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ENVIRONMENTAL ASSESSMENT OF THE FINAL EFFLUENT GUIDELINES FOR THE IRON AND STEEL INDUSTRY

Volume I

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EXECUTIVE SUMMARY

This report presents an environmental assessment of the water quality-related benefits that would be expected from the U.S. Environmental Protection Agency's (EPA) promulgation of final effluent limitations guidelines, pretreatment standards, and new source performance standards for the iron and steel point source category. EPA estimates that, under current (baseline) conditions, 22 iron and steel facilities[1] discharge approximately 4.43 million pounds per year (lb/year) of priority and nonconventional pollutants. The final rule is expected to reduce this pollutant loading by 22 percent, to 3.44 million lb/year. The final rule is also estimated to provide annual monetized benefits ranging from $1.4 million to $7.3 million (2001 dollars). The range reflects the uncertainty in evaluating the effects of the final rule and in placing a monetary value on those effects. The estimate of reported benefits also understates the total benefits expected to result under this final rule. Additional benefits, which cannot be quantified in this assessment, include improved ecological conditions from improvements in water quality, improvements to recreational activities (other than fishing), and reduced discharge of conventional pollutants. Table ES-1 summarizes the environmental effects and benefits of the final effluent guidelines and standards.

Summary of Environmental Effects/Benefits

(a) Ambient Water Quality Effects

EPA analyzed the environmental effects associated with discharges from 22 iron and steel facilities. The analysis compared modeled instream pollutant concentrations to ambient water quality criteria (AWQC)[2] or to toxic effect levels. EPA estimates that current discharge loadings

[1] Of a total of 254 iron and steel facilities potentially affected by the proposed rule, EPA presents here the analysis results for the 22 facilities (in the cokemaking and sintering subcategories) affected by the final rule. The assessment also includes results for 29 pollutants (in addition to the regulated chlorinated furans), primarily metals, in the sintering subcategory based on preliminary loadings.

[2] In performing this analysis, EPA used guidance documents published by EPA that recommend numeric human health and aquatic life water quality criteria for numerous pollutants. States often consult these guidance documents when adopting water quality criteria as part of their water quality standards. However, because those State-adopted criteria may vary, EPA used the nationwide criteria guidance as the most representative values.

Table ES-1. Summary of Environmental Effects/Benefits of the Final Effluent Guidelines and Standards for the Iron and Steel Industry [a]

	Current	Final Rule	Summary of Benefits
Loadings (million lb/yr) [b, c]	4.43	3.44	22 percent reduction
Number of Instream Excursions for Pollutants That Exceed AWQC	82 at 15 streams	72 at 14 streams	1 stream becomes "contaminant-free" [d] Monetized benefits (recreational/nonuse) = $0.12 to $0.44 million
Excess Annual Cancer Cases[e]	0.9	0.4	Reduction of 0.5 cases each year Monetized benefits = $1.3 to $6.9 million
Population Potentially Exposed to Other Noncarcinogenic Health Risks[e]	5000	5000	Health effects to exposed population not eliminated
POTWs Experiencing Inhibition	none of 7	none of 7	No baseline impacts
Improved POTW Biosolid Quality	0 metric tons	0 metric tons	No baseline impacts
Total Monetized Benefits			**$1.4 to 7.3 million** (2001 dollars)

a. Modeled results from 15 direct and 8 indirect facilities; 1 facility is both a direct and an indirect discharger.
b. Loadings are representative of 50 priority and nonconventional pollutants evaluated; 3 conventional pollutants and 7 nonconventional pollutants are not included.
c. Loadings are adjusted for POTW removals.
d. "Contaminant-free" from iron and steel discharges; however, potential contamination from other point source discharges and nonpoint sources is still possible.
e. Through consumption of contaminated fish.

contribute to instream concentrations in excess of AWQC in 82 cases at 15 receiving streams. The final rule is expected to reduce the number of instream concentrations exceeding AWQC to 72 at 14 receiving streams, allowing 1 stream to obtain "contaminant-free" status. EPA monetizes the attainment of the contaminant-free status based on improvements in recreational fishing opportunities and on the nonuse (intrinsic) value of the streams. The estimated monetized benefit of this improvement ranges from $0.12 million to $0.44 million (2001 dollars).

(b) Human Health Effects

EPA estimates that carcinogens in the current discharge loadings from the 22 iron and steel facilities could be responsible for 0.9 total excess annual cancer cases from the consumption of contaminated fish. The final rule is expected to reduce the carcinogenic loadings and the estimated excess annual cancer cases to 0.4. The estimated monetized benefit of these reductions in human health effects ranges from $1.3 million to $6.9 million (2001 dollars). In addition, EPA projects that the final rule will not eliminate the hazard to approximately 5000 people potentially exposed to systemic toxicant effects from consumption of contaminated fish. EPA, therefore, projects no potential economic benefits from reduced systemic effects.

(c) POTW Effects

EPA estimates that none of the 7 publicly owned treatment works (POTWs) considered in this assessment are experiencing inhibition problems or impaired biosolid quality due to iron and steel wastewater discharges. EPA, therefore, projects no potential economic benefits from reduced biosolid disposal costs.

(d) Basis of Conclusions

This environmental assessment bases its conclusion of the water quality-related benefits on aggregate site-specific analyses of current conditions and of changes expected to result from compliance with the final iron and steel effluent guidelines and standards for Best Available Technology Economically Achievable (BAT) and Pretreatment Standards for Existing Sources

(PSES). The final regulations limit the discharges of pollutants into navigable waters of the United States and the introduction of pollutants into POTWs from existing sources and from new sources in two iron and steel subcategories. These categories are cokemaking and sintering. Many iron and steel facilities have more than one subcategory-defined production line. Only loadings from the two subcategories are aggregated to estimate the combined environmental effects of the final rule.

Modeling Techniques

EPA employed stream dilution modeling techniques to assess the potential impacts and benefits of the final effluent guidelines and standards. Using site-specific analyses, EPA estimated instream pollutant concentrations for 50 priority and nonconventional pollutants[3] under current (baseline) and final treatment levels. Chapter 10 of the Technical Development Document explains more about these estimates. EPA analyzed the effects on water quality from direct and indirect discharge operations separately. EPA had sufficient data to analyze water quality impacts for all 22 of the iron and steel facilities being evaluated. EPA combined the impacts for each of the subcategories to estimate water quality effects as a result of the final rule.

EPA assessed the potential impacts and benefits in terms of effects on aquatic life, human health, and POTW operations. EPA projected the benefits to aquatic life by comparing the modeled instream pollutant concentrations to published EPA aquatic life criteria guidance or to toxic effect levels. EPA projected human health benefits by (1) comparing estimated instream pollutant concentrations to health-based toxic effect values or criteria derived using standard EPA methodology, and (2) estimating the potential reductions of carcinogenic risk and noncarcinogenic hazard (systemic) from consuming contaminated fish and drinking water. Because of the hydrophobic nature of the seven chlorinated dibenzofuran (CDF) congeners under evaluation, EPA projected human health benefits for these pollutants using the Office of Research and Development's (ORD) Dioxin Reassessment Evaluation (DRE) model to estimate the potential reduction of carcinogenic risk and noncarcinogenic hazard from consuming contaminated fish.

[3]Evaluations do not include the impacts of 3 conventional and 7 nonconventional pollutants when modeling the effects of the final rule on receiving stream water quality and POTW operations or when evaluating the potential fate and toxicity of discharged pollutants. The discharge of these pollutants may adversely affect human health and the environment.

The assessment estimated upper-bound individual cancer risks, population risks, and systemic hazards using modeled instream pollutant concentrations and standard EPA assumptions. The assessment evaluated modeled pollutant concentrations in fish and drinking water to estimate cancer risk and systemic hazards among the general population (drinking water only), sport anglers and their families, and subsistence anglers and their families. EPA assessed improvements in aquatic habitats using its findings of reduced occurrence of instream pollutant concentrations in excess of both aquatic life and human health criteria or toxic effect levels. EPA expects that these improvements in aquatic habitats will improve the quality and value of recreational fishing opportunities and nonuse (intrinsic) values of the receiving streams.

The environmental assessment also evaluated the potential inhibition of POTW operations and potential contamination of sewage biosolids (which limits its use for land application) based on current and final pretreatment levels. EPA estimated inhibition of POTW operations by comparing modeled POTW influent concentrations to available inhibition levels. EPA assessed the potential contamination of sewage biosolids by comparing projected pollutant concentrations in sewage biosolids to available EPA regulatory standards for land application and surface disposal of sewage biosolids.

Pollutant Fate and Toxicity[4]

EPA identified a total of 60 pollutants of concern (22 priority pollutants, 3 conventional pollutants, and 35 nonconventional pollutants) at treatable levels in waste streams from the 22 iron and steel facilities. EPA evaluated 50 of these pollutants with sufficient data to assess their potential fate and toxicity on the basis of known physical-chemical properties, and aquatic life and human health toxicity data.

Most of the 50 pollutants have at least one known toxic effect. EPA determined that 20 exhibit moderate to high toxicity to aquatic life, 19 are classified as known or probable human carcinogens, 37 are human systemic toxicants, 16 have drinking water values, and 23 are designated

[4]Revisions to the pollutant loadings, prior to rulemaking signature, resulted in minor changes to the results of this analysis. Due to time constraints, the preamble and economic analysis do not reflect these changes, which had no impact on the overall monetized benefits.

as priority pollutants. In terms of projected partitioning among media, 17 of the evaluated pollutants are moderately to highly volatile (potentially causing risk to exposed populations via inhalation), 27 have a moderate to high potential to bioaccumulate in aquatic biota (potentially accumulating in the food chain and causing increased risk to higher trophic level organisms and to exposed human populations via consumption of fish and shellfish), 20 are moderately to highly adsorptive to solids, and 7 are resistant to biodegradation or are slowly biodegraded.

Documented Impacts[5]

This report also summarizes documented environmental impacts on aquatic life, human health, and receiving stream water quality. The summaries are based on a review of an EPA enforcement and compliance report, State 303(d) lists of impaired waterbodies, and State fishing advisories.

States identified at least 3 impaired waterbodies, with industrial point sources as a potential source of impairment, that receive direct discharges from 3 and iron steel facilities (and other sources). Eight additional waterbodies that receive direct discharges are also identified as impaired. However, the States did not identify the potential sources of impairment. States also issued fish consumption advisories for 9 waterbodies that receive direct discharges from 10 iron and steel facilities (and other sources). The advisories were reported in the *1997 Update of Listing of Fish and Wildlife Advisories*. In addition, EPA identified in its *1998 Enforcement and Compliance Assurance Accomplishment Reports* by the Office of Enforcement and Compliance Assurance (OECA) significant noncompliance (SNC) rates (most egregious violations under each program or statute) for iron and steel facilities. Of the 27 integrated mills inspected in fiscal years (FY) 1996 and 1997, 26 facilities were out of compliance with one or more statutes, and 18 facilities were in SNC. In FY 1998, of the 23 integrated mills inspected, the number in SNC included 9 facilities for water permits, 17 facilities for air, and 7 facilities with Resource Conservation and Recovery Act (RCRA) violations. SNC rates for 91 mini-mills included 19 facilities for air, 2 facilities for water permits, and 4 facilities for RCRA. Key compliance and environmental problems included groundwater

[5] Revisions to the pollutant loadings, prior to rulemaking signature, resulted in minor changes to the results of this analysis. Due to time constraints, the preamble and economic analysis do not reflect these changes, which had no impact on the overall monetized benefits.

contamination from slag disposal, contaminated sediments from steelmaking, electric arc furnace dust, unregulated sources, SNCs from recurring and single peak violations, and no baseline testing.

1. INTRODUCTION

This environmental assessment quantifies the water quality-related benefits associated with achievement of the Best Available Technology (BAT) and Pretreatment Standards for Existing Sources (PSES) promulgated by the U.S. Environmental Protection Agency (EPA) to regulate iron and steel facilities. Using site-specific analyses of current conditions and changes in discharges associated with the final regulation, EPA estimated instream pollutant concentrations for 50 priority and nonconventional pollutants from direct and indirect discharges in two industry subcategories (cokemaking and sintering) using stream dilution modeling.

The assessment evaluates the potential impacts and benefits to aquatic life by comparing the modeled instream pollutant concentrations to published EPA aquatic life criteria guidance or toxic effect levels. The assessment evaluates the potential benefits to human health by (1) comparing estimated instream concentrations to health-based water quality toxic effect levels or EPA's published water quality criteria, and (2) estimating the potential reduction of carcinogenic risk and noncarcinogenic hazard (systemic) from consuming contaminated fish or drinking water. Because the hydrophobic nature of the seven chlorinated dibenzofuran (CDF) congeners under evaluation, EPA projected human health benefits for these pollutants using the Office of Research Development's (ORD) Dioxin Reassessment Evaluation (DRE) model to estimate the potential reduction of carcinogenic risk and noncarcinogenic hazard from consuming contaminated fish. The assessment monetizes reductions in carcinogenic risks using estimated willingness-to-pay values for avoiding premature mortality to which monetary values can be applied. The assessment projects potential ecological benefits, including nonuse (intrinsic) benefits, by estimating improvements in recreational fishing habitats and, in turn, by estimating a monetary value for enhanced recreational fishing opportunities. The assessment estimates economic productivity benefits on the basis of reduced POTW sewage sludge contamination (e.g., reducing contamination increases the number of allowable sludge uses or disposal options).

In addition, the assessment evaluates the potential fate and toxicity of pollutants of concern associated with iron and steel wastewater on the basis of known characteristics of each chemical. The assessment also reviews recent reports and databases for evidence of documented environmental impacts (e.g., case studies) on aquatic life, human health, and receiving stream water quality.

This assessment does not evaluate impacts associated with releases of 3 conventional pollutants (biological oxygen demand [BOD], oil and grease (measured as hexane extractable material [HEM]), and total suspended solids [TSS]), and 7 nonconventional pollutants (chemical oxygen demand [COD], total organic carbon [TOC], total recoverable phenolics, total kjeldahl nitrogen, nitrate/nitrite, amenable cyanide, and weak acid dissociable cyanide). However, the discharge of these pollutants may adversely affect human health and the environment. For example, habitat degradation may result from increased suspended particulate matter that reduces light penetration and primary productivity or from the accumulation of sludge particles that alter benthic spawning grounds and feeding habitats. Oil and grease can have lethal effects on fish by coating the surface of gills and causing asphyxia, by depleting oxygen levels as a result of excessive BOD, or by reducing stream reaeration because of surface film. Oil and grease can also have detrimental effects on waterfowl by destroying the buoyancy and insulation of their feathers. Bioaccumulation of oily substances can cause human health problems including tainting of fish and bioaccumulation of carcinogenic polycyclic aromatic compounds. High COD and BOD_5 levels can deplete oxygen concentrations in water, which can result in fish mortality or other adverse effects in fish. High TOC levels may interfere with water quality by causing taste and odor problems in water and mortality in fish.

Following this introduction, Section 2 of this report describes the methodologies used to evaluate projected water quality impacts and projected impacts on POTW operations for direct and indirect discharging facilities (including potential human health risks and benefits, ecological benefits, and economic productivity benefits); to evaluate the potential fate and toxicity of pollutants of concern; and to evaluate documented environmental impacts. Section 3 describes data sources and information used to evaluate water quality impacts, such as facility-specific data; information used to evaluate POTW operations; water quality criteria; and information used to evaluate human health risks and benefits, ecological benefits, economic productivity benefits, pollutant fate and toxicity, and documented environmental impacts. Section 4 provides a summary of the results of this assessment, and Section 5 is a complete list of references cited in the report. The appendices presented in Volume II provide additional detail on the specific information addressed in the main report.

2. METHODOLOGY

2.1 Projected Water Quality Impacts

This assessment evaluates the water quality impacts and associated risks/benefits of iron and steel discharges at various treatment levels by (1) comparing projected instream concentrations with ambient water quality criteria (AWQC[6]), (2) estimating the human health risks and benefits associated with the consumption of fish and drinking water from waterbodies impacted by iron and steel facilities, (3) estimating the ecological benefits associated with improved recreational fishing habitats on impacted waterbodies, and (4) estimating the economic productivity benefits based on reduced sewage sludge contamination at POTWs receiving the wastewater of iron and steel facilities. The assessment analyzes the impacts and associated risks/benefits for 15 direct discharging facilities and 8 indirect discharging facilities. The following sections describe the methodologies used in this evaluation.

2.1.1 Comparison of Instream Concentrations with Ambient Water Quality Criteria

The instream concentration analysis quantifies and compares current and BAT/PSES pollutant releases and uses stream modeling techniques to evaluate potential aquatic life and human health impacts resulting from those releases. The analysis compares projected instream concentrations for each pollutant to EPA water quality criteria or, for pollutants for which no water quality criteria have been developed, to toxic effect levels (i.e., lowest reported or estimated toxic concentration). The analysis also evaluates inhibition of POTW operation and sludge contamination. Sections 2.1.1.1 through 2.1.1.3 describe the methodologies and assumptions used for evaluating the impacts of direct and indirect discharging facilities.

[6] In performing this analysis, EPA used guidance documents published by EPA that recommend numeric human health and aquatic life water quality criteria for numerous pollutants. States often consult these guidance documents when adopting water quality criteria as part of their water quality standards. However, because those State-adopted criteria may vary, EPA used the nationwide criteria guidance as the most representative values.

2.1.1.1 *Direct Discharging Facilities*

Using a stream dilution model that does not account for fate processes other than complete immediate mixing, the analysis calculates projected instream concentrations at current and BAT treatment levels for stream segments with direct discharging facilities. For stream segments with multiple iron and steel facilities, pollutant loadings are summed, if applicable, before concentrations are calculated. The dilution model used for estimating instream concentrations is as follows.

$$C_{is} = \frac{L/OD}{FF + SF} \; x \; CF \qquad \text{(Eq. 1)}$$

where:

C_{is}	=	instream pollutant concentration (micrograms per liter [μg/L])
L	=	facility pollutant loading (pounds/year [lb/year])
OD	=	facility operation (days/year)
FF	=	facility flow (million gallons/day [gal/day])
SF	=	receiving stream flow (million gal/day)
CF	=	conversion factors for units

The analysis uses various resources, as described in Section 3.1.1 of this report, to derive the facility-specific data (i.e., pollutant loading, operating days, facility flow, and stream flow) used in Eq. 1. One of 3 receiving stream flow conditions (1Q10 low flow, 7Q10 low flow, and harmonic mean flow) is used for the two treatment levels; use depends on the type of criterion or toxic effect level intended for comparison. To estimate potential acute and chronic aquatic life impacts, the analysis uses the 1Q10 and 7Q10 flows, which are the lowest 1-day and the lowest consecutive 7-day average flow during any 10-year period, respectively, as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991). EPA defines the harmonic mean flow as the inverse mean of reciprocal daily arithmetic mean flow values. EPA recommends the long-term harmonic mean flow as the design flow for assessing potential human health impacts because it provides a more conservative estimate than the arithmetic mean flow. Because 7Q10 flows have no consistent relationship with the long-term mean dilution, they are not appropriate for assessing potential human health impacts.

For assessing impacts on aquatic life, the analysis uses the facility operating days to represent the exposure duration; the calculated instream concentration is thus the average concentration *on days the facility is discharging wastewater*. For assuming long-term human health impacts, it sets the operating days (exposure duration) at 365 days. The calculated instream concentration is thus the average concentration *on all days of the year*. Although this calculation for human health impacts leads to a lower calculated concentration because of the additional dilution from days when the facility is not in operation, it is consistent with the conservative assumption that the target population is present to consume drinking water and contaminated fish every day for an entire lifetime.

Because stream flows are not available for hydrologically complex waters such as bays, estuaries, and oceans, the analysis uses site-specific critical dilution factors (DFs) or estuarine dissolved concentration potentials (DCPs) to predict pollutant concentrations for facilities discharging to estuaries and bays, if applicable, as follows:

$$C_{es} = \left[\left(\frac{L/OD}{FF} \right) x \ CF \right] / \ DF \qquad \text{(Eq. 2)}$$

where:

C_{es}	=	estuary pollutant concentration (Fg/L)
L	=	facility pollutant loading (lb/year)
OD	=	facility operation (days/year)
FF	=	facility flow (million gal/day)

DF = critical dilution factor
CF = conversion factors for units

$$C_{es} = \frac{L \ x \ DCP \ x \ CF}{BL} \qquad \text{(Eq. 3)}$$

where:

C_{es} = estuary pollutant concentration (μg/L)
L = facility pollutant loading (lb/year)
DCP = dissolved concentration potential (milligrams per liter [mg/L])
CF = conversion factor for units
BL = benchmark load (10,000 tons/year)

A survey of States and Regions conducted by EPA's Office of Pollution Prevention and Toxics (OPPT), *Mixing Zone Dilution Factors for New Chemical Exposure Assessments*, Draft Report, (U.S. EPA, 1992a), provides the site-specific critical DFs. The analysis uses acute critical DFs to evaluate acute aquatic life effects, whereas it uses chronic critical DFs to evaluate chronic aquatic life or adverse human health effects. The analysis assumes that the drinking water intake and fishing location are at the edge of the chronic mixing zone.

The Strategic Assessment Branch of the National Oceanic and Atmospheric Administration's (NOAA) Ocean Assessments Division developed DCPs based on freshwater inflow and salinity gradients to predict pollutant concentrations in each estuary in the National Estuarine Inventory (NEI) Data Atlas. NOAA applies these DCPs to predict concentrations. NOAA did not consider pollutant fate and designated the DCPs to simulate concentrations of nonreactive dissolved substances under well-mixed steady-state conditions given an annual load of 10,000 tons. In addition, the DCPs reflect the predicted estuary-wide response and may not be indicative of site-specific locations.

The analysis determines potential impacts on freshwater quality by comparing projected instream pollutant concentrations (Eq. 1) at reported facility flows, 1Q10 and 7Q10 low flows, and harmonic mean receiving stream flows with EPA AWQC or toxic effect levels for the protection of aquatic life and human health. The analysis compares projected estuary pollutant concentrations (Eq. 2 and Eq. 3), based on critical DFs or DCPs, to EPA AWQC or toxic effect levels to determine impacts. To determine water quality criteria excursions, the analysis divides the projected instream or estuary pollutant concentration by the EPA water quality criteria or toxic effect levels. A value greater than 1.0 indicates an excursion.

CDD/CDF Congeners

Although hydrophobic chemicals like CDD and CDF congeners become associated primarily with suspended particulates and sediments, concentrations will be found in the water column near the discharge point. This is particularly true if discharges are assumed to be continuous. Therefore, although the stream dilution approach is conservative, it provides a reasonable estimate of dioxin-related water quality impacts on aquatic life. However, use of the stream dilution model to assess human health impacts (water quality excursions) from the discharge of CDD/CDF congeners is inappropriate. EPA uses ORD's Dioxin Reassessment Evaluation (DRE) model, which provides more reliable information regarding the partitioning of CDD/CDF congeners between sediment and the water column, and thus their bioavailability to fish, to estimate the carcinogenic and noncarcinogenic risks from these contaminants. (see Section 2.1.2.)

2.1.1.2 ***Indirect Discharging Facilities***

The analysis uses a 2-stage process to assess the impacts of indirect discharging facilities. First, water quality impacts are evaluated as described in subsection (a) below. Next, impacts on POTWs are considered as described in subsection (b).

(a) Water Quality Impacts

Using a stream dilution model that does not account for a fate process other than complete immediate mixing, the analysis calculates projected instream concentrations at current and PSES treatment levels for stream segments receiving wastewaters from indirect discharging facilities. For stream segments with multiple iron and steel facilities, pollutant loadings are summed, if applicable, before concentrations are calculated. The dilution model used for estimating instream concentrations is as follows:

$$C_{is} = (L/OD) \ x \ \frac{(1 - TMT) \ x \ CF}{PF + SF} \qquad \text{(Eq. 4)}$$

where:

C_{is}	=	instream pollutant concentration (µg/L)
L	=	facility pollutant loading (lb/year)
OD	=	facility operation (days/year)
TMT	=	POTW treatment removal efficiency
PF	=	POTW flow (million gal/day)
SF	=	receiving stream flow (million gal/day)
CF	=	conversion factors for units

The analysis uses various resources, as described in Section 3.1.1 of this report, to derive the facility-specific data (i.e., pollutant loading, operating days, facility flow, and stream flow) used in Eq. 4. One of 3 receiving stream flow conditions (1Q10 low flow, 7Q10 low flow, and harmonic mean flow) is used for the two treatment levels. The analysis uses site-specific critical DFs or estuarine DCPs to predict pollutant concentrations for facilities discharging to estuaries and bays, if applicable, as follows:

$$C_{es} = \left[\left(\frac{L/OD \ x \ (1 - TMT)}{PF} \right) \ x \ CF \right] / \ DF \qquad \text{(Eq. 5)}$$

where:

C_{es}	=	estuary pollutant concentration (μg/L)
L	=	facility pollutant loading (lb/year)
OD	=	facility operation (days/year)
TMT	=	POTW treatment removal efficiency
PF	=	POTW flow (million gal/day)
DF	=	critical dilution factor
CF	=	conversion factors for units

$$C_{es} = \frac{L \ x \ (1 - TMT) \ x \ DCP \ x \ CF}{BL} \qquad \text{(Eq. 6)}$$

where:

C_{es}	=	estuary pollutant concentration (μg/L)
L	=	facility pollutant loading (lb/year)
TMT	=	POTW treatment removal efficiency
DCP	=	dissolved concentration potential (mg/L)
CF	=	conversion factors for units
BL	=	benchmark load (10,000 tons/year)

The analysis determines potential impacts on freshwater quality by comparing projected instream pollutant concentrations (Eq. 4) at reported POTW flows, 1Q10 and 7Q10 low flows, and harmonic mean receiving stream flows with EPA AWQC or toxic effect levels for the protection of aquatic life and human health. The analysis compares projected estuary pollutant concentrations (Eq. 5 and Eq. 6), based on critical DFs or DCPs, to EPA AWQC or toxic effect levels to determine impacts. To determine water quality criteria excursions, the analysis divides the projected instream or estuary pollutant concentration by the EPA AWQC or toxic effect levels. (See Section 2.1.1.1 for discussion of stream flow conditions, application of DFs or DCPs, assignment of exposure duration, and comparison with criteria or toxic effect levels.) A value greater than 1.0 indicates an excursion.

(b) Impacts on POTWs

The analysis calculates impacts on POTW operations in terms of inhibition of POTW processes (i.e., inhibition of microbial degradation processes) and contamination of POTW sludges. Contamination is defined as a pollutant concentration that exceeds the levels at which sewage sludge may be land applied or surface disposed under 40 CFR Part 503. To determine inhibition of POTW operations, the analysis divides calculated POTW influent levels (Eq. 7) by chemical-specific inhibition threshold levels. Excursions are indicated by a value greater than 1.0.

$$C_{pi} = \frac{L/OD}{PF} \ x \ CF \qquad \text{(Eq. 7)}$$

where:

C_{pi} = POTW influent concentration (μg/L)
L = facility pollutant loading (lb/year)
OD = facility operation (days/year)
PF = POTW flow (million gal/day)
CF = conversion factors for units

The analysis evaluates contamination levels of sludge (and thus its use for land application, etc.) by dividing projected pollutant concentrations in sludge (Eq. 8) by available EPA-developed criteria values for sludge. A value greater than 1.0 indicates an excursion.

$$C_{sp} = C_{pi} \ x \ TMT \ x \ PART \ x \ SGF \qquad \text{(Eq. 8)}$$

where:

C_{sp} = sludge pollutant concentration (milligrams per kilogram [mg/kg])
C_{pi} = POTW influent concentration (μg/L)
TMT = POTW treatment removal efficiency
PART = chemical-specific sludge partition factor
SGF = sludge generation factor (5.96 parts per million [ppm])

The analysis derives facility-specific data and information used to evaluate POTWs from the sources described in Sections 3.1.1 and 3.1.2. For facilities that discharge to the same POTW, the analysis sums their individual loadings, if applicable, before calculating the POTW influent and sludge concentrations.

The partition factor is a measure of the tendency for the pollutant to partition in sludge when it is removed from wastewater. For predicting sludge generation, the model assumes that 1,400 pounds of sludge are generated for each 1 million gallons of wastewater processed (Metcalf & Eddy, Inc.,1972). This results in a sludge generation factor of 5.96 mg/kg per Fg/L (i.e., for every 1 Fg/L of pollutant removed from wastewater and partitioned to sludge, the concentration in sludge is 5.96 mg/kg dry weight).

2.1.1.3 *Assumptions and Caveats*

The instream and POTW analyses assume the following:

- Background concentrations of each pollutant, both in the receiving stream and in the POTW influent, are equal to zero; therefore, the analysis evaluates only the impacts of discharging facilities.

- The analysis uses an exposure duration of 365 days to determine the likelihood of actual excursions of human health criteria or toxic effect levels.

- Complete mixing of discharge flow and stream flow occurs across the stream at the discharge point; therefore, the analysis calculates an "average stream" concentration, even though the actual concentration may vary across the width and depth of the stream.

- The intake process water and noncontact cooling water at each facility, and the water discharged to a POTW, are obtained from a source other than the receiving stream for 7 iron and steel facilities as identified in the facility questionnaire; all other noncontact cooling waters and process waters are obtained from the receiving stream.

- The stream dilution model includes the process water and noncontact cooling water in estimating the instream concentrations only for those facilities whose waters are obtained from a source other than the receiving stream.

- The pollutant load to the receiving stream is continuous and is representative of long-term facility operations. These assumptions may overestimate risks to human health and aquatic life, but may underestimate potential short-term effects.

- The analysis uses 1Q10 and 7Q10 receiving stream flow rates to estimate aquatic life impacts; harmonic mean flow rates are used to estimate human health impacts. It estimates 1Q10 low flows using the results of a regression analysis of 1Q10 and 7Q10 flows from representative U.S. rivers and streams conducted by Versar, Inc., for EPA's Office of Pollution Prevention and Toxics (OPPT) (Versar, 1992a). Harmonic mean flows are estimated from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991). These flows may not be the same as those used by specific States to assess impacts.

- The analysis adjusts the 7Q10 receiving stream flow rate to equal the facility or POTW flow rate for receiving streams where the facility or POTW flow rate is greater than the 7Q10 flow rate.

- The analysis assumes effluent pollutant concentrations at BAT treatment levels are equal to effluent pollutant concentrations at current treatment levels for those pollutants and sites/subcategories where pollutants were never detected above minimum levels or where there is a projected reduction in flow but not a projected reduction in load (i.e., loads used in the cost-effectiveness analysis).

- The analysis does not consider pollutant fate processes such as sediment adsorption, volatilization, and hydrolysis. This may result in estimated instream concentrations that are environmentally conservative (higher).

- The analysis assigns a removal efficiency of zero to pollutants without a specific POTW treatment removal efficiency value (provided by EPA or found in the literature). Pollutants without a specific partition factor are assigned a value of zero.

- Sludge criteria levels are available for only 2 pollutants: mercury and selenium.

- The analysis uses AWQC or toxic effect levels developed for freshwater organisms for facilities discharging to estuaries or bays.

2.1.2 Estimation of Human Health Risks and Benefits

The analysis evaluates the potential benefits to human health by estimating the risks (carcinogenic and noncarcinogenic hazard [systemic]) associated with reducing pollutant levels in fish tissue and drinking water from current to final treatment levels. EPA monetizes the reduction in carcinogenic risks using estimated willingness-to-pay values for avoiding premature mortality. Sections 2.1.2.1 and 2.1.2.2 describe the methodology and assumptions used to evaluate the human health risks and benefits (carcinogenic and systemic) from the consumption of fish tissue and drinking water derived from waterbodies impacted by direct and indirect discharging facilities.

2.1.2.1 *Carcinogenic and Systemic Human Health Risks and Benefits*

(a) Fish Tissue

To determine the potential benefits, in terms of reduced cancer cases, associated with reducing pollutant levels in fish tissue, the analysis estimates lifetime average daily doses (LADDs) and individual risk levels for each pollutant discharged from a facility on the basis of the instream pollutant concentrations calculated at current and BAT/PSES treatment levels in the site-specific stream dilution analysis (see Section 2.1.1). EPA presents estimates for sport anglers and their families, and subsistence anglers and their families. LADDs are calculated as follows:

$$LADD = (C \times IR \times BCF \times F \times D) / (BW \times LT) \qquad \text{(Eq. 9)}$$

where:

LADD	=	potential lifetime average daily dose (milligrams per kilogram per day [mg/kg-day])
C	=	exposure concentration (mg/L)
IR	=	ingestion rate (see Section 2.1.2.2, Assumptions)
BCF	=	bioconcentration factor (liters per kilogram [L/kg]; whole body x 0.5)
F	=	frequency duration (365 days/year)
D	=	exposure duration (70 years)

BW = body weight (70 kg)
LT = lifetime (70 years x 365 days/year)

Individual risks are calculated as follows:

$$R = LADD \ x \ SF \qquad \text{(Eq. 10)}$$

where:

R = individual risk level
LADD = potential lifetime average daily dose (mg/kg-day)
SF = cancer slope factor $(mg/kg\text{-}day)^{-1}$

The analysis then applies the estimated individual pollutant risk levels to the potentially exposed populations of sport anglers and subsistence anglers to estimate the potential number of excess annual cancer cases occurring over the life of the population. It then sums the number of excess cancer cases on a pollutant, facility, and overall industry basis. The analysis assumes the number of reduced cancer cases to be the difference between the estimated risks at current and BAT/PSES treatment levels.

Because of the hydrophobic nature of the two CDD congeners and the two CDF congeners, the analysis estimates LADDs and individual risk levels for these pollutants based on the pollutant fish tissue concentrations calculated at current and PSES treatment levels using the DRE model. The DRE model calculates the fish tissue concentration by calculating the equilibrium between CDD/CDF congeners in fish tissue and CDD/CDF congeners adsorbed to the organic fraction of sediments suspended in the water column. The analysis calculates LADDs as follows:

$$LADD = \frac{(CFT \ x \ IR \ x \ F \ x \ D \ x \ CF)}{(BW \ x \ LT)} \qquad \text{(Eq. 11)}$$

where:

LADD	=	potential lifetime average daily dose (mg/kg-day)
CFT	=	fish tissue concentration (mg/kg)
IR	=	ingestion rate (see Section 2.1.2.2, Assumptions)
F	=	frequency duration (365 days/year)
D	=	exposure duration (70 years)
BW	=	body weight (70 kg)
LT	=	lifetime (70 years x 365 days/year)
CF	=	conversion factor

Individual risks are then calculated as shown in Eq. 10.

EPA estimates a monetary value of benefits to society from avoided cancer cases using estimates of society's willingness to pay to avoid the risk of cancer-related premature mortality. Although it is not certain that all cancer cases will result in death, to develop a worst-case estimate, this analysis values avoided cancer cases on the basis of avoided *mortality*. To value mortality, the analysis uses a range of values recommended by an EPA Office of Policy Analysis (OPA) review of studies quantifying individuals' willingness to pay to avoid risks to life (Fisher, Chestnut, and Violette, 1989; and Violette and Chestnut, 1986). The reviewed studies used hedonic wage and contingent valuation analyses in labor markets to estimate the amounts that individuals are willing to pay to avoid slight increases in risk of mortality or the amount they will need to be compensated to accept a slight increase in risk of mortality. The willingness-to-pay values estimated in those studies are associated with small changes in the probability of mortality. To estimate a willingness to pay for avoiding certain or high-probability mortality events, EPA extrapolated the estimated values for a 100 percent probability event.[7] EPA uses the resulting estimates of the value of a "statistical life saved" to value regulatory effects that are expected to reduce the incidence of mortality.

From this review of willingness-to-pay studies, OPA recommends a range of $1.6 to $8.5 million (1986 dollars) for valuing an avoided event of premature mortality or a statistical life saved. A more recent survey of value-of-life studies by Viscusi (1992) also supports this range with the

[7] These estimates, however, do not represent the willingness to pay to avoid the certainty of death.

finding that value-of-life estimates are clustered in the range of \$3 to \$7 million (1990 dollars). Updating to 2001 dollars yields a range of \$2.6 to \$13.7 million.

The analysis estimates potential reductions in risks due to reproductive, developmental, or other chronic and subchronic toxic effects by comparing the estimated lifetime average daily dose and the oral reference dose (RfD) for a given chemical pollutant as follows:

$$HQ = ORI/RfD \qquad \text{(Eq. 12)}$$

where:

HQ = hazard quotient
ORI = oral intake (LADD x BW, mg/day)
RfD = reference dose (mg/day assuming a body weight of 70 kg)

The analysis then calculates a hazard index (i.e., sum of individual pollutant hazard quotients) for each facility or receiving stream. A hazard index greater than 1.0 indicates that toxic effects may occur in exposed populations. The analysis then sums and compares the sizes of the affected subpopulations at current and BAT/PSES treatment levels to assess benefits in terms of reduced systemic toxicity. Although the analysis could not estimate the monetary value of benefits to society associated with a reduction in the number of individuals exposed to pollutant levels that are likely to result in systemic health effects, it expects any reduction in risk will yield human health-related benefits.

The analysis does not estimate the noncarcinogenic hazard of the CDD/CDF congeners on the basis of the oral intake and RfD because the establishment of an RfD for these pollutants, using the standard conventions of uncertainty, will likely be one or two orders of magnitude below average background population exposures. This situation precludes using an RfD for determining an acceptable level of CDD exposure, because at ambient background levels, effects are not readily apparent (personal communication from William Farland, Director of the National Center for Environmental Assessment, to Andrew Smith, State Toxicologist, Maine Bureau of Health, January 24, 1997 - Appendix D). Therefore, the analysis evaluates potential systemic effects of the CDD/CDF congeners by comparing the estimated LADDs (converted to units of toxic equivalent [TEQ] by multiplying by the congener-specific toxic equivalent factor [TEF]) to ambient background levels of 41 picograms (pg) TEQ/day as estimated by EPA in the 2000 Review Draft Document *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds* (U.S. EPA, 2000a). EPA estimates that adverse impacts associated with dioxin exposures may occur at or within on order of magnitude of average background exposures. As exposures increase within and above this range, the probability and severity of systemic effects most likely increase. For this assessment, fish tissue exposures greater than one order of magnitude above ambient background concentration indicate that toxic effects may occur in exposed populations. The analysis sums and compares the sizes of the affected subpopulations at the various treatment levels to assess benefits in terms of reduced systemic toxicity.

(b) Drinking Water

The analysis determines potential benefits associated with reducing pollutant levels in drinking water in a manner similar to that used for fish tissue. The analysis calculates LADDs for drinking water consumption as follows:

$$LADD = (C \times IR \times F \times D) / (BW \times LT) \qquad \text{(Eq. 13)}$$

where:

LADD	=	potential lifetime average daily dose (mg/kg-day)
C	=	exposure concentration (mg/L)
IR	=	ingestion rate (2L/day)
F	=	frequency duration (365 days/year)

D	=	exposure duration (70 years)
BW	=	body weight (70 kg)
LT	=	lifetime (70 years x 365 days/year)

The analysis applies estimated individual pollutant risk levels greater than 10^{-6} (1E-6) to the populations served by any drinking water utilities within 50 miles downstream of each discharge site to determine the number of excess annual cancer cases that may occur during the life of the population. It evaluates systemic toxicant effects by estimating the sizes of populations exposed to pollutants from a given facility, the sum of whose individual hazard quotients yields a hazard index greater than 1.0. If applicable, EPA estimates a monetary value of benefits to society from avoided cancer cases, as described above in subsection (a).

2.1.2.2 *Assumptions and Caveats (Carcinogenic and Systemic Analyses)*

The analyses of human health risks and benefits use the following assumptions:

- A linear relationship exists between pollutant loading reductions and benefits attributed to the cleanup of surface waters.

- The analysis does not assess synergistic or antagonistic effects of multiple chemicals on aquatic ecosystems; therefore, the total benefit of reducing toxics may be under- or over-estimated.

- EPA's Science Advisory Board (SAB) recently recommended that the value of a statistical life (VSL) be adjusted downward using a discount factor to account for latency in cases (such as cancer) where there is a lag between exposure and mortality. This adjustment was not performed in the current analysis because EPA requires more information to estimate latency periods associated with cancers caused by iron and steel pollutants. For example, the risk assessments for several pollutants are based on data from animal bioassays; these data are not sufficiently reliable to estimate a latency period for humans.

- The analysis estimates the total number of individuals who might consume recreationally caught fish and the number who rely on fish on a subsistence basis in each State, in part by assuming that these anglers regularly share their catch with family members;

therefore, the number of anglers in each State is multiplied by the State's average household size. The analysis does not include benefits to the general population because the location of facilities in relation to commercial fisheries is unknown.

- Subsistence anglers make up 5 percent of the resident anglers in a given State; the other 95 percent are sport anglers.

- Recreationally valuable species occur or are taken in the vicinity of the discharges included in the evaluation.

- The analysis of fish tissue uses ingestion rates of 12.1 grams per day for sport anglers and 124.1 grams per day for subsistence anglers (U.S. EPA, 2000b). These ingestion rates are based on uncooked fish weights and use data from all ages of the population surveyed. They represent the 90^{th} and the 99^{th} percentiles, respectively, of the empirical distribution of the U.S. per capita freshwater/estuarine finfish and shellfish consumption, and do not include the consumption of marine fish.

- A State's resident anglers fish all rivers or estuaries within a State equally, and the fish are consumed only by the population within that State.

- The analysis estimates the sizes of populations potentially exposed to discharges to rivers or estuaries that border more than one State using only populations within the State in which the facility is located.

- The analysis estimates the size of the population potentially exposed to fish caught in an impacted waterbody in a given State using the ratio of impacted river miles to total river miles or of impacted estuary square miles to total estuary square miles. The number of miles potentially impacted by a facility's discharge is 50 miles for rivers (U.S. EPA, 1992b) and the total surface area of the various estuarine zones for estuaries.

- When estimating the pollutant concentration in drinking water or fish, the analysis does not consider pollutant fate processes (e.g., sediment adsorption, volatilization, hydrolysis); consequently, estimated concentrations are environmentally conservative (higher).

2.1.3 Estimation of Ecological Benefits

The analysis evaluates the potential ecological benefits of the final regulation by estimating improvements in the recreational fishing habitats that are adversely impacted by iron and steel wastewater discharges. The analysis first identifies stream segments in which the final regulation is expected to eliminate all occurrences of pollutant concentrations in excess of both aquatic life and human health AWQC or toxic effect levels (see Section 2.1.1). The analysis expects that the elimination of pollutant concentrations in excess of AWQC will result in significant improvements in aquatic habitats, which will then improve the quality and value of recreational fishing opportunities. The estimate of the monetary value to society of improved recreational fishing opportunities is based on the concept of a "contaminant-free fishery" as presented by Lyke (1993).

Research by Lyke (1993) shows that anglers may place a significantly higher value on a contaminant-free fishery than a fishery with some level of contamination. Specifically, Lyke estimates the consumer surplus[8] associated with Wisconsin's recreational Lake Michigan trout and salmon fishery, and the additional value of the fishery if it was completely free of contaminants affecting aquatic life and human health. Two analyses form the basis of Lyke's results:

1. A multiple-site, trip-generation, travel cost model was used to estimate net benefits associated with the fishery under baseline conditions (i.e., contaminated).
2. A contingent valuation model was used to estimate willingness-to-pay values for the fishery if it was free of contaminants.

Both analyses used data collected from licensed anglers before the 1990 season. The estimated incremental-benefit values associated with freeing the fishery of contaminants range from 11.1 percent to 31.3 percent of the value of the fishery under current conditions.

[8] Consumer surplus is generally recognized as the best measure from a theoretical basis for valuing the net economic welfare or benefit to consumers from consuming a particular good or service. An increase or decrease in consumer surplus for particular goods or services as the result of regulation is a primary measure of the gain or loss in consumer welfare resulting from the regulation.

To estimate the gain in value of stream segments identified as showing improvements in aquatic habitats as a result of the final regulation, the analysis estimates the baseline recreational fishery value of the stream segments on the basis of estimated annual person-days of fishing per segment and estimated values per person-day of fishing. To calculate annual person-days of fishing per segment, the analysis uses estimates of the affected (exposed) recreational fishing populations (see Section 2.1.2). The analysis then multiplies the number of anglers by estimates of the average number of fishing days per angler in each State to estimate the total number of fishing days for each segment. The analysis calculates the baseline value for each fishery by multiplying the estimated total number of fishing days by an estimate of the net benefit that anglers receive from a day of fishing, where net benefit represents the total value of the fishing day, exclusive of any fishing-related costs (license fee, travel costs, bait, etc.) incurred by the angler. This analysis uses a range of median net benefit values for warm-water and cold-water fishing days ($34.49 and $43.68, respectively, in 2001 dollars). Summing all benefitting stream segments provides a total baseline recreational fishing value of stream segments that are expected to benefit by elimination of pollutant concentrations in excess of AWQC.

To estimate the increase in value resulting from elimination of pollutant concentrations in excess of AWQC, the analysis multiplies the baseline value for benefitting stream segments by the incremental gain in value associated with achievement of the "contaminant-free" condition. Using Lyke's estimated increase in value, from 11.1 to 31.3 percent, multiplying the baseline value by these values yields a range of the expected increase in value for stream segments that are expected to benefit by elimination of pollutant concentrations in excess of AWQC.

In addition, EPA expects nonuse (intrinsic) benefits to the general public as a result of the improvements in water quality described above. These nonuse benefits (option values, aesthetics, existence values, and request values) are based on the premise that individuals who never visit or otherwise use a natural resource might nevertheless be affected by changes in its status or quality (Fisher and Raucher, 1984). Nonuse benefits are not associated with current use of the affected ecosystem or habitat, but rather arise from (1) the *realization* of the improvement in the affected ecosystem or habitat that results from reduced effluent discharges, and (2) the value that individuals place on the *potential for use* sometime in the future. Nonuse benefits can be substantial for some resources, and Fisher and Raucher conservatively estimate nonuse values as one-half of the recreational benefits. Because this approximation applies only to recreational fishing benefits for recreational anglers and does not take into account nonuse values for nonanglers or for uses other than fishing by anglers, EPA estimates only a portion of the nonuse benefits.

2.1.3.1 *Assumptions and Caveats*

The ecological benefits analysis uses the following major assumptions:

- The analysis does not consider background concentrations of the iron and steel pollutants of concern in the receiving stream.

- The estimated benefit of improved recreational fishing opportunities is only a limited measure of the value to society of the improvements in aquatic habitats expected to result from the final regulation; increased assimilation capacity of the receiving stream, improvements in taste and odor, or improvements to other recreational activities, such as swimming and wildlife observation, are not addressed.

- The analysis includes significant simplifications and uncertainties; thus, the monetary value to society of improved recreational fishing opportunities may be over- or underestimated. (see Sections 2.1.1.3 and 2.1.2.2.)

- Potential overlap may exist in the valuation of improved recreational fishing opportunities and avoided cancer cases from fish consumption. This potential is considered to be minor in terms of numerical significance.

2.1.4 Estimation of Economic Productivity Benefits

The analysis estimates potential economic productivity benefits on the basis of reduced sewage sludge contamination due to the final regulation. The treatment of wastewaters generated by iron and steel facilities produces a sludge that contains pollutants removed from the wastewaters. As required by law, POTWs must use environmentally sound practices in managing and disposing of this sludge. The analysis expects the PSES levels to generate sewage sludges with reduced pollutant concentrations. As a result, the POTWs may be able to use or dispose of the sewage sludges with reduced pollutant concentrations at lower costs.

To determine the potential benefits, in terms of reduced sewage sludge disposal costs, the analysis calculates the sewage sludge pollutant concentrations at current and PSES levels (see Section 2.1.1.2). It then compares pollutant concentrations to sewage sludge pollutant limits for surface disposal and land application (minimum ceiling limits and pollutant concentration limits). The analysis projects that a POTW that meets all pollutant limits as a result of pretreatment will benefit from the increase in options for sewage sludge use or disposal. The amount of the benefit deriving from changes in sewage sludge use or disposal practices depends on the sewage sludge use or disposal practices employed under current levels. The analysis assumes that POTWs will choose the least expensive sewage sludge use or disposal practice for which their sewage sludge meets pollutant limits. POTWs with sewage sludge whose baseline qualifies for land application will dispose of their sewage sludge by land application; likewise, POTWs with sewage sludge that meets surface disposal limits (but not the land application ceiling or pollutant limits) will dispose of their sewage sludge at surface disposal sites.

EPA calculates the economic benefit for POTWs receiving wastewater from an iron and steel facility by multiplying the cost differential between baseline and postcompliance sludge use or disposal practices by the quantity of sewage sludge that shifts into meeting land application (minimum ceiling limits and pollutant concentration limits) or surface disposal limits. Using these cost differentials, the analysis calculates cost reductions from changes in sewage sludge use or disposal for each POTW.

$$SCR = PF \ x \ S \ x \ CD \ x \ PD \ x \ CF \qquad \text{(Eq. 14)}$$

where:

SCR	=	estimated POTW sewage sludge use or disposal cost reductions resulting from the final regulation (1997 dollars)
PF	=	POTW flow (million gal/year)
S	=	sewage sludge to wastewater ratio (1,400 lb [dry weight] per million gallons of water)
CD	=	estimated cost differential between least costly composite baseline use or disposal method for which POTW qualifies and least costly use or disposal method for which POTW qualifies postcompliance (1997 dollars/dry metric ton)
PD	=	percentage of sewage sludge disposed
CF	=	conversion factor for units

2.1.4.1 *Assumptions and Caveats*

The economic productivity benefits analysis uses the following major assumptions:

- Of the POTW sewage sludge generated in the United States, 13.4 percent is generated at POTWs that are located too far from agricultural land and surface disposal sites for these use or disposal practices to be economical. The analysis does not associate this percentage of sewage sludge with benefits from shifts to surface disposal or land application.

- The analysis does not estimate benefits expected from reduced record-keeping requirements and exemption from certain sewage sludge management practices.

- No definitive source of cost-saving differentials exists. The analysis may overestimate or underestimate the cost differentials.

- Sewage sludge use or disposal costs vary by POTW. Actual costs incurred by POTWs affected by the final iron and steel regulation may differ from those estimates.

- Because of the unavailability of data on baseline pollutant loadings from all industrial sources, those data are not included in the analysis.

2.2 Pollutant Fate and Toxicity

Human and ecological exposure and risk from environmental releases of toxic chemicals depend largely on toxic potency, intermedia partitioning, and chemical persistence. These factors in turn depend on chemical-specific properties relating to toxicological effects on living organisms, physical state, hydrophobicity/lipophilicity, and reactivity, as well as on the mechanism and media of release and site-specific environmental conditions.

The methodology used in assessing the fate and toxicity of pollutants associated with iron and steel wastewaters consists of three steps: (1) identification of pollutants of concern, (2) compilation of physical-chemical and toxicity data, and (3) categorization assessment. The following sections describe these steps in detail, as well as present a summary of the major assumptions and limitations associated with this methodology.

2.2.1 Identification of Pollutants of Concern

EPA conducted a sampling and analytical program at 18 steel industry sites. EPA sampled and analyzed a broad list of pollutants to identify pollutants present in wastewaters from each type of process operation and to determine their fate in industry wastewater treatment systems. In general, EPA identified as pollutants of concern those pollutants that met these following screening criteria:

- The pollutant was detected at greater than or equal to ten times the minimum level (ML) concentration in at least 10 percent of all untreated process wastewater samples, and
- The mean detected concentration in untreated process wastewater samples was greater than the mean detected concentration in the source water samples.

(This is a simplification of the methodology employed in identifying pollutants of concern. See Section 7 of the *Technical Support Document* for more details.)

In the waste streams from direct discharging iron and steel facilities, EPA detected 60 pollutants (22 priority pollutants, 3 conventional pollutant parameters, and 35 nonconventional pollutants) in waste streams that met the selection criteria. EPA identified these pollutants as pollutants of concern and evaluated them to assess their potential fate and toxicity based on known characteristics of each chemical.

In the waste streams from indirect discharging iron and steel facilities, EPA detected 35 pollutants (14 priority, 3 conventional pollutant parameters, and 18 nonconventional pollutants) in waste streams that met the selection criteria. EPA identified these pollutants as pollutants of concern and evaluated them to assess their potential fate and toxicity based on known characteristics of each chemical.

2.2.2 Compilation of Physical-Chemical and Toxicity Data

The chemical-specific data needed to conduct the fate and toxicity evaluation for this study include aquatic life criteria or toxic effect data for native aquatic species, human health reference doses (RfDs) and cancer potency slope factors (SFs), EPA maximum contaminant levels (MCLs) for drinking water protection, Henry's Law constants, soil/sediment (organic-carbon) adsorption coefficients (K_{oc}), and bioconcentration factors (BCFs) for native aquatic species and aqueous aerobic biodegradation half-lives (BD).

Sources of the above data include EPA AWQC documents and updates, EPA's Assessment Tools for the Evaluation of Risk (ASTER) and the associated Aquatic Information Retrieval System (AQUIRE) and Environmental Research Laboratory-Duluth fathead minnow database, EPA's Integrated Risk Information System (IRIS), EPA's 1997 Health Effects Assessment Summary Tables (HEAST), EPA's 1998 Region III Risk-Based Concentration (RBC) Table, EPA's 1996 Superfund Chemical Data Matrix, EPA's 1989 Toxic Chemical Release Inventory Risk Screening Guide, Syracuse Research Corporation's CHEMFATE database, EPA and other government reports, scientific literature, and other primary and secondary data sources. To ensure that the examination is as comprehensive as possible, this analysis has taken alternative measures to compile data for chemicals for which physical-chemical property and/or toxicity data are not presented in the sources listed above. To the extent possible, EPA estimates values for the chemicals using the quantitative structure-activity relationship (QSAR) model incorporated in ASTER or, for some physical-chemical properties, using published linear regression correlation equations.

(a) Aquatic Life Data

The analysis obtains ambient criteria or toxic effect concentration levels for the protection of aquatic life primarily from EPA's AWQC documents and EPA's ASTER. For several pollutants, EPA has published ambient water quality criteria for the protection of freshwater aquatic life from acute effects. The acute value represents a maximum allowable 1-hour average concentration of a pollutant at any time that protects aquatic life from lethality. For pollutants for which no acute water quality criteria have been developed by EPA, the analysis uses an acute value from published aquatic toxicity test data or an estimated acute value from the ASTER QSAR model. When selecting values from the literature, the analysis prefers measured concentrations from flow-through studies under typical pH and temperature conditions. In addition, the test organism must be a North American resident species of fish or invertebrate. The hierarchy used to select the appropriate acute value is listed below in descending order of priority.

1. National acute freshwater quality criteria
2. Lowest reported acute test values (96-hour LC_{50} for fish and 48-hour EC_{50}/LC_{50} for daphnids)
3. Lowest reported LC_{50} test value of shorter duration, adjusted to estimate a 96-hour exposure period
4. Lowest reported LC_{50} test value of longer duration, up to a maximum of 2 weeks exposure
5. Estimated 96-hour LC_{50} from the ASTER QSAR model

The analysis uses BCF data from numerous data sources, including EPA's AWQC documents and EPA's ASTER. Where measured BCF values are not available for several chemicals, the analysis estimates the parameter using the octanol-water partition coefficient or solubility of the chemical. Lyman et al. (1982) details such methods. The analysis then reviews multiple values and selects a representative value according to the following guidelines:

- Resident U.S. fish species are preferred over invertebrates or estimated values.
- Edible tissue or whole fish values are preferred over nonedible or viscera values.
- Estimates derived from octanol-water partition coefficients are preferred over estimates based on solubility or other estimates, unless the estimate comes from EPA's AWQC documents.

The analysis uses the most conservative value (i.e., the highest BCF) among comparable candidate values.

(b) Human Health Data

Human health toxicity data include chemical-specific RfD for noncarcinogenic effects and potency SF for carcinogenic effects. The analysis obtains RfDs and SFs first from EPA's IRIS, and secondarily uses EPA's HEAST or EPA's Region III RBC Table. The RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious noncarcinogenic health effects over a lifetime (U.S. EPA, 1989a). A chemical with a low RfD is more toxic than a chemical with a high RfD. Noncarcinogenic effects include systemic effects (e.g., reproductive, immunological, neurological, circulatory, or respiratory toxicity), organ-specific toxicity, developmental toxicity, mutagenesis, and lethality. EPA recommends a threshold-level assessment approach for these systemic and other effects, because several protective mechanisms must be overcome prior to the appearance of an adverse noncarcinogenic effect. In contrast, EPA assumes that cancer growth can be initiated from a single cellular event and therefore should not be subject to a threshold-level assessment approach.

The SF is an upper-bound estimate of the probability of cancer per unit intake of a chemical over a lifetime (U.S. EPA, 1989a). A chemical with a large SF has greater potential to cause cancer than a chemical with a small SF.

Other chemical designations related to potential adverse human health effects include EPA assignment of a concentration limit for protection of drinking water, and EPA designation as a priority pollutant. EPA establishes drinking water criteria and standards, such as the MCL, under authority of the Safe Drinking Water Act (SDWA). Current MCLs are available from EPA's Office of Water. EPA has designated 126 chemicals and compounds as priority pollutants under the authority of the Clean Water Act (CWA).

(c) Physical-Chemical Property Data

The analysis uses 2 measures of physical-chemical properties to evaluate environmental fate: Henry's Law constant (HLC) and organic-carbon adsorption partition coefficient (K_{oc}).

HLC is the ratio of vapor pressure to solubility and is indicative of the propensity of a chemical to volatilize from surface water (Lyman et al., 1982). The larger the HLC, the more likely that the chemical will volatilize. The analysis obtains most HLCs from EPA's Office of Pesticides and Toxic Substances' (OPTS) 1989 *Toxic Chemical Release Inventory Risk Screening Guide* (U.S. EPA, 1989b), the Office of Solid Waste's (OSW) *Superfund Chemical Data Matrix* (U.S. EPA, 1996a), or the QSAR system (U.S. EPA, 1998-1999), maintained by EPA's Environmental Research Laboratory in Duluth, Minnesota.

K_{oc} is indicative of the propensity of an organic compound to adsorb to soil or sediment particles and, therefore, to partition to such media. The larger the K_{oc}, the more likely that the chemical will adsorb to solid material. The analysis obtains most K_{oc}s from Syracuse Research Corporation's CHEMFATE database and EPA's 1989 *Toxic Chemical Release Inventory Risk Screening Guide* (U.S. EPA, 1989b).

The biodegradation half-life (BD) is the empirically derived length of time during which half the amount of a chemical in water is degraded by microbial action in the presence of oxygen. BD is indicative of the environmental persistence of a chemical released into the water column. The analysis obtains most BDs from the *Handbook of Environmental Degradation Rates* (Howard, 1991) and EPA's Environmental Research Laboratory-Duluth's QSAR.

2.2.3 Categorization Assessment

The objective of evaluating fate and toxicity potential is to place chemicals into groups with qualitative descriptors of potential environmental behavior and impact. These groups are based on categorization schemes derived for the following descriptors:

- Acute aquatic toxicity (high, moderate, or slightly toxic)
- Volatility from water (high, moderate, slight, or nonvolatile)
- Adsorption to soil/sediment (high, moderate, slight, or nonadsorptive)
- Bioaccumulation potential (high, moderate, slight, or nonbioaccumulative)
- Biodegradation potential (fast, moderate, slow, or resistant)

With the use of appropriate key parameters, and where sufficient data exist, these categorization schemes identify the relative aquatic and human toxicity and bioaccumulation potential for each chemical associated with iron and steel wastewater. In addition, the categorization schemes identify the potential of each chemical to partition to various media (air, sediment/sludge, or water) and to persist in the environment. The analysis uses these schemes for screening purposes only; they do not take the place of detailed pollutant assessments that analyze all fate and transport mechanisms.

This evaluation also identifies chemicals that (1) are known, probable, or possible human carcinogens; (2) are systemic human health toxicants; (3) have EPA human health drinking water standards; and (4) are designated as priority pollutants by EPA. The results of this analysis can provide a qualitative indication of potential risk posed by the release of these chemicals. Actual risk depends on the magnitude, frequency, and duration of pollutant loading; site-specific environmental conditions; proximity and number of human and ecological receptors; and relevant exposure pathways. The following discussion outlines the categorization schemes and presents the ranges of parameter values that define the categories.

(a) Acute Aquatic Toxicity

Key Parameter: Acute aquatic life criteria/LC_{50} or other benchmark (AT) (Fg/L)

Using acute criteria or lowest reported acute test results (generally 96-hour and 48-hour durations for fish and invertebrates, respectively), the analysis groups chemicals according to their relative short-term effects on aquatic life.

Categorization Scheme:

AT < 100	Highly toxic
1,000 ≥ AT ≥ 100	Moderately toxic
AT > 1,000	Slightly toxic

This scheme, used as a rule-of-thumb guidance by EPA's OPPT for Premanufacture Notice (PMN) evaluations, indicates chemicals that could potentially cause lethality to aquatic life downstream of discharges.

(b) Volatility from Water

Key Parameter: Henry's Law constant (HLC) (atm-m^3/mol)

$$HLC = \frac{\text{Vapor Pressure (atm)}}{\text{Solubility (mol/m}^3\text{)}} \qquad \text{(Eq. 15)}$$

HLC is the measured or calculated ratio of vapor pressure to solubility at ambient conditions. This parameter indicates the potential for organic substances to partition to air in a two-phase (air and water) system. A chemical's potential to volatilize from surface water can be inferred from HLC.

Categorization Scheme:

$HLC > 10^{-3}$	Highly volatile
$10^{-3} \geq HLC \geq 10^{-5}$	Moderately volatile
$10^{-5} > HLC \geq 3 \times 10^{-7}$	Slightly volatile
$HLC < 3 \times 10^{-7}$	Essentially nonvolatile

This scheme, adopted from Lyman et al. (1982), indicates chemical potential to volatilize from process wastewater and surface water, thereby reducing the threat to aquatic life and human health via contaminated fish consumption and drinking water, yet potentially causing risk to exposed populations via inhalation.

(c) Adsorption to Soil/Sediments

Key Parameter: Soil/sediment (organic-carbon) adsorption coefficient (K_{oc})

K_{oc} is a chemical-specific adsorption parameter for organic substances that is largely independent of the properties of soil or sediment and can be used as a relative indicator of adsorption to such media. K_{oc} is highly inversely correlated with solubility, well correlated with octanol-water partition coefficient, and fairly well correlated with BCF.

Categorization Scheme:

$K_{oc} > 10{,}000$	Highly adsorptive
$10{,}000 \geq K_{oc} \geq 1{,}000$	Moderately adsorptive
$1{,}000 > K_{oc} \geq 10$	Slightly adsorptive
$K_{oc} < 10$	Essentially nonadsorptive

This scheme evaluates substances that may partition to solids and potentially contaminate sediment underlying surface water or land receiving sewage sludge applications. Although a high K_{oc} value indicates that a chemical is more likely to partition to sediment, it also indicates that a chemical may be less bioavailable.

(d) Bioaccumulation Potential

Key Parameter: Bioconcentration factor (BCF)

$$BCF = \frac{Equilibrium\ chemical\ concentration\ in\ organism\ (wetweight)}{(Mean\ chemical\ concentration\ in\ water)} \qquad \text{(Eq. 16)}$$

BCF is a good indicator of potential to accumulate in aquatic biota through uptake across an external surface membrane.

Categorization Scheme:

BCF > 500	High potential
500 ≥ BCF ≥ 50	Moderate potential
50 > BCF ≥ 5	Slight potential
BCF < 5	Nonbioaccumulative

This scheme identifies chemicals that may be present in fish or shellfish tissues at higher levels than in surrounding water. These chemicals may accumulate in the food chain and increase exposure to higher-trophic-level populations, including people who consume their sport catch or commercial seafood.

(e) Biodegradation Potential

Key Parameter: Aqueous aerobic biodegradation half-life (BD) (days)

Biodegradation, photolysis, and hydrolysis are three potential mechanisms of organic chemical transformation in the environment. The analysis selects BD to represent chemical persistence on the basis of its importance and the abundance of measured or estimated data relative to other transformation mechanisms.

Categorization Scheme:

$BD \leq 7$	Fast
$7 < BD \leq 28$	Moderate
$28 < BD \leq 180$	Slow
$180 < BD$	Resistant

This scheme is based on classification ranges given in a recent compilation of environmental fate data (Howard, 1991). The scheme gives an indication of chemicals that are likely to biodegrade in surface water and therefore not persist in the environment. However, biodegradation products can be less toxic, equally as toxic, or even more toxic than the parent compound.

2.2.4 Assumptions and Limitations

The following two subsections summarize the major assumptions and limitations associated with the data compilation and categorization schemes.

(a) Data Compilation

- If data are readily available from electronic databases, the analysis does not search other primary and secondary sources.
- Many of the data are estimated and therefore can have a high degree of associated uncertainty.
- For some chemicals, neither measured nor estimated data are available for key categorization parameters. In addition, chemicals identified for this study do not represent a complete set of wastewater constituents. As a result, this analysis does not completely assess iron and steel wastewater.

(b) Categorization Schemes

- The analysis does not consider receiving waterbody characteristics, pollutant loading amounts, exposed populations, and potential exposure routes.
- For several categorization schemes, the analysis groups chemicals using arbitrary order-of-magnitude data breaks. Combined with data uncertainty, this may lead to an overstatement or understatement of the characteristics of a chemical.
- Data derived from laboratory tests may not accurately reflect conditions in the field.
- Available aquatic toxicity and bioconcentration test data may not represent the most sensitive species.
- The biodegradation potential may not be a good indicator of persistence for organic chemicals that rapidly photodegrade or hydrolyze, since the analysis does not consider these degradation mechanisms.

2.3 Documented Environmental Impacts

EPA reviewed State 303(d) lists of impaired water, State fishing advisories, and reports for evidence of documented environmental impacts on aquatic life, human health, and the quality of receiving water due to discharges of pollutants from iron and steel facilities. The analysis compiles and summarizes reported impacts by facility.

3. DATA SOURCES

3.1 Water Quality Impacts

The analysis uses readily available EPA and other agency databases, models, and reports to evaluate water quality impacts. The following six sections describe the various data sources used in the analysis.

3.1.1 Facility-Specific Data

EPA's Engineering and Analysis Division (EAD) provided projected iron and steel facility effluent process flows, facility operating days, and pollutant loadings (Appendix A) in April 2002 (U.S. EPA, 2002). EAD determined an average performance level (the "long-term average") that a facility with well-designed and well-operated model technologies (which reflect the appropriate level of control) is capable of achieving. This long-term average (LTA) was calculated from data from the facilities using the model technologies for the option. The LTAs were based on pollutant concentrations collected from three data sources: EPA sampling episodes, the 1997 analytical and product follow-up survey, and data submitted by industry. Facilities reported the annual quantity discharged to surface waters and POTWs in one of two versions (short or detailed) of the *U.S. EPA Collection of 1997 Iron and Steel Industry Data* (U.S. EPA, 1997a). EAD multiplied the annual quantity discharged by the facility (facility flow) by the LTA for each pollutant and converted the results to the proper units to calculate the loading (in pounds per year) for each pollutant at each facility. (This is a simplification of the methodology employed. See Section 11 of the *Technical Support Document* for more details).

The analysis identifies the locations of iron and steel facilities on receiving streams using the U.S. Geological Survey (USGS) cataloging and stream segment (reach) numbers contained in EPA's Industrial Facilities Discharge (IFD) File (U.S. EPA, 2000c). It also uses latitude-longitude coordinates, if available, to locate facilities or POTWs that have not been assigned a reach number in the IFD database. The names, locations, and flow data for the POTWs to which the indirect facilities discharge are obtained from the 1997 iron and steel questionnaire (U.S. EPA, 1997a), EPA's 1996 Needs Survey (U.S. EPA, 1996b), the IFD database, and EPA's Permit Compliance System (PCS) (U.S. EPA, 2000d). If these sources do not yield information for a facility, alternative measures are taken to obtain a complete set of receiving streams and POTWs.

The analysis obtains the receiving stream flow data from either the W.E. Gates study data or measured stream flow data, both of which are contained in EPA's GAGE file (U.S. EPA, 2000e). The W.E. Gates study contains calculated average and low flow statistics based on the best available flow data and on drainage areas for reaches throughout the United States. The GAGE file also includes average and low flow statistics based on measured data from USGS gaging stations. EPA contacted State environmental agencies for additional information, as necessary. The analysis obtains dissolved concentration potentials (DCPs) for estuaries and bays from the Strategic Assessment Branch of NOAA's Ocean Assessments Division (NOAA/U.S. EPA, 1989a-c, 1991) (Appendix B). Critical dilution factors are obtained from the *Mixing Zone Dilution Factors for New Chemical Exposure Assessments* (U.S. EPA, 1992a).

3.1.2 Information Used To Evaluate POTW Operations

The primary source of the POTW treatment removal efficiencies is the *Fate of Priority Pollutants in Publicly Owned Treatment Works*, commonly referred to as the "50-POTW Study" (U.S. EPA, 1982). This study presents data on the performance of 50 well-operated POTWs that employ secondary biological treatment in removing pollutants. Each sample was analyzed for 3 conventional, 16 nonconventional, and 126 priority toxic pollutants. Additionally, because of the large number of pollutants of concern for the iron and steel industry, EPA also uses data from the National Risk Management Research Laboratory (NRMRL) Treatability Database (formerly called the Risk Reduction Engineering Laboratory (RREL) database) (U.S. EPA, 1995a). For pollutants of concern not found in the 50-POTW Study, EPA uses data from the NRMRL database, using only treatment technologies representative of typical POTW secondary treatment operations (activated sludge, activated sludge with filtration, aerated lagoons).

The analysis obtains inhibition values from the *Guidance Manual for Preventing Interference at POTWs* (U.S. EPA, 1987) and from *CERCLA Site Discharges to POTWs: Guidance Manual* (U.S. EPA, 1990a). The most conservative values for activated sludge are used. For pollutants with no specific inhibition value, the analysis uses a value based on compound type, such as aromatics (Appendix C).

The analysis obtains sewage sludge regulatory levels, if available for the pollutants of concern, from the *Standards for the Use or Disposal of Sewage Sludge, Final Rule* (U.S. EPA, 1995b). The analysis uses pollutant limits established for the final use or disposal of sewage sludge when the sewage sludge is applied to agricultural and nonagricultural land (Appendix C). Sludge partition factors are obtained from the *Report to Congress on the Discharge of Hazardous Wastes to Publicly-Owned Treatment Works (Domestic Sewage Study)* (U.S. EPA, 1986) (Appendix C).

3.1.3 Water Quality Criteria

The analysis obtains the AWQC (or toxic effect levels) for the protection of aquatic life and human health from a variety of sources, including EPA criteria documents, EPA's ASTER, and EPA's IRIS (Appendix C). It uses ecological toxicity estimations when published values are not available. The hierarchies used to select the appropriate aquatic life and human health values are described in the following sections.

3.1.3.1 *Aquatic Life*

EPA establishes AWQC for many pollutants for the protection of freshwater aquatic life (acute and chronic criteria). The acute value represents a maximum allowable 1-hour average concentration of a pollutant at any time and can be related to acute toxic effects on aquatic life. The chronic value represents the average allowable concentration of a toxic pollutant over a 4-day period at which a diverse genera of aquatic organisms and their uses should not be unacceptably affected, provided that these levels are not exceeded more than once every 3 years.

For pollutants for which no AWQC are developed, the analysis uses specific toxicity values (acute and chronic effect concentrations reported in published literature or estimated using various application techniques). When selecting values from the literature, the analysis prefers measured concentrations from flow-through studies under typical pH and temperature conditions. The test organism has to be a North American resident species of fish or invertebrate. The hierarchies used to select the appropriate acute and chronic values are listed below in descending order of priority.

Acute Aquatic Life Values:

1. National acute freshwater quality criteria

2. Lowest reported acute test values (96-hour LC_{50} for fish and 48-hour EC_{50}/LC_{50} for daphnids)

3. Lowest reported LC_{50} test value of shorter duration, adjusted to estimate a 96-hour exposure period

4. Lowest reported LC_{50} test value of longer duration, up to a maximum of 2 weeks of exposure

5. Estimated 96-hour LC_{50} from the ASTER QSAR model

Chronic Aquatic Life Values:

1. National chronic freshwater quality criteria

2. Lowest reported maximum allowable toxicant concentration (MATC), lowest-observed-effect concentration (LOEC), or no-observed-effect concentration (NOEC)

3. Lowest reported chronic growth or reproductive toxicity test concentration

4. Estimated chronic toxicity concentration from a measured acute:chronic ratio for a less sensitive species, QSAR model, or default acute:chronic ratio of 10:1

3.1.3.2 *Human Health*

EPA establishes AWQC for the protection of human health in terms of a pollutant's toxic effects, including carcinogenic potential, using two exposure routes: (1) ingesting the pollutant via contaminated aquatic organisms only, and (2) ingesting the pollutant via both water and contaminated aquatic organisms. The values are determined as follows.

<u>For Toxicity Protection (ingestion of organisms only)</u>:

$$HH_{oo} = \frac{RfD \ x \ CF}{IR_f \ x \ BCF} \qquad \text{(Eq. 17)}$$

where:

HH_{oo}	=	human health value (µg/L)
RfD	=	reference dose for a 70-kg individual (mg/day)
IR_f	=	fish ingestion rate (0.0065 kg/day)
BCF	=	bioconcentration factor (L/kg)
CF	=	conversion factor for units (1,000 µg/mg)

<u>For Carcinogenic Protection (ingestion of organisms only)</u>:

$$HH_{oo} = \frac{BW \ x \ RL \ x \ CF}{SF \ x \ IR_f \ x \ BCF} \qquad \text{(Eq. 18)}$$

where:

HH_{oo}	=	human health value (µg/L)
BW	=	body weight (70 kg)
RL	=	risk level (10^{-6})
SF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$

IR_f = fish ingestion rate (0.0065 kg/day)
BCF = bioconcentration factor (L/kg)
CF = conversion factor for units (1,000 μg/mg)

<u>For Toxicity Protection (ingestion of water and organisms)</u>:

$$HH_{wo} = \frac{RfD \ x \ CF}{IR_w + (IR_f \ x \ BCF)} \qquad \text{(Eq. 19)}$$

where:

HH_{wo} = human health value (μg/L)
RfD = reference dose for a 70-kg individual (mg/day)
IR_w = water ingestion rate (2 L/day)
IR_f = fish ingestion rate (0.0065 kg/day)
BCF = bioconcentration factor (L/kg)
CF = conversion factor for units (1000 μg/mg)

<u>For Carcinogenic Protection (ingestion of water and organisms)</u>:

$$HH_{wo} = \frac{BW \ x \ RL \ x \ CF}{SF \ x \ (IR_w + (IR_f \ x \ BCF))} \qquad \text{(Eq. 20)}$$

where:

HH_{wo} = human health value (μg/L)
BW = body weight (70 kg)
RL = risk level (10^{-6})
SF = cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_w = water ingestion rate (2 L/day)
IR_f = fish ingestion rate (0.0065 kg/day)
BCF = bioconcentration factor (L/kg)
CF = conversion factor for units (1,000 μg/mg)

The analysis derives the values for ingesting water and organisms by assuming an average daily ingestion rate of 2 liters of water, an average daily fish consumption rate of 6.5 grams of potentially contaminated fish products, and an average adult body weight of 70 kilograms (U.S. EPA, 1991). If EPA has established a slope factor, the analysis uses values protective of carcinogenicity to assess the potential effects on human health.

The analysis develops protective concentration levels for carcinogens in terms of nonthreshold lifetime risk level, using criteria at a risk level of 10^{-6} (1E-6). This risk level indicates a probability of 1 additional case of cancer for every 1 million persons exposed. Toxic effects criteria for noncarcinogens include systemic effects (e.g., reproductive, immunological, neurological, circulatory, or respiratory toxicity), organ-specific toxicity, developmental toxicity, mutagenesis, and lethality.

The hierarchy used to select the most appropriate human health criteria values is listed below in descending order of priority:

1. Human health criteria values calculated using EPA's IRIS RfDs or SFs in conjunction with adjusted 3 percent lipid BCF values derived from *Quality Criteria for Water* (U.S. EPA, 1980). Three percent is the mean lipid content of fish tissue reported in the study from which the average daily fish consumption rate of 6.5 g/day is derived.

2. Human health criteria values calculated using current IRIS RfDs or SFs and representative BCF values for common North American species of fish or invertebrates or estimated BCF values.

3. Human health criteria values calculated using RfDs or SFs from EPA's HEAST or EPA's Region III RBC Table in conjunction with adjusted 3 percent lipid BCF values derived from *Quality Criteria for Water* (U.S. EPA, 1980).

4. Human health criteria values calculated using current RfDs or SFs from HEAST or EPA's Region III RBC Table and representative BCF values for common North American species of fish or invertebrates or estimated BCF values.

5. Criteria from the *Quality Criteria for Water* (U.S. EPA, 1980).

6. Human health values calculated using RfDs or SFs from data sources other than IRIS, HEAST, or Region III RBC Table.

This hierarchy is based on Section 2.4.6 of the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991), which recommends using the most current risk information from IRIS when estimating human health risks. In cases where chemicals have both RfDs and SFs from the same level of the hierarchy, the analysis calculates human health values using the formulas for carcinogenicity, which always result in the more stringent value, given the risk levels employed.

3.1.4 Information Used To Evaluate Human Health Risks and Benefits

The analysis obtains fish ingestion rates for adult sport and subsistence anglers from the draft report *Estimated Per Capita Fish Consumption in the United States, Based on the Data Collected by the United States Department of Agriculture's 1994-1996 Continuing Survey of Food Intakes by Individuals* (U.S. EPA, 2000a). Fish ingestion rates for children are obtained from the *Exposure Factors Handbook* (U.S. EPA, 1997b). Data on average household size are obtained from the *Statistical Abstract of the United States: 1995* (U.S. Bureau of the Census, 1995). Population and birth rate data are obtained from the *Statistical Abstract of the United States: 1997* (U.S. Bureau of the Census, 1997). Data concerning the number of anglers in each State (i.e., resident anglers) are obtained from the 1991 *National Survey of Fishing, Hunting, and Wildlife Associated Recreation* (U.S. Dept. of the Interior FWS, 1991) (Site-specific information is used for special cases). The total number of river miles or estuary square miles within a State are obtained from the 1990 *National Water Quality Inventory Report to Congress* (U.S. EPA, 1990b). The analysis identifies drinking water utilities located within 50 miles downstream from each discharge site using EPA's REACHSCAN (U.S. EPA, 2000f). The population served by a drinking water utility is obtained from EPA's Safe Drinking Water Information System (SDWIS) (U.S. EPA, 2000g). Total suspended solids (TSS) concentrations (effluent and receiving stream) used in the DRE model are obtained from EAD and from the *Analysis of STORET Suspended Sediments Data for the United States* (Versar, 1992b), respectively. Willingness-to-pay values are obtained from OPA's review of the 1989 and 1986 studies "The Value of Reducing Risks of Death: A Note on New Evidence" (Fisher et al., 1989) and *Valuing Risks: New Information on the Willingness to Pay for Changes in*

Fatal Risks (Violette and Chestnut, 1986). The analysis adjusts values to 1997 on the basis of the relative change in the Employment Cost Index of Total Compensation for all Civilian Workers. Information used in the evaluation is presented in Appendix D and E.

3.1.5 Information Used To Evaluate Ecological Benefits

The analysis uses the concept of a "contaminant-free fishery" and the estimate of an increase in the consumer surplus associated with a contaminant-free fishery which are presented in *Discrete Choice Models to Value Changes in Environmental Quality: A Great Lakes Case Study*, a thesis submitted at the University of Wisconsin-Madison (Lyke, 1993). The analysis uses data concerning the number of resident anglers in each State and average number of fishing days per angler in each State obtained from the 1991 *National Survey of Fishing, Hunting, and Wildlife Associated Recreation* (U.S. Dept. of the Interior, FWS, 1991) (Appendix D). Median net benefit values for warm-water and cold-water fishing days are obtained from *Nonmarket Values from Two Decades of Research on Recreational Demand* (Walsh et al., 1990). The analysis adjusts values to 1997, on the basis of the change in the Consumer Price Index for all urban consumers, as published by the Bureau of Labor Statistics. The concept and methodology of estimating nonuse (intrinsic) benefits, based on improved water quality, are obtained from "Intrinsic Benefits of Improved Water Quality: Conceptual and Empirical Perspectives" (Fisher and Raucher, 1984).

3.1.6 Information Used To Evaluate Economic Productivity Benefits

The analysis obtains sewage sludge pollutant limits for surface disposal and land application (ceiling limits and pollutant concentration limits) from the *Standards for the Use or Disposal of Sewage Sludge, Final Rule* (U.S. EPA, 1995b). Cost savings resulting from shifts in sludge use or disposal practices (from composite baseline use and disposal practices) are obtained from the *Regulatory Impact Analysis of Proposed Effluent Limitations, Guidelines and Standards for the Metal Products and Machinery Industry (Phase I)* (U.S. EPA, 1995c). The analysis adjusts savings, if applicable, to 1997 using the Construction Cost Index published in the *Engineering News Record*. In that report, EPA consulted a wide variety of sources, including the following:

- 1988 National Sewage Sludge Survey
- 1985 EPA *Handbook for Estimating Sludge Management Costs*
- 1989 EPA *Regulatory Impact Analysis of the Proposed Regulations for Sewage Sludge Use and Disposal*
- Interviews with POTW operators
- Interviews with State government solid waste and waste pollution control experts
- Review of trade and technical literature on sewage sludge use or disposal practices and costs
- Research organizations with expertise in waste management

Information used in the evaluation is presented in Appendix D.

3.2 Pollutant Fate and Toxicity

The analysis obtains the chemical-specific data needed to conduct the fate and toxicity evaluation from various sources as discussed in Section 2.2.2 of this report. Aquatic life and human health values are presented in Appendix C, as well as physical-chemical property data.

3.3 Documented Environmental Impacts

The analysis obtains data concerning environmental impacts from the 1998 State 303(d) lists of impaired waterbodies (U.S. EPA, 1998a), the 1998 *National Listing of Fish and Wildlife Consumption Advisories* (U.S. EPA, 1998b), and EPA's *Enforcement and Compliance Assurance, FY 98 Accomplishments Report* (U.S. EPA, 1999).

4. SUMMARY OF RESULTS

4.1 Projected Water Quality Impacts

4.1.1 Comparison of Instream Concentrations with Ambient Water Quality Criteria

The results of this analysis indicate the water quality benefits of controlling discharges from iron and steel facilities to surface waters and POTWs. The following two sections summarize potential aquatic life and human health impacts on receiving stream water quality and on POTW operations and their receiving streams for direct and indirect discharges. All tables referred to in these sections are presented at the end of Section 4.

4.1.1.1 *Direct Discharging Facilities*

The analysis evaluates the effects of direct wastewater discharges on receiving stream water quality at **current** and **BAT** discharge levels for 15 iron and steel facilities directly discharging 50 pollutants to 13 receiving streams (Table 1). At **current** discharge levels, these 15 facilities discharge 3.83 million pounds per year of priority and nonconventional pollutants (Table 2). The iron and steel guidelines will reduce these loadings to 3.10 million pounds per year at **BAT** discharge levels, a 19 percent reduction.

The analysis projects that modeled instream pollutant concentrations will exceed **human health criteria** or toxic effect levels (developed for consumption of water and organisms) in 69 percent of the receiving streams (9 of the total 13) at **current** and **BAT** discharge levels (Table 3). Using a target risk of 10^{-6} (1E-6) for the carcinogens, the analysis projects that 6 pollutants at **current** and **BAT** discharge levels will exceed instream criteria or toxic effect levels (Table 4). The analysis also projects a total of 5 pollutants will exceed **human health criteria** or toxic effect levels (developed for consumption of organisms only) in 69 percent of the receiving streams (9 of the total

13) at **current** and **BAT** discharge levels (Tables 3 and 4). The final iron and steel guidelines will reduce the magnitude of the **human health** excursions.

The analysis projects that modeled instream pollutant concentrations of 4 pollutants will exceed **acute aquatic life criteria** or toxic effect levels in 15 percent of the receiving streams (2 of the total 13) at **current** discharge levels (Tables 3 and 4). The analysis also projects modeled instream concentrations of 11 pollutants will exceed **chronic aquatic life criteria** or toxic effect levels in 38 percent of the receiving streams (5 of the total 13) (Tables 3 and 4). The final iron and steel guidelines will reduce **acute aquatic life** excursions to 3 pollutants in 8 percent of the receiving streams (1 of the total 13) and will reduce **chronic aquatic life** excursions to 9 pollutants in 23 percent of the receiving streams (3 of the total 13).

4.1.1.2 *Indirect Discharging Facilities*

The analysis evaluates the effects of POTW wastewater discharges on receiving stream water quality at **current** and **PSES** discharge levels for 8 indirect iron and steel facilities discharging 26 pollutants to 7 POTWs located on 7 receiving streams (Table 5). At **current** discharge levels, after accounting for POTW removal, these 8 facilities discharge 0.60 million pounds per year of priority and nonconventional pollutants (Table 2). The iron and steel guidelines will reduce these loadings to 0.34 million pounds per year at **PSES** discharge levels, a 43 percent reduction.

Using a target risk of 10^{-6} (1E-6) for the carcinogens, the analysis projects that modeled instream pollutant concentrations will exceed **human health criteria** or toxic effect levels (developed for both the consumption of water and organisms and for the consumption of organisms only) in 71 percent of the receiving streams (5 of the total 7) at **current** and **PSES** discharge levels (Tables 6 and 7).

The analysis projects that modeled instream concentrations of 1 pollutant will exceed **acute aquatic life criteria** or toxic effect levels in 14 percent of the receiving streams (1 of the total 7) at

current discharge levels (Tables 6 and 7). The final iron and steel guidelines will eliminate this excursion. The analysis also projects modeled instream concentrations of 3 pollutants will exceed **chronic aquatic life criteria** or toxic effect levels in 43 percent of the receiving streams (3 of the total 7) at both **current** and **PSES** discharge levels (Tables 6 and 7).

In addition, the analysis evaluates the potential impact of the 8 indirect discharging iron and steel facilities, which discharge to 7 POTWs, in terms of inhibition of POTW operation and contamination of sludge. The analysis projects that no inhibition problems or sludge contamination problems will occur at any of the POTWs (Table 8).

4.1.2 Estimation of Human Health Risks and Benefits

The analysis evaluates the potential benefits to human health by estimating the risks (carcinogenic and systemic) associated with current and reduced pollutant levels in fish tissue and drinking water. Sections 4.1.2.1 and 4.1.2.2 summarize potential human health impacts (carcinogenic and systemic) from the consumption of fish tissue and drinking water that are derived from waterbodies impacted by direct and indirect discharging facilities. The analysis estimates risks for recreational (sport) and subsistence anglers and their families, as well as the general population (drinking water).

4.1.2.1 *Direct Discharging Facilities*

The analysis evaluates the effects of direct wastewater discharges on human health from the consumption of fish tissue and drinking water at **current** and **BAT** discharge levels for 15 iron and steel facilities directly discharging 50 pollutants to 13 receiving streams.

Fish Tissue (Carcinogenic and Systemic) -- At **current** discharge levels, 12 receiving streams have total estimated individual-pollutant cancer risks greater than 10^{-6} (1E-6) due to the discharge of 12 carcinogens (Tables 9 and 10). The analysis projects total estimated risks greater than 10^{-6} (1E-6) for **sport anglers** and **subsistence anglers**. At **current** discharge levels, total excess annual cancer cases are estimated to be 8.5E-1. At **BAT** discharge levels, 12 receiving streams still have a total estimated individual-pollutant cancer risk greater than 10^{-6} (1E-6) due to the discharge of 12 carcinogens (Tables 9 and 10). The analysis again projects total estimated risks greater than 10^{-6} (1E-6) for **sport anglers** and **subsistence anglers**. Total excess annual cancer cases will be reduced to an estimated 3.7E-1 at **BAT** discharge levels (Table 9). Based on the reduction of total excess cancer cases (5E-1), the monetary value of benefits to society from avoided cancer cases ranges from $1,300,000 to $6,900,000 (2001 dollars).

In addition, the analysis projects systemic toxicant effects (hazard index greater than 1.0) in 1 receiving stream from 8 pollutants at **current** discharge levels (Table 11). An estimated population of 5000 **sport** and **subsistence anglers** and their families are projected to be affected. The iron and steel guidelines are not projected to eliminate systemic toxicant effects.

Drinking Water -- At **current** and **BAT** discharge levels, the analysis projects that 5 receiving streams will have total estimated individual pollutant cancer risks greater than 10^{-6} (1E-6) due to the discharge of 4 carcinogens (Table 12). Estimated risks range from 2.0E-6 to 3.4E-5. Drinking water utilities are located within 50 miles downstream of 1 site that discharges 1 carcinogen with risks greater than 10^{-6} (1E-6). However, EPA has published a drinking water standard for the 1 carcinogen, and the analysis assumes that drinking water treatment systems will reduce concentrations to below adverse effect thresholds. Therefore, the analysis projects no total excess annual cancer cases (Table 12). In addition, the analysis projects no systemic toxicant effects (hazard index greater than 1.0) at **current** or **BAT** discharge levels (Table 11).

4.1.2.2 *Indirect Discharging Facilities*

The analysis evaluates the effects of POTW wastewater discharges on human health from the consumption of fish tissue and drinking water at **current** and **PSES** discharge levels for 8 iron and steel facilities discharging 26 pollutants to 7 POTWs with outfalls on 7 receiving streams.

Fish Tissue (Carcinogenic and Systemic) -- At **current** discharge levels, 6 receiving streams have total estimated individual-pollutant cancer risks greater than 10^{-6} (1E-6) due to the discharge of 3 carcinogens (Tables 13 and 14). The analysis projects total estimated risks greater than 10^{-6} (1E-6) for both **sport anglers** and **subsistence anglers**. At **current** discharge levels, total excess annual cancer cases are estimated to be 2.6E-2 (Table 13). At **PSES** discharge levels, the 6 receiving streams still have total estimated individual-pollutant cancer risks greater than 10^{-6} (1E-6) due to the discharge of the 3 carcinogens (Tables 13 and 14). The analysis again projects total estimated risks greater than 10^{-6} (1E-6) for both **sport anglers** and **subsistence anglers**. Total excess annual cancer cases will be reduced to 2.5E-2 at **PSES** levels (Table 13). Based on the reduction of total excess cancer cases (1.0E-3), the monetary value of benefits to society from avoided cancer cases is $2,600 to $14,000 (2001 dollars). In addition, the analysis projects no systemic toxicant effects (hazard index greater than 1.0) at **current** or **PSES** discharge levels (Table 15).

Drinking Water -- At **current** and **PSES** discharge levels, the analysis projects that 1 receiving stream will have total estimated individual-pollutant cancer risks greater than 10^{-6} (1E-6) (Table 16). However, there are no drinking water utilities located within 50 miles downstream of the discharge site. In addition, the analysis projects no systemic toxicant effects (hazard index greater than 1.0) at **current** or **PSES** discharge levels (Table 15).

4.1.3 Estimation of Ecological Benefits

The analysis evaluates the potential ecological benefits of the final regulation by estimating improvements in the recreational fishing habitats that are adversely impacted by direct and indirect iron and steel wastewater discharges. Impacts include acute and chronic toxicity, sublethal effects on metabolic and reproductive functions, physical destruction of spawning and feeding habitats, and loss of prey organisms. These effects will vary because of the diversity of species with differing sensitivities. For example, lead exposure can cause spinal deformities in rainbow trout. Copper exposure can affect the growth activity of algae. In addition, copper and cadmium can be acutely toxic to aquatic life, including finfish. The following sections summarize the potential monetary benefits for direct and indirect iron and steel discharges, as well as additional benefits that are not monetized.

4.1.3.1 *Direct Discharging Facilities*

The analysis evaluates the effects of direct wastewater discharges on aquatic habitats at **current** and **BAT** discharge levels for 15 iron and steel facilities discharging 50 pollutants to 13 receiving streams (Tables 1 and 3). The analysis projects that the final regulation will completely eliminate instream concentrations in excess of AWQC at 1 receiving stream (Table 3). The analysis estimates the monetary value of improved recreational fishing opportunities by first calculating the baseline value of the benefitting stream segment (Table 17). From the estimated total of 21,300 person-days fished on the 1 stream segment and the value per person-day of recreational fishing ($34.49 to $43.68, 2001 dollars), the analysis estimates a baseline value of $735,000 to $930,000 for the 1 stream segment (Table 17). The value of improving water quality in these fisheries is then calculated on the basis of the increase in value (11.1 percent to 31.3 percent) to anglers of achieving a contaminant-free fishing stream (Lyke, 1993). The resulting estimate of the increase in value of recreational fishing to anglers ranges from $82,000 to $291,000 (2001 dollars) (Table 17). In addition, the estimate of the nonuse (intrinsic) benefits to the general public, as a result of the same improvements in water quality, ranges from $41,000 to $145,000 (2001 dollars) (Table 17). The analysis estimates these nonuse benefits as one-half of the recreational benefits, which may be significantly underestimating them.

4.1.3.2 *Indirect Discharging Facilities*

The analysis evaluates the effects of indirect wastewater discharges on aquatic habitats at **current** and **PSES** discharge levels for 8 iron and steel facilities discharging 26 pollutants to 7 POTWs with outfalls located on 7 receiving streams (Tables 5 and 6). The analysis projects that the final regulation will not eliminate instream concentrations in excess of AWQC. (Table 6).

4.2 Pollutant Fate and Toxicity

Levels of human exposure, ecological exposure, and risk from environmental releases of toxic chemicals depend largely on toxic potency, intermedia partitioning, and chemical persistence. These exposure and risk factors depend on the chemical-specific properties of toxicological effects on living organisms, physical state, hydrophobicity/lipophilicity, and reactivity, as well as on the mechanism and media of release and site-specific environmental conditions.

Using available data on the physical-chemical properties, and aquatic life and human health toxicity data for the 60 direct discharge iron and steel pollutants of concern, the analysis determines the following: 20 pollutants exhibit moderate to high toxicity to aquatic life, 37 are human systemic toxicants, 19 are classified as known or probable carcinogens, 16 have drinking water values (10 with enforceable health-based maximum contaminant levels (MCLs), 4 with a secondary MCL, and 2 with an action level for treatment) and 23 are designated by EPA as priority pollutants (Tables 18, 19, and 20). In terms of projected environmental partitioning among media, 17 of the evaluated pollutants are moderately to highly volatile (potentially causing risk to exposed populations via inhalation), 27 have a moderate to high potential to bioaccumulate in aquatic biota (potentially accumulating in the food chain and causing increased risk to higher trophic level organisms and to exposed human populations via fish and shellfish consumption), 20 are moderately to highly adsorptive to solids, and 7 are resistant to biodegradation or are slowly biodegraded.

In addition, using available data on the physical-chemical properties, and aquatic life and human health toxicity data for the 35 indirect discharge iron and steel pollutants of concern, the analysis determines the following: 12 exhibit moderate to high toxicity to aquatic life, 15 are human systemic toxicants, 9 are classified as known or probable carcinogens, 5 have drinking water values (all with enforceable health-based MCLs), and 14 are designated by EPA as priority pollutants (Tables 21, 22, and 23). In terms of projected environmental partitioning among media, 13 of the pollutants are moderately to highly volatile, 14 have a moderate to high potential to bioaccumulate in aquatic biota, 13 are moderately to highly adsorptive to solids, and 7 are resistant to biodegradation or are slowly biodegraded.

4.3 Documented Environmental Impacts

The analysis reviews information received from reports, State 303(d) lists of impaired waterbodies, and State fishing advisories for documented impacts due to discharges from iron and steel facilities. States identified at least 3 impaired waterbodies, with industrial point sources as a potential source of impairment, that receive direct discharges from iron and steel facilities (and other sources). These waterbodies are included on the States' 303(d) prioritized lists of impaired waterbodies (Table 24). Section 303(d) of the Water Quality Act of 1987 requires States to identify waterbodies that do not meet state water quality standards and to develop a "total maximum daily load" or TMDL for each listed waterbody. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, which is then allocated to the pollutant's sources. States also have issued fish consumption advisories for 9 waterbodies that receive direct discharges from 10 iron and steel facilities (and other sources) (Table 25). The advisories include mercury and dioxins, iron and steel pollutants of concern. In addition, EPA's *Enforcement and Compliance Assurance, FY 98 Accomplishments Report* (U.S. EPA, 1999) identified significant noncompliance (SNC) rates (most egregious violations under each program or statute) for iron and steel facilities (Table 26). Of the 27 integrated mills inspected in fiscal years (FY) 1996 and 1997, 96 percent were out of compliance with one or more statutes, and 65 percent were in SNC. In FY 1998, of the 23 integrated mills inspected, 39.1 percent of the facilities were in SNC with their water permits, 72.7 percent with air violations, and 30.4 percent with RCRA violations. SNC rates for 91 mini-mills were 21.2 percent for air, 2.7 percent for water permits, and 4.5 percent for RCRA. Key compliance and environmental problems included groundwater contamination from slag disposal, contaminated sediments from steelmaking, electric arc furnace dust, unregulated sources, SNCs from recurring and single peak violations, and no baseline testing.

4.4 Summary of Environmental Effects/Benefits from Final Effluent Guidelines and Standards

EPA estimates that the annual monetized benefits resulting from the final effluent guidelines and standards will range from $1.4 million to $7.3 million (2001 dollars). Table 27 summarizes these effects/benefits. The range reflects the uncertainty in evaluating the effects of this final rule and in placing a monetary value on these effects. The estimate of reported benefits also understates the total benefits expected to result under this final rule. Additional benefits, which cannot be quantified in this assessment, include improved ecological conditions from improvements in water quality, improvements to recreational activities (other than fishing), and reduced discharge of conventional and other pollutants.

Table 1. Evaluated Pollutants of Concern (50) Discharged from 15 Direct Discharging Iron and Steel Facilities

CAS Number	Pollutant	Subcategory	
		Cokemaking	Sintering
50328	Benzo(a)pyrene	X	
56553	Benzo(a)anthracene	X	
57125	Total Cyanide	X	X*
62533	Aniline	X	
67641	Acetone	X	
71432	Benzene	X	
85018	Phenanthrene	X	X*
91203	Naphthalene	X	
91576	2-Methylnaphthalene	X	
95487	o-Cresol	X	X*
100027	4-Nitrophenol		X*
105679	2,4-Dimethylphenol	X	X*
106445	p-Cresol	X	X*
108952	Phenol	X	X*
110861	Pyridine	X	X*
112958	n-Eicosane	X	
129000	Pyrene	X	
132649	Dibenzofuran	X	
205992	Benzo(b)fluoranthene	X	
206440	Fluoranthene	X	X*
218019	Chrysene	X	
302045	Thiocyanate	X	X*
593453	n-Octadecane	X	
612942	2-Phenylnaphthalene	X	
7429905	Aluminum		X*
7439896	Iron		X*
7439976	Mercury	X	X*
7439921	Lead		X*
7439954	Magnesium		X*
7439965	Manganese		X*
7439987	Molybdenum		X*
7440020	Nickel		X*
7440280	Thallium		X*
7440326	Titanium		X*

Table 1. Evaluated Pollutants of Concern (50) Discharged from 15 Direct Discharging Iron and Steel Facilities (Cont'd)

CAS Number	Pollutant	Subcategory	
		Cokemaking	Sintering
7440382	Arsenic		X*
7440428	Boron		X*
7440439	Cadmium		X*
7440473	Chromium		X*
7440508	Copper		X*
7440666	Zinc		X*
7664417	Ammonia As Nitrogen (NH3-N)	X	X*
7782492	Selenium	X	X*
16984488	Fluoride		X*
51207319	2,3,7,8-Tetrachlorodibenzofuran		X
57117314	2,3,4,7,8-Pentachlorodibenzofuran		X
57117416	1,2,3,7,8-Pentachlorodibenzofuran		X
57117449	1,2,3,6,7,8-Hexachlorodibenzofuran		X
60851345	2,3,4,6,7,8-Hexachlorodibenzofuran		X
67562394	1,2,3,4,6,7,8-Heptachlorodibenzofuran		X
70648269	1,2,3,4,7,8-Hexachlorodibenzofuran		X

* Preliminary loadings.

Source: U.S. EPA, Engineering and Analysis Division (EAD), April 10, 2002, Loading Files

Table 2. Summary of Pollutant Loadings for Evaluated Iron and Steel Facilities

	Loadings (Million Pounds-per-Year)*		Total**
	Direct Dischargers	Indirect Dischargers	
Current	3.83	0.60 ***	4.43
BAT / PSES	3.10	0.34 ***	3.44
No. of Pollutants Evaluated	50	26	50
No. of Facilities Evaluated	15	8	22 ****

* Loadings are representative of pollutants evaluated; conventional and nonconventional pollutants such as TSS, BOD, COD, TOC, TKN, total phenols, amenable cyanide, nitrate/nitrite, weak acid dissociable cyanide, and oil and grease are not evaluated.

** The same pollutant may be discharged from a number of direct and indirect facilities; therefore, the total does not equal the sum of pollutants.

*** Accounts for POTW removal; loadings prior to POTW removal are 1.74 million pounds-per-year (current) and 1.18 million pounds-per-year (PSES).

**** One facility is both a direct and an indirect discharger.

Source: U.S. EPA, Engineering and Analysis Division (EAD), April 10, 2002, Loading Files.

Table 3. Summary of Projected Criteria Excursions for Iron and Steel Direct Dischargers (All Subcategories)

	Acute Aquatic Life	Chronic Aquatic Life	Human Health Water and Orgs.	Human Health Orgs. Only	Total*
Current					
Stream (No.)	2	5	9	9	10
Pollutants (No.)	4 (1.3-2.7)	11 (1.0-23.3)	6 (1.1-1,020)	5 (1.1-1,020)	16
Total Excursions	**4**	**15**	**21**	**20**	
BAT**					
Stream (No.)	1	3	9	9	9
Pollutants (No.)	3 (1.3-2.7)	9 (1.1-23.3)	6 (1.1-894)	5 (1.1-894)	14
Total Excursions	**3**	**11**	**19**	**18**	

NOTE: Numbers in parentheses represent the range in the magnitude of excursions.
Number of streams evaluated = 13, number of facilities = 15, and number of pollutants = 50.
Pollutants detected at or below the minimum level were assumed to be present at the minimum level.

* Pollutants may exceed criteria on a number of streams; therefore, total does not equal sum of pollutants exceeding criteria.

** Projected excursions calculated assuming effluent pollutant concentrations at **BAT** are equal to effluent pollutant concentrations at **current** for those pollutants and sites/subcategories where pollutants were never detected above minimum level. Also, projected excursions calculated assuming effluent pollutant concentrations at **BAT** are equal to effluent pollutant concentrations at **current** for select pollutants and sites/subcategories where there is a projected reduction in flow but not a projected reduction in load (i.e., loads used in the cost-effectiveness analysis).

April 10, 2002, Loading Files.

Table 4. Summary of Pollutants Projected to Exceed Criteria for Iron and Steel Direct Dischargers (All Subcategories)

	Number of Excursions							
	Acute Aquatic Life		Chronic Aquatic Life		Human Health Water and Orgs.		Human Health Orgs. Only	
	Current	BAT	Current	BAT	Current	BAT	Current	BAT
Aluminum	0	0	1 (1.8)	1 (1.8)	0	0	0	0
Ammonia as N	1 (1.3)	1 (1.3)	1 (5.1)	1 (5.1)	0	0	0	0
Arsenic	0	0	0	0	1 (28.5)	1 (28.5)	1 (3.6)	1 (3.6)
Benzo(a)anthracene	0	0	0	0	5 (1.1-725)	4 (2.6-42)	5 (1.1-68)	4 (2.5-40)
Benzo(a)pyrene	0	0	1 (2.1)	1 (1.8)	8 (1.7 - 1,020)	8 (1.6 - 894)	8 (1.8 - 1,020)	8 (1.6 - 894)
Benzo(b)fluoranthene	0	0	0	0	5 (1.6-74)	4 (6.0-74)	5 (1.6-74)	4 (6.0-74)
Boron	0	0	1 (3.0)	1 (3.0)	0	0	0	0
Cyanide	1 (1.7)	0	4 (1.4-7.1)	3 (3.4-4.0)	0	0	0	0
Fluoride	1 (2.7)	1 (2.7)	1 (23.3)	1 (23.3)	0	0	0	0
Iron	0	0	0	0	1 (1.1)	1 (1.1)	0	0
Lead	0	0	1 (4.0)	1 (4.0)	0	0	0	0
Magnesium	0	0	1 (1.1)	1 (1.1)	0	0	0	0
Selenium	0	0	1 (1.6)	0	0	0	0	0
Thallium	0	0	0	0	1 (4.0)	1 (4.0)	1 (1.1)	1 (1.1)
Thiocyanate	0	0	2 (1.0 - 2.3)	0	0	0	0	0
Zinc	1 (1.5)	1 (1.5)	1 (1.3)	1 (1.3)	0	0	0	0

NOTE: Number of pollutants evaluated = 50; AWQC or toxic effect levels were not available for all pollutants (See Appendix C).
Numbers outside parentheses represent the number of excursions; numbers in parentheses represent the range in the magnitude of excursions.

April 10, 2002, Loading Files.

Table 5. Evaluated Pollutants of Concern (26) Discharged from 8 Indirect Discharging Iron and Steel Facilities

CAS Number	Pollutant	Cokemaking Subcategory
50328	Benzo(a)pyrene	X
56553	Benzo(a)anthracene	X
57125	Total Cyanide	X
62533	Aniline	X
67641	Acetone	X
71432	Benzene	X
85018	Phenanthrene	X
91203	Naphthalene	X
91576	2-Methylnaphthalene	X
95487	o-Cresol	X
105679	2,4-Dimethylphenol	X
106445	p-Cresol	X
108952	Phenol	X
110861	Pyridine	X
112958	n-Eicosane	X
129000	Pyrene	X
132649	Dibenzofuran	X
205992	Benzo(b)fluoranthene	X
206440	Fluoranthene	X
218019	Chrysene	X
302045	Thiocyanate	X
593453	n-Octadecane	X
612942	2-Phenylnaphthalene	X
7439976	Mercury	X
7664417	Ammonia As Nitrogen (NH3-N)	X
7782492	Selenium	X

Source: U.S. EPA, Engineering and Analysis Division (EAD), April 10, 2002, Loading Files

Table 6. Summary of Projected Criteria Excursions for Iron and Steel Indirect Dischargers (Cokemaking Subcategory)

	Acute Aquatic Life	Chronic Aquatic Life	Human Health Water and Orgs.	Human Health Orgs. Only	Total*
Current					
Stream (No.)	1	3	5	5	5
Pollutants (No.)	1 (1.6)	3 (1.2 - 5.7)	3 (1.1 - 144)	3 (1.1 - 144)	6
Total Excursions	**1**	**5**	**8**	**8**	
PSES					
Stream (No.)	0	3	5	5	5
Pollutants (No.)	0	3 (1.2 - 2.6)	3 (1.0 - 144)	3 (1.0 - 144)	6
Total Excursions	**0**	**5**	**8**	**8**	

NOTE: Numbers in parentheses represent the range in the magnitude of excursions.
Number of streams evaluated = 7, number of facilities = 8, and number of pollutants = 26.
Pollutants detected at or below the minimum level were assumed to be present at the minimum level.

* Pollutants may exceed criteria on a number of streams; therefore, total does not equal sum of pollutants exceeding criteria.

April 10, 2002, Loading Files.

Table 7. Summary of Pollutants Projected to Exceed Criteria for Iron and Steel
Indirect Dischargers (Cokemaking Subcategory)

	Number of Excursions							
	Acute Aquatic Life		Chronic Aquatic Life		Human Health Water and Orgs.		Human Health Orgs. Only	
	Current	PSES	Current	PSES	Current	PSES	Current	PSES
Benzo(a)anthracene	0	0	0	0	1 (2.8)	1 (2.8)	1 (2.6)	1 (2.6)
Benzo(a)pyrene	0	0	0	0	5 (4.7 - 144)	5 (4.7 - 144)	5 (4.7 - 144)	5 (4.7 - 144)
Benzo(b)fluoranthene	0	0	0	0	2 (1.1 - 9.8)	2 (1.0 - 9.8)	2 (1.1 - 9.8)	2 (1.0 - 9.8)
Cyanide	1 (1.6)	0	3 (1.2 - 5.7)	3 (1.2 - 2.6)	0	0	0	0
Thiocyanate	0	0	1 (1.4)	1 (1.4)	0	0	0	0
Selenium	0	0	1 (2.2)	1 (2.2)	0	0	0	0

NOTE: Number of pollutants evaluated = 26; AWQC or toxic effect levels were not available for all pollutants (See Appendix C).
Numbers outside parentheses represent the number of excursions; numbers in parentheses represent the range in the magnitude of excursions.

April 10, 2002, Loading Files.

Table 8. Summary of Projected POTW Inhibition and Sludge Contamination Problems from Iron and Steel Indirect Dischargers (Cokemaking Subcategory)

	Biological Inhibition	Sludge Contamination	Total
Current			
POTWs (No.)	0	0	0
Pollutants (No.)	0	0	0
Total Problems	**0**	**0**	
PSES			
POTWs (No.)	0	0	0
Pollutants (No.)	0	0	0
Total Problems	**0**	**0**	

NOTE: Number of POTWs evaluated = 7, number of facilities = 8, and number of pollutants = 26.
Pollutants detected at or below minimum level were assumed to be present at the minimum level.

April 10, 2002, Loading Files.

Table 9. Summary of Potential Human Health Impacts for Iron and Steel Direct Dischargers (All Subcategories) (Fish Tissue Consumption)

	Total Individual Cancer Risks > 10^{-6}	Total Excess Annual Cancer Cases
<u>Current</u>		
Streams (No.)	12	NA/NA
Carcinogens (No.)	12	NA
Sport Anglers	11 (1.4E-6 to 2.2E-3)	5.5E-1
Subsistence Anglers	12 (2.8E-6 to 2.2E-2)	3.0E-1
TOTAL		**8.5E-1**
<u>BAT</u>*		
Streams (No.)	12	NA/NA
Carcinogens (No.)	12	NA
Sport Anglers	10 (1.2E-6 to 1.8E-3)	2.4E-1
Subsistence Anglers	12 (2.8E-6 to 1.9E-2)	1.3E-1
TOTAL		**3.7E-1**

NOTE: Number of streams evaluated = 13, number of facilities = 15 and number of pollutants = 50.
Table presents results for those streams/facilities for which the projected excess cancer risk exceeds 10^{-6} (1E-6).
Primary chemicals contributing to the excess cancer risk are included in summary even if cancer risk did not exceed 10^{-6} (1E-6).
Pollutants detected at or below minimum level were assumed to be present at the minimum level.

NA = Not Applicable

* Projected cancer risks/cases calculated assuming effluent pollutant concentrations at **<u>BAT</u>** are equal to effluent pollutant concentrations at **<u>current</u>** for those pollutants and sites/subcategories where pollutants were never detected above minimum level. Also, projected cancer risks/cases calculated assuming effluent pollutant concentrations at **<u>BAT</u>** are equal to effluent pollutant concentrations at **<u>current</u>** for select pollutants and sites/subcategories where there is a projected reduction in flow, but not a projected reduction in load (i.e., loads used in the cost-effectiveness analysis).

April 10, 2002, Loading Files.

Table 10. Summary of Pollutants Projected to Cause Human Health Impacts for Iron and Steel Direct Dischargers (All Subcategories) (Fish Tissue Consumption)

	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Sport Anglers	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Subsistence Anglers
Current:		
Stream No. 1		
Benzo(a)anthracene	1.3E-4/3.6E-3	1.3E-3/1.9E-3
Benzo(a)pyrene	1.9E-3/5.2E-2	1.9E-2/2.7E-2
Benzo(b)fluoranthene	1.4E-4/3.7E-3	1.4E-3/2.0E-3
Chrysene	1.2E-6/3.3E-5	1.3E-5/1.9E-5
Stream No. 2		
Benzo(a)anthracene	2.0E-6/5.5E-5	2.1E-5/3.0E-5
Benzo(a)pyrene	4.3E-5/1.2E-3	4.4E-4/6.3E-4
Benzo(b)fluoranthene	2.9E-6/8.0E-5	3.0E-5/4.3E-5
Stream No. 3		
2,3,4,7,8-Pentachlorodibenzofuran	0/NA	2.8E-6/1.0E-5
Stream No. 4		
Arsenic	6.5E-6/4.4E-4	6.7E-5/2.4E-4
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.3E-5/8.8E-4	1.3E-4/4.6E-4
1,2,3,4,7,8-Hexachlorodibenzofuran	1.3E-5/8.8E-4	1.3E-4/4.6E-4
1,2,3,6,7,8-Hexachlorodibenzofuran	1.3E-5/8.8E-4	1.3E-4/4.6E-4
1,2,3,7,8-Pentachlorodibenzofuran	6.5E-5/4.4E-3	6.7E-4/2.4E-3
2,3,4,6,7,8-Hexachlorodibenzofuran	1.3E-5/8.8E-4	1.3E-4/4.6E-4
2,3,4,7,8-Pentachlorodibenzofuran	6.5E-5/4.4E-3	6.7E-4/2.4E-3
2,3,7,8-Tetrachlorodibenzofuran	3.9E-6/2.6E-4	4.0E-5/1.4E-4
Stream No. 5		
Benzo(a)anthracene	1.8E-5/4.8E-4	1.1E-4/1.5E-4
Benzo(a)pyrene	2.3E-4/6.1E-3	2.4E-3/3.3E-3
Benzo(b)fluoranthene	1.6E-5/4.2E-4	1.6E-4/2.2E-4
Chrysene	0/NA	1.1E-6/1.5E-6
Stream No. 6		
Benzo(a)anthracene	1.8E-7/7.4E-6	1.9E-6/4.1E-6
Benzo(a)pryene	4.7E-6/1.9E-4	4.8E-5/1.0E-4
Benzo(b)fluoranthene	2.7E-7/1.1E-5	2.8E-6/6.0E-6
Stream No. 7		
Benzo(a)anthracene	3.6E-7/5.1E-6	3.7E-6/2.8E-6
Benzo(a)pyrene	4.4E-6/6.3E-5	4.5E-5/3.4E-5
Benzo(b)fluoranthene	4.4E-7/6.3E-6	4.5E-6/3.4E-6
Stream No. 8		
Benzo(a)pyrene	1.1E-6/4.5E-5	1.1E-5/2.4E-5
Benzo(b)fluoranthene	2.8E-7/1.1E-5	2.8E-6/6.1E-6

Table 10. Summary of Pollutants Projected to Cause Human Health Impacts for Iron and Steel Direct Dischargers (All Subcategories) (Fish Tissue Consumption) (Continued)

	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Sport Anglers	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Subsistence Anglers
Stream No. 9		
1,2,3,4,7,8-Hexachlorodibenzofuran	2.6E-7/1.2E-5	2.1E-6/5.0E-6
1,2,3,6,7,8-Hexachlorodibenzofuran	1.8E-7/8.1E-6	1.9E-6/4.5E-6
1,2,3,7,8-Pentachlorodibenzofuran	1.0E-7/4.5E-6	1.0E-6/2.4E-6
2,3,4,6,7,8-Hexachlorodibenzofuran	1.5E-7/6.7E-6	1.5E-6/3.5E-6
2,3,4,7,8-Pentachlorodibenzofuran	1.4E-6/6.3E-5	1.4E-5/3.3E-5
2,3,7,8-Tetrachlorodibenzofuran	1.8E-7/8.1E-6	1.8E-6/4.3E-6
Stream No. 10		
Benzo(a)anthracene	1.5E-7/8.6E-6	1.5E-6/4.5E-6
Benzo(a)pyrene	3.2E-6/1.8E-4	3.3E-5/9.9E-5
Benzo(b)fluoranthene	2.2E-7/1.3E-5	2.2E-6/6.6E-6
Stream No. 11		
Benzo(a)anthracene	4.6E-6/6.7E-4	4.7E-5/3.6E-4
Benzo(a)pyrene	1.1E-4/1.6E-2	1.1E-3/8.7E-3
Benzo(b)fluoranthene	1.1E-5/1.6E-3	1.1E-4/8.7E-4
Stream No. 12		
Benzo(a)anthracene	1.0E-5/7.6E-3	1.1E-4/4.4E-3
Benzo(a)pyrene	6.0E-4/4.6E-1	6.1E-3/2.4E-1
Benzo(b)fluoranthene	1.5E-5/1.1E-2	1.6E-4/6.4E-3
Chrysene	1.0E-7/7.6E-5	1.1E-6/4.4E-5

Table 10. Summary of Pollutants Projected to Cause Human Health Impacts for Iron and Steel Direct Dischargers (All Subcategories) (Fish Tissue Consumption) (Continued)

	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Sport Anglers	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Subsistence Anglers
BAT*:		
Stream No. 1		
Benzo(a)anthracene	7.4E-5/2.0E-3	7.6E-4/1.1E-3
Benzo(a)pyrene	1.6E-3/4.4E-2	1.7E-2/2.4E-2
Benzo(b)fluoranthene	1.4E-4/3.7E-3	1.4E-3/2.0E-3
Chrysene	7.4E-7/2.0E-5	7.6E-6/1.1E-5
Stream No. 2		
Benzo(a)anthracene	0/NA	7.4E-6/1.1E-5
Benzo(a)pyrene	1.7E-5/4.6E-4	1.8E-4/2.6E-4
Benzo(b)fluoranthene	1.3E-6/3.6E-5	1.4E-5/2.0E-5
Stream No. 3		
2,3,4,7,8-Pentachlorodibenzofuran	0/NA	2.8E-6/1.0E-5
Stream No. 4		
Arsenic	6.5E-6/4.4E-4	6.7E-5/2.4E-4
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.3E-5/8.8E-4	1.3E-4/4.6E-4
1,2,3,4,7,8-Hexachlorodibenzofuran	1.3E-5/8.8E-4	1.3E-4/4.6E-4
1,2,3,6,7,8-Hexachlorodibenzofuran	1.3E-5/8.8E-4	1.3E-4/4.6E-4
1,2,3,7,8-Pentachlorodibenzofuran	6.5E-5/4.4E-3	6.7E-4/2.4E-3
2,3,4,6,7,8-Hexachlorodibenzofuran	1.3E-5/8.8E-4	1.3E-4/4.6E-4
2,3,4,7,8-Pentachlorodibenzofuran	6.5E-5/4.4E-3	6.7E-4/2.4E-3
2,3,7,8-Tetrachlorodibenzofuran	2.6E-6/1.8E-4	2.7E-5/9.6E-5
Stream No. 5		
Benzo(a)anthracene	1.8E-5/4.8E-4	1.1E-4/1.5E-4
Benzo(a)pyrene	2.3E-4/6.1E-3	2.4E-3/3.3E-3
Benzo(b)fluoranthene	1.6E-5/4.2E-4	1.6E-4/2.2E-4
Chrysene	0/NA	1.1E-6/1.5E-6
Stream No. 6		
Benzo(a)anthracene	1.5E-7/6.2E-6	1.5E-6/3.2E-6
Benzo(a)pryene	3.6E-6/1.5E-4	3.6E-5/7.8E-5
Benzo(b)fluoranthene	2.7E-7/1.1E-5	2.8E-6/6.0E-6
Stream No. 7		
Benzo(a)anthracene	3.6E-7/5.1E-6	3.6E-6/2.7E-6
Benzo(a)pyrene	4.4E-6/6.3E-5	4.5E-5/3.4E-5
Benzo(b)fluoranthene	4.4E-7/6.3E-6	4.5E-6/3.4E-6
Stream No. 8		
Benzo(a)pyrene	9.4E-7/3.9E-5	9.7E-6/2.1E-5
Benzo(b)fluoranthene	2.4E-7/9.8E-6	2.5E-6/5.4E-6

Table 10. Summary of Pollutants Projected to Cause Human Health Impacts for Iron and Steel Direct Dischargers (All Subcategories) (Fish Tissue Consumption) (Continued)

	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Sport Anglers	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Subsistence Anglers
Stream No. 9		
1,2,3,4,7,8-Hexachlorodibenzofuran	0/NA	1.1E-6/2.6E-6
1,2,3,6,7,8-Hexachlorodibenzofuran	0/NA	1.1E-6/2.6E-6
1,2,3,7,8-Pentachlorodibenzofuran	0/NA	5.6E-7/1.3E-6
2,3,4,6,7,8-Hexachlorodibenzofuran	0/NA	1.1E-6/2.6E-6
2,3,4,7,8-Pentachlorodibenzofuran	0/NA	5.6E-6/1.3E-5
2,3,7,8-Tetrachlorodibenzofuran	0/NA	2.3E-7/5.4E-7
Stream No. 10		
Benzo(a)anthracene	1.2E-7/6.8E-6	1.2E-6/3.7E-6
Benzo(a)pyrene	2.9E-6/1.6E-4	2.9E-5/8.8E-5
Benzo(b)fluoranthene	2.2E-7/1.2E-5	2.2E-6/6.7E-6
Stream No. 11		
Benzo(a)anthracene	4.6E-6/6.7E-4	4.7E-5/3.6E-4
Benzo(a)pyrene	1.1E-4/1.6E-2	1.1E-3/8.7E-3
Benzo(b)fluoranthene	1.1E-5/1.6E-3	1.1E-4/8.7E-4
Stream No. 12		
Benzo(a)anthracene	8.3E-6/6.3E-3	8.5E-5/3.4E-3
Benzo(a)pyrene	2.0E-4/1.5E-1	2.0E-3/8.0E-2
Benzo(b)fluoranthene	1.5E-5/1.1E-2	1.6E-4/6.4E-3
Chrysene	8.3E-8/6.3E-5	8.5E-7/3.4E-5

NOTE: Number of streams evaluated = 13, number of facilities = 15, and number of pollutants = 50. Table presents results for those streams/facilities for which the projected excess cancer risk exceeds 10^{-6} (1E-6). Primary chemicals contributing to the excess cancer risk are included in summary, even if cancer risk did not exceed 10^{-6} (1E-6).
Pollutants detected at or below minimum level were assumed to be present at the minimum level.

* Projected cancer risks/cases calculated assuming effluent pollutant concentrations at **BAT** are equal to effluent pollutant concentrations at **current** for those pollutants and sites/subcategories where pollutants were never detected above minimum level. Also, projected cancer risks/cases calculated assuming effluent pollutant concentrations at **BAT** are equal to effluent pollutant concentrations at **current** for select pollutants and sites/subcategories where there is a projected reduction in flow, but not a projected reduction in load (i.e., loads used in the cost-effectiveness analysis).

NA = Not Applicable

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Table 11. Summary of Potential Systemic Human Health Impacts for Iron and Steel Direct Dischargers (All Subcategories) (Fish Tissue and Drinking Water Consumption)

	Fish Tissue Hazard Indices > 1	Drinking Water Hazard Indices >1
Current		
Streams (No.)	1	0
Pollutants (No.)	8*	0
General Population	NA	0
Sport Anglers	1 (2.2)	0
Subsistence Anglers	1 (22.8)	0
Affected Population	5,000	
BAT**		
Streams (No.)	1	0
Pollutants (No.)	8*	0
General Population	NA	0
Sport Anglers	1 (2.2)	0
Subsistence Anglers	1 (22.8)	0
Affected Population	5,000	

NOTE: Number of streams evaluated = 13, number of facilities = 15, and number of pollutants = 50.
Table presents results for those streams/facilities for which the projected hazard indices exceed 1.0.
Pollutants detected at or below minimum level were assumed to be present at the minimum level.
NA = Not Applicable

* 1,2,3,4,7,8-Hexachlorodibenzofuran; 1,2,3,6,7,8-Hexachlorodibenzofuran; 1,2,3,7,8-Pentachlorodibenzofuran; 2,3,4,6,7,8-Hexachlorodibenzofuran, 2,3,4,7,8-Pentachlorodibenzofuran; 1,2,3,4,6,7,8-Heptachlorodibenzofuran; 2,3,7,8-Tetrachlorodibenzofuran; and Thallium.

** Projected hazard indices calculated assuming effluent pollutant concentrations at **BAT** are equal to effluent pollutant concentrations at **current** for those pollutants and sites/subcategories where pollutants were never detected above minimum level. Also, projected hazard indices calculated assuming effluent pollutant concentrations at **BAT** are equal to effluent pollutant concentrations at **current** for select pollutants and sites/subcategories where there is a projected reduction in flow, but not a projected reduction in load (i.e., loads used in the cost-effectiveness analysis).

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Table 12. Summary of Potential Human Health Impacts for Iron and Steel Direct Dischargers (All Subcategories) (Drinking Water Consumption)

	Total Individual Cancer Risks > 10^{-6}	Total Excess Annual Cancer Cases
Current		
Streams (No.)	5	NA
Carcinogens (No.)	4** (2.0E-6 to 3.4E-5)	NA
With Drinking Water Utility # 50 miles	1	NA
Carcinogens (No.)	1*** (8.9E-6)	0
BAT*		
Streams	5	NA
Carcinogens (No.)	4** (2.0E-6 to 2.9E-5)	NA
With Drinking Water Utility # 50 miles	1	NA
Carcinogens (No.)	1*** (3.0E-6)	0

NOTE: Number of streams evaluated = 13, number of facilities = 15, and number of pollutants = 50. Table presents results for those streams/facilities for which the projected excess cancer risk for any pollutant exceeds 10^{-6} (1E-6). Primary chemicals contributing to the excess cancer risk are included in summary even if cancer risk did not exceed 10^{-6} (1E-6).

Pollutants detected at or below minimum level were assumed to be present at the minimum level.

* Projected cancer risks/cases calculated assuming effluent pollutant concentrations at **BAT** are equal to effluent pollutant concentrations at **current** for those pollutants and sites/subcategories where pollutants were never detected above minimum level. Also, projected cancer risks/cases calculated assuming effluent pollutant concentrations at **BAT** are equal to effluent pollutant concentrations at **current** for select pollutants and sites/subcategories where there is a projected reduction in flow, but not a projected reduction in load (i.e., loads used in the cost-effectiveness analysis).

** Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Arsenic.

*** Benzo(a)pyrene. EPA has published a drinking water standard for the 1 carcinogen and it is assumed that drinking water treatment systems will reduce concentrations below adverse effect thresholds.

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Table 13. Summary of Potential Human Health Impacts for Iron and Steel Indirect Dischargers (Cokemaking Subcategory)(Fish Tissue Consumption)

	Total Individual Cancer Risks > 10^{-6}	Total Excess Annual Cancer Cases
Current		
Streams (No.)	6	NA/NA
Carcinogens (No.)	3	NA
Sport Anglers	5 (9.3E-6 to 2.8E-4)	1.7E-2
Subsistence Anglers	6 (2.7E-6 to 2.9E-3)	9.3E-3
TOTAL		**2.6E-2**
PSES		
Streams (No.)	6	NA/NA
Carcinogens (No.)	3	NA
Sport Anglers	5 (4.9E-6 to 2.8E-4)	1.6E-2
Subsistence Anglers	6 (1.4E-6 to 2.9E-3)	8.6E-3
TOTAL		**2.5E-2**

NOTE: Number of streams evaluated = 7, number of facilities = 8, and number of pollutants = 26.
Table presents results for those streams/facilities for which the projected excess cancer risk exceeds 10^{-6} (1E-6).
Primary chemicals contributing to the excess cancer risk are included in summary even if cancer risk did not exceed 10^{-6} (1E-6).
Pollutants detected at or below minimum level were assumed to be present at the minimum level.

NA = Not Applicable

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Table 14. Summary of Pollutants Projected to Cause Human Health Impacts for Iron and Steel Indirect Dischargers (Cokemaking Subcategory) (Fish Tissue Consumption)

	Cancer Risks >10^{-6}/ Excess Annual Cancer Cases Sport Anglers	Cancer Risks >10^{-6}/ Excess Annual Cancer Cases Subsistence Anglers
Current:		
Stream No. 1		
Benzo(a)pyrene	0/NA	2.7E-6/8.0E-6
Stream No. 2		
Benzo(a)anthracene	4.9E-6/2.0E-4	5.0E-5/1.1E-4
Benzo(a)pyrene	2.6E-4/1.1E-2	2.7E-3/5.8E-3
Benzo(b)fluoranthene	1.8E-5/7.4E-4	1.8E-4/3.9E-4
Stream No. 3		
Benzo(a)anthracene	1.6E-7/7.2E-6	1.6E-6/3.8E-6
Benzo(a)pryene	8.6E-6/3.9E-4	8.8E-5/2.1E-4
Benzo(b)fluoranthene	5.8E-7/2.6E-5	6.0E-6/1.4E-5
Stream No. 4		
Benzo(a)anthracene	2.2E-7/9.9E-6	2.2E-6/5.2E-6
Benzo(a)pyrene	1.3E-5/5.8E-4	1.3E-4/3.1E-4
Benzo(b)fluoranthene	1.2E-6/5.4E-5	1.2E-5/2.8E-5
Stream No. 5		
Benzo(a)anthracene	1.8E-7/1.2E-5	1.9E-6/6.8E-6
Benzo(a)pyrene	9.8E-6/6.6E-4	1.0E-4/3.6E-4
Benzo(b)fluoranthene	6.6E-7/4.5E-5	6.8E-6/2.4E-5
Stream No. 6		
Benzo(a)anthracene	3.8E-7/5.6E-5	3.9E-6/3.0E-5
Benzo(a)pyrene	2.3E-5/3.4E-3	2.3E-4/1.8E-3
Benzo(b)fluoranthene	2.0E-6/2.9E-4	2.1E-5/1.6E-4

Table 14. Summary of Pollutants Projected to Cause Human Health Impacts for Iron and Steel Indirect Dischargers (Cokemaking Subcategory) (Fish Tissue Consumption) (Continued)

	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Sport Anglers	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Subsistence Anglers
PSES:		
Stream No. 1		
Benzo(a)pyrene	0/NA	1.4E-6/4.1E-6
Stream No. 2		
Benzo(a)anthracene	4.9E-6/2.0E-4	5.0E-5/1.1E-4
Benzo(a)pyrene	2.6E-4/1.1E-2	2.7E-3/5.8E-3
Benzo(b)fluoranthene	1.8E-5/7.4E-4	1.8E-4/3.9E-4
Stream No. 3		
Benzo(a)anthracene	1.6E-7/7.2E-6	1.6E-6/3.8E-6
Benzo(a)pyrene	8.6E-6/3.9E-4	8.8E-5/2.1E-4
Benzo(b)fluoranthene	5.8E-7/2.6E-5	6.0E-6/1.4E-5
Stream No. 4		
Benzo(a)anthracene	1.2E-7/5.4E-6	1.3E-6/3.1E-6
Benzo(a)pyrene	4.2E-6/1.9E-4	4.3E-5/1.0E-4
Benzo(b)fluoranthene	6.0E-7/2.7E-5	6.2E-6/1.5E-5
Stream No. 5		
Benzo(a)anthracene	1.8E-7/1.2E-5	1.9E-6/6.8E-6
Benzo(a)pyrene	9.8E-6/6.6E-4	1.0E-4/3.6E-4
Benzo(b)fluoranthene	6.6E-7/4.5E-5	6.8E-6/2.4E-5
Stream No. 6		
Benzo(a)anthracene	3.7E-7/5.4E-5	3.8E-6/2.9E-5
Benzo(a)pyrene	1.7E-5/2.5E-3	1.7E-4/1.3E-3
Benzo(b)fluoranthene	1.7E-6/2.5E-4	1.9E-5/1.5E-4

NOTE: Number of streams evaluated = 7, number of facilities = 8, and number of pollutants = 26. Table presents results for those streams/facilities for which the projected excess cancer risk exceeds 10^{-6} (1E-6). Primary chemicals contributing to the excess cancer risk are included in summary, even if cancer risk did not exceed 10^{-6} (1E-6).
Pollutants detected at or below minimum level were assumed to be present at the minimum level.

NA = Not Applicable

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Table 15. Summary of Potential Systemic Human Health Impacts for Iron and Steel Indirect Dischargers (Cokemaking Subcategory) (Fish Tissue and Drinking Water Consumption)

	Fish Tissue Hazard Indices > 1	Drinking Water Hazard Indices >1
Current		
Streams (No.)	0	0
Pollutants (No.)	0	0
General Population	NA	0
Sport Anglers	0	0
Subsistence Anglers	0	0
PSES		
Streams (No.)	0	0
Pollutants (No.)	0	0
General Population	NA	0
Sport Anglers	0	0
Subsistence Anglers	0	0

NOTE: Number of streams evaluated = 7, number of facilities = 8, and number of pollutants = 26.
Table presents results for those streams/facilities for which the projected hazard indices exceed 1.0.
Pollutants detected at or below minimum level were assumed to be present at the minimum level.
NA = Not Applicable

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Table 16. Summary of Potential Human Health Impacts for Iron and Steel Indirect Dischargers (Cokemaking Subcategory) (Drinking Water Consumption)

	Total Individual Cancer Risks > 10^{-6}	Total Excess Annual Cancer Cases
Current		
Streams (No.)	1	NA
Carcinogens (No.)	1* (3.9E-6)	NA
With Drinking Water Utility # 50 miles	0	NA
Carcinogens (No.)	0	0
PSES		
Streams	1	NA
Carcinogens (No.)	1* (3.9E-6)	NA
With Drinking Water Utility # 50 miles	0	NA
Carcinogens (No.)	0	0

NOTE: Number of streams evaluated = 7, number of facilities = 8, and number of pollutants = 26. Table presents results for those streams/facilities for which the projected excess cancer risk for any pollutant exceeds 10^{-6} (1E-6). Primary chemicals contributing to the excess cancer risk are included in summary even if cancer risk did not exceed 10^{-6} (1E-6).

Pollutants detected at or below minimum level were assumed to be present at the minimum level.

* Benzo(a)pyrene

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Table 17. Summary of Ecological (Recreational and Nonuse) Benefits for Iron and Steel Direct Dischargers (All Subcategories)

Data	Number of Stream Segments with Concentrations Exceeding AWQC Eliminated	Total Fishing Days	Baseline Value of Fisheries ($ 2001)	Increased Value of Fisheries ($ 2001)
Cokemaking and Sintering	1	21,300	$735,000 - $930,000	$82,000 - $291,000

NOTE: Value per person-day of recreational fishing = $34.49 (warm water) and $43.68 (cold water).

Increased value of contaminant-free fishing = 11.1 to 31.3 percent.

Data	Number of Stream Segments with Concentrations Exceeding AWQC Eliminated	Increased Nonuse Value ($ 1997)
Cokemaking and Sintering	1	$41,000 - $145,000

NOTE: Nonuse value estimated as one-half of the recreational benefits.

Table 18. Potential Fate and Toxicity of Pollutants of Concern (60) Discharged from 15 Direct Discharging Iron and Steel Facilities

No.	CAS Number	Name	Acute Aquatic Toxicity	Volatility from Water	Adsorption to Solids	Bioaccumulation Potential	Biodegra-dation Potential	Carcinogen	Systemic Toxicant	Drinking Water Value	Priority Pollutant
1	C002	BOD 5-day (carbonaceous)	Unknown	Unknown	Unknown	Unknown	Unknown				
2	C004	Chemical Oxygen Demand (COD)	Unknown	Unknown	Unknown	Unknown	Unknown				
3	C005	Nitrate/Nitrite (NO2 + NO3-N)	Unknown	Unknown	Unknown	Unknown	Unknown				
4	C009	Total Suspended Solids (TSS)	Unknown	Unknown	Unknown	Unknown	Unknown				
5	C012	Total Organic Carbon (TOC)	Unknown	Unknown	Unknown	Unknown	Unknown				
6	C020	Total Recoverable Phenolics	Unknown	Unknown	Unknown	Unknown	Unknown				
7	C021	Total Kjeldahl Nitrogen (TKN)	Unknown	Unknown	Unknown	Unknown	Unknown				
8	C025	Amenable Cyanide	Unknown	Unknown	Unknown	Unknown	Unknown				
9	C036	Hexane Extractable Material (HEM)	Unknown	Unknown	Unknown	Unknown	Unknown				
10	C042	Weak Acid Dissociable Cyanide	Unknown	Unknown	Unknown	Unknown	Unknown				
11	50328	Benzo(a)pyrene	High	Slight	High	High	Resistant	X		M	X
12	56553	Benzo(a)anthracene	High	Slight	High	High	Resistant	X			X
13	57125	Total Cyanide	High	Unknown	Slight	Nonbioaccumulative	Moderate		X	M	X
14	62533	Aniline	Moderate	Slight	Slight	Slight	Moderate	X			
15	67641	Acetone	Slight	Moderate	Slight	Nonbioaccumulative	Fast		X		
16	71432	Benzene	Slight	High	Slight	Slight	Moderate	X	X	M	X
17	85018	Phenanthrene	Moderate	Moderate	High	Moderate	Resistant				X
18	91203	Naphthalene	Slight	Moderate	Slight	Slight	Moderate	X	X		X
19	91576	Methylnaphthalene, 2-	Slight	Moderate	Moderate	High	Moderate		X		
20	95487	o-Cresol	Slight	Slight	Slight	Slight	Fast	X	X		
21	100027	Nitrophenol, 4-	Slight	Nonvolatile	Slight	Moderate	Fast		X		X
22	105679	Dimethylphenol, 2,4-	Slight	Slight	Slight	Moderate	Fast		X		X
23	106445	p-Cresol	Slight	Slight	Slight	Slight	Fast	X	X		
24	108952	Phenol	Slight	Slight	Slight	Nonbioaccumulative	Fast		X		X
25	110861	Pyridine	Slight	Slight	Nonadsorptive	Nonbioaccumulative	Fast		X		
26	112958	n-Eicosane *	Slight	Unknown	High	High	Moderate				
27	129000	Pyrene	Moderate	Moderate	High	High	Resistant		X		X
28	132649	Dibenzofuran	Slight	Moderate	Moderate	High	Moderate		X		
29	205992	Benzo(b)fluoranthene	Unknown	Moderate	High	High	Resistant	X			X
30	206440	Fluoranthene	High	Moderate	High	High	Resistant		X		X
31	218019	Chrysene	Moderate	Moderate	High	High	Resistant	X			X
32	302045	Thiocyanate	Moderate	Unknown	Unknown	Unknown	Unknown				
33	593453	n-Octadecane *	Slight	Unknown	High	High	Moderate				
34	612942	Phenylnaphthalene, 2-	Moderate	Moderate	High	High	Moderate				
35	7429905	Aluminum	Moderate	Unknown	Unknown	Moderate	Unknown		X	SM	
36	7439896	Iron	Unknown	Unknown	Unknown	Unknown	Unknown		X	SM	
37	7439921	Lead	High	Unknown	Unknown	Slight	Unknown	X		TT	X
38	7439954	Magnesium	Slight	Unknown	Unknown	High	Unknown				
39	7439965	Manganese	Unknown	Unknown	Unknown	Unknown	Unknown		X	SM	
40	7439976	Mercury	High	High	High	High	Unknown		X	M	X
41	7439987	Molybdenum	Unknown	Unknown	Unknown	Unknown	Unknown		X		
42	7440020	Nickel	Moderate	Unknown	Slight	Slight	Unknown		X		X

Table 18. Potential Fate and Toxicity of Pollutants of Concern (60) Discharged from 15 Direct Discharging Iron and Steel Facilities

No.	CAS Number	Name	Acute Aquatic Toxicity	Volatility from Water	Adsorption to Solids	Bioaccumulation Potential	Biodegra-dation Potential	Carcinogen	Systemic Toxicant	Drinking Water Value	Priority Pollutant
43	7440280	Thallium	Slight	Unknown	Unknown	Moderate	Unknown		X	M	X
44	7440326	Titanium	Unknown	Unknown	Unknown	Unknown	Unknown		X		
45	7440382	Arsenic	Moderate	Unknown	Unknown	Slight	Unknown	X	X	M	X
46	7440428	Boron	Unknown	Unknown	Unknown	Unknown	Unknown		X		
47	7440439	Cadmium	High	Unknown	Unknown	Moderate	Unknown	X	X	M	X
48	7440473	Chromium	Moderate	Unknown	Unknown	Slight	Unknown		X	M	X
49	7440508	Copper	High	Unknown	Unknown	Moderate	Unknown		X	TT	X
50	7440666	Zinc	Moderate	Unknown	Unknown	Slight	Unknown		X	SM	X
51	7664417	Ammonia As Nitrogen (NH3-N)	Slight	Moderate	Nonadsorptive	Unknown	Moderate				
52	7782492	Selenium	High	Unknown	Unknown	Nonbioaccumulative	Unknown		X	M	X
53	16984488	Fluoride	Slight	Unknown	Unknown	Unknown	Unknown		X	M	
54	51207319	Tetrachlorodibenzofuran, 2,3,7,8-	Unknown	Moderate	High	High	Unknown	X	X		
55	57117314	Pentachlorodibenzofuran, 2,3,4,7,8-	Unknown	Slight	High	High	Unknown	X	X		
56	57117416	Pentachlorodibenzofuran, 1,2,3,7,8-	Unknown	Slight	High	High	Unknown	X	X		
57	57117449	Hexachlorodibenzofuran, 1,2,3,6,7,8-	Unknown	Slight	High	High	Unknown	X	X		
58	60851345	Hexachlorodibenzofuran, 2,3,4,6,7,8-	Unknown	Moderate	High	High	Unknown	X	X		
59	67562394	Heptachlorodibenzofuran, 1,2,3,4,6,7,8-	Unknown	Moderate	High	High	Unknown	X	X		
60	70648269	Hexachlorodibenzofuran, 1,2,3,4,7,8-	Unknown	Moderate	High	High	Unknown	X	X		

Note: Metals, because of their physical/chemical properties, are, in general, not applicable to categorization into groups based on volatility, adsorption to solids, and biodegradation potential.

M= Maximum Contaminant Level (MCL) established for health-based effect.
SM= Secondary Maximum Contaminant Level (SMCL) established for taste or aesthetic effect.
TT= Treatment technology action level established.
* Aquatic toxicity data for n-decane are reported based on structural similarity.

Table 19. Iron and Steel Toxicants Exhibiting Systemic and Other Adverse Effects*
(Direct Dischargers)

	Cas Number	Toxicant	Reference Dose Target Organ and Critical Effects
1	57125	Total Cyanide	Whole Body, Thyroid, Nerve: weight loss, thyroid effects, and myeline degeneration
2	67641	Acetone	Liver, Kidney: increased liver and kidney weights and nephrotoxicity
3	71432	Benzene	(b)
4	91203	Naphthalene	Body Weight: decreased body weights
5	91576	Methylnaphthalene, 2-	(b)
6	95487	o-Cresol	Body Weight, Nervous System: decreased body weights and neurotoxicity
7	100027	Nitrophenol, 4-	(b)
8	105679	Dimethylphenol, 2,4-	General Toxicity, Blood: Lethargy, hematological changes
9	106445	p-Cresol	Nervous System, Respiratory, Whole Body: hypoactivity, distress, maternal death
10	108952	Phenol	Reproductive: reduced fetal body weights
11	110861	Pyridine	Liver: increased liver weights
12	129000	Pyrene	Kidney effects (renal tubular pathology, decreased kidney weights)
13	132649	Dibenzofuran	(b)
14	206440	Fluoranthene	Kidney, Liver, Blood: nephropathy, increased liver weights, hematological alterations, and clinical effects
15	7429905	Aluminum	(b)
16	7439896	Iron	(b)
17	7439965	Manganese	Nervous System: CNS effects
18	7439976	Mercury	Nervous System: neurotoxicity
19	7439987	Molybdenum	Urine, Joint, Blood: increased uric acid, pain and swelling, decreased copper level
20	7440020	Nickel	Body Weight: decreased body and organ weights
21	7440280	Thallium	(b)
22	7440326	Titanium	(b)
23	7440382	Arsenic	Skin: hyperpigmentation, keratosis, possible vascular complications
24	7440428	Boron	Testis: testicular atrophy, spermatogenic arrest
25	7440439	Cadmium	Kidney: significant proteinuria
26	7440473	Chromium	No adverse effects observed (c)
27	7440508	Copper	Irritation of Gastrointestinal System (b)
28	7440666	Zinc	Blood: anemia
29	7782492	Selenium	Respiratory: clinical selerosis
30	16984488	Fluoride	Dental: objectionable dental fluorosis
31	51207319	Tetrachlorodibenzofuran, 2,3,7,8-	Reproductive and developmental effects, immunotoxicity, chloracne
32	57117314	Pentachlorodibenzofuran, 2,3,4,7,8-	Reproductive and developmental effects, immunotoxicity, chloracne
33	57117416	Pentachlorodibenzofuran, 1,2,3,7,8-	Reproductive and developmental effects, immunotoxicity, chloracne
34	57117449	Hexachlorodibenzofuran, 1,2,3,6,7,8-	Reproductive and developmental effects, immunotoxicity, chloracne
35	60851345	Hexachlorodibenzofuran, 2,3,4,6,7,8-	Reproductive and developmental effects, immunotoxicity, chloracne
36	67562394	Heptachlorodibenzofuran, 1,2,3,4,6,7,8-	Reproductive and developmental effects, immunotoxicity, chloracne
37	70648269	Hexachlorodibenzofuran, 1,2,3,4,7,8-	Reproductive and developmental effects, immunotoxicity, chloracne

* Chemicals with EPA-verified or provisional human health-based reference doses (RfD), referred to as "systemic toxicants."
(a) Values for nitrate are assumed.
(b) RfD is an EPA-NCEA provisional value; Contact EPA-NCEA Superfund Technical Support Center for supporting
(c) RfD based on no-observed-adverse-effect level (NOAEL).

Table 20. Iron and Steel Human Carcinogens Evaluated, Weight-of-Evidence Classifications, and Target Organs (Direct Dischargers)

	CAS Number	Carcinogen	Weight-of-Evidence Classification	Target Organs
1	50328	Benzo(a)pyrene	B2	Stomach, Lungs
2	56553	Benzo(a)anthracene	B2	Liver, Lungs
3	62533	Aniline	B2	Spleen, Body Cavity
4	71432	Benzene	A	Blood
5	91203	Naphthalene*	C	Lungs
6	95487	o-Cresol*	C	Skin
7	106445	p-Cresol*	C	Bladder
8	205992	Benzo(b)fluoranthene	B2	Lungs, Skin
9	218019	Chrysene	B2	Liver
10	7439921	Lead*	B2	Kidney
11	7440382	Arsenic	A	Lungs, Skin
12	7440439	Cadmium*	B1	Lungs, Trachea, and Bronchi
13	51207319	Tetrachlorodibenzofuran, 2,3,7,8-	B2**	Liver
14	57117314	Pentachlorodibenzofuran, 2,3,4,7,8-	B2**	Liver
15	57117416	Pentachlorodibenzofuran, 1,2,3,7,8-	B2**	Liver
16	57117449	Hexachlorodibenzofuran, 1,2,3,6,7,8-	B2**	Liver
17	60851345	Hexachlorodibenzofuran, 2,3,4,6,7,8-	B2**	Liver
18	67562394	Heptachlorodibenzofuran, 1,2,3,4,6,7,8-	B2**	Liver
19	70648269	Hexachlorodibenzofuran, 1,2,3,4,7,8-	B2**	Liver

A= Human carcinogen
B1= Probable human carcinogen (limited human data)
B2= Probable human carcinogen (animal data only)
C= Possible human carcinogen
* Not included in Risks and Benefits Analysis; quantitative estimate of carcinogenic risk from oral exposure not available.
** Classified as a carcinogen based on TEF of dioxin

Table 21. Potential Fate and Toxicity of Pollutants of Concern (35) Discharged from 8 Indirect Discharging Iron and Steel Facilities

No.	CAS Number	Name	Acute Aquatic Toxicity	Volatility from Water	Adsorption to Solids	Bioaccumulation Potential	Biodegra-dation Potential	Carcinogen	Systemic Toxicant	Drinking Water Value	Priority Pollutant
1	C002	BOD 5-day (carbonaceous)	Unknown	Unknown	Unknown	Unknown	Unknown				
2	C004	Chemical Oxygen Demand (COD)	Unknown	Unknown	Unknown	Unknown	Unknown				
3	C005	Nitrate/Nitrite (NO2 + NO3-N)	Unknown	Unknown	Unknown	Unknown	Unknown				
4	C009	Total Suspended Solids (TSS)	Unknown	Unknown	Unknown	Unknown	Unknown				
5	C012	Total Organic Carbon (TOC)	Unknown	Unknown	Unknown	Unknown	Unknown				
6	C020	Total Recoverable Phenolics	Unknown	Unknown	Unknown	Unknown	Unknown				
7	C021	Total Kjeldahl Nitrogen (TKN)	Unknown	Unknown	Unknown	Unknown	Unknown				
8	C036	Hexane Extractable Material (HEM)	Unknown	Unknown	Unknown	Unknown	Unknown				
9	C042	Weak Acid Dissociable Cyanide	Unknown	Unknown	Unknown	Unknown	Unknown				
10	50328	Benzo(a)pyrene	High	Slight	High	High	Resistant	X		M	X
11	56553	Benzo(a)anthracene	High	Slight	High	High	Resistant	X			X
12	57125	Total Cyanide	High	Unknown	Slight	Nonbioaccumulative	Moderate		X	M	X
13	62533	Aniline	Moderate	Slight	Slight	Slight	Moderate	X			
14	67641	Acetone	Slight	Moderate	Slight	Nonbioaccumulative	Fast		X		
15	71432	Benzene	Slight	High	Slight	Slight	Moderate	X	X	M	X
16	85018	Phenanthrene	Moderate	Moderate	High	Moderate	Resistant				X
17	91203	Naphthalene	Slight	Moderate	Slight	Slight	Moderate	X	X		X
18	91576	2-Methylnaphthalene	Slight	Moderate	Moderate	High	Moderate		X		
19	95487	o-Cresol	Slight	Slight	Slight	Slight	Fast	X	X		
20	105679	2,4-Dimethylphenol	Slight	Slight	Slight	Moderate	Fast		X		X
21	106445	p-Cresol	Slight	Slight	Slight	Slight	Fast	X	X		
22	108952	Phenol	Slight	Slight	Slight	Nonbioaccumulative	Fast		X		X
23	110861	Pyridine	Slight	Slight	Nonadsorptive	Nonbioaccumulative	Fast		X		
24	112958	n-Eicosane *	Slight	Unknown	High	High	Moderate				
25	129000	Pyrene	Moderate	Moderate	High	High	Resistant		X		X
26	132649	Dibenzofuran	Slight	Moderate	Moderate	High	Moderate		X		
27	205992	Benzo(b)fluoranthene	Unknown	Moderate	High	High	Resistant	X			X
28	206440	Fluoranthene	High	Moderate	High	High	Resistant		X		X
29	218019	Chrysene	Moderate	Moderate	High	High	Resistant	X			X
30	302045	Thiocyanate	Moderate	Unknown	Unknown	Unknown	Unknown				
31	593453	n-Octadecane *	Slight	Unknown	High	High	Moderate				
32	612942	2-Phenylnaphthalene	Moderate	Moderate	High	High	Moderate				
33	7439976	Mercury	High	High	High	High	Unknown		X	M	X
34	7664417	Ammonia As Nitrogen (NH3-N)	Slight	Moderate	Nonadsorptive	Unknown	Moderate				
35	7782492	Selenium	High	Unknown	Unknown	Nonbioaccumulative	Unknown		X	M	X

Note: Metals, because of their physical/chemical properties, are, in general, not applicable to categorization into groups based on volatility, adsorption to solids, and biodegradation potential.

M= Maximum Contaminant Level (MCL) established for health-based effect.
* Aquatic toxicity data for n-decane are reported based on structural similarity.

Table 22. Iron and Steel Toxicants Exhibiting Systemic and Other Adverse Effects*
(Indirect Dischargers)

	Cas Number	Toxicant	Reference Dose Target Organ and Critical Effects
1	57125	Total Cyanide	Weight loss, thyroid effects, and myeline degeneration
2	67641	Acetone	Increased liver and kidney weights and nephrotoxicity
3	71432	Benzene	(b)
4	91203	Naphthalene	Eye damage, decreased body weight
5	91576	2-Methylnaphthalene	(b)
6	95487	o-Cresol	Decreased body weights and neurotoxicity
7	105679	2,4-Dimethylphenol	General Toxicity, Blood: Lethargy, hematological changes
8	106445	p-Cresol	Hypoactivity, distress, maternal death
9	108952	Phenol	Reduced fetal body weight in rats
10	110861	Pyridine	Liver: increased liver weights
11	129000	Pyrene	Kidney effects (renal tubular pathology, decreased kidney weights)
12	132649	Dibenzofuran	(b)
13	206440	Fluoranthene	Nephropathy, increased liver weights, hematological alterations, and clinical effects
14	7439976	Mercury	CNS effects
15	7782492	Selenium	Respiratory: clinical selerosis

* Chemicals with EPA-verified or provisional human health-based reference doses (RfD), referred to as "systemic toxicants."
(a) Values for nitrate are assumed.
(b) RfD is an EPA-NCEA provisional value; Contact EPA-NCEA Superfund Technical Support Center for supporting documentation.

Table 23. Iron and Steel Human Carcinogens Evaluated, Weight-of-Evidence Classifications, and Target Organs (Indirect Dischargers)

	CAS Number	Carcinogen	Weight-of-Evidence Classification	Target Organs
1	50328	Benzo(a)pyrene	B2	Stomach, Lungs
2	56553	Benzo(a)anthracene	B2	Liver, Lungs
3	62533	Aniline	B2	Spleen, Body Cavity
4	71432	Benzene	A	Blood
5	91203	Naphthalene*	C	Lungs
6	95487	o-Cresol*	C	Skin
7	106445	p-Cresol*	C	Bladder
8	205992	Benzo(b)fluoranthene	B2	Skin and Lungs
9	218019	Chrysene	B2	Liver

A= Human Carcinogen
B2= Probable human carcinogen (animal data only)
C= Possible human carcinogen
* Not included in Risks and Benefits Analysis; quantitative estimate of carcinogenic risk from oral exposure not available.

Table 24. Modeled Direct Discharging Iron and Steel Facilities Located on Waterbodies Listed Under Section 303(d) of Clean Water Act (1998)

State	Facility Name	City	Watershed	Waterbody Name	Parameters of Concern	Priority for TMDL Development	Potential Sources of Impairment
Alabama	Empire Coke	Holt	Upper Black Warrior 03160112	Black Warrior River	Organic Enrichment/DO	Low	Dam Construction, Flow Regulations/Modifications
Illinois	National Steel	Granite City	Cahokia-Joachim 07140101	Horseshoe Lake	Metals, Nutrients, Siltation, Organic Enrichment/DO, Suspended Solids, Noxious Aquatic Plants	1	Point Sources, Industrial Point Sources, Agriculture, Crop Production, Urban Runoff/ Storm Sewers, Resource Extraction, Dredge Mining, In-place Contaminants
Indiana	LTV Steel Co.	East Chicago	Little Calumet -Galien 04040001	Indiana Harbor Canal	Dissolved Oxygen, Mercury, PCBs, Lead, Pesticides	1998-2000	—
	Bethlehem Steel Corp	Chesterton	Little Calumet-Galien 04040001	Little Calumet River	Cyanide, E. Coli, Mercury, PCBs, Pesticides, Impaired Biotic Communities	2000-2012	—
Kentucky	AK Steel Corp.	Ashland	Little Scioto-Tygarts 05090103	Ohio River	Pathogens, PCBs, Priority Organics	Second Priority	—
Maryland	Bethlehem Steel Corp.	Sparrows Point	Gunpowder-Patapsco 02060003	Bear Creek	Chromium, PCBs, Zinc	High	Point Sources, Nonpoint Sources, Legacy, Unknown

Table 24. Modeled Direct Discharging Iron and Steel Facilities Located on Waterbodies Listed Under Section 303(d) of Clean Water Act (1998) (Continued)

State	Facility Name	City	Watershed	Waterbody Name	Parameters of Concern	Priority for TMDL Development	Potential Sources of Impairment
Ohio	AK Steel Corp.	Middletown	Lower Great Miami 05080002	Dicks Creek/Great Miami River	Metals, Ammonia, Organic Enrichment/DO, Thermal Modification, Flow Alteration	7	Municipal Point Sources, Industrial Point Sources, Land Disposal, Wastewater Hydromodification, Flow Regulation/Modification
Pennsylvania	Koppers Industry	Monessen	Lower Monongahela 05020005	Monongahela River	Pesticides (Chlordane), Priority Organics(PCBs)	—	—
	Shenango, Inc.	Pittsburgh/Neville Island	Upper Ohio 05030101	Ohio River	Pesticides (Chlordane), Priority Organics (PCBs)	—	—
Utah	Geneva Steel	Provo/Vineyard	Utah Lake 16020201	Utah Lake	Total Dissolved Solids, Total Phosphorus, Ammonia, Benzene, Benzopyrene, BOD, Chlorine Residual, Cyanide, Lead, Napthalene, Oil and Grease, Fecal Coliform, pH, Phenolics, Total Suspended Solids	High	—
West Virginia	Wheeling-Pittsburgh Steel Wheeling-Pittsburgh Steel	Wheeling Follansbee	Upper Ohio 05030101	Ohio River	PCBs, Chlordane, Aluminum	Low/High	—

NOTE: Facilities may be located on waterbodies listed under Section 303(d) of CWA for other states (e.g., Ohio River). Listings are presented based on location (state) of facility.
Source: 1998 TMDL Tracking System Data, Version 1.1, July 1998.

Table 25. Modeled Direct Discharging Iron and Steel Facilities Located on Waterbodies with State/Tribal/Federal Fish Consumption Advisories[a]

Facility NPDES	Facility Name	City	Discharge Type	Receiving Stream	Advisory Area/No.[b]	Pollutant	Species	Population[c]	Comments
IL0000329	National Steel	Granite City	Direct	Horseshoe Lake	Mississippi River	Chlordane	Shovelnose Sturgeon (fish and eggs)	NCGP	Advisory within 50 miles downstream of discharge site
IN0000205	LTV Steel Company	East Chicago	Direct	Indiana Harbor Ship Canal	All Indiana Rivers and Streams Statewide	Mercury, PCBs	Common Carp>15"	NCSP, RGP, NCGP	
					Grand Calumet River and Indiana Harbor Ship Canal	Mercury, PCBs	All Fish	NCGP	
					Lake Michigan and tributaries	Mercury, PCBs	Chinook Salmon, Black Crappie>7", Brook Trout, Brown Trout, White Sucker>15", Longnose Sucker 14-23", Walleye>17", Whitefish, Lake Trout, Rainbow Trout, Largemouth Bass>4", Common Carp, All Catfish Species, Coho Salmon>17", Pink Salmon, Northern Pike>10", Longnose Sucker>23", Goldfish>4", Golden Shiner 3-6"	NCSP, RGP, NCGP	

Table 25. Direct Discharging Iron and Steel Facilities Located on Waterbodies With State/Tribal/Federal Fish Consumption Advisories[a] (continued)

Facility NPDES	Facility Name	City	Discharge Type	Receiving Stream	Advisory Area/No.[b]	Pollutant	Species	Population[c]	Comments
IN0000175	Bethlehem Steel Corp.	Chesterton	Direct	Little Calumet River	All Indiana Rivers and Streams Statewide	Mercury, PCBs	Common Carp>15"	NCSP, RGP, NCGP	
					Lake Michigan and Tributaries	Mercury, PCBs	Chinook Salmon, Black Crappie>7", Brook Trout, Brown Trout, White Sucker>15", Longnose Sucker 14-23", Walleye>17", Whitefish, Lake Trout, Rainbow Trout, Largemouth Bass>4", Common Carp, All Catfish Species, Coho Salmon>17", Pink Salmon, Northern Pike>10", Longnose Sucker>23", Goldfish>4", Golden Shiner 3-6"	NCSP, RGP, NCGP	
KY0000558	AK Steel Corp	Ashland	Direct	Ohio River	Ohio River	Chlordane, PCBs	Paddlefish (fish and eggs), Channel Catfish, Common Carp, White Bass	NCGP	
NY0001368	Bethlehem Steel Corp.	Lackawanna	Direct	Smokes Creek	Niagara River/2	PCBs, Mirex, Dioxins	Coho Salmon, Chinook Salmon, American Eel, Channel Catfish, Common Carp, Lake Trout, Brown Trout, White Perch, Rainbow Trout, White Sucker, Smallmouth Bass, All fish (NCSP)	RGP, NCGP, NCSP	Advisories within 50 miles downstream of discharge site
OH0009997	AK Steel Corporation	Middletown	Direct	Great Miami River	All Ohio Waterbodies Statewide	Mercury	All Fish	RSP	
					Great Miami River/2	Mercury, Lead, PCBs	Channel Catfish, Smallmouth Bass, Common Carp, White Bass, Largemouth Bass, Rock	RGP, RSP, NCGP	

Table 25. Direct Discharging Iron and Steel Facilities Located on Waterbodies With State/Tribal/Federal Fish Consumption Advisories[a] (continued)

Facility NPDES	Facility Name	City	Discharge Type	Receiving Stream	Advisory Area/No.[b]	Pollutant	Species	Population[c]	Comments
PA0217034	Koppers Industries	Monessen	Direct	Monongahela River	Ohio River	Chlordane, PCBs	Common Carp, Channel Catfish	NCGP	Advisory within 50 miles downstream of discharge site
					Monongahela River	Chlordane, PCBs	Common Carp, Channel Catfish	NCGP	
PA0002437	Shenango Inc.-Neville Coke & Iron	Pittsburgh/ Neville Island	Direct	Ohio River	Ohio River	Chlordane, PCBs	Common Carp, Channel Catfish	NCGP	
WV0004499 WV0023281	Wheeling-Pittsburgh Steel Wheeling-Pittsburgh Steel	Follansbee Wheeling	Direct Direct	Ohio River	Ohio River	Chlordane, PCBs, Dioxins	Common Carp, Channel Catfish, Smallmouth Bass, Largemouth Bass, White Bass, Freshwater Drum, Flathead Catfish, Hybrid Striped Bass, Sauger	NCGP, RGP	

Table 25. Direct Discharging Iron and Steel Facilities Located on Waterbodies With State/Tribal/Federal Fish Consumption Advisories[a] (continued)

Footnotes:

NOTE: Facilities may be located on waterbodies with fish consumption advisories issued by other states (e.g., Ohio River - PA, OH, KY). Advisories are listed based on location (state) of facility.
Based on facilities (sample set) included in environmental assessment.
Source: 1997 Update of Listing of Fish and Wildlife Advisories (LFWA), March 1998.

NCGP	=	No consumption advisory for general population
NCSP	=	No consumption advisory for sensitive subpopulations (e.g., pregnant women, nursing mothers, children)
RGP	=	Restrict consumption of specific species for general population
RSP	=	Restrict consumption of specific species for sensitive subpopulations
CFP	=	Commercial fishing ban

a	=	Includes advisories within 50 miles downstream of discharge site as noted.
b	=	Multiple advisories have been combined.
c	=	Consumption of specific species by specific populations not noted. See LFWA for this information.

Table 26. Significant Noncompliance (SNC) Rates for Iron and Steel Mills

Industry	Number of Facilities	Percentage of Facilities in Significant Noncompliance as of June 1998			Historical Noncompliance*				Key Compliance and Environmental Problems
		Air	Water	RCRA	Air	Water	RCRA	Total	
Integrated Mills	23	72.7%	39.1%	30.4%	5.0	5.4	5.7	7.9	Groundwater slag contamination, contaminated sediment, arc furnace dust, unregulated sources, SNCs from reoccurring and single peak violations, no baseline testing
Mini Mills	91	21.2%	2.7%	4.5%	1.5	2.7	1.7	3.9	

Note: SNC data are based on inspected facilities. SNC refers to the most egregious violations under each program or statute.
* Average number of quarterly periods, June 1996 - June 1998, with one or more violations or noncompliance events.

Source: *Enforcement and Compliance Assurance, FY 98 Accomplishments Report*, USEPA Office of Enforcement and Compliance Assurance, June 1999.

Table 27. Summary of Environmental Effects/Benefits of the Final Effluent Guidelines and Standards for the Iron and Steel Industry [a]

	Current	Final Rule	Summary of Benefits
Loadings (million lb/yr) [b, c]	4.43	3.44	22 percent reduction
Number of Instream Excursions for Pollutants That Exceed AWQC	82 at 15 streams	72 at 14 streams	1 stream becomes "contaminant-free" [d] Monetized benefits (recreational/nonuse) = $0.12 to $0.44 million
Excess Annual Cancer Cases[e]	0.9	0.4	Reduction of 0.5 cases each year Monetized benefits = $1.3 to $6.9 million
Population Potentially Exposed to Other Noncarcinogenic Health Risks[e]	5,000	5,000	Health effects to exposed population not eliminated
POTWs Experiencing Inhibition	none of 7	none of 7	No baseline impacts
Improved POTW Biosolid Quality	0 metric tons	0 metric tons	No baseline impacts
Total Monetized Benefits			**$1.4 to 7.3 million** (2001 do1lars)

a. Modeled results from 15 direct and 8 indirect facilities; 1 facility is both a direct and an indirect discharger.
b. Loadings are representative of 50 priority and nonconventional pollutants evaluated; 3 conventional pollutants and 7 nonconventional pollutants are not included.
c. Loadings are adjusted for POTW removals.
d. "Contaminant-free" from iron and steel discharges; however, potential contamination from other point source discharges and nonpoint sources is still possible.
e. Through consumption of contaminated fish.

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NOTE: Most of these references are available in the Environmental Assessment/Benefits Docket EPA-821-R-02-005.