lead
- lead health risk endpoints other than infant mortality, IQ detriment, or selected hypertension-related illnesses
- lead-related risks to women (all ages) and to men under 40 or over 59 years of age
- exposure from shrimp and finfish uptake of pollutants via sediment or the food chain
- pH-dependent leach rates
- platform-related contaminants in commercial finfish or shellfish other than shrimp

**Ecologic Risk Reductions**

- all pollutants
- all offshore species and ecosystems

**Fishery Benefits**

- commercial fisheries
- recreational fisheries

**Intrinsic Benefits**

- existence value
- bequest value

consumption) to 8 exceedences (6 marine chronic, 1 marine acute, and 1 human health for fish consumption) from the current baseline of 4 to 10 exceedences for sea water and pH 5 extraction, respectively. (These ranges result from the uncertainty over the appropriate leaching factors that are selected).

To assess potential water quality impacts for the benthos, projected pore water concentrations of pollutants in drilling fluids and cuttings discharges were also compared to federal water quality criteria/toxic benchmarks at the edge of a 100-meter mixing zone. Using an impact radius for exploration that is based on sediment barium levels taken from studies of 1 and 2 well scenarios, there are 5 (4 marine chronic and 1 human health for fish consumption) to 13 (7 marine chronic, 3 marine acute, and 3 human health for fish consumption) projected pore water quality exceedences for drilling fluids and cuttings under current baseline conditions, depending on the leachability of the trace metals. For the selected option (3 Mile Gulf/California) the water quality exceedences within 3 miles drop to zero.

Produced water pollutant concentrations in the water column, using a 100-meter mixing zone, were also compared to EPA's water quality criteria/toxic benchmarks. Depending on the effluent discharge rate and the depth of the receiving water, a maximum of 16 exceedences (9 marine chronic, 3 marine acute, and 4 human health for fish consumption) are exhibited at current (BPT) discharge conditions. Under the selected option, only a maximum of 11 exceedences (5 marine chronic, 2 marine acute, and 4 human health for fish consumption) are projected.

A review of the available literature identified 23 field impact studies that were summarized for their findings on the environmental effects of drilling fluids and cuttings discharges. This review indicates that these discharges are capable of producing localized (less than several kilometers) impacts. These discharges have not been shown to result in regional-scale impacts. However, existing studies may not be sufficient to conclude regional-scale impacts are not occurring.

When viewed as a whole, the 7 field studies of the impacts of produced water show that produced water contaminants locally can accumulate in sediments, impact benthic fauna, and have the potential for bioaccummulation. Factors that influence the degree to which these effects have been observed include site-specific parameters such as discharge volume, discharge configuration, effluent contaminant levels, water depth, degree of hydrologic mixing and confounding factors such as proximity to other produced water discharges or drilling and other operational discharges. However, these factors apparently operate in a complex manner, and cannot easily be used to predict the potential extent of contaminant changes.

A review of seven studies indicates that localized benthic impacts occur, and may extend up to several kilometers, although water column impacts to biota have been observed beyond 500 meters in a high energy environment. Such impacts are highly dependent on the specific characteristics of the site.

Other non-quantified, non-monetized benefits assessed in this RIA are recreational fishing, commercial fishing, aesthetic quality of the near-platform waters, and benefits to threatened or endangered species that inhabit the Gulf of Mexico. These potential benefits predictions are highly speculative, but any positive impact of the regulation will be appreciable. A 0.1% increase in recreational value would yield benefits of about $12 to $14 million per year (RCG/Hagler, Bailly, 1991). There are no data that indicate adverse effects on the endangered species found in the Gulf of Mexico (the Kemp's Ridley Turtle and the Brown Pelican), but the proposed regulation will possibly reduce environmental stress on these and other important marine species.

**Overview of Full Social Benefits and Costs**

The RIA provides a discussion of the range of categories that might be evaluated in a full social accounting of the benefits and costs associated with the effluent guidelines. In additional to direct compliance costs, losses to domestic producers (producer surplus loss) may be incurred to the extent the marginal cost curve shifts upward as a result of the guidelines. Other cost categories evaluated (e.g., tax revenues), while reflecting potentially important distributional impacts, do not belong in a true benefit-cost analysis because they represent transfers of costs or benefits generated (and accounted for) elsewhere. Additional impacts evaluated, notably sectoral employment losses and gains, appear to cancel one another out; they furthermore should be viewed as distributional impacts, not true social costs, in a national analysis absent conditions of high unemployment. Finally, while monetized estimates are not available for all benefit categories, a range of potentially significant benefits (discussed above), including recreational and commercial fishing, ecologic and nonuse values, and additional health benefits, exists in addition to the selected health-related benefits quantified in this RIA.

# 1.0 INTRODUCTION

This report has been prepared to comply with Executive Order 12291 which requires the Agency to complete a Regulatory Impact Analysis (RIA) for each major rule it proposes or promulgates. The accompanying regulation, defining best available technology economically achievable (BAT), best conventional pollutant control technology (BCT), and new source performance standards (NSPS) for the offshore subcategory of the oil and gas extraction point source category, meets the Order's definition of a major rule.

The principal requirement of the Executive Order is that the Agency perform an analysis comparing the benefits of the regulation to the costs that the regulation imposes. Wherever possible, the costs and benefits are to be expressed in monetary terms. To address this analytical requirement, this report is organized into six major sections:

- Background
- Need for the Regulation
- Evaluation of Alternatives and Technology Options
- Evaluation of Costs and Economic Impacts
- Evaluation of Benefits and Water Quality Impacts
- Overview of Full Social Benefits and Costs.

Chapter 2 ("Background") discusses the history of the regulation.

Chapter 3 ("Need for the Regulation") briefly explains marketplace failures that water pollution control regulations are intended to correct. Also, the Agency's legal mandate for developing effluent limitation guidelines for the offshore subcategory of the oil and gas extraction industry is summarized. In addition, this section discusses the environmental factors necessitating the development of these regulations.

Chapter 4 ("Evaluation of Alternatives and Technology Options") describes the options considered for the technology-based effluent limitations required for this industry.

Chapter 5 ("Evaluation of Costs and Economic Impacts") presents: (1) the costs of the regulation, (2) the associated financial impacts on the industry in terms of closures, profitability, and cost as a percent of sales, (3) secondary impacts, and (4) the cost-effectiveness of the regulation.

Chapter 6 ("Evaluation of Benefits and Water Quality Impacts") presents the benefits and water quality improvements that the Agency expects to occur from the implementation of this regulation.

Chapter 7 ("Overview of Full Social Benefits and Costs") provides a supplement to the RIA's quantified analysis of compliance costs and selected health-related benefits by describing the range of categories of costs and benefits associated with the regulation, with empirical information provided as appropriate or available.

## 2.0 BACKGROUND

The 1972 Federal Water Pollution Control Act, as amended by the 1977 Clean Water Act Amendments and the Water Quality Act of 1987 (Clean Water Act), requires EPA to develop technology-based effluent limitations guidelines and standards for categories of industries, including the oil and gas extraction category, of which offshore oil and gas activities are a subcategory. These effluent limitations guidelines and standards are defined based upon the following levels of pollution control:

- Best Conventional Pollutant Control Technology (BCT)
- Best Available Technology Economically Achievable (BAT)
- New Source Performance Standards (NSPS).

BCT limitations control discharge of conventional pollutants: BOD, TSS, oil and grease, pH, and fecal coliform. BAT limitations address listed toxic pollutants that are discharged from existing sources of pollution based on the best available, economically achievable control technology developed for that particular industry. NSPS limitations require new sources within a particular industry to meet the most stringent limitations attainable, based on the best demonstrated available technology.

The Natural Resources Defense Council (NRDC) filed suit against EPA on December 29, 1979, seeking an order to compel the Administrator to promulgate final NSPS for the offshore subcategory. In settlement of the suit (NRDC vs. Costle, D. D.C. No. 79-3442 (JHP)), the Agency agreed to take steps to issue such standards. Because of the length of time that had passed since the proposal, EPA believed that additional data should be examined and reproposal was necessary. Consequently, the Agency withdrew the proposed NSPS on August 22, 1980 (45 FR 56115). The proposed BAT regulations were withdrawn on March 19, 1981 (46 FR 17567). On August 26, 1985, EPA reproposed BCT, BAT, and NSPS for the subcategory (50 FR 34595).

The Settlement Agreement was revised in April 1990. Under the modified agreement, EPA was to propose or repropose BAT and BCT effluent limitations guidelines and NSPS for produced water, drilling fluids and drill cuttings, well treatment fluids, and produced sand by November 16, 1990. EPA was to promulgate final guidelines and standards covering these waste streams by June 19, 1992. The court on May 28, 1992, granted an extension of this promulgation deadline to January 15, 1993.

EPA also was to determine by November 16, 1990, whether to propose effluent limitations guidelines and NSPS covering deck drainage and domestic and sanitary wastes and, if it determined to do so, to promulgate final guidelines and standards covering those waste streams by June 30, 1993.

For the offshore subcategory, the current BPT regulations limit the discharge of oil and grease in produced water to a daily maximum of 72 mg/l and a 30-day average of 48 mg/l; prohibits the discharge of free oil in deck drainage, drilling fluids, drill cuttings, and well treatment fluids; requires a minimum residual chlorine content of 1 mg/l in sanitary discharges for facilities continuously manned by 10 or more persons; and prohibits the discharge of floating solids in sanitary wastes.

On August 26, 1985, EPA proposed effluent limitations guidelines for certain waste streams covering BCT, BAT, NSPS (shallow water), and NSPS (deep water). The Agency received comments and collected additional data after the August 26, 1985 proposal. On October 21, 1988, the Agency published a Notice of Data Availability for public review and comment on new technical, economic, and environmental assessment information relating to the regulation of the waste streams. The notice presented variations on the originally proposed BAT and NSPS limitations on the mercury and cadmium content of discharged drilling fluids. The notice presented limitations of 5 mg/kg and 3 mg/kg, respectively, of cadmium and mercury in the stock barite based on the use of existing barite supplies and limitations of 2.5 mg/kg and 1.5 mg/kg, respectively, of cadmium and mercury in the drilling fluid (whole fluid basis). The notice also discussed EPA's initial investigation into the application of an oil content limitation on drilling waste streams.

On January 9, 1989, EPA published Correction to Notice of Data Availability (54 FR 634) concerning the analytical method for the measurement of oil content and diesel oil. The 1988 notice had inadvertently published an incomplete version of that method.

On November 26, 1990, EPA published an initial proposal and reproposal of the rule (55 FR 49094). The Agency presented the major regulatory options for drilling fluids, drill cuttings, produced water, deck drainage, produced sand, well treatment/workover fluids, and domestic and sanitary waste.

On March 13, 1991, EPA published an additional proposal/reproposal (56 FR 10664). A listing of the *Federal Register* notices tracing the history of this rulemaking is presented in Table 2-1.

**Table 2-1**
**Summary of Offshore Oil and Gas Subcategory *Federal Register* Notices**

| Level of Control | Action | Date |
|---|---|---|
| BPT | Interim Final | September 15, 1975 (40 *FR* 42543) |
| BAT/NSPS | Proposal | September 15, 1975 (40 *FR* 42572) |
| BPT/BAT/NSPS | Final (BPT) Reserved (BAT/NSPS) | April 13, 1979 (44 *FR* 22069) |
| NSPS | Withdraw Proposal | August 22, 1980 (45 *FR* 56115) |
| BAT | Withdraw Proposal | March 19, 1981 (46 *FR* 17567) |
| BAT/BCT/NSPS | Proposal | August 26, 1985 (50 *FR* 34592) |
| BAT/BCT/NSPS | Notice of Data Availability (Drillings Fluids & Cuttings) | October 21, 1988 (53 *FR* 34592) |
| BAT/BCT/NSPS | Correction to Notice of Data Availability | January 9, 1989 (54 *FR* 634) |
| BAT/BCT/NSPS | Initial Proposal | November 26, 1990 (55 *FR* 49094) |
| BAT/BCT/NSPS | Reproposal | March 13, 1991 (56 *FR* 10664) |

# 3.0 NEED FOR THE REGULATION

The Executive Order requires that the Agency identify the need for the regulation being promulgated. This section will discuss: (1) the reasons the marketplace does not provide for adequate water pollution control absent appropriate incentives or standards; (2) the environmental factors that indicate the need for additional water pollution controls are necessary for the offshore subcategory of the oil and gas extraction industry; and (3) the legal requirements that dictate the necessity for and timing of this regulation.

## 3.1 MARKET FAILURES

The need for environmental regulations, and effluent guidelines for the offshore oil and gas subcategory of the oil and gas extraction industry, arises from the failure of the marketplace to provide a level of pollution control desired by society. Two important market considerations, the concepts of public goods and externalities, explain this discrepancy between the supply of environmental protection provided by private entities and the level of environmental quality desired by the general public. As a result, under market conditions individuals and firms will not provide sufficient safeguards against important health, recreational, ecological, and aesthetic damages that may result from their discharges.

In making production decisions, private entities will only consider those costs and benefits that accrue to them personally, i.e. internalized costs and benefits. To the extent that the actions of private entities result in environmental externalities, external costs imposed upon society will be overlooked in the production decision. Under these circumstances, the prices incurred and charged for products fail to reflect the full social costs of production.

The failure to account for social costs and benefits is inherent in a market system without government intervention. Under such conditions, firms in competitive product markets that voluntarily devote resources to pollution control in order to avoid the social costs of resource degradation risk a competitive disadvantage relative to their competitors. Thus, the marketplace cannot be expected to generate a socially desirable level of pollution control, and some form of market intervention needs to be considered as a means of improving social welfare.

Additionally, in the absence of government intervention, public goods will not be protected or provided by the free market at the quantity and quality desired by the public. The benefits of a healthy environment exhibit the properties of public goods: they are predominantly non-excludable and non-rival. Because many environmental amenities are non-excludable, individuals utilize but do not assume ownership of these goods and, therefore, will not invest adequate resources in their protection.

## 3.2 ENVIRONMENTAL FACTORS

As a result of the market's failure to promote control of water pollution, the condition of the nation's rivers, streams, coastal areas, and oceans has degraded. Federal, state, and local regulatory programs have since contributed to the cleanup of the most visible problems; however, many waterbodies are still adversely affected by pollutant discharges. Chapter 6 discusses the water quality impacts of the offshore subcategory, oil, and gas extraction discharges.

Total pollutants that would be discharged by drilling fluids and drill cuttings waste streams under current regulations, are estimated at 1.9 billion lbs/year. After the regulations are implemented, discharges of total pollutants would decrease by approximately 223 million lbs/year (SAIC, 1992).

Produced water (BAT) limitations are projected to reduce the total pollutants discharged by approximately 27.6 million lbs/year. Produced water (NSPS) limitations are projected to reduce the total pollutants discharged by approximately 13.3 million lbs/year.

## 3.3 LEGAL REQUIREMENTS

The Agency is promulgating effluent limitations guidelines and standards for the Offshore Oil and Gas Extraction Subcategory under the authority of Sections 301, 304, 306, 307, and 501 of the Clean Water Act (the Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. 1251 et seq., as amended by the Clean Water Act Amendments of 1977, Pub. L. 95-217 and the Water Quality Act of 1987, Pub. L. 100-4, also called the "Act"). These effluent limitations guidelines and standards are also being promulgated in response to the Settlement Agreement described above and in accordance with EPA's Effluent Guidelines Plan under section 304(m) of the Clean Water Act (57 FR 41000; September 8, 1992).

# 4.0 EVALUATION OF ALTERNATIVES AND TECHNOLOGY OPTIONS

This chapter presents alternatives to the regulation and describes the technology options for the effluent limitations for the offshore oil and gas industry. In addition, this chapter provides an overview of the industry and the waste streams to be regulated.

## 4.1 ALTERNATIVES TO THE REGULATION

Potential alternatives to uniform national effluent limits based on available technology include: allowing waivers from national standards for the non-toxic priority pollutants (nonconventionals) based on economic or site-specific water quality considerations; or establishing a single effluent limitation which would apply to a number of discharge pipes on one platform or even on a number of platforms (the "bubble" concept). This RIA, however, is limited to an evaluation of alternatives for technology-based effluent limitations guidelines such as those selected for the offshore subcategory of the oil and gas extraction industry in the March 13, 1991, Federal Register (56 FR 10664). The specific regulatory options considered are outlined in sections 4.4 and 4.5 of this chapter.

## 4.2 INDUSTRY OVERVIEW

### 4.2.1 Background

The offshore subcategory (as defined in 40 CFR 435.10) of the Oil and Gas Extraction Point Source Category covers those structures involved in exploration, development, and production operations seaward of the inner boundary of the territorial seas. The inner boundary of the territorial seas is defined in section 502(8) of the Clean Water Act as:

> . . .the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters.

In some areas the inner boundary of the territorial seas is clearly established and is shown on maps. For example, the Texas General Land Office (Survey Division) has available 7.5 minute quadrangle maps for the entire coastline of Texas which clearly show the inner boundary of the territorial seas. Additionally, the Louisiana State Minerals Board (Civil and Engineering Division) has available maps for the Louisiana coastline showing the inner boundary of the territorial seas. In other areas such as Alaska the baseline is not clearly established.

Ocean discharge criteria applicable to this industrial subcategory were promulgated on October 3, 1980 (45 FR 65942) under section 403(c) of the Act. These criteria are to be used in making site-specific assessments of the impacts of discharges. Section 403 evaluations may lead to limitations imposed through section 402 National Pollutant Discharge Elimination System (NPDES) permits. Section 403 is intended to prevent unreasonable degradation of the marine environment and to authorize imposition of effluent limitations, including a prohibition of discharge, if necessary, to ensure this goal. In 403(c) determinations where it is questionable whether the discharge is beyond the baseline or not, the appropriate state agency is consulted to make site-specific determinations. In relation to the implementation of the BPT effluent limitations guidelines, no problems have been associated with the definition of the inner boundary of the territorial seas.

Exploration and development activities for the extraction of oil and gas include work necessary to locate, drill, and complete wells. Exploration activities involve the drilling of wells to determine the potential hydrocarbon reserves. They are usually of short duration at a given site, involve a small number of wells, and generally are conducted from mobile drilling units. The major waste streams from exploration activities are drilling fluids and drill cuttings.

Development activities involve the drilling and completion of production wells once a commercial hydrocarbon reserve has been identified. These operations, in contrast to exploration activities, usually involve a large number of wells and are typically conducted from a fixed platform. The major waste streams are drilling fluids and drill cuttings. Other associated waste streams include fracturing and well stimulation fluids, well treatment, and well completion fluids.

Production operations include all post-completion work necessary to bring hydrocarbon reserves from the producing formation. They begin as each well is completed during the development phase. The major waste stream associated with production activities is produced water; however, produced sand is a minor associated waste stream. Both of these waste streams originate with the gas or oil product stream and are separated from the oil product in the initial processing of the production stream.

### 4.2.2 Existing Facilities

An estimated 2,549 structures produce or develop oil and/or gas in the offshore waters of the United States. This estimation is based upon information from the Tobin Database, and includes all tracts leased offshore in the Gulf of Mexico, California, and Alaska. There are no development or production platforms in the Atlantic Ocean.

Table 4-1 presents the number of existing producing structures according to distance from shore. Approximately 8% of the total are located within the 3-mile distance, and 17% of the total are located within the 4-mile distance.

**Table 4-1**
**Existing Producing Platforms**
**According to Distance from Shore**

| Region | Within 3 Miles | 3-4 Miles | Beyond 4 Miles | Total |
|---|---|---|---|---|
| Gulf of Mexico | 201 | 209 | 2,107 | 2,517 |
| California | 10 | 4 | 18 | 32 |
| Atlantic | 0 | 0 | 0 | 0 |
| Alaska | 0 | 0 | 0 | 0 |
| Total | 211 | 213 | 2,125 | 2,549 |

Source: ERG, 1992a

### 4.2.3 New Sources

The 1985 proposed guidelines include a definition for the term "new source." As discussed in that proposal, provisions in the National Pollutant Discharge Elimination System (NPDES) regulations define new source (40 CFR 122.2) and establish criteria for a new source determination (40 CFR 122.29(b)). In 1985, EPA proposed special definitions which are consistent with 40 CFR 122.29 and which provide that 40 CFR 122.2 and 122.29(b) shall apply "except as otherwise provided in an applicable new source performance standard.

Section 306(a)(2) of the Clean Water Act defines a new source to mean "any source, the construction of which is commenced" after publication of the proposed NSPS. Drilling rigs are moved from site to site for several years while production platforms are built onshore and transported to an offshore site. A drilling rig or production platform is determined as a new source, not by the date of the building of such structures, but by the date the rig or platform is placed at the offshore site where the drilling and production activity and discharge would occur. The Act defines "construction" to mean "any placement, assembly, or installation of facilities or equipment...at the premises where such equipment will be used."

While the provisions in the NPDES regulations that define new source (40 CFR 122.29(b)) were applicable to the offshore subcategory, two terms were defined in the proposed subcategory-specific new source definition -- "water area" and "significant site preparation work" -- because of certain unique aspects of the activities in this subcategory. In the 1985 proposed guidelines, "water area" was defined to mean the specific geographical location where the exploration, development, or production activity is conducted, including the water area and the ocean floor beneath such activities. Therefore, if a new platform is built at or moved from a different location, it would be considered a new source if placed at the new site where its oil and gas activities take place even if the platform is placed next to an existing platform.

The second special term proposed in 1985, "significant site preparation work" was defined as "the process of surveying, clearing, and preparing an area of the ocean floor for the purpose of constructing or placing a development or production facility on or over the site." Exploration activities were not considered to be "significant site preparation work" because such activities are not necessarily followed by development or production activities at that site.

In the final rule, EPA is following the approach explained in the 1985 proposal, but in addition, EPA is excluding from the definition of "new source" those facilities that as of the effective date of the Offshore Guidelines are subject to an existing general permit pending EPA's issuance of new source NPDES general permits. EPA will apply NSPS to appropriate (those where there is significant site preparation work for development or production) facilities within the Offshore Subcategory.

In terms of development operations, offshore drilling varies from year to year, depending on such factors as the hydrocarbon economic market conditions, state and federal leasing programs and reservoir discoveries. In 1981, almost 1,500 wells were drilled offshore, culminating the upward trend of the 1970s. The average number of wells drilled during the 1972-1982 time period was 1,100 wells/year. Drilling activity has declined since 1982, and in a 1988 notice, the Agency estimated that between 1986 and the year 2000, an average of 759 wells/year would be drilled (based on an average oil price for the years 1986-2000 to be $21/barrel). Of these 759 wells/year, 456 wells/year would become producing wells drilled on new and existing structures, and the remaining 303 wells/year would be dry holes. The projected distribution of wells drilled, by region and distance from shore, is shown in Table 4-2.

Between the years 1993 and 2007, an estimated 759 new platforms installed offshore will be producing oil or gas. Table 4-3 shows the distribution of new producing and discharging structures according to region and distance from shore.

**Table 4-2**
**Estimate of Average Annual Number of Wells Drilled, BAT and NSPS**
**According to Distance from Shore**
**1993-2007**
**$21/bbl Scenario**

| Region | Within 3 Miles | 3-4 Miles | 4-8 Miles | Beyond 8 Miles | Total |
|---|---|---|---|---|---|
| Gulf of Mexico | 60 | 12 | 64 | 579 | 715 |
| California | 0 | 0 | 29 | 3 | 32 |
| Alaska | * | * | * | * | 12 |
| Total | 60 | 12 | 93 | 582 | 759 |

* Not presented because Alaska is exempt from zero discharge requirements for drilling fluids and drill cuttings.

Source: ERG, 1992a

**Table 4-3**
**Total Projected NSPS Structures**
**According to Distance from Shore**
**1993-2007**

| Region | Within 3 Miles | 3-4 Miles | Beyond 4 Miles | Total |
|---|---|---|---|---|
| Gulf of Mexico | 102 | 38 | 615 | 755 |
| California | 0 | 0 | 0 | 0 |
| Alaska | 2 | 0 | 2 | 4 |
| Total | 104 | 38 | 617 | 759 |

Source: ERG, 1992a

## 4.3 DISCHARGE CHARACTERIZATION OF MAJOR WASTE STREAMS CONSIDERED IN THE RIA

This regulatory effort focuses on the major waste streams from exploration, development, and production operations based on their volumes and potential toxicity. This RIA for the final promulgation of the rule evaluated the costs and benefits of controlling three major waste streams: drilling fluids, drill cuttings, and produced water. The volumes and potential toxicity of the other miscellaneous wastes are generally less than these discharges, and therefore were not considered in this RIA.

### 4.3.1 Drilling Fluids

Drilling fluids, or muds, are suspensions of solids and dissolved materials in a base of water or oil that are used primarily in rotary drilling operations to carry cuttings from the hole to the surface, and maintain hydrostatic pressure downhole. Drilling fluids can be water-based or oil-based. Oil-based drilling fluids are those in which oil serves as the continuous phase with water as the dispersed phase. Such fluids contain blown asphalt and usually one to five percent water emulsified into the system with caustic soda or quicklime and an organic acid. Silicate, salt, and phosphate may also be present. Oil-based drilling fluids have been more costly and more toxic than water-based drilling fluids, and are used for particularly demanding drilling conditions (deep or highly deviated wells), including offshore wells.

In water-based drilling fluids, water is the suspending medium for solids and is the continuous phase, whether or not oil is present. Water-based drilling fluids are used for more routine drilling conditions offshore and are composed of anywhere from 30 percent to 90 percent water by weight, with a variety of mud additives constituting the remainder.

Drilling fluids are specifically formulated to meet the physical and chemical requirements of a particular well. Mud composition is affected by geographic location, well depth, rock type, and is altered as well depth, geologic formations, and other conditions change. The number and nature of mud components varies by well, and several products may be used at any given time to control the properties of a mud system. The eight basic functions of a drilling fluid are as follows:

1. Transport drill cuttings to the surface
2. Suspend drill cuttings in the annulus when circulation is stopped
3. Control subsurface pressure
4. Cool and lubricate the bit and drill string
5. Support the walls of the wellbore
6. Help suspend the weight of the drill string and casing

7. Deliver hydraulic energy upon the formation beneath the bit
8. Provide a suitable medium for running wireline logs.

Four basic components account for approximately 90 percent by weight of all materials contained in drilling fluids: barite, clays, lignosulfonate, and lignites. Other components include lime, caustic soda, soda ash, and a multitude of specialty additives. These additives are used to modify the characteristics of drilling fluids as dictated by well requirements to control site-specific drilling conditions.

### 4.3.2 Drill Cuttings

Drilling fluids circulate in the bore hole and move up the annular space between the drill string and the borehole to the surface, carrying drill cuttings with them. Cuttings are removed from the drilling fluids in a step-wise process which removes particles of decreasing size.

Upon reaching the surface, fluids and cuttings pass to the shale shaker, which is a vibrating screen that removes large particles from the fluid. Standard shaker screens generally remove particles larger than 440 $\mu$m; particles down to approximately 150 $\mu$m are removed by fine screen shakers. A desilter, a hydrocyclone using centrifugal forces, can then be used to remove silt-size particles (larger than 15 to 25 $\mu$m). After removal, the cuttings are usually discharged from the rig near the water surface or shunted below the surface of the sea. Processed drilling fluids return to the mud tanks for recirculation to the well.

Solids removal system discharges consist of: drill cuttings, wash solution, and drilling mud that still adheres to the cuttings. At one well drilled on the Southern California outer continental shelf, normal cuttings discharged from solids control equipment comprised 0-96 percent cutting solids and only 4 percent adhered drilling fluids. However, data from one well drilled on the mid-Atlantic outer continental shelf and one well drilled in Alaskan waters suggested cuttings discharges were approximately 40 percent drill cuttings and 60 percent drilling fluids.

### 4.3.3 Produced Water

Produced water (also known as production water or produced brine) is process water discharged during oil and gas extraction. It is composed of the formation water, which has been brought to the surface with the oil and gas, injection water (if used for secondary oil recovery and has broken through into the oil formation), and various chemicals added during the oil/water separation process. Produced water contains dissolved, emulsified, and particulate crude oil constituents, natural and added salts, organic chemicals, solids, and trace metals. Produced water constitutes the major waste stream from offshore oil and gas production activities.

## 4.4 DRILLING FLUIDS AND DRILL CUTTINGS TREATMENT OPTIONS

Most offshore oil and gas facilities are operating under Best Professional Judgement (BPJ) permits that are more stringent than BPT effluent guidelines. The BMJ permit issued in 1986 for the Gulf of Mexico OCS is used as the baseline for determining the costs and benefits for this RIA because this level of control most accurately represents the technology-based pollutant control being used by most facilities.[1] This BPJ Baseline "option" is included only for analytical purposes (i.e., to enable the incremental costs and benefits of the other options to be derived). Offshore subcategory operations off of Alaska are also covered by NPDES permits having BPJ determinations of BAT and BCT that are more stringent than BPT. Currently, however, operations in the territorial seas of Texas and Louisiana are operating under an administratively extended BPT general permit unless state BPJ permits have been issued, and facilities located in federal waters offshore of California also are operating under an administratively extended BPT permit unless an individual permit has been issued by EPA.

Four options are considered in this RIA for drilling fluids (three options only in the benefits analysis); these are presented in Table 4-4. Option 1, 3 Mile Gulf/California, is the Agency's selected option. The following requirements are included in some combination in the various options considered:

- No discharge of diesel oil
- No discharge of "free oil" as measured by the static sheen test
- Toxicity limitation as measured by a 96-hour LC50 test
- Limitations on cadmium and mercury in stock barite
- Zero discharge of fluids and cuttings based on distance from shore. The zero discharge requirement is presumed to be met by barging the drilling fluids and drill cuttings to shore for disposal.

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[1] Subsequent to development of this RIA, EPA Region 6 has reissued a new BPJ general permit covering the western and central Gulf of Mexico (57 FR 54642, November 19, 1992). Some of the permit conditions used for this RIA have been revised by the new permit. However, in order to ensure timely promulgation of the final effluent guidelines, those changes were not incorporated into this analysis.

**Table 4-4**
**Drilling Fluids and Drill Cuttings**
**Regulatory Options Considered**

| Option | Short Form of Title | Description |
|---|---|---|
| Option 1 | 3 Mile Gulf/California | Drilling wastes from wells located within three miles of shore must meet zero discharge requirements. The disposal of drilling wastes from wells located beyond three miles of shore must meet limitations on toxicity, no discharge of diesel oil, no discharge of free oil as determined by the static sheen test, and limitations on mercury and cadmium content in the stock barite. Alaska is exempt from the zero discharge requirement, but must meet all the requirements for wells drilled beyond three miles of shore. |
| Option 2[a] | 4 Mile Gulf/California | The requirements are the same as in the 3 Mile Gulf/California option, except that the boundary determining the zero discharge requirement is set at four miles from shore. |
| Option 3 | 8 Mile Gulf/3 Mile California | California and Alaska must meet the same requirements as in the 3 Mile Gulf/California option. For the Gulf of Mexico and other regions, drilling wastes from wells within eight miles of shore must meet zero discharge requirements, while wastes from wells beyond eight miles of shore must meet limits on toxicity, no discharge of free oil, no discharge of diesel, and metals limitation on the barite. |
| Option 4 | Zero Discharge Gulf/California | Alaska must meet the same requirements as in the 3 Mile Gulf/California option. All other regions must meet zero discharge requirements for all drilling wastes regardless of the distance from shore. |

[a] The 4 Mile Gulf/California option, while not considered in the final benefits analysis, is comparable to the preferred option in the March 1991 proposal.

## 4.5 PRODUCED WATER TREATMENT OPTIONS

Four options are considered in the final RIA for BAT- and NSPS-produced water, and a fifth, Filter 4 Miles, was considered in the Economic Impact Analysis and Cost-Effectiveness Analysis but was not found to be cost-effective. All of these options include the use of improved gas flotation technology for treatment of produced water. The options are presented in Table 4-5.

The Agency has selected the Flotation All option (Option 2) for both BAT and NSPS. This option requires all production structures to treat produced water discharges using gas flotation technology to achieve approximately 29 mg/l oil and grease and 42 mg/l oil and grease, respectively, for monthly average and daily maximum. EPA has determined this option to be economically achievable and technically feasible.

**Table 4-5**
**Produced Water BAT and NSPS**
**Regulatory Options Considered**

| Option | Short Form of Title | Description |
|---|---|---|
| Option 1[a] | BPT All | Best Practicable Technology required for all structures. This option is the same as current practices, and therefore involves no incremental costs or removals. |
| Option 2 | Flotation All | All discharges of produced water, regardless of water depth or distance from shore, would be required to meet limitations on oil and grease content at 29 mg/l monthly average and a daily maximum of 42 mg/l. The technology basis for these limits is improved operating performance of gas flotation. |
| Option 3 | Zero 3 Miles Gulf and Alaska | No discharge of produced water within 3 nautical miles from shore. Facilities located more than 3 miles from shore would be required to meet oil and grease limitations of 30 mg/l monthly average and 40 mg/l daily maximum. All wells off California and existing singe-well dischargers in the Gulf of Mexico would be excluded from the zero discharge requirement but would be required to comply with oil and grease limitations. |
| Option 4 | Zero Discharge Gulf and Alaska | No discharge of produced water based on reinjection of the produced water. All facilities off California and all currently existing single-well dischargers in the Gulf of Mexico would be excluded from zero discharge limitation but would be required to comply with oil and grease limitations. |
| Option 5[a] | Filter 4 Miles | Granular filtration required for discharges of produced water within 4 miles of shore. BPT required for all structures beyond 4 miles. |

[a] While these two options were considered in the Economic Impact Analysis, they were not considered in the benefits analysis for the following reasons: Option 1 involves no incremental benefits, and Option 5 was found to be less cost-effective than the Flotation All option, so was removed from the analysis.

# 5.0 COSTS AND ECONOMIC IMPACTS

This section presents the estimated costs for each of the regulatory options considered for the offshore subcategory of the oil and gas extraction industry, as estimated in the Economic Impact Analysis of Final Effluent Limitations Guidelines and Standards of Performance for the Offshore Oil and Gas Industry (ERG, 1993a). These costs are evaluated in terms of their associated economic impacts on the subcategory. The cost-effectiveness of these options for pollutant removal is also evaluated based on the Cost-Effectiveness Analysis of Effluent Limitations Guidelines and Standards of Performance for the Offshore Oil and Gas Industry (ERG, 1993b).

To analyze the cost and economic impacts of the effluent guidelines regulations, 34 model projects were defined. These projects account for a diversity of platform size (i.e., number of wellslots), location, and production type encountered in offshore areas. Costs for these model projects were applied to projections of future offshore oil and gas activity in the regions considered.

The analysis evaluates one projection of future offshore oil and gas activity. The projection covers a 15-year time period and assumes an average $21/bbl oil price and restricted or constrained development activities in the Atlantic and the Pacific. This scenario is considered the most reasonable given recent oil prices and moratoria. All incremental costs of increased pollution control are calculated using current permit requirements as the baseline.

## 5.1 AGGREGATE COSTS[1]

### 5.1.1 Drilling Fluids and Drill Cuttings

The annual average cost associated with each option is a function of the average number of wells drilled per year, percentage of wells that incur the zero discharge requirement, volume of waste generated per well, toxicity failure rates, and other assumptions.

The total and per-well costs for each region are summarized in Table 5-1. In general, wells within a specified distance of shore must meet a zero discharge requirement for drilling fluids and cuttings. Wells beyond that distance must meet (in addition to BPT requirements): metals limitation of 1 mg/kg mercury and 3 mg/kg cadmium in the stock

[1] Regulatory costs were developed by the Engineering and Analysis Division, U.S. Environmental Protection Agency, and are presented in ERG (1992a).

**Table 5-1**
**Drilling Fluids and Drill Cuttings Summary of Costs**
**Thousands of Dollars ($1986)**

| Option # | Option Name | Region | Average Annual # of Wells | Costs | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Drilling Fluids | Drill Cuttings | Emission Offsets | Total Costs | Per-Well Costs |
| Option 1 | 3 Mile Gulf/California | Gulf | 715 | $12,322 | $6,463 | $0 | $18,785 | $26 |
| | | Pacific | 32 | $0 | $80 | $16 | $96 | $3 |
| | | Alaska | 12 | $0 | $73 | $0 | $73 | $6 |
| | | Total | 759 | $12,322 | $6,616 | $16 | $18,954 | |
| Option 2 | 8 Mile Gulf/3 Mile California | Gulf | 715 | $22,822 | $10,300 | $0 | $33,122 | $46 |
| | | Pacific | 32 | $0 | $80 | $16 | $96 | $3 |
| | | Alaska | 12 | $0 | $73 | $0 | $73 | $6 |
| | | Total | 759 | $22,822 | $10,453 | $16 | $33,291 | |
| Option 3 | Zero Discharge Gulf/California | Gulf | 715 | $102,815 | $39,537 | $0 | $142,352 | $199 |
| | | Pacific | 32 | $4,235 | $1,500 | $261 | $5,996 | $187 |
| | | Alaska | 12 | $0 | $73 | $0 | $73 | $6 |
| | | Total | 759 | $107,050 | $41,110 | $261 | $148,421 | |
| Option 4 | 4 Mile Gulf/California (1991 Preferred Option) | Gulf | 715 | $13,980 | $7,068 | $0 | $21,048 | $29 |
| | | Pacific | 32 | $0 | $80 | $16 | $96 | $3 |
| | | Alaska | 12 | $0 | $73 | $0 | $73 | $6 |
| | | Total | 759 | $13,980 | $7,221 | $16 | $21,217 | |

Note: Alaska is exempt from zero discharge requirements under all options, but must meet requirements for disposal of drilling fluids and drill cuttings that apply beyond the 3 Mile Zero Discharge Zone.

Source: Engineering & Analysis Division, EPA, as presented in ERG, 1993a barite, a toxicity limitation (LC50 of 30,000 ppm suspended particulate phase), and no discharge of "free oil" as determined by a static sheen test.

The costs reflect the varying percentages of the wells that must meet the zero discharge requirement, i.e., they are weighted average costs of the option-specific boundary for "within" (zero discharge) and "beyond" (clean barite, toxicity test, and sheen test) requirements. The costs do not change for Alaska because of the exemption from the zero discharge requirement. Costs for the Pacific include the costs for emissions offsets, which will be incurred because California is a non-attainment area under Clean Air Act requirements. Drilling wastes that fail toxicity or sheen tests or must meet zero discharge requirements must be barged to shore. Offsets must be paid to address the emissions from barging. If a project is located within the zero discharge area, all drilling wastes from all wells for that project must be barged.

Option 1, 3 Mile Gulf/California, is the selected option. Total annual costs for this option approximate $19 million.[2] The costs are approximately $26,000 per well in the Gulf of Mexico and $3,000 per well in the Pacific for this option,

### 5.1.2 Produced Water BAT (Existing Sources)

Only existing projects in production in the Gulf of Mexico and the Pacific are expected to bear incremental costs of additional pollution control under BAT. The cost for a given technology to reduce pollution will depend on whether treatment and disposal of produced water takes place at the platform or at a centralized onshore facility. Roughly 37 percent of produced water in the Gulf of Mexico is transported to shore for treatment and disposal (DOI, 1991), as it is often less expensive to treat production wastes at a centralized location. This analysis assumes that the 37 percent of BAT structures that are currently piping their produced water to shore will continue to do so. Because no estimates of the percentage of platforms that use onshore treatment or the volume of produced water that is treated onshore were available, disposal costs for the Pacific are calculated assuming that 100 percent of the structures dispose of their water at the platform. Should it be more cost-effective to treat the water on land but to dispose of it at the platform, the costs as calculated will be conservatively high.

The model-specific capital and O&M costs were entered into the BAT economic models to calculate the annualized cost of the regulation. The annualized costs were calculated

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[2] Cost estimates, as developed by ERG (1993a), are in 1986 dollars. Because barge rates have remained constant since that time, 1991 dollar equivalents for costs related to drilling fluids and cuttings have not changed significantly and are therefore unchanged from the 1986 estimates (ERG, Memorandum of October 21, 1992 from Maureen Kaplan to Mahesh Podar).

over the remaining lifetime of the project and account for projects shutting down early because of an increase in the annual O&M costs.

The total costs of the regulatory options are obtained by multiplying the number of each model project by the per-project cost of each disposal option. Table 5-2 shows the total capital, O&M, and annualized Year 1 and Year 15 costs for each of the regulatory options under consideration (including the 1991 preferred option, Filter 4 Miles) (Kaplan, 1992b). The peak (Year 1) annual costs for the selected option, Flotation All, are $96.3 million ($108.4 million in 1991 dollars) while by Year 15, costs are 0.[3] Because all existing structures will be affected in Year 1, the highest cost for BAT pollution control options will be in the first year of the regulation. As existing projects come to the end of their economic lives, the number of structures incurring BAT costs will decline.

### 5.1.3 Produced Water NSPS (New Sources)

As with the BAT analysis, the per-project capital and O&M costs for each technology were input into the NSPS economic models to derive the annualized costs. It was assumed that 80 percent of new structures would have been constructed with a gas flotation system regardless of this rulemaking. For these projects, it was assumed that the incremental capital costs would be incurred to upgrade the flotation system. Table 5-3 presents the total capital costs, total annual O&M, Year 1 cost, and Year 15 cost for new projects for the five NSPS regulatory options (including the 1991 preferred option, Filter 4 Miles) (Kaplan, 1992b). The Year 1 annualized cost for the selected option, Flotation All, is $0.8 million ($0.9 million in 1991 dollars), and the Year 15 annualized cost of this option is $12 million ($13.6 million in 1991 dollars). This Year 15 cost represents the cumulative costs associated with all new structures assumed to enter the industry at a constant rate over this period.

### 5.1.4 Combined Regulatory Options

Combined costs were calculated for two packages of selected regulatory options. Package A includes the selected options for drilling fluids and cuttings (3 Mile Gulf/California) and produced waters (Flotation All). Package B contains the selected option for drilling fluids and cuttings, the Zero 3 Miles Gulf option for BAT produced water, and the Zero 3 Miles Gulf and Alaska option for NSPS produced water. Both

[3] Cost estimates and economic impacts, as developed by ERG (1993a), are in 1986 dollars. Using the ENR construction cost index, 1991 dollar equivalents have been calculated for costs related to produced waters and are presented in this report.

**Table 5-2**
**Total Costs of BAT Produced Water Options**
**Thousands of Dollars ($1986)**

| Option No. | Option Title | Region | Total O&M Cost** | Total Capital Cost | Year 1 (Peak) Annualized Cost* | Year 15 Annualized Cost |
|---|---|---|---|---|---|---|
| 1 | BPT All | Gulf | $0 | $0 | $0 | $0 |
| | | Pacific | $0 | $0 | $0 | $0 |
| | | Total | $0 | $0 | $0 | $0 |
| 2 | Flotation All (includes RA Monitoring) | Gulf | $44,874 | $361,188 | $90,800 | $0 |
| | | Pacific | $1,724 | $21,300 | $5,490 | $0 |
| | | Total | $46,598 | $382,488 | $96,290 | $0 |
| 3 | Zero 3 Miles Gulf (Gulf 1B = Flotation) | Gulf | $52,424 | $444,170 | $110,002 | $0 |
| | | Pacific | $1,724 | $21,300 | $5,472 | $0 |
| | | Total | $54,147 | $465,470 | $115,474 | $0 |
| 4 | Zero Discharge Gulf (Gulf 1B = Flotation) | Gulf | $290,807 | $2,677,330 | $648,745 | $0 |
| | | Pacific | $1,724 | $21,300 | $5,472 | $0 |
| | | Total | $292,531 | $2,698,630 | $654,217 | $0 |
| 5 | Filter 4 Miles (1991 Preferred Option) | Gulf | $11,851 | $88,996 | $23,874 | $0 |
| | | Pacific | $2,399 | $69,110 | $14,761 | $0 |
| | | Total | $14,250 | $158,106 | $38,635 | $0 |

Note: Option 2: Analysis includes radium monitoring costs for all projects.
Option 3: All Gulf 1B projects, all Gulf projects beyond 3 miles of shore, and all Pacific projects must meet only the flotation limits of Option 2.
Option 4: All Pacific projects must comply with only the flotation limits of Option 2.

* Analysis includes radium monitoring costs.
** Analysis excludes radium monitoring costs; they are incurred only in the first two years of regulation.

Source: ERG, 1993a

**Table 5-3**
**Total Costs of NSPS Produced Water Options**
**Thousands of Dollars ($1986)**

| Package | Option | Region | Total O&M Cost | Total Capital Cost | Year 1 Annualized Cost | Year 15 Annualized Cost |
|---|---|---|---|---|---|---|
| 1 | BPT All | Gulf | $0 | $0 | $0 | $0 |
| | | Pacific | $0 | $0 | $0 | $0 |
| | | Alaska | $0 | $0 | $0 | $0 |
| | | Total | $0 | $0 | $0 | $0 |
| 2 | Flotation All | Gulf | $5,025 | $82,770 | $792 | $11,882 |
| | | Pacific | $0 | $0 | $0 | $0 |
| | | Alaska | $41 | $2,166 | $14 | $203 |
| | | Total | $5,066 | $84,936 | $806 | $12,085 |
| 3 | Zero 3 Miles Gulf and Alaska (Pacific = Flotation) | Gulf | $22,637 | $336,829 | $3,417 | $51,262 |
| | | Pacific | $0 | $0 | $0 | $0 |
| | | Alaska | $3,795 | $98,603 | $709 | $10,631 |
| | | Total | $26,431 | $435,431 | $4,126 | $61,893 |
| 4 | Zero Discharge Gulf and Alaska (Gulf = Flotation) | Gulf | $151,354 | $2,225,021 | $22,235 | $333,525 |
| | | Pacific | $0 | $0 | $0 | $0 |
| | | Alaska | $4,956 | $121,287 | $897 | $13,450 |
| | | Total | $156,309 | $2,346,308 | $23,132 | $346,974 |
| 5 | Filter 4 Miles (1991 Preferred Option) | Gulf | $8,503 | $78,002 | $986 | $14,791 |
| | | Pacific | $0 | $0 | $0 | $0 |
| | | Alaska | $621 | $12,229 | $95 | $1,429 |
| | | Total | $9,123 | $90,232 | $1,081 | $16,219 |

Note: Option 3: All Gulf and Alaska projects beyond 3 miles of shore, and all Pacific projects must meet only the flotation limits of Option 2.
Option 4: All Pacific projects must comply with only the flotation limits of Option 2.

Source: ERG, 1993a

packages include costs for regulation of workover fluids and produced sand not presented in this RIA. First-year costs for Package A are $126 million ($134 million in 1991 dollars) and $144 million ($160 million in 1991 dollars) for Package B. (Workover fluids and produced sand comprise 4.5 percent and 3.8 percent of the package costs, respectively.) Fifteen-year costs, the point at which all BAT projects will have reached the end of their economic lifetimes and NSPS costs are at their peak, are estimated at $36 million for Package A ($38 million in 1991 dollars) and $86 million for Package B ($94 million in 1991 dollars). More old projects are anticipated to cease production than new projects will begin production over the 15-year period.

## 5.2 COST-EFFECTIVENESS

Cost-effectiveness is defined as the incremental annualized cost of a pollution control option in an industry "or industry subcategory" per incremental "pound equivalent" of pollutant removed annually by that control option. Because different pollutants have different potential effects on human and aquatic life, cost-effectiveness analyses account for differences in toxicity among the pollutants with toxic weighting factors. Thus, the amount of pollutant removed by a control option is weighted by its relative toxicity. Toxic weighting factors for pollutants are derived using ambient water quality criteria and toxicity values. In this study of an industry that discharges into the ocean, chronic saltwater aquatic criteria were used wherever available. These toxic weighting factors were then standardized by relating them to a particular pollutant, copper. The final weights are used to calculate the "pound equivalent" unit, a standard measure of toxicity used by EPA in evaluating point source controls. Cost-effectiveness is calculated as the ratio of incremental annual cost of an option to the incremental pound equivalents removed by that option.

Cost-effectiveness analysis was conducted for four options considered for drilling fluids and drill cuttings, five options considered for BAT produced water (including current practices--BPT All), and four options considered for NSPS produced water (including current practices--BPT All). For each option considered, the pound equivalents of pollutants removed were obtained by multiplying the pounds of each pollutant removed annually by that pollutant's toxic weighting factor and summing the pound equivalents for each approach. Regional totals were then summed to obtain the national totals. Removals represent the incremental quantities of pollutants that would be removed.

Table 5-4 shows the cost-effectiveness analysis for drilling fluids and drill cuttings. The costs and removals are based on the $21/bbl oil price and a restricted development scenario. Cost-effectiveness for the 3 Mile Gulf/California option is $44 per pound equivalent removed. The incremental cost-effectiveness for the other options is approximately $72-73 per pound equivalent.

**Table 5-4**
**Cost-Effectiveness for Offshore Oil and Gas Drilling Fluids and Drill Cuttings**

| | Total Annual | | | Incremental | | |
|---|---|---|---|---|---|---|
| Option | PE Removed | Cost (1986 $) ($000) | Cost (1981 $) ($000) | PE Removed | Cost (1981 $) ($000) | Incremental Cost-Effectiveness $/PE (1981 $) |
| Current | 0 | $0 | $0 | -- | -- | -- |
| 3 Mile Gulf/California | 357,955 | $18,954 | $15,664 | 357,955 | $15,664 | $43.76 |
| 4 Mile Gulf/California | 383,702 | $21,217 | $17,535 | 25,747 | $1,870 | $72.64 |
| 8 Mile Gulf/3 Mile California | 521,490 | $33,291 | $27,513 | 137,789 | $9,979 | $72.42 |
| Zero Discharge Gulf/California | 1,822,906 | $148,421 | $122,662 | 1,301,415 | $95,149 | $73.11 |

Note: Factor for converting 1986 dollars to 1981 dollars is 1.21.
The cost-effectiveness is standardized in 1981 dollars to facilitate comparison among numerous regulated industries.
Projects in Alaska are exempt from the barging requirement, but must comply with the other limitations.

Source: ERG, 1993b

Table 5-5 shows the cost-effectiveness analysis for BAT produced water.[4] As the BPT All option is the same as current practices, no incremental costs or removals are associated with this option. Incremental cost-effectiveness for the selected option, Flotation All, is $33 per pound equivalent. Incremental cost-effectiveness ranges from $244 to $653 per pound equivalent for the other options.

Table 5-6 shows the cost-effectiveness analysis for NSPS produced water.[5] As with BAT produced water, the BPT All option under NSPS has no incremental costs or removals associated with it. The cost-effectiveness of the remaining options ranges from $16 per pound equivalent for the Flotation All selected option to $295 per pound equivalent for the Zero Discharge Gulf and Alaska option.

Table 5-7 summarizes the range in cost-effectiveness for the offshore oil and gas industry effluent controls compared to the cost-effectiveness of BAT regulations for other industries. Table 5-8 summarizes the same information for NSPS regulations. All costs are shown in 1981 dollars in order to facilitate comparisons with cost-effectiveness ratios for removals in other industries.

## 5.3 ECONOMIC IMPACTS AND ECONOMIC ACHIEVABILITY

### 5.3.1 Economic Impacts on the Oil and Gas Industry

Economic impacts of the options considered are examined in detail in the report Economic Impact Analysis of Effluent Limitations Guidelines and Standards of Performance for the Offshore Oil and Gas Industry (ERG, 1993a). Offshore development is financed by a small number of very large major and independent oil companies. Data on publicly held companies were used to define balance sheets for representative major and independent oil companies. These balance sheets were then used to judge the impact of pollution control requirements of these proposed effluent guidelines and standards. Two methods for financing the regulatory costs were considered: working capital (as measured by working capital and the current ratio) and long-term debt (as measured by the long-term debt to equity ratio and the debt to capital ratio).

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[4] The Filter 4 Miles option is included in this analysis, although it was not one of the final regulatory options considered because it is not cost-effective.

[5] The Filter 4 Miles option does not appear because it has lower removals and higher costs than the Flotation All option. The Filter 4 Miles option is therefore considered dominated by the Flotation All option, and is removed from the analysis.

Table 5-5
Cost-Effectiveness for Offshore Oil and Gas Bat Produced Water

| | Total Annual | | | Incremental | | |
|---|---|---|---|---|---|---|
| Option | PE Removed | Cost (1986 $) ($000) | Cost (1981 $) ($000) | PE Removed | Cost (1981 $) ($000) | Incremental Cost-Effectiveness $/PE (1981 $) |
| Current (BPT All) | 0 | 0 | $0 | -- | -- | -- |
| Filter 4 Miles | 48,887 | $38,635 | $31,930 | 48,887 | $31,930 | $653.13 |
| Flotation All | 1,480,176 | $96,290 | $79,578 | 1,431,289 | $47,649 | $33.29 |
| Zero 3 Miles Gulf (Gulf 1b = Flotation) | 1,507,861 | $115,474 | $95,433 | 27,685 | $15,855 | $572.67 |
| Zero Discharge Gulf (Gulf 1b = Flotation) | 3,334,240 | $654,217 | $540,675 | 1,826,379 | $445,242 | $243.78 |

Note: Factor for converting 1986 dollars to 1981 dollars is 1.21.
The Flotation All option includes the cost of monitoring for radium.

Source: ERG, 1993b

**Table 5-6**
**Cost-Effectiveness for Offshore Oil and Gas NSPS Produced Water**

| | Total Annual | | | Incremental | | |
|---|---|---|---|---|---|---|
| Option | PE Removed | Cost (1986 $) ($000) | Cost (1981 $) ($000) | PE Removed | Cost (1981 $) ($000) | Incremental Cost-Effectiveness $/PE (1981 $) |
| Current (BPT All) | 0 | 0 | $0 | -- | -- | -- |
| Flotation All | 601,169 | $12,085 | $9,987 | 601,169 | $9,987 | $16.11 |
| Zero 3 Miles Gulf and Alaska | 823,960 | $62,200 | $51,405 | 146,320 | $41,163 | $281.32 |
| Zero Discharge Gulf and Alaska | 1,623,246 | $347,281 | $287,009 | 799,286 | $235,605 | $294.77 |

Note: Factor for converting 1986 dollars to 1981 dollars is 1.21.

Source: ERG, 1993b

**Table 5-7**
**Industry Comparison of Cost-Effectiveness for Direct Dischargers -- Toxic and Nonconventional Pollutants Only**
**Copper-Based Weights 1981 Dollars**

| Industry | Pounds Equivalent Currently Discharged (000's) | Pounds Equivalent Remaining at Selected Option (000's) | Cost-Effectiveness of Selected Option(s) ($/Pound Equivalent) |
|---|---|---|---|
| Aluminum Forming | 1,340 | 90 | 121 |
| Battery Manufacturing | 4,126 | 5 | 2 |
| Carmaking | 12 | 0.2 | 10 |
| Coal Mining | BAT=BPT | BAT=BPT | BAT=BPT |
| Coil Coating | 2,289 | 9 | 49 |
| Copper Forming | 70 | 8 | 27 |
| Electronics I | 9 | 3 | 404 |
| Electronics II | NA | NA | NA |
| Foundries | 2,308 | 39 | 84 |
| Inorganic Chemicals II | 32,503 | 1,290 | [a] |
| Inorganic Chemicals II | 605 | 27 | 6 |
| Iron and Steel | 40,746 | 1,040 | 2 |
| Leather Tanning | 259 | 112 | BAT=BPT |
| Metal Finishing | 3,305 | 3,268 | 12 |
| Nonferrous Metals Forming | 34 | 2 | 69 |
| Nonferrous Metals Manufacturing I | 6,653 | 313 | 4 |
| Nonferrous Metals Manufacturing II | 1,004 | 12 | 6 |
| Offshore Oil and Gas | | | |
| - Drilling Fluids and Drill Cuttings | -- | -- | BAT=NSPS[d] |
| - Produced Water | 3,808 | 2,328 | 33 |
| - Produced Sand | -- | -- | BAT=NSPS[d] |
| Organic Chemicals, and Plastics and Synthetics[b] | 54,225 | 9,735 | 5 |
| Pesticides | 2,461 | 371 | 15 |
| Pharmaceuticals | 208 | 4 | 1 |
| Plastics Molding and Forming | 44 | 41 | BAT=BPT |
| Porcelain Enameling | 1,086 | 63 | 6 |
| Petroleum Refining | BAT=BPT | BAT=BPT | BAT=BPT |
| Pulp and Paper[c] | 1,330 | 748 | 18 |
| Steam Electric | | | |
| Textile Mills | BAT=BPT | BAT=BPT | BAT=BPT |
| Timber | | | |

[a] Less than a dollar.
[b] Reflects costs and removals of both air and water pollutants.
[c] PCB control for Deink subcategory only.
[d] The major impact of the regulation on drilling fluids and drill cuttings will occur under NSPS. Impacts for produced sand are also estimated on a combined BAT/NSPS basis.

Source: ERG, 1993b

**Table 5-8**
**Industry Comparison of Cost-Effectiveness for New Source Performance Standards**
**Toxic and Nonconventional Pollutants Only**
**Copper-Based Weights**
**(1981 Dollars)**

| Industry | Incremental[a] Pounds Equivalent Removed | Cost-Effectiveness of Selected Option(s) ($/Pound Equivalent) |
|---|---|---|
| Aluminum Forming | 509 | 190 |
| Battery Manufacturing | 1,612 | 47 |
| Carmaking | NA | NA |
| Coal Mining | | |
| Coil Coating | 5,004 | 13 |
| Copper Forming | 216 | 132 |
| Electronics I | NA | NA |
| Electronics II | 427 | 183 |
| Foundries | | |
| Inorganic Chemicals I | | |
| Inorganic Chemicals II | NA | NA |
| Iron and Steel | | |
| Leather Tanning | | |
| Metal Finishing | 26,208 | [b] |
| Nonferrous Metals Manufacturing I | NA | NA |
| Nonferrous Metals Manufacturing II | 32,570 | 9 |
| Offshore Oil and Gas | | |
| - Drilling Fluids and Drill Cuttings | 357,955 | 44 |
| - Produced Water | 601,169 | 17 |
| - Produced Sand | 10,842 | 291 |
| Organic Chemicals, and Plastics and Synthetics[b] | NA | NA |
| Pesticides | NA | NA |
| Petroleum Refining | | |
| Pharmaceuticals | NA | NA |
| Plastics Molding and Forming | NA | NA |
| Porcelain Enameling | 2,500 | 38 |
| Pulp and Paper[c] | NA | NA |
| Steam Electric | | |
| Textile Mills | NA | NA |
| Timber | | |

[a] Incremental pound equivalent removed from next less stringent option considered.
[b] Less than a dollar.
[c] Incremental treatment required for conventional pollutants only.

Source: ERG, 1993b

Financial impacts are minimal for a typical major oil company under any set of pollution control options. The financial ratios affected by debt financing change 0.5 percent or less for all options considered for drilling fluids, drill cuttings, and produced water (BAT and NSPS). The financial ratios affected by financing through working capital also change by less than 0.5 percent except for the Zero Discharge options, which were not selected for the final rule.

The change in financial ratios for a typical independent oil company under the various regulatory options is greater than that seen for a typical major oil company. Financial ratios affected by debt financing increase by 1 percent or less under the regulatory options investigated for each waste system. For all waste streams, the financial ratios affected by financing through working capital change by 4.5 percent or less, except for the Zero Discharge options, which were not selected for the final rule.

Financial impacts were considered for two regulatory packages, which combine effluent control options in the source categories. Under regulatory Package A, which includes the 3 Mile Gulf/California option for drilling fluids and drill cuttings and the Flotation All option for BAT produced water and NSPS produced water, the financial ratios affected by debt financing change by 0.1 percent for a typical major and by 0.2 percent for a typical independent, even in Year 1 of the regulation. Financial ratios affected by working capital change by 0.5 percent or less for majors and independents even in Year 1, except for a working capital decline of 4.6 percent for a typical independent oil company. A typical independent, however, may not choose to fund all of these expenditures out of working capital and may be more likely to use some mix of working capital and debt (thereby reducing the estimated impact on working capital).

### 5.3.2 <u>Impacts on Production</u>

The estimated total amount of production from BAT and NSPS structures[6] was compared to the total production under the two sets of regulatory options. The range in potential production loss varies from 0.1 to 0.2 percent.

[6] Production is expressed in terms of BOE (barrels-of-oil equivalent) in order to compare both oil and gas production on a common basis. The conversion factor is based on the heating value of the product. A barrel of oil is 5.8 million BTU and an MMCF of gas is 1,021 million BTU. An MMCF of gas is equivalent to 176.03 BOE.

### 5.3.3 Secondary Impacts of the Regulations

The impact of the effluent guidelines regulations on federal revenues, state revenues, and the balance of payments was analyzed. Federal revenues are impacted by the tax effects of effluent guidelines expenditures and by potential reduction in lease/bonus bids. The potential impact of the regulations on federal revenues in the first year is estimated to be between $114 and $136 million in 1986 dollars ($129 and $153 million in 1991 dollars), depending upon the regulatory package. State revenues might be affected by reductions in lease/bonus bids. The maximum impact of the guidelines on state revenues is $7 to $8.6 million ($8 to $10 million in 1991 dollars). For Texas' and Louisiana's estimated share of the impact, lost revenues are less than 0.1 percent of the state's total 1986 revenues. No significant impacts on the balance of trade or inflation are projected.

## 5.4 CONCLUSION

The first-year costs (1991 dollars) for selected options are $19 million for drilling fluids and cuttings, and $108.4 million and $0.9 million for produced waters BAT and NSPS, respectively. The significant costs for BAT produced waters will decrease with each subsequent year, as existing structures come to the end of their economic lives. The incremental cost-effectiveness (1981 dollars) of the selected options is $44 per pound equivalent removed for drilling and fluids and drill cuttings, $33 per pound equivalent removed for BAT produced water, and $16 per pound equivalent removed for NSPS produced water. The economic impacts of the pollution control options are minimal for a typical major oil company under any set of options. Impacts on a typical independent oil company are somewhat greater. Given a regulatory package including the 3 Mile Gulf/California option for drilling fluids and drill cuttings and the Flotation All option for produced water, working capital may decline by 5 percent in the event that an independent should choose to fund all expenditures out of working capital. All other ratios would change by no more than 0.4 percent.

# 6.0 EVALUATION OF BENEFITS AND WATER QUALITY IMPACTS

## 6.1 INTRODUCTION

The Agency has attempted to identify and, where possible, quantify in monetary terms, the environmental benefits of the effluent limitations guidelines for the offshore subcategory of the oil and gas extraction industry. This benefit assessment has pursued three principal lines of investigation: 1) assessment of benefits that can be quantified and monetized, including estimates of national health-related benefits that could result from controlling pollutants in effluent discharges from drilling and production waste streams, 2) assessment of water quality improvements attributable to the guidelines that can be quantified but not easily monetized, and 3) compilation of case studies of documented environmental impacts from these discharges that, similar to water quality improvements, can be quantified but not easily monetized. Monetized results focus almost exclusively on the benefits associated with human health risk reduction through reduced concentration of platform-related pollutants in recreationally-caught finfish species and commercial shrimp. Both carcinogenic and systemic human toxicants are considered. These quantified and monetized incremental benefits are compared to the annualized incremental cost in the Gulf of Mexico for the BAT and NSPS control options under consideration for proposal.

The RIA addresses the benefits of three major waste streams identified for this industrial subcategory: drilling fluids, drill cuttings, and produced water. These waste streams were selected because they comprise the majority of effluent discharge volumes from oil and gas exploration, development, and production facilities, and because of their toxicity and potential for causing adverse environmental effects. In this chapter, benefits associated with three options for drilling fluids and cuttings and three options for produced water are evaluated. (See Tables 4-5 and 4-6 for a listing of options for drilling fluids and cuttings, produced water (BAT), and produced water (NSPS), respectively.)

The quantified benefits assessment presented in this RIA is restricted to analysis of operations in the Gulf of Mexico. The vast majority of production platforms are located in the Gulf of Mexico, which has 2,517 of the 2,549 total U.S. offshore producing structures projected to be affected by the rule. Therefore, the greatest portion of environmental benefits would reasonably be expected to occur in the Gulf of Mexico. Additionally, regional-scale environmental information and fisheries landings data, which are important to the required modeling and predictive approach of the benefits assessment, are available for a Gulf of Mexico analysis. Finally, the Gulf of Mexico offshore waters and ecosystems have a far greater degree of environmental homogeneity (e.g., bathymetric and habitat conditions) than other regions, such as the southern California outer continental shelf (OCS) or the northern, western, and southeastern OCS regions of Alaska. Heterogeneity of the aquatic ecosystems in these areas requires more site-specific or platform-specific modeling and predictive analyses that are less easily developed into a regional or subcategory-wide assessment.

## 6.2 OVERVIEW OF THE METHODOLOGY FOR ESTIMATING MONETIZED BENEFITS

Human health benefits of the regulations were quantified and assigned monetary values, to the extent feasible given limitations on data availability, the state of knowledge, and EPA-accepted methodologies. There are three major types of health risk reductions relevant to the guidelines covering the major waste streams of this industrial subcategory--carcinogenic risk reduction, systemic toxicant risks (expressed as a fraction of the RfD values), and as a special case of systemic toxicants notable in its own right, lead-related risk reductions. Carcinogenic and lead-related impacts are monetized. Systemic toxicant risks are quantified but not monetized.

This RIA focuses almost exclusively on the benefits associated with reduced risks to human health. Estimating the monetized benefits of an improvement in health and environmental quality requires that a chain of events and physical relationships be specified and understood. Thus, to estimate the benefits of water pollution controls directed at reducing pollutant loadings, links have to be made from the regulatory action (change in effluent limits) all the way through to outcomes that are of direct value to society. These benefits are estimated through the application of existing studies that credibly link physical changes in the marine environment to changes in human activities and social values using results from existing models. This approach was used to evaluate effluent guidelines for the iron and steel industry and for the organic chemicals, plastics, and synthetic fibers industry.

Health risks for drilling fluids and cuttings are determined for the consumption of both commercially-caught shrimp by the general population, and recreationally-caught finfish by fishermen and their families, that are projected to be exposed to discharges from oil and gas structures in offshore subcategory areas of the Gulf of Mexico region. The categories of finfish considered in the analysis are reef species typically caught around offshore structures, which act as artificial reefs. For produced water, only human health risks from consumption of recreationally-caught finfish are assessed. Impacts of this regulation on commercial finfish catch are very difficult to project, and are thought to be potentially smaller than impacts on recreational finfish catch because commercial fishermen avoid the immediate areas around offshore oil and gas structures in order to protect their equipment and because commercial finfisheries are mobile (compared to the reef species typical of the targeted recreational finfish catch). Only those health risk reduction benefits that are readily quantified and monetized have been assessed. When interpreting the results presented in this section, it should be recognized that the analysis addresses only a portion of the full range of risk reductions that the final regulations will attain.[1]

Human health benefits arise from reduction in the risk of adverse health effects due to reductions in exposure to contaminants that enter the environment through regulated wastewaters. The extent of the reduced levels of contamination in fish tissue depends on the change in ambient concentrations of the relevant pollutants and their bioconcentration in applicable fish species. Levels of contaminants in recreational fish tissue are estimated for the current baseline and for each regulatory option (using chemical-specific leaching factors for metal pollutants for drilling fluids and cuttings), by combining average effluent concentrations of pollutants with transport and fate modeling analyses to estimate the projected environmental concentrations of these pollutants. These projected concentrations were developed for pollutants in seawater (water column exposure scenarios) for both drilling fluids and produced water; they also were developed for sediment pore water (benthic exposure scenarios) for drilling fluids. Then, using chemical-specific bioconcentration factors, and fish lipid content factors for organic pollutants, fish tissue pollutant concentrations are predicted from projected seawater and pore water concentrations.[2] All of these projections are made on an incremental basis, i.e., they only account for exposures to pollutants in the regulated waste stream and do not include any analyses that include exposures to these pollutants from other pollution or natural sources. For two radioactive produced water pollutants (i.e., $^{226}$Ra and $^{228}$Ra) and two reinjection regulatory options evaluated by this RIA, the tissue concentrations measured in edible portions of fish and crabs near platforms (CSA, 1992) were used instead of tissue levels projected from modeling.

Health benefits for carcinogens and most systemic toxicants are calculated based on scenarios that reflect national shrimp and recreational finfish consumption patterns, including both average individual risks and the "high end"[3] consumer risks. For the systemic toxicant lead, health benefits are calculated using a harvest-based mass balance distribution of exposure scenarios for shrimp and fish consumption. This scenario is based on the distribution of national fish consumption levels weighted by the proportion

[1] Omitted benefits include, but are not limited to: (1) adverse health effects from lead in women (all ages) and in men below the age of 40 or over the age of 59; (2) adverse lead-related health effects other than the endpoints quantified; (3) lead-related exposure associated with shrimp or finfish uptake of lead through the sediments directly, or indirectly, through the food chain; (4) recreational and commercial fishery improvements; (5) ecologic benefits; and (6) nonuse values.

[2] These analyses are described in greater detail in Avanti (1993).

[3] The high end risk descriptor is a plausible estimate of the individual risk for those persons at the upper end of the risk distribution. See EPA "Guidance on Risk Characterization for Risk Managers and Risk Assessors." February 26, 1992. Office of the Administrator.

of the U.S. population consuming fish at that level, all of which are normalized to the total amount of fish consumed. Standard dose-response data are used to translate reduced exposure levels into reduced levels of health risk.

Cancer risks are quantified and monetized using average individual exposure levels, which are applied to the exposed population (national shrimp consumers and Gulf offshore recreational anglers), and Agency-established unit risk factors. Average exposures are based on human intake of pollutant levels consistent with the relevant shrimp and recreational finfish harvests (i.e., there is a mass balance between impacted fish harvested and subsequent human exposure). The linear, no threshold dose-response relationship for carcinogens enables the straight-forward quantification of total excess cancer cases. Regulatory actions resulting in reduced mortality are valued in this analysis at $1.97 million to $9.96 million (in 1991 dollars) per statistical fatality avoided, representing a widely accepted range of values in the literature (see U.S. EPA, 1989a, Violette and Chestnut, 1983, 1986).

Risk reductions associated with lead intake from drilling fluids require more complex analyses, because the dose-response functions are not linear. Therefore, different exposure scenarios are applied to population subcategories to maintain a mass balance between edible shrimp and fish tissue harvests and human intake. The analysis is further subdivided into three types: benefits to infants, benefits to adult males, and benefits to children. Because the appropriate methods of quantifying and/or valuing several of the important health effects associated with lead exposure are not yet firmly established, the monetized lead benefits represent only a limited portion of the total range of human health benefits that may be attributed to reduced lead exposure.

The benefits estimation approach for drilling fluids and cuttings and produced waters, respectively, is discussed in greater detail in sections 6.3 and 6.4.

## 6.3 MONETIZED BENEFITS: DRILLING FLUIDS AND CUTTINGS

The estimated benefits of the effluent guidelines for drilling fluids and cuttings are predominantly derived from reducing the amount of lead in edible shrimp tissue harvested commercially from platform-impacted waters of the Gulf (over 15 million kilograms per year). Additionally, lead concentrations in edible fish tissue, based on water column concentrations (omitting uptake via sediment or food chain), were applied to estimates of recreationally-caught Gulf finfish to derive applicable health benefits. Additionally, the more modest benefits associated with decreased carcinogenic risks from commercially-caught shrimp and recreationally-caught finfish were estimated. For both risk categories, benefits were estimated using a saltwater leach scenario and an alternative pH-dependent leach scenario.

Major toxic effects of lead include inhibition of heme synthesis, kidney disfunction, and damage to the central nervous system. Broad symptoms include increased blood pressure and reduced learning ability. Based on previous Agency research relating lead intake to selected adverse health effects, reductions in the number of cases of these health endpoints were quantified for the offshore oil and gas effluent guidelines options. These lead-related benefits include (1) decreased infant mortality; (2) reduced I.Q. impairments in children; and (3) reduced risks of heart disease, strokes, hypertension and death in males between 40 and 59 years of age.

Benefits were estimated for several regulatory options beyond baseline practices (BPJ, or "dirty" barite muds). Estimates were prepared for Gulf of Mexico locations only. The options include:

- 3 Mile Gulf/California. Zero discharge (i.e., the transport of muds and cuttings to shore for appropriate land-based waste management and disposal) for all platforms within three miles of shore. Under this option, Best Available Technology (BAT), consisting of using "clean" barite muds, applies to all platforms beyond three miles of shore. Alaska is exempt from the zero discharge requirement.

- 8 Mile Gulf/3 Mile California. Zero discharge for platforms within eight miles of shore, and BAT for platforms beyond. California and Alaska must meet the same requirements as in the 3 Mile Gulf/California option.

- Zero Discharge Gulf/California. Zero discharge for all platforms. Alaska is exempt, but must meet the same requirements as in the 3 Mile Gulf/California option.

### 6.3.1 Summary of Benefits Estimation Approach

Lead-Related Benefits. All of the lead-related benefits analysis draws upon, and is consistent with, the Agency's previous research on lead. These previous findings are reflected in Agency analyses and documents prepared for the lead phasedown in gasoline, the lead in drinking water rulemaking, and the sludge disposal program (U.S. EPA, 1985, 1986(a), 1986(b), 1989(a), 1989(b), 1991).

Lead concentrations in edible shrimp tissue and recreationally caught finfish tissue, and estimates of the shrimp and finfish harvests impacted by platform operations, were prepared for each drilling fluids and cuttings regulatory option by Avanti Corporation (1993).

The impacted shrimp harvest was allocated across the estimated 50 million Americans who consume shrimp. The impacted finfish harvest was allocated across the estimated 1.7 million individuals consuming recreationally-caught Gulf finfish. Estimates of human exposure were made at four intake levels that reflect the distribution of shrimp or finfish consumption levels across the population of shrimp or finfish eaters (e.g., individuals who consume relatively low amounts of impacted shrimp, versus those who eat relatively high levels of shrimp).

Seafood consumption levels, coupled with the option-specific lead concentrations in edible shrimp or finfish tissue, provide estimates of the daily lead intake via shrimp and finfish for each exposure group (for each regulatory option). Using age-specific adsorption factors to distinguish lead uptake levels in children versus adults, lead intake levels were transformed into estimates of lead uptake. Using prior Agency lead research (U.S. EPA 1989(b)), lead uptake was used to estimate changes in the distribution of blood lead levels (PbB) above the baseline (no shrimp-related or finfish-related lead exposure) distribution.

Within each exposure group, the populations were distributed across age and sex categories for which risk reduction analysis can be performed: children, adult males, and pregnant women (whose blood lead level affects the risk of infant mortality).[4] For the children within each exposure group, established Agency research linking elevated blood lead levels to IQ impairments was used to estimate the option-specific reductions in: 1) the total level of IQ point decrements, and 2) the number of children with IQ levels below 70. For the expected number of pregnant women within each exposure group, established Agency research linking elevated blood lead levels to reduced fetal birth weight and, hence, increased infant mortality, was used to estimate the option-specific reductions of infant deaths. For the expected number of males between the ages of 40 and 59 within each exposure group, established Agency research was used that links: 1) elevated blood lead levels to hypertension and, subsequently, 2) the increased risk of strokes, cardiovascular heart disease (CHD), and premature fatality due to hypertension-related causes. These results were used to estimate the option-specific reductions of strokes, CHD events, and death in the male population between 40 and 59 years of age.

[4] Results of this distribution, based on 50 million shrimp consumers, are as follows: for children (5-year-old cohort), 645,000 individuals were in the low exposure group, 82,500 were in the moderate exposure group, 21,750 were in the moderately high exposure group, and 750 were in the highest group. For pregnant women (newborn infants), 722,517 were in the low exposure group, 92,415 were in the moderate exposure group, 24,364 were in the moderately high exposure group, and 840 were in the highest group. For males (aged 40-59), 4,988,000 were in the low exposure group, 638,000 were in the moderate exposure group, 160,000 were in the moderately high exposure group, and 5,800 were in the highest group. A full discussion of this procedure can be found on pages 2-8 and 3-4 of the benefits analysis for the offshore oil and gas guidelines (RCG/Hagler, Bailly, 1993).

Cancer Risk Reduction Benefits. In conformance with standard Agency risk assessment procedures for carcinogens, excess cancer cases were estimated by multiplying the average exposure levels (at each option) by the established Agency carcinogenic slope factor (CSF), by the total exposed population.

## 6.3.2 Results

### Reduced Cancer Risk

Estimated carcinogenic risks posed by drilling fluids and cuttings are associated with exposure to arsenic. Relatively few health benefits accrue from the estimated arsenic-related cancer risk reductions of the regulatory options for drilling fluids and cuttings. Carcinogenic risks for the average scenario from finfish and shrimp consumption combined are orders of magnitude below the $10^{-4}$ to $10^{-6}$ range targeted for most Agency programs. Compared to a baseline ("current") average excess risk level of $6 \times 10^{-8}$, regulatory options range from $4 \times 10^{-8}$ for the selected option (3 Mile Gulf/California) to zero for the Zero Discharge option.[5]

Monetized benefits associated with reduced cancer cases amount to between $51,200 and $448,200 per year over the range of regulatory options. The selected option for drilling fluids and cuttings results in an incremental reduction in annual excess cancer cases of 0.026, and associated monetized benefits ranging from $51,200 to $258,900 per year.

### Lead-related Risk Reductions

Lead-related monetized benefits based on exposure via shrimp consumption dominate the estimated benefits for drilling fluids and cuttings. Lead-related benefits are based on reduced infant mortality, IQ impacts in children, and health benefits to adult males. Appreciable benefits are accrued especially to adult males as discussed below. The estimated number of reductions in health effects (cases avoided) at each regulatory option is shown in Table 6-1. For drilling fluids and cuttings, estimable lead-related exposures via recreational finfish consumption are so low that no discernable lead-related benefits can be attributed to the regulatory options.

As shown in Table 6-2, most of the monetized benefits are obtained at the 3 Mile Gulf/California option, with small incremental benefits realized at more stringent options. All of the benefit levels shown in these tables are related to the use of a saltwater leach

[5] The Agency currently is reviewing new evidence of the carcinogenic endpoints and potency of arsenic, and the carcinogenic slope factor for arsenic may be revised to reflect higher health risks per unit of exposure (Dr. Charles Abernathy, U.S. EPA, personal communication, October 1992).

**Table 6-1**
**Annual Incremental Lead-Related**
**Health Effects Reductions for Drilling Fluids and Cuttings**
**(Salt Water Leach Scenario, Gulf of Mexico, Shrimp Only)**

| Benefit Category | Cases Avoided - From Baseline to Regulatory Options | | |
|---|---|---|---|
| | 3 Mile Gulf/ California | 8 Mile Gulf/ 3 Mile California | Zero Discharge Gulf/California |
| Infant Mortality | 0.31 | 0.31 | 0.33 |
| Children | | | |
| IQ < 70 | 0.65 | 0.70 | 0.70 |
| IQ points | 142.00 | 144.00 | 151.00 |
| Adult Males | | | |
| Hypertension | 243.50 | 247.00 | 259.00 |
| Stroke | 1.29 | 1.29 | 1.42 |
| Heart Disease | 6.966 | 7.095 | 7.48 |
| Death | 9.114 | 9.159 | 9.68 |

scenario for calculating the bioavailability of lead in the marine environment. The alternative scenario evaluated (using a pH-dependent leach rate to estimate fish tissue concentrations) would increase human intake of lead to a significant degree, and the resulting benefit levels would increase by more than a factor of six times greater than the values shown in Table 6-2.[6]

[6] While available data appear to support use of a weak acid extraction (pH 5.0-5.3), benefits summarized in this RIA are based on a saltwater leach scenario to avoid any potential overestimate of benefits. This issue is discussed on page 6-17 of the RIA, and a full discussion is found in Avanti, 1993, Appendix C.

**Table 6-2**
**Monetized Lead-Related Benefits of Drilling Fluids and Cutting Options Gulf of Mexico (Salt Water Leach Scenario, Shrimp Only)**

| Regulatory Option | Annual Benefits[a] (millions 1991 dollars) |
|---|---|
| Baseline - Current | -- |
| 3 Mile Gulf/California | \$28.0 - \$103.3 |
| 8 Mile Gulf/3 Mile California | \$28.4 - \$104.4 |
| Zero Discharge Gulf/California | \$29.9 - \$110.1 |

a Relative to baseline.

Lead-Related Benefits to Infants: Reduced Infant Mortality

There are many likely benefits to infants that could be attributed to reduced lead exposure via maternal blood. However, the only effect quantified and valued in EPA's prior lead analyses, and therefore in this analysis, is the reduced risk of mortality in the first year of life. The monetized lead-related benefits of reduced infant mortality for all options evaluated range from \$0.7 million to \$3.3 million per year.

Lead-Related Benefits to Adult Males: Reduced Circulatory System-Related Effects

Elevated blood lead (PbB) levels in adult males have been linked statistically to several adverse health risks associated with the circulatory system: increased incidence of hypertension, strokes, cardiovascular heart disease events (CHDs, e.g., heart attacks), and premature death. Estimated monetized health benefits for all evaluated options (except the "Current" Baseline) range from \$26.7 million to \$106.1 million per year when applied to males aged 40 to 59.[7]

[7] Hypertension results apply to males aged 20 to 74. Other health effects are estimated for males aged 40 to 59 because data and reliable quantification methods have yet to be developed to allow credible extension of the results to a broader population.

Benefits to Children: IQ Impacts, Future Earnings, and Special Education Costs

Children are considered especially vulnerable to lead exposure. Of the health effects related to lead in children, the most analytically tractable is the relationship between PbB and intelligence, typically measured in IQ points. Based on estimated PbB levels, the number of children with a specific adverse impact was estimated, and was limited to (1) the present value of future earning losses due to the IQ decrements associated with elevated PbB levels and (2) the expense of supplemental education for those additional children with IQ levels below 70 points due to shrimp-related exposures. The present value of lost earnings is valued at $4,588 per IQ point decrement. The lead-related monetized health benefit to children of moving from the current level of treatment to more stringent options ranges is as high as $0.7 million per year.

**Summary of Results: Drilling Fluids and Cuttings**

The total monetized benefits of the options for drilling muds and cuttings are shown in Table 6-3. In addition to the lead-related benefits described above, the values also reflect modest reductions in cancer risk as associated with arsenic. These "total" benefits are understated due to the omission of several potentially significant benefits. Omitted benefits include, but are not limited to: (1) adverse health effects from lead in women

**Table 6-3**
**Total Monetized Benefits and Costs[a]**
**Drilling Muds and Cuttings**
**Gulf of Mexico**
**(Salt Water Leach Scenario)**

| Regulatory Option | Annual Benefits[b,c] (millions 1991 dollars) | Annual Costs (millions 1991 dollars) |
|---|---|---|
| Baseline - Current | -- | -- |
| 3 Mile Gulf/California | $28.1 - $103.6 | $18.8 |
| 8 Mile Gulf/3 Mile California | $28.5 - $104.7 | $33.1 |
| Zero Discharge Gulf/California | $30.0 - $110.5 | $142.4 |

a Benefits and costs in this table are for Gulf of Mexico operations only.
b Health benefits primarily based on reduced lead exposure, only partially on reduced arsenic-related carcinogenic risks.
c Relative to baseline.

and in men below the age of 40 or over the age of 59; (2) adverse lead-related health effects other than the endpoints quantified; (3) lead-related exposure associated with shrimp or finfish uptake of lead through the sediments directly, or indirectly, through the food chain; (4) Recreational and commercial fishery improvements; and (5) nonuse values.

## 6.4 MONETIZED BENEFITS: PRODUCED WATER

The benefits associated with produced water at existing or new sources (NSPS) are related to three regulatory options:

- Flotation All. Improved gas flotation for all platforms (BAT).
- Zero 3 Miles Gulf and Alaska. Zero discharge (re-injection) at platforms within three miles of shore, and BAT for platforms beyond three miles. BAT required for California wells.
- Zero Discharge Gulf and Alaska. Zero discharge for all platforms except California. BAT required for California wells.

Benefit estimates were prepared for Gulf of Mexico locations only. The methodology for estimation of benefits associated with the produced water options is the same as that described above under Drilling Fluids and Cuttings. Benefit estimates, however, are based on exposure via recreationally-harvested finfish only; shrimp-related exposures could not be estimated for produced waters.

**Reduced Carcinogenic Risk**

Carcinogenic risks from recreationally harvested finfish were estimated for arsenic, benzene, and benzo(a)pyrene (preliminary estimates of potential carcinogenic risk reductions from radium exposure are discussed in a separate section below). Average excess lifetime cancer risk under the Baseline "current" option is $4.5 \times 10^{-7}$ for existing sources and $6 \times 10^{-7}$ for new sources. For the evaluated BAT options, lifetime excess risk ranges from none (Zero Discharge) to $2.5 \times 10^{-7}$ for selected option (Flotation All). For NSPS, lifetime excess risk ranges from none to $3.3 \times 10^{-7}$ for the selected option.

Monetized benefits from reduced cancer risk at average exposure levels are small for both BAT and NSPS, as shown in Table 6-4. Incremental benefits amount to between $5,900 to $59,700 per year for BAT and between $7,800 to $79,700 per year for NSPS. For the selected option, incremental annualized BAT benefits range from $5,900 to $29,900 per year, and NSPS benefits range from $7,800 to $39,800 per year.

**Table 6-4**
**Excess Cancer Case Reduction Benefits due to Produced Waters**
**(Moderate Fish Harvest) (1)**

| Regulatory Scenario | Annual Excess Cancer Cases | | Monetized Benefits (3) (Thousands of 1991 dollars) | |
|---|---|---|---|---|
| | Total | Incremental Reduction (2) | Low | High |
| | BAT Produced Waters | | | |
| Baseline | 0.006 | -- | -- | -- |
| Flotation All | 0.003 | 0.003 | $ 5.9 | $29.9 |
| Zero 3 Miles Gulf and Alaska (4) | 0.002 | 0.004 | $ 7.8 | $39.8 |
| Zero Discharge Gulf and Alaska | 0 | 0.006 | $11.8 | $59.7 |
| | NSPS Produced Waters | | | |
| Baseline | 0.008 | -- | -- | -- |
| Flotation All | 0.004 | 0.004 | $ 7.8 | $39.8 |
| Zero 3 Miles Gulf and Alaska | 0.003 | 0.005 | $ 9.8 | $49.8 |
| Zero Discharge Gulf and Alaska | 0 | 0.008 | $15.7 | $79.7 |

(1) Arsenic, benzene, and benzo(a)pyrene only; does not include risk reductions associated with radium or other pollutants controlled by the regulation.
(2) Relative to baseline.
(3) Cancer cases avoided valued at $1.97 million to $9.96 million.
(4) Improved gas flotation for all other platforms.

## Reduced Lead Exposures

Lead exposures from recreationally-harvested finfish are also reduced through the impact of the produced waters regulatory options. The associated benefits are as high as $114,000 per year for BAT and $145,000 per year for NSPS at zero discharge. For the selected option, benefits amount to between $20,900 and $77,700 per year for BAT and between $26,700 and $99,300 for NSPS.

**Radium-Related Benefits**[8]

For the purposes of this RIA, EPA has used the very limited amount of data available concerning radium concentrations in edible fish tissue, and human exposure levels consistent with fish consumption patterns for recreational anglers, to develop a highly preliminary, order of magnitude estimate of the benefits from the options considered. The data upon which this estimate is based, however, are not definitive for risk assessment or for making regulatory decisions.

Limited industry data, drawn from a preliminary draft report by Continental Shelf Associates to the American Petroleum Industry (CSA, 1992), indicate mean concentrations of $^{226}Ra$ of 0.18 pCi/g and $^{228}Ra$ of 0.91 pCi/g in fish fillets and edible portions of crabs. These concentration data pertain only to observations drawn from around two offshore production platforms in the northern Gulf of Mexico, and, as such, may not accurately reflect actual conditions throughout the Gulf. Nonetheless, for the purposes of developing an initial and highly preliminary risk assessment, human exposure to rig-impacted finfish was derived by the Agency based on recreational effort and harvest data for anglers who fish around platforms in the relevant Gulf states (assuming half of the anglers share their harvest with another individual). A population of roughly 900,000 persons were estimated exposed to offshore catch within three miles.[9] The Agency's carcinogenic slope factors for $^{226}Ra$ and $^{228}Ra$ are used to estimate lifetime cancer risk associated with the ingestion of radium-contaminated seafood.[10] Based on the very limited amount of fish tissue concentration data, the central tendency individual risk is estimated to be on the order of $10^{-5}$.[11]

Assuming that fish tissue concentrations of radium are reduced to zero under the zero discharge regulatory options, for both BAT and NSPS the estimated risk level and preliminary exposure scenario result in 0.128 cancer deaths avoided per year under the

[8] Calculation of benefits associated with the Zero 3 Miles Gulf and Alaska and Zero Discharge Gulf and Alaska options for radium are described in EPA memorandum dated September 25, 1992, from Alexandra Tarnay to Mahesh Podar.

[9] A more complete description of the derivation of the number of recreational anglers offshore in the Gulf is found in RCG/Hagler, Bailly (1993).

[10] Carcinogenic slope factors and the calculation of lifetime risk of cancer are described in an EPA memorandum dated December 6, 1991, from John Mauro to Alexander Tarnay.

[11] This risk level is associated with total radium concentrations in fish tissue, reflecting the contribution of radium from both produced waters and background.

Zero 3 Miles Gulf and Alaska option.[12] The benefits of avoiding these excess cancer deaths are estimated at between $0.5 million and $2.6 million per year. Under the Zero Discharge Gulf and Alaska option, a preliminary estimate of 0.26 cancer deaths are avoided per year for both BAT and NSPS, corresponding to combined BAT and NSPS benefits of between $1.0 million and $5.2 million per year.[13]

**Summary of Results: Produced Water**

The quantified and monetized benefits are based on reduced human health risks by way of exposure to selected carcinogens (arsenic, benzene and benzo(a)pyrene), radionuclides, and lead through the consumption of recreationally harvested finfish. The estimated benefit levels are relatively modest, as shown in Table 6-5 for existing platforms and NSPS. It is important to note, however, that these quantified and monetized values omit several important benefits. These omitted benefits include (but are not limited to): (1) Lead-related risk reductions for women and for men other than those between the ages of 40 and 59; (2) Lead-related health effects other than those evaluated; (3) Recreational and commercial fishery benefits; (4) Any potential health risk reduction or other benefits as may be associated with produced water impacts on commercially harvested shrimp; and (5) Any nonuse values or ecologic benefits that may be associated with the regulatory options.

## 6.5 COMPARISON OF MONETIZED BENEFITS TO COSTS

The combined human health benefits of regulating drilling fluids and cuttings and produced water for the selected options (3 Mile Gulf/California and Flotation All) are between $28 and $104 million per year in 1991 dollars.[14] In addition, under an alternative, pH-dependent leach scenario, benefits of the selected options may amount to

[12] If, however, the concentrations of radium found in clams at a site far from oil and gas activity off Florida's Gulf Coast (see section 6.6.2, below) are representative of background radium levels, and radium concentrations are not reduced to zero under the regulatory options, the number of avoided deaths, and thus benefits, will be overestimated.

[13] Radium-related risk reduction benefits were also estimated for the selected option for produced waters (Flotation All); however, these were based on estimated reductions in fish tissue concentrations rather than the actual fish tissue data from CSA (1992). The preliminary rough estimate of lifetime risk reductions for the Flotation All option are on the order of $10^{-7}$ to $10^{-8}$, yielding monetized benefits ranging from $7,500 to $37,400 per year for existing sources and NSPS combined.

[14] Benefits estimates are for the Gulf of Mexico only. Ninety-nine percent of existing oil and gas structures are located in the Gulf.

**Table 6-5**
**Total Monetized Benefits for Produced Waters**
**(Thousands of 1991 Dollars)**
**Gulf of Mexico**

| Regulatory Option | Existing Sources | NSPS |
|---|---|---|
| Baseline | -- | -- |
| Flotation All | $29.8 - $122.5 | $39.0 - $161.6 |
| Zero 3 Miles Gulf and Alaska | $278.7 - $1,417.5 | $298.7 - $1,464.3 |
| Zero Discharge Gulf and Alaska | $542.4 - $2,773.2 | $554.8 - $2,824.8 |

over $600 million per year. These benefit estimates do not include several categories of potential benefits, such as recreational fishing, commercial fishing, nonuse benefits, and other potential health-related benefits. The total annualized costs (1991 dollars) of the selected options are estimated to be $121.9 million for the Gulf region in Year 1 and $32.2 million in Year 15.[15] Costs are projected to decline steadily after Year 1 as existing platforms cease operation. Assuming a straight-line decline in existing BAT projects over the 15-year time frame, benefits could begin to exceed costs as early as Year 9 (Kaplan, 1992a).

**Drilling Fluids and Cuttings**

Monetized human health benefits that result from the proposed regulatory options for drilling fluids and drill cuttings are based on reduced lead exposure and arsenic-related carcinogenic risks. The lead-related benefits dominate the results (accounting for more than 99 percent of the benefits). Benefits are reported for a saltwater leach scenario. An alternative pH-dependent leach scenario results in significantly higher benefit levels (see RCG/Hagler, Bailly, 1992).

For the selected option, estimated benefits of $28.1 to $103.6 million per year compare to estimated annualized costs of $18.8 million. Incremental benefits from the evaluated options for drilling fluids and cuttings range from as much as $103.6 million per year for 3 Mile Gulf/California to as much as $110.5 million per year for Zero Discharge.

[15] Costs throughout this chapter are for the Gulf of Mexico only, in order to present appropriate figures for comparison to benefits. They therefore differ from the total costs for all regions presented in Chapter 5.

Estimated annualized costs of the regulatory options for the Gulf of Mexico range from $18.8 to $142.4 million.

**Produced Water**

Monetized human health benefits that result from the proposed regulatory options for BAT and NSPS produced waters are based primarily on reduced lead exposure, and arsenic-related and other carcinogenic risks. Incremental benefits for produced water are significantly lower than costs.

For the selected option, benefits of between $69,000 and $284,000 per year compare to estimated Year 1 costs of $103 million and Year 15 costs of $13 million. Incremental benefits from the range of evaluated options for produced waters vary from as much as $284,000 per year for Flotation All (BAT and NSPS) to as much as $5.6 million per year for Zero Discharge. First-year costs of the evaluated options are estimated to be between $103 and $755 million and Year 15 costs are estimated to be between $13 and $376 million.

## 6.6 ANALYSIS OF NON-MONETIZED BENEFITS[16]

An assessment of quantified, non-monetized water quality benefits compares projected water column and sediment pore water pollutant concentrations resulting from discharges at the current level of treatment, and for evaluated options, to acute and chronic marine and human health (fish consumption only) criteria/toxic values.

Under CWA Section 403(c) and its implementing regulations (40 CFR 125.120-125.124), EPA shall determine whether a marine discharge will cause unreasonable degradation of the marine environment based on a number of factors, specified in Section 125.122(a). One of these factors is "marine water quality criteria" developed pursuant to Section 304(c)(1). The criteria are not enforceable limitations, as is the case with state water quality standards. Rather, they are guidelines that are considered in the assessment of potential water quality or human health impacts as one of 10 factors considered by EPA in making a Section 403 determination.

These criteria are federal guidelines developed from laboratory and other pollutant-specific data for the protection of marine water quality and human health due to consumption of organisms. For the preparation of this analysis for the RIA, in addition to published or proposed water quality criteria, toxic benchmarks also were calculated for

16 This analysis summarizes more detailed assessments of non-monetized benefits presented in Avanti (1993).

pollutants for which no criteria or updated recalculations were available (refer to the environmental analysis presented in Avanti, 1993, for futher details). These toxic benchmarks represent estimates of pollutant-specific criteria based on available published literature. However, these toxic benchmarks have not been subject to the formal promulgation process, including public comment.

This assessment projects exceedences of these values by drilling fluids, drill cuttings, and produced water discharges. The quantified, non-monetized benefits identified for the selected options include: (1) for drilling fluids and drill cuttings, elimination of the projected aquatic life and human health toxic values exceedences within 3 miles from the shore and reduction of projected impacts beyond 3 miles from shore; and (2) for produced water, reduction of projected impacts.

The assessment of quantified, non-monetized impacts also reviews and summarizes case studies of localized impacts found near oil and gas drill sites and platforms located in the Gulf of Mexico, off Southern California, and in Alaskan waters. Discharged drilling fluids and drill cuttings cause contamination of sediments with heavy metals and hydrocarbons. Documented biological effects include elimination and inhibited growth of seagrasses, declined abundance in benthic species, altered benthic community structure, decreased coral coverage, and bioaccumulation of heavy metals. Biological impacts from single wells occur on a scale from several hundred meters to several kilometers; chemical impacts have been noted from several to tens of kilometers. Produced water discharges are shown to cause contamination of sediments with polynuclear aromatic hydrocarbons (PAH), metals, and radioniclides, local elimination and depressed abundance of benthic species, and alteration of benthic communities. Studies do not indicate that larger-scale (more than several hundred to a thousand meters) impacts occur. However, these studies are not adequate to conclude that regional-scale impacts do not occur.

### 6.6.1 Water Column and Pore Water Quality

The potential effects on water quality of selected effluent discharges from this industrial subcategory have been analyzed. Drilling fluids and drill cuttings are discharged in large quantities and have demonstrated the capability to produce adverse benthic impacts. Produced water is released in large volumes and contains varying levels of trace metals and organic pollutants. Therefore, these waste streams have a high potential for adverse water quality effects. Analyses conducted for these waste streams include assessments of water quality in the water column for both drilling muds and produced water; sediment pore water quality was analyzed for drilling fluids (and adherent cuttings). These assessments are conducted for the current baseline and for each of the regulatory options considered for both drilling fluid and produced water waste streams. Water quality benefits from the regulatory options considered arise from reductions in the number and/or degree of projected exceedences of EPA's water quality criteria/toxic benchmarks for aquatic life and human health (fish consumption only).

**Drilling Fluids and Cuttings**

Water column water quality benefits for drilling fluids are based on projected concentrations of subcategory-wide pollutants at the edge of a 100-meter mixing zone and comparison of these projected levels to EPA's marine water quality criteria or toxic benchmarks. Predictions of pollutant concentrations are based on EPA's estimates of subcategory-wide pollutants in these waste streams and estimates of drilling mud dilution based on results of model runs of the Offshore Operators Committee (OOC) Mud Discharge Model. The soluble portion of metals present in drilling fluids discharges is considered in the determination of benefits. The percentage of metal leached at seawater pH and weakly acidic pH (pH 5.0-5.3) are used to establish a range for the amount of metal available for intake by biota. Dilution of the pollutants in the discharge plume at the edge of the 100-m mixing zone is applied against the effluent concentration. The projected pollutant concentrations are then compared to EPA's marine water quality criteria or toxic benchmarks for aquatic life and human health (fish consumption only).

An issue of continuing comment and uncertainty is drilling fluid trace metal contaminant bioavailability. Two views on this issue are: (1) seawater extraction (pH 7.5 - 8.0) is the more appropriate technique for estimating bioavailability, or (2) a weak acid extraction (pH 5.0 - 5.3) is more appropriate. The Agency believes the weak acid extraction to be a scientifically defensible basis for projecting potential impacts of drilling fluids, although the Agency has conducted analyses based on both approaches to present the full range of potential impacts. However, to present a conservative projection of benefits, the quantified and monetized benefits assessment in this RIA is based primarily on seawater extraction leach data rather than the weak acid leach rate scenario.

Pore water quality benefits for drilling fluids and cuttings are assessed by projecting the concentration of the subcategory-wide pollutants in the sediment at the edge of the 100 meter mixing zone. The projections of pollutant concentration are derived from studies in which barium levels in the sediment were measured at various distances from the discharging structures; all measured pollutants in the drilling fluids and cuttings are assumed to be distributed in a manner consistent with barium's distribution at 100 meters. The pore water concentration of each pollutant is calculated from the sediment concentration at 100 meters using equilibrium partitioning ($K_{oc}$ * $f_{oc}$) for organics and percentage leach for metals. The projected pore water concentrations are then compared to EPA's marine water quality criteria or toxic benchmarks to determine the nature and magnitude of the water quality exceedences.

The results of these analyses are presented below. More detailed discussion of water column and pore water quality benefits, and considerations in estimating these benefits, is presented in The Environmental Analysis of the Final Effluent Guidelines for the Offshore Oil and Gas Industry (Avanti, 1993).

Several factors affect the scope and reliability of these data and analyses.

- First, for water column benefits, it is difficult to generalize about plume behavior of discharged drilling fluids in the Gulf of Mexico. An effort has been made to be conservative with respect to protecting water quality, primarily by basing results on the maximum authorized discharge rate (1000 bbl/hr) for a range of water depths. Conceptual and practical limitations (necessary ambient data) are responsible for a limited ability to model the fate of these discharges in shallow (<5 m depth) water.

- Second, only listed, toxic pollutants have been included for both water column and benthic benefits. Other nonconventional pollutants are likely to be present on a case-by-case basis, and may be a substantial source of potential environmental impacts. The exclusion of these pollutants could result in the underestimation of potential environmental benefits in the RIA.

- Third, average pollutant concentrations are used throughout, rather than more conservative estimates, such as the upper 90th or 95th percentile concentrations. Using large-scale average concentrations can lead to underestimating impacts particularly if threshold-type effects are involved, such as for systemic toxicants.

- Finally, because of both the variation in organic carbon content on a Gulf-wide basis and the uncertainties associated with $K_{oc}$ values, calculations for sediment benefits should be considered as a first-order approximation.

**Produced Water**

In the development of the RIA, the benefits associated with the regulation of produced water are assessed, using gas flotation technology or zero discharge. Water column water quality benefits for produced water are based on predictions of concentrations of pollutants at the edge of a 100-meter mixing zone and comparison of these levels to EPA's marine water quality criteria or toxic benchmarks. Predictions of pollutant concentrations are based on EPA's estimates of the average concentrations of these pollutants in produced water and estimates of produced water dilution based on the results of CORMIX model runs. Numerous water column scenarios were developed, based on various flow rates and water depths. Input data and assumptions generally represent average case current speed, density structure, and effluent density conditions.

The discharge modeling is subject to opposing uncertainties and assumptions. Using model runs limited to 5- to 40-meter water depths may underestimate available dilution for waters deeper than 40 meters and overestimate dilution for waters shallower than 5 meters. Discharge rates were examined over the range of 50 to 73,580 bbl/day, which include most platforms, including average platforms. However, a few larger central processing facilities discharge at rates twice as high as the maximum rate modeled. Conversely, the limitation on potential ambient conditions is evident and discharges in very shallow water (1-2 meters) or under usually stagnant or stratified conditions are not included.

Similar to the case for drilling fluids, a second consideration is that using only listed toxic pollutants restricts the number of potentially important pollutants. Their presence could have an impact on water quality and/or living resources. Likewise, average pollutant concentrations, which can lead to an underestimate of potential benefits at a local level, are used throughout this assessment.

Biocides in produced water also are not considered in this RIA. The potential impacts of biocides could not be assessed because necessary and sufficient data on the materials used, their chemical and toxicological properties, and their usage levels and frequencies are not available.

## Results

Federal water quality criteria or toxic benchmarks for marine organisms acute effects, marine organisms chronic effects, and human health for fish consumption (Versar, 1992) are compared to the projected incremental concentration of pollutants in the water column (for drilling fluids, drill cuttings, and produced water), and the sediment pore water (for the drilling fluids and drill cuttings).

### Drilling Fluids and Cuttings

Drilling fluid pollutant concentrations at the edge of the 100 meter mixing zone are projected at three water depths -- 5 meters (13th percentile of wells drilled), 19.8 meters (median depth for wells drilled), and 50 meters (79th percentile of wells drilled) at the maximum discharge rate (1000 bbl/hr) authorized under existing NPDES general permits. These are then compared to water quality criteria/toxic benchmarks to determine which pollutants exceed the criteria/benchmarks and the magnitude of the exceedence. Drilling fluid pollutant concentrations were projected for the soluble portion of trace metals in drilling fluids; using leach factors based on both a pH 5 extraction and a mean seawater pH extraction. The magnitude of water quality exceedences, (the factor by which the water column pollutant concentration exceeds the water quality criterion/benchmark value) is presented in Table 6-6 for pollutants for which at least one exceedence is projected. A blank cell indicates that the water quality criterion/toxic benchmark is not exceeded at that discharge profile.

**Table 6-6**
**Magnitude of Water Quality Exceedences Due to Drilling Fluid Discharges in the Water Column**

| | | Mean Seawater Leach Conditions | | | | | | pH 5 Leach Conditions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Current conditions | | | BAT/NSPS | | | Current conditions | | | BAT/NSPS | | |
| **Pollutant** | **Criterion/benchmark** | **5m** | **19.8m** | **50m** | **5m** | **19.8m** | **50m** | **5m** | **19.8m** | **50m** | **5m** | **19.8m** | **50m** |
| Iron | Marine chronic | 26.6 | 17.7 | 7.7 | 26.6 | 17.7 | 7.7 | 98.1 | 65.4 | 28.6 | 98.1 | 65.4 | 28.6 |
| Chromium (VI) | Marine chronic | 1.7 | 1.1 | | | | | 42.5 | 28.3 | 12.4 | 18.2 | 12.1 | 5.3 |
| Arsenic | Human health[a] | 1.9 | 1.3 | | 1.1 | | | 22.6 | 15.1 | 6.6 | 13.4 | 8.9 | 3.9 |
| Copper | Marine chronic | | | | | | | 15.7 | 10.5 | 4.6 | 7.4 | 4.9 | 2.1 |
| Copper | Marine acute | | | | | | | 15.7 | 10.5 | 4.6 | 7.4 | 4.9 | 2.1 |
| Mercury | Marine chronic | 2.2 | 1.5 | | | | | 13.5 | 9.0 | 3.9 | 1.9 | 1.3 | |
| Lead | Marine chronic | | | | | | | 7.6 | 5.1 | 2.2 | 4.0 | 2.7 | 1.2 |
| Chromium | Marine chronic | | | | | | | 4.1 | 2.7 | 1.2 | 1.8 | 1.2 | |
| Mercury | Human health[a] | | | | | | | 2.3 | 1.5 | | | | |
| Chromium (VI) | Marine acute | | | | | | | 1.9 | 1.3 | | | | |

(a) Fish consumption only

Under current conditions, as many as 10 exceedences (6 marine chronic, 2 marine acute, 2 human health for fish consumption) are projected due to drilling fluid discharges of 1000 bbl/hr in 5 meters water depth; this is based on the assumption of a pH 5 extraction. This drops to 8 exceedences (6 marine chronic, 1 marine acute, 1 human health for fish consumption) under the recommended option in areas in which discharges are allowed, and, of course, no exceedences within the zone in which discharge is prohibited. Given the differences in solubility of metals, in a seawater pH extraction the current water quality impacts analysis projects 4 exceedences (3 marine chronic, 1 human health for fish consumption) at the edge of the 100 meter mixing zone for discharges in 5 meters water depth. This incidence of exceedences drops to 2 (1 marine chronic, 1 human health for fish consumption) under the proposed BAT/NSPS option for those waters in which drilling fluids may still be discharged. The incidence of exceedences in the zone in which discharge is prohibited drops to zero.

To assess potential water quality impacts for the benthos, projected pore water concentrations of pollutants in drilling fluids and cuttings discharges at the edge of the 100 meter mixing zone are also compared to EPA's marine water quality criteria/toxic benchmarks. The projections of pollutant concentrations are derived from studies in which barium levels in the sediment were measured at various distances from the discharging structures (Petrazzuolo, 1983; Boothe and Presley, 1985). The assumption is made that pollutants within drilling fluids and cuttings behave in a manner consistent with barium's behavior and would be found in the same compositional ratio (based on model well calculations of EPA/EAD) at 100 meters as they are found in the discharged fluids. A range of exceedences is projected because different levels of barium are found at the edges of the 100 meter mixing zone at the sites studied, which supported from 1 to 25 wells on a single drilling structure. Pore water quality analyses were performed for drilling fluids and cuttings discharges from exploration and development platforms, based on the mean and maximum barium concentrations projected at 100 meters from the discharge. Tables 6-7 and 6-8 provide the projections of pore water quality exceedences for drilling fluid and cuttings discharges using mean seawater extraction for trace metals and using pH 5 barite extraction for trace metals, respectively. Under current baseline conditions, for exploration wells having 1 or 2 wells, the number of exceedences projected ranges from 5 (4 marine chronic, 1 human health for fish consumption) based on mean seawater metal extraction, to 13 (7 marine chronic, 3 marine acute, 3 human health for fish consumption) based on pH 5 barite extraction of trace metals. Pore water quality was also projected at the edge of the 100 meter mixing zone of the largest development platform included in these studies — a 25-well site, sampled 5.5 years after cessation of discharge. The projected exceedences at that site range from 12 (8 marine chronic, 2 marine acute, 2 human health for fish consumption) to 20 (9 marine chronic, 8 marine acute, 3 human health for fish consumption) under mean seawater metal extraction and pH 5 barite extraction scenarios, respectively.

**Table 6-7**
**Magnitude of Pore Water Quality Exceedences Due to Drilling Fluids and Cuttings Discharges Using Mean Seawater Extraction for Trace Metals**

| Chemical | Criterion/benchmark | Exploration Wells | | | | Development Platforms | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Ba Projection[b] | | Maximum Ba Projection[c] | | Mean Ba Projection[d] | | Maximum Ba Projection[e] | |
| | | Current | BAT/NSPS | Current | BAT/NSPS | Current | BAT/NSPS | Current | BAT/NSPS |
| Iron | Marine chronic | 48.0 | 48.0 | 57.0 | 57.0 | 146 | 146 | 314 | 314 |
| Mercury | Marine chronic | 4.0 | | 4.7 | | 12.1 | 1.7 | 26.1 | 3.7 |
| Arsenic | Human health [a] | 3.4 | 2.0 | 4.0 | 2.4 | 10.3 | 6.1 | 22.3 | 13.2 |
| Chromium (VI) | Marine chronic | 3.0 | 1.3 | 3.6 | 1.5 | 9.2 | 3.9 | 19.8 | 8.5 |
| Lead | Marine chronic | 1.3 | | 1.5 | | 3.8 | 2.0 | 8.1 | 4.3 |
| Copper | Marine chronic | | | | | 2.1 | | 4.5 | 2.1 |
| Copper | Marine acute | | | | | 2.1 | | 4.5 | 2.1 |
| Mercury | Human health [a] | | | | | 2.1 | | 4.5 | |
| Iron | Marine acute | | | | | 1.5 | 1.5 | 3.1 | 3.1 |
| Nickel | Marine chronic | | | | | 1.7 | 1.7 | 3.6 | 3.6 |
| Chromium | Marine chronic | | | | | | | 1.9 | |
| Cadmium | Marine chronic | | | | | | | 1.4 | |

(a) Human health for fish consumption
(b) Derived from mean barium concentration projected at 100 m among exploration sites at Mustang Island, West Flower Garden Banks, East Flower Garden Banks, and West Cameron; samples taken 0-3 months after cessation of discharge.
(c) Derived from maximum barium concentration projected at 100 m among above exploration sites. Maximum concentration at East Flower Garden Banks, sampled 0.03 yrs after drilling.
(d) Derived from mean barium concentration projected at 100 m among development platforms at Brazos, Matagorda, Vermilion 321, High Island, and 4 sites at Baker Bank; samples taken 0-5.5 years after cessation of discharge.
(e) Derived from maximum barium concentration projected at 100 m among above development sites. Maximum concentration at Vermilion 321 -- a 25-well site sampled 5.5 yrs after drilling.

Table 6-8
Magnitude of Pore Water Quality Exceedences Due to Drilling Fluids and Cuttings Discharges Using pH 5 Barite Extraction for Trace Metals

| Chemical | Criterion/benchmark | Exploration Wells | | | | Development Platforms | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Ba Projection[b] | | Maximum Ba Projection[c] | | Mean Ba Projection[d] | | Maximum Ba Projection[e] | |
| | | Current | BAT/NSPS | Current | BAT/NSPS | Current | BAT/NSPS | Current | BAT/NSPS |
| Iron | Marine chronic | 177 | 177 | 210 | 210 | 537 | 537 | 1159 | 1159 |
| Chromium (VI) | Marine chronic | 76.8 | 32.8 | 90.8 | 38.8 | 232 | 99.4 | 501 | 214 |
| Arsenic | Human health [a] | 40.9 | 24.2 | 48.4 | 28.6 | 124 | 73.3 | 267 | 158 |
| Copper | Marine chronic | 28.4 | 13.3 | 33.7 | 15.8 | 86.1 | 40.4 | 186 | 87.1 |
| Copper | Marine acute | 28.4 | 13.3 | 33.7 | 15.8 | 86.1 | 40.4 | 186 | 87.1 |
| Mercury | Marine chronic | 24.5 | 3.5 | 29.0 | 4.1 | 74.1 | 10.6 | 160 | 22.8 |
| Lead | Marine chronic | 13.7 | 7.2 | 16.2 | 8.6 | 41.6 | 21.9 | 89.6 | 47.2 |
| Chromium | Marine chronic | 7.5 | 3.2 | 8.8 | 3.8 | 22.6 | 9.7 | 48.7 | 20.8 |
| Mercury | Human health [a] | 4.2 | | 5.0 | | 12.7 | 1.8 | 27.4 | 3.9 |
| Chromium (VI) | Marine acute | 3.5 | 1.5 | 4.1 | 1.8 | 10.6 | 4.5 | 22.8 | 9.7 |
| Iron | Marine acute | 1.8 | 1.8 | 2.1 | 2.1 | 5.4 | 5.4 | 11.6 | 11.6 |
| Nickel | Marine chronic | 1.1 | 1.1 | 1.4 | 1.4 | 3.5 | 3.5 | 7.4 | 7.4 |
| Chromium (VI) | Human health [a] | 1.1 | | 1.3 | | 3.4 | 1.5 | 7.4 | 3.2 |
| Lead | Marine acute | | | | | 2.5 | 1.3 | 5.4 | 2.9 |
| Cadmium | Marine chronic | | | | | 2.4 | 1.2 | 5.3 | 2.5 |
| Chromium | Marine acute | | | | | 1.1 | | 2.4 | |
| Mercury | Marine acute | | | | | | | 1.9 | |
| Zinc | Marine chronic | | | | | | | 1.3 | 1.3 |
| Zinc | Marine acute | | | | | | | 1.2 | 1.2 |
| Cadmium | Marine acute | | | | | | | 1.1 | |

(a) Human health for fish consumption.
(b) Derived from mean barium concentration projected at 100 m among exploration sites at Mustang Island, West Flower Garden Banks, East Flower Garden Banks, and West Cameron; samples taken 0-3 months after cessation of discharge.
(c) Derived from maximum barium concentration projected at 100 m among above exploration sites. Maximum concentration at East Flower Garden Banks, sampled 0.03 yrs after drilling.
(d) Derived from mean barium concentration projected at 100 m among development platforms at Brazos, Matagorda, Vermilion 321, High Island, and 4 sites at Baker Bank; samples taken 0-5.5 years after cessation of discharge.
(e) Derived from maximum barium concentration projected at 100 m among above development sites. Maximum concentration at Vermilion 321 -- a 25-well site sampled 5.5 yrs after drilling.

For the selected option (Zero Discharge, 3 Miles) the water quality exceedences within 3 miles drop to zero. In waters beyond 3 miles, the number of projected pore water quality exceedences drop to between 3 (2 marine chronic, 1 human health for fish consumption) for mean seawater extraction and 11 (7 marine chronic, 3 marine acute, 1 human health for fish consumption) based on the mean barium concentration at 100 meters determined for exploration wells for pH 5 barite extraction , and between 9 (6 marine chronic, 2 marine acute, 1 human health for fish consumption) and 17 (9 marine chronic, 5 marine acute, 3 human health for fish consumption) based on the maximum barium concentration determined at 100 meters for the modeled development platforms, again depending on the leachability of the trace metals.

**Produced Water**

Produced water pollutant concentrations are projected at the edge of a 100 meter mixing zone based on four selected flow rates for produced water, discharging in four different water depths -- 5 meters, 15.2 meters (median depth), 30 meters, and 60 meters. The flows used included 160, 760, 2830, and 9890 BPD, which respectively represent the 42nd, 50th, 85th, and 100th percentiles of the number of offshore structures. Projected concentrations are then compared to water quality criteria/toxic benchmarks to determine which pollutants exceed criteria/benchmarks and the magnitude of these exceedences. The magnitude of water quality exceedences (the factor by which the water column pollutant concentration exceeds the water quality criterion/benchmark value) is presented in Table 6-9 for pollutants for which at least one exceedence is projected. A blank cell indicates that the water quality criterion/toxic benchmark is not exceeded at that discharge profile.

The table indicates that at the shallowest selected water depth (5 m) and highest selected discharge rate (9890 BPD), as many as 16 water quality exceedences (9 marine chronic, 3 marine acute, 4 human health for fish consumption) are projected due to produced water discharges under current conditions. Under the recommended BAT/NSPS option and the same depth and flow conditions, the number of projected exceedences drops to 11 (5 marine chronic, 2 marine acute, 4 human health for fish consumption). The projected water column water quality benefits can be determined at the various depths and flowrates by comparing the number of projected exceedences under current conditions and under the BAT/NSPS option.

**Table 6-9**
**Magnitude of Water Quality Exceedences**
**Due to Produced Water Discharges in the Water Column**
**at Selected Discharge Rates and Water Depths**

| Pollutant | WQ Criterion | Current Conditions | | | | BAT/NSPS | | | | Current Conditions | | | | BAT/NSPS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 m Depth | | | | 5 m Depth | | | | 15.2 m Depth | | | | 15.2 m Depth | | | |
| | Flow (BPD): | 160 | 760 | 2830 | 9890 | 160 | 760 | 2830 | 9890 | 160 | 760 | 2830 | 9890 | 160 | 760 | 2830 | 9890 |
| Radium (226+228) | Human health[a] | 2.8 | 20.3 | 52.7 | 121.6 | 2.5 | 18.3 | 47.4 | 109.5 | | 4.1 | 10.7 | 29.3 | | 3.7 | 9.6 | 26.4 |
| Arsenic | Human health[a] | 2.0 | 14.5 | 37.6 | 86.8 | 1.3 | 9.3 | 24.1 | 55.5 | | 2.9 | 7.6 | 20.9 | | 1.9 | 4.9 | 13.4 |
| Benzo(a)pyrene | Human health[a] | | 6.6 | 17.2 | 39.7 | | 2.7 | 6.9 | 15.9 | | 1.3 | 3.5 | 9.6 | | | 1.4 | 3.8 |
| Nickel | Marine chronic | | 3.7 | 9.5 | 21.9 | | 2.3 | 6.1 | 14.0 | | | 1.9 | 5.3 | | | 1.2 | 3.4 |
| Copper | Marine acute | | 2.7 | 7.1 | 16.3 | | 1.7 | 4.5 | 10.4 | | | 1.4 | 3.9 | | | | 2.5 |
| Copper | Marine chronic | | 2.7 | 7.1 | 16.3 | | 1.7 | 4.5 | 10.4 | | | 1.4 | 3.9 | | | | 2.5 |
| Total Xylenes | Marine chronic | | 2.5 | 6.5 | 15.1 | | | 2.6 | 6.0 | | | 1.3 | 3.6 | | | | 1.5 |
| Benzene | Human health[a] | | | 1.9 | 4.5 | | | | 1.8 | | | | 1.1 | | | | |
| Naphthalene | Marine chronic | | | 1.3 | 3.0 | | | | 1.6 | | | | | | | | |
| Lead | Marine chronic | | | 1.1 | 2.4 | | | | 1.5 | | | | | | | | |
| Nickel | Marine acute | | | | 2.4 | | | | 1.2 | | | | | | | | |
| Ethylbenzene (C2) | Marine chronic | | | | 1.6 | | | | | | | | | | | | |
| Iron | Marine chronic | | | | 1.6 | | | | | | | | | | | | |
| Zinc | Marine chronic | | | | 1.5 | | | | | | | | | | | | |
| Zinc | Marine acute | | | | 1.3 | | | | | | | | | | | | |
| Benzene | Marine chronic | | | | 1.2 | | | | | | | | | | | | |

[a] Fish consumption only

**Table 6-9 (cont.)**
**Magnitude of Water Quality Exceedences**
**Due to Produced Water Discharges in the Water Column**
**at Selected Discharge Rates and Water Depths**

| Pollutant | WQ Criterion | Current Conditions | | | | BAT/NSPS | | | | Current Conditions | | | | BAT/NSPS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 m Depth | | | | 30 m Depth | | | | 60 m Depth | | | | 60 m Depth | | | |
| | Flow (BPD): | 160 | 760 | 2830 | 9890 | 160 | 760 | 2830 | 9890 | 160 | 760 | 2830 | 9890 | 160 | 760 | 2830 | 9890 |
| Radium (226+228) | Human health[a] | | | 3.8 | 10.3 | | | 3.4 | 9.3 | | | | 7.2 | | | | 6.4 |
| Arsenic | Human health[a] | | | 2.7 | 7.4 | | | 1.7 | 4.7 | | | | 5.1 | | | | 3.3 |
| Benzo(a)pyrene | Human health[a] | | | 1.2 | 3.4 | | | | 1.4 | | | | 2.3 | | | | |
| Nickel | Marine chronic | | | | 1.9 | | | | 1.2 | | | | 1.3 | | | | |
| Copper | Marine acute | | | | 1.4 | | | | | | | | | | | | |
| Copper | Marine chronic | | | | 1.4 | | | | | | | | | | | | |
| Total Xylenes | Marine chronic | | | | 1.3 | | | | | | | | | | | | |
| Benzene | Human health[a] | | | | | | | | | | | | | | | | |
| Naphthalene | Marine chronic | | | | | | | | | | | | | | | | |
| Lead | Marine chronic | | | | | | | | | | | | | | | | |
| Nickel | Marine acute | | | | | | | | | | | | | | | | |
| Ethylbenzene (C2) | Marine chronic | | | | | | | | | | | | | | | | |
| Iron | Marine chronic | | | | | | | | | | | | | | | | |
| Zinc | Marine chronic | | | | | | | | | | | | | | | | |
| Zinc | Marine acute | | | | | | | | | | | | | | | | |
| Benzene | Marine chronic | | | | | | | | | | | | | | | | |

[a] Fish consumption only

### 6.6.2 Produced Water Radioactivity Study

In 1991, the Agency conducted a limited study of three offshore oil and gas platforms located off the coast of Louisiana. The purpose of the study was to generate data on radium concentrations in the produced water, generate basic data on distribution of radium around the platforms in the water column and sediments and to make a preliminary estimate of risk to human health from the consumption of fish and shellfish harvested in the vicinity of produced water discharges. The results of the study may be found in EPA 1993.

### 6.6.3 Case Studies

An extensive review of the literature to identify and review potentially applicable field impact studies was undertaken by EPA to document impacts caused by drilling and production discharges. A total of 1,169 potentially relevant studies were identified for this RIA. This total includes more than 800 of the potentially relevant studies that were identified in the 1991 RIA. Industry submitted 29 studies during the comment period, while the remainder of the potentially relevant studies were either recently completed studies or were identified via more detailed literature searches than were conducted for the 1991 RIA. Only field studies that assessed environmental impacts in the offshore subcategory were summarized for this RIA (3 studies that had been included in the 1991 RIA were dropped because they addressed coastal subcategory sites). This evaluation resulted in 30 relevant studies whose summaries are included in this RIA.

Results of this updated review of potentially applicable field impact studies are discussed below. This review found that localized biological effects (<500 meters to several kilometers) were observed for drilling and production wastes, and that regional-scale impacts in sediment chemistry could be inferred. Regional-scale biological or ecological alterations, however, have not been demonstrated. Five areas of discussion relevant to the ability of these studies to demonstrate conclusive adverse environmental impacts at anything other than local scales are discussed below.

These comments are not so much directed at the studies conducted, which were often state of the art and/or resource limited, but are intended to give greater weight to the limitations of their observations of impact due to the natural, anthropogenic, technical, and cost factors that all act separately or together to reduce our ability to demonstrate the type and extent of environmental changes from discharges of this industrial subcategory. The comments below are offered to give the findings of these studies some perspective and to address the level of confidence we can have when we make or accept statements about the limited nature of the documented impacts of these discharges.

One source of concern in evaluating field studies of offshore oil and gas discharges is the type of study design used to detect potential environmental alterations. In the Gulf of

Mexico, where drilling has occurred for decades, a host of rig monitoring studies have been conducted, i.e., studies of single exploratory well operations. Several factors contribute to the reduced ability of such studies to detect changes. One factor is the absence of necessary reference values. That is, studies often did not have comparative annual or temporal reference data ("baseline" or pre-drilling conditions) to evaluate drilling programs less than a year in duration. The lack of such comparative data introduces uncertainty in any observed changes because of the potential contribution of seasonal effects. Also, in many studies spatial reference stations were either not used or, as more often was the case, an assumption was made that stations located at 1 kilometer or 2 kilometers from the discharge site could validly serve as reference stations. However, most often there was no analysis or consideration of these "reference" stations with respect to their comparability to the discharge site, their independence from drilling-related effects of the discharge site, or their independence from the effects of other nearby drilling or production activities.

Also, related to this concern about study design is the historical insistence on the selection of exploratory sites, at which only one well was drilled, for impact studies. This approach necessarily reduces our ability to detect environmental changes when compared to multiple-well development facilities. For the expedience of cost effectiveness, the effort to measure environmental changes should be pursued in cases where the potential magnitude of change would be the greatest, and thus most easily detected. Specifically, if changes due to drilling discharges were to be examined, a development drilling platform with 24+ wellslots would afford a better study site than a single-well, exploratory site because of the greatly increased pollutant loadings and concomitant potential for causing adverse environmental changes. Yet, although sediment chemistry at development sites has been studied, primarily after the fact, no benthic biological studies of development drilling have occurred in the Gulf of Mexico. One such study has been initiated offshore of southern California. A hard bottom study has begun, but a soft bottom study has been suspended because the scheduled placement of the platform has not occurred.

The second and third sources of concern in evaluating offshore oil and gas case studies are related--natural, sampling, and analytical variability is one concern; statistical power is the other. Because of high levels of natural, sampling, and analytical variability and high costs inherent to marine field studies, the statistical power of such studies is limited. Thus, many studies have shown "no effect" or have shown statistically significant adverse effects to a limited spatial extent (several hundred meters). These statements, however, also should be considered in light of the limiting question: "How large an effect could be observed?" The answer for most studies is that the magnitude of change that would be required in order to statistically observe such a change have ranged from "large" for chemistry data to "very large" for biological data. For example, one of the most sophisticated and well-funded studies conducted sampled 60 photoquadrants per station per cruise. However, because of the combined types of variability involved, this relatively large effort resulted in the ability of the study to statistically detect 70 percent changes or greater (reductions) in coral coverage. This level of detectability gives some measure of definition to and confidence in the conclusion that "No statistically significant changes were noted."

The fourth source of concern in evaluating these case studies is the issue of "background" or the reference value against which changes are measured. This consideration applies both to the spatial and temporal changes. For example, drilling fluid components have been shown to be regionally dispersed: studies have found large mass transport (up to 95 percent of discharged particulates) beyond 3 kilometers of the discharge site and document the transport of solid components at least 35 miles from the discharge point. Thus, defining sampling stations at 1 kilometer or 2 kilometers distant from a discharge site as reference stations may not be a very sound assumption. In studies thorough enough to address the issue of nearby drilling activity, the study invariably identifies other previous or concurrent well-drilling operations, ranging from single wells being located from 500 meters to a few kilometers from the discharge point to multiple (225) wells drilled within a 10-mile radius of the study area. Both situations cast serious doubt on the establishment of a true "background" level for comparative purposes.

The fifth and last source of concern in evaluating any field impact study is the issue of confounding factors, which is an inherent problem of all field studies and has accounted for some uncertainty concerning environmental changes related to oil and gas discharges. This factor was and is a significant one in the Gulf of Mexico, where heavy ship traffic, and commercial fishing, and the large influence of the Mississippi River have confounded study plans and the interpretation of their results.

Given the wide distribution of mud components, the situation is akin to that of acid precipitation impacts assessment -- there are great difficulties (technical and financial) in measuring low-level, regional-scale effects at meaningful levels of statistical power and in ascribing cause-effect relationships. Assessing large scale, low-level impacts is very difficult in such cases. When even large effects (e.g., >50 percent) may often go unnoticed or unprovable, assessing more subtle changes is nearly impossible in any way other than extrapolation. Nonetheless, total impacts at the 1-10 percent effect level that occur over many square kilometers, and which cannot be statistically resolved and thus are not documented, may easily exceed the total impacts associated with changes at the 50-100 percent effect level that can be documented within a few hundred meters of a discharge.

In view of the above discussion, it is perhaps surprising to find any evidence of documented adverse impacts due to drilling and production wastes. Evidence is largely based on alteration of pollutant concentrations in sediments, which although easier to demonstrate, is of uncertain ecological significance. However, localized adverse biological effects have been noted; these findings should be appropriately weighted in light of the considerations discussed above.

## Results

### Drilling Fluids and Cuttings

A review of the available literature identified 23 field impact studies that were analyzed for their findings on the environmental effects of drilling fluids and cuttings discharges. A synthesis of this review is provided below. This review suggests that these discharges are capable of producing localized impacts. These discharges have not been shown to result in regional-scale impacts; however, in view of comments discussed above these studies may not be sufficient to conclude regional-scale impacts are not occurring. A tabulated summary is provided in Table 6-10.

Modeling of drilling fluid plume dispersion and field studies of discharge plumes indicate that, in general, plume dispersion is sufficient to minimize water quality impacts and water column toxicity concerns in energetic, open waters of the OCS. This generalization does not necessarily extend to shallow water or to the benthos (see below).

In shallow water areas (i.e., less than 5 meters), field data on plume dispersion are limited, and may not be sufficient to conclude that water column effects present only a minor potential concern. Some modeling data suggest water quality and toxicity parameters could be adversely affected under shallow water conditions. In water depths of less than 5 meters, the reliability of most models that are suitable for application to drilling fluid discharges comes into question. Also, resuspension is not addressed by these models and becomes a relatively more important process in shallow water. Thus, the potential water column impacts of those discharges in shallow waters is not known with any degree of confidence.

The principal impacts of these discharges are benthic effects, due to the very high solids content of drilling fluids (10 percent to 70 percent solids by weight). Benthic community changes have been hypothesized to be due largely to physical effects. However, no studies have quantitatively discriminated between impacts from physical effects (altered sediment texture) and chemical effects (sediment-associated toxics). It is reasonable to assume that both effects occur, and that either could predominate, depending on the characteristics of the discharged mud.

**Table 6-10**
**Marine Studies of Drilling Fluids Impacts[17]**

| Study Site | Site Description | Water Depth (m) | Observed Impacts | | Author's Comments |
|---|---|---|---|---|---|
| | | | Sediment | Biota | |
| Northwestern Gulf of Mexico<br>(Boothe and Presley, 1989) | OCS | 13-102 | Elevated: Ba up to 3000 m, Pb (3.8x) @ 500 m, hydrocarbons (5x) @ 250 m, also Cd, Cu, Zn | ND[18] | |
| Mustang Island Block 792<br>Northwestern Gulf of Mexico<br>(Boothe and Presley, 1985) | OCS | 24 | Distance-dependent elevation of Ba and Cr up to 1000 m; elevated Pb and Ni | Elevated Cd, Cu, Fe in shrimp to 1000 m | Metals in shrimp and sediment Pb and Ni thought not to be distance-dependent |
| Mustang Island Block A-85<br>Northwestern Gulf of Mexico<br>(Gettleson and Laird, 1980) | OCS | 72-77 | Distance-dependent elevation of Ba and Cr out to 2400 m | TV cameras and still camera surveys found no apparent changes in composition of infaunal activity | Cr values elevated further than 2400 m may be due to other discharge sites |
| South Texas Shelf<br>Gulf of Mexico<br>(US DOI, 1976) | OCS | 36 | ND | Declined abundance up to 1000 m (benthics)<br>Cr, Cu, Fe, Ni, V uptake (squid) | |
| Matagorda Island Area, Block 622<br>Gulf of Mexico<br>(CSA, 1989a) | OCS | 24-26 | Elevated Ba (2x background) up to 5000 m; elevated Cr to 3000 m; elevated hydrocarbons out to 25 m | Diversity of macroinfaunal assemblages increased with distance from discharge | Balanced biological community assemblage near outfall |

17 Bibliographic information for all studies appears in Appendix A.

18 ND = no data

**Table 6-10 (cont.)**
**Marine Studies of Drilling Fluids Impacts**

| | Site | Water | Observed Impacts | | |
|---|---|---|---|---|---|
| Study Site | Description | Depth (m) | Sediment | Biota | Author's Comments |
| Mid-Atlantic<br><br>(EG&G, 1982) | OCS | 120 | Physical/chemical changes @ 800 m | Altered communities @ 300 m<br><br>Uptake of Ba, Hg, Pb in mollusk | Reanalysis of data showed Hg increase due to an artifact |
| Beaufort Sea<br><br>(Crippen and Hold, 1980) | Canadian Waters | 7 | Elevated As, Cd, Cr, Hg, Pb, and Zn | No bioaccumulation observed based on linear regressions; low benthic densities, and biomass | Biological impairment primarily attributed to gravel island construction and erosion |
| Beaufort Sea<br><br>(Boehm et al., 1990) | Territorial Sea | 1.7-24 | Sediment trace metals elevated compared to prior regional study.<br><br>Saturated hydrocarbons lower than in prior regional study. PAHs - no change from prior study; saturated hydrocarbon and PAH showed between station differences. | No changes detected.<br><br>Elevated levels of PAH in bivalve tissue | Sediment trace metal and saturated hydrocarbon mainly due to increases, changes in analytical procedures<br><br>Differences in sediment saturated hydrocarbon and PAH levels ascribed to grain size distribution (depositional environment). Elevated PAHs in bivalve tissue not ascribed to drilling wastes because of absence of petroleum marker compounds. |

**Table 6-10 (cont.)**
**Marine Studies of Drilling Fluids Impacts**

| Study Site | Site Description | Water Depth (m)[†] | Observed Impacts | | Author's Comments |
|---|---|---|---|---|---|
| | | | Sediment | Biota | |
| Beaufort Sea (Snyder-Conn et al., 1990) | OCS | 1-3 | Generally, distance-dependent elevations of Al, As, Ba, Cr, Pb, and Zn; also some patchiness observed | | Elevated levels of Ba, Cr, Pb, and Zn at certain stations at all 3 discharge sites and of Al at 1 of 3 sites; persisted 2 to 4 years after discharge. Patchiness ascribed to in-place melting of ice-rafted muds or reworked sediments |
| Beaufort Sea (Sohio, 1981) | State Waters[19] | 2-20 | No observed effects between pre- versus post-discharge surveys | Simulated above-ice disposal site study; reduced abundance: 99% 1st year, 95% 2nd, 64% 3rd using artificial substrate trays | |
| Beaufort Sea (Sohio, 1982) | State Waters[2] | 1-4 | Ba, Cd, Cr, Cu, Pb, and Zn variously increased at various above-ice disposal sites | Individual trace metal levels in biota show variable pre- versus post-discharge results in individual species | Only Ba, Cr, and Zn attributed to drilling wastes<br><br>Bioaccumulation difficult to assess due to small sample sizes |

19 The administrative status of the waters where these study sites are located is undecided with respect to whether the sites are in the Territorial Sea or are inland waters; however, the site characteristics are generally typical of Beaufort Sea offshore subcategory areas.

**Table 6-10 (cont.)**
**Marine Studies of Drilling Fluids Impacts**

| Study Site | Site Description | Water Depth (m) | Observed Impacts: Sediment | Observed Impacts: Biota | Author's Comments |
|---|---|---|---|---|---|
| Alabama State Waters, Block 132 (CSA and BV&A, 1989b) | Territorial Sea | 40-60 | Elevated Ba to 500 m; 2-5 fold increase at 1000 m<br>Elevated Cd, Pb, Cr, Fe behind barrier islands<br>Elevated oil and grease between pre-drilling and post-drilling surveys | Elevated As in oysters behind barrier island | Elevations of metals in sediment and biota not considered to be related to drilling discharges; study site located in proximity to dredge spoil disposal area |
| Pensacola Area, Block 996 Gulf of Mexico (CSA, 1989b) | OCS | 50-60 | Increased Ba deposition to 2000 m | Reduced bryozoan coverage within 2000 m of discharge | |
| Alabama State Waters, Block 132 Gulf of Mexico (CSA and BV&A, 1989a) | Territorial Seas | 40-60 | Elevated Cd, Hg, Ba during drilling | ND | |
| Gainesville Area, Block 707 Gulf of Mexico (CSA, 1988; Thompson et al., In: Engelhardt et al. (Eds.), 1988) | OCS | 20-25 | ND | Burial by cuttings at 25 m; 14% decrease in algal coverage at 500 m algal; coverage increased 14% at reference point<br>Seagrass eliminated within 300 m of drill site; growth inhibited beyond 300 m to a distance of 3.7 km | Some aspects of the discharge of drilling effluents impacted the growth of the seagrass around the discharge site; impacts considered ephemeral because recolonization occurred at survey 2 years later. |
| East Breaks Area, Block 166 Gulf of Mexico (CSA, 1986a) | OCS | 200-375 | Elevated Ba at edge of bank (approx 3500 m) | ND | |

Table 6-10 (cont.)
Marine Studies of Drilling Fluids Impacts

| Study Site | Site Description | Water Depth (m) | Observed Impacts | | Author's Comments |
|---|---|---|---|---|---|
| | | | Sediment | Biota | |
| West Cameron Area, Block 663<br>Gulf of Mexico<br>(CSA, 1986b) | OCS | 130-160 | Elevated Ba at 4000 m | ND | |
| Central Gulf of Mexico<br>(Tillery and Thomas, 1980) | OCS | -- | Concentration gradients decreasing with distance for Ba, Cd, Cr, Cu, Ni, Pb, V, and Zn at one or more platform | Cu, Fe, and Ni in sheepshead were higher than similar organisms in Gulf of Mexico by 1.9-fold, 2.3-fold, and 2-fold;<br>Cu and Fe in spadefish were 2.2-fold and 2.1-fold higher | Mobility of species and the limited knowledge of life cycles prevented correlation of trace metals in tissues with discharges from oil and gas structures |
| South Marsh Island Area, Block 161<br>Gulf of Mexico<br>(CSA, 1984) | OCS | 80-88 | Ba increase to 3400 m<br>Ba increase at approx. 3 mi | ND | |
| Mustang Island Area, Block A-85<br>Gulf of Mexico<br>(CSA, 1982) | OCS | 70-90 | Ba increased during drilling to 1506 m; cores showed Ba enrichment due to previous drilling | ND | |
| Georges Bank<br>North Atlantic Offshore Area<br>(Bothner, 1985) | OCS | 55-175 | 25% of barite deposited within 6 km; Ba transport to 35 km | ND | |
| Santa Maria Basin<br>Southern California Offshore Area<br>(Steinhauer, 1990) | OCS | 90-410 | | Sediment flux related to decreased soft coral coverage; statistical power of study limited to 70% or greater | |

The most clearly documented point source effect of these discharges has been alterations in sediment barium (Ba), a tracer for drilling fluids solids. (Because all metals except chromium are transported in the same way as Ba, Ba is used as an indicator of the presence of other toxic metals.) Observations on sediment alterations from field studies of both single-well and multiple-well facilities include:

- Increases in Ba levels of 2-fold to 100-fold above background at the discharge site, with typical values of 10-fold to 40-fold
- Average measured background levels are reached at 1,000-3,000 meters; single transect values have been elevated at up to 8,000 meters
- Increases in Ba fall off logarithmically with distance from the discharge site; regression analyses project background levels are achieved at 2,000-20,000 meters.

Increases in a suite of other trace metals associated with drilling fluids (As, Cd, Cr, Cu, Hg, Pb, Zn) have also been variously observed. These increases:

- Are of a lower magnitude than seen for Ba (generally not more than 5- to 10-fold above background)
- Are more spatially limited, when compared to background levels, than seen for Ba (generally within 250-500 meters of the discharge site)
- Are noted consistently as a group but are variable for any specific chemical among the various studies.

Observations of the long-term, regional scale fate of drilling fluid solids indicate that the materials may be very widely dispersed over large areas. Dispersion is related directly to bottom energies of the receiving water (shallow waters being more energetic than deeper waters).

- In shallow water (13-34 meters) only about 6 percent of discharged Ba was accounted for within a 3 kilometer radius of three discharge sites; in contrast, for three discharge sites in deeper waters (76-102 meters), 47 percent to 84 percent of the discharged Ba was found within a 3 kilometer radius.
- At these same six sites, Ba concentrations 3 kilometers from the discharge sites ranged from 1.2 to 2.9 times predicted background at the shallow

water sites and at the deep water sites ranged from 2.0 to 4.3 times predicted background.

- Drilling fluid solids can be transported over long distances (35-65 kilometers) to regional areas of deposition, albeit at low concentrations, based on a study of eight wells.

Biological effects have routinely been detected statistically at distances of several hundred meters. Less routinely, effects have been observed at greater distances (1-2 kilometers). These effects more typically are found to fall into one of two categories: those that are statistically significant at the level of individual stations but cannot be integrated into an easily defined pattern or those that are not statistically significant at the level of individual stations but do form significant correlations at larger levels of integration.

Specific observations are as follows:

- The most affected community appears to be seagrasses. Data on seagrasses are limited to a single study of a seagrass species near its biographic limits, but it documented damage much more severe than in any other study to date. Seagrasses were completely absent within 300 meters of the discharge site, and were only 25 percent recovered at a distance of 3.7 kilometers from the discharge site.

- Fauna also have been affected, including changes in abundance, species richness (number of species), and diversity. Taxa include annelids, mollusks, echinoderms, and crustaceans.

- Alterations to benthic community structure are virtually always observed within 300 meters of the discharge site. However, changes have been noted in some cases at 500-1,000 meters.

- Changes have been ascribed to purely physical alterations in sediment texture and to platform-associated structural effects (i.e., from the fouling community — marine life fixed to underwater structures) more frequently than to toxic effects. These causes are plausible, but there are no systematic studies of their relative contribution to observed impacts. Also, alterations due to physical causes may not be any less adverse than those due to toxic pollutants, and may be more persistent.

- Bioaccumulation has been observed for a suite of metals (Ba, Cd, Cu, Hg, Ni, Pb, V), but the magnitudes of this effect are usually low (i.e., less than a factor of 5).

- Elevated Cd, Cu, and Fe levels in white shrimp (commercially important) out to 1000 m.

**Produced Water**

When viewed as a whole, limited field studies of the impacts of produced water show that their contaminants can accumulate in sediments, disturb benthic fauna, and can potentially bioaccumulate. Factors that influence the degree to which the affects will be observed include site-specific parameters such as discharge volume, effluent contaminant levels, water depth, and hydrologic mixing. However, these factors apparently operate in a complex manner, and cannot easily be used to predict the potential extent of contaminant changes.

A review of the seven studies indicates that localized benthic impacts occur and may extend up to several kilometers, although water column impacts to biota have been observed beyond 500 m in a high energy environment. A finding of this review is that such impacts can be highly dependent on the specific characteristics of the site. A tabular summary of the findings of these studies is presented in Table 6-11 and is discussed below.

The high energy environment mentioned above, was the subject of two recently completed studies of a produced water discharge to the California territorial sea. Produced water is discharged from a diffuser located in 10-12 meters of water, about 200-300 m from shore, at a rate of 16,000 bbl/day. Both studies observed impacts to biota near the outfall and to distances up to 1000 m. One study documented benthic community density as inversely proportional with distance from the outfall with the exception of polychaetes, typically an opportunistic species. Chronic (life-cycle) impacts were highly correlated to distance from the outfall for mussels (out to 1000 m or greater).

**Table 6-11**
**Marine Studies of Produced Water Impacts[20]**

| Study Site | Site Description | Water Depth (m) | Observed Impacts | | Author's Comments |
|---|---|---|---|---|---|
| | | | Sediment | Biota | |
| Eugene Island, Block 105 Offshore Louisiana<br><br>(Neff, Sauer, and Maciolek, 1988) | OCS | 8.5 | Gradient of decreasing total hydrocarbon concentrations; PAH elevations <100 m; low level steranes, triterpanes, and phenols near platform | Faunal density decreased with distance from discharge, but diversity increased | Benthic communities characteristic of those under natural environmental or pollutant stress; sediment grain size most important factor in community structure<br><br>Unable to attribute steranes, triterpanes, and phenols in sediments to produced water |
| South Texas Shelf<br><br>(Middleditch, 1981) | OCS | 20 | Concentration gradients decrease with increasing distance from discharge for alkanes in surficial sediments | Depressed abundance within immediate vicinity of platform | Benthic impacts ascribed to scouring beneath platforms; not discharge related |

20 Bibliographic information for all studies cited appears in Appendix A.

**Table 6-11 (cont.)**
**Marine Studies of Produced Water Impacts**

| Study Site | Site Description | Water Depth (m) | Observed Impacts | | Author's Comments |
|---|---|---|---|---|---|
| | | | Sediment | Biota | |
| Eugene Island, Block 18 Offshore Louisiana<br><br>(Rabalais et al., 1991) | Territorial Sea | 2-3 | Elevated Ba, Al, Cr, V, Zn, and Cd detected out to 1000 m<br><br>Distance -dependent PAH elevations to 1000 m; alkylated PAH elevations to 250 m<br><br>Sediment cores indicated $Pb^{210}$ up to 1.4-2.1 times higher than "natural" waters | Reduced numbers of species and individuals (below back-ground) at discharge and out to 300 m | Differences in biological as-semblages were related to distance from discharge, not due to sediment grain size or organic content; no seasonal differences |
| South Timbalier, Block 52 Platform "C"<br><br>(Steimle Associates, 1992) | OCS | 18 | Elevated radionuclide ($Ra^{226}$, $Ra^{228}$, $Pb^{210}$) levels out to 1000 m | Elevated radionuclide ($Ra^{226}$, $Ra^{228}$) levels in mollusks and crustaceans sampled from platform legs | $Pb^{210}$ levels in biota were all below the lower level of detection. Sediment grain size and total organic content of sediments also evaluated at each sample station. |

**Table 6-11 (cont.)**
**Marine Studies of Produced Water Impacts**

| Study Site | Site Description | Water Depth (m) | Observed Impacts | | Author's Comments |
|---|---|---|---|---|---|
| | | | Sediment | Biota | |
| Eugene Island, Block 189<br><br>(CSA, 1992) | OCS | 22 | Concentrations of radionuclides ($Ra^{226}$, $Ra^{228}$, $Pb^{210}$) above detection limits occurred out to 2000 m | Spider crab--<br>tissue: $Ra^{228}$ above DL[21]<br>shell: $Ra^{226}$ and $Ra^{228}$ above DL to 2000 m<br>Barnacles--<br>$Ra^{228}$ above DL at all 4 depths (7-40 ft) at 2 platform legs and 2 depths at a third; $PB^{210}$ above DL at 1 depth on 1 platform leg<br>Stone crab--<br>$Ra^{228}$ above DL at all 4 depths of 1 platform leg and at 2 depths on another<br>Red Snapper (bone sample)--<br>$Ra^{228}$ above DL | Concentrations in sediments increased with distance from discharge<br><br>Sediment grain size also analyzed; coarser sediments (sand and gravel) occurred <50 m from platform (possibly due to barnacle shells); silt and clay predominant >50 m from platform |

21 DL = Detection Limit

**Table 6-11 (cont.)**
**Marine Studies of Produced Water Impacts**

| Study Site | Site Description | Water Depth (m) | Observed Impacts: Sediment | Observed Impacts: Biota | Author's Comments |
|---|---|---|---|---|---|
| Ship Shoal, Block 169<br><br>(CSA, 1992) | OCS | 17 | Concentrations of $Ra^{226}$ above detection limits out to 2000 m, $Ra^{228}$ and $Pb^{210}$ out to 300 m | Spider crab--<br>tissue: $Ra^{226}$ and $Ra^{228}$ above DL to 300 m<br>shell: $Ra^{226}$ above DL to 100 m; $Ra^{228}$ above DL to 2000 m<br>Catfish (tissue)--<br>$Ra^{228}$ above DL to 300 m<br>Barnacles--<br>$Ra^{226}$ above DL at 10 ft depth<br>on 1 leg; $Ra^{228}$ at 40 ft depth on 1 leg<br>Stone crab--<br>$Ra^{228}$ above DL at 40 ft depth<br>of 1 leg and at 3 depths on another leg<br>Red snapper (fillet, skin, and bone samples)--<br>$Ra^{228}$ above DL<br>Bluefish (skin sample)--<br>$Ra^{228}$ above DL | Sediment $Ra^{226}$ was only radionuclide consistently above detection limits<br><br>Sediment grain size was also analyzed; stations < 20 m of platform had higher % gravel than other stations; stations >20 m had similar % sand-silt-clay; significant amounts of barnacle shells found near platform |

Table 6-11 (cont.)
Marine Studies of Produced Water Impacts

| Study Site | Site Description | Water Depth (m) | Observed Impacts | | Author's Comments |
|---|---|---|---|---|---|
| | | | Sediment | Biota | |
| Santa Barbara Channel, California<br><br>(Osenberg et al., In Press, 1992) | Territorial Sea | 10-12 | % organic matter ranged from 1.05 - 1.86% ($\bar{x}$ = 1.29); % silt-clay ranged from 4.4-17.8% ($\bar{x}$ = 10.2); neither showed a gradient with respect to the outfall | Nematode density inversely proportional to distance from outfall; Echinoderms, larval crustaceans, nemertean worms, and polychaetes densities were directly proportional to distance from outfall; impacts to 100 m<br><br>Impacts on mussel performance were highly correlated to distance from outfall; observed at least to 100 m and perhaps >1000 m | High energy ocean discharge; no other discharges or natural disturbances nearby (at least several km)<br><br>Performance impacts may occur up to 1 km; study had no stations, therefore no resolution between 100 and 1000 m |
| Santa Barbara Channel, California<br><br>(Raimondi and Schmitt, In Press, 1992) | Territorial Sea | 10-12 | ND | Acute and chronic effects to pre-competent Red Abalone larvae; survivorship during critical developmental stages (e.g., settlement) reduced by 50% within 10 m of outfall; 30% within 100 m.<br><br>Distance-dependent reductions in completion of larval metamorphosis was observed at 5 m and 100 m, but not as far as 500 m from outfall | Competent larvae was unaffected by distance from outfall; causal effects determined by field study during period of no discharge<br><br>Laboratory experiment was also used to validate field observations; larval settlement reduced 15-20% at 0.01-0.1% produced water |

The other study of this site identified acute and chronic toxic effects to pre-competent (the initial 5-7 days of the planktonic phase) Red Abalone larvae. Survivorship during the critical developmental stage referred to as settlement by competent larvae (the 2-5 week period following the initial planktonic phase) was reduced by 50 percent within 10 m of the outfall and 30 percent within 100 m. Larvae that were released in the competent phase were unaffected by distance from the outfall, demonstrating the effect of the discharge on the critical pre-competent life stage. Distance-dependent reductions in the completion of larval metamorphosis were observed between 5 m and 500 m from the outfall. These results were corroborated by laboratory analysis, using appropriately diluted aliquts of the same produced water.

A study of a produced water discharge site in the Gulf of Mexico (Eugene Island, Block 18) was completed in 1991. The discharge of approximately 21,000 bbl/day of produced water into 2-3 m of water was evaluated. Elevated Ba, Al, Cr, V, Zn, and Cd was detected in sediments out to 1000 m from the outfall. PAH values were elevated in a distance-dependent relationship from the outfall out to 1000 m. Sediment cores indicated that radionuclides ($^{210}Pb$) were elevated from 1.4 to 2.1 times higher than "natural" waters.

Biota were impacted to distances up to 300 m from the outfall. Reductions in both the numbers of species and individuals were documented to be below background levels. The author of the study noted that differences in biological assemblages were related to distance from the discharge, not to sediment grain size, organic content, or seasonal differences.

Two production platform sites located on the upper continental shelf were studied in 1986. One facility discharged 2,750 bbl/day into 1.8-3 m of water, while the other facility discharged 1,570 bbl/day into 8 m of water. It was found that at the deeper water (8 m) site, background levels of petroleum hydrocarbons were found at all but the 20 m sampling sites, although sediment hydrocarbon levels could also be interpreted as indicative of a patchy distribution of sediment contamination. At the shallow water (1.8-3 m) site, elevated PAH concentrations occurred from 300-1,000 m from the outfall. Sediments were particularly contaminated with phenanthrene, exhibiting average levels at 100 m sampling stations at least 85 times background (i.e., 85 x the average level observed at the 1,000 m stations). Interpretation of data from this study is complicated by the occurrence of two other produced water outfalls and a development drilling platform within the sampling grid at one of the study sites.

A study of a production platform located in 20 meters of water on the South Texas OCS was conducted. The study site was located in a highly active oceanographic area. Current data and surficial sediment data indicate considerable movement of fine-grained material at the site, serving as a potential mechanism for transporting contaminated sediments from the site. Also, the discharge rate at the platform was relatively low (600 bbl/day) compared to values observed in EPA's 30 platform study (a mean of 4,011 bbl/day excluding central processing facilities, a mean of 9,577 bbl/day including such facilities).

Alterations in benthic fauna (depressed abundance) were observed at stations located within 100 meters of the platform. Also, petroleum hydrocarbon levels in fish tissues collected near the platform were measured in two species that actively fed on the platform's fouling community, one species that fed much less on the community, and one highly mobile species unlikely to feed on the fouling community. Tissue levels of petroleum hydrocarbons corresponded to the use of the fouling community as a food source.

Two case studies were completed in early 1992 that focused on documenting the extent of radionuclide contamination in sediment and biota near three produced water outfalls on the central Gulf of Mexico OCS (Steimle Associates, 1992; Continental Shelf Associates, 1992). Impacts detected in these studies at the Eugene Island Block 189, Ship Shoal Block 169, and South Timbalier Block 52 platforms are included in Table 20.

A screening-level risk assessment commissioned by the U.S. Department of Energy was conducted using, in part, data from these two studies (Brookhaven National Lab, 1992). Two analytical approaches were used in the analysis: a direct assessment using measured concentrations of radium in organisms, and a predictive modeling approach.

For platform workers, the direct risk assessment found potential individual lifetime risks that may exceed $1 \times 10^{-4}$ for only one of the maximum fishing platforms. This estimate ($<1.2 \times 10^{-4}$) is inflated because the calculations were based on whole fish. In the predictive assessment for platform workers, one scenario had predicted individual lifetime risks greater than $1 \times 10^{-4}$ ($1.1 \times 10^{-4}$) the 25,000 bbl/day discharge, with the maximum radium concentrations (600 pCi/1 Ra-226 and 600 pCi/1 Ra-228), and the maximum number of fishing days (200).

The direct risk assessment for recreational fisherman estimated potential individual lifetime risks for the three offshore outfalls that ranged form $1.4 \times 10^{-5}$ to $<3.3 \times 10^{-5}$ for fishermen ingesting 20 g per day, and $<6.4 \times 10^{-5}$ to $<1.5 \times 10^{-4}$ for the ingestion rate of 93.3 g/day. Only one value may represent risk greater than $1 \times 10^{-4}$ (South Timbalier, maximum ingestion rate, $<1.5 \times 10^{-4}$), and this risk estimate is inflated because it is based on whole fish.

Based on the limited data available, and the conservative assumptions and worst-case modeled scenarios presented, lifetime risks to the most sensitive subpopulations (platform workers and recreational fishermen) appear to be small. Risks are not expected to exceed 1 x $10^{-4}$, even under worst-case situations. Background concentrations of radium are expected to present a lifetime risk of approximately 8 x $10^{-7}$ to 4 x $10^{-6}$ for platform workers and 5 x $10^{-7}$ to 2 x $10^{-6}$ for recreational fishermen.

### 6.6.4 Other Non-Monetized Benefits

The non-quantified, non-monetized benefits assessed in this RIA are increased recreational fishing use and enjoyment, increased commercial fishing benefits, improved aesthetic quality of the near-platform waters, and benefits to threatened or endangered species that inhabit the Gulf of Mexico.

While no direct changes are anticipated in the abundance or composition of the offshore recreational fishery, recreational fishing benefits may accrue to society because of the regulations in three indirect ways:

- There are no data to indicate the degree to which fishing levels or utility may be constrained by the perception that the Gulf's fisheries, particularly for those species caught near rigs, pose a risk to health; to the extent the regulation changes those perceptions, recreational fishing values may increase.

- To the degree that the regulation improves the aesthetic quality of the near-platform waters frequented by anglers, they may increase the average consumer surplus associated with a fishing day, and/or might induce higher levels of participation.

- While no analytically discernable direct improvements to the target fishery are attributable to the regulations, it is conceivable that more subtle ecosystem impacts may arise that could enhance the fishery. (For example, the guidelines may reduce pollutant concentrations, positively affect lower-level organisms in the food chain, improve reproductive success, increase the ability to avoid predation, improve growth.)

Absent data to further evaluate these hypotheses, any prediction of potential recreational fishing benefits is speculative. However, given the extremely high value of the activity, if the regulations do have any positive impact on recreation, then the benefits will be appreciable. For example, even if the impacts are limited to only a 0.1 percent increase in recreational value, the regulation's recreational fishing benefits would still be on the order of $12 to $14 million per year (RCG/Hagler, Bailly, 1991).

Other potential benefits not related to health risk reductions include nonuse benefits associated with environmental improvements in water quality, which have been shown to be potentially significant in magnitude. A review of the literature by Fisher and Raucher (1984) revealed that in freshwater settings such benefits were generally no less than 50 percent of the associated recreational values. Additionally, the regulation may have a beneficial impact on two federally-designated endangered species, the Kemp's Ridley Turtle and the Brown Pelican, for which the Gulf of Mexico is part of their habitat. Although there are no data to indicate adverse impacts on these species, given that the bioconcentration of pollutants in fish tissue is sufficient to pose some risks to human health, it is possible that the regulations will reduce stresses on these endangered populations.

Finally, the commercial fishery in the Gulf of Mexico is a vital component of the regional economy. While there are data to suggest correlations between oil and gas extraction activities and fisheries catch statistics, definitive causal relationships cannot be developed. As described above for recreational fishing, absent evidence of fishery mortality associated with offshore oil and gas effluent, no direct links can be established between the proposed regulations and commercial fishery benefits. However, indirect impacts on the size or composition of the fishery, or on consumer demand for Gulf fishery products, may generate commercial fishery benefits. There are no data with which to evaluate the likelihood or potential magnitude of such benefits.

## 6.7 LIMITATIONS

A number of significant categories of benefits have been excluded from this analysis. First, the monetized health benefits (Avanti Corporation, 1993; RCG/Hagler, Bailly, Inc., 1993) are based on a limited set of contaminants controlled by the regulation (selected carcinogens and lead) for which the necessary effluent, transport and fate, and health effects data exist. Second, for lead, the Agency has only been able to address a limited set of the adverse health impacts associated with the contaminant. Third, those lead-related health risks that have been quantified and valued in this section have been applied to small subsets of the exposed population. Finally, some of the valuation concepts applied are highly conservative (e.g., valuing reductions in some adverse health impacts according to the medical costs avoided rather than the willingness-to-pay to avoid the health effect).

Predictions could not be made to quantify direct impacts of current discharges and proposed regulations on composition and abundance of finfish and shellfish population, recreational fishing and other recreational activities, commercial fishing, or nonuse benefits. Therefore, the quantified, monetized results in this RIA focus almost exclusively on the benefits associated with a limited set of health risk reductions.

# 7.0 OVERVIEW OF FULL SOCIAL BENEFITS AND COSTS

As a supplement to the analysis of compliance costs and selected health-related benefits presented in Chapters 5 and 6, this chapter provides an overview of a full social accounting of benefits and costs of the effluent guidelines for offshore oil and gas. Table 7-1 provides an overview, or "ledger" of these social costs and benefits, with empirical and conceptual information included as available or appropriate. The text below provides brief descriptions of these social costs and benefits. Where applicable, the text briefly identifies issues related to the conceptual appropriateness of including these items in a proper economic analysis. Also described, as applicable, are empirical estimates of their magnitude.

## 7.1 SOCIAL COSTS

Cost estimates for many categories of social costs are available in the Economic Impact Analysis of Effluent Limitations Guidelines (ERG, 1993a).

### 7.1.1 Direct Compliance Costs

As estimated for the RIA effort, these include the expected capital and O&M costs borne by the industry to comply with the selected regulatory options (inclusive of the direct costs of barging and land disposal of muds and cuttings). These costs are estimated to range from $32.2 to $121.9 million per year, varying according to the number of existing and new projects required to comply with the guidelines in each year.

### 7.1.2 Welfare Effects of Increased Compliance/Production Costs

For *producer* surplus, a loss to domestic producers may be realized to the extent the supply (marginal cost) curve is shifted upward (i.e., inward) due to the guidelines.

For *consumer* surplus, given the size of the competitive global market for oil and gas, global market prices are not likely to be impacted by the regulations. Therefore, no price impacts would be anticipated on final oil and gas products domestically. Hence, no consumer surplus impacts are anticipated.

**Table 7-1**
**Social Benefit-Cost Ledger for Offshore Oil and Gas Effluent Guidelines**

| Social Costs[1] | Social Benefits |
|---|---|
| 1. Direct compliance costs: $32.2 to $121.9 million per year<br>2. Welfare effects of increased costs<br>a) Producer surplus loss (decrease in revenues in excess of marginal costs [supply curve]): projected total 15-year production loss of 15 million BOE<br>b) Consumer surplus (no impact anticipated — no change in world market price of oil and gas)<br>3. Regional/sectoral employment loss (job dislocation from reduced platforms activity)<br>a) Direct job losses: because regulations would be expected to cause shutdown in only very few cases, job loss is expected to be minimal<br>b) Impacts on support industries (e.g., rig construction and maintenance services, geophysical and other services): since well operations purchase and operate disposal equipment, they are anticipated to bear costs (included under Compliance Costs); therefore, no negative impacts on service industries are anticipated<br>4. Government revenues lost (pecuniary impact)<br>a) Federal — tax revenues lost: $12 to $41 million per year; loss from lower lease bids: $22 to $72 million per year<br>b) State — loss from lower lease bids: $1.9 to $6.3 million per year<br>5. Balance of trade/energy security (increased U.S. market share for imported oil and gas): because production declines over the entire 15-year period do not exceed 0.2 percent, the change in the balance of trade expected from this regulatory effort will be insignificant relative to other factors<br>6. Risks and costs posed by transport and disposal of muds and cuttings<br>a) Barge traffic<br>b) Transfer<br>c) Land disposal<br>7. Lost potential to create aquatic habitat as cuttings that would otherwise be disposed of offshore are transported to land | 1. Monetized direct health risk reduction benefits — lead and cancer-related health effects for subcategories considered: $28.2 to $103.9 million per year<br>2. Unquantified, non-monetized direct human health benefits<br>a) Lead uptake via sediment and food chain<br>b) Lead risks to women (all ages) and men (other than 40-59 years old)<br>c) Leads risks for health end points other than those covered by item 1, above<br>d) Carcinogenic and systemic risks not included in item 1 above<br>3. Unquantified and non-monetized benefits apart from human health<br>a) Recreational angling (consumer surplus)<br>b) Commercial fishing (consumer and producer surplus)<br>c) Ecologic and nonuse benefits (consumer surplus)<br>4. Regional/sectoral employment gain<br>a) Job creation — direct and indirect — from pollution control and waste handling: activity for support services will increase temporarily due to the need to retrofit 2000 existing facilities<br>b) Job creation and tax revenues from enhanced recreation and tourism (indirect, pecuniary impact)<br>5. Increased oil and gas reserves (to extent exploration reduces near-term extraction and consumption) |

[1] Cost ranges reflect minimum (Year 15) and maximum (Year 1) costs based on number of facilities affected.

### 7.1.3 Regional/Sectoral Employment Loss

To the extent that offshore exploration and production activities decline due to the regulations, then some direct job loss/dislocation may be anticipated in the oil and gas sector in the impacted regions (i.e., the Gulf states). Additional, indirect employment impacts may be felt in sectors that support the oil and gas sector, and via a ripple effect through the regional economy as a whole.

Conceptually, any such employment impacts are not relevant for a proper benefit-cost analysis. Although job dislocations impose hardships on those impacted, they reflect an "optimal" reallocation of productive resources away from an externality-causing activity (in which productive resources such as labor and capital are over-employed, and production is too high from the social welfare perspective, absent internalization of the externality). Furthermore, the job losses will be counterbalanced by employment stimulus in the pollution abatement and other sectors that will realize demand growth due to compliance efforts by the oil and gas sector. Therefore, the impact on employment is a socially optimal adjustment, and reflects a pecuniary (distributional) impact rather than a true social cost.

### 7.1.4 Loss of Tax and Lease Revenues by State and Federal Governments

Near-term reductions in lease and tax revenues may be anticipated to the extent that exploration and/or production are curtailed due to the regulation. The estimated combined impact on revenue losses to state and federal governments is between $36 and $119 million per year. This impact, although of potential fiscal importance to the impacted government entities, does not warrant inclusion in a properly designed benefit-cost analysis. First, the losses in revenue reflect a pecuniary rather than a real cost, and such distributional or transfer payments do not belong in a true benefit-cost calculus. (If such costs are counted both for the industry (e.g., decreased income) and for the government (e.g., decreased tax revenues from affected firms), then double-counting will occur.) Second, while the revenues may be foregone in the near-term, they are actually being postponed rather than foregone entirely. This is because the price of oil and gas will rise over time as energy resource stocks become depleted, and rising long run prices will induce exploration and/or production, yielding future development of the oil and gas resources for which extraction may be temporarily postponed due to the regulation.

### 7.1.5 Balance of Trade and National Energy Security

To the extent that domestic production is curtailed due to the regulations, the loss will be made up by increasing importation of foreign petroleum supplies. This may have implications for the national trade balance and "energy security." Production declines due to the regulation, however, are expected to be insignificant relative to other factors affecting the balance of trade. Additionally, as noted in section 7.1.4 above, any oil and gas production foregone in the short run due to the regulations will not be "lost," but merely will be postponed. Thus, the impact will be merely temporal, with any adverse trade balance impacts experienced in the near-term counterbalanced by the contribution postponed development will provide to the trade balance in the future. Likewise, oil and gas left untapped now will be available to meet potential future energy security needs.

### 7.1.6 Risks and Costs Posed by Transport and Disposal of Drilling Fluids and Cuttings

The transport, handling and ultimate land-based disposal of drilling wastes may impose financial costs and risks on society. The compliance-related expense of these activities has been included in the direct compliance cost estimates provided in Chapter 4. Additional costs may be associated with land-based disposal of muds and cuttings; initial research, however, reveals that land disposal will not be a problem in terms of landfill capacity, as it appears that disposal facilities exist with applicable permits in place and waiting for these wastes (pers. comm., Gary Petrazzuolo, Avanti Corp.).

It is conceivable that transport of muds and cuttings and other waste handling/transfers will create opportunities for accidental releases and spills, thereby posing environmental risks and the possibility of human casualties. One issue associated with potential risk is whether there would be an increase in Offshore Supply Vessel (OSV) traffic. From 1969 to 1989 the accident rate for OSVs in U.S. ports for the Gulf of Mexico was 2.6 per thousand trips. Accidents include collisions, groundings, fire, explosion, and capsizing. Spills might be expected to occur in roughly one to ten percent of these accidents (pers. comm., Virgil Keith, ECO, Inc.). The accident rate does not include spills from on-loading and off-loading. However, analysts (pers. comm., Kavanaugh, Petrazzuolo, Keith) have pointed out that the same OSVs that routinely carry supplies from shore to platforms can, on their return to shore, carry containerized muds and cuttings. Hence, there may be minimal (if any) increases in OSV traffic and, therefore risks of accidents.

A second issue concerns the possibility of accidents on land when muds and cuttings are trucked from ports to landfills for disposal, or the possibility of accidents associated with increased crane activity both at platforms and at ports. On land, additional truck traffic would be associated with a proportionate increase in accidents, causing damages, injuries and, possibly, environmental risks.

A final risk-related issue is that if spills occur, the muds and cuttings released will pose risks. However, absent transport to shore, <u>all</u> muds and cuttings will end up in the marine environment. Thus accidents may result in a less than complete elimination of releases within 3 miles of shore, and it is true that should accidental releases occur in near-coastal waters, then the harm posed may be greater than had the wastes been released at the originating platform further offshore.

## 7.2 SOCIAL BENEFITS

### 7.2.1 Monetized Direct Human Health Benefits

These are the benefits already described in Chapter 6 (predominantly related to reduced exposure to lead). The estimated monetized benefits amount to between $28.2 and $103.9 million per year.

### 7.2.2 Unquantified and Non-monetized Direct Human Health Benefits

These benefits are also described in Chapter 6, and include lead-related risk reductions to women (of all ages) and males other than those between the ages of 40 to 59 years. Not included in the analysis are any indirect human health impacts, such as the increased well-being and decreased stress posed on the family members of those who otherwise would have been stricken with an adverse health effect. Also excluded from the analysis are any productivity gains to be realized throughout the economy due to a healthier (reduced incidence of adverse health effects) and brighter (fewer IQ-impaired) work force.

### 7.2.3 Unquantified and Non-monetized Benefits Apart from Human Health

As described in Chapter 6, these include potential beneficial impacts on the recreational and/or commercial fisheries, and any aesthetic, nonuse, or ecologic benefits.

### 7.2.4 Regional/Sectoral Employment Gains

As noted under the discussion for section 7.1.3 under social costs, this benefit reflects the counterbalancing of potential job losses in the oil and gas sector through the economic stimulus provided in other sectors due to demand created by regulatory compliance expenditures. Additionally, any increased recreational or tourism impacts may have positive ripple effects through lodging, dining and other sectors. As previously described, such pecuniary benefits, because they reflect transfer effects rather than real benefits or costs (unless new employees would otherwise be unemployed), do not belong in a national benefit-cost analysis.

### 7.2.5 Increased Oil and Gas Reserves

As described above under social costs (sections 7.1.4 and 7.1.5), to the extent that production is curtailed due to the regulations, then the stock of future oil and gas will be increased. Accordingly, reductions in near-term extraction activities preserve opportunities for future development of reserves.

## 7.3 CONCLUSIONS

This chapter examines the range of categories that might be evaluated in a full social accounting of the benefits and costs associated with the effluent guidelines. In additional to direct compliance costs discussed in this chapter and in Chapter 4, losses to domestic producers (producer surplus loss) may be incurred to the extent the marginal cost curve shifts upward as a result of the guidelines. Other cost categories discussed (e.g., tax revenues), while reflecting potentially important distributional impacts, do not belong in a true benefit-cost analysis because they represent transfers of costs or benefits generated (and accounted for) elsewhere. Additional impacts, notably sectoral employment losses and gains, appear to cancel one another out; they furthermore should be viewed as distributional impacts, not true social costs, in a national analysis absent conditions of high unemployment. Finally, while monetized estimates are not available for all benefit categories, a range of potentially significant benefits--recreational and commercial fishing, ecologic and nonuse values, and additional health benefits--are discussed in this chapter and in Chapter 6.

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# APPENDIX A

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