United States
Environmental Protection
Agency

Office of Water Regulations
and Standards (WH-552)
Washington, DC 20460

EPA 440/1-85/061-B
October 1985

Water

EPA

Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the

Ore Mining and Dressing

Point Source Category

Gold Placer Mine

Subcategory

Development Document
for Proposed
Effluent Limitations Guidelines and
New Source Performance Standards
for the
Ore Mining and Dressing Point Source Category
Gold Placer Mine Subcategory

Lee M. Thomas
Administrator

Lawrence J. Jensen
Assistant Administrator for Water

Edwin L. Johnson
Director
Water Regulations and Standards

Jeffery D. Denit
Director, Industrial Technology Division

Baldwin M. Jarrett
Project Officer

October 1985

Industrial Technology Division
Office of Water
U. S. Environmental Protection Agency
Washington, D. C. 20460

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

SECTION I

EXECUTIVE SUMMARY

This development document presents the technical data base developed by EPA to support effluent limitations guidelines and standards for the Gold Placer Mine Subcategory of the Ore Mining and Dressing Point Source Category. The Clean Water Act of 1977 sets forth various levels of technology to achieve these limitations: best practicable technology (BPT), best available technology economically achievable (BAT), best conventional pollutant control technology (BCT), and best available demonstrated technology (BADT). Effluent limitations guidelines based on the application of BPT, BAT, and BCT are to be achieved by existing sources. New source performance standards (NSPS) based on BADT are to be achieved by new facilities. These effluent limitations guidelines and standards are required by Sections 301, 304, 306, 307, and 501 of the Clean Water Act of 1977 (P.L. 95-217). They augment the regulations promulgated on December 3, 1982 for other subcategories of the ore mining industry.

The Act included a timetable for issuing these standards. However, EPA was unable to meet many of the deadlines and, as a result, in 1976, it was sued by several environmental groups. In settling this lawsuit, EPA and the plaintiffs executed a "Settlement Agreement" which was approved by the court. This Agreement required EPA to develop a program and adhere to a schedule in promulgating effluent limitations guidelines, new source performance standards, and pretreatment standards for 65 "priority" pollutants and classes of pollutants for 21 major industries, including the Ore Mining and Dressing industry. See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified, 12 ERC 1833 (D.D.C. 1979), modified by Orders dated October 26, 1982, August 2, 1983, January 6, 1984, July 5, 1984, and January 7, 1985. Many of the basis elements of the Settlement Agreement were incorporated into the Clean Water Act of 1977. Like the Agreement, the Act stressed control of toxic pollutants, including the 65 "priority" pollutants and classes of pollutants.

At present there are over 600 commercial gold placer mines which are active in a given mining season (total operations including recreational and assessment mines may number over 1000) in the United States. Approximately two-thirds of these mines are located in Alaska. All existing gold placer mines are point sources and direct dischargers; there are no known existing indirect dischargers and no new source indirect dischargers are anticipated. (Indirect dischargers are those facilities which discharge to a publicly owned treatment works or "POTW".) Consequently, pretreatment standards, which control the level of pollutants which may be discharged from an industrial plant to a publicly owned treatment works, are not included in this proposal.

To recognize inherent differences in the ore mining industrial category, EPA established subcategories within the larger category. The 1982 regulation for the ore mining and milling industry was divided into 11 major subcategories based upon metal ore and 27 subdivisions based upon whether the discharge was from a mine or mill, and then further based upon the process employed at the mill. Included in the subcategory for gold ores is a subdivision for gold placer mines which reserved effluent limitations and standards for these mines because EPA did not have sufficient technical or economic data to develop appropriate regulations.

An extensive sampling and analysis effort was undertaken in 1983 and 1984 and extends to the present. As part of this effort, 68 placer mines were visited for screening and wastewater sampling. Of these 68 mines, 26 were visited two or more times for verification sampling, and 21 treatability studies were performed at 19 of these mines, Also, data collected by EPA Regions VI, VIII, IX and X were reviewed. Twenty-nine of the mines visited also provided cost and operating information. Studies were performed by EPA on gold recovery using recycle water with high TSS concentrations in a sluice. Similar data and information were supplied by Alaska Department of Environmental Conservation. The data base also includes National Pollutant Discharge Elimination System (NPDES) discharge monitoring reports (DMR's) and other data submitted by the industry.

Two studies have been performed to determine the cost of implementation of the various control technologies considered. The first exercise determined the cost of technologies based on model (typical) mines. The second costs the technologies in 1984 dollars based on data from approximately 11 placer mines for which we have information from an economic survey.

Subcategorization of the Gold Placer Mine Industry

EPA is proposing to remove gold placer mines from the subcategory promulgated for all gold ores, i.e., hard rock ores, and establish a separate subcategory specifically for gold placer mines because gold placer mines and the recovery of gold from placer deposits uses different mining and processing methods. EPA has also determined that based on technical and economic considerations, separate effluent limitations guidelines and standards are appropriate for various groups of placer mines based on the mining method and the mine's size or process capacity. Accordingly, the Agency has further subdivided the industry into non-commercial mines, e.g., small mines including recreational and assessment mines (<20 yd^3/day of paydirt), which are not included in this regulation and commercial mines (>20 yd^3/day). Commercial mines are further subdivided by mining method into large dredges (>4000 yd^3/day) and all other mining methods. The costs to implement technology developed in this document when applied to the economic models indicates that small commercial mines with a capacity of 20 to 500 yd^3/day are often marginally profitable. Therefore, EPA is proposing separate limitations for these mines with this capacity (all mining methods) and mines over 500 yd^3/day (all mining methods).

Summary of the Recommended Limitations and Standards

The effluent limitations and standards proposed in this document are intended to control the discharge of process wastewater from the gold recovery process. However, other wastewater, including mine surface drainage, seepage, and ground-water infiltration into existing settling ponds, is often commingled, treated, and discharged. Under this proposed regulation, these combined waste streams would have to meet certain effluent limitations and standards, i.e., those that apply to process wastewater from operations processing 20-500 yd^3/day (all mining methods). For facilities required to meet a no discharge of process wastewater requirement, the volume of water that may be discharged under this provision cannot include the volume of water subject to the no discharge standard.

This regulation also proposes a storm exemption when there is excessive precipitation, under certain conditions, i.e., the treatment system was designed, constructed, and operated to contain or treat the volume or flow that would result from a 5-year, 6-hour rainfall plus the normal volume or flow from the gold recovery process. Because of pond design and site differences, the design condition is based on a 5-year, 6-hour rainfall rather than the 10-year, 24-hour rainfall available to the rest of the ore industry.

Best Practicable Technology (BPT)

The factors considered in defining BPT include the total cost of application of BPT in relation to the effluent reduction benefits. In general, BPT represents the average of the best existing performance of operations with common characteristics and focuses on end-of-pipe treatment rather than process controls. Four effluent control technologies were considered for BPT: (1) simple settling, (2) simple settling with 80 percent recycle, (3) flocculant addition to the blowdown from 80 percent recycle, and (4) 100 percent recycle of process water used in gold recovery. While the 1977 date for compliance with BPT, has passed, BPT is being proposed because existing treatment at many placer mines is inadequate to establish a baseline for treatment. BPT for all commercial mines larger than 20 yd^3/day, except large dredges, is based on simple settling (Option 1) to achieve 0.2 ml/l settleable solids and 2000 mg/l TSS in the effluent. BPT for large dredges is based on recycle of process water from the pond used to float the dredge (Option 4) to achieve no discharge of process wastewater. The provision for commingled water and the storm exemption described above would both apply.

Best Conventional Pollutant Control Technology (BCT)

BCT replaces BAT for control of the conventional pollutants: total suspended solids (TSS), pH, biochemical oxygen demand (BOD), oil and grease (O&G), and fecal coliform. Fecal coliform, BOD, and O&G were not found in significant concentrations above background of the intake water at gold placer mines. The pH of the discharges was also about the same as the pH of the intake water, approximately neutral. However, solids in the wastewater discharges from gold placer mines have long been identified as the major pollutant in placer mine discharges. TSS, a conventional pollutant, is the parameter which measures solids.

The same four technologies considered for BPT were considered for BCT. The Act requires BCT limitations to be considered in light of the cost to implement the technology to obtain the limitations when compared to costs at publicly owned treatment works to obtain similar levels and the cost-effectiveness of treatment beyond BPT. The "cost reasonableness" of each technology was determined for each subcategory based on the cost per pound of solids, e.g., TSS, removed. BCT for small commercial mines (20 to 500 yd^3/day) is proposed equal to BPT (2000 mg/l for TSS) because of the potential cost effects on this group of more stringent requirements. BCT for large commercial mines (over 500 yd^3/day) including large dredges is proposed as no discharge of process wastewater. BPT for large dredges is already proposed as no discharge and no more stringent technology to control TSS could be identified, so BPT = BCT for this segment. The cost of solids removed by total recycle of process wastewater (no discharge of process wastewater) at commercial mines processing more than 500 yd^3/day is less than 4 mils per pound of solids. Although EPA has not promulgated a "cost-reasonableness" BCT methodology, this cost is sufficiently low to pass any test that may be promulgated. Recycle technology at 100 percent is in use at some large commercial mines and is available to the other mines as a process change without loss of recoverable gold based on pilot tests conducted.

As in BPT, the net volume of mine drainage and infiltration groundwater may be discharged subject to limitations on TSS (2000 mg/l). The storm exemptions for relief from precipitation also apply.

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

The presence or absence of the 126 toxic pollutants and a nonconventional pollutant, e.g., settleable solids, was determined, in EPA's sampling and analysis program. All 126 toxic pollutants have been excluded from regulation in the gold placer mine subcategory based upon one of the criteria contained in the Settlement Agreement cited previously: (1) they were not detected, (2) they were present at levels not treatable by known technologies, or (3) they were effectively controlled by technologies upon which other effluent limitations are based. Two toxic pollutants, arsenic and mercury, were identified in treatable amounts in the discharges from placer mines. However, EPA is not proposing limitations for these pollutants because EPA believes they will be adequately controlled by BCT limitations on TSS and BAT limitations on settleable solids. Therefore, for small commercial mines (20 to 500 yd^3/day), BPT = BCT = BAT. More stringent limitations for small commercial mines are not proposed because the costs identified in this document are not economically achievable. For large commercial mines, (over 500 yd^3/day) including large dredges, EPA is proposing no discharge of process wastewater, BCT = BAT; no more stringent technology upon which to base limitations has been identified.

The commingled wastewater provision and storm exemption described above would be available at BAT.

NEW SOURCE PERFORMANCE STANDARDS (NSPS)

New facilities have an opportunity to implement the best and most efficient ore mining and milling processes and wastewater treatment technologies. Accordingly, Congress directed EPA to consider the best demonstrated process changes and end-of-pipe treatment technologies capable of reducing pollution to the maximum extent feasible through a standard of performance which includes, "where practicable, a standard permitting zero discharge of pollutants."

Standards for new source gold placer mines are proposed based on the same technology proposed for BCT and BAT. The same general characteristics of wastewater, costs to treat, and percentages of pollutant removals are expected in new sources as found in existing sources. New source standards equivalent to existing source limitations would not pose a barrier to entry.

Solicitation of Comments

This document supports a rulemaking proposed by EPA for regulating the wastewater discharges from gold placer mines. The Agency requests comments relating to errors, deficiencies, or omissions in this document with facts and information that will correct or supplement the data.

SECTION II

INTRODUCTION

PURPOSE

In the effluent limitations guidelines and standards for the ore mining and dressing point source category, the gold placer mining industry was classified as follows:

Category: Ore Mining and Dressing

Subcategory: Copper, Lead, Zinc, Gold, Silver and Molybdenum Ores

Subdivision: Mills or Hydrometallurgical Beneficiation

Process: Gravity Separation Methods (Including dredge, placer, or other physical separation methods; mine drainage or mines and mills).

During the BPT round of rulemaking (promulgated in 1978) and BAT rulemaking (promulgated in 1982), the effluent limitations guidelines for this segment were reserved.

EPA has conducted various studies to determine the presence and concentrations of toxic (or "priority") pollutants in the waste water discharged from the gold placer mining segment. This development document presents the technical data base compiled by EPA with regard to these pollutants, as well as conventional and nonconventional pollutants, and evaluates their treatability for regulation under the provisions of the Clean Water Act.

This document outlines the technology options considered and the rationale for the option selected at each technology level. These technology levels are the basis for the limitations and standards of the proposed regulations. No pretreatment standards are proposed, because there are no known indirect dischargers in this segment, nor are there likely to be, because most operations are rural and far from any publicly owned treatment works (POTW).

LEGAL AUTHORITY

These regulations are proposed under authority of Sections 301, 304, 306, 307, 308, and 501 of the Clean Water Act (the Federal Water Pollution Control Act Amendments of 1972, 33 USC 1251 *et seq.*, as amended by the Clean Water Act of 1977, P.L. 95-217) (the "Act").

The Clean Water Act

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters," Section 101(a). By 1 July 1977, existing industrial dischargers were required to achieve "effluent limitations requiring the application of the best practicable control technology currently available" (BPT), Section 301(b)(1)(A). By 1 July 1983, these dischargers were required to achieve "effluent limitations requiring the application of the best available technology economically achievable . . . which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants" (BAT), Section 301(b)(2)(A). New industrial direct dischargers were required to comply with Section 306 new source performance standards (NSPS), based on best available demonstrated technology. The requirements for direct dischargers were to be incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402 of the Act. Although Section 402(a)(1) of the 1972 Act authorized the setting of requirements for direct dischargers on a case-by-case basis, Congress intended that, for the most part, control requirements would be based on regulations promulgated by the Administrator of EPA. Section 304(b) of the Act required the Administrator to promulgate regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT. Moreover, Sections 304(c) and 306 of the Act required promulgation of regulations for designated industry categories, Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 301(a) of the Act authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

EPA was unable to promulgate many of these regulations by the dates contained in the Act. In 1976, EPA was sued by several environmental groups, and in settlement of this lawsuit, EPA and the plaintiffs executed a settlement agreement that was approved by the Court. This agreement required EPA to develop a program and adhere to a schedule for promulgating for 21 major industries BAT effluent limitations guidelines and new source performance standards covering 65 priority pollutants and classes of pollutants. See Settlement Agreement in _Natural Resources Defense Council, Inc. v. Train_, 8 ERC 2120 (D.D.C. 1976), _modified_, 12 ERC 1833 (D.D.C. 1979), _modified_ by Orders of October 26, 1982, August 2, 1983, January 6, 1984, July 5, 1984, and January 7, 1985.

On 27 December 1977, the President signed into law the Clean Water Act of 1977 (P.L. 95-217). Although this act made several important changes in the federal water pollution control program, its most significnt feature was its incorporation of several basic elements of the NRDC Settlement Agreement program for toxic pollution control. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act required the achievement, by 1 July 1984, of effluent limitations requiring application of BAT for toxic pollutants, including the 65 priority pollutants and classes of pollutants that Congress declared toxic under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards are now aimed principally at toxic pollutant controls. Moreover, to strengthen the toxics control program, Section 304(e) of the Act authorizes the Administrator to prescribe best management practices (BMPs) to control the release or toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

This proposed regulation provides effluent limitations guidelines for BAT and establish NSPS on the basis of the authority granted in Sections 301, 304, 306, 307, and 501 of the Clean Water Act. As explained earlier, pretreatment standards (PSES and PSNS) were not proposed for the gold mining segment of the ore mining and dressing point source category, since no known indirect dischargers exist nor are any known to be in the planning stage. In general, ore mines and mills, particularly gold placer mines in Alaska and several other states, are located in rural areas, far from any POTW.

GENERAL CRITERIA FOR EFFLUENT LIMITATIONS

BPT Effluent Limitations

The factors considered in defining BPT include the total cost of applying such technology in relation to the effluent reductions derived from such application, the age of equipment and facilities involved, the process employed, nonwater quality environmental impacts (including energy requirements), and other factors the Administrator considers appropriate [Section 304(b)(1)(B)]. In general, the BPT technology level represents the average of the best existing performances of plants of various ages, sizes, processes, or other common characteristics. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. BPT focuses on end-of-pipe treatment rather than process changes or internal controls, except where the latter are common industry practice. The cost/benefit inquiry for BPT is a limited balancing, committed to EPA's discretion, which does not requre the Agency to quantify benefits in monetary terms. See, e.g., American Iron and Steel Institute v. EPA, 526 F.2d 1027 (3rd Cir. 1975). In balancing costs in relation to effluent reduction benefits, EPA considers the volume and nature of discharges expected after application of BPT, the general environmental effects of the pollutants, and the cost and economic impacts of the required pollution control level. The Act does not require or permit consideration of water quality problems attributable to particular point sources or industries, or water quality improvements in particular water bodies. Therefore, EPA has not considered these factors. See Weyerhaeuser Co. v. Costle, 590 F.2d 1011 (D.C. Cir. 1978).

BAT Effluent Limitations

The factors considered in assessing BAT include the age of equipment and facilities involved, the process employed, process changes, and non-water quality environmental impacts, including energy requirements [Section 304(b)(2)(B)]. At a minimum, the BAT technology level represents the best economically achievable performance of plants of various ages, sizes, processes, or other shared characteristics. As with BPT, uniformly inadequate performance may require transfer of BAT from a different subcategory or category. BAT may include process changes or internal controls, even when these technologies are not common industry practice. The statutory assessment of BAT "considers" costs, but does not require a balancing of costs against effluent reduction benefits (see Weyerhaeuser v. Costle, supra). In developing the proposed BAT regulations, however, EPA has given substantial weight to the rasonableness of costs. The Agency has considered the volume and nature of discharges, the volume and nature of discharges expected after application of BAT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels.

Despite this expanded consideration of costs, the primary determinant of BAT is effluent reduction capability. As a result of the Clean Water Act of 1977, 33 USC 1251, et seq., the achievement of BAT has become the principal national means of controlling water pollution due to toxic pollutants.

BCT Effluent Limitations

The 1977 Amendments added Section 301(b)(2)(E) to the Act establishing best conventional pollutant control technology (BCT) for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are those specified in Section 304(a)(4) [biological oxygen demanding pollutants (BOD5), total suspended solids (TSS), fecal coliform, and pH], and any additional pollutants defined by the Administrator as "conventional" (to date, the Agency has added one such pollutant, oil and grease, 44 FR 44501, July 30, 1979).

BCT is not an additional limitation but replaces BAT for the control of conventional pollutants. In addition to other factors specified in Section 304(b)(4)(B), the Act requires that BCT limitations be assessed in light of a two-part "cost-reasonableness" test. American Paper Institute v. EPA, 660 F.2d

954 (4th Cir. 1981). The first test compares the cost for private industry to reduce its conventional pollutants with the costs to publicly owned treatment works for similar levels of reduction their discharge of these pollutants. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find that limitations are "reasonable" under both tests before establishing them as BCT. In no case may BCT be less stringent than BPT.

EPA published its methodology for carrying out the BCT analysis on August 29, 1979 (44 FR 50372). However, the cost test was remanded by the United States Court of Appeals for the Fourth Circuit. American Paper Institute v. EPA, 660 F.2d 954 (4th Cir. 1981). The Court of Appeals ordered EPA to correct data errors underlying EPA's calculation of the first test and to apply the second cost test. (EPA had argued that a second cost test was not required.) The Agency proposed a revised BCT methodology October 29, 1982 (47 FR 49176) and a notice of availability of additional data on September 20, 1984 (49 FR 37046). EPA expects to promulgate the final methodology shortly.

New Source Performance Standards

The basis for NSPS under Section 306 of the Act is best available demonstrated technology (BADT). New operations have the opportunity to design and utilize the best and most efficient processes and wastewater treatment technologies. Congress therefore directed EPA to consider the best demonstrated process changes, in-plant controls, and end-of-pipe treatment technologies that reduce pollution to the maximum extent feasible.

Pretreatment Standards for Existing Sources

Section 307(b) of the Act requires EPA to promulgate pretreatment standards for existing sources (PSES).

There are no ore mines, including gold placer operations, that currently discharge to a POTW. By the nature of their locations, it is unlikely that any indirect dischargers exist. Therefore, no PSES are proposed at this time.

Pretreatment Standards for New Sources

Section 307(c) of the Act requires EPA to promulgate pretreatment standards for new sources (PSNS) at the same time that it promulgates NSPS. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the BADT, including process changes, in-plant controls, and end-of-pipe treatment technologies, and to use plant site selection to ensure adequate treatment system installation. Due to the location of placer gold deposits, future operations are expected to be located in rural areas far from any POTW. Therefore, no PSNS are proposed at this time.

PRIOR EPA REGULATIONS

On 6 November 1975, EPA published interim final regulations establishing BPT requirements for existing sources in the ore mining and dressing industry (see 40 FR 41722). These regulations became effective upon publication. However, concurrent with their publication, EPA solicited public comments with a view to possible revisions. On the same date, EPA also published proposed BAT and NSPS (see 40 FR 51738) for the ore mining and dressing point source category, which included gold placer mines.

On 24 May 1976, as a result of the public comments received, EPA suspended certain portions of the interim final BPT regulations, including the portion which applied to gold placer mines, and solicited additional comments (see 41 FR 21191). EPA promulgated revised, final BPT regulations for the ore mining and dressing industry on 11 July 1978 (see 43 FR 29711, 40 CFR Part 440), which reserved the section on gold placer mines. On 8 February 1979, EPA published a clarification of the BPT requlations as they apply to storm runoff (see 44 FR 7953). On 1 March 1979, the Agency amended the final regulations by deleting the requirements for cyanide applicable to froth flotation mills in the base and precious metals subcategory (see 44 FR 11546).

On 10 December 1979, the United States Court of Appeals for the Tenth Circuit upheld the BPT regulations, rejecting challenges brought by five industrial petitioners, Kennecott Copper Corp., v. EPA, 612 F.2d 1232 (10th Cir. 1979). The Agency withdrew the proposed BAT, NSPS, and pretreatment standards on 19 March 1981 (see 46 FR 17567).

On 14 June 1982, EPA again proposed BAT, BCT, and NSPS, again reserving limitations for gold placer mines. On December 3, 1982, final BAT and NSPS limitations for the ore mining point source category were promulgated without limitations for gold placer mines.

HISTORY OF REGULATION OF GOLD PLACER MINING

Effluent limitations guidelines and standards are not directly enforceable against dischargers. Instead, they are incorporated into a National Pollutant Discharge Elimination System (NPDES) permit, which is required by Section 402(a)(1) of the Clean Water Act for the discharge of pollutants from a point source into the waters of the United States. If EPA has not established industry-wide effluent limitations guidelines and standards to cover a particular type of discharge, Section 402(a)(1) of the Act expressly authorizes the issuance of permits upon "such conditions as the Administrator determines are necessary to carry out the provisions of this Act." In other words, this section authorizes a determination of the appropriate effluent limitations (e.g., BPT, BCT, BAT), on a case-by-case basis, based on the Agency's "best professional judgment" (BPJ).

The establishment of technology-based effluent limitations in NPDES permits is a two-step process. First, EPA must identify the appropriate technology basis. The second step in the permitting process is the setting of precise effluent limitations which can be met by application of that technology. The Clean Water Act does not require dischargers to install the technology which is the basis of the limitations; dischargers may meet the effluent limitations in any way they choose. In addition to technology-based standards, Sections 402 and 301(b)(1)(C) of the Clean Water Act require a permit to include any more stringent limitations including those necessary to meet water quality standards established pursuant to any state law or regulation or any other Federal law or regulation. Under Section 401 of the Act, no NPDES permit may be issued unless the state has granted or waived certification that the discharge will comply with the applicable provisions of the Act; if the state includes conditions as part of its certification, EPA must include those conditions in the permit.

1. <u>The 1976-1977 BPT Permits</u>

In 1976 and 1977, EPA issued 170 permits to Alaska placer miners. Because there were no effluent limitations guidelines promulgated for the placer mining industry at that time, these permits were based on BPJ. In addition, these permits included limitations designed to satisfy Alaska's water quality standards.

Each of the permits had identical effluent limitations, monitoring requirements, and reporting requirements. The permits required treatment of process wastes so that the maximum daily concentration of settleable solids was 0.2 milliliters per liter (ml/l). In addition, the permits required monthly monitoring for this pollutant or instead of monitoring to establish compliance with the settleable solids limitation, each permittee was given the option of installing a settling pond with the capacity to hold 24 hours' water use. In addition, the permittee could not cause an increase in turbidity of 25 JTU (Jackson Turbidity

Units) over natural turbidity in the receiving stream at a point measured 500 feet downstream from the final discharge point. EPA added the turbidity limitation at the request of the State of Alaska, which included this requirement in its certification of these permits under Section 401 of the Clean Water Act, to ensure compliance with its state water quality standards. The technology basis for the settleable solids limitation was settling ponds.

In June 1976, Gilbert Zemansky requested an adjudication of the 1976 NPDES permits as an interested party. Subsequently, the Trustees for Alaska (Trustees) and the Alaska Miners Association (Miners), as well as others, were admitted as additional parties to the proceeding. The Trustees and Zemansky argued that the permit terms were not stringent enough and that EPA should have selected recycle as the model BPT technology and required zero discharge of any pollutants, while the Miners argued that the terms were too stringent and not achievable. After the initial adjudicatory hearing, the Regional Administrator for Region X issued his Initial Decision on October 25, 1978, upholding the terms of the permits.

The Trustees, Zemansky, and the Miners each petitioned the Administrator of EPA to review the initial decision. On March 10, 1980, the EPA Administrator issued his decision on review. The Administrator held that the Regional Administrator's findings regarding settling pond technology "conclusively establish that any less stringent control technology does not satisfy the requirements of BPT." Decision of the Administrator (Ad. Dec.). Ad. Dec. at 15. The Administrator also found that "the Regional Administrator was in doubt about the facts respecting the extra costs of recycling ...." Therefore, the Administrator remanded the proceedings to the Regional Administrator "for the limited purpose of reopening the record to receive additional evidence on the extra cost of recycling in relationship to the effluent reduction benefits to be achieved from recycling." Ad. Dec. at 22. The Administrator directed the Regional Administrator to determine whether recycling constitutes BPT based on the additional evidence received.

After the Administrator rendered his decision, the Trustees requested the Administrator to: (1) determine the effluent limitations necessary to meet state water quality standards; (2) determine appropriate effluent monitoring requirements in the event the Regional Administrator did not determine that zero discharge was required; and (3) direct the Regional Administrator on remand to determine effluent limitations for total suspended solids or turbidity, for arsenic, and for mercury based on BPT in the event he did not determine that zero discharge is required. On July 10, 1980, the Administrator issued a Partial Modification of his decision, directing the Presiding Officer "to allow additional evidence to be received if he determines on the basis of the record that such additional evidence is needed to make the requested determinations." Partial Modification of Remand at 3.

The hearing on remand was held in March and June 1981, and the Presiding Officer issued his Initial Decision on Remand (Rem.

Dec.) on March 17, 1982. After reviewing the costs and effluent reduction benefits associated with both settling ponds and recycle, the Presiding Officer held that "the preponderance of the evidence in this case indicates that zero discharge is not 'practicable' for gold placer miners in Alaska." Rem. Dec. at 17. He also ordered EPA to modify the permits to include monitoring requirements for settleable solids and turbidity, and to require monitoring for arsenic and mercury, for at least one season, "to determine whether or not [they] constitute a problem with placer mining." Rem. Dec. at 19-20.

On September 20, 1983, the Administrator denied review of the Initial Decision on Remand. Both the Trustees for Alaska and Zemansky, as well as the Alaska Miners Association, petitioned the Ninth Circuit Court of Appeals for review. (Case No. 83-7764 and Case No. 83-7961). The Ninth Circuit consolidated the cases and issued its decision in Trustees for Alaska v. EPA and Alaska Miners Association v. EPA on December 10, 1984 (749 F.2d 549).

In this court proceeding, the Miners raised various legal issues, including certain constitutional challenges, each of which was dismissed by the Court. Specifically, the Court held that: (1) the Clean Water Act's permit requirements applied to placer mining, i.e., when discharge water is released from a sluice box it is a point source; (2) EPA's failure to establish effluent limitations guidelines and standards for the placer mining industry could only be challenged in district court; and (3) the Miners' challenge to the assignment of the burden of proof in the administrative hearings was not timely; it should have been raised when the permit regulations establishing that standard were promulgated.

The Court also dismissed the Miners' constitutional claims as too speculative or premature. The Miners had claimed, e.g., that the permit conditions constituted a taking of their vested property rights in violation of the Fifth Amendment; the permits' self-monitoring, reporting, and recordkeeping provisions infringed their constitutional privilege against self-incrimination; and the permits' inspection provisions infringed their rights under the Fourth Amendment to be free from unreasonable searches.

The Court dismissed most other challenges to the permits as moot since the permits expired before this case reached the Ninth Circuit, and EPA had issued two sets of subsequent permits (in 1983 and 1984) based on newer, more complete records by the time the Court heard this case. The Court specifically held that EPA's choice of settling ponds as "best practicable control technology" (BPT) was moot because a different standard, "best available technology" (BAT), now applies.

However, the Court held that the form of the limitations included in the permits to ensure achievement of state water quality standards was not moot since both the permits at issue and the subsequent permits incorporated state water quality standards directly into the permits. After reviewing the definition of "effluent limitation," the legislative history of the 1972 amendments to the Clean Water Act, and relevant court cases, the

Court held that EPA should not have incorporated the state water quality standard for turbidity, which was a receiving water standard, directly into the permits. Instead, the Court held that the permits must include end-of-pipe effluent limitations necessary to achieve the water quality standards. The Court also held that EPA should have given the Trustees the "opportunity to present in a public hearing their case for proposed effluent limitations or monitoring requirements for arsenic and mercury."

2. The 1983 Permits

During the proceedings on the 1976-1977 permits, EPA issued additional permits to Alaskan placer miners. In 1983, EPA issued 269 new permits. The 1983 permits were issued for the 1983 mining season and differed from the 1976 permits in several respects. For example, the 1983 permits contained a daily maximum discharge limit of 1.0 ml/l and a monthly average discharge limit of 0.2 ml/l on settleable solids. The 1983 permits also included a limit on arsenic based on the Alaska state water quality standards.

The Trustees for Alaska and Gilbert Zemansky requested an evidentiary hearing on the 1983 permits which the EPA Region X Regional Administrator granted. On Febraury 16, 1984, the proceedings were dismissed for several reasons, including expiration of the 1983 permits and the Agency's intent to issue new permits that would take effect in the next mining season (i.e., the summer of 1984). No one appealed the decision within the Agency or petitioned for judicial review of the decision.

3. The 1984 and 1985 Permits

In 1984, EPA issued BAT permits to 445 placer miners (the first set was issued on June 8, 1984; additional permits were issued on June 14, 1984). The technology basis for the BAT permits, like the BPT permits, is settling ponds. Based on additional data developed since the BPT permits were issued, the instantaneous maximum settleable solids discharge limit is 1.5 ml/l and the monthly average limit is 0.7 ml/l. Monitoring is required twice per day, each day of sluicing. The permits incorporate Alaska's state water quality standards for turbidity and arsenic and require visual monitoring for turbidity.

On January 31, 1985, in response to the Ninth Circuit opinion which held that permits must include end-of-pipe effluent limitations necessary to achieve state water quality standards (see above), EPA proposed to modify the 1984 permits to include effuent limitations for turbidity (5 NTU's above background) and arsenic (0.05 mg/l). On February 12, 1985, EPA proposed permits for 93 additional mines. These permits proposed the same limitations as the 1984 permits, except they include the effluent limitations for turbidity and arsenic just mentioned rather, than simply citing the state water quality standards. On May 10, 1985, EPA issued both the modified permits to miners holding permits in 1984 and the new permits to the 1985 applications. Various parties have challenged these permits; they are currently being adjudicated.

INDUSTRY OVERVIEW

Placer mining consists of excavating waterborne or glacial deposits, e.g., gold-bearing gravels or sands, which can then be separated by physical or gravity separation means (e.g., sluices).

The industry includes operations employing various dredging techniques (including clam shell, continuous bucket, dragline or suction dredges) and hydraulic (i.e., water cannons).

Alaska

The Alaskan gold placer mining industry is thought to have over 700 operations (Reference 1) although only about 540 operations applied for NPDES permits in 1985. Reference 2 indicates that there were 304 active placer gold operations in Alaska in 1982 with an estimated annual production in excess of 160,000 troy ounces. Most of these operations are intermittent or seasonal and many would be classifed as recreational or week-end operations.

Idaho

Based upon a review of application for dredging and placer mining permits in Idaho and other information in the Idaho Department of Land files (Reference 3), there are approximately 29 active gold placer mines and 42 inactive mines in the state. Twenty-seven of the 29 active operations are located in ten counties with the majority of these (19) located in two counties. The volume of ore sluiced per day ranges from approximately 36 cubic yards to

4,800 cubic yards, with the sizes and types of operations being basically similar to those in Alaska and Montana. Most of the mines use open cut methods, but there are also at least three large-scale dredging operations.

Montana

There are 50 gold placer mines (employing mechanical, open-cut methods) in Montana which have discharge permits or are otherwise known to exist. It is likely that there may be another 60 mines that do not have discharge permits (some may not discharge wastewater). The mines are located in the western portion of of the state. There are no known hydraulic mining operations or mechanical dredges operating in Montana. However, the Montana Department of Health and Environmental Sciences has issued water discharge permits to approximately 97 suction dredges, which generally are quite small (2- to 4-inch diameter). The mining methods, classification methods, wastewater treatment technologies, and size of the operations all appear similar to those encountered in Alaska (Reference 4).

Colorado

A review of the Colorado Water Pollution Control Division's files indicated that only four gold placer mines in the state had permits to discharge wastewater. Other sources indicate that there may be as many as 19 more mines in the state (Reference 5). This apparent discrepancy may be explained by several possibilities including: (a) no discharge of wastewater; (b) inactive status; (c) improper classification as a placer mine;

and (d) discharge without a permit. The mines for which permits have been issued are relatively small (less than 150 cubic yards/day), seasonal, open-cut mines employing settling ponds for treatment of wastewater.

California

According to the U.S. Bureau of Mines (Reference 6), one large dredging operation was expected to recover 20,000 to 25,000 troy ounces of gold annually. There are likely to be other operations, but no data on these operations are available. It has been estimated that there may be as many as 25 operating mines in California, but all are thought to be zero discharge operations.. (Reference 7).

Nevada

According to Reference 6, 157 troy ounces of gold were obtained from placer deposits in Nevada. However, little is known about any active placer operations. It has been estimated that there are six commercial placer mines in Nevada (Reference 7).

Oregon

Several small placer mines are small suction dredges were reported as operating along gold-bearing drainages in southwestern Oregon (Reference 6). Production is unknown. It is thought that there may be 25 to 50 operations in Oregon (Reference 7).

Washington

It has been estimated that there are 30 operating placer mines in Washington, but little is known about them. No state discharge standards are in effect.

For purposes of this document and the proposed limitations and standards, EPA is creating a separate subcategory in the ore mining and dressing point source category known as "gold placer mining" to include placer mining operations which process more than 20 cubic yards per day by gravity separation methods, including hydraulic mining, suction dredge mining, and all mechanical mining practices.

The 20-cubic-yard-per-day cutoff would exclude the smaller recreational or assessment operations. This proposed regulation also does not cover mining in marine waters or in the coastal zone (beach) because: (1) the Agency does not, at present, have a data base adequate to address this group; and (2) the limitations that might be developed may require different conditions because of uncertainty about the technology employed, the reasonableness of various treatment alternatives, and the potential need to protect certain marine water resources.

GENERAL APPROACH AND METHODOLOGY

From 1973 through 1976, the EPA Effluent Guidelines Division attempted to obtain data on Alaskan gold placer operations as part of its general study of the ore mining and dressing point source category. Because the industry itself was so large and diverse, the Agency determined after promulgating interim final

BPT limitations that the data base on placer gold operations, in general, and placer gold operations in Alaska, Colorado, Montana, California, Idaho, Washington, Oregon, and Nevada, in particular, were inadequate to form the basis of national effluent limitations guidelines and standards. From 1977 through the present, the Agency itself and its contractors have undertaken several sampling surveys and data collection efforts aimed at resolving various issues. The following paragraphs briefly describe the major study tasks and their results as presented in this report.

Industry Data Base Development and Subcategorization Review

First, EPA studied the gold placer mining industry to determine whether there were differences in type of deposit, processes employed, equipment used, age and size of operations, water usage, wastewater constituents, or other factors indicating the need to develop separate effluent limitations and standards for different segments of the industry. This study included identification of raw wastewater and treated effluent characteristics, including: the sources and volume of water used, the processes employed, and the sources of pollutants and wastewater and the constituents of wastewater, including toxic pollutants. EPA then identified the constituents of wastewaters that should be considered for effluent limitations guidelines and standards of performance. EPA was aided in this study by having previously examined and sampled (for a 10-year period) the ore mining industry in general and various operations in the gold mining subcategory in particular. The data from these studies were useful in selecting the pollutants (conventional, nonconventional, and toxic) that should receive emphasis in the sampling programs.

Next, EPA identified several distinct control and treatment technologies that are in use or capable of being used in the placer mining segment. The Agency compiled and analyzed historical and newly generated data on effluent quality resulting from the application of these technologies. The long-term performance, operational limitations, and reliability of each treatment and control technology were also identified. In addition, EPA considered the non-water quality environmental impacts of these technologies, including impacts on air quality, solid waste generation, water availability, and energy requirements.

Data Gathering Efforts.

Data collected for the placer mining industry included extensive studies:

1. KRE Treatability Study - 1984
2. KRE Reconnaissance Study - 1984
3. EPA Region X - 1984 Reconnaissance Study
4. FTA Reconnaissance Study - 1984 (Lower 48)
5. Shannon and Wilson - 1984 Wastewater Treatment Technology Project
6. FTA and KRE - 1983 Treatability Studies
7. Dames and Moore - 1976 Reconnaissance Study

8. **Calspan Corp. - 1979 Reconnaissance Study**

9. **EPA/NEIC - 1977 Reconnaissance Study**

10. **ADEC - 1977, 1978, 1979 Reports**

11. **R&M Consultants - 1982 Treatability Study, Site Visits, and Pond Design Manual (for ADEC)**

12. **EPA Region X - 1982 Reconnaissance Study**

13. **EPA Region X - 1983 Reconnaissance Study**

14. **Canadian Dept. Env. - 1981 and 1983 Yukon Studies**

These studies are described in detail in later sections of this document. In all, over 100 mines representing operations in several states have been sampled.

Subcategorization Review.

Section IV outlines the factors considered in potential subcategorization. Two subcategories or segments were recommended for exclusion: (1) operations processing less than 20 cubic yards per day, and (2) marine or coastal zone operations.

Sampling Program

The collection of detailed analytical data on conventional, nonconventional, and toxic pollutant concentrations in raw and treated process wastewater streams was completed in a comprehensive sampling program. The sampling and analytical methodology is described in Section V. The BPT and BAT development efforts showed that organic priority pollutants would not be expected to be significant in this industry group. Therefore, the sampling programs undertaken by the various groups were modified to emphasize certain pollutants.

Wastewater Characteristics

The results of the historical and recent effluent data collection efforts are summarized in Section VI. Particular emphasis has been placed upon 1983 and 1984 data.

Treatment System Cost Estimates

Section IX presents the general approach to cost estimating, discusses the assumptions made, and gives the detailed cost estimates for alternative levels of treatment and control. For each subcategory, the total estimated installed cost of typical treatment systems is developed on the basis of model plant design specifications. Estimated incremental costs are given for each of the advanced level treatment alternatives. The Agency then estimated the cost impact of installation of the various treatment alternatives.

REFERENCES

1. USEPA - Region X, "Draft General NPDES Permit for Placer Mining in the State of Alaska," February 14, 1983.

2. Alaska Office of Mineral Development, "Alaska's Mineral Industry - 1982," Special Report 31, 1993.

3. Harty, D. M., Frontier Technical Asso., Inc., Letter to B. M. Jarrett, USEPA - ITD, November 30, 1984.

4. Harty, D. M., Frontier Technical Asso., Inc., Letter to B. M. Jarrett, USEPA - ITD, November 16, 1984.

5. Harty, D. M., Frontier Technical Asso., Inc., Letter to B. M. Jarrett, USEPA - ITD, November 5, 1984.

6. Minerals Yearbook - 1982, Volume 1, "Metals and Minerals," U.S. Bureau of Mines, 1983.

7. Harty, D. M. and Terlecky, P. M., Frontier Technical Asso., Inc., Letter to B. M. Jarrett, USEPA - ITD, March 5, 1984.

8. USEPA - Region X, "Draft of General NPDES Permit for Placer Mining in the State of Alaska," February 1984.

9. USEPA - Response report as a result of public hearings held in Fairbanks, Alaska, on April 3 and 5, 1984.

SECTION III

INDUSTRY PROFILE

HISTORICAL PERSPECTIVE

Discovery and Exploitation

Prior to the Alaska purchase in 1867, the existence of placer gold in Alaska was known to the Russians, the English of the Hudson Bay Company, and members of the Western Union Telegraph exploration party, but little exploitation of these deposits took place (1). The placer gold industry in Alaska was started primarily by California gold rush prospectors moving up the coast. Significant events which stimulated this industry were gold discoveries in the Juneau vicinity (1880), Rampart (1882), Forty-mile district (1886), and Birch Creek (Circle) district (1893). The Klondike gold rush of 1897-1898 in Canada also stimulated Alaskan prospecting. Additional deposits were discovered in Nome (1898), Fairbanks (1902), and the Tolovana (Livengood) district (1914). High-grade deposits were mined out rapidly, but the introduction of large-scale permafrost thawing, hydraulic stripping, and mechanized excavation methods increased the productivity of placer mining and allowed working of lower-grade deposits (1). Mechanical dredges were introduced in Nome in 1905 and large electric-powered dredges were employed in Nome and Fairbanks in the 1920's.

In 1940, Alaska was the leading gold-producing state with production of 750,000 troy ounces,* mostly from placer mines.

*One troy ounce is equal to 31.1 grams (1.097 ounces avoirdupois).

Placer mining activity was substantially reduced during World War II, and operations after the war remained at a low level because of rising operating costs and a government-fixed gold price of $35 per troy ounce. Dredging was reduced to only a few operations in the 1960's. Relaxation of federal restrictions on prices and private ownership of gold in the 1970's and an increase in the market price stimulated gold mining activity in the later 1970's; several hundred placer mines came into operation. In 1982, gold production was more than 160,000 troy ounces from placer mining alone (total Alaskan gold production for 1982 from lode and placer mines was in excess of 175,000 troy ounces).

Almost all of the gold produced in the United States outside of Alaska is produced in the following 17 states: Alabama, Arizona, California, Colorado, Georgia, Idaho, Montana, Nevada, New Mexico, North Carolina, Oregon, South Carolina, South Dakota, Utah, Virginia, Washington, and Wyoming. Gold mining in the United States began in North Carolina, with Georgia joining in production in 1829, and Alabama in 1830. Production began in other states as prospectors moved west. The most important gold discovery, because of its influence on western development, was at Sutter's Mill in California in 1848. Later discoveries were made in most other Western states and territories.

Early mining was largely by placer methods with miners working stream deposits by various hydraulic techniques. The gold was recovered by gravity separation or by amalgamation with mercury. During the period 1792 through 1964, 88 percent of the production came from gold ores (51 percent - lode; 37 percent - placers) and 12 percent as a byproduct from other metal mines. The total U.S. gold production as of 1980 was 319 million ounces with lode gold mining supplying about 50 percent, placer mining 35 percent, and base metal mining (byproduct) accounting for 15 percent (2). Lode mining is defined as "hard rock" mining using either open pit or underground methods of mining minerals that are in place as originally deposited in the earth's crust or that have been reconsolidated into a composite mass with waste rock. The sought after mineral is not in a "free" or loose state.

Gold Prices

Gold prices during the last 20 years have been subject to wide variation as illustrated below:

Year	Tr.Oz.
1934 - 1968	$ 35
1974 (Dec.)	200
1975 (Dec.)	162
1977 (Dec.)	161
1978 (Dec.)	208
1979 (Nov.)	392
1980 (Jan.)	>800
1982 (Mar.)	315
1983 (Dec.)	390
1984 (Dec.)*	315

The industry should be viewed against the backdrop of fluctuating prices since rising prices stimulate prospecting, dictate the number of active operations, cause increases in production, and allow the mining of lower grade ores, while decreasing prices have the opposite effects.

*Wall St. Journal (12/18/84)

DESCRIPTION OF THE INDUSTRY

Nature of Deposits

Placer mining is the process involved in the extraction of gold or other metals and minerals from alluvial deposits which may be from recent ("young" placers) or ancient deposits ("old," "ancient," or "fossil" placers). Currrent placer mining activity generally takes place in young placers originating as waterborne or glacially-deposited sediments. For many years, gold has been the most important product obtained, although considerable platinum, silver, tin (as cassiterite, SnO_2), phosphate, monazite, rutile, ilmenite, zircon, diamond and other heavy, weather-resistant metals or minerals have been produced from these deposits at various locations in the world. Since gold has a high specific gravity (19.3), it settles out of water rapidly and is found associated with other heavy minerals in the deposits.

Most placer deposits consist of unconsolidated or semiconsolidated sand and gravel that actually contain very small amounts of native gold and other heavy minerals. Most are stream deposits and occur along present stream valleys or on benches or terraces of pre-existing streams (4). Placer gold deposits are also occasionally found as beach or offshore deposits as at Nome, Alaska.

Residual placers are defined as deposits found spread over a local gold bearing lode deposit as a residual of the decay or erosion of that deposit and are found at a number of localities such as Flat, Happy, and Chicken Creeks in the Iditarod District of Alaska, but have not been an important source of gold. Creek bench deposits are found in virtually all the districts. Modern creek placers occupy the present creek channels and usually contain gravels from a few feet to 10 feet or more thick. The ancient placers are those in benches or terraces along present streams. The deeply buried channels or "deep gravels" are deposits of ancient streams which are now buried by alluvium. The best examples of these deposits are in the interior of Alaska, particularly in the Fairbanks, Hot Springs, Tolovana, and the Yukon-Tanana region. The gravels are ordinarily 10 to 40 feet thick but are buried under "muck" or black humus, fine gray sand, silt, and clay which may be 10 to 30 feet or more thick (5).

Bench placers have the characteristics of modern creek placers but are higher than the present bed of the stream. Present streams have cut into the deposits forming surface terraces that resemble benches. High-bench deposits result from the action of streams of a former drainage system with no direct relation to existing drainage channels. These high gravels are sometimes called "bar" deposits. Some of the best examples are in the Rampart, Hot Springs, and Ruby Districts. Some of the high bench deposits near Nome between Dexter and Anvil Creeks have been very productive (5).

Beach placers are resorted deposits that have been formed by wave action which erodes adjacent alluvial deposits and concentrates their gold along the beach. Examples of these deposits are at Lituya Bay, Yakataga and Kodiak Island. The most important beach placers are at and near Nome. At Nome, there are both submerged and elevated beach placers formed at times particularly over the last million years when sea level fluctuated. In most cases, the beach lines, usually gravels, covered with muck and overburden, have been very productive. Their thickness ranges from 30 to 100 feet (5).

Other types of placers include river bar, gravel plain, those associated with bedding planes and crevices of the bedrock, and some placers in which the bedrock has formed or is overlain by a sticky clay or "gumbo" in which the gold may be distributed (5).

The presence of beds of clay or "hardpan" in placer deposits may influence the distribution of the gold. The clay beds form impervious layers on which concentration of gold takes place and prevent the gold from working below them (6).

<u>Location</u>

According to a study conducted by Louis Berger and Associates (7), placer mining is more than twice as important in the area north of the Alaska Range (with Fairbanks as the center of placer

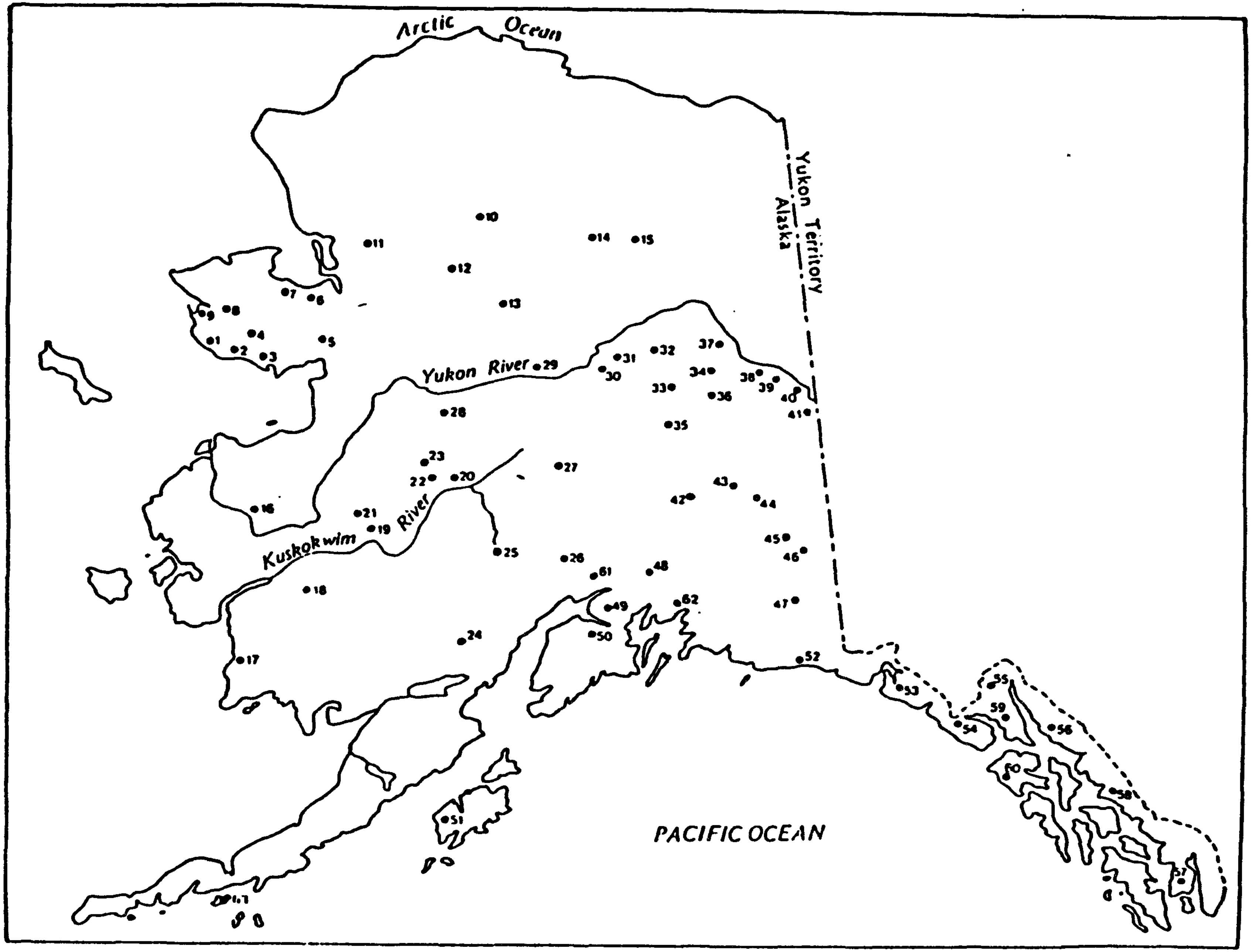


Figure III-1. Principal Placer Gold-Producing Camps in Alaska (Source: Ref. 6).

Table III-1. Mineral Activity in Alaska by Mining Camp as of 1982 (Source: Ref. 7).

Map No.	Camp(b)	Gold Production (tr. oz.)	Discovery Date
1.	Nome	4,348,000	1898
2.	Solomon	251,000	1899
3.	Bluff	90,200	1899
4.	Council	588,000	1897
5.	Koyuk	52,000	1899
6.	Fairhaven (Candle)	179,000	1901
7.	Fairhaven (Inmachuk)	277,000	1900
8.	Kougarok	150,400	1900
9.	Port Clarence	28,000	1898
10.	Noatak	39,000	1898
11.	Kobuk (Squirrel River)	7,000	1909
12.	Kobuk (Shungnak)	15,000	1898
13.	Koyukuk (Hughes)	211,000	1910
14.	Koyukuk (Nolan)	290,000	1893
15.	Chandalar	35,708	1905
16.	Marshall (Anvik)	120,000	1913
17.	Goodnews Bay	29,700	1900
18.	Kuskokwim (Aniak)	230,600	1901
19.	Kuskokwim (Georgetown)	14,500	1909
20.	Kuskokwim (McKinley)	173,500	1910
21.	Iditarod	1,364,404	1908
22.	Innoko	400,000	1906
23.	Tolstoi	87,200	
24.	Iliamna (Lake Clark)	1,500	1902
25.	Skwentna (included in Yentna production)		
26.	Yentna (Cache Creek)	115,200	1905
27.	Kantishna	65,000	1903
28.	Ruby	420,000	1907
29.	Gold Hill	1,200	1907
30.	Hot Springs	450,000	1898
31.	Rampart	105,000	1882
32.	Tolovana	387,000	1914
33.	Fairbanks	7,940,000	1902
34.	Chena (included in Fairbanks production)		
35.	Bonnifield	50,000	1903
36.	Richardson	103,000	1905
37.	Circle	800,000	1983
38.	Woodchopper-Coal Creek (included in Circle production)		
39.	Seventymile (included in Fortymile production)		
40.	Eagle	45,000	1895
41.	Fortymile	417,000	1886
42.	Valdez Creek	44,000	1904
43.	Delta	2,500	
44.	Chistochina-Chisna	177,000	1898
45.	Nabesna	93,500	1899
46.	Chisana	50,000	1910
47.	Nizina	143,500	1901
48.	Nelchina	2,900	1912
49.	Girdwood	125,000	1895
50.	Hope (included in Girdwood) production)		
51.	Kodiak	4,800	1895
52.	Yakataga	15,709	1898
53.	Yakutat	2,500	1867
54.	Lituya Bay	1,200	1867
55.	Porcupine	61,000	1898
56.	Juneau(Gold Belt)	7,107,000	1880
57.	Ketchikan-Hyder	62,000	1898
58.	Sumdum	15,000	1869
59.	Glacier Bay	11,000	
60.	Chichagof	770,000	1871
61.	Willow Creek	652,052	1897
62.	Prince William Sd.	137,900	1894
63.	Unga Island	107,900	1891

$% $%

(a)-Compiled from U.S. Geological Survey publications, U.S. Bureau of Mines records, Alaska Division of Geological and Geophysical Survey records and publications, Mineral Industry Research Laboratory research projects, and other sources.

(b)-Camp names are those that appear in official recording-district records. Many are also known by other names, some of which are shown in parentheses.

mining activity) compared to the area south of the range. Other centers where placer mining activity is important in Alaska are Nome, Glenallen, Talkeetna, Palmer, Ruby, Circle, Hot Springs, and Juneau (7). Figure III-1 and Table III-1 taken from Reference 7 illustrate the principal placer mining areas of the state and some salient statistics concerning them.

Production

Accurate production figures for the Alaskan gold placer mining industry have been difficult to obtain in the past. Historically, Bureau of Mines figures tend to underestimate what the actual production has been based upon field surveys and surveys by the State of Alaska.

Most placer deposits contain a few cents to several dollars worth of gold per cubic yard (1 cubic yard weighs about 1.5 tons); a rich placer deposit would contain only a few grams of gold per ton of gravel. The largest placer deposits have yielded several million ounces of gold, but most have been much smaller (4). The Bureau of Mines has estimated that placer deposits contributed as much as 3 percent of the U.S. total annual production in 1982, but reliable estimates of Alaskan placer gold production apparently are difficult to obtain. Taking the State of Alaska's 1982 estimates of placer production (1) and comparing them to the Bureau of Mines 1982 total gold production (latest year published - see Reference 8) indicates that Alaska placer deposits may contribute approximately 10 percent (or more) of total U.S. gold production. The majority of this gold may not end up as bullion

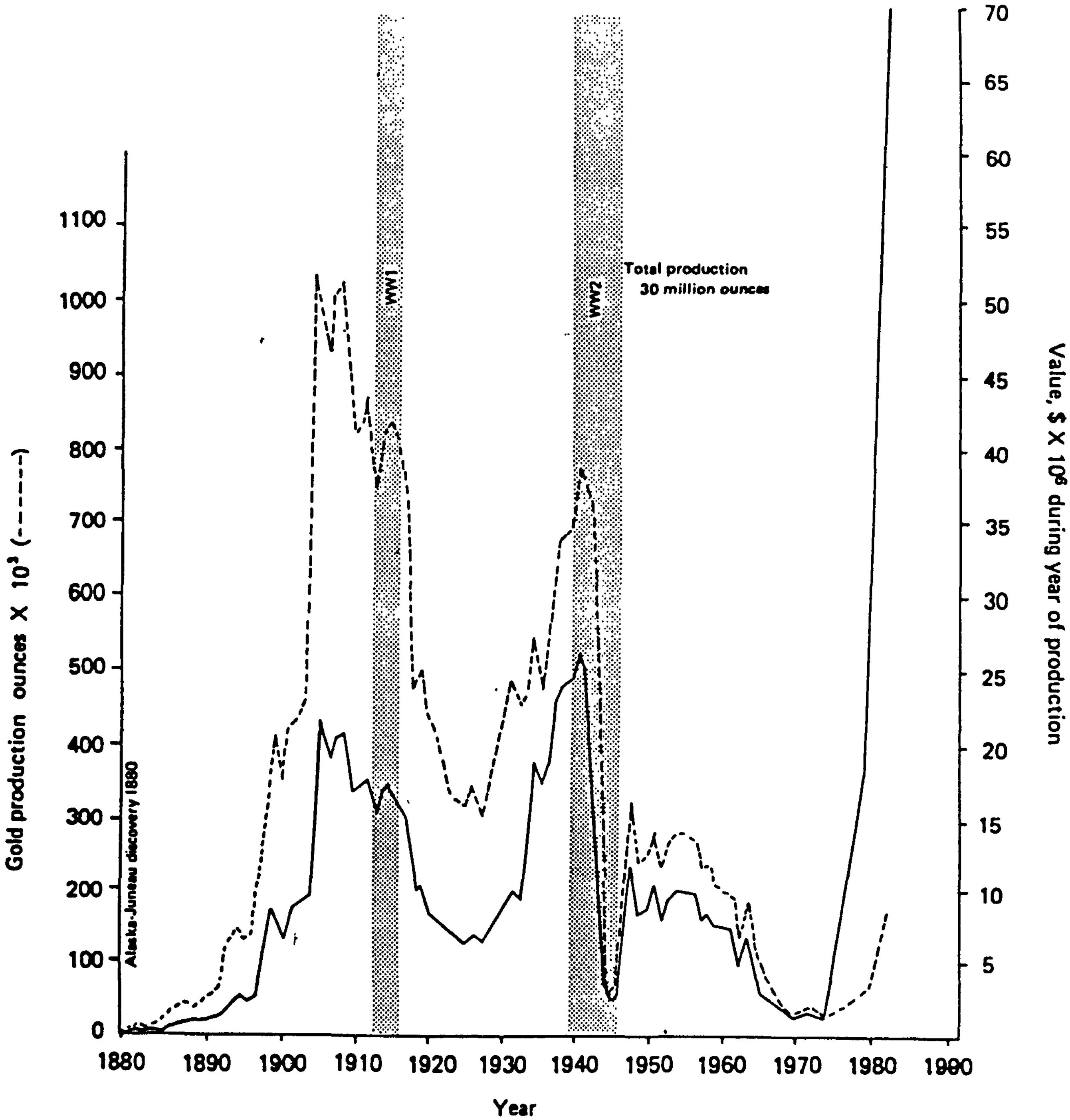


Figure III-2. Gold Production and Value of Production in Alaska for 1880-1982 (Source: Ref. 1) production, however; most probably finds its way into the jewelry market.

Figure III-2 from Reference 1 is a plot of historical gold production and value in Alaska for the period 1880-1982. Based upon recent estimates, placer gold production in Alaska exceeded 160,000 troy ounces in 1982 and probably accounted for nearly 95 percent of total gold production from both lode ores and placers (1).

Number of Operations

The total number of active placer gold operations in Alaska is difficult to determine. The EPA estimated in 1983 that there were over 700 operations although only about 250 applied for water discharge permits (3).

EPA Region X issued 446 permits in 1984. None of these are for mines processing less than 20 cubic yards per day. Perhaps the best estimate of the number of operations may be obtained by review of the so-called "tri-agency" forms for placer mining. This form is required by the Alaska Department of Natural Resources, the Department of Environmental Conservation, and the Department of Fish and Game for any working mine. It serves as an annual application for a land use and water use permit and for a mining license. The tri-agency form requires information concerning the owner and operator of the mine, location, method of operation, equipment, and employment, among other data (7).

There were 507 tri-agency applications submitted in 1982. A breakdown of these operations is given below (7):

Category*	Employees		Number of Operations
Recreational or Assessment (R/A)	1-3		137
Small	3-4		238
Medium	4-7		120
Large	>6		12
		Total	507

*Size based upon annual expenditures for operating expenses:

R/A - <$10,000; Small - $10,000 to $125,000; Medium - $125,000 to $800,000; Large - >$800,000.

An independent survey by the Alaska Division of Geological and Geophysical Surveys estimated that there were at least 304 active placer gold operations in 1982 (1). This figure can be compared to a total of 370 mines resulting from subtracting the number of recreational mines (137) from the total number of tri-agency applications. It should also be pointed out that the use of the tri-agency form has two limitations: (1) it indicates the miner's intentions before the mining season begins but does not necessarily reveal actual mining activities, and (2) a number of operators of recreational, assessment, and other small miners may not always complete and file the forms (7).

Section II, "Introduction," outlines what information is available on the number of operations in other states besides Alaska. Additional data on individual operations for Alaska and other states are presented in tables at the conclusion of this section.

SUMMARY OF MINING AND PROCESSING METHODS

General

The mining and processing methods in use today in Alaska and the other gold placer mining states are similar in many respects to those in use elsewhere in the ore mining and dressing industry. Three important differences exist in this segment, namely: (a) the nature of the deposits - a great deal of material must be excavated or moved and then processed to remove an accessory or trace constituent (gold), and because gravity separation methods are used, this requires a great deal of water per unit or production; (b) the climate and location of many operations dictate harsh operating conditions and constant maintenance; (c) permanently frozen overburden and deposits must be thawed in order to be exploited.

The actual mining season varies with location and availability of water but generally ranges between 85 to 137 days with the average operation probably in the 100 to 115 operating day range. This range is most typical for operations in the industry as a whole, but there are a few operations in the contiguous states which operate with long seasons (270 days) or even year-round.

Before 1930, opencut placer mines operated with steam-powered shovels, scrapers, draglines, cableway excavators, and reciprocating and pulseometer pumps. The development of the lightweight diesel engine, which resulted in the advent of diesel-powered bulldozers, draglines, and pumps brought about a revolution in opencut placer mining methods in Alaska (9), as well as other states.

The introduction in the mid-1930's of efficient modern excavating equipment and portable centrifugal pump units made it possible to work many deposits that could not be mined earlier by the more cumbersome machines. Improvements in gravel washing and recovery systems were developed simultaneously.

Readily movable steel sluiceboxes with hoppers and grizzlies, mounted on steel trestles with skids, replaced awkward and less desirable wooden structures. The steel sluiceplate, often called the slick plate, was one of the most influential improve-ments; it was responsible for the development of simple and flexible mining techniques. The use of portable diesel-driven centrifugal pumps allowed the recirculation of wastewater to supplement limited water supplies. Utilization of draglines and bulldozers in combination with established hydraulic methods facilitates the removal of both frozen and thawed overburden as well as the handling of gravel and bedrock during sluicing. Improved dryland dredges, using revolving trommels and stacker conveyors mounted on crawler-type tracks, were developed into successful washing and recovery devices at several properties (9).

The choice of excavation equipment, recovery system, and arrangement of the mining method is based essentially upon the size and physical characteristics of the deposits as well as on the water supply, the ultimate choice depending on the funds available for initial capital investment and the personal preference of the operator (9).

Mining Methods

Dredging Systems. Dredging systems are classified as hydraulic or mechanical depending upon the method of digging, and both are capable of high production. A floating dredge consists of a supporting hull with a mining control system, excavating and lifting mechanism, beneficiation circuits, and waste-disposal systems. These are all designed to work as a unit to dig, classify, recover values, and dispose of waste (10).

a. Hydraulic Dredging Systems. Whether the lifting force is suction,suction with hydrojet assistance, or entirely hydrojet, hydraulic dredging systems have been used much less frequently in placer mining than mechanical systems.

However, in digging operations where mineral recovery is not the objective, the hydraulic or suction dredge has greater capacity per dollar of invested capital than any mechanical system because the hydraulic system both excavates and transports. The hydraulic dredge is superior when the dredged material must be moved some distance to the point of processing. Because it is much more economical to treat the placer gravels aboard the dredge, the hydraulic systems with their inherent dewatering problems are at a disadvantage (10).

Hydraulic digging is best suited to relatively small-size loose material. It has the advantage over mechanical systems in such ground when the material must be transported from the dredge whether by pipeline or barge. In easy digging, excavation by hydraulic systems has reached depths of about 225 feet, but excavation for mineral recovery to date has been much less, only about one-quarter of that depth. The interest in offshore mining has stimulated the development of hydraulic dredging equipment.

Even with efficiently designed units and powerful pumps, the size of the gold that can be captured by hydraulic dredging is limited. The ability of a hydraulic system to pick up material in large part depends upon intake and transport velocities that must be increased relative to specific gravity and size of particles. If the gold occurs as nuggets, especially large nuggets, the velocity required for capturing the gold can cause excessive abrasion in the entire system. In addition, higher velocities require more horsepower. On the other hand, when the flake size of the gold is very fine, higher velocities make gold recovery very difficult during dewatering.

The digging power of hydraulic systems has been greatly increased with underwater cutting heads. One disadvantage of a cutterhead is that it must be designed with either right- or left-hand cutting rotation, which results in less efficient digging when the dredge is swung in one direction, especially in tough formations. As digging becomes more difficult and the cutterhead is swung across the face in the direction so that its blades are cutting from the old face to the new, the cutterhead tries to climb onto and ride the scarp. This produces considerable impact stress through the power-delivery system and reduces the capacity of the cutter. Because hydraulic dredges, even with cutterheads, dig less effectively than mechanical dredges, gold particles which are trapped in bedrock crevices are more difficult to recover (10).

The principal uses of hydraulic dredges have been for nonmining jobs such as in digging, deepening, reshaping, and maintaining harbors, rivers, reservoirs, and canals; in building dams and levees; and in landfill and reclamation projects. Hydraulic systems in mining have been used to produce sand and gravel, mine marine shell deposits for cement and aggregate, reclaim mill tailings for additional mineral recovery, and to mine deposits containing diamonds, tin, titanium minerals, and monazite (10).

(b) Mechanical Dredging Systems. Digging systems on continuous mechanical dredges can be a bucket-ladder, rotary-cutter, or bucket-wheel excavator, each with advantages peculiar to specific situations. The bucket-ladder or bucket-line dredge has been the traditional placer-mining tool, and is still the most flexible method where dredging conditions vary. Placer dredges, rated according to bucket size, have ranged from 1 1/2 to 20 cubic feet, although larger equipment has been used in harbor work.

Excavation equiment consists of a chain of tandem digging buckets that travel continuously around a truss or plate-girder ladder, scooping a load as they are forced against the mining face while pivoting around the lower tumbler, and then dumping as they pivot around the upper tumbler. The ladder is raised or lowered as required by a large hoisting winch through a system of cables and sheaves. Before the development of the deep dig-ging dredges, the maximum angle of ladder when in its lowest digging

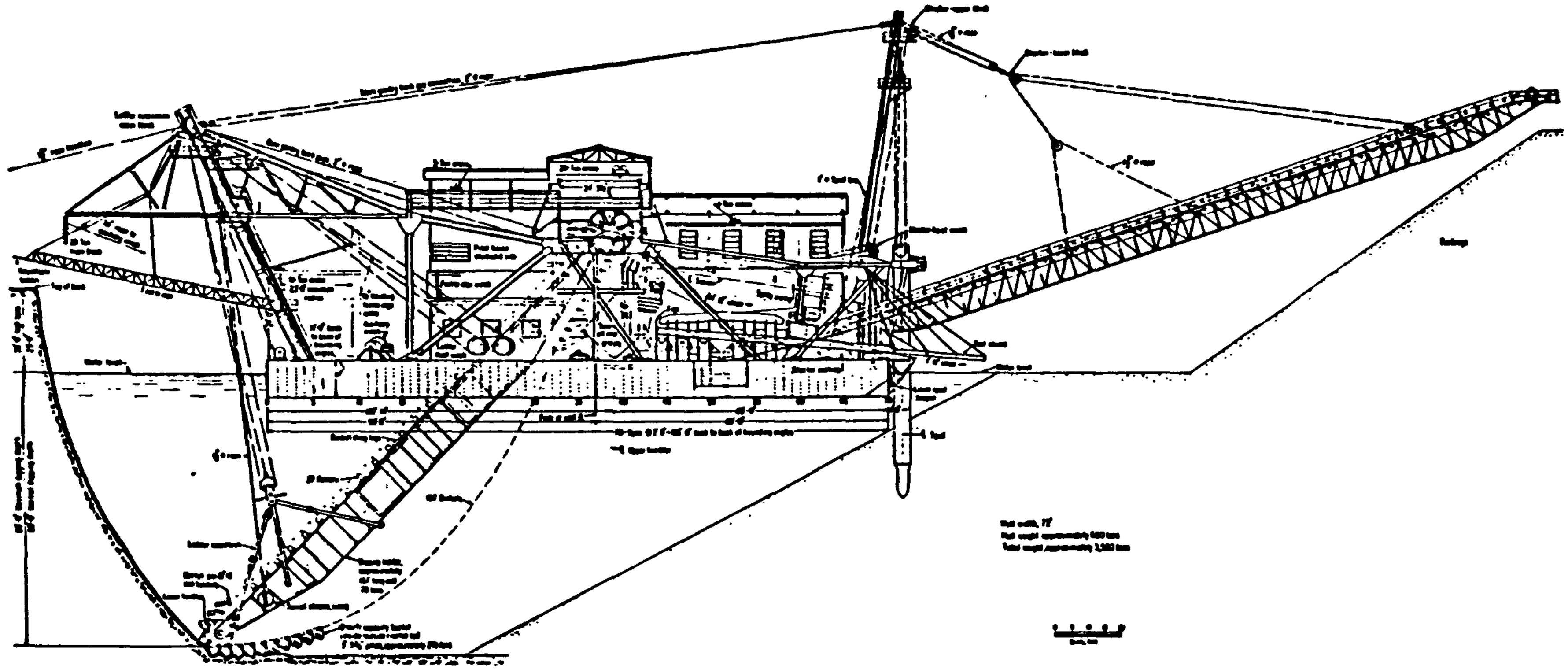


Figure III-3. Side View of 18-Cubic-Foot Yuba Manufacturing Division. 110 Dredge Designed to Dig 85 Feet Below Water.

position was usually 45 below the horizontal. During the last few years in Malaysia, 18-cubic-foot dredges digging from 130 to 158 feet below water level have often been operating at angles of 55 and sometimes more. At its upper position, the ladder inclines about 15 below the horizontal. Figure III-3 is a side view of the 18-cubic-foot Yuba Manufacturing Division, Yuba Industries, Inc., No. 110 dredge that was designed to dig 85 feet below water level (10).

Compared with any hydraulic system, the bucket-line dredge is more efficient in capturing values that lie on bedrock or in scooping up the material which sloughs or falls from the under-water face. It is more efficient when digging in hard formations, because its heavy ladder can be made to rest on the buckets providing them with more ripping force. Bucket size and speed can be varied with formation changes in the deposit according to the volume of material that can be processed through the gold-saving plant. Most bucket-line dredges used in placer mining have compact gravity-system processing plants mounted on the same hull as the excavating equipment. The waste stacking unit, also mounted on the same hull, combines with other dredge functions to make the dredge a complete and effi-cient mining unit. The advantages of an integral waste dis-tributing system trailing behind the excavator become readily apparent when considering that up to 10,000 cubic yards of oversize waste must be disposed of each day on a large dredge. To assure a high percentage of running time, dredge components must be designed for long life and relatively easy and quick replacement of parts.

Dredging experience has shown that most parts need to be larger and heavier than theoretical engineering designs indicate, and the simpler their design, the lower their replacement and installation costs (10).

The advantages of the bucket-line dredge as compared to the hydraulic dredge are as follows:

1. It lifts only payload material, whereas a hydraulic system expends considerable energy lifting water;
2. It loses fewer fines, which contain most of the fine or small fraction gold;
3. It can dig more compact materials;
4. It can clean bedrock more efficiently;
5. It allows more positive control of the mining pattern;
6. It has a simpler waste disposal system compared to a hydraulic system with an onshore treatment plant;
7. It requires less horsepower.

The disadvantages of mechanical systems compared to hydraulic systems include: (1) they require more initial capital investment per unit of capacity; and (2) they require a secondary pumping system if the excavated materials must be transferred to a beneficiation plant which is distant from the dredge (10).

To date, a bucket-wheel excavator has not been used as part of a mining dredge but, conceivably, if integrally designed into the total unit, it could have distinct advantages. Bucket-wheel control would be similar to that of a bucket line, its ladder maneuvered vertically by a winch-cable-sheave system. Its outstanding advantage on land, the ability to discharge directly onto its ladder conveyor, cannot be fully utilized to dig underwater unless the diameter of the bucket wheel is sufficiently large with respect to the depth of the gravel and possibly unless the bucket transfer and conveying systems are modified. The bucket wheel would seem to have its greatest promise on a hydraulic dredge to replace the cutterhead. With hydraulic lift and transport, it should compare favorably with the bucket-line system. Capable of working in either direction, it could overcome the weakness of the cutterhead, which can operate efficiently in only one direction, and in tough formations it should increase output (10).

Open Cut Methods. Many perenially frozen and thawed, buried gold placer deposits in Alaska cannot be mined profitably without modern earthmoving equipment. In general, this equipment is used to mine deposits where the size, depth, and characteristics of the deposit and the topography and condition of the underlying bedrock prohibit dredging, or where an inadequate water supply prohibits hydraulicking. Bulldozers, draglines, and scrapers are used in combination with hydraulic methods to mine some deposits by open-cut methods. As indicated earlier, the choice of excavation equipment, recovery system and the mining method is based on the size, degree of consolidation, the physical characteristics of the deposits, and the water supply (9, 11).

a. Bulldozers. Whether used exclusively or in combination with other earthmoving equipment, bulldozers are employed in all phases of open-cut placer mining. They are used for stripping muck and barren gravel overburden, pushing pay dirt to sluiceboxes, stacking tailings, and constructing ditches, ponds, and roads. Rippers attached to bulldozer blades may be used to excavate bedrock where gold has penetrated fractures and joints or frozen ground (9, 11,12). According to a Canadian study, bulldozers are utilized at about 80 percent of Yukon Territory placer mines (12).

The tractor sizes range from 60 to 180 horsepower, but the 150 horsepower models generally are used in mining. Straight blades are preferred because angle blades have less load capacity.

Scrapers have limited utility but may be used in special circumstances.

b. Draglines. Although draglines are less mobile than bulldozers, they can move materials at a lower cost per unit. Because of their high initial cost, however, their use is generally limited to those operations which have large reserves to warrant the additional expenditure for equipment. Draglines are used essentially for the same purposes as bulldozers. The 1 1/2 cubic yard bucket capacity is preferred although the 3/4, 1, and 2 cubic yard sizes are not uncommon (11).

Draglines are not used extensively in Alaska or in Canada's Yukon placer industry. Draglines have been used effectively for cleaning settling ponds (12).

c. Loaders. Front-end loaders are the second most common equipment type and are used at about 50 percent of Yukon Territory placer mines (12). Although they are usually mounted on rubber tired wheels, they also can be track-mounted. Front-end loaders have the following advantages (12):

(1) The economic load and carry distance may be as far as 700 feet;

(2) Classification equipment such as grizzlies can be more easily utilized than with bulldozers;

(3) Wheel loaders have a greater flexibility in moving material (e.g., out of pits, around tailings piles).

Hydraulic Methods. Hydraulic mining, also known as hydraulicking, utilizes water under pressure which is forced through nozzles to break and transport the placer gravel to the recovery unit (usually a sluice box). The adjustable nozzles are also known as monitors or giants. They are also used to break up or wash away overburden. If done in stages, frozen muck can be thawed effectively. A pump, or occasionally, gravity is used to produce the required pressure.

Monitors or giants can swing in a full circle and through a wide vertical angle. The weight of the nozzle is counterbalanced by a weight box. A giant is normally mounted on a timber or iron sled in order to ease relocation.

The amount of material moved by hydraulic mining is measured by cubic yards per miners inch/day (1.5 cubic feet per minute is considered to be a miners inch). Most giants are operated under pressure exceeding 100 pounds/square inch and use 1,700 to 50,000 gallons of water per minute.

Table III-2. Estimated Monitor Discharge Rates for Various Nozzle Sizes and Pressures (Source: Ref. 9).

	Water Discharged (GPM)			
	Head			
Nozzle Diameter (in.)	100 ft.	200 ft.	300 ft.	400 ft.
2	703	995	1,219	1,406
3	1,660	1,244	2,753	3,179
4	2,842	4,002	4,899	5,655
5	4,413	6,246	7,630	8,826

Table III-3. Typical Operating Data for Hydraulicking in the Yukon (Source: Reference 12).

Category	Typical Values
Number of Giants	1 to 10
Nozzle Size (Diameter)	2 to 6 inches
Efficient Working Pressure	50 to 120 lb/in^2
Pipeline Diameter	8 to 24 inches
Vol. Stripped/Unit Volume*	0.8 to 1.25 yd^3/1,000 gal. (50 yd^3/hr at 1,000 gpm)
Wastewater Quality	
a. Suspended Solids	270,000 mg/l (at 1 yd^3/1,000 gal.)
b. Settleable Solids	75 to 300 ml/l

*Efficient large-scale operation.

Other Associated Activities. There are many activities which occur at mine sites which are either directly or in-directly related to operation of a placer mine. The remaining portions of this subsection address these activities.

a. Prospecting and Evaluation. Sampling methods include various types of drilling (mainly churn drilling) and excavating (trenches pits and shafts). Other than possible erosion of disturbed soils, sampling methods generally involve only minor effects on water quality. However, processing of samples can in some circumstances produce significant quantities of a sediment-laden effluent.

Processing methods and the resultant amount of sediment produced depend on the size of sample processed. Small samples, from a few pounds up to a few tons, can be processed by hand with a rocker and a pan. A steady flow of four or five gallons per minute is sufficient to operate a small (1 x 4 foot) rocker. With reuse, net consumption may be as low as 50 to 100 gallons per cubic yard (13).

Bulk samples of up to several cubic yards can be excavated by hand or with a tractor-mounted backhoe. These samples are processed in a small sampling sluice 6 inches to 24 inches in width and 6 to 20 feet in length. When working by hand, two people can process and evaluate one to three cubic yards per day (13). When working with a backhoe and excavating relatively closely spaced test pits, about 100 cubic yards per day can be processed. Water requirements vary from a minimum of 50 gallons per minute for a 6-inch sluice to several hundred gallons per minute for a 24-inch sluice.

b. Stripping Vegetation. Mining areas are stripped for the following purposes (12):

(1) To remove the insulating layer to allow thawing of permafrost;

(2) To remove organic material which would interfere with processing;

(3) To expose the overburden and mineable paydirt.

Both heavy equipment and hydraulicking are used for stripping vegetation. Mechanical strip-ping of vegetation can expose erodible soils and, therefore, can significantly degrade water quality. Where stripped soils are on a slope, gully erosion can result. Hydraulic removal of vegetation is usually a part of hydraulic thawing and stripping overburden and can significantly degrade water quality.

c. Thawing Permafrost. There are basically four methods of thawing frozen ground (12):

1. Mechanical removal of the insulating layer of surface vegetation and overburden, and solar thawing;
2. Hydraulic removal (using monitors) of the surface vegetation and combined cold surface water and solar thawing;
3. Cold water thawing of the frozen ground by driving closely spaced well points and injecting cold water into the thawed ground that precedes the well point;
4. Diverting surface water over or against frozen ground (ground sluicing).

d. <u>Stripping</u> <u>Overburden</u>. In many districts, pay gravels are overlain by silty, organic-rich deposits of barren, frozen muck which must be removed prior to mining. Geologically, the muck is thought to be primarily colluvium (material transported by unconcentrated surface runoff) but may also contain loess (wind-blown deposits). Some areas of muck are particularly noted for a high organic and/or high ice content. Other types of overburden are barren alluvial gravels, broken slide rock, or glacial deposits (12). There are two primary methods of stripping used - mechanical and hydraulic. Each will be discussed below.

Mechanical stripping referes to the use of excavating equipment for removal of overburden. Miners who mechanically strip overburden generally utilize the same equipment for mining. Few have specialized stripping equipment, e.g., shovels, scrapers, draglines, bucket wheel excavators. Mechanical stripping can be constrained by permafrost, severe space limitations for overburden dumps, difficult workability of weak thawing silts, and thick overburden deposits (12).

If the hydraulicking is done in stages, frozen muck can be thawed effectively and stripped. Pumps and occasionally gravity are used to produce the required water pressure (12). The major constraint to the application of hydraulicking, other than environmental considerations, is probably lack of an adequate water supply. Construction of storage reservoirs and lengthy ditches and diversions are frequently necessary. Although the water quality effects stem primarily from the hydraulicking itself, unstable diversions, ditches, and reservoir dikes washed out by floods also contribute to the sediment load.

Processing Methods

There probably is no such thing as a single "typical" mine due to the wide variation in processing equipment used, overburden characteristics and methods of removal, type of deposit, size range of the gold recovered, topography, etc. Therefore, the actual equipment and mining methods used will probably be some combination of mining methods and processing technology discussed here.

Virtually all of the present placer mining operations use some type of sluice box to perform the primary processing function, beneficiation; but some jigs are used on dredges.

Many operations make use of feed classification. Some of the most prominent equipment is discussed under various headings below.

Classification. Classification (screening) involves the physical separation of large rocks and boulders from smaller materials such as gravel, sand, and silt or clay. The object of classification is to prevent the processing of larger-sized material which is unlikely to contain values. Placer miners who were interviewed as part of a previous study reported that this practice improves the efficiency of gold recovery (14). The reason was attributed to the fact that a lower flow rate of water may be required compared to the high flow rate necessary to wash large rocks through the sluice. The low flow rate enhances the settling and entrapment of smaller-sized gold particles in the sluice. Use of increased rates of flow when classification is not practiced is thought to cause some of the finer gold particles to be washed through the sluice and lost (14). Operating considerations also are enhanced by preventing the entry of large rocks and boulders which must be removed manually when lodged in the box.

a. Grizzlies. A grizzly is a large screen of a fixed opening size which serves to reject oversize material and prevent it from entering the sluice. This oversize material is then discarded. Typically, a grizzly would be inclined to ease removal of the rejected material.

The advantage of a grizzly is that it prevents processing of coarse material which is unlikely to contain gold, and it allows a shallower depth of flow over the sluice riffles which enhances recovery of fine gold. This can result in a water use reduction.

b. Trommels. A trommel is a wet-washed, revolving screen which offers the following advantages (1):

(1) It washes the gravel clean and helps in disintegrating gold-bearing clayey material by impact with oversize material and strong jets of water; and

(2) It screens and distributes slimes, sand, and fine gravel (usually less than 1/2 inch) to the processing section and discards the oversize material.

Taggert (Reference 15) reported that plants equipped for removal of oversize material with subsequent treatment in sluices are capable of processing 60 to 67 percent more gravel per unit area of a sluice.

c. <u>Fixed Punchplate Screen-High Pressure Wash (Ross Box)</u>. The Ross Box is essentially a punchplate with hole sizes generally 1/2 to 3/4 inches. A dump box receives the pay gravel while a header with several nozzles delivers wash water into the dump box in a direction opposite to the flow of the gravel.

This turbulent washing action washes undersize material through the punchplate where it is diverted to outside channels fitted with riffle sections. These side channel sluices handle only material smaller than 3/4 inch. Oversize material is washed down the center channel which is fitted with riffles to collect coarse nuggets (12).

d. <u>Vibrating Screens</u>. A vibrating screen is a screen which uses vibration to improve the rate at which classification occurs. Generally, 1/2 to 3/4 inch screens are used with the oversize material rejected to a chute. These screens are loaded by a front-end loader or a backhoe. Typically, one to four cubic yards of material are screened at one time. In some configurations, several size screens are stacked and different size classifications are sluiced independently. Wet screening is sometimes used to break up clay and loosely bound particles.

<u>Sluices</u>. A sluice is a long, sloped trough into which water is directed to effect separation of gold from ore. The ore slurry flows down the sluice and the gold, due to its relatively high density, is trapped in riffles along the sluice. Other heavy

minerals present in the ore are also trapped in these riffles. These other minerals are generically called "black sands" and are separated from the gold during final clean-up, i.e., in small sluices, gold wheels and amalgamation.

Sluice boxes are usually constructed of steel. Typically, a sluice is 6 to 12 meters (20 to 40 feet) long, and 61 to 122 cm (24 to 48 inches) wide. Longer sluices are used where the ore is not broken up prior to sluicing. Shorter and narrower sluices are used in prospecting and during clean-up operations. Water depths in sluices may vary from 3.8 cm to 15.2 cm (1.5 inches to 6 inches). The slope of the sluice boxes ranges from 8.3 cm to 16.6 cm vertical per meter horizontal (1 to 2 inches per foot). The grade of sluice boxes can be varied depending upon the ore. In general, the recovery of fine gold requires shallower and wider sluices and steeper grades (5). The majority of the gold is recovered in the first several feet of riffles (5).

a. <u>Hungarian Riffles</u>. The Hungarian riffle design is generally considered best for use in placer mining (4). Hungarian riffles are essentially angle irons mounted transversely in the sluice box as shown in Figure III-4a. The riffles are spaced 3.8 to 7.6 cm (1.5 to 3 inches) apart (4). The size and spacing of the riffles are designed to maximize gold capture and to minimize packing of the riffles with non-gold bearing particles. These riffles are sometimes custom-modified with notches and holes to improve gold recovery. The miners place carpets under the riffles (resembling artificial turf) to capture and retain the gold for further processing. Sections of riffles can be removed to withdraw the carpets.

b. Horizontal Pole Riffles. Wooden poles placed per-pendicular to the flow have been used to create riffles at placer mines. Horizontal pole riffles are sketched in Figure III-4b. This type of riffle has been used in small-scale, remotely located operations because the riffle can be made with locally available materials. Wooden poles are not as durable as their steel counterparts, and their use has largely been discontinued.

c. Longitudinal Pole Riffles. Wooden poles, usually spruce, are placed parallel to the direction of flow through the sluice (5). The spacing between these pole riffles varies from 3.8 cm to 7.6 cm (1.5 inches to 3 inches). Similar to horizontal pole riffles, longitudinal pole riffles are not believed to be in widespread use.

d. Other Riffle Types. Wooden blocks, rocks, rubber and plastic strips, railroad rails, expended metal, heavy wire screen, and cocoa mats have been used at various times as riffles in the placer gold mining industry (5, 17). These riffle designs are not in common use today.

Often undercurrents are used to withdraw a portion of the slurry from the sluice box and re-sluice it using a different riffle configuration. These undercurrents are usually located near the bottom of the sluice to recover fine gold that otherwise would remain in the tailings. Screens usually cover the entrance of the undercurrents, and undercurrent sluices are relatively short.

Clean-Up Methods. Many accessory heavy minerals found in the pay gravels are also concentrated by the methods discussed in this section. Therefore, it is essential that the concentrate collected from the sluice is separated into gold values and the unwanted accessory heavy minerals. The following discussion presents methods in use today.

a. Jigs. In general, the concentrate is fed as a slurry to a chamber in which agitation is provided by a pulsating plunger or other such mechanism. The feed separates into layers by density within the jig with the lighter gangue being drawn off at the top with the water overflow, and the denser mineral (in this case gold) drawn off on a screen on the bottom. Several jigs may be used in series to achieve acceptable recovery and high concentrate grade (18). In addition to clean up of concentrate from sluices, large jigs are also used as the primary beneficiation process to recover gold from paydirt in lieu of sluices. Large dredges often use a number of jigs in series to recover gold from sized or screened paydirt and at least one open cut mine is using jigs in the primary recovery or beneficiation of sized paydirt.

b. Tables. Shaking tables of a wide variety of designs have found widespread use as an effective means of achieving gravity separation of finer ore particles 0.08 mm (0.003 inch) in diameter. Fundamentally, they are tables over which flow ore particles suspended in water. A series of ridges or riffles perpendicular to the water flow traps heavy particles while lighter ones are suspended and flow over the obstacles with the water stream. The heavy particles move along the ridges to the edge of the table and are collected as concentrates (heads) while the light material which follows the water flow is generally a waste stream (tails). Between these streams may be some material (middlings) which has been partially diverted by the riffles. These are often collected separately and returned to the table feed. Reprocessing of heads or tails, or both, and multiple-stage tabling are common.

c. Spirals. Spiral separators i.e., Humphrey concentrators, provide an efficient means of gravity separation for large volumes of material between 0.1 mm and 2 mm (0.004 to 0.08 in) in diameter. Spirals have been widely applied, particularly in the processing of heavy sands for titanium minerals (19). Spirals consist of a helical conduit (usually of five turns) about a vertical axis. The ore, or in this case concentrate, is fed to the conduit at the top and flows down the spiral under gravity. The heavy minerals concentrate along the inner edge of the spiral from which they may be withdrawn through a series of ports. Wash-water may also be added through ports along the inner edge to improve the separation efficiency. In large plants, several to hundreds of spirals may be run in parallel, although in placer mining operations, a small number is usually sufficient. At least one dredge and one open cut mine have been reported as using spirals in the primary recovery of gold from placer deposits.

d. Gold Wheels. A gold wheel is a gravity separation device used during cleanup to separate the gold from the "black sand." The wheel may vary between 30 cm to 112 cm (12 inches to 44 inches) in diameter and may rotate at a rate up to 42 rpm. The rotational speed can be controlled by the operator. Inside the wheel, there are 0.64 cm (1/4 inch) to 1.27 cm (1/2 inch) channels arranged in a helix. The wheel is tilted with only small angles being capable of separating materials of relatively different specific gravities. Conversely, steeper angles separate materials with little difference in specific gravity. Water is sprayed onto the wheel from several ports at a rate of 10 gpm or less. This water can be recirculated if needed. Gold concentrate is placed along the perimeter of the wheel, and the gold works its way to the center where it is withdrawn. The lighter material flows over the perimeter of the wheel and is captured and reworked to recover any remaining gold. Surfactants (e.g., soap) are sometimes added to the water to aid in directing flow of the gold to the center.

e. Small Sluices. Small sluices are simply scaled-down versions of the sluices described above. The advantage of using a small sluice is that only small amounts of concentrate are processed at a rate conducive to maximize gold separation from other heavy minerals in the concentrate. Several passes or several small sluices may be used in series to ensure that no gold is lost. Only small amounts of water are required because the size range of the concentrate is relatively restricted.

f. Magnetic Methods. A large proportion of the heavy mineral concentrate from which the gold is extracted may contain minerals (primarily magnetite) which exhibit magnetic prop-erties. The basic process involves the transport of the concentrate through a region of high magnetic field gradient. In large-scale applications of this method, an electromagnet may be used, but at small operations, a hand magnet is often em-ployed. This method is often applied along with other methods to effect the best separation of the gold from other heavy minerals in the concentrate.

g. Chemical Methods. There are two chemical methods in use in the gold industry today which may be used in association with gold placer mining: amalgamation and cyanidation. Amalgamation was used on a wider scale in the past but is not commonly used today except for cleanup of a concentrate. Cyanidation is not known to be used for extraction of gold from a concentrate but could be used to rework tailings from placer operations by heap leaching. This guideline does not cover wastewater from such methods.

1. Amalgamation. Amalgamation is the process by which mercury is alloyed, generally to gold or silver, to produce an amalgam. The amalgam is placed in a small retort to recover the mercury for reuse and to reclaim the gold. However, since placer gold can be purchased directly for jewelry, mercury is seldom used. This is because after amalgamation, it must be retorted. This reduces its value because the gold is tarnished and often welded together (9). An amalgamator, which would be a cylinder of some

type (even a small cement mixer would do) is turned either manually or mechanically. Mercury is introduced with the concentrate and becomes amalgamated with the gold. The amalgam is then retorted and the mercury recovered.

2. Cyanidation. The use of this process is unknown in Alaska for primary extraction of placer gold but has been used elsewhere to recover gold from low grade ores by heap or vat leaching. It has been economically applied in the recovery of gold from tailings left by hard rock gold mills. The cyanidation process involves the extraction of gold or silver from fine-grained or crushed ores, tailings, low grade mine rock, etc., by the use of potassium or sodium cyanide in dilute, weakly alkaline solutions. After dissolution of the gold, the gold is absorbed onto activated carbon or precipitated with metallic zinc. The gold may be recovered by filtering with the filtrate being returned to the leaching solution. A more complete description of this process may be found in Reference 18.

Small-Scale Methods. The methods described in this sub-section are primarily utilized by recreational or asseessment operations. The various small-scale methods are similar to regular methods in that they employ principles based upon gravity separation. Small-scale methods are responsible for only a very small percentage of all placer gold production. A few representative methods are described below.

a. Gold Pan and Batea. Panning currently is mostly used for prospecting and recovering valuable material from concen-trates.

The pan is a circular metal dish that varies in diameter from six to eighteen inches with sixteen-inch pans being quite common. The pans often are two to three inches deep and have 30- to 40-degree sloping sides. The pan with the mineral-bearing gravel or sand is immersed in water, shaken to cause the heavy material to settle toward the bottom of the pan, and then the light material is washed away by swirling and overflownig water. This is repeated until only the heavy con-centrates remain. In some countries, a conical-shaped wood pan, called a batea, is used. This unit has a 12- to 30-inch diameter with a 150-degree apex angle. It is often used to recover valuable metals from river channels and bars.

b. Long Tom. A long tom is essentially a small sluice box with various combinations of riffles, matting, expanded metal screens, and occasionally amalgamating plates. A long tom usually has a greater capacity than a rocker box and does not require the labor of rocking. It consists of a short receiving launder, an open washing box six to twelve feet long with the lower end a perforated plate or screen set at an angle, and a short sluice with riffles. The component boxes are usually set on slopes ranging from one to one and one-half inches per foot.

c. Rocker Box. Rocker boxes are used to sample placer deposits or to mine high-grade areas when installation of larger equipment is not justified. The box is constructed of wood and is essentially a short, sloped box chute over which the pay dirt and water flow as the box is rocked back and forth. A screen is mounted at the head of the box to reject oversize material. It may be fitted with riffles and usually has a canvas bottom.

d. Dip Box. The dip box is useful where water is scarce and where an ordinary sluice cannot be used because of the terrain. It is portable and has about the same capacity as the rocker box. The box is about six to twelve feet long, and twelve inches wide with six-inch sides. The bottom of the box is covered with burlap, canvas, or thin carpet to catch the gold. Over this is laid a one-by-three-foot strip of heavy wire screen of about 1/4-inch mesh. Material is dumped or shoveled into the upper end and washed by pouring water over it from a dipper, bucket, hose, or pipe until it passes through the box. Large rocks are removed by hand and riffles may be added to the lower section of the box to improve recovery (17).

e. Suction Dredge. Small suction dredges have been used successfully while prospecting or for recreational or small (part-time) ventures. The pump sizes most commonly found in use vary from one to four inches. The pump is usually floated immediately above the area being worked. There are two basic assemblies that are commonly used: (1) the gold-saving device is in a box next to the suction pipe and carried under water, and (2) the other system uses two hoses in the nozzle - one transporting water to the head and the other transporting material to the surface of a gold-saving device (9).

INDUSTRY PRACTICE

Until recently, little detailed information was available concerning placer mining operations in Alaska and other states. However, during the last few years, EPA has embarked upon efforts described elsewhere in this document to identify specific operations and obtain information concerning mining practices, wastewater treatment technologies employed, flow, etc. This information has been obtained by site and sampling visits, review of tri-agency report forms, visits to state pollution control agencies, and from other sources.

The objective of Table III-4 to Table III-8 is to provide information and data gathered at mining operations in this industry subcategory. Discussion of an operation or presentation of data and information does not imply that the mining operation is exemplary, typical, or represents good wastewater treatment. This list does not include all existing mines, particularly with respect to the hundreds of recreational or assessment operations which are known to exist. Rather, the tables that follow present a summary of data and information that EPA has obtained which serve to illustrate the range of opera-tions in the United States today.

Some characteristics of the operations emerge from examination of the information gathered, however, which serve to place the gold placer mining industry in perspective. Most operations are located in remote areas far from supplies and the amenities of civilization. Many operations are family-owned and operated and probably over 95 percent employ seven (or fewer) persons. Most of the operations are seasonal generally averaging between 100 to 115 operating days per year. The size of the operations ranges from processing less than 20 cubic yards per day to as much as 12,000 cubic yards per day (10). Although gold is very valuable, the amount contained in the paydirt is very low with even the richest deposits containing only a few grams of gold per cubic yard; the gold gives a value of a few cents to over eight dollars per cubic yard of pay dirt and more depending upon the current international price for gold.

Wastewater treatment technology employed in the industry generally ranges from no treatment to settling ponds and discharge or to recycle of wastewater. The majority of mines provide some settling, and a few employ tailings filtration for solids removal. No advanced treatment technology or chemical methods are known to be employed in Alaskan operations today although some operators have tried flocculant addition in the lower 48 states. Recycle ranges from nonexistent to 100 percent, but at most operations recycle is employed primarily to conserve water and occurs only intermittently. Electric power is usually generated on-site by the operators with fuel delivered periodically to the site, often by air.

The remainder of this section consists of Tables III-4, III-5, III-6, III-7, and III-8 which are profiles of the Alaska, California, Colorado, Idaho, and Montana gold placer mines surveyed and for which some data were available. Although limited production has been reported from other states, we have no precise data on the number of mines or production in other states. Figure III-4 gives the locations for the various mining districts in Alaska.

TABLE III-4. PROFILE OF ALASKAN PLACER GOLD OPERATIONS

MINE CODE	LOCATION (DISTRICT)(1)	OPER. DAYS PER YEAR	CLASSIFICATION METHOD USED(2)	VOLUME SLUICED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGIES USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (GPM)
4109	50	100	Screens	1,350	Open Cut	Settling Ponds (2)	0	3,000
4110	50	60	Trommel and hyd. prewash	750	Open Cut and Hyd.	Settling Ponds (5)	75	1,000
4126	31	245	Trommel	6,800	Mech. Drdg.	Settling Ponds (5)	100	0
4127	31	245	Trommel	Unk.	Mech. Drdg.	Settling Ponds (2)	>0	3,140
4132	5	Unk.	None	90	Open Cut	Settling Ponds (2)	0	1,350
4133	5	180	Unk.	1,000	Open Cut	Settling Ponds (2)	0	675
4134	5	210	None	2,000	Open Cut	Settling Ponds (3)	0	23,000
4138	4	80	Vibrating Screens	90	Open Cut	Settling Ponds(10)	30	1,050
4169	50	189	None	900	Open Cut	Settling Ponds (5)	98	224
4170	50	132	Grizzly	1,000	Open Cut	Settling Pond (1)	0	2,400
4171	50	112	Trommel	1,000	Open Cut	Settling Pond (1)	0	1,800
4172	47	122	Trommel	2,750	Open Cut	Settling Ponds (3)	~ 17	6,000
4173	47	138	None	3,500	Open Cut	Settling Ponds (3)	>0	3,500
4174	47	122	Grizzly	2,500	Open Cut	Settling Ponds (2)	50	1,260
4175	47	102	None	1,000	Open Cut	None	0	8,000
4176	47	120	Grizzly	1,250	Open Cut	Settling Pond (1)	0	3,500
4178	47	90	Grizzly	1,500	Open Cut	Settling Ponds (3)	0	2,500
4180	47	131	Vibrating Screens	1,900	Open Cut	Settling Pond (1)	0	2,500

1. Location by Mining district; see Figure III-4.

TABLE III-4. PROFILE OF ALASKAN PLACER GOLD OPERATIONS

MINE CODE	LOCATION (DISTRICT)(1)	OPER. DAYS PER YEAR	CLASSIFICATION METHOD USED(2)	VOLUME SLUICED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGIES USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (GPM)
4183	47	Unk.	Unk.	Unk.	Open Cut	None	>0	1,400
4185	47	107	Trommel	800	Open Cut	Settling Ponds (2)	<50	3,200
4189	50	122	Trommel	950	Open Cut	Settling Ponds (4)	0	1,500
4190	51	104	None	2,500	Open Cut	Settling Ponds (2)	50	1,800
4193	51	80	Derocker	900	Open Cut	Settling Pond (1)	50	700
4197	59	102	Screens	200	Open Cut	Settling Pond (1)	75	450
4211	14	152	Trommel	4,000	Drdg.	Settling Pond with Tailings Filtration	>0	3,600
4213	50	120	None	250	Open Cut	Settling Ponds (2)	97	60
4216	12	132	Vibrating Screen	300	Open Cut	Settling Ponds (3)	0	800
4217	12	154	Vibrating Screen	350	Open Cut	Settling Ponds (3)	0	2,000
4219	53	162	None	1,000	Open Cut	Settling Ponds (4)	93	450
4222	31	150	Trommel	700	Mech. Drdg.	Settling Pond (1)	45	1,800
4223	47	120	Grizzly	1,000	Open Cut & Suct. Drdg.	Settling Pond (1)	0	2,500
4224	51	65	None	300	Open Cut	Settling Ponds (2)	0	2,000
4225	47	120	None	900	Open Cut	Settling Ponds (4)	50	3,000
4226	50	162	Jig	1,500	Open Cut	Settling Ponds (2)	50	2,200
4227	51	183	None	Unk.	Hyd. & Open Cut	Settling Pond (1)	0	4,000

1. Location by Mining district; see Figure III-4.

TABLE III-4. PROFILE OF ALASKAN PLACER GOLD OPERATIONS

MINE CODE	LOCATION (DISTRICT)(1)	OPER. DAYS PER YEAR	CLASSIFICATION METHOD USED(2)	VOLUME SLUICED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGIES USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (GPM)
4229	47	135	Unk.	1,400	Open Cut	Settling Ponds (5)	0	5,800
4230	58	120	Unk.	300	Open Cut	Settling Pond (1)	0	6,700
4231	50	168	Trommel	500	Open Cut	Settling Pond (1)	90	800
4232	47	108	FPS	1,020	Open Cut	Settling Ponds (2)	50	2,000
4233	5	162	Grizzly	99	Open Cut	Settling Ponds (3)	0	417
4234	58	90	Grizzly	500	Hyd. (Booming)	None	0	1,500
4235	47	107	None	1,000	Open Cut	Settling Pond (1)	0	3,000
4236	58	213	Trommel	2,000	Open Cut	Settling Pond (1)	0	580
4239	14	Unk.	None	Unk.	Open Cut	Settling Ponds (2)	>0	450
4240	47	122	Vibrating Screen & Grizzly	500	Open Cut	None	0	2,000
4241	47	117	Grizzly	850	Open Cut	Settling Pond (1)	0	2,300
4242	47	89	None	800	Open Cut	Settling Ponds (4)	0	3,500
4243	51	107	Unk.	26	Hyd. and Open Cut	Settling Ponds (2)	0	1,500
4244	51	122	None	615	Open Cut	Settling Ponds (2)	0	3,000
4245	51	88	Unk.	400	Open Cut	Settling Ponds (2)	0	2,500
4247	5	150	FPS	500	Open Cut	Settling Pond (1)	0	2,000

1. Location by Mining district; see Figure III-4.
2. FPS = Fixed punch-plate screen.

TABLE III-5. PROFILE OF CALIFORNIA PLACER GOLD MINES

MINE CODE	COUNTY	OPER. DAYS PER YEAR	CLASS. METHOD	VOLUME PROCESSED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGY USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (gpm)
4260	Yuba	364	Trommel Jigs	12,360	Mech. Dredge	Seepage Ponds	Partial	0

TABLE III-6. PROFILE OF COLORADO PLACER GOLD MINES

MINE CODE	COUNTY	OPER. DAYS PER YEAR	CLASS. METHOD	VOLUME PROCESSED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGY USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (gpm)
4267*	San Juan	60	Screens	<135	Open Cut	Settling Pond (1)	0	300
4268***	Arapahoe	Seasonal	Screens	Unk.	Open Cut	Settling Ponds (2)**	>0	35
4269	Gilpin	150	Trommel	100-150	Open Cut	Settling Ponds (3)	>0	120
4270	Montrose	Unk.	Unk.	150	Open Cut	Settling Ponds (2)	Unk.	13

* Requested inactivation of his discharge permit
** One pond for each of the discharge points
***Sand and gravel also recovered at this mine

TABLE III-7. PROFILE OF IDAHO PLACER GOLD MINES

MINE CODE	COUNTY	OPER. DAYS PER YEAR	CLASS. METHOD	VOLUME PROCESSED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGY USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (gpm)
4271	Idaho	Seasonal	Trommel	320	Open Cut	Settling Ponds (3) (possible use of flocculants)	100	0
4272	Idaho	Seasonal	Screen, Trommel	100	Open Cut	Settling Ponds (2)	100	0
4273	Idaho	Seasonal	Trommel	100	Open Cut	Settling Ponds (2)	approx. 100	approx. 0
4274	Shoshone	Seasonal	Screens	100	Open Cut	Settling Ponds (2)	0	approx. 670
4275	Idaho	Seasonal	Unk.	100	Unk.	Settling Ponds (3)	Unk.	Unk.
4276	Custer	Seasonal	Grizzly, Screens	320-400	Open Cut	Settling Ponds (3)	Partial	Unk.
4277	Idaho	Seasonal	Grizzly, Vibrating Screens, Crusher	320	Open Cut	Settling Ponds (3)	100	0
4278	Owyhee	Unk.	Grizzly, Trommel Jigs & Table	Unk.	Open Cut	Settling Ponds (4)	Unk.	Unk.
4279	Idaho	Seasonal	Trommel	800-1000	Floating Wash Plant	Settling Ponds (2)	100	0
4280	Ada	Unk.	Unk.	Unk.	Open Cut	Unk.	Unk.	Unk.
4281	Idaho	Unk.	Unk.	approx. 1600	Open Cut	Settling Ponds (?)	0	Unk.
4282	Boise	Seasonal	Trommel	Unk.	Open Cut	Settling Ponds (?)	0	Unk.
4283	Boise	Seasonal	Unk.	Unk.	Open Cut	Settling Ponds (?)	0	Unk.

TABLE III-7. PROFILE OF IDAHO PLACER GOLD MINES (continued)

MINE CODE	COUNTY	OPER. DAYS PER YEAR	CLASS. METHOD	VOLUME PROCESSED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGY USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (gpm)
4284	Bonneville	Seasonal	Trommel	approx. 125	Open Cut	Settling Ponds (3)	100	0
4285	Unk.	Year Round	Magnetic Separators, Amalgamation	4,800	Open Cut	Settling Pond (3) (lined with bentonite)	approx. 100	Slight
4286	Power	Year Round	Vibrating Screen	280	Open Cut	Settling Ponds (2)	100	0
4287	Idaho	Seasonal	Unk.	120-160	Open Cut	Settling Ponds (3)	100	0
4288	Boise	Seasonal	Grizzly, Trommel	500	Open Cut	Settling Ponds (2)	100	0
4289	Idaho	Seasonal	Trommel	320	Open Cut	Settling Ponds (4) Flocculants maybe used	100	0
4290	Idaho	Seasonal	Trommel, Jigs	800	Open Cut	Settling Ponds (?) with use of settling agents (flocculants?)	0	approx. 900
4291	Idaho	Year Round	Trommel, Vibrating Screens	500	Open Cut	Settling Ponds (2)	0	2,500
4292	Idaho	240	Screens	160	Open Cut	Settling Ponds (2)	Partial	20
4293	Unk.	Seasonal	Trommel	125	Open Cut	Settling Ponds (2)	Partial	Unk.
4294	idaho	Unk.	None	800	Open Cut	Settling Ponds (?)	0	Unk.
4295	Clearwater	Unk.	Unk.	800	Dredge	Settling Pond (1)	Partial	Unk.

TABLE III-7. PROFILE OF IDAHO PLACER GOLD MINES (continued)

MINE CODE	COUNTY	OPER. DAYS PER YEAR	CLASS. METHOD	VOLUME PROCESSED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGY USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (gpm)
4296	Boise	approx. 180	Grizzly, Trommel, Screens, Magnetic Separator, Jigs & Table	1,600	Open Cut	Settling Ponds (4)	approx. 100	approx. 0
4297	Idaho	Unk.	Trommel, Screens, Jigs, Bowls	1,600	Open Cut and Suction Dredge	Settling Ponds (3) with discharge to tailings	unk.	approx. 0
4298	Elmore	Unk.	Grizzly, Trommel	36	Open Cut	Settling Ponds (3)	Partial	Unk.
4299	Idaho	Unk.	Unk.	800	Suction Dredge	Settling Pond (1)	Partial	0

TABLE III-8. PROFILE OF MONTANA PLACER GOLD MINES

MINE CODE	COUNTY	OPER. DAYS PER YEAR	CLASS. METHOD	VOLUME PROCESSED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGY USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (gpm)
4261	Lewis & Clark	270	Grizzly, Trommel	320-500	Open Cut	Settling Ponds (3)	100	0
4264	Broadwater	200	Grizzly, Trommel	200	Open Cut	Settling Ponds (2)	100	0
4262	Missoula	270	Trommel	300-400	Open Cut	Settling Ponds (4)	100	0
4263	Broadwater	100	Trommel	300	Open Cut	Settling Ponds (4)	Partial	Unk.
4341	Broadwater	+90	Trommel	100	Open Cut	None	0	Unk.
4300	Meagher	Unk.	Unk.	Unk.	Open Cut	Settling Pond (1)	Unk.	0
4301	Ravalli	Unk.	Unk.	100	Open Cut	Settling Pond (1)	0	800
4302	Missoula	Unk.	None	15	Open Cut	Settling Pond (1)	0	190
4303	Powell	Unk.	Unk.	25	Open Cut	Settling Pond (1)	0	150
4304	Powell	Unk.	Trommel	Unk.	Open Cut	Settling Pond (1)	0	Unk.
4305	Powell	Unk.	Unk.	40 to 60	Open Cut	Settling Ponds (?)	Unk.	250
4306	Broadwater	Unk.	Unk.	2	Open Cut	Settling Pond (1)	0	0
4307	Powell	Unk.	Unk.	40 to 60	Open Cut	Settling Pond (1)	0	380
4308	Meagher	Unk.	Trommel	50 to 100	Open Cut	Settling Pond (1)	0	160
4309	Meagher	Unk.	Unk.	100	Open Cut	Settling Pond (1)	Partial	0
4310	Meagher	Unk.	Unk.	40 to 50	Open Cut	Settling Pond (1)	0	0
4311	Powell	Unk.	Unk.	Unk.	Open Cut	Settling Pond (1)	0	250

TABLE III-8. PROFILE OF MONTANA PLACER GOLD MINES (continued)

MINE CODE	COUNTY	OPER. DAYS PER YEAR	CLASS. METHOD	VOLUME PROCESSED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGY USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (gpm)
4312	Mineral	Unk.	Unk.	2 to 3	Open Cut	Settling Pond (1)	0	0
4313	Lewis and Clark	Unk.	Trommel	37	Open Cut	Settling Pond (1)	Partial	0
4314	Lewis and Clark	Unk.	Unk.	50	Open Cut	Settling Pond (1)	0	25
4315	Lewis and Clark	Unk.	Unk.	24	Open Cut	Settling Pond (1)	approx. 100	approx. 0
4316	Powell	Unk.	Vibrating Screens	50	Open Cut	Settling Ponds (3)	0	250
4317	Meagher	Unk.	Trommel	400	Open Cut	Settling Ponds (3)	0	400
4318	Meagher	Unk.	Trommel	160	Open Cut	Settling Ponds (4)	0	400
4319	Granite	Unk.	Trommel	150	Open Cut	Settling Pond (1)	0	300
4320	Madison	Unk.	Unk.	100	Open Cut	Settling Ponds (4)	Partial	< 900
4321	Jefferson	Unk.	Trommel	500	Open Cut	Settling Ponds (5)	0	< 100
4322	Lincoln	Unk.	Unk.	200	Open Cut	Settling Pond (1)	Partial	400
4323	Powell	Unk.	Shaker Screens	60	Open Cut	Settling Ponds (2)	0	150
4324	Beaverhead	Unk.	Trommel	700	Open Cut	Settling Pond (1)	0	Unk.
4325	Silver Bow	Unk.	Wash Plant	300	Open Cut	Settling Pond (1)	0	600 to 700
4326	Madison	Unk.	Unk.	250	Open Cut	Settling Ponds (2)	> 0	1,500

TABLE III-8. PROFILE OF MONTANA PLACER GOLD MINES (continued)

MINE CODE	COUNTY	OPER. DAYS PER YEAR	CLASS. METHOD	VOLUME PROCESSED (CU. YD/DAY)	MINING METHOD	WASTEWATER TREATMENT TECHNOLOGY USED	RECYCLE (%)	DAILY DISCHARGE VOLUME (gpm)
4327	Meagher	Unk.	Trommel Grizzly Screens	325	Open Cut	Settling Pond (1)	0	100
4328	Lewis and Clark	Unk.	Unk.	300	Open Cut	Settling Ponds (3)	>0	700
4329	Beaverhead	Unk.	Trommel	300	Open Cut	Settling Ponds (3)	0	300
4330	Powell	Unk.	Trommel	25	Open Cut	Settling Ponds (?)	>0	3,000
4331	Lewis and Clark	Unk.	Trommel	Unk.	Open Cut	Settling Ponds (2)	0	600
4332	Powell	Unk.	Trommel	200	Open Cut	Settling Ponds (2)	>0	approx. 0
4333	Powell	Unk.	Grizzly Trommel Jigs	600	Open Cut	Settling Ponds (3)	100	0
4334	Meagher	Unk.	Trommel	50	Open Cut	Settling Pond (1)	0	500
4335	Silver Bow	Unk.	Trommel	>100	Open Cut	Settling Ponds (2)	if water needed	150
4336	Meagher	Unk.	Unk.	50 to 100	Open Cut	Settling Pond (1)	Unk.	320
4337	Mineral	Unk.	Unk.	50	Open Cut	Settling Ponds (4)	approx. 100	approx. 0
4338	Powell	Unk.	Unk.	300	Open Cut	Settling Ponds (3)	approx. 100	approx. 0
4339	Madison	Unk.	Unk.	250	Open Cut	Settling Pond (1)	approx. 100	approx. 0
4340	Jefferson	Unk.	Unk.	20	Open Cut	Settling Pond (1)	approx. 100	approx. 0

REFERENCES

1. Alaska Office of Mineral Development, "Alaska's Mineral Indstry - 1982," Special Report 31, 1983.

2. Mineral Facts and Problems, 1980 Edition, U.S. Bureau of Mines Bull. 671.

3. USEPA-Region X, "Draft General NPDES Permit for Placer Mining in the State of Alaska," February 14, 1983.

4. U. S. Geological Survey, United States Mineral Resources (Gold), U.S.G.S. Professional Paper 820, 1973, p. 263-275.

5. Wimmler, N. L., "Placer Mining. Methods and Costs in Alaska," U. S. Department of Commerce, Bureau of Mines, Bulletin No. 259, p. 10-15, 1927.

6. Jackson, C. F., "Small-Scale Placer Mining Methods," U.S. Department of Interior, Bureau of Mines Information Circular IC 6611R, February 1983, p. 15-18.

7. Louis Berger and Associates, "The Role of Placer Mining in the Alaska Economy," prepared for the State of Alaska Department of Commerce and Economic Development, March 1983.

8. U. S. Department of the Interior, Minerals Yearbook - Preprint "Gold" 1982, U. S. Bureau of Mines (Author J. M. Lucas) Report No. 1804-1, October 20, 1980.

9. Alaska Department of Environmental Conservation, "Placer Mining/Water Quality - Problem Description," Alaska Water Quality Management Planning Program Section 208 Study (P.L. 92-500), November 1977.

10. Romanowitz, C. M., Bennett, and Dare, W. L., "Gold Placer Mining - Placer Evaluation and Dredge Selection," U. S. Bureau of Mines Information Circular 8462, 1970.

11. Thomas, B. I., Cook, D. J., Wolff, E., and Kerns, W. H., "Placer Mining in Alaska - Methods and Costs at Operations Using Hydraulic and Mechanical Excavation Equipment with Nonfloating Washing Plants," U. S. Bureau of Mines Information Circular 7926, 1959.

12. Sigma Resources Consultants, Limited, "Water Use Technology for Placer Mining Effluent Control," Department of Indian and Northern Affairs, Canada, Report No. QS-Y006-000-EE-Al, Whitehorse, Yukon Terr., 1981.

13. Wells, J. H., "Placer Examination, Principles and

Practice," U. S. Bureau of Land Management, U. S. Department of Interior, 1969.

14. Bainbridge, K. L., "Evaluation of Wastewater Treatment Practices Employed at Alaskan Gold Placer Mining Operations," Calspan Corporation Report No. 6332-M-2, July 17, 1979.

15. Taggert, A. F., Handbook of Mineral Dressing, John Wiley, New York, 1945.

16. Lapedes, D. N. (ed), McGraw-Hill Encyclopedia of Environmental Science, 1974, p. 342-346.

17. West, J. M., "How to Mine and Prospect for Placer Gold," U. S. Department of the Interior, Bureau of Mines Information Circular No. 8517, 1971.

18. USEPA, "Final Development Document of Effluent Limitations and Standards for the Ore Mining and Dressing Point Source Category," EPA Report 440/1-82/061, November 1982.

19. Harty, D. M. and Terlecky, P. M., "Titanium Sand Dredging Wastewater Treatment Practices," Frontier Technical Associates, Inc., Report No. 1804-1, October 20, 1980.

SECTION IV

INDUSTRY SUBCATEGORIZATION

During development of effluent limitations and new source standards of performance for the ore mining and dressing category in 1982, consideration was given to whether uniform and equitable guidelines could be applied to the industry as a whole, or whether different limitations and standards ought to be established for various subparts of the industry. The ore mining and dressing industry was subdivided into eleven subcategories or subparts based primarily upon ore type. The subcategories were further subdivided into subdivisions: discharges from mines (mine drainage) and discharges from mill or beneficiation processes. Currently, placer gold mining is included in Subpart J, Copper, Lead, Zinc, Gold, Silver, and Molybdenum Ores Subcategory of the final subcategorization scheme promulgated in 1982 for the Ore Mining and Dressing Point Source Category. In this notice, EPA is proposing to designate placer mining as a separate subcategory because the placer deposits and extraction techniques are significantly different than those covered under Subpart J.

In developing this proposed placer mining regulation, EPA considered whether further subcategorization of the placer mining industry was necessary. Like many types of mining, placer operations are conducted as land surface activities with resultant water pollution problems that are affected by variable influences such as size of the operation, climate, topography, mining and wastewater control practices and other factors. Unlike many other segments of the ore mining industry, placer operations are often located directly within the bed of the stream or river to which the solid and wastewater effluents are also discharged.

Similar to those originally identified for the ore mining and dressing industry, the following specific factors were used by the Agency to review the technical aspects of gold placer mines.

1. Size
2. Mining Method
3. Ore Processing Method (including Classification)
4. Treatability of Pollutants (including mineralogy of the ore and overburden)
5. Topography and Geographic Location
6. Treatment/Control Techniques (including Recycle)
7. Climate and Rainfall
8. Water Use or Water Balance
9. Solid Waste Generation
10. Number of Employees
11. Energy Requirements
12. Reagent Use
13. Age of Facility

A comprehensive analysis of the above listed technical considerations reveals there is justification for further subcategorization of the placer mining industry. A detailed discussion of each of these factors is presented below.

Size (Capacity to Process Ore)

An industry profile demonstrates a convenient and rational means to divide the industry on the basis of size (capacity to mine, or through-put, calculated as cubic yards per day of paydirt processed), which is closely related to mining method (to be discussed later). One conceptual division is based on whether a facility is "non-commercial" or"commercial" (i.e. small capacity versus large capacity). The non-commercial (recreational, hobby and assessment types of operations) tend to be very small, while the commercial operations vary in size from fairly small to very large. The non-commercial mines or operators may number over 1000 and be the largest percentage of the industry both in Alaska and in the contiguous 48 states. However, EPA has been unable to obtain any variable data on the number and location of these very small operations as discussed below. For purposes of this proposed regulation, we have define "non-commercial" as mines that process less than 20 cubic yards of ore per day. Because they process a low total volume of ore, they generally discharge a very low volume of process water. These small mines characteristically have little mechanized equipment, and are usually intermittent in operation. They include weekend panners, small suction dredges, small sluices, and rocker box operations. Table IV-1 is a partial profile of small gold mines. The assessment group includes those operations that could develop a commercial or larger type of operation, but for one of several reasons, is doing only a limited amount of work adequate to maintain legal control of their property. This group also covers

Table IV-1. Partial Profile of Small (< 20 cubic yards/day) Placer Gold Mines. 1

Mine Name/Owner	State	Oper. Days per Year	Class. Method	Volume Processed (cu.Yd/Day)	Mining Method	Wastewater Treatment Technology Used	Recyle (%)	Daily Discharge Volume (gpm)
1-EW	MT	Unk.	None	15	Open-Cut	Settling Pond (1)	0	180
2-PJ	MT	Unk.	Unk.	2	Open-Cut	Settling Pond (1)	0	Unk.
3-ES	MT	Unk.	None	2-3	Open-Cut	Settling Pond (1) and seepage	0	250
4-JD	MT	Unk.	Unk.	20	Open-Cut	Settling Pond (1)	approx. 100	approx. 0
5-HM	MT	Unk.	None	2	Suction Dredge	Settling Pond (1)	0	10
6-GH	MT	Unk.	None	10	Open-Cut	Settling Ponds	0	200
7-AH	MT	Unk.	Wash Plant	15-20	Open-Cut	Settling Pond (1)	0	100 (part time)
8-CN	MT	Unk.	None	0.5	Hand Shovel	None	0	80
9-EC	MT	Unk.	None	Unk.	Suction Dredge	None	0	175
10-JD	MT	Unk.	Unk.	20	Open-Cut	Settling Pond (1)	100	0
11-JA	MT	Unk.	Unk.	3	Suction Dredge	Settling Pond (1)	>0	170
12-AC	AK	150	Unk.	2-4	Suction Dredge	None	0	Unk.

1 Frontier TEchnical Associates, Inc. Report of 1984 Field Survey, David Harty.

prospecting, testing, and development work.

This proposal designates all mining operations that process or handle less than 20 cubic yards of pay dirt per day as "small recreational/assessment (non-commercial mines)."

Commercial gold placer mines vary in size from 20 cubic yards per day (generally somewhat more to be truly commercial) to many thousands of cubic yards per day processed by the largest dredges. As mentioned above, many factors influence the ultimate size of a placer mine. Examination of the available data base shows another means to delineate a group of mines by size and mining method which also have other features in common. This type of mine is characterized by its very large size, use of dredging technology, and extensive use of recycle (approaching 100 percent). Table IV-2 is a partial summary of industry facilities processing 4,000 cubic yards or more of pay dirt per day by dredging methods. Based upon the size and mining method characteristics of this group, they have been subcategorized as the "large dredging" segment. The dredging technique is discussed in detail in Section III, "Industry Profile."

A large group of mines remains between the two segments discussed above. These are larger than 20 cubic yards per day and encompass all mining methods except dredges processing in excess of 4,000 cubic yards per day. These facilities generally use similar mining and processing methods, have similar constraints and limitations placed upon their operations, and have similar wastewater problems.

Table IV-3 illustrates the percentage small, non-commercial mines versus larger, commercial mining ventures by location (Alaska vs. Lower 48).

Table IV-2. Dredge Placer Mines Having Production Greater Than 4,000 yd^3/day[1]

Mine	Production (yd^3/day)	Mining Method	Wastewater Treatment	Recycle
4126 (AK)	6,800	Dredge	SP (5)	100%
4127 (AK)	6,800*	Dredge	SP (2) &S	High Rate
4211 (AK)	4,000	Dredge	SP & TF	High Rate
4260 (CA)	12,360	Dredge	SP & S	Approx. 100%

*Production data not available but dredge and operation are quite similar to #4126

SP = Settling ponds; ( ) indicates number of ponds
TF = Tailing filtration
S = Seepage

[1]Frontier Technical Associates, Inc. 1983 Field Survey.

Table IV-3. Gold Placer Industry Profile

Location	Very Small, <20 yd^3/Day Recreational, Non-Commercial	>20 yd^3/Day Commercial	Total
Alaska	400 + [2]	300 +[2]	700 +
Lower 48 States	1,400 + [1]	230-250[3]	1,250 +
Total	1,400 +	550 +	1,950 +

[1]Source - EPA Estimate
[2]Source is a review of Alaskan Tri-State Agency Permits, plus a review of EPA NPDES permit applications
[3]Source - a review of State Agencies in the following states: California, Colorado, Idaho, Montana, Nevada, Oregon, Washington

Figures IV-1 and IV-2 are plots of production versus percentage of mines in each production interval for Alaska (separately on Figure IV-1) and California, Colorado, Idaho, and Montana (shown as a group on Figure IV-2). These data show the same general distribution by size for the two areas. There are several minor differences between these two general areas of location of the industry; harsher climatic conditions, shorter length of operating season, the availability of water, and slightly higher costs to operate prevail in Alaska.

EPA has concluded that the many similarities in the mines of Alaska and the contiguous 48 states are compelling; none of the above-mentioned differences are of such significance as to warrant subcategorizaton on this geographical basis.

EPA believes size is an appropriate criterion for subcategorization because many of the differences between mines are directly related to size. Principal among these are the mining and ore processing methods employed, mass of pollutants discharged in the wastewater, and economic viability of the mine.

Mining Method Employed

There are two general mining methods being employed in the industry today - mechanical and hydraulic. The choice of mining method is determined by the general geology, grade of ore (assay), size, configuration and depth of the deposit, type and thickness of overburden, geographic details of the site, and availability of water. The mechanical approach to mining

Figure IV-1. Distribution of Alaska Placer Gold Mines by Size (Source: Computer Summary of Tri-Agency Forms - 1983).

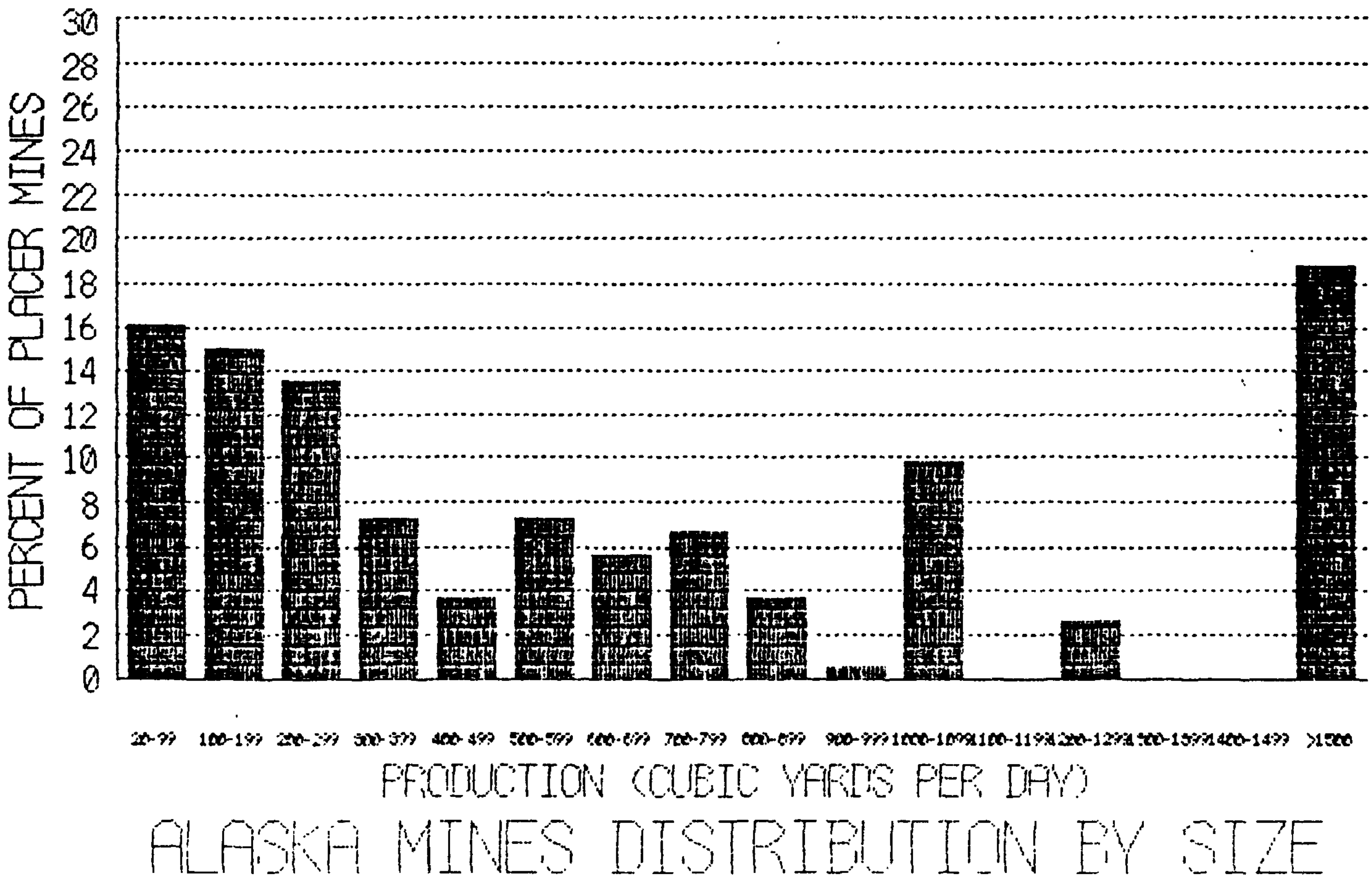
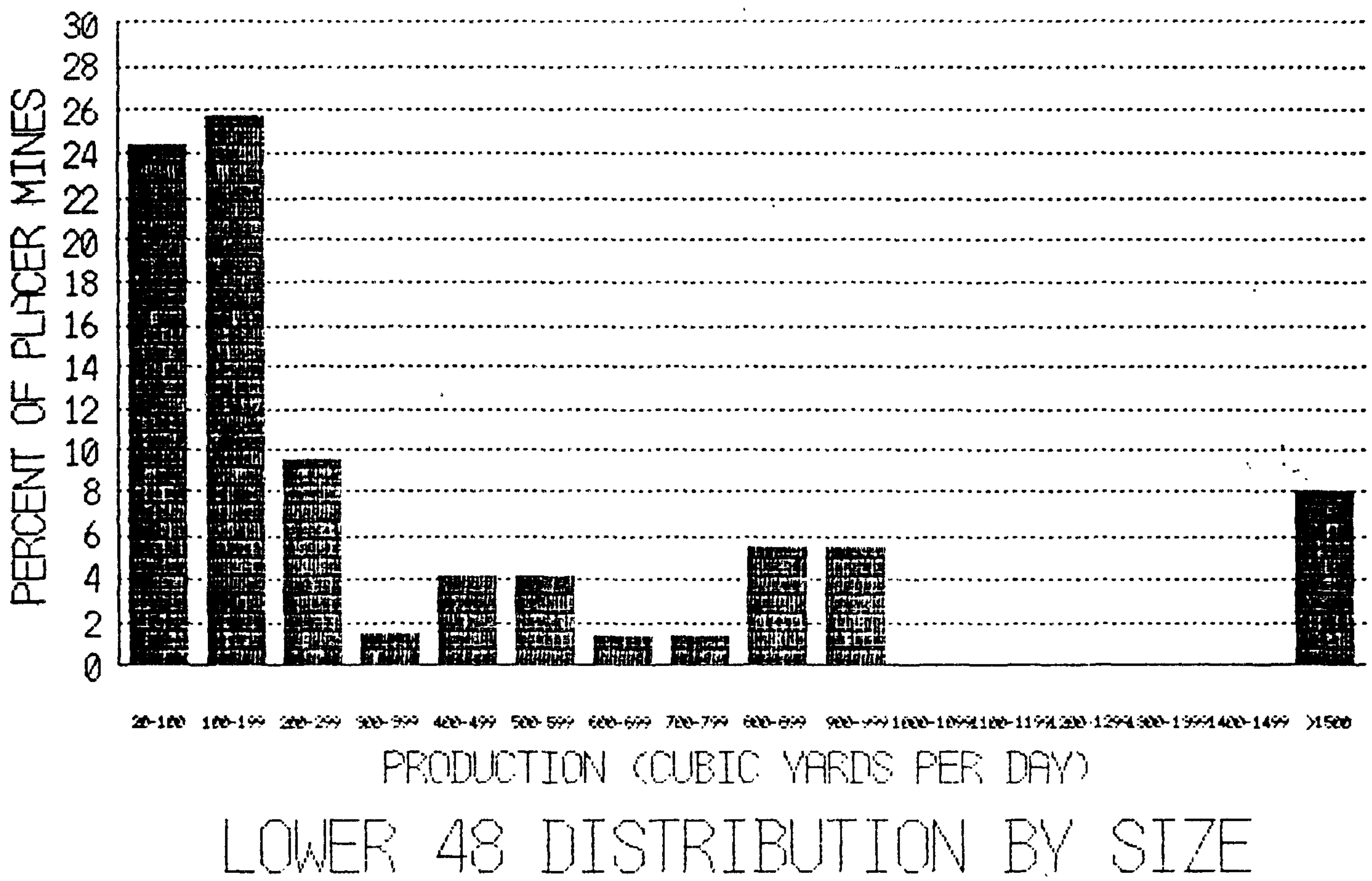


Figure IV-2. Distribution of Placer Mines in the Lower 48 States by Size (source: Permit Files from Montana, Idaho, Colorado, and California).



utilizes little or no water in the method. With the advent and adaptation of the small, high powered diesel engines to tractors, loaders, shovels, draglines, backhoes, and vehicles, the miner is able to move mechanically larger volumes of material (ore and waste) economically, thus significantly expanding this segment of the industry. A 200- to 400-horsepower diesel tractor has the capability to rip, strip, move, stockpile, or feed 3,000 to 6,000 cubic yards daily. The mines employs a surface, open-cut method.

Another mining method in current use that is classified as mechanical mining is the use of mechanical buckets in dredging operations. The ore is cut, mined, and moved mechanically in buckets attached to a continuous chain. The dredge has a self contained method to process the ore (See Section III) and to dispose of the waste material. As presented under the "Size" section above, the very large dredge processing in excess of 4,000 cubic yards per day of paydirt is one of the proposed segments of subcategorization. This subcategorization is based on both size and utilizaion of a unique mining method. (See Section III, "Industry Profile").

The hydraulic system of mining uses varying amounts of water, i.e., small suction dredges often use less than 10 GPM and large hydraulic water canons can use over 10,000 GPM. The small suction dredges are often used in the non-commercial category by hobbyist. A few large suction dredge operations have existed in the past, but due to inefficiencies in operation and depth restrictions these have been (or are being) replaced by mechanical dredges. The hydraulic water canon mining technique, although still in use is being replaced by mechanical means. The hydraulic system, if used to clear or move overburden, utilizes a large volume of water and generates a large volume of pollutants in the wastewater. The hydraulic system can also be used to thaw overburden but is very water use-intensive. The smaller hydraulic canons are being used to load ore into the sluices, for mixing purposes and for the movement of wastes. Regardless of the mining method employed, the processing of pay dirt generally employs similar gravity and physical separation methods to produce a concentrate (See Section III). Thus the very large dredge is segmented as a subcategory on the basis of size and unique mining method with limited or no discharge of wastewater. Since differences in mining method in general (other than the very large dredge) track the proposed scheme of subcategorizaton by size (capacity) it has not been proposed as a separate basis of subcategorization.

Ore Processing Methods (Including Classification)

The gold placer mining industry currently utilizes several gravity and physical separation methods to process ore and recover the free gold. As mentioned previously, the scope of this rulemaking proposal is limited to this particular type of ore processing. Currently, the industry in all areas of the country utilizes straight sluicing, sluices with punch plates and undercurrents, sluices with varying degrees of classification, jigs, spirals, cyclones, and tables (See Section III) to produce gold. Although physical classification of the ore by particle size is considered a part of ore processing, it was also examined as a potential discrete basis for subcategorization. The various methods of classification all reach the same result - reduced volume of ore to process by separating a portion(s) by particle size into a direct waste component (gangue or tailings) which reduces the total amount of water needed to process the ore and therefore, reduces the wastewater to the treatment system or receiving stream. (See "Placer Mining Wastewater Treatment Technology Project, Phase 3 Final Report - Draft, January 1985 by Shannon & Williams, Inc.)." The total tonnage of particulate matter in the wastewater effluent is reduced by the amount classified out of the ore (See Section III for types of classification). Based on the wide variations in type and degree of classification utilized, plus the fact there is no fundamental difference in the type of pollutants produced with or without classification, the Agency is not proposing classification as a means of subcategorization.

Treatability (mineralogy of the ore and overburden)

The gold placer mining industry generates wastewater that is relatively consistent in the types of pollutant ("muddy water" subject to variation in composition from different sources), while the quantity of pollutants found in the wastewater varies considerably. The amount of pollutants depends on several factors in addition to the size of operation. The mineralogy of the waste rock and soil involved, amount of classification used, and the degree of recycle or treatment employed bear directly upon the quantity of pollutants produced and discharged to the environment.

The mineralogy of an ore deposit often determines the recovery (beneficiation) process to be used (See Section III). Consideration must be given to both the valuable portion (free gold in this case) and the waste (gangue) portion of the "pay dirt." Placer deposits are either alluvial or glacial in origin (See Section III). The alluvial deposits generally concentrate the heavier portions of the "pay dirt," while glacial action tends to scatter all segments of the deposit on a random basis. Both types produce a wide range of particle shapes and sizes, and particle composition varies by the original source of the material. The miner has no control over particle size and distribution or composition (colloidal matter) in the deposit, but all of these factors directly affect the treatability of the effluent. Settling rates for the particles vary by size, shape, and composition (specific gravity). In addition, if the particle is colloidal (in addition to small in size) the electromagnetic forces involved tend to keep these particles in suspension for a longer period of time. However, treatment options considered (see Section VIII) may overcome this difficulty by application of settling aids which cause the fine particles to coagulate and thus settle out sooner. The wide range of particle size, distribution, and composition possible in these ores make it impossible to use treatability or mineralogy as a basis for subcategorization. This is an area where additional work could be done.

Topography and Geographic Location

As discussed in Section III, "Industry Profile," and in other areas of this section, there are more than 700 placer operations in Alaska and as many as 1,300 mines in the 48 contiguous states (non-commercial and commercial) with the vast majority located in seven western states (California, Colorado, Idaho, Montana, Nevada, Oregon, and Washington). The majority of site-specific information the Agency has is representative of mines in Alaska.

Topography differs between mining areas and from site to site within areas (i.e., seashore marine gravels to broad, gently sloping valleys to rugged, narrow, steeply sloping valleys). These differences can affect the operation, particularly as regards waste disposal and settling pond location and size. Rainfall accumulation and runoff from steep slopes can cause problems as well. Narrow valleys with steep slopes place constraints upon the location of ponds in terms of area available (or whether it can even be built), construction costs, and the costs associated with pumping against a greater head for recycle. Topography has an impact on construction and cost of operation. However, based on the current data available to the Agency, topography does not significantly affect wastewater characteristics or treatability, and thus is not proposed as a basis for subcategorization at this time.

Regardless of the geographic location, the industry members have similar problems regarding wastes (both liquid and solids). Logistics, operation, and communications problems are enhanced in the more remote areas but these do not affect the quantity or quality of the effluent wastewater from a given operation. There is a wide range of site specific conditions present throughout the industry, but as also discussed under size or capacity to process ore, the similarities in mines regardless of geographic location is significant. Therefore, geographic location is not proposed as a basis for subcategorization.

Treatment and Control Technologies

Currently the gold placer mining industry practices one type of end of pipe wastewater treatment and control technology: settling pond(s) (either single or multiple in series) and either with or without recycle. There are a number of variations in site specific layouts. Pond efficiencies can be enhanced if a bypass diversion channel is incorporated in all sites as a standard design item.

This diversion would serve several purposes:

1) Separate normal stream flow from the treatment system, thus reducing the load on the pond(s) and increasing settling capacity and efficiency.

2) Provide relatively good quality water for dilution purposes with plant effluent at end-of-pipe discharge prior to final effluent sampling point.

3) Provide an inplace storm flow runoff facility to minimize chances of filling the ponds with extraneous material or breaching the pond berms and thus allowing excessive wastewater discharge to the stream system.

The effectiveness of settling due to varying operating and maintenance practices covers the full range from nil to quite good. Classification of the ore prior to sluicing allows for a reduction in the amount of water required to process that same amount of raw ore as discussed above.

Recycle of the process water stream is the most effective method of operation to reduce the pollutants going to the stream system. High rate recycle is currently employed in the industry, particularly by dredges and sites that are water short. A number of mine sites have adequate process water (without recycle) in the early part of the season, but as the summer progresses the surface water deminishes and recycle is employed on an as required basis. The Agency has been told that recycle with subsequent increases in total suspended solids in the wash water reduces the recovery of fine gold. Recent tests have shown that recycle, within the limits of pilot demonstration, does not adversely affect fine gold recovery. (See Section VIII). More work is needed in this area and the Agency invites comments on this subject. While there are some exceptions in degree, all of the treatment technologies discussed are generally applicable regardless of type, size, location and all other factors.

Accordingly, since the applicable technologies for all types and configurations of placer mines are similar, it is unnecessary to subcategorize on this basis.

Climate and Rainfall

There is a wide diversity of climatic and rainfall conditions in the locations where placer mines are operated. Unlike a number of other industries, placer mine operators cannot choose a location with more favorable climate or rainfall conditions, but must accommodate whatever is present at the discovery site. Some mines are located in regions close to the coast and as a result have milder climate and more abundant rainfall, which in turn allows for a longer mining season with fewer problems as relates to availability of process water. Other mines are located in interior areas including mountainous terrain with resultant colder, harsher climates and possibly reduced rainfall for part of the operating season. These areas have shorter mining seasons, and may have to contend with permafrost and a shortage of water. Some of these areas are fed by glacial meltwater, which compensates for the lack of adequate rainfall.

Although climate and rainfall have a direct bearing on the length of mining season, to some degree on the types of mining and recovery processes used, occurrence of permafrost, and availability of process water (possibly necessitating recycle) they do not control the size of mining operation, the quality or quantity of wastewater (except as it affects the degree of recycle employed), or the treatment technology used. Therefore, these factors are not proposed as a basis for subcategorization.

Water Use or Water Balance

Water use or water balance is directly controlled by the mining method, the recovery process employed and is site specific. The type of deposit, type and amount of overburden, water availability, climate and rainfall or geographic location affect the water use or water balance. Due to the extreme variability of all the factors involved plus the fact that waste characteristics are essentially constant (subject to degree of recycle for mechanical operations and dredge operation methodology), the Agency is not proposing subcategorization of this segment by water use or water balance.

Solid Waste Generation

Physical and chemical characteristics of solid waste generated by treatment of gold placer mining wastewater are determined by the paydirt and overburden characteristics. These are beyond the control of the operator and are site specific. The miner recovers a fraction of a percent of the material mined (less than a fraction of an ounce per ton mined). The majority of the solids removed in the beneficiation process simply fall out in front of the sluice before wastewater treatment. The characteristics of the solid waste generated by wastewater treatment are unrelated to differences in currently employed mining and process technology with the exception of total recycle in both mechanical and dredge operations (i.e., zero discharge). Current wastewater process technology is virtually identical in this segment (settling ponds) for all types of mining operations. Therefore, this factor is not a basis for subcategorization.

Number of Employees

The amount and quality of process wastewater generated is directly related to the size (through-put capacity), the mining and recovery processes employed, the amount of water available, the degree of recycle employed, the effectiveness wastewater treatment employed, plus the site-specific factors related to each individual mine (i.e., treatability, mineralogy, location, topography, geology, overburden and paydirt characteristics, etc.). A larger mine requires more people for its operation, so there is a correlation between number of employees and the size factor considered above.

Energy Requirements

Energy requirements in this segment vary widely. The main use of energy in wastewater control and treatment is for pumping recycle water when recycle is required. However, this energy requirement would be only a slight increase over the energy presently required to supply process water at mines pumping wash water to the beneficiation process. Energy for pond construction and maintenance is only a small fraction of the energy required for mining and processing. It is very difficult to reliably identify energy requirements specifically related to wastewater treatment. Therefore energy requirements is not selected as a basis for subcategorization.

Reagent Use

Current operations for which the Agency has information do not use reagents to recover free gold in the gold placer industry. Mercury coated copper recovery plates located in the flow stream at the end of the sluices have been employed in the past but seem to have lost their appeal in the current operating schemes. None were observed during the last several years of site visits by the Agency. In addition, this subcategory (gold placer mines) is limited in scope to include only physical and gravity separation (recovery) methods. Thus the use of reagents would be covered under the existing regulation for the ore mining and dressing point source category at 40 CFR Part 440, Subpart J.

Facility Age

Many placer mines have been operated in the same general location in excess of 50 years (usually under different management). A number of these deposits have been reworked several times to recover gold which was missed by previous operators for one of several reasons (i.e., inefficiencies in the operation, oversight by the operator, or extension of the deposit in depth or area). Mining equipment and processing equipment (sluices) are repaired or replaced as needed. The same operating techniques and wastewater treatment systems applicable to this industry may be employed at old or new mines or at new locations within an existing operation as required without consideration of the age of the facility. Therefore age of the operation is not a useful basis of subcategorization.

Subcategorization Based on the Technical Aspects of Gold Placer Mines

Table IV-4 is a summary of the subcategorization for the gold placer mining industry based upon technical consideration. This scheme employs the size and mining method as the basis for subcategorization. It is recommended that no limitations be proposed for small operations (recreational/assessment) processing less than 20 cubic yards per day as discussed in this section. Dredging offshore, coastal zone (beach placers) or within river operations are not included in the proposed regulation due to lack of data.

Table IV-4. Subcategorization for Gold Placer Mines Based on Technical Consideration

	Process Rate (yd^3/Day)
Small Mines (All Methods)	<20
Intermediate Mines (All Mining Methods)	>20
Very Large Dredges	>4,000

Economic Considerations

EPA's economic assessment of the proposed regulation is presented in the "Economic Analysis of Proposed Effluent Limitations and Standards for the Gold Placer Mining Industry." This report estimates the required investment and annual costs for existing sources in the industry as a whole and for typical new sources covered by the proposed regulation. Compliance costs are based on engineering estimates of capital requirements and construction expenses as set forth in Section IX of this document. These estimates include the full cost for settling ponds and/or recycle equipment at mine sites, since accurate, mine-specific information on treatment-in-place is unavailable. The economic analyses also estimates the impacts of the costs of the regulation, price changes, production changes, profitability changes, mine shut-downs, employment changes, local community impacts, balance of trade effects, and industry structure changes.

The analysis indicates that mines processing less than 50 yd^3/hr, 10 hours per day, i.e., 500 yd^3/day are generally not viable operations and are projected to be unprofitable in the baseline.

Although no exact determination can be made, EPA's analysis indicates a miner's potential for earning a profit increases as the size of the operation approaches and exceeds 500 yds^3 processed per day. The Agency has therefore chosen this level of production as a boundary or cut-off. Just as most mines below this size level are projected to be unprofitable, most mines above this size level are projected to be financially healthy. The Agency has subcategorized to reflect the differential impacts for mines of a size that processes less than 500 yd^3/day of paydirt as summarized in Table IV-5.

Table IV-5. Proposed Subcategorization for Gold Placer Mines

	Process Rate (yd^3/day)
Small Mines (All Methods)	<20
All Mines (All Methods)	>20 and <500
All Mines (All Methods except large dredges)	>500
Large Dredges	>4000

SECTION V

SAMPLING AND ANALYSIS METHODS

GENERAL

The sampling and analysis program discussed in this section was undertaken primarily to develop a data base for proposal of effluent limitations and standards for placer mining, to support EPA Region X in acquiring data to develop NPDES permit conditions and to identify pollutants of concern in the industry, with emphasis on suspended and settleable solids, turbidity, and toxic metals (particularly arsenic and mercury). A data base has been developed over several years based on sampling and analysis programs from which the data have been drawn. A listing of these programs is presented below:

1. Treatability Studies--1984; Kohlmann Ruggiero Engineers (KRE)
2. Reconnaissance Study--1984; KRE
3. Reconnaissance Study--1984; EPA Region X
4. Reconnaissance Study--1984; Frontier Technical Associates (FTA) (Lower 48)
5. Wastewater Treatment Technology Project; Shannon and Wilson
6. Treatability Studies-- 1983; FTA and KRE
7. Reconnaissance Study--1983; FTA and KRE
8. Reconnaissance Study--1983; EPA Region X
9. Reconnaissance Study--1982; EPA Region X

10. Environment Canada--1983 Yukon Study

11. Canadian Department of Indian and Northern Affairs--1981 Yukon Study

12. R&M Consultants--1982 Treatability Study, Site Visits and Pond Design Manual (for ADEC)

13. Calspan Corporation--1979 Reconnaissance Study

14. Alaska Department of Environmental Conservation--1977, 1978, and 1979 Reports

15. EPA-National Enforcement Investigations Center--1977 Reconnaissance Study

16. Dames & Moore--1976 Reconnaissance Study (for Calspan)

This section identifies the sites sampled and parameters analyzed for the EPA and contractor studies for 1984, 1983 and 1982 (1-9 above) and summarizes the results. It also describes sample collection, preservation, and transportation techniques. Finally it describes the pollutant parameters quantified, the methods of analyses, and the general approach used to ensure reliability of the analytical data produced. The raw data obtained during these programs are included in the record supporting the proposed rule and are also discussed in Section VI, Wastewater Characterization.

Detailed analytical data on conventional, nonconventional, and toxic pollutant concentrations in raw and treated process wastewater streams were collected in a comprehensive sampling program. Data developed for the 1982 ore mining regulations indicated that organic priority pollutants would not be expected to be significant in placer mining wastewaters because the paydirt (ore) consists of natural earth materials and reagents are not generally used.

Therefore, the sampling efforts by the various groups listed above were modified to emphasize certain pollutants.

The discussions that follow generally pertain to the most recent sampling efforts undertaken by the EPA (1984, 1983, and 1982) and its contractors, FTA (1983) and KRE (1984 and 1983), particularly with respect to site selection and reconnaissance.

SITE SELECTION FOR RECONNAISSANCE STUDY

Faced with the responsibility for developing effluent limitations for placer mining, EPA discovered that economic and financial information about the Alaskan segment of the industry was virtually non-existent. The largest body of such information was the partial and anecdotal representations developed in the course of public hearings. This lack of information demonstrated the need to obtain data on mining economics for use in formulating effluent limitations guidelines and standards.

The Agency, with the cooperation of the miners, conducted an information-gathering effort during the 1983 and 1984 mining seasons. EPA had previously committed itself to an examination of effluent and receiving water quality characteristics; this two-year study was expanded to incorporate an economic and financial component.

Site visits were conducted by EPA Region X personnel to seven mines during the 1984 mining season. In addition, KRE conducted engineering site visits at ten mines (including several that were covered by Region X) and visited an additional ten mines to obtain economic and operational data during 1984. Frontier Technical Associates (FTA) visited six placer gold mines in the lower 48 states, five in Montana and one in California, to obtain operational, economic and water quality information relative to the operation of mines outside of Alaska.

Although EPA has historical data from gold placer mines from as early as 1976 and many subsequent years, the Agency primarily relied upon the studies performed in 1984 since these technical data on treatment performance are relatively current and more fully documented than early studies. The majority of the available cost and economic data were also obtained in 1984. The Alaska mine sites in the 1984 studies used both for engineering site visits and sampling, were selected from available data from previous studies and through discussions with EPA Region X, Alaska Department of Environmental Conservation (ADEC), miners' trade associations, the Placer Miners Advisory Committee (PMAC), and individual miners. These mines were selected to be as representative as possible of placer mines considering such factors as: location, type of mining, size, amount and type of overburden, topography, and treatment employed. The majority of the data are for Alaska because the majority of placer mines in the U.S. are located in Alaska. However, data on facilities in the "lower 48" were also collected generally from state contacts and some site visits. These data were also used in the analyses. All site visits included the collection of data on existing treatment, and the Alaska work provided data on pilot-scale treatment technology, high rate recycle, costs of operations and treatment, and the economic viability of mines.

Actual engineering site visits (reconnaissance visits) were conducted by EPA Region X personnel (49 sites), Frontier Technical Associates (five sites), and Kohlmann, Ruggiero Engineers (six sites) during the 1983 mining season. During 1982, EPA Region X also conducted reconnaissance sampling visits at 51 sites. At each site sampled by FTA and KRE, two separate sampling episodes were conducted (one mine had only one episode, because it shut down soon after arrival of sampling personnel). Although most of the sites visited by EPA had only one sampling episode, a few were visited more than once.

Treatability studies consisting of on site settling tests were conducted at a total of 19 different mines during the 1983 and 1984 mining seasons by Frontier Technical Associates and Kohlman, Ruggiero Engineers. These settling tests included jar tests and settling tube experiments employing unaided as well as flocculant-aided settling.

For the 1983 sampling effort conducted by Region X (Reconnaissance Study), a size-structured random sample was drawn from 409 Tri-Agency Annual Placer Mining Applications on file at EPA Region X. A primary sampling group of 34 mines was supplemented by a similarly structured secondary group of 31 mines to provide an adequate sample in the event of nonresponse, failure to locate, intermittent or ceased operations, or other obtacles to information-gathering and sampling.

The 34-mine sample proved impossible to achieve. Distance, accessibility, intermittent nature of the industry, equipment breakdowns, and locational uncertainties combined to reduce the sample size. Both time and budget constraints made it necessary to treat the primary and secondary sample components as a single sample of 65 mines, and to attempt to contact each potential respondent at least once rather than to make repeated visits to the primary sample group in order to verify the operational status of each. The characteristics of the sampling effort are presented in Table V-1 prepared by EPA Region X, while a list of facilities visited (by mine code) for EPA, FTA, and KRE is presented in Table V-2.

Effluent samples were obtained at each mine visited in 1983 and 1984 that was visited during the time the mine was sluicing. The parameters that were analyzed by EPA, FTA and KRE during the reconnaissance program are shown in Table V-3.

Samples at each mine were obtained from the following locations:

1. Intake water
2. Influent to treatment
3. Effluent from treatment
4. 500 feet downstream of discharge into receiving stream

Sample numbers, locations, dates, times, etc. were noted and a sketch of the site and sample locations was prepared. Field measurements of pH, temperature, turbidity, and settleable solids were recorded.

Table V-1. Composition of Sampled Mining Operations (Respondents to EPA Region X Economic Survey; Source: EPA Region X).

Category*	Number of Respondents
Small:	
No Recyle	9
Partial Recycle	5
Full Recycle	7
Medium:	
No Recycle	6
Partial Recycle	6
Full Recycle	7
Large:	
No Recycle	1
Partial Recycle	1
Full Recycle	1

Total Sample:	65
Positive Response:	43
Non-Response:	1
Status Undetermined:	21

*Sluicing capacity:

Small: 100-750 cu.yd./day
Medium: 750-3500 cu.yd./day
Large: >3500 cu.yd./day

Table V-2. List of Facilities Visited in the Reconnaissance Sampling Effort.

MINE CODE	EPA83	EPA82	FTA83	KRE83	FTA84	KRE84	EPA84
4107		X					
4109	X	X		X			
4110	X			X			
4126	X						
4127	X						
4132	X						
4133	X						
4134	X		X				
4138			X				
4167		X					
4168		X					
4169	X	X				X	
4170	X	X					
4171	X	X					
4172		X		X			
4173	X	X		X		X	
4174	X	X					
4175	X	X					
4176	X	X					
4177		X					
4178	X						
4179		X					
4180	X	X				X	
4181		X					
4182		X					
4184		X					
4185	X	X		X			
4186		X					
4187		X					
4188		X					
4189	X	X		X			
4190	X	X					
4191		X					
4192		X					
4193	X	X					
4194		X					
4195		X					
4196		X					
4197	X	X					
4198		X					
4199		X					

Table V-2. (Cont.)

MINE CODE	EPA83	EPA82	FTA83	KRE83	FTA84	KRE84	EPA84
4200		X					
4201		X					
4202		X					
4203		X					
4204		X					
4205		X					
4206		X					
4207		X					
4208		X					
4209		X					
4210		X					
4211	X	X					
4212		X					
4213	X						
4216	X		X				
4217	X	X	X				
4219	X						
4222	X						
4223	X	X					
4224	X						
4225	X						
4226	X						
4227	X						
4229	X						
4230	X						
4231	X						
4232	X						
4233	X						
4234	X						
4235	X						
4236	X						
4237	X	X					
4239	X						
4240	X						
4241	X						
4242	X						
4243	X	X					
4244	X	X					
4245	X					X	
4247	X		X			X	
4248						X	
4249						X	X
4250						X	X

Table V-2. (Cont.)

MINE CODE	EPA83	EPA82	FTA83	KRE83	FTA84	KRE84	EPA84
4251						X	
4252						X	
4253							X
4254							X
4255							X
4260					X		
4262					X		

Table V-3. List of sample parameters by Study Group.

Parameter	EPA (1983)	FTA (1983)	KRE (1983)	KRE (1984)	EPA (1
pH	x	x	x	x	-
TSS	x	x	x	x	-
Set. Solids	x	x	x	x	x
Turbidity	x	x	x	x	-
Total As	x	x	x	x	-
Diss. As	x	x	x	-	-
Tot. Rec. As	x	x	x	-	-
Tot. Hg	**	x	x	x	-
Diss. Hg	**	x	-	-	-
Spec. Gravity	x	-	-	-	-
Temperature	x	x	x	x	-

** Only a few sites sampled by EPA were analyzed for mercury.

At each site visited by Region X, KRE, and FTA, technical operating data as well as financial data were collected during an interview using a fact sheet. Each miner was requested to discuss the operational economics and financing of his mine. The interviews followed an outline prepared by EPA Region X (1983) and EPA/ITD (1984). The miners were informed of the purpose and voluntary nature of the interview, and were assured code numbers independent of other means of identification would be up for the sample group and are used in this report.

Employment of a pre-selected random sample as an information gathering procedure was used by Region X in the 1983 study based largely upon the needs of the economic component of the study. The Agency had sampled effluent and receiving waters during the 1982 mining season, employing the simple selection strategy of taking samples at any mine whose sluice was in operation at the time it was visited. It was reasoned that information developed only from mines with operational sluices might bias the economic study toward the more efficient and better situated operations.

Stratification of the sample was based on the requirements of the water sampling portion of the study. This was intended to obtain information from mines of various sizes and with a broad range of sluice water treatment or controls (e.g., sedimen-tation, recycle). The final composition of the sample was a compromise that reflected the competing requirements of economic and effluent control data-gathering. The table below presents a summary comparison of the size distribution of permitted mines in Alaska and the mines sampled:

Size*	Permitted Mines	Sampled Mines**
100-750 cu.yd./day	78%	49%
750-3500 cu.yd./day	20%	44%
>3500 cu.yd./day	3%	7%
Mean Capacity (yd3/day)	756	1170
Mean Employment (persons)	4.3	6.0

* Sluicing capacity

** Applies to EPA 1983 Region X sampling only (FTA and KRE sampled two mines not sampled by EPA)

SAMPLE COLLECTION, PRESERVATION, AND TRANSPORTATION

Collection, preservation, and transportation of samples were accomplished in accordance with procedures outlined in Appendix III of "Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants" (published by the EPA Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, March 1977, revised April 1977) and in "Sampling Screening Procedure for the Measurement of Priority Pollutants" (published by the EPA Effluent Guidelines Division, Washington, D.C., October 1976). Analysis of conventional and nonconventional pollutants were performed according to the following EPA methods:

Parameter	EPA Method
pH	150.1
TSS	160.2
Sett. Solids	160.5
Temperature	170.1
Turbidity	180.1

All methods listed above are from "Methods for Chemical Analysis of Water and Wastes," EPA Report No. EPA/4-79-020, March 1979, USEPA Enviromental Monitoring and Support Laboratory, Cincinnati, OH.

All samples obtained were grab samples. In general, the following types of samples were collected at each site:

1. Total suspended solids--sample filtered in the field using preweighed glass fiber filters; filter weighed subsequently in the laboratory;

2. Total metals--sample collected for determination of total arsenic and mercury; preserved in the field with 1:1 HNO3

to a pH less than 2;

3. Total recoverable metals--samples collected for determination of total recoverable arsenic; preserved in the field with five ml/l concentrated nitric acid;

4. Dissolved metals--sample filtered through a 0.45 micron filter; preserved with 1:1 HNO_3 to a pH less than 2;

5. Settleable solids--determined immediately in the field using an Imhoff cone;

6. Turbidity--sample analyzed in the field using a field nephelometer (dilutions often necessary);

7. pH and Temperature--analyzed in the field using a calibrated pH meter and a thermometer.

All sample containers were labeled to indicate sample number, sample site, sampling point, individual collecting the sample, type of sample (influent, effluent, etc.), sampling dates and times, preservative used (if any), etc.

All samples being sent for outside analysis were packed in waterproof plastic foam-insulated chests which were used as shipping containers. Sample shipments were made by air freight to the laboratories as soon as possible.

Associated Data Collection

Drawings and other data relating to mine operations were obtained during site sampling visits. These additional data included information on production, sluice capacity, operating days, number of employees, mining methods, ore grade, water use and source, wastewater treatment and control, etc. Sketches of each site were prepared showing sample locations, site layout, etc. A trip report was prepared for each site giving the results of the data collection effort as well as sampling results.

SECTION VI

WASTEWATER CHARACTERIZATION

The sampling programs described in Section V provided the data EPA used to determine the presence and concentration of pollutants in placer mining wastewater. These data, "wastewater characterization," are available in the public record along with details of their collection, screening and evaluation. In developing effluent limitations and standards, EPA relied primarily on the 1984 reconnaissance and the 1984 treatability data. EPA found that earlier data collection efforts did not always document the operating conditions of the treatment system at the mine sites. However, the 1984 data (Group I) does take into account the maintenance, construction and operation of treatment systems that are typical of mines found in Alaska.

For the purpose of the wastewater characterization, the reconnaissance data have been classified into three groups:

<u>Group</u>

I. 1984 data collected by Kohlmann Ruggiero Engineers (KRE).

II. 1984 data collected by KRE plus the 1984 data collected in long-term sampling by Region X.

III. 1983 data collected by Frontier Technical Associates (FTA) and KRE together with the 1984 data from Group II above.

Data that passed the Agency's engineering evaluation of the treatment ponds, as discussed below, are included in the three groups. The data in Group I are contained in Group II, and the data in Group II are contained in the data in Group III. All three groups were analyzed. It was not possible, however, to subject the Group II and Group III data to a rigorous engineering evaluation because some essential information concerning the settling pond systems was not well documented during the site visits conducted in 1983. Missing information includes pond area, pond depth, pond short-circuiting, "scouring" from the ponds, quiescent settling or turbulent flow conditions. The evaluation of the data in Group I includes the information obtained at the time the mines were selected and at the time the existing treatment was sampled. Existing treatment was evaluated by sampling influent, and raw and treated effluent; observing flow patterns in the ponds to identify short-circuiting; determining retention times in the ponds; and determining flows to and from the mines.

The wastewater samples were analyzed for settleable solids, total suspended solids, turbidity, and in some cases, total arsenic, and total mercury. Appendix VI-2 contains a complete listing of the data that was used by the Agency in each of the three groups.

The Agency developed long term averages for settleable solids (SS), total suspended solids (TSS), and turbidity (NTU) based on each of the three groups of data described. In developing these levels, EPA assumed that the data followed a delta-lognormal distribution as explained in Appendix VI-1. (See Aitchison and Brown, The Lognormal Distribution.) The use of the delta-lognormal distribution is based on past experience with data on pollutant levels. When there are no values below the detection limit, the delta-lognormal distribution is the usual lognormal distribution. The Agency used Group I data to develop effluent limitations for daily and long term levels. For comparison, EPA calculated limitations based on the data from each of the three groups. The daily levels apply to a single grab sample taken in the effluent from a mine because the delta-lognormal distribution was applied to data on the individual grab samples.

The results of the calculations are given in Table VI-1 for the 3 data groups. In developing confidence levels of treatment effectiveness, EPA used the delta-lognormal distribution as explained in Appendix VI-1.

In using the delta-lognormal, the Agency used estimates of the proportion below the detection limit, and the log-variance, ^{2}, that was pooled over mines. Individual estimates by mine were used for the log-means, The statistical expressions used to compute the daily and monthly levels are listed in Appendix VI-1. A summary of daily and monthly levels is in Table VI-1.

<u>Treatablility Analysis</u>

The 1984 field work of installed treatment performance also included some pilot scale treatability studies (discussed in Section VIII) which compared unaided settling with settling assisted by various poly-electrolytes (flocculants). For wastewater samples from operating mines, these studies seem to show the potential improvement in treatment that could be achieved by using poly-electrolytes to assist simple, unaided settling at full scale. For each site, samples of raw discharge were prepared as described in the "1984 Alaskan Placer Mining Study and Testing Report," Kohlmann Ruggiero Engineers, January 31, 1985. This report also contains all the detailed results of the settling tests for each of the polyelectrolytes tested.

TABLE VI-1

Daily and Long Term Levels for Settleable Solids (SS), Total Suspended Solis (TSS), Turbidity (NTU)

	Data Used	Settleable Solids ml/l		TSS mg/l		Turbidity NTU	
Group		Daily	Monthly	Daily	Monthly	Daily	Monthl
I	K 1984	1.1	0.2	11,600	2,400	7,900	2,600
II	K & R-10 1984	0.9	0.2	6,800	1,800	4,400	1,800
III	K, F, R-10 83/84	3.2	0.5	6,300	1,700	3,400	1,400

Index

Data

K - Kohlmann Engineering Data - 1984
R-10 - Region 10 Data - 1984
F - Frontier Data - 1983

Method based on the delta-lognormal distribution (see Appendix VI-1).

NOTE: Settleable solids detection limits used = 0.1 ML/L.

Because of the ability to control sampling and settling conditions, pilot test data are used here to:

1. Establish the correlations of total suspended solids with

arsenic and mercury.

2. Verify long-term averages for settleable solids and total suspended solids with unaided settling and verify preliminary engineering judgement that flocculant-assisted settling was possible; define general operating parameters, and proper dose rates.

<u>Correlations of Total Suspended Solids (TSS) with Arsenic (As) and Mercury (Hg)</u>

The correlations of total suspended solids with arsenic and mercury as shown in Appendix VI-3B and Appendix VI-3C, support the general expectation that arsenic and mercury are components of the total suspended solids. Consequently, treatment or control of total suspended solids in the effluent will provide a corresponding control of these correlated pollutants. The correlations of TSS with arsenic and mercury are important because there were too few determinations of effluent arsenic and mercury to reliably establish the effectiveness of treatment for these pollutants. The treatability data used for the correlations are given in Appendix VI-3 along with a graphical display of the data. The Spearman rank correlations are 0.83 for TSS with As and 0.61 for TSS with Hg. These correlations are statistically significant ($P \leq 0.05$). The Spearman rank correlation was used because this correlation is not affected by transformations that do not change the order of the pollutant measures. For example, log-transformed values would have the same Spearman rank correlations.

Long-Term Averages for Treatability Data

The two-hour settling test data summarized in Appendix VI-4 was used to compare simple settling with the flocculant assisted settling. The long-term averages for these tests are shown in Table VI-2. These comparisons are based on the two-hour data from all mines in the settling study. These pilot study results show the flocculant-assisted settling provides a substantial reduction in SS and TSS over simple settling.

These data were also used as a basis for comparison with test results at actual mines of the long-term averages for TSS and SS with pilot test settling at 2, 3 and 6 hours. Pilot test results and actual performance of ponds were both defined from effluent samples taken from mines used in the evaluation of existing treatment. To evaluate the suitability of existing treatment, a preliminary visit was conducted at a group of mines. Sites were then chosen for long term sampling of existing treatment and pilot testing. Subsequently, it should be noted that upon arrival for sampling and testing, several of the selected mines were found to have undergone substantial degradation in treatment during the interim or to be otherwise inappropriate choices to represent a minimum standard of treatment. These facilities were omitted from the analysis of existing treatment and, for consistency, from the analysis of treatability data. In particular, one mine had completely filled its settling pond with solids, one mine was suffering from scouring of solids from the ponds, one mine was recycling 100 percent of its wastewater, and one mine was encountering overburden with a very high percentage of colloidal material.

A summary of long-term averages from the treatability tests is given in Table VI-3. Table VI-3 shows that between 3 and 6 hours settling time can achieve concentrations of settleable solids below 0.2 ml/l.

TABLE VI-2

Table of the Long-Term Average for Settleable Solids (SS) and Total Suspended Solids (TSS) with Two-Hours of Plain Settling and Two-Hours of Flocculant Assisted Settling

Data Used* KRE-1984	Settleable Solids SS ml/l	Total Suspended Solids TSS mg/l
Without flocculant	1.1	7,090
With flocculant	**	26

*See Appendix VI-4

**Eight values all at or below the SS detection limit of 0.1 ml/l.

TABLE VI-3

Table of Long-Term Averages for
Settleable Solids (SS) and Total Suspended Solids (TSS)
With Plain Settling at Two Hours, Three Hours, and Six Hours

Data Used* KRE-1984	Settleable Solids SS ml/l	Total Suspended Solids TSS mg/l
Plain Settling		
2 hours	0.8	5040
3 hours	0.2	4300
6 hours	**	3450

*Kohlmann Engineering Test Data with Mines 4169, 4247, 4248, and 4251 deleted.

**Five observations at or below the SS detection limit of 0.1 ml/l.

Virtually all commercial gold placer mines operating in 1984 and 1985 had settling ponds of varying numbers, sizes, and efficiencies. However, most of the ponds observed by EPA and the EPA contractors, and the data that has been obtained on existing ponds indicates that the ponds lack in design, construction, or maintenance to consistantly produce an acceptable effluent quality or concentration of solids (settleable solids and TSS). TSS effluent limitations for eleven other subcategories of the ore industry were promulgated and the limitations sustained in the courts with a daily maximum of 30 mg/l based on treatment facilities being constructed and maintained to provide 24 hours retention. A retention time of 24 hours at most placer mines is not practicable as discussed in Section X. In Section VIII and IX of this document, treatment facilities to control solids with simple setttling technology are designed and costed to provide 6 hours of settling in well designed, constructed, and operated settling ponds which reduce the flow velocity to a minimum and have sufficient volume for sludge to preclude remixing or cutting of solids from the sludge back into the effluent. Though the long term levels for solids based on 1984 data from existing treatment at placer mines is 0.2 ml/l settleable solids, the calculated daily maximum is over 0.2 ml/l. However, the data used to calculate these levels include some data points or grab samples, which are believed to represent poor sampling techniques, upsets of the treatment, an overload or slug to the treatment, short circuiting, or poor maintenance. These data points are "out liers" because they generally exceed the variability found in well constructed and maintained ponds.

The instantaneous maximum settleable solids limitation being proposed is 0.2 ml/l based on simple settling in properly designed, constructed and operated ponds providing 6 hours of retention time. Long term average (monthly average) TSS limitation being proposed is 2000 mg/l based on simple settling.

APPENDIX VI-1

STATISTICAL METHODOLOGY

$%Methodology and Algorithm for Developing$%

$%Daily and Monthly Achievable Levels$%

The methodology used for calculation of achievable levels or limits is described below. For these calculations, the data are assumed to follow the delta-lognormal distribution (J. Aitchison and J.A.C. Brown (1957). $%The Lognormal Distribution$%, Cambridge University Press) in which δ is the proportion of observations, if any, at or below the detection limit. For the reconnaissance data, the parameter μ takes on distinct values for each mine, while the parameters δ and σ^2, and μ , were taken as common because there were too few data values to obtain separate parameter estimates for each mine. Consequently, to apply the following formulae to the treatability data, use the formulae as if there were only one mine.

Consider the data for a pollutant such as settleable solids

·Let x_{ij} represent j^{th} observation for i^{th} mine where there are a total of c mines.

Hence for x_{ij}, $i = 1, \ldots, c$

$j = 1, \ldots, n_i$

where n_i = number of observations for mine i and

$$N = \sum_{i=1}^{c} n_i = \text{total number of observations.}$$

Let DL = detection limit. Hence, for each mine we calculate

m_i = the number of obsrvations for mine i $\leq$ DL.

Let $M = \sum_{i=1}^{c} m_i$ = total number of observations overall $\leq$ DL

Hence,

$(n_i - m_i)$ = number of observations for mine i > DL

and

$$\sum_{i=1}^{c} (n_i - m_i) = N - M = \text{total number of observations overall} > DL$$

1. Let $\hat{\delta} = M/N$ represent the overall proportion of observations less than or equal to the detection limit.

2. The mean of the logtransformed values, excluding observations at or below the detection limit is calculated for each mine via:

$$\hat{\mu}^{i} = \sum_{j=1}^{n_i - m_i} y_{ij}/(n_i - m_i)$$

where $y_{ij} = \ln(x_{ij})$ $\quad i = 1, \ldots, c$

$j = 1, \ldots, n_i$

3. The variance of the logtransformed values, excluding observations at or below the detection limit, is calculated via:

$$\hat{\sigma}^2 = \frac{\sum_{i=1}^{c} \sum_{j=1}^{(n_i - m_i)} (y_{ij} - \bar{y}_{i.})^2}{\sum_{i=1}^{c} (n_i - m_i - 1)}$$

where $\bar{y}_{i.} = \sum_{j=1}^{(n_i - m_i)} y_{ij}/(n_i - m_i)$

4. Mean of delta-lognormal distributions for each mine is:

$$E_i = \hat{\delta}\ (DL/2) + (1 - \hat{\delta})[\exp(\hat{\mu}_i + \hat{\sigma}^2/2)]$$

where DL is the detection limit.

The long-term averages for the treatability studies shown in Tables VI-2 and VI-3 are computed using this expression for the mean of the delta-lognormal distribution. In the treatability studies the settling data were analyzed without distinguishing the mines because of the limited data available.

5. Variance of delta-lognormal distributions for each mine is:

$$V_i = (1 - \hat{\delta})[e^{2\hat{\mu}_i + \hat{\sigma}^2}]\ [e^{\hat{\sigma}^2} - (1 - \hat{\delta})].$$

6. Daily achievable-level calculated for each mine is:

$$L_i = e^{\hat{\mu}_i + \hat{z}(0.99)\hat{\sigma}}$$

where $z_{(0.99)} = Z\left(\frac{0.99 - \hat{\delta}}{1 - \hat{\delta}}\right)$.

7. Monthly achievable-level calculated for each mine is:

$$L30_i = E_i + Z(0.95) \quad * \; V_i(30)$$

where $V_i(30) = \sqrt{V_i/30}$.

8. Overall daily achievable-level is:

$$MU1 = \sum_{i=1}^{c} L_i/c.$$

This level limits the value of a single grab sample.

9. Overall monthly achievable-level is:

$$MU30 = \sum_{i=1}^{c} L30_i/c.$$

The monthly achievable-level is based on 30 grab samples during the month.

Note imputations used:

a. If there does not exist a $\hat{\mu}_i$ for any particular mine, then set $\hat{\mu}_i$ = overall $\hat{\mu}$

where $\hat{\mu} = \sum_{i:1}^{c} \sum_{j:1}^{n_i - m_i} y_{ij}/(N - M)$.

b. If no values exist below the detection limit, then the above formulae reduce to the assumption that the concentration values follow a lognormal distribution.

APPENDIX VI-2

LISTING OF EFFLUENT POLLUTANT VALUES FOR

SETTLEABLE SOLIDS (SS),
TOTAL SUSPENDED SOLIDS (TSS),
TURBIDITY,
ARSENIC
AND
MERCURY

BY MINE NUMBER

(GROUP III DATA GROUPS I AND II ARE SUBSETS OF GROUP III)

PLACER MINES-EFFLUENT DATA
NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:●-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4248 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

MINENO=4109

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
1	81383		0.10					550.00		592.00				F	●
2	62783		0.50			0.0715		850.00		950.00		<	0.0002	K	●
3	82783		0.60			0.0827		910.00		956.00			0.0006	K	●

MINENO=4110

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
4	81683					0.0051				3.20			0.0020	K	●
5	81783	<	0.10			0.0055		75.00		21.00			0.0002	K	●

MINENO=4127

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
6	80383							1400.00		1280.00				F	●

MINENO=4132

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
7	72783		0.80					900.00		1380.00				F	●

MINENO=4133

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
8	72983		2.50					1300.00		2460.00				F	●

MINENO=4134

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
9	72783		0.10					240.00		116.00				F	●
10	72783		0.10					400.00		528.00				F	●
11	82383		0.10					540.00		338.00				F	●
12	82383		0.10							962.00				F	●

NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:●-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4248 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

MINENO=4138

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
13	81883	<	0.10					260.00		25.00			0.0002	K	●
14	81883	<	0.10					400.00		31.00			0.0007	K	●

MINENO=4169

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
15	72283		0.10							2467.00				F	
16	71084	<	0.10					9360.00		3520.00				K	
17	71084		0.10					13320.00		5380.00				K	
18	71084	<	0.10	*		0.7000		16200.00		5860.00	*		0.0009	K	
19	71184	<	0.10	*		0.3300		7560.00		2900.00	*		0.0009	K	
20	71184	<	0.10					9000.00		3220.00				K	
21	71184	<	0.10					10800.00		4680.00				K	
22	71284	<	0.10					12600.00		3280.00				K	
23	71284	<	0.10	*	<	0.0020		14040.00		3360.00	*	<	0.0005	K	
24	72384	<	0.10					3200.00		3720.00				R	
25	72394	<	0.10					5000.00		3820.00				R	
26	72384	<	0.10					4400.00		3980.00				R	
27	72394	<	0.10					4000.00		4420.00				R	
28	72384	<	0.10					4400.00		4420.00				R	
29	72384	<	0.10					3700.00		4760.00				R	
30	72494	<	0.10					3600.00		3140.00				R	
31	72484	<	0.10					3800.00		3280.00				R	
32	72494	<	0.10					3600.00		3520.00				R	
33	72494	<	0.10					3600.00		3540.00				R	
34	72494	<	0.10					5800.00		3540.00				R	
35	72484	<	0.10					3800.00		3620.00				R	
36	72584	<	0.10					3400.00		2900.00				R	
37	72594							3800.00		2940.00				R	
38	72584	<	0.10					3600.00		3740.00				R	
39	72584	<	0.10					3400.00		4060.00				R	
40	72584	<	0.10					3500.00		4080.00				R	
41	72584	<	0.10					3400.00		4200.00				R	

MINENO=4170

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
42	80883		0.10					170.00		71.00				F	●

PLACER MINES-EFFLUENT DATA
NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:●-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4248 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

MINENO=4171

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
43	80483		0.60					600.00		678.00				F	●

MINENO=4172

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
44	82983		0.80			0.6130		7800.00		6120.00			0.0005	K	●
45	82983		1.00			0.3380		8500.00		6890.00			0.0005	K	●

MINENO=4173

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
46	80683		0.10					4400.00		3320.00				F	●
47	82093		1.70			0.4470		5800.00		2860.00			0.0014	K	●
48	82083		2.00			0.3290		3500.00		4100.00			0.0008	K	●
49	72984		0.90			0.4490		8100.00		4620.00		<	0.0005	K	●
50	73084	<	0.10					2850.00		1276.00				K	●
51	73084		0.20	*		0.1650		5700.00		3515.00	*	<	0.0005	K	●

MINENO=4176

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
52	80583		1.90					2100.00		2920.00				F	●

MINENO=4180

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
53	80383		0.40					2300.00		1340.00				F	●
54	80393		2.20					4500.00		3900.00				F	●
55	72584		0.10					1350.00		996.00				K	●
56	72584	<	0.10	*		0.1120		2880.00		11050.00	*	<	0.0005	K	●
57	72684	T	0.00					2592.00		336.00				K	●
58	72684		0.20	*		0.2620		5040.00		773.00	*	<	0.0005	K	●

PLACER MINES-EFFLUENT DATA
NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:●-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4240 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

10:42 FRIDAY, DECEMBER 7, 1984 4

MINENO=4185

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
59	81183		0.35					1400.00		1660.00				F	●
60	82783		0.20			0.2290		1200.00		902.00			0.0003	K	●
61	82783		0.10			0.2000		1100.00		1600.00			0.0002	K	●

MINENO=4189

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
62	80483		0.10					95.00		74.00				F	●
63	82383	<	0.10			0.0026		36.00		16.00			0.0008	K	●
64	82383		0.10			0.0149		75.00		16.00			0.0006	K	●

MINENO=4190

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
65	81783		0.10					2000.00		1560.00				F	●

MINENO=4197

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
66	71983		0.10					163.00		177.00				F	●

MINENO=4211

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
67	82383		0.10					3.20		1.10				F	●

MINENO=4213

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
68	72683		1.50					3400.00		3750.00				F	●
69	72584		0.40					2400.00		3760.00				R	●
70	72684	<	0.10											R	●

PLACER MINES-EFFLUENT DATA
NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:●-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4248 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

MINENO=4215

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
71	82383	<	0.10					540.00		338.00			0.0002	K	●
72	82383	<	0.10							962.00			0.0008	K	●

MINENO=4216

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
73	72983		0.80					1400.00		1980.00				F	●
74	83083		0.15					1050.00		838.00			0.0002	K	●
75	83083		0.80					2300.00		1770.00			0.0008	K	●

MINENO=4217

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
76	72983		0.10					140.00		35.00				F	●
77	81983	<	0.10					670.00		175.00			0.0007	K	●

MINENO=4219

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
78	73183		0.10					500.00		88.00				F	●
79	82583		0.10					3100.00		1800.00				F	●

MINENO=4222

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
80	80483		0.10					100.00		41.00			.	F	●

MINENO=4224

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
81	81883		0.10					340.00		428.00				F	●

PLACER MINES-EFFLUENT DATA
NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:●-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4248 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

MINENO=4225

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
82	81383		1.20					950.00		1090.00				F	●

MINENO=4226

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
83	82583		0.10					1600.00		1200.00				F	●

MINENO=4227

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
84	81983		0.12					260.00		553.00				F	●

MINENO=4229

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
85	80383		0.10					78.00		1660.00				F	●

MINENO=4233

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
86	82283		0.22					340.00		811.00				F	●

MINENO=4236

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
87	81083		0.45					260.00		412.00				F	●

MINENO=4239

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
88	82383		0.10					80.00		7.00				F	●

PLACER MINES-EFFLUENT DATA
NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:●-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4248 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

MINENO=4242

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
89	80683		0.10					1100.00		665.00				F	●

MINENO=4244

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
90	81683		0.10					390.00		532.00				F	●
91	80184	<	0.10					1440.00		530.00				K	●
92	80184		0.20	*		0.0510		2340.00		1468.00	*	<	0.0005	K	●
93	80284	T	0.00					432.00		103.00				K	●
94	80284	T	0.00	*		0.0390		720.00		1175.00	*	<	0.0005	K	●

MINENO=4247

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
95	82583		1.20					3500.00		3360.00			0.0014	K	
96	82683		0.90					3600.00		2240.00			0.0010	K	
97	81584		0.70					1044.00		619.00				K	
98	81584		8.00			0.1190		9000.00		8440.00			0.0009	K	

MINENO=4248

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
99	71084	<	0.10					8.80		9.60				R	
100	71084	<	0.10					21.00		27.00				R	
101	71084	<	0.10					30.00		41.00				R	
102	71084	<	0.10					28.00		42.00				R	
103	71084	<	0.10					32.00		43.00				R	
104	71084	<	0.10					34.00		49.00				R	
105	71184	<	0.10			3.0000		7.40		7.60				R	
106	71284	<	0.10			2.0000		5.20		4.80				R	

PLACER MINES-EFFLUENT DATA
NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:•-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4240 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

MINENO=4249

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
107	72384	T	0.00			0.3120		285.00		117.00			0.0023	K	•
108	72494		0.00					540.00		339.00				K	•
109	72494	<	0.10			0.2000		1044.00		491.00			0.0007	K	•
110	73094	<	0.10					840.00		720.00				R	•
111	73084	<	0.10					740.00		780.00				R	•
112	73084	<	0.10					760.00		784.00				R	•
113	73094	<	0.10					680.00		800.00				R	•
114	73094	<	0.10					740.00		840.00				R	•
115	73084	<	0.10					840.00		940.00				R	•
116	73184	<	0.10					1100.00		800.00				R	•
117	73194	<	0.10					925.00		860.00				R	•
118	73184	<	0.10					1000.00		880.00				R	•
119	73184	<	0.10					1100.00		940.00				R	•
120	73184	<	0.10					1080.00		990.00				R	•
121	80184	<	0.10					1450.00		1250.00				R	•
122	80184	<	0.10					1600.00		1300.00				R	•
123	80184	<	0.10					1350.00		1330.00				R	•
124	80184	<	0.10					1400.00		1330.00				R	•
125	80184	<	0.10					1500.00		1370.00				R	•
126	80184	<	0.10					1600.00		1380.00				R	•

MINENO=4250

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
127	80884	T	0.00					97.00		48.65				K	•
128	80884	T	0.00			0.1900		99.00		115.50		<	0.0005	K	•
129	80984	T	0.00					186.00		103.60				K	•
130	80984		0.00			0.2240		135.00		425.00		<	0.0005	K	•

MINENO=4251

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
131	81284		1.60					1440.00		792.00				K	
132	81284		6.50			0.3760		2520.00		1431.00			0.0013	K	

PLACER MINES-EFFLUENT DATA 10:42 FRIDAY, DECEMBER 7, 1984 9

NOTE1: K-KOHLMANN RUGGIERO ENGINEERS 83/84 DATA
R-REGION10 1984 DATA F-FRONTIER 1983 DATA
NOTE2:●-CORRESPONDS TO THE SIX GOOD MINES OF KOHLMANN DATA
TO THE MINES OF REGION 10 DATA AND FRONTIER 1983 DATA.
MINE NO:4169 HAS PROBLEM WITH SOIL TYPE
MINE NO:4248 HAS 100% RECYCLE
MINE NO:4251 HAS SCOURING PROBLEM
MINE NO:4247 POND IS FULL

MINENO=4252

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
133	81884	T	0.00					324.00		187.00				K	●
134	81884		0.20	*	<	0.0020		2448.00		1562.00	*		0.0005	K	●
135	81984		0.30	*		0.0120		1656.00			*		0.0006	K	●
136	81984	T	0.00					558.00		286.50				K	●

MINENO=4253

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
137	71884	<	0.10					87.00		68.00				R	●
138	71984	<	0.10					120.00		140.00				R	●

MINENO=4254

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
139	71884	<	0.10					38.00		33.00				R	●

MINENO=4255

OBS	DATE	SETSNOTE	SETTSOL	ASASTER	ASNOTE	TOTAS	TURBNOTE	TURBIDTY	TSSNOTE	TSS	HGASTER	HGNOTE	TOTHG	NOTE1	NOTE2
140	80684	<	0.10					2.30		4.00				R	●
141	80684	<	0.10					2.80		4.00				R	●
142	80884	<	0.10			19.0000		4.40		9.60				R	●

APPENDIX VI-3

A. Treatability Data Used to Establish the Correlations of TSS with AS and Hg.

B. Graphical Presentation of the Data in A.

C. Summary of the TSS Correlations with As and Hg.

APPENDIX VI-3A

Treatability Data Used to Establish the Correlations of TSS with As and Hg

LISTING OF OBSERVATIONS USED IN CALCULATION OF CORRELATIONS
KOHLMANN ENGINEERING TEST DATA
MINES 4169, 4247, 4248, AND 4251 DELETED

OBS	MINENO	TSS	TOTAS	TOTHG
1	4109	5790.0	0.2350	0.0007
2	4109	1870.0	0.2370	0.0006
3	4109	1360.0	0.2030	0.0006
4	4109	11360.0	0.4430	0.0007
5	4109	19.0	0.0002	0.0002
6	4109	39.0	0.0068	0.0002
7	4110	2030.0	0.1240	.
8	4110	1506.0	0.0769	0.0006
9	4110	1156.0	0.0645	0.0003
10	4110	14300.0	0.2810	0.0007
11	4110	139.0	0.0098	0.0002
12	4110	124.0	0.0166	0.0002
13	4138	1910.0	0.5610	0.0057
14	4138	1706.0	0.4370	0.0029
15	4138	2260.0	0.4890	0.0047
16	4138	10302.0	1.5400	0.0136
17	4138	16.0	0.0002	0.0002
18	4138	2.9	0.0002	0.0002
19	4172	30580.0	0.6680	0.0120
20	4172	10360.0	0.8300	0.0012
21	4172	8345.0	0.6080	0.0008
22	4172	28280.0	0.4520	0.0110
23	4172	68.0	0.0022	0.0002
24	4172	18.0	0.0051	0.0002
25	4173	27930.0	0.6620	0.0005
26	4173	8384.0	0.1380	0.0005
27	4173	27930.0	0.6620	0.0005
28	4173	84.0	0.0130	0.0005
29	4173	7954.0	0.1550	0.0005
30	4173	31.0	0.0160	0.0005
31	4173	12350.0	0.7070	0.0034
32	4173	8320.0	0.6190	0.0024
33	4173	8490.0	0.7020	0.0024
34	4173	30500.0	1.1400	0.0008
35	4173	336.0	0.0433	0.0004
36	4173	356.0	0.0240	0.0002
37	4180	26424.0	0.6000	0.0027
38	4180	4260.0	0.4830	0.0022
39	4180	23312.0	0.3250	0.0005
40	4180	8.0	0.0030	0.0005
41	4180	23175.0	0.3250	0.0005
42	4180	58.0	0.0530	0.0005
43	4185	9705.0	0.7800	0.0004
44	4185	3970.0	0.7460	0.0003
45	4185	2610.0	0.6680	0.0004
46	4185	18310.0	0.6480	0.0007
47	4185	44.0	0.0057	0.0002
48	4185	31.0	0.0033	0.0002
49	4189	9395.0	0.2280	0.0020
50	4189	2236.0	0.0750	0.0004
51	4189	1584.0	0.0589	0.0002
52	4189	15200.0	0.1820	0.0020
53	4189	29.0	0.0016	0.0006
54	4189	33.0	0.0025	0.0002

LISTING OF OBSERVATIONS USED IN CALCULATION OF CORRELATIONS
KOHLMANN ENGINEERING TEST DATA
MINES 4169, 4247, 4248, AND 4251 DELETED

OBS	MINENO	TSS	TOTAS	TOTHG
55	4215	12000	0.3910	0.0012
56	4215	2868	0.2960	0.0008
57	4215	2348	0.2820	0.0009
58	4215	10700	0.1780	0.0011
59	4215	13	0.0010	0.0008
60	4215	23	0.0004	0.0003
61	4216	4202	0.3130	0.0018
62	4216	2278	0.1900	0.0002
63	4216	1688	0.1680	0.0005
64	4216	5990	0.3670	0.0016
65	4216	145	0.0088	0.0002
66	4216	115	0.0103	0.0004
67	4217	2840	0.2560	0.0022
68	4217	3076	0.2170	0.0013
69	4217	2840	0.2830	0.0012
70	4217	19	0.0025	0.0004
71	4217	17	0.0002	0.0004
72	4244	28126	0.4400	0.0005
73	4244	5498	0.4290	0.0005
74	4244	1802	0.3740	0.0005
75	4244	12	0.0020	0.0005
76	4244	7244	0.3870	0.0005
77	4244	266	0.0110	0.0005
78	4244	8313	0.3870	0.0005
79	4244	7772	0.3740	0.0005
80	4249	47420	1.6500	0.0014
81	4249	2180	0.1880	0.0009
82	4249	47420	1.6500	0.0014
83	4249	38	0.0120	0.0005
84	4249	24417	0.4250	0.0005
85	4249	46	0.0890	0.0005
86	4250	54332	2.4000	0.0030
87	4250	583	0.3910	0.0005
88	4250	54332	2.4000	0.0030
89	4250	21	0.0540	0.0005
90	4250	57979	0.5140	0.0015
91	4250	116	0.0290	0.0005
92	4250	57979	0.5140	0.0015
93	4250	299	0.2420	0.0005
94	4252	4492	0.0650	0.0020
95	4252	2190	0.0080	0.0015
96	4252	4492	0.0650	0.0020
97	4252	157	0.0100	0.0005
98	4252	8942	0.0100	0.0010
99	4252	2	0.0060	0.0005
100	4252	8942	0.0100	0.0010
101	4252	36	0.0060	0.0005

APPENDIX VI-3B

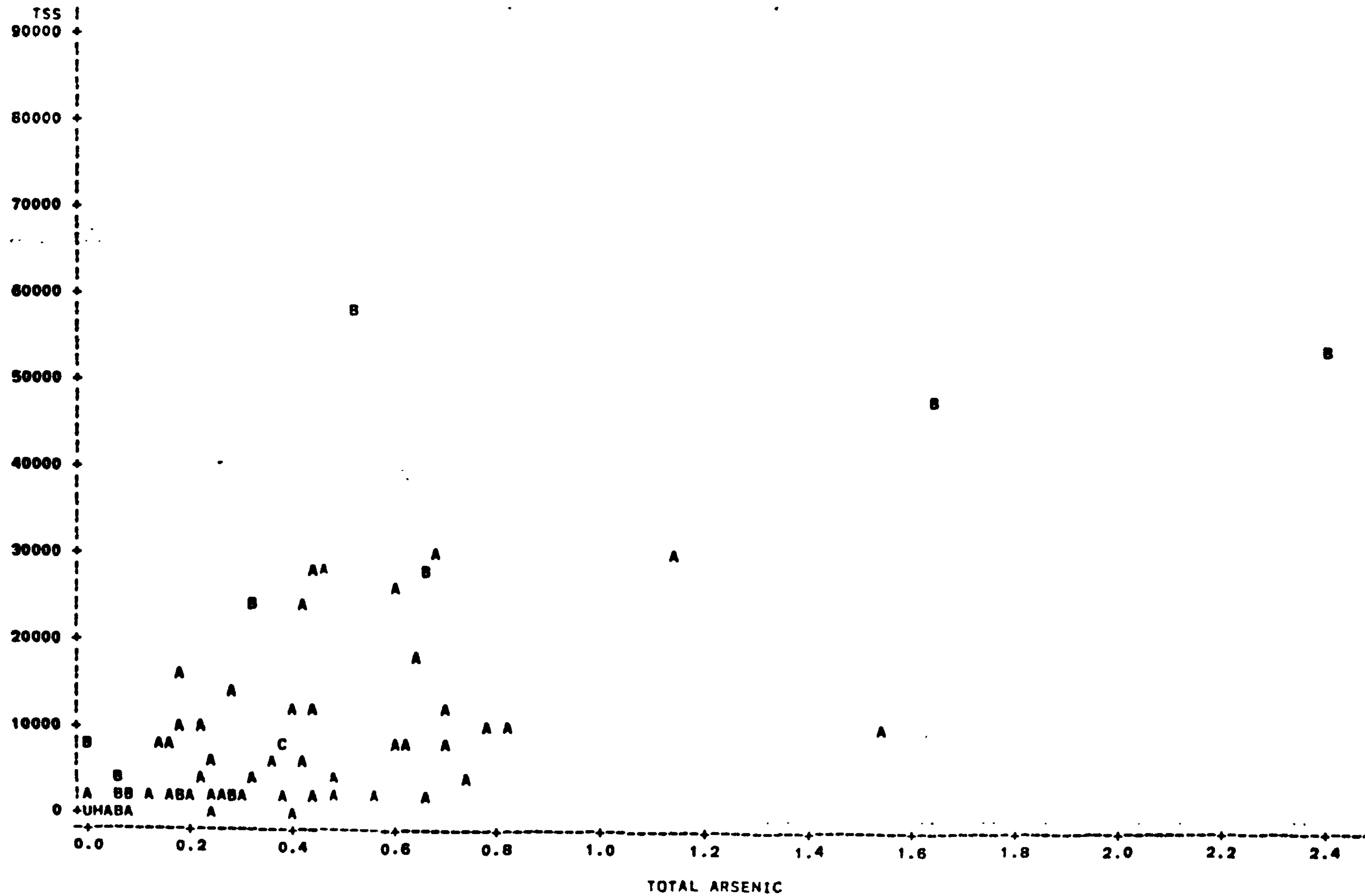
Graphical Display of the Data from Appendix VI-3A

i) TSS vs. As

ii) TSS vs. Hg

PLOT OF OBSERVATIONS USED IN CALCULATION OF CORRELATIONS
KOHLMANN ENGINEERING TEST DATA
MINES 4169, 4247, 4248, AND 4251 DELETED
ALL MINES COMBINED

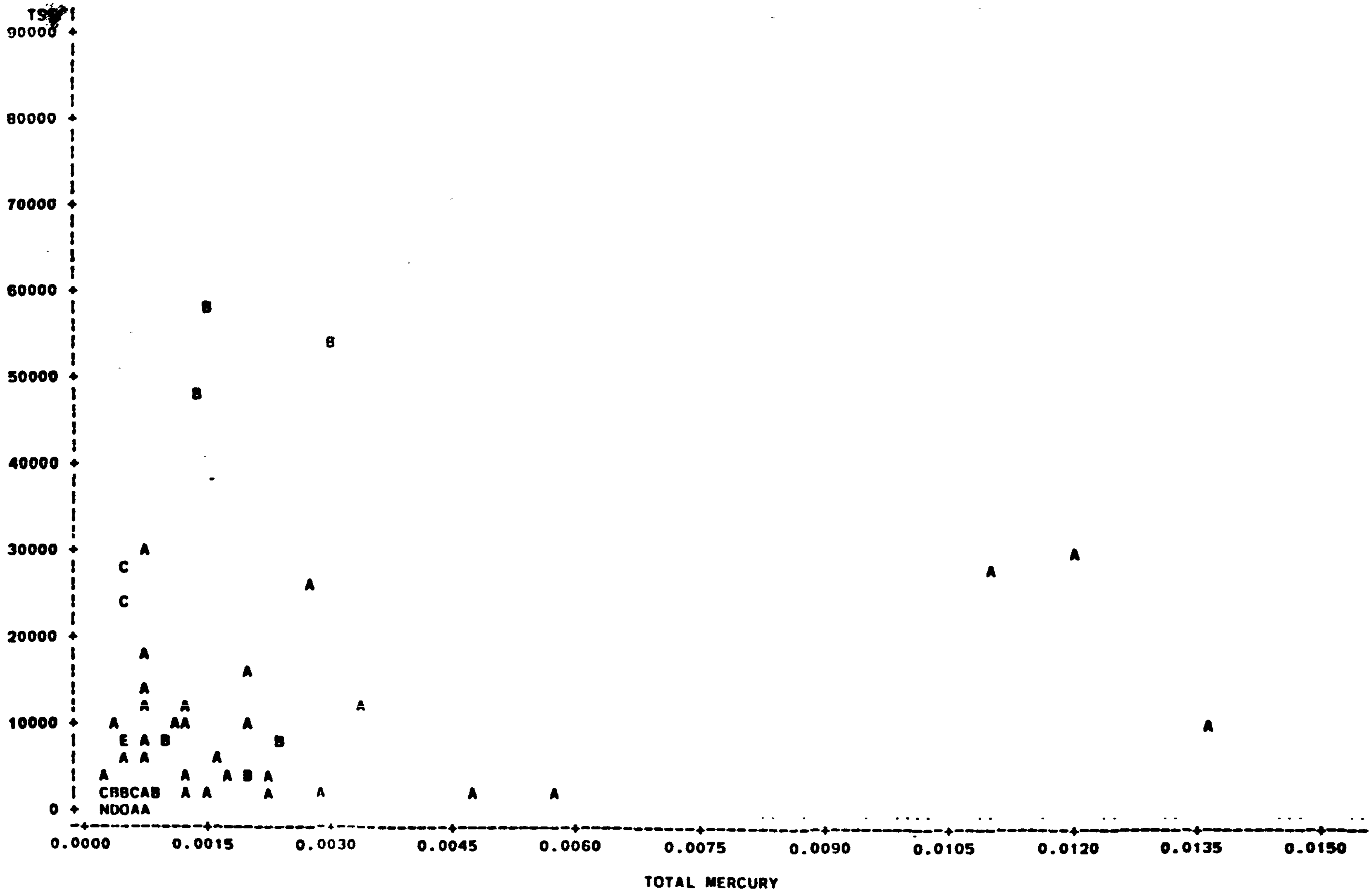
PLOT OF TSS*TOTAS LEGEND: A = 1 OBS, B = 2 OBS, ETC.



PLOT OF OBSERVATIONS USED IN CALCULATION OF CORRELATIONS
KOHLMANN ENGINEERING TEST DATA
MINES 4169, 4247, 4248, AND 4251 DELETED
ALL MINES COMBINED

15:52 THURSDAY, FEBRUARY 14, 1985 18

PLOT OF TSS*TOTHG LEGEND: A = 1 OBS. B = 2 OBS. ETC.



NOTE: 1 OBS HAD MISSING VALUES

APPENDIX VI-3C

Summary of the TSS Correlations with As and Hg

PLOT OF OBSERVATIONS USED IN CALCULATION OF CORRELATIONS
KOHLMANN ENGINEERING TEST DATA
MINES 4169, 4247, 4248, AND 4251 DELETED
ALL MINES COMBINED

VARIABLE	N	MEAN	STD DEV	MEDIAN	MINIMUM	MAXIMUM
TSS	101	8843.54336634	10892.96901852	2348.00000000	2.00000000	37370.00000000
TOTAS	101	0.33159406	0.45250898	0.20299995	0.00020000	2.40000000
TOTHG	100	0.00129300	0.00216101	0.00050000	0.00020000	0.01360000

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	TSS
TOTAS	0.74073 0.0001 101
TOTHG	0.27891 0.0050 100

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	TSS
TOTAS	0.83342 0.0001 101
TOTHG	0.60679 0.0001 100

KENDALL TAU B CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVAT

	TSS
TOTAS	0.65674 0.0001 101
TOTHG	0.43384 0.0001 100

APPENDIX VI-4

Summary of 1984 Treatability Data Used to Compare Plain Settling with the Best Flocculant Settling at Two-Hours Using All Mines

During 1984, treatability experiments were performed by KRE for the USEPA-ITD. Settling tests were run both with and without flocculant addition. These experiments are more completely described in Section VIII of this document. Table VI-2 summarizes the results of two-hour samples taken during these tests at each of the ten mines studied.

STUDY OF TEN PLACER MINES
AS ANALYZED BY KOHLMAN ENGINEERS
TESTS PERFORMED WITH AND WITHOUT FLOCCULANT

OBS	MINENO	TEST	TSS	SETSNOTE	SETTSOL	TURBIDTY	ASNOTE	TOTAS	HGNOTE	TOTHG
1	4169	P	10160		0.9	27000		0.375		0.0018
2	4169	F	10	T		19	<	0.002	<	0.0005
3	4248	P	190	T		196		0.047		0.0008
4	4248	F	12		0.0	21		0.007	<	0.0005
5	4249	P	2180		0.3	5850		0.188		0.0009
6	4249	F	46		0.0	176		0.089	<	0.0005
7	4180	P	4260		1.4	6885		0.488		0.0027
8	4180	F	7		0.0	20		0.003	<	0.0005
9	4173	P	8384		1.7	10800		0.138	<	0.0005
10	4173	F	31		0.0	190		0.016	<	0.0005
11	4244	P	6635		1.5	5815		0.401	<	0.0005
12	4244	F	15		0.0	129		0.002	<	0.0005
13	4250	P	583	<	0.1	180		0.391	<	0.0005
14	4250	F	21	T		32		0.054	<	0.0005
15	4251	P	251	T		540		0.101	<	0.0005
16	4251	F	10		0.0	20		0.009	<	0.0005
17	4247	P	10374		1.7	17640		0.137		0.0019
18	4247	F	62		0.0	185		0.002	<	0.0005
19	4252	P	2190		0.5	3870		0.008		0.0015
20	4252	F	35		0.0	92		0.006	<	0.0005

SECTION VII

SELECTION OF POLLUTANT PARAMETERS

The Agency has studied placer mining wastewaters as well as other ore mining and dressing wastewaters to determine the presence or absence of toxic, conventional, and nonconventional pollutants. According to the requirements of the Clean Water Act of 1977 (CWA), 129 toxic or "priority" pollutants are to be studied in the formulation of these guidelines (see Section 307 (a)(1), Table 1 of the Act).

EPA and its contractors conducted sampling and analysis at facilities which represented a wide range of locations, operating conditions, processes, water use rates, topography, production rates, and treatment technologies (settling ponds-single or multiple; recycle-partial and total). Any of the priority pollutants present in treated effluent discharges are subject to regulation by BAT effluent limitations guidelines.

The Settlement Agreement in Natural Resources Defense Council v. Train, 8 ERC 2120 (D.D.C. 1976), modified 12 ERC 1833 (D.D.C. 1979) and by October 26, 1982, August 2, 1983, January 6, 1984, July 5, 1984, and January 7, 1985 provides a number of provisions for the exclusion of particular pollutants and categories of pollutants from regulation. Although this regulation is not being issued under a schedule established in the NRDC Consent Decree, EPA has decided to apply the criteria for regulating (or in the alternative excluding from regulation) toxic pollutants of classes of pollutants established in Paragraph 8 of the Agreement.

The criteria for exclusion of pollutants are summarized below:

1. Equal or more stringent protection is already provided by an effluent limitation guideline or standard promulgated pursuant to Section 301, 304, 306, 307(a), or 307(c) of the CWA.

2. The pollutant is present in the effluent discharge solely as the result of its presence in the intake water taken from the same body of water into which it is discharged.

3. The pollutant is not detectable in the effluent within the category by approved analytical methods or methods representing the state-of-the-art capabilities.

4. The pollutant is detected in only a small number of sources within the category and is uniquely related to only those sources.

5. The pollutant is present in only trace amounts and is neither causing nor likely to cause toxic effects.

6. The pollutant is present in amounts too small to be effectively reduced by technologies known to the Administrator.

7. The pollutant is effectively controlled by the technologies upon which are based other effluent limitations and guidelines.

DATA BASE

The table on the next page presents a summary of the data sources consulted for various aspects of this study:

Reference	Ref. No.
1. BPT Development Document and Supplements for Ore Mining	(1)
2. BAT Development Document and Supplements for Ore	(2)

Mining

Reference	Ref. No.
3. FTA Treatability Study-1983	(3)
4. KRE Treatability Study-1983	(4)
5. EPA Reconnaissance Study-1983	-
6. FTA Reconnaissance Study-1983	(3)
7. EPA Reconnaissance Study-1982	-
8. R&M Consultants-1982	(5)
9. Environment Canada--1983 Yukon Study	(6)
10. Canadian Dept. of Indian & North. Affairs	(7)
11. Calspan Reconnaissance Study-1979	(8)
12. EPA-NEIC 1977 Reconnaissance Study	(9)
13. Alaska DEC Reports	(10)
14. Dames & Moore-1976 Reconnaissance Study	(11)
15. KRE Reconnaissance Study - 1984	(12)
16. EPA Region X Reconnaissance/Treatability Study - 1984	-
17. Shannon and Wilson Study - 1984	(13)

These sources of data describe numerous studies performed by the EPA and Alaska Department of Environmental Conservation (ADEC) and their contractors for each. Extensive data have been developed during the course of these studies, and these data have been used to choose the pollutant parameters for regulation as well as those excluded from regulation.

SELECTED POLLUTANT PARAMETERS

Several conventional and nonconventional pollutants were found in the wastewater of each of the facilities visited. Most of the sampling efforts for toxic pollutants associated with the placer mining industry located in Alaska have evaluated the arsenic and mercury levels in the treated wastewater. Few studies have evaluated the wastewater for the presence of other metals, or other toxic pollutants. On the basis of its study of the entire ore mining and dressing industry in the United States, EPA excluded 114 of the toxic organic pollutants during the 1982 BAT rulemaking for the industry (2). No information has been developed during the course of these studies or provided to EPA by the public which indicates that any of the organic priority pollutants are present in amounts which are treatable. In addition, organic reagents are not used in this industry because it relies on gravity separation methods to extract gold from the ore. Therefore, organic pollutants are not expected to be present in the wastewater from placer mining operations.

The parameters considered for regulation in this industry include:

Conventional: pH, Total Suspended Solids (TSS)

Nonconventional:	Settleable Solids (SS), Turbidity (TUR)
Toxics:	Arsenic (AS) (total), Mercury (HG) (total)

EXCLUSION OF TOXIC POLLUTANTS THROUGHOUT THE ENTIRE SUBCATEGORY

Toxic Organic Compounds

The toxic organic compounds are primarily synthetic and generally are not naturally associated with metal ores as mentioned above.

During the 1984 Reconnaissance Study by KRE, samples for the priority toxic organics were obtained and analyzed. Treated final effluent samples from the following ten mines were analyzed for the presence of toxic organics:

Mine 4169
Mine 4248
Mine 4249
Mine 4180
Mine 4173
Mine 4244
Mine 4250
Mine 4251
Mine 4247
Mine 4252

Only two priority organics were detected in the final effluent at some of the mines. None of the remaining priority organics were detected at any of the mines. The following priority organics were detected:

Mine	Pollutant	Concentration
Mine 4249	Methylene Chloride	22 ug/l

Mine 4173	Methylene Chloride	23 ug/l
Mine 4247	Methylene Chloride	17 ug/l
	Bis (2-Ethylhexyl) Phthalate	68 ug/l

In the sampling for the priority organics, 117 toxic organics were not detected and therefore were excluded from further consideration based on Criterion 3 above (i.e., the pollutant is not detectable by approved analytical methods). The two priority organics detected are also being excluded based on Criteria 5 and 6 (i.e., the pollutant is present in only trace amounts and is neither causing nor likely to cause toxic effects; and the pollutant is present in amounts too small to be effectively reduced by technologies known to the Administrator). In addition, the presence of these two priority organics in other mining industries has been attributed to sample and laboratory contamination (2); EPA believes such contamination is the source of these pollutants in placer mine wastewater as well.

Current placer gold mining practice does not use reagents or chemicals for the processing of gold from paydirt. All processing relies on physical or gravity separation, so any contaminants or pollutants present generally would originate from the ore itself naturally. In addition, oil and grease could be present in some instances from hydraulic fluids or fuels. Ordinarily, good housekeeping practices will control this parameter. Therefore, based on data available for the ore mining industry as a whole and knowledge of the processes and ores exploited for placer gold mining, the Agency proposes to exclude all toxic priority organic pollutants.

Toxic Metal Pollutants

Table VII-1 presents the results of toxic metals sampling at ten Alaskan placer mines during 1984, which was performed for USEPA by one of its subcontractors, Kohlmann Ruggiero Engineers. These toxic metal pollutants are excluded from regulation based on Criteria 3, 5 and 6 (see selection of pollutant parameters). The remaining toxic metals, arsenic and mercury, are excluded based on Criterion 7 (the pollutant is effectively controlled (or removed) by the technologies upon which are based other effluent limitations and guidelines). See Section VI.

CONVENTIONAL POLLUTANT PARAMETERS

pH

This parameter is regulated for every segment of the ore mining and dressing point source category. High or low pH values can result in solubilization of certain ore components and can adversely affect receiving water pH. Acid conditions can result in the oxidation of sulfide minerals in certain ores. To the best of the Agency's knowledge and belief, based upon the extensive sampling to date, pH problems have not been encountered in placer mining discharges.

Total Suspended Solids (TSS) and Turbidity (TUR)

Suspended solids and turbidity are important parameters in both municipal and industrial water supply practices. Finished

Table VII-1. Priority Metals Sampling Results from Placer Gold Mines Final Effluents.

Mine Code	TSS	Concentration (mg/l)												
		Ag	As	Be	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	Sb	Ti
4180	773	<0.02	0.275	<0.01	0.01	0.09	0.15	<0.0005	0.16	0.075	<0.005	0.12	0.005	<0.002
4180	773	<0.02	0.412	<0.01	0.02	0.13	0.30	0.0007	0.24	0.155	<0.005	0.26	0.002	<0.002
4173	3,515	<0.02	0.066	<0.01	<0.01	0.09	0.08	<0.0005	<0.10	0.028	<0.005	0.08	<0.002	<0.002
4173	3,515	<0.02	0.072	<0.01	<0.01	0.08	0.09	0.0006	0.12	0.032	<0.005	0.09	<0.002	<0.002
4250	425	<0.02	0.168	<0.01	<0.01	<0.05	0.04	<0.0005	<0.1	0.006	<0.005	<0.02	0.015	<0.002
4250	425	<0.02	0.167	<0.01	<0.01	0.09	0.09	<0.0005	<0.1	0.006	<0.005	0.07	0.015	<0.002
4251	1,431	<0.02	0.004	<0.01	<0.01	0.08	0.10	<0.0005	<0.10	0.007	<0.005	0.08	0.011	<0.002
4251	1,431	<0.02	0.064	<0.01	<0.01	0.09	0.11	<0.0005	<0.10	0.056	<0.005	0.15	0.034	<0.002
4247	619	<0.02	0.075	<0.01	0.05	0.35	0.49	0.0009	0.38	0.150	<0.005	0.89	0.002	<0.002
4247	619	<0.02	0.032	<0.01	0.02	0.10	0.27	0.0008	0.11	0.080	<0.005	0.33	0.002	<0.002
4252	-	<0.02	0.009	<0.01	<0.01	<0.05	0.05	<0.0005	<0.1	0.016	<0.005	0.03	<0.002	<0.002
4252	-	<0.02	0.004	<0.01	<0.01	<0.05	0.05	0.0050	<0.1	0.018	<0.005	0.04	<0.002	<0.002
4169	3,360	<0.02	0.220	0.02	0.08	0.56	0.52	0.0005	1.06	0.230	<0.005	0.90	<0.002	0.004
4169	3,360	<0.02	0.220	0.02	0.08	0.48	0.45	0.0006	0.40	0.195	<0.005	0.78	<0.002	0.004
4244	1,175	<0.02	0.085	<0.01	0.03	0.23	0.14	<0.0005	<0.10	0.27	<0.005	0.29	<0.002	<0.002
4248	178	<0.02	0.110	<0.01	0.01	0.22	0.14	0.0011	0.38	0.019	<0.005	0.26	<0.002	<0.002
4248	178	<0.02	0.120	<0.01	<0.01	0.25	0.14	0.0009	0.36	0.021	<0.005	0.28	<0.002	<0.002
4249	117	<0.02	0.078	<0.01	<0.01	0.06	0.05	<0.0005	0.12	0.011	<0.005	0.02	<0.002	<0.002
4249	117	<0.02	0.077	<0.01	<0.01	0.06	0.06	<0.0005	<0.10	0.013	<0.005	0.03	<0.002	<0.002

drinking waters have a maximum limit of 1 turbidity nit where the water enters the distribution system. This limit is based on health considerations as it relates to effective chlorine disinfection. Suspended matter provides areas where microorganisms do not come into contact with the chlorine disinfectant (NAS, 1974). The ability of common water treatment processes (i.e., coagulation, sedimentation, filtration, and chlorination) to remove suspended matter and achieve acceptable final turbidities is a function of the composition of the material as well as its concentration. Because of the variablity of such removal efficiency, it is not possible to delineate a general raw water criterion for these uses.

Turbid water interferes with recreational use and aesthetic enjoyment of water. Turbid waters can be dangerous for swimming, especially if diving facilities are provided, because of the possibility of unseen submerged hazards and the difficulty in locating swimmers in danger of drowning (NAS, 1974). The less turbid the water the more desirable it becomes for swimming and other water contact sports. Other recreational pursuits such as boating and fishing will be adequately protected by suspended solids criteria developed for protection of fish and other aquatic life.

Fish and other aquatic life requirements concerning suspended solids can be divided into those whose effect occurs in the water column and those whose effect occurs following sedimentation to the bottom of the water body. Noted effects are similar for both fresh and marine waters.

The effects of suspended solids on fish have been reviewed by the European Inland Fisheries Advisory Commmission (1965). This review identified four means by which suspended solids adversely affect fish and fish food populations:

(1) by acting directly on the fish swimming in water which solids are suspended, and either killing them or reducing their growth rate, resistance to disease, etc etera;

(2) by preventing the successful development of fish eggs and larvae;

(3) by modifying natural movements and migrations of fish;

(4) by reducing the abundance of food available to the fish.

Settleable materials which blanket the bottom of water bodies damage the invertebrate populations, block gravel spawning beds, and if organic, remove dissolved oxygen from overlying waters (EIFAC, 1965; Edberg and Hofsten, 1973). In a study downstream from the discharge of a rock quarry where inert suspended solids were increased to 80 mg/l, the density of macroinvertebrates decreased by 60 percent while in areas of sediment accumulation benthic invertebrate populations also decreased by 60 percent regardless of the suspended solid concentrations (Gammon, 1970). Similar effects have been reported downstream from an area which was intensively logged. Major increases in stream suspended solids (25 ppm suspended solids upstream vs. 390 ppm downstream) caused smothering of bottom invertebrates, reducing organism density to only 7.3 per square foot versus 25.5 per square foot upstream (Tebo, 1955).

Solids in suspension that will settle in one hour under quiescent conditions because of gravity are settleable solids.

When settleable solids block gravel spawning beds which contain eggs, high mortalities result although there is evidence that some species of salmonids will not spawn in such area (EIFAC, 1965).

It has been postulated that silt attached to the eggs prevents sufficient exchange of oxygen and carbon dioxide between the egg and the overlying water. The important variables are particle size, stream velocity, and degree of turbulence (EIFAC, 1965).

Deposition of organic materials to the bottom sediments can cause imbalances in stream biota by increasing bottom animal density, principally worm populations, and diversity is reduced as pollution-sensitive forms disappear (Mackenthun, 1973). Algae likewise flourish in such nutrient-rich areas although forms may become less desirable (Tarzwell and Gaufin, 1953).

Plankton and inorganic suspended materials reduce light penetration into the water body, reducing the depth of the photic zone. This reduces primary production and decreases fish food. The NAS committee recommended that the depth of light penetration not be reduced by more than 10 percent (NAS, 1974). Additionally, the near surface waters are heated because of the greater heat absorbency of the particulate material which tends to stabilize the water column and prevents vertical mixing (NAS, 1974). Such mixing reductions decrease the dispersion of dissolved oxygen and nutrients to lower portions of the water body. Accordingly, the Agency proposes to regulate settleable solids, total suspended solids, and turbidity.

Arsenic

Arsenic is found to a small extent in nature in the elemental form. It occurs mostly in the for of arsenites of metals or as arsenopyrite ($FeS_2.FeAs_2$).

Arsenic is normally present in sea water at concentrations of 2 to 3 micrograms per liter and tends to be accumulated by oysters and other shellfish. Concentrations of 100 mg/kg have been reported in certain shellfish. Arsenic is a cumulative poison with long-term chronic effects on both aquatic organisms and mammalian species, and a succession of small doses may add up to a final lethal dose. It is moderately toxic to plants and highly toxic to animals--especially, as arsine (AsH_3).

Arsenic trioxide, is exceedingly toxic, when it was studied in concentrations of 1.96 to 40 mg/l, it was found to be harmful in that range to fish and other aquatic life. Work by the Washington Department of Fisheries on pink salmon has shown that a level of 5.3 mg/l of As_2O_3 for 8 days is extremely harmful to this species; on mussels, a level of 16 mg/l is lethal in 3 to 16 days.

Severe human poisoning can result from 100-mg concentrations, and 130 mg has proved fatal. Arsenic can accumulate in the body faster than it is excreted and can build to toxic levels from small amounts taken periodically through lung and intestinal walls from the air, water, and food. Arsenic is a normal constituent of most soils, with concentrations ranging up to 500 mg/kg. Although very low concentrations of arsenates may actually stimulate plant growth, the presence of excessive soluble arsenic in irrigation waters will reduce the yield of crops, the main effect appearing to be the destruction of chlorophyll in the foliage. Plants grown in water containing one mg/l of arsenic trioxides show a blackening of the vascular bundles in the leaves. Beans and cucumbers are very sensitive, while turnips, cereals, and grasses are relatively resistant. Old orchard soils in Washington that contain 4 to 12 mg/kg of arsenic trioxide in the topsoil were found to have become unproductive.

Arsenic is known to be present in many complex metal ores--particularly, the sulfide ores of cobalt, nickel and other ferroalloy ores, antimony, lead, gold and silver. It may also be solubilized in mining and milling by oxidation of the ore and appear in the effluent stream.

Mercury

Elemental mercury occurs as a free metal in certain parts of the world; however, since it is rather inert and insoluble in water, it is not likely to be found in natural waters. Although elemental mercury is insoluble in water, many of the mercuric and mercurous salts, as well as certain organic mercury compounds, are highly soluble in water. Concentrations of mercury in surface waters have usually been found to be much less than 5 micrograms per liter.

The accumulation and retention of mercurial compounds in the nervous system, their effect on developing tissue, and the ease of their transmittal across the placenta make them particularly dangerous to humans. Continuous intake of methyl mercury at dosages approaching 0.3 mg Hg per 70 kg (154 lb) of body weight per day will, in time, produce toxic symptoms.

Mercury's cumulative nature also makes it extremely dangerous to aquatic organisms, since they have the ability to absorb significant quantities of mercury directly from the water as well as through the food chain. Methyl mercury is the major toxic form; however, the ability of certain microbes to synthesize methyl mercury from the inorganic forms renders all mercury in waterways potentially dangerous. Fresh-water phytoplankton, macrophytes, and fish are capable of biologically magnifying mercury concentrations from water 1,000 times. A concentraction factor of 5,000 from water to pike has been reported, and factors of 10,000 or more have been reported from water to brook trout. The chronic effects of mercury on aquatic organisms are not well-known. The lowest reported levels which have resulted in the death of fish are 0.2 micrograms per liter of mercury, which killed fathead minnows exposed for six weeks. Levels of 0.1 microgram per liter decrease photosynthesis and growth of marine algae and some freshwater phytoplankton.

SURROGATE/INDICATOR RELATIONSHIPS

The Agency believes that it may not always be feasible to directly limit each toxic which is present in a waste stream. Surrogate or indicator relationships provide an alternative to direct limitation of toxic pollutants accoring to Criterion 7. Section VI discusses the data analysis which has been performed to determine the presence of total arsenic and mercury in placer gold mining treated effluent. Based upon the relationships developed, these metals have been shown to be associated with the suspended portion of the wastewater stream rather than the dissolved. Furthermore, the data available to the Agency indicate that control of TSS will result in control of the toxic metals to levels below those normally considered to be possible with chemical treatment technologies as used in other segments of the ore mining industry. The levels achieved both in the reconnaissance sampling and treatability studies indicate that control of TSS to the levels indicated will result in arsenic and mercury levels near or below the Alaska water quality criteria levels most of the time (see Section VI).

SECTION VII

REFERENCES

1. USEPA, "Develoment Document for Interim Final and Proposed Effluent Limitations Guidelines for the Ore Mining and Industry," EPA Report No. EPA 440/1-75/061c, October, 1975.

2. USEPA, "Development Document for Effluent Limitations Guidelines and Standards for the Ore Mining and Dressing Point Source Category," EPA Report No. 440/1-82/061, November, 1982.

3. Harty, D.M. and Terlecky, P.M., "Reconnaissance Sampling and Settling Column Test Results at Alaskan Placer Gold Mines," Frontier Technical Associates Report No. FTA-84-1402-1.

4. Kohlmann and Ruggiero Engineers, "Treatability Testing of Placer Gold Mine Sluice Waters in Alaska, U.S.", Prepared for USEPA Effluent Guidelines Divison, January, 1984.

5. R&M Consultants, Inc., "Placer Mining Wastewater Settling Pond Demonstration Project", Prepared for the Alaska Department of Environmental Conservation, June, 1982.

6. Environment Canada, "The Use of Flocculants in Placer Mining" (a supplement to the paper 'The Attainment and Cost of Placer Mining Effluent Guidelines'), Canadian Environmental Protection Service, Yukon Branch, June 13, 1983.

7. Canadian Department of Indian and Northern Affairs, "Water Use Technology for Placer Mining Effluent Control," Report No. QS-Y006-000-EE-A, 1981.

8. Bainbridge, K.L., "Evaluation of Wastewater Treatment Practices Employed at Alaskan Gold Placer Mining Operations", Report No. 6332-M-2, Calspan Corporation, Buffalo, N.Y., July 17, 1979.

9. USEPA National Enforcement Investigations Center, "Evaluation of Settleable Solids Removal Alaska Gold Placer Mines", EPA Report No. 330/2-77-021, September, 1977.

10. Alaska Department of Environmental Conservation, "Placer Mining and Water Quality" (Summary Report), November, 1979; Supplements: Problem Description-Nov. 1977; Technical Alternatives-June 1978; Management Alternatives-Sept. 1978.

11. Dames & Moore, "Water Quality Data at Selected Active Placer Mines in Alaska" Report No. 9149-001-22, September 17, 1976, prepared for Calspan Corporation.

12. Kohlmann Ruggiero Engineers, "1984 Alaskan Placer Mining Study and Testing Summary Report," Revised November 8, 1984, Preliminary Draft, Prepared for EPA Effluent Guidelines Division, Washington, D.C.

13. Shannon and Wilson, Inc. "Placer Mining Wastewater Treatment Technology Project Phase 1, 2 and 3 Report," Prepared for State of Alaska Department of Environmental Conservation, November 1984.

SECTION VIII

CONTROL AND TREATMENT TECHNOLOGY

This section discusses the techniques for pollution abatement available to the placer gold mining industry. General categories of techniques are: in-process controls, end-of-pipe treatment, and best management practices. The current or potential use of each technology in this and similar industries and the effectiveness of each are discussed.

Selection of the optimal control and treatment technology for wastewater generated by this industry is influenced by several factors:

1. There are some differences in wastewater composition and treatability caused by ore mineralogy, ore particle size and distribution, and processing techniques.

2. Geographic location, topography, and climatic conditions often influence the amount of water to be handled, treatment and control strategies, and costs.

3. Seasonal nature of the operation where mines operate only during the mining season often causes a mine operator to rebuild the treatment facility each season the mine is operated.

In-Process Control Technology

This section discusses process changes available to existing mines to improve the quality or reduce the quantity of wastewater discharged from mines. The techniques are process changes that may be made within existing mining operations.

1. Classification or Screening

Mines which employ classification (sizing or screening) of the ore prior to sluicing typically use less water than mines which do not classify. Several different classification devices are commonly employed at placer gold mines. These devices are trommels, screens (fixed and vibrating), and grizzlies. Each of these devices removes oversized material prior to sluicing. Removal of oversized material reduces water usage because less material is sluiced and a lower water velocity is required to push the smaller rocks down the sluices. Descriptions of trommels, screens, and grizzlies are found in Section III. Estimated water use rates for each of the classification devices and for mines using no classification are shown in Table VIII-1. Average water usage at mines employing classification methods (screens, trommels, and grizzlies) is approximately 2,500 gallons per cubic yard (9.5 m3 of water per m3 of paydirt). At mines using no classification, the average water usage is 4,062 gallons per cubic yard (15.4 m3/m3). Based on these water usage rates, classification reduces water usage, and the volume of wastewater for treatment, on the average of approximately 38 percent. Classification or screening is common practice in the industry because of mines in water short areas and many operators consider it good mining practice which not only reduces water use, but protects the sluice from the hammering of large rocks. In

Table VIII-1. Water Use Rates at Placer Gold Mines (Source: Reference 1)

Class. Method	Mines	Water Usage ga/cu. yd.) Avg.	Range
Screens (Vib. & Ross Box)	8	2,901	947 to 6,000
Trommels	9	1,981	209 to 7,411
Trommels (Excl. Dredges)	6	1,054	209 to 2,400
Grizzlies	9	1,884	1,440 to 3,360
No Classification	10	4,062	900 to 8,970

Avg. Water Use--All Classification Methods Combined = 2,498.5 or approx. 2,500 gal/cu. yd. sluiced

Section III, table 4 to 8, over 50% of the mines use some form of classification.

2. High Pressure - Low Volume Spray Nozzles

The amount of water required at gold placer mines is affected by the cohesiveness of ore particles. Mines washing ores which contain cohesive clay particles generally use significantly greater volumes of water to break up the ore during beneficiation than mines washing ores with larger particle sizes and less clay. Screening in conjunction with high pressure, low volume spray nozzles before the separation process can assist in breaking up the agglomerated paydirt into particles and use less water than large volume hydraulic monitors.

3. Sluice design

Water usage in the sluice is a function of slope, width, water depth, riffle type, riffle spacing, and ore particle size as discussed in 2 above and size distribution of the ore as discussed in 1 above under classification. However, sluice design and the efficiency of a given sluice in recovering gold is most often the result of trial and error by the miner to obtain the best recovery of gold from a particular paydirt. It is beyond the scope of this document to make specific recommendations other than the two suggestions in 1 and 2 above that should be used universally in designing and operating a sluice. Mining texts and handbooks offer rules of thumb which the more efficient miner customizes and perfects to the individual operation, including controlled water use.

4. Flow Control

Water use in the sluice at many mines can be reduced by stopping the influent flow to the beneficiation process during extended periods when ore is not being loaded into the process thereby decreasing the total flow into the settling ponds and increasing the settling time.

END-OF-PIPE TREATMENT TECHNOLOGIES

This subsection presents a discussion of technologies which may be employed for the treatment of wastewater discharged at placer mining operations. Most mines are in remote locations, so that the type of equipment and the availability of outside construction services must be considered. For a given site, the terrain is most important to define design, construction and maintenance requirement for treatment facilities. The following factors were also considered in reviewing the available and appropriate treatment and control facilities for gold placer mines.

1. Engineering considerations for construction of treatment facilities in most mining locations, including settling pond size, number of ponds, drainage diversion, water use reduction.

2. The length of the mining season which ranges from about four (4) months in Alaska to 5-10 months in the Western States.

3. Design considerations due to climate, especially rainfall.

4. Construction equipment available to, and practices employed by, the mining crew to install treatment or control facilities.

The ore industry currently uses some form of sedimentation technology which involves generally one of the following: settling basins, clarifiers, or ponds. Large concrete settling basins and clarifiers normally found at typical "hard rock" ore mines are generally not found nor adaptable to conditions related to seasonal operation and the remote location of placer mines. These conditions, combined with the treatability of wastewater and the costs of treatment make many wastewater treatment technologies that are used at some other ore mining operations impractical at placer mining operations. These include granular media filtration, adsorption, chemical treatment, and ion exchange.

Technology Description

Simple Settling

The use of ponds for both primary or secondary settling is a standard approach to treatment throughout the ore mining industry and in particular for placer mining. The wastewater entering these ponds from the mining and ore processing operations contain a high solids loading. Primary settling ponds are often used to remove the heavy particles and then secondary settling ponds are used to remove the finer particles.

The size of settling ponds is determined by the overflow rate or detention time needed to remove the solids. In general, detention time is used to determine the pond size in the mining industry. Engineering tests at several sites in Alaska during 1983 and 1984, using quiescent settling conditions, revealed that the largest portion of suspended and settleable solids removal occurred during the first 2 to 3 hours of settling.(13) Additional settling beyond three to six hours, while assuring removal of any residual settleable solids, does not greatly alter the removal of suspended solids from the wastewater.(13) Based on the data obtained in pilot settling tests, engineering requirements and experience for design and construction of actual field installations, doubling the settling time (i.e., 3-hrs pilot test vs. 6-hr. field design) would be required to compensate for flow velocities and sludge storage in the pond.

DESIGN CONSTRUCTION AND OPERATION OF SETTLING PONDS

To achieve the desired results or effluent from a settling pond(s), the pond must be properly designed, installed and maintained. It was apparent from the visits to many mine sites that ponds which were installed although of sufficient volume at the beginning of the mining season, due to accumulation of sludge, were of insufficient size to treat the wastewater later in the season. Also, the ponds at some mines visited were "short-circuiting" (i.e., wastewater flowed straight through the pond without much, if any settling) due to improper placement of the influent and effluent points.

A properly designed pond should have the influent in the middle of one end and the effluent at the middle of the other end. Ideal ponds have the length two (2) to three (3) times the width, and adjustable weirs at the influent and effluent points. These weirs are utilized to determine the flow into and out of the ponds and to control water height in the ponds.

The disposal of sludge deposited in the ponds can be handled by two methods. (1) Sludge can be removed from the ponds periodically, using mechanical means such as dredges, slurry pumps, front end loaders, back hoes or dredge lines, and disposed in the area used for tailings disposal; or (2) sludge can be left in the pond for the entire season. Both approaches require the pond volumes to be increased above that required for detention of the wastewater being treated so that the volume of sludge does not intrude on the volume required for proper wastewater detention and treatment. The increased volume of the ponds will depend upon the method of sludge disposal being utilized, and the amount of solids present in the wastewater that will settle. The ponds will be smaller in volume if the sludge is removed periodically.

Therefore, sizing the settling pond for a mine site the following must be determined.

1. Volume of wastewater to be treated
2. Amount of sludge to be handled
3. Method of sludge handling.

Using this data ponds of proper size to treat the wastewater generated can be designed and installed.

<u>DETERMINATION OF WASTEWATER VOLUME TO BE TREATED</u>

The volume of wastewater to be treated in placer mining operations is determined from: (1) the actual amount of water used in the beneficiation process (sluicing); (2) the amount of ground water or infiltration which enters the pond; (3) the storm water runoff from the beneficiation process area and the mine area for a given storm intensity[1] which enters the pond; and (4) the water flow from any other sources, i.e., small creeks, which are not diverted around the ponds but enter the ponds. The waters from these four sources are combined to produce the total volume of water used to size the treatment ponds.

The size of the ponds and cost of construction discussed in Section IX are based on the volume of water to be treated. At most mine sites the major flow to be treated is the process waste water used for beneficiation process, i.e., sluicing. Minimizing process wastewater use by high pressure, low volume nozzles for pre-wash, and ore classification will result in smaller ponds and lower costs for treament of process wastewater.

[1]As discussed in Section X, relief or an exemption is provided to wastewater treatment facilities which are overcome by storm water runoff if the treatment facility is designed, constructed, and operated to contain or treat the volume of wastewater that would result from a 5-year, 6-hour rainfall. Therefore, the 5-year, 6-hour rainfall should be the storm intensity used.

DETERMINATION OF SLUDGE VOLUME TO BE HANDLED

The volume of sludge is computed by determining the amount of suspended solids present in the wastewater entering the pond and the amount of suspended solids present in the wastewater discharging the pond after the required settling time. Using the difference between the influent and effluent suspended solids and the volume of wastewater being treated, the amount of sludge to be handled can be computed. Using this data and the methods of sludge handling, the volume of the pond required for sludge storage can be determined.

POND DESIGN EXAMPLE

An example of the sizing of a pond at a placer mining site is offered below:

A. Design Criteria

1. Flow: Flows are mine specific and only the process wastewater is considered in this example. The sluicing water rate is based on an assumed rate of sluicing 80 cubic yards per hour (or 800 cubic yards per day for a 10-hr day) using an assumed 2500 gallons of water per cubic yard. The wastewater discharging the sluice would be about 3,400 gpm.

2. Detention time for wastewater: 6 hours

3. Maximum pond velocity to avoid scouring ("critical velocity") should be about 2 feet per minute or less.

4. Sludge volume is based on an influent quality of 30,000 mg/l and an effluent quality of 2,000 mg/l of total suspended solids. Sludge on the pond bottom is assumed to have 50 percent solids.

5. For the purpose of this example, the sludge will remain in the ponds for the entire mining season. Assume 100 days of sluicing at 10 hours per day.

B. Detention

The volume is computed by multiplying the flow by the detention time required and converting to cubic feet by dividing the results by gallons per cubic feet.

Volume = 3,400 x 6 x 60/7.48 = 164,700 cubic feet.

C. Cross-section and Surface Areas

These are determined by trial and error to achieve the dimensions suitable for a mine site.

Assume a depth of 3 feet. Surface area required is:

164,700/3 = 54,900 square feet.

Using a length to width ratio of 2.5 to 1, the width would be 150 feet and the length: 375 feet.

D. Check Critical Velocity

Convert flow to cubic feet per second.

Divide flow by 448: 3400/448 = 7.59 cfs.

Divide by crossectional area: 7.59/150 x 3 = 0.02 fps, which equals 1.0 fpm, e.g., below critical velocity.

E. Sludge Determination

Subtract effluent suspended solids from influent suspended solids:

30,000 - 2,000 = 28,000 mg/1 remaining in pond.

Using this volume and flow, the amount of solids is computed for the mining season:

(28,000 x 3400 x .012 x 10/24) x 100 = 47,600,000 pounds per year.

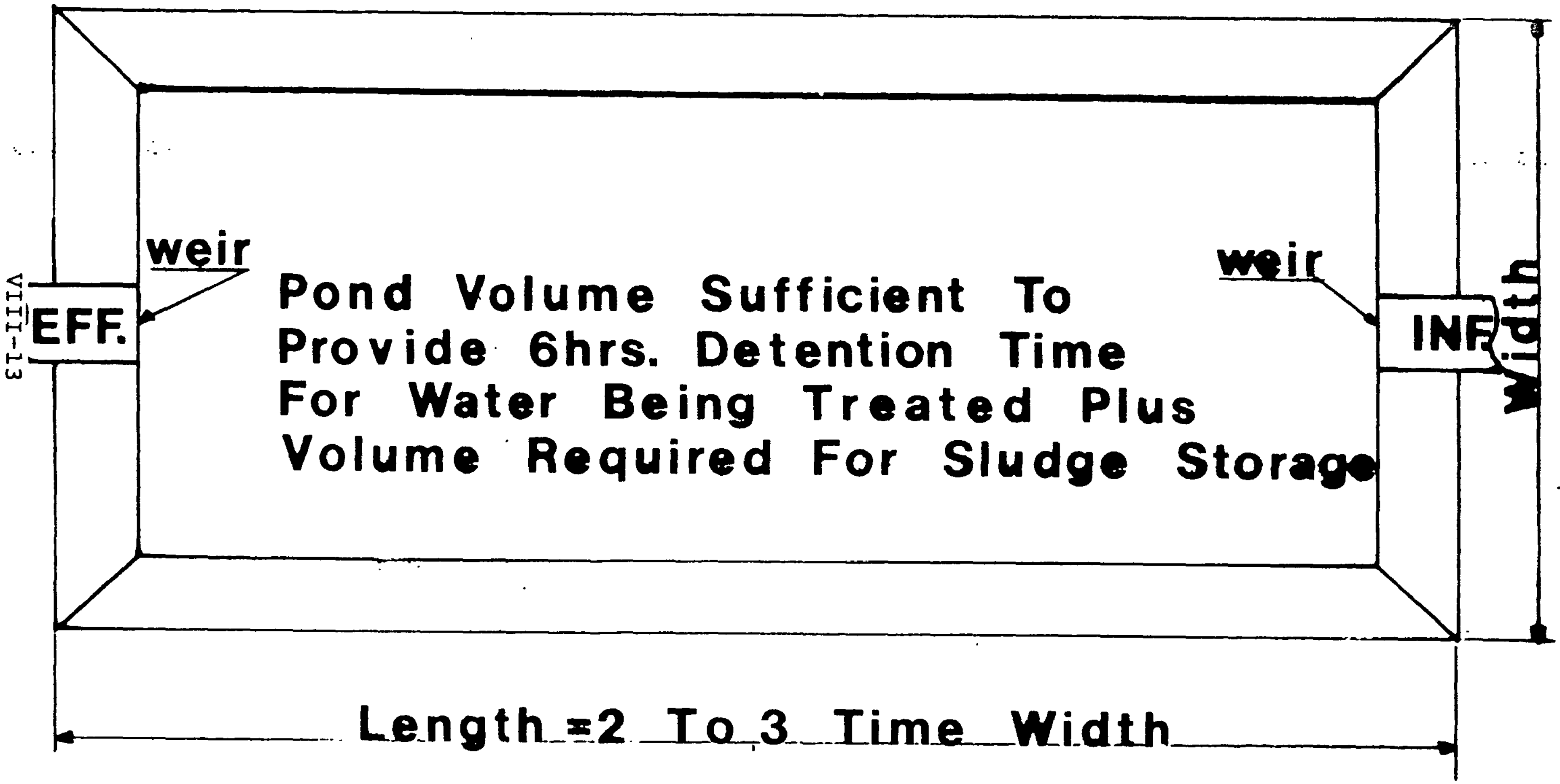
Assume 50% solids in the sludge, the volume of the pond to maintain this sludge can be determined. For this example, the volume for sludge storage for the year is:

$$\frac{47,600,000 \times .5}{62.4} = 1,525,641 \text{ cubic feet}$$

Based on this example, a pond or ponds having a usable volume for the combined total of water volume and the sludge volume, that is 1,580,541 cubic feet, or 58,539 cubic yards, must be constructed.

SETTLING POND PLAN

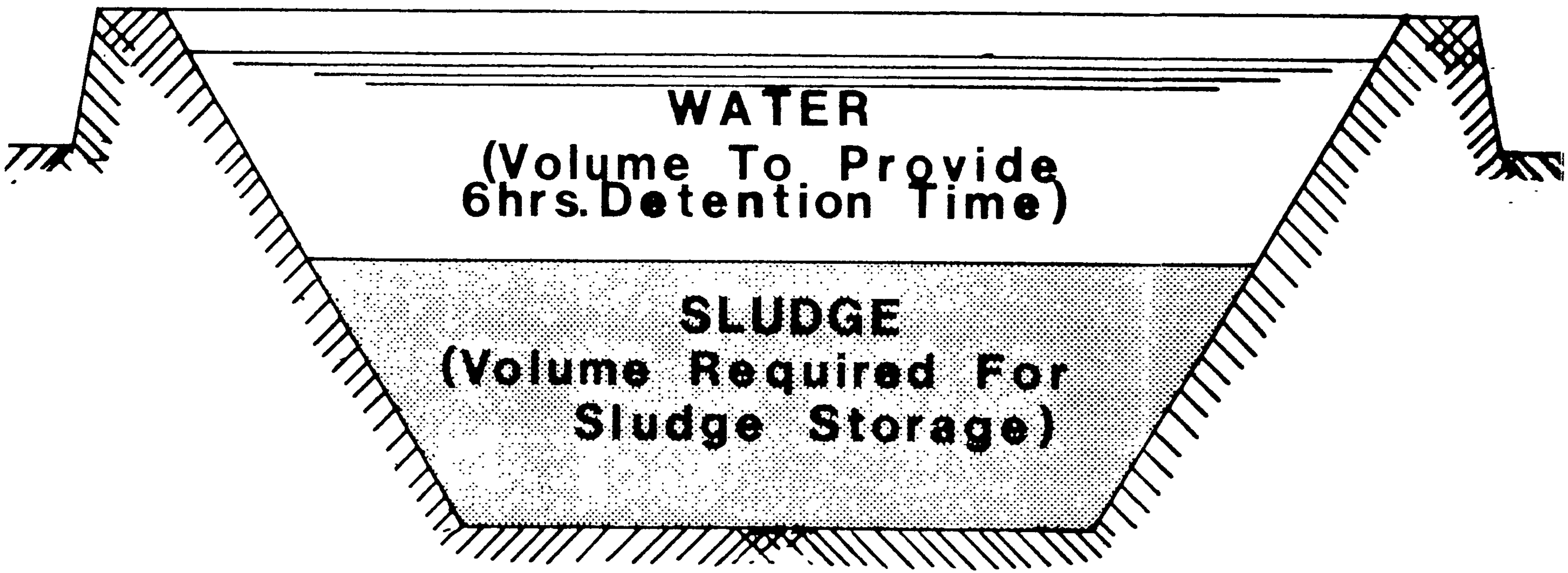
Figure VIII--1



(RE

SETTLING POND SECTION

Figure VIII -2



This pond would provide the required detention time for the process wastewater and volume for a mining season's sludge production, while achieving a settleable solids level of less than 0.2 ml/l as determined from treatability testing of simple settling.(13)

Coagulation and Flocculation

The majority of the suspended solids present in placer mine effluent from simple settling are colloidal in size and do not readily settle without the aid of chemicals. In general, two types of chemicals are used in the treatment of waters: those that precipitate materials from solution (e.g., lime), and those that coagulate small particles into particles large enough to settle by gravity or be removed by other physical methods. The major chemicals used for coagulation are organic or inorganic materials (polyelectrolytes). Polymers operate by forming a physical bridge between particles, thereby causing them to agglomerate forming a floc. The floc, e.g., agglomeration of small particles, is generally settleable. When the polyelectrolyte alone does not form particles that will settle due to lack of ample weight, coagulant aids such as lime or ferric sulfate are used to add the required weight.

Coagulant aids are normally added ahead of the settling facility. The coagulant or polyelectrolyte must be added and mixed with the wastewater by an action such as turbulence to ensure complete mixing and dispersion of the coagulant into the wastewater. After complete mixing, the wastewater treated with polymer must pass through a flocculation stage which allows the particles to come in contact with each other so that the agglomeration can occur to form a floc.

The use of flocculant system at a mine site can be relatively simple operation. A polyelectrolyte feed system would be installed prior to the settling pond. The feed system would be a batch type operation where the polyelectrolyte solution is prepared daily and a metering pump is utilized to feed the solution into the wastewater.

Table VIII-2. Summary of Two-hour Settling Tests Performed During the 1984 Testing Program*

Parameters	Polymer Aided Settling Mean Value	Polymer Aided Settling Range
Settleable solids (ml/l/hr)	Trace	0.0 - Trace
Total suspended solids (mg/l)	25	8 - 62
Turbidity (NTU)	88	19 - 185
Total mercury (mg/l)	0.019	<0.002- 0.089
Total arsenic (mg/l)	<0.0005	0.0005

*Extrapolated from plots of field data

If a turbulent (mixing) area is not present prior to the settling pond, a section to create turbulence can be constructed, a serpentine channel or placing constrictions in the channel that will cause turbulence.

Settling tests in Alaska during the 1983 mining season confirmed the use of polyelectrolytes as a method to treat placer mining wastewater and the 1984 tests confirmed the viability of treating placer mining wastewaters with polyelectrolyte.(12 and 13) The 1983 testing was utilized to determine the feasibility of using polyelectrolyte in the treatment of placer mining wastewaters and the 1984 testing program was designed to determine the quality of water discharging ponds at various detention times and determine the optimum dosage of polyelectrolyte. The 1984 testing program consisted of running several two-hour settling tests and at least one long-term (24-hour) settling test at each site. Table VIII-2 present summaries of the 1984 testing program.

Natural Filtration

Removal of solids by filtration is achieved by passing the wastewater through a medium where the pore sizes are smaller than the particles being removed, thereby trapping the particles. At many placer mines, filtration is performed naturally as the wastewater is discharged through the tailings from the mining operations. Those particles larger than the pore size in the tailings are trapped and removed. Tailings filtration may be beneficial in that the fines are recombined with the coarse tailings. No specific data are available to determine the removal efficiencies or the effluent quality from existing treatment at placer mines because the discharge is not generally discrete, but is most often diffuse in the form of seepage.

Recycle of Process Waters

A major method of reducing the pollution load on the receiving waters is the recycling of process water. This also conserves water and is a present practice at many placer mines. Approximately 50% of the mines recycle all or a portion of their wastewater. Recycling of process waters at a placer mine is a relatively simple operation, requiring the installation of a pump at the pond and piping to the head of the mining operation. The size of the pumps and piping would be based on the process flow required and the percentage to be recycled.

Recycling of wastewater at gold placer mines has several advantages and disadvantages as summarized below:

Advantages	Disadvantages
1. Allows mining especially in water short areas and minimizes water use elsewhere.	1. Higher pumping costs are incurred because of additional energy requirements and expected increased pump wear.
2. Reduces mass of pollutant load to the receiving stream.	2. Higher piping costs because more pipe may be required, additional wear on the pipe and steel pipe may be required in place of plastic pipe.
3. Smaller or fewer settling ponds may be required to meet effluent limitations.	

A concern of the industry is that fine gold recovery decreases when recycled water containing suspended solids is reused in the sluice. However, only limited scientific data were available to address this issue. Therefore, the Alaska Department of Environmental Conservation (ADEC) funded a study (Reference 3) to address the potential loss of gold recovery during recycle. This

FIGURE 3

PILOT TEST
RECYCLE FACILITY

(PLAN VIEW)
scale: 1/2"=1'

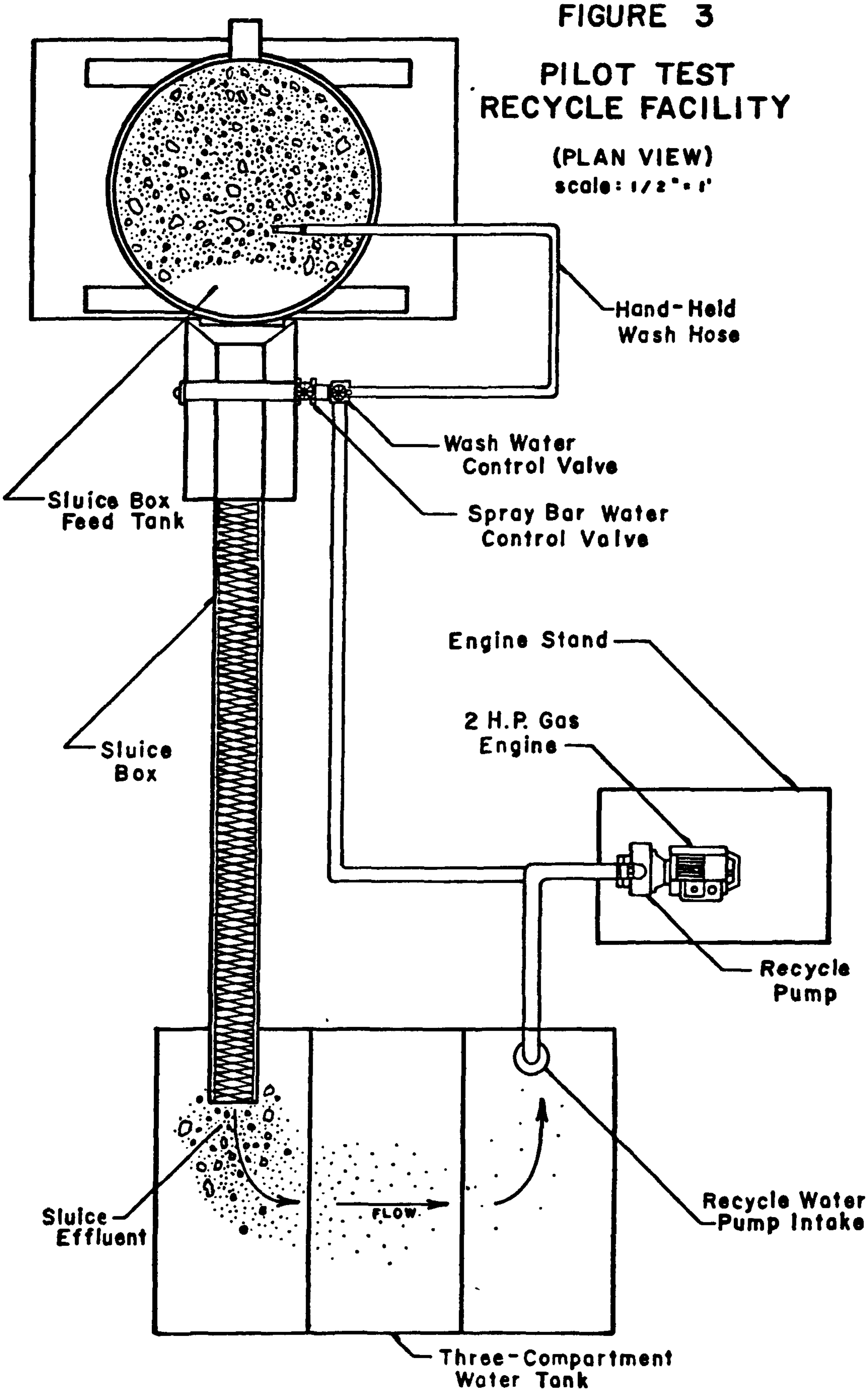
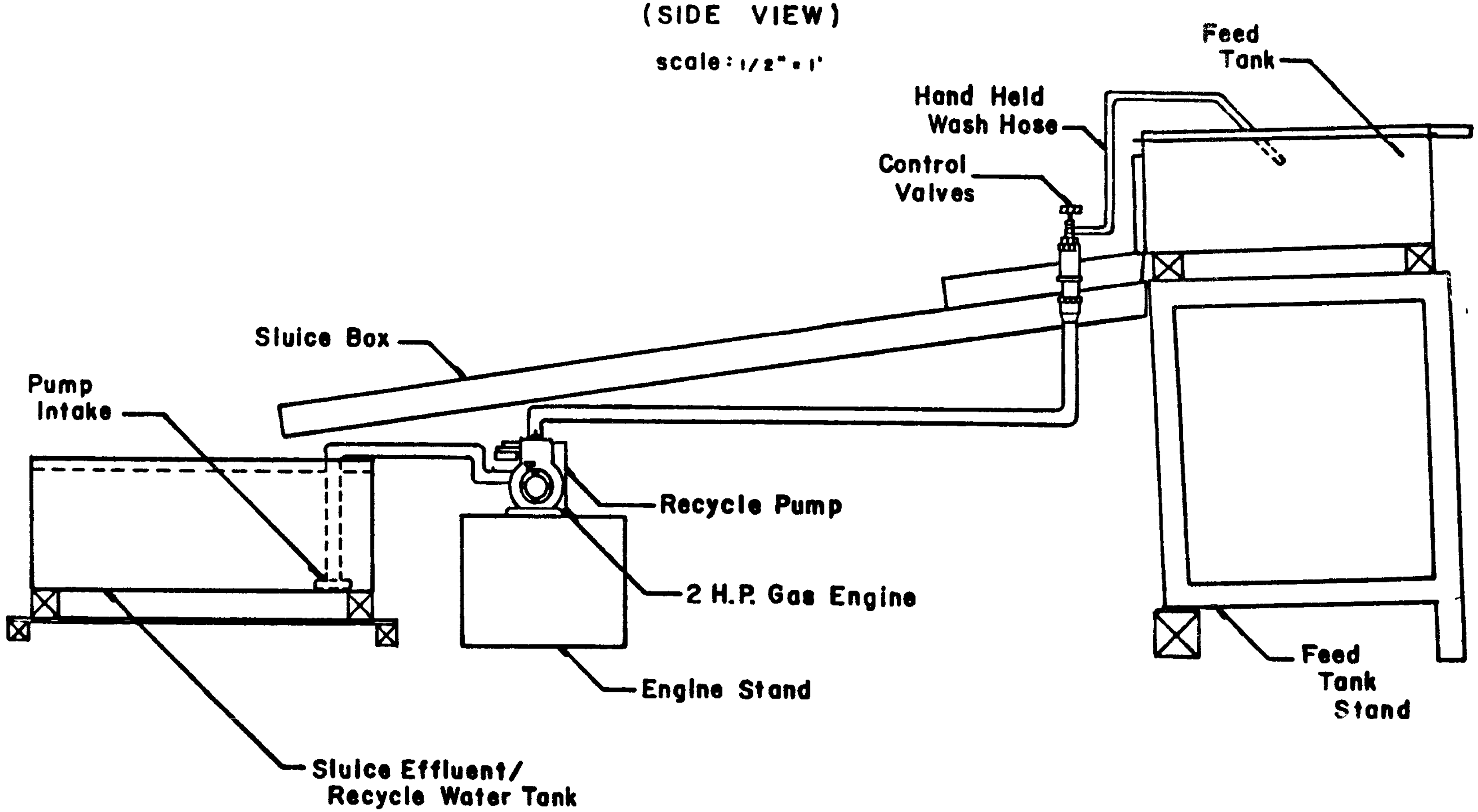


FIGURE 4

PILOT TEST RECYCLE FACILITY

(SIDE VIEW)

scale: 1/2" = 1'



study was divided into two parts, a pilot-scale study and a field study. EPA expanded on this study and funded a supplemental study on the effects of recycle on gold recovery. The EPA study, Reference 4, used essentially the same set-up as the ADEC study. In both of these studies, a six-inch-wide, eight-foot-long sluice with a feed hopper and slick plate were used (see Figure VIII-3 and Figure VIII-4). The slope of the sluice during both studies was set at 1.75 inches per foot.

In the EPA-funded study, ore from an operating mine in the Fairbanks District was used. The paydirt was screened and only material finer than 0.75 inch was used in the pilot-scale tests. A new batch of ore with an unknown quantity of gold was used during each run. The material was resluiced after each run to determine the gold loss. The gold used in the study was -30 to +60 mesh. A known quantity of gold was added to the ore prior to each run in order to have a statistically significant amount of gold in the sluice box. The target TSS levels in the test runs were as follows:

Table VIII-3

Test No.	TSS Concentration (mg/l)
1	0
2	25,000
3	50,000
4	100,000
5	200,000
6	200,000

The size distribution of gold added during each test run is shown in Table VIII-4. The major results of this study are summarized on Tables BIII-5 and VIII-6. At all suspended solids

Table VIII-4. Size Distribution of Gold Added to Each Run.

Run No.	-30 + 50 Mesh	-50 + 60 Mesh	Total
1	9.9612	2.5279	12.4891
2	10.0079	2.6490	12.6569
3	10.2561	2.4956	12.7517
4	10.3743	2.5238	12.8981
5	9.8473	2.6621	12.5094
6	10.2897	2.5169	12.8066
Total	60.7365	15.3753	76.1118

Note: Amounts of gold are presented in grams.

Source: Reference 4

Table VIII-5. Pilot Test Water Quality Data (Sluice Influent).

SLUICE INFLUENT

Parameter	Run 1	2	3	4	5	6
Suspended Solids	217	39,100	58,800	90,100	194,000	187,000
Turbidity	95	24,000	30,000	46,000	134,000	108,000
Settleable Solids	-0.1	180	270	400	680	650
Specific Gravity	0.998	1.022	1.034	1.052	1.122	1.118
Viscosity @ 20°C	1.0	1.8	2.0	3.0	4.2	4.1
Visc. @ Run Temp.	2.0	3.2	2.9	4.9	7.7	6.2
Run Duration	34	39	37	38	38	14
Water Duty	0.22	0.19	0.21	0.20	0.20	0.56

SLUICE EFFLUENT

	1	2	3	4	5	6
Suspended Solids	10,000	48,000	65,100	98,300	199,000	204,000
Turbidity	2,200	24,000	33,000	39,000	128,000	100,000
Settleable Solids	25	200	290	420	680	660
Specific Gravity	1.004	1.029	1.039	1.060	1.122	1.133
Viscosity @ 20°C	1.5	1.7	2.2	2.8	4.4	4.9
Visc. @ Run Temp.	3.0	3.1	3.1	4.6	8.1	7.3

Units:

Suspended Solids	mg/L
Turbidity	NTU
Settleable Solids	ml/L
Specific Gravity	gm/cc at 20° C
Viscosity	cp(centipoise) - gm mass/cm sec
Run Duration	min
Water Duty	yd^3/1000 gal (cubic yards of pay dirt sluiced using 1000 gallons of water)

Note: "-0.1" denotes less than 0.1

Source: Reference 4

Table VIII-6. Percent Gold Recovery.

TOTAL GOLD

Run	Riffle 1	2	3	4	Gold Loss*
1	99.63	0.32	-0.01	0.01	0.04
2	99.59	0.38	0.02	0.01	-0.01
3	99.54	0.39	-0.01	-0.01	0.05
4	99.40	0.52	0.04	0.03	0.02
5	99.08	0.71	0.04	0.03	0.13
6	97.84	1.83	0.08	0.08	0.18

-50 + 80 MESH GOLD

Run	Riffle 1	2	3	4	Gold Loss*
1	99.00	0.81	0.02	0.05	0.12
2	98.97	0.94	0.05	0.02	0.03
3	98.96	0.86	0.03	0.04	0.11
4	98.41	1.41	0.06	0.08	0.04
5	97.96	1.79	0.10	0.04	0.11
6	95.42	4.03	0.25	0.09	0.21

Note: "-0.01" denotes less than 0.01 percent.

*Recovered after sluicing by suction dredge

Source: Reference 4

Table VIII-7. Recycle of Wastewater at Alaskan Placer Gold Mines.

	Volume of Ore Sluiced Per Day (yd^3/day)					
	$\leq$ 1000		1000 to 2500		$\geq$ 2500	
Recycle Percent	No. of Mines	Percent of Industry	No. of Mines	Percent of Industry	No. of Mines	Percent of Industry
0	95	42.6	14	6.3	4	1.8
1-24	4	1.8	1	0.4	0	0
25-49	6	2.7	5	2.2	2	0.9
50-74	23	10.3	5	0	3	1.4
75-89	8	3.6	0	0.4	0	0
90-99	8	3.6	1	0.7	0	0
100	38	17.0	3	1.4	3	1.4
Total	182	81.6	29	12.9	12	5.5

Table VIII-8. Recycle of Wastewater at Alaskan Placer Gold Mines Expressed by Production.

	Volume of Ore Sluiced Per Day (yd^3/day)					
	$\leq$ 1000		1000 to 2500		$\geq$ 2500	
Recycle Percent	No. of yd^3/day	Percent of Industry	No. of yd^3/day	Percent of Industry	No. of yd^3/day	Percent of Industry
0	24,070	14.4	23,800	14.3	13,600	8.1
1-24	690	0.4	1,500	0.9	0	0
25-49	2,510	1.5	9,000	5.4	11,000	6.6
50-74	11,040	6.6	9,700	5.8	21,050	12.6
75-89	3,240	2.0	0	0	0	0
90-99	4,620	2.8	1,200	0.7	0	0
100	11,245	6.8	4,700	2.8	13,800	8.3
Total	57,415	34.5	49,900	29.9	59,450	35.6

concentrations, over 99.5 percent of the gold was recovered. The results of this study and the ADEC study indicate that gold loss due to recycle is minimal.

Recycle Practices at Alaska Placer Gold Mines. Recycle pratices at various production levels were investigated (5). It was determined that partial and 100 percent recycle are practiced at all mine sizes; however, approximately one-half (50.7 percent) do not recycle any process wastewater.

Table VIII-7 lists the number of mines recycling wastewater, grouped by production level and the amount of recycle employed. Table VIII-8 lists the percentage of mines practicing recycle by percentage of recycle. This information was derived from Reference 5 and was obtained from a computerized summary of Tri-Agency Forms compiled from mines which submitted completed Tri-Agency Forms in 1984. These forms are submitted by the miner prior to the mining season and are an estimate of what the miner intends to do, not necessarily what will actually be done. The table below summarizes the Alaskan gold placer industry by production level from information submitted on Tri-Agency Forms.

Table VIII-9

	<1000	1000 to 2500	>2500
Mines	81.6%	13.0%	5.4%
Production	34.5%	29.9%	35.6%

The larger mines are small in number but sluice approximately one-third of the total volume of material. Based on production levels above, 21.3 percent of the industry is achieving 90-100 percent recycle of the process wastewater.

Geographic Distribution of Mines Which Recycle. The geographic distribution of mines practicing some degree of recycle was examined to determine if location played any significant role in determination of recycle practices. The table below summarizes the approximate percentage of mines in each mining district and the corresponding percentage of partial and total wastewater recycling operations (Reference 6):

Table VIII-10

Mining District	Percentage of Mines Recycling	Percentage of Mining Operations
Circle	15.4	17.5
Fairbanks	26.4	24.2
Forty Mile	7.3	7.2
Hot Springs	1.8	1.3
Iditarod	0.0	0.9
Innok	0.9	0.0
Koyukuk	6.4	6.3
Kuskikwin	3.6	2.3
Seward	2.7	4.6
Seward Peninsula	6.4	4.0
Other Districts	29.1	30.9

Based upon the analysis presented above, recycling of wastewater at placer gold mines in Alaska is practiced in all major Alaskan mining districts. Many facilities which recycle do so because of limited water availability.

Treatment System Options

After a review of available data, it is apparent that treatment of placer mine wastewater should be based on the use of simple settling with or without recycle or polymer addition to the blow down from recycle. The settling ponds should be sized for six hours detention time. In addition, the pond should have a volume sufficient to store the amount of sludge expected without interfering with the detention time. In evaluating the use of primary and secondary settling ponds, polyelectrolyte use and recycling, several arrangements and points of polyelectrolyte application were considered. After an in-depth review of potential systems, five alternative treatment systems are being considered. These systems or options are presented schematically on Figure VIII-5 through VIII-7.

Option 1

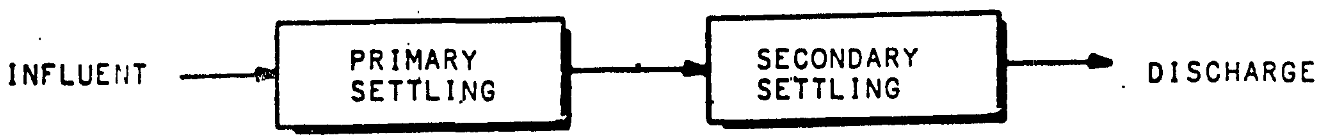
This option consists of using one primary pond. The pond would be sized for six hours detention time of process water plus 20 percent for freeboard, and the volume necessary to store the expected sludge volume.

Option 2

This option utilizes two settling ponds, primary and secondary. The primary pond, designed to settle the heavy particles, would be sized for one hour detention time of process water. Flow from the primary pond would be further treated in a secondary pond sized for six hours detention time for the process water. This

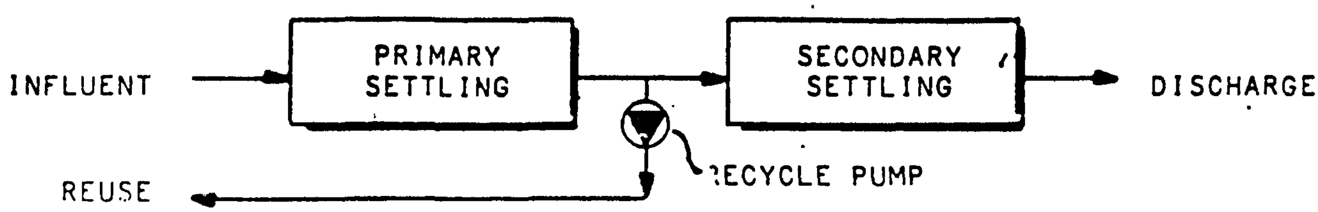
FIGURE VIII-5 PLACER MINING WASTEWATER TREATMENT OPTIONS

OPTION 1

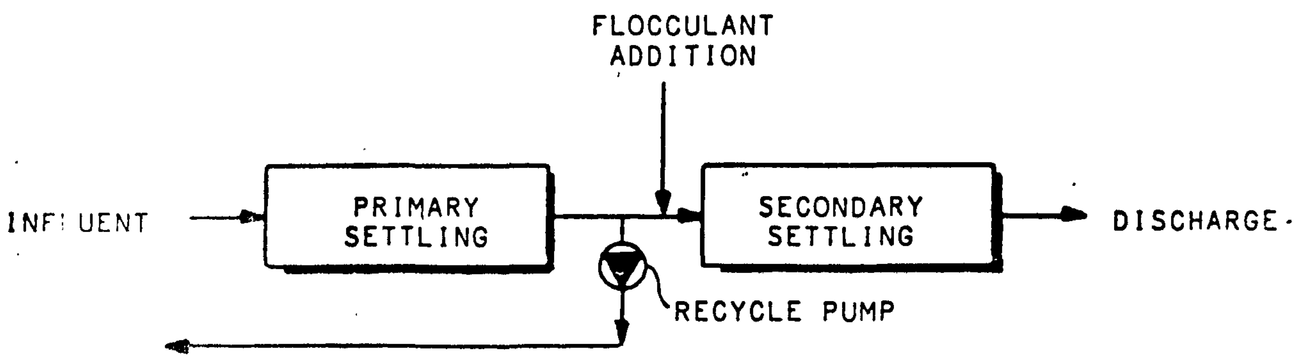


OPTION 2

FIGURE VIII-6. PLACER MINING WASTEWATER TREATMENT OPTIONS

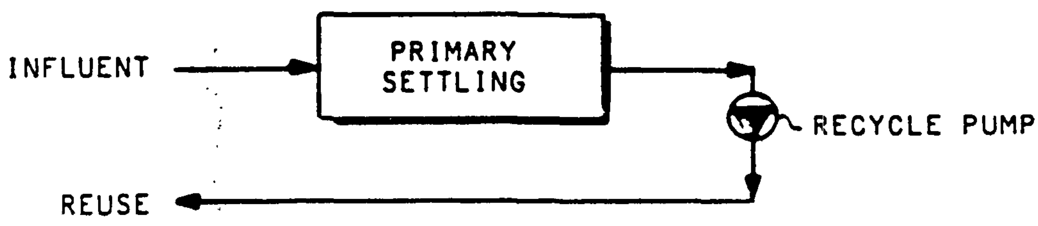


OPTION 3



OPTION 4

FIGURE VIII-7. PLACER MINING WASTEWATER TREATMENT OPTIONS



OPTION 5

approach allows for the construction of a small primary pond near the mining operation which would be reconstructed as the mining area moves, and the construction of a larger secondary pond once a season to treat all the process water.

Option 3

This option employs the same two-pond system as Option 2 but includes recycle after the primary pond. The primary pond would be sized for one hour detention of process water. Eighty percent of the water would be returned to the beneficiation process for reuse and the remainder (the 20 percent blowdown) would be further treated in a secondary pond. The secondary pond would be sized for the blowdown on that portion of the wastewater not recycled. This approach would reduce the pollution load or the mass of pollutants to the receiving water by eighty percent due to recycle.

Option 4

This option is the same as Option 3, except that a flocculant aid (polyelectrolyte) is added between the primary and secondary ponds after the water has been recycled. Again the pollution load to the receiving water would be reduced because of recycle as in Option 3 and the use of polyelectrolyte on the blowdown would further reduce the pollution load to the receiving water over the reduction obtained by Option 3.

Option 5

This option is the same as Option 1, using one primary pond as a holding pond, but the total volume of process water is recycled. This option would have no discharge of process wastewater from the beneficiation process.

HISTORICAL DATA SUMMARY

As discussed in Section V, the EPA data base consists of 16 studies and sampling and analysis programs from 1976 to 1984. Additional studies and analysis are being performed now and more will be conducted in 1986. Below is a summary of the data gathered during seven studies conducted by EPA, Alaska Department of Environmental Conservation, their contractors and the Canadian Department of Indian and Northern Affairs. Data from many different facilities over several years have been collected. However, as summarized below and as can be found in the individual reports, the data for existing facilities prior to 1984 was not adequate to propose effluent limitations guidelines and standards. Therefore, EPA is relying primary upon the data and information obtained in 1984 studies of existing treatment, interpretation of pretreatment studies and the engineering assessment of the basic treatment process to propose effluent limitations and standards.

Dames and Moore Study - 1976

This study was one of the first studies conducted which attempted to evaluate water quality from mining operations (7). Many of the mines visited did not have settling ponds installed, and therefore little information on the effectiveness of settling ponds was obtained.

NEIC Study - 1977

The EPA National Enforcement Investigations Center sampled eight mines with ponds (8). The effluent water quality from the single or multiple pond settling systems is summarized in Table VIII-11. The results indicate a wide range of settleable solids levels achieved ranging from <0.1 to 15 ml/l. Mercury was not detected in the effluent from any of the settling ponds. The ponds are characterized as not being designed or built to obtain effluent goals, but to provide a temporary holding pond or sump for process water for the beneficiation process, i.e., sluice.

Calspan Study - 1979

In 1978, Calspan Corporation sampled the effluent from eleven operating Alaskan placer gold operations (9). The effluent data from the ten active mining operations with settling ponds are summarized in Table VIII-12. Five mines achieved settleable solids readings of less than 0.1 ml/l. The total suspended solids (TSS) concentrations ranged from 76 to 5,700 mg/l in the effluent. No turbidity readings were obtained. Arsenic concentrations in the final effluent ranged from <0.002 mg/l to 1.2 mg/l. It was noted that the highest settleable solids and TSS readings occurred with the highest arsenic and mercury data which suggested a concentration of TSS with arsenic and mercury.

Table VIII-11. Historical Data Summary from NEIC Study - 1977.

Mine Code	Settling Pond Effluent Data* Settleable Solids (ml/l/hr)	Total Turbidity (NTU)	TSS (mg/l)	Total Arsenic (mg/l)	Total Mercury (mg/l)
4139	15	1,200	4,000	0.560	<0.0001
4114	NA	140	NA	NA	NA
4140	1.3	740	1,000	NA	NA
Unknown	<0.1	130	220	0.057	<0.0002
4107	NA	5,200	22,000	2.5	<0.001
4141	<0.1	79	120	0.031	<0.0002
4134	0.4	1,300	1,420	0.280	<0.0002
4142	0.3	1,800	2,080	0.270	<0.0002

*Two additional mines sampled, however no pond effluent samples were obtained.

NA - Not Analyzed

Table VIII-12. Historical Data Summary from Calspan Study - 1979.

	Settling Pond Effluent Data*			
Mine Code	Settleable Solids (ml/l/hr)	TSS (mg/l)	Total Arsenic (mg/l)	Total Mercury (mg/l)
4126	<0.1	57	0.250	<0.0002
4127	2.5	5,700	1.20	0.0005
4132	0.4 to 0.8	1,040	0.050	<0.0002
4133	<0.1	170	0.060	0.0002
4134	0.3 to 0.42	1,620	0.050	<0.0002
4144	1.5 to 2.8	1,770	0.080	<0.0002
4135	0.7 to 0.9	474	0.022	<0.0002
4136	<0.1	150	<0.002	<0.0002
4137	<0.1	262	<0.002	<0.0002
4138	<0.1	235	0.010	<0.0002

*One additional mine was sampled, however there were no settling ponds at this mine.

Pond retention time and volume were not measured, but the visual assessment indicated inadequately sized ponds are included in this data.

R & M Consultants Study - 1982

The R & M study included an evaluation of a demonstration pond, settling column tests, and a reconnaissance study (10). R & M Consultants visited and sampled seven mines employing settling pond treatment technology. The effluent from these ponds was sampled, and the results are presented in Table VIII-13. Ponds sampled do not necessarily represent adequately sized ponds. Therefore, the results do not indicate the best effluent quality that can be achieved. Settleable solids concentrations ranged from <0.1 to 19.5 ml/l. At one mine, an increase in settleable solids, turbidity, and TSS increased during the year indicating that the pond was filling up. Turbidity readings in the pond effluent during this study ranged from 160 to 6,900 NTU and averaged 2,676 NTU.

R & M Treatability Study - 1982

One of the major objectives of the R & M study was to evaluate the sedimentation rates of particles from placer mine sluice discharges (10). Settling column tests were conducted on the wastewater from 15 individual mines. Wastewater was obtained from sluice box effluents. Turbidity values were taken 1.5 feet and 5.5 feet below the initial height of the settling column. The R & M study concluded "that reductions in turbidity to the Alaska standard of 25 NTU above natural conditions could probably

Table VIII-13. Historical Data Summary from R&M Reconnaisance Study - 1982.

Mine Code	Trip No.	Settleable Solids (ml/l/hr)	Turbidity (NTU)	TSS (mg/l)
		Settling Pond Effluent Data		
2	1	<0.1	1,100	776
	2	Ponds Washed Out		
	3	Ponds Washed Out		
3	1	<0.1	1,400	776
	2	<0.1	850	468
	3	0.1	1,300	600
6	1	0.1	1,400	910
	2	<0.1	1,500	878
	3	<0.1	1,100	1,180
8	1	No ponds during this visit		
	2	18	5,000	19,900
	3	2	2,100	2,310
9	1	1.7	1,800	1,090
	2	5.5	4,000	2,070
	3	19.5	NA	NA
13	1	<0.1	1,800	660
	2	<0.1	160	410
14	1	0.1	4,500	2,960
	2	4.5	7,900	5,160
	3	6.5	6,900	6,470

*Mine 1 not included since settling pond effluent samples were not obtained. Mines 4, 5, 6, 10, 11 and 12 were not included since no settling ponds were employed at these sites.

NA - Not Analyzed

not be obtained in a practical manner by sedimentation alone." R & M Consultants' extrapolation of the data indicated that approximately 60 days of sedimentation would be necessary to achieve the 25 NTU standard under the laboratory conditions of the test. Based on the settling column tests, R & M concluded that it would not be practical to design a demonstration settling pond to achieve state turbidity standards.

A 22-day settling column test was conducted at one mine. After 528 hours of quiescent settling, the TSS and turbidity values were 120 mg/l and 390 NTU, respectively. Even after 22 days, a considerable amount of dilution water from the creek would be needed to meet the State of Alaska water quality standard for turbidity.

At 15 mines, six-day settling column tests were conducted. The average TSS concentration from the 15 mines after six days of quiescent settling was 931.3 mg/l. The average turbidity reading obtained at the end of the same period was 1,543.7 NTU.

KRE 1984 - Reconnaissance and Treatability Study

Kohlmann Ruggiero Engineers (KRE) gathered data during the 1984 mining season at gold placer mines in Alaska. Studies included treatability tests of effluents with and without polyelectrolyte settling aids, flow determination, sampling and profiling the mine's equipment costs, physical layout, and wastewater treatment system. The details of this study can be found in Reference 13.

Mine sites were screened using available data from 1983 and through discussions with EPA, Region X, Alaska DEC, individual miners and miners' associations. Twenty mines were selected for futher screening and on-site visits. These twenty mines were selected to be representative of mines found over the State of Alaska considering: geographical location, type of mining, size, depth and type of overburden, topography, and treatment employed (including high rate recycle).

These twenty mine sites were visited in June 1984 by EPA, KRE, and a consulting mining engineer; an engineering work-up and fact sheet was completed at each mine. The mines represented the 7 mining districts with the largest population of mines; mines had capacities of 50 yd^3/day to over 3000 yd^3/day; water use varied from once-through to over 90 percent recycle; overburden varied from none to over 60 ft; and mines located in broad flood plains and narrow valleys were represented. The data collected were reviewed by EPA-ITD and KRE, and ten mines were selected as representative of the site factors considered. These ten mines were than sampled and on-site treatability studies were performed.

During the month of July and August 1984, a field crew from KRE visited each of the 10 mines selected and conducted on-site treatability testing as well as sampling and analyses for settleable solids and turbidity. Samples were prepared for laboratory analyses of TSS, arsenic, and mercury and flow measurements were made at each of the 10 mines selected. The crew were on site two to four days at each mine.

At each mine, the treatability tests were performed in three parts. First, jar tests were used to select the appropriate polyelectrolytes and to determine dosage at each site. Second, settling column tests, with and without polyelectrolytes, were conducted over a period of two hours. Finally, a long-term (up to 24 hours) unaided settling test was conducted.

The existing wastewater treatment system was evaluated by sampling the influent water, effluent from the sluice, effluent from the ponds or discharge to the receiving water, and other points to evaluate water quality, i.e., recycle water and run off. Using dye, flow patterns were observed to determine detention time or identify short-circuiting in the ponds. Flow meters or weirs were used to determine the flow from the sluice and discharge from the ponds. The sizes of the ponds were measured using a range finder and the depths were determined using a "sinker" at various locations in the ponds.

Field observations by EPA personnel and contractors reveal that properly designed, operated, and maintained settling ponds will remove very high percentages of pollutants associated with the solids encountered in the wastewater from placer mines. An evaluation of the ten existing treatment facilities tested by KRE in 1984 indicated that 4 of the mines should not be included in the data base to determine effluent limitations because two of the mines selected had not maintained the ponds and the ponds were filled with sludge causing short circuiting and severly reduced detention time; one mine had no point source discharge because of recycle; and one mine was identified as having an unique distribution of collodial clays in the paydirt. For the six mines remaining the arithmetic average of analysis are:

Averages (6 mines)

	Water Supply	Sluice Discharge	Final Effluent	% Removed
Settleable Solids (ml/l)	0.1	50	1.0	98.0
TSS (mg/l)	275	30,000	2,000	93.3
Turbidity (NTU)	300	22,500	4,000	82.2
Arsenic (mg/l)	0.0425	0.9000	0.3100	65.6
Mercury (mg/l)	<0.0005	0.0070	0.0009	87.1

The installations used in the above tabulated averages are still mixed in quality of basic design parameters (size, flow control, and storage capacity for sludge resulting in reduced settling and detention times), and operation and maintenance performance. Based on observed conditions at the mines and at the mine's treatment installations, two mines were identified as not having properly designed, constructed, and maintained treatment systems to serve as representative of best or even good treatment. Eliminating the data from these two mines and averaging the analysis from the remaining mines:

Averages (4 best of 6)

	Water Supply	Sluice Discharge	Final Effluent	% Removed
Settleable Solids (ml/l)	0.10	66	0.1	99.9
TSS (mg/l)	275	35,722	496	98.6
Turbidity (NTU)	300	22,837	808	96.5
Arsenic (mg/l)	0.0425	0.7364	0.1288	82.5
Mercury (mg/l)	<0.0005	0.0013	<0.0005*	61.5

*Results below the detection limit of 0.0005 mg/l.

The second phase of this 1984 field study consisted of performing settling tests, e.g., plain settling without polyelectrolyte and aided settling with polyelectrolyte. Jar tests were conducted to identify the flocculant type and dosage. The results indicated an optimal dosage of polyelectrolyte of about 2.0 mg/l.

A combination of polymers in many instances proved more effective in reducing the contaminant levels than application of a single polymer. These tests are not all inclusive but offer a comparison between plain settling and flocculant-assisted settling. Numerical averaging is used below and all values tabulated represent the average level after a detention time of two hours.

	Plain Settling	All Flocculant Assisted Tests	Best Flocculant Assisted Test
Settleable Solids (ml/l)	0.75	<0.1	Trace
TSS (mg/l)[1]	4472	85	24.7
Turbidity (NTU)	9268	375	88
Arsenic (mg/l)	0.432	0.0257	0.0181
Mercury (mg/l)	0.0057	<0.0005	<0.0005

[1] Total suspended solids values (TSS) used to determine the average after two hours settling are emperical observations taken from the settling curves constructed for each individual test and are conservativly high.(13) The TSS concentration in the actual supernatant would be less than the value used here.

These tests indicate a considerable reduction in solids can be achieved by flocculant-assisted settling. The water samples at the beginning of the tests and at the end of two hours were analyzed for arsenic and mercury. These analyses for mercury and arsenic indicate that mercury and arsenic are related to TSS and are thus in the suspended or precipitated state and would be removed incidentally with the removal of the suspended solids (TSS) as discussed in Section VI.

In addition to the 2 hour settling tests, a 24 hour plain settling test was performed on these same 10 mines. The wastewater was sampled at 1 1/2 to 1 ft below the surface at 0, 1, 2, 3, 6, and 24 hours. As for the 2 hour settling test, the solids in the supernatant would be consistantly less than indicated here because the water was sampled well below the surface of the testing device. A tabulation of these time periods for the 10 mines is presented below.

Settling Time-Hours		Settleable Solids ml/l	Suspended Solids mg/l	Turbidity NTU
0	Range	3.2 to 125	5,580 to 51,413	2,016 to 34,560
	Average	47.3	27,000	20,000
1	Range	0.2 to 6	400 to 11,825	603 to 21,600
	Average	1.75	6,600	10,000
2	Range	0 to 1.0	183 to 12,320	281 to 32,000
	Average	0.47	5,200	11,300
3	Range	0 to 0.4	116 to 12,700	128 to 30,240
	Average	0.16	4,900	9,950
6	Range	0 to 0.1	29 to 12,000	38 to 35,280
	Average	0.05	3,900	9,650
24	Range	0 to <0.1	19 to 9,120	27 to 25,200
	Average	<0.1	2,800	7,700

The results show a decrease in all parameters throughout the 24 hour period. Comparing the 2 hour test with the 24 hour test results indicates the improvement from 6 hours to 24 hours is minimal. Because of the obvious increased construction costs (four times the volume) for the increased detention time of 6 to 24 hours, for design purposes, ponds to provide 6 hours of detention time are used in the technology to attain effluent limitations and to determine cost of construction.

In Section VI the long term, daily, and monthly achievable levels are determined statistically using the effluent data obtained in 1984 at existing facilities sampled by EPA contractors and EPA Region X sampling teams, and data from treatability studies conducted by EPA contractors. As discussed above, some of the effluent data from existing facilities does not represent good treatment which can be obtained by properly designed, constructed, and operated settling ponds. Also, by refering to the data, i.e., total suspended solids analysis for the same day, in Appendix VI-2 of Section VI, large differences in reported values are observed which, if considered as individual values, cause a large standard deviation from the mean and push up the long term average. The effect of using data from under sized or poorly constructed and operated treatment facilities is two fold: (1) it increases the simple average or mean and (2) the peak values, e.g., out liers, increase the statistically determined attainable long term average limitations.

EPA believes that simple settling facilities designed, constructed, and operated as outlined in this section can consistently attain less than 0.2 ml/l settleable solids and less than 2000 mg/l total suspended solids as indicated by the KRE 1984 - Treatability Studies.

FTA and KRE Treatability Studies - 1983

The FTA and KRE treatability studies evaluated both unaided and polymer-aided settling. The details of these studies are found in References 12 and 13. Unaided settling column tests were conducted at each of the eleven mines visited by FTA and KRE. The results of unaided settling column tests have already been summarized in Table VI-3.

Canadian Department of Indian and Northern Affairs Treatability Study

The treatability studies performed for the Canadian Department of Indian and Northern Affairs by Sigma Resources Consultants were similar to both the FTA and KRE treatability studies. Unaided and polymer-aided settling column tests and coagulation jar tests using organic polymers were performed at several mines. Unaided settling column tests were performed at four placer gold mines and polymer-aided settling column tests were performed at two mines. All mines were located in the Yukon Territory of Canada.

Settling column tests were performed on simulated sluice effluents. Soil samples from the mine were mixed with a known volume of water to produce the simulated wastewater. A six-inch-diameter, six-foot-long plexiglas column with sampling ports at 1, 3, and 5 feet from the bottom was used. Settling column tests were performed to determine settling rates and settling pond effluent quality. These settling column tests were conducted for a period of 18 to 19 hours. Turbidity values at the end of unaided settling tests ranged from 80 NTU to 2,200 NTU.

Two organic polymers, Superfloc 1128 and Separan MG 200, were used in performing standard jar tests on simulated placer mine wastewaters. Superfloc 1128 is a non-ionic polymer, which was also used in the FTA treatability study. Separan MG 200 is an anionic polymer. In this study, Separan MG 200 produced the best results at each of the mines tested. Relatively low dosages of this anionic polymer removed a high percentage of the turbidity and suspended solids from the wastewater. Polymer dosages between 3 and 20 mg/l were effective. Jar tests at an additional mine proved ineffective in that 20 mg/l of Separan MG 200 was required to produce a supernatant TSS of 500 mg/l.

Lime, alum, and ferric chloride were independently tested on this wastewater at dosages of 100 mg/l. Using these inorganic coagulants, TSS concentrations between 100 and 200 mg/l were achieved.

Based on the jar tests, two polymer-aided settling column tests were conducted. The duration of these tests were relatively short as most of the turbidity and suspended solids were removed from the wastewater during the first few minutes of the test.

Polymer dosages selected for use in the column tests were 3 mg/l and 10 mg/l. At these dosages, final TSS concentrations of 30.5 mg/l and 10.5 mg/l, respectively, were achieved.

In summary, this Canadian treatability study of Yukon gold placer mine wastewaters supports the basic conclusions of the FTA, KRE, and R & M treatability studies. First, unaided or natural settling of gold placer mining wastewater over relatively long periods of time does not produce a high quality effluent. Secondly, several organic polymers have been identified which can produce relatively low turbidity and suspended solids concentrations in placer gold mining wastewater at dosages of approximately 10 mg/l.

Best Management Practices

Section 304(e) of the Clean Water Act authorizes the Administrator to prescribe "best management practices" ("BMP") and Section 402(a)(1) of the Act allows the Administrator to prescribe conditions in a permit which are necessary to carry out the provisions of the Act including BMP's. The discharges to be controlled by BMPs are plant site runoff, spillage or leaks, sludges, or waste disposal and drainage from raw material storage.

The gold placer mining industry has direct controls and limitations on the storm water runoff which is mine drainage and the groundwater infiltration and seepage which enters the treatment system and is commingled with "process wastewater" as discussed in Section X of this Development Document. Similarly the runoff from the "process area" discussed in Section X is included in the "process wastewater" controlled by effluent limitations guidelines and standards.

Minimizing the volume of water contaminated and going to mine drainage is desirable because the volume of mine drainage and mass of pollutants which is commingled to be treated is less. Diversion of water around a mine site to prevent its contact with the active mine and pollution-forming materials is an effective and widely applied control technique at many ore mines.

Runoff

Runoff from outside of the mine area and groundwater seepage from the surrounding hillsides should be diverted around the active mining area at placer mines because this reduces the volume of wastewater to be treated and can improve the performance of existing treatment systems. For a given settling pond or group of ponds as the volume of wastewater discharged into a pond decreases, the retention time within the settling pond increases, which increases the removal of settleable and suspended solids.

Control of the runoff from outside the active mining area is practiced by many surface ore mines, but was not observed that frequently at gold placer mines. Control technology or BMP's include bypass ditches and berms to divert runoff away from the mine which can be built using the mining and construction equipment at the placer mine.

Regrading and recontouring of the surface left after mining and of the tailings and waste from the sluice can decrease surface runoff going to mine drainage and also often decrease erosion of the area after mining has ceased.

As mentioned above under in-process controls, influent to the beneficiation process should be controlled or the flow stopped during extended periods when the gold recovery process is not being loaded. While it is a process control, it is also a best management practice which reduces the leak of excessive wastewater to the treatment system. Also, influent to the process or make-up water to a recycle system can use mine drainage rather than influent from the receiving stream which will also reduce the amount of wastewater to be treated. The use of mine drainage in the process as all or part of the required or allowed influent is widely practiced by the industry.

As discussed above under design construction and operation of settling ponds, sludge deposited in the ponds is generally handled by mechanically cleaning the ponds periodically during the mining season, by building a new pond as the old pond fills with sludge and is left, or by building the original pond with sufficient volume to hold the sludge produced in a season and still provide sufficient retention time for the wastewater. Regardless, the sludge produced in wastewater treatment should be handled and disposed of in a manner which precludes through best management practices the introduction of the sludge to the waters protected by the effluent limitations. These practices include:

1. Constructing the settling pond out of the stream and out of the flood plain where practicable. Sludge left in the pond will then have less probability of being washed out during periods of heavy flow in the stream.

2. Sludge that is removed mechanically should be covered and stored as far as practicable from the stream. Tailings from the recovery process can be used to intermingle and to cover the sludge.

3. Ponds that are to be abandoned at the end of the mining season or are abandoned during the season because they filled with sludge should be dewatered or drained to the interface of the sludge and the ponds filled and leveled with tailings from the recovery process.

1. Harty, D. M. and Terlecky, P. M., "Water Use Rates at Alaskan Placer Gold Mines Using Classification Methods," Memorandum to B. M. Jarrett, USEPA-EGD, 29 February 1984.

2. Kohlmann Ruggerio Engineers, "1984 Alaskan Placer Mining Study and Testing Summary Report," Preliminary Draft, September

Guidelines Division.

3. Shannon and Wilson, "Placer Mining Wastewater Treatment Technology Project, Phase 2 Report," Prepared for the State of Alaska Department of Environmental Conservation, November 1984.

4. Petterson, L. A.; Tsigonis, R. C.; Cronin, J. E.; and Hanneman, K. L., "Investigation of the Effect of Total Suspended Solids Levels on Gold Recovery in a Pilot Scale Sluice," September 1984.

5. Harty, D. M. and Terlecky, P. M., "Existing Wastewater Recycle Practices at Alaskan Placer Gold Mines," Frontier Technical Associates Memorandum to B. M. Jarrett, USEPA-EGD, 29 February 1984.

6. Harty, D. M. and Terlecky, P. M., "Geographic Distribution of Mines Employing Partial or Total Recycle." Frontier Technical Associates Memorandum to B. M. Jarrett, USEPA-EGD, 2 March 1984.

7. Dames and Moore, "Water Quality Data at Selected Active Placer Mines in Alaska," Report No. 9149-001-22, September 17, 1976, prepared for Calspan Corporation.

8. USEPA National Enforcement Investigations Center, "Evaluation of Settleable Solids Removal Alaska Gold Placer Mines," EPA Report No. 330/2-77-021, September, 1977.

9. Bainbridge, K. L., "Evaluation of Wastewater Treatment Practices Employed at Alaskan Gold Placer Mining Operations," Report No. 6332-M-2, Calspan Corporation, Buffalo, N.Y., July 17, 1979.

10. R&M Consultants, Inc., "Placer Mining Wastewater Settling Pond Demonstration Project," Prepared for the Alaska Department of Environmental Conservation, June, 1982.

11. Harty, D. M. and Terlecky, P. M., "Reconnaissance Sampling and Settling Column Test Results at Alaskan Placer Gold Mines," Frontier Technical Associates Report No. FTA-84-140211, November 15, 1983, Prepared for USEPA Effluent Guidelines Division.

12. Kohlmann Ruggiero Engineers, "Treatability Testing of Placer Gold Mine Sluice Waters in Alaska, U.S.," Prepared for USEPA Effluent Guidelines Division, January 1984.

13. Kohlmann Ruggiero Engineers, P. C., 1984 Alaskan Placer Mining Study and Testing Report (Draft).

SECTION IX

COST, ENERGY, AND OTHER NON-WATER QUALITY ISSUES

DEVELOPMENT OF COST DATA BASE

General

Generalized capital and annual costs for wastewater treatment processes at placer mining facilities are based on cubic yards of paydirt processed. Assumptions regarding the costs, cost factors, and methods used to derive the capital and annual costs are documented in this section. All costs are expressed in 1984 dollars (Engineering News Record, Construction Cost Index (CCI) = 4161; third quarter of 1984).

The cost estimates were based on assumptions regarding system loading and hydraulics, treatment process design criteria, and material, equipment, personnel, and energy costs. These assumptions are documented in detail in this section. The estimates prepared have an accuracy of plus or minus 30 percent.

Fourth quarter 1984 vendor quotations were obtained for all major equipment and packaged systems. Construction costs were based on standard cost manual figures (see References IX-1 and IX-2) adjusted to the fourth quarter, 1984.

The wastewater treatment unit processes studied are as follows:

Primary Settling
Secondary Settling
Flocculant (Polyelectrolyte) Addition
Recycle

The unit processes were used in five treatment options (See Section VIII) as follows:

1. Primary settling with a six-hour detention time.

2. Primary settling, with a one-hour detention time, followed by secondary settling with a six-hour detention time.

3. Primary settling, with a one-hour detention time, followed by 80 percent recycle of the primary pond effluent to the sluice and secondary settling of the remaining 20 percent for six hours.

4. Primary settling, with a one-hour detention time, followed by 80 percent recycle of the primary pond effluent to the sluice and flocculant addition prior to secondary settling, with a six-hour detention time of the remaining 20 percent of the flow.

5. Primary settling, with a six-hour detention time, and recycle of 100 percent of the treated water to the sluice.

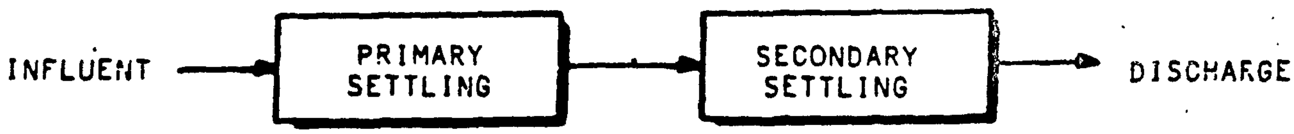
It should be noted that, due to the limitations of this cost estimating approach, the cost for equipment necessary to recycle 50 percent of the flow or more is basically the same. Therefore, the cost for options using 80 or 100 percent recycle can be used to estimate the cost of recycle of another percentage of 50 percent or more.

The above five options are shown schematically in Figures IX-1 through IX-3.

FIGURE IX-1. PLACER MINING - WASTEWATER TREATMENT OPTIONS

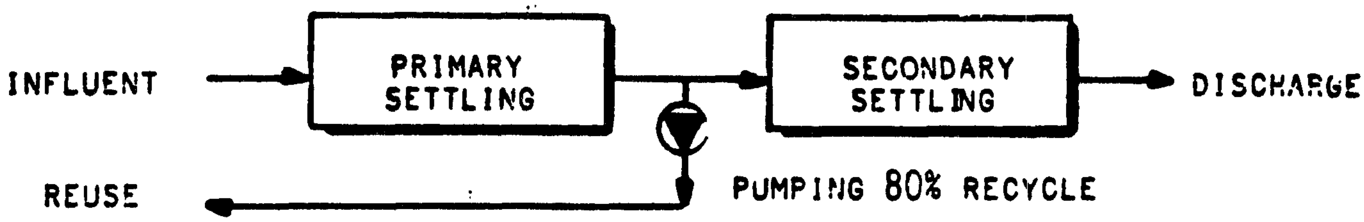
COSTING STUDY

OPTION 1

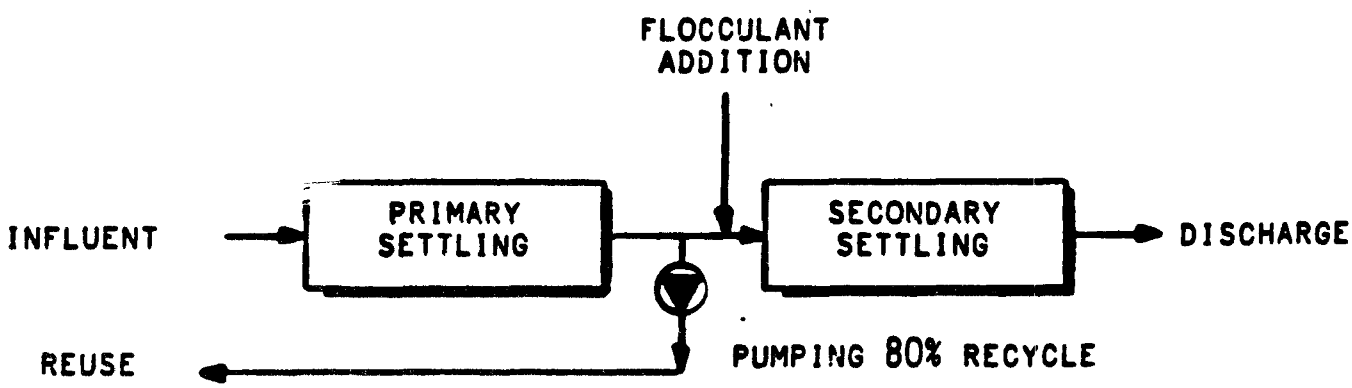


OPTION 2

FIGURE IX-2. PLACER MINING - WASTEWATER TREATMENT COSTING STUDY



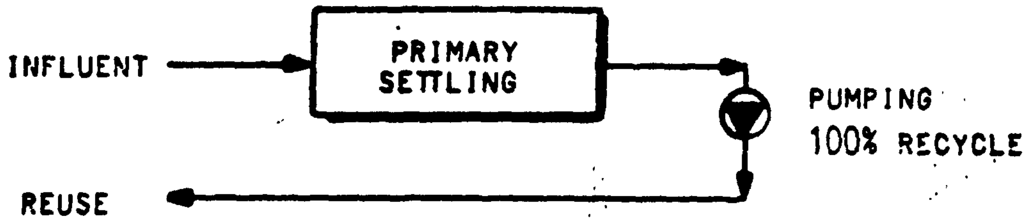
OPTION 3



OPTION 4

FIGURE IX-3. PLACER MINING - WASTEWATER TREATMENT OPTIONS

COSTING STUDY



OPTION 5

CAPITAL COST

Capital Cost of Facilities

Figure IX-4 presents a schematic representation of a generic placer mine treatment system. This diagram shows the distances assumed between the various facilities which were used to determine the materials required for the systems and the costs of those materials.

Settling Ponds.

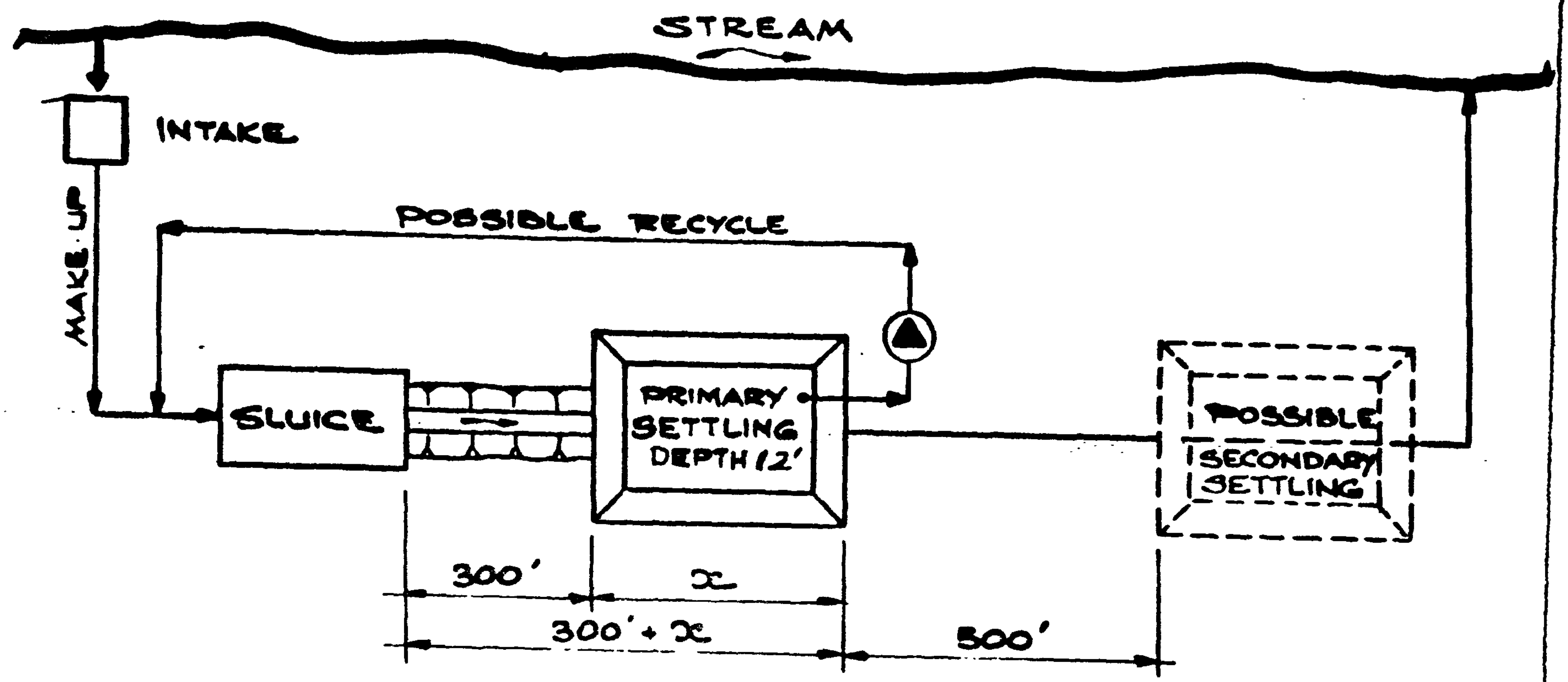
Construction costs for settling ponds were based upon assumptions (specifically documented later in this section) regarding the retention time and geometry of the ponds. Costs for earth moving were based on a cost per cubic yard of material moved. The cost of earth moving was determined by contacting Caterpillar Tractor Co. and determining the earth-moving capacity of a new piece of equipment. The capacities and costs supplied by the manufacturer, are as follows:

Equipment	Operating Capacity	Lease Cost*
D-6	100 yd^3/hr	$ 71.44/hr
D-7	200 yd^3/hr	$ 90.37/hr
D-8	300 yd/hr	$114.74/hr
D-9	500 yd/hr	$182.45/hr

*Includes equipment, insurance, fuel and nominal maintenance. Fuel cost was $1.75 gallon (Source: Lease Agency in Anchorage; costs applicable to Fairbanks area).

(These estimates also reflect maneuvering time.)

FIGURE IX-4. PLACER MINING INDUSTRY GENERIC WATER SYSTEM SCHEMATIC



The estimated costs and hours to construct the settling ponds were determined using a new machine. A sludge density (settled solids) of 50 percent was used to calculate pond volumes needed.

Piping.

Capital costs for piping, were calculated for aluminum pipe, were obtained from various suppliers and from References 1 and 2. The costs include the cost of the pipe, delivery to the site, and installation. Piping was sized based on normal velocities and pressure drops used in engineering design. A minimum velocity of 2 1/2 feet per second was used.

Pumps.

Capital costs for horizontal centrifugal pumps with diesel engine drives were otained from vendor telephone quotations and from References 1 and 2. Installation and delivery costs were added. The costs include piping and valves at the pump location.

Polyelectrolyte Feed Systems.

The capital costs for polyelectrolyte feed systems were obtained from vendor telephone quotations; an installation and delivery cost was added. The cost of a small electrical generator to supply power to the polyelectrolyte feed system was also added.

Capital Cost of Land

Land costs were not included in the estimates since the facilities would be constructed on land which is part of the mining claims. Therefore, no additional costs would be incurred for the land needed for the treatment facilities.

Capital Cost of Contingencies

Unless otherwise stated, a contingency cost of 20 percent was added to the total capital costs generated to cover taxes, insurance, over-runs, and other contingencies.

Deliveries and Installation Costs

All equipment costs were increased by 60 percent to account for delivery and installation at remote regions in Alaska. The 60 percent factor for Alaska was suggested by a contact with Dodge Reports.

ANNUAL COST

Annual Cost of Amortization

Initial capital costs were amortized on the basis of a 15 percent annual interest rate with assumed life expectancy of 5 years for general civil, structural, mechanical, and electrical equipment. However, since the settling ponds will be constructed yearly, their cost is written off every year.

$$CRF = \frac{(r)(1+r)^n}{(1+r)^n - 1}$$

where CRF = capital recovery factor
r = annual interest rate - 15 percent, and
n = useful life in years - 5 years.

Therefore, CRF = 0.29832.

Annual cost of amortization was computed as:

$$Ca = B\ (CRF)$$

where Ca = annual amortization cost, and

B = initial capital cost.

Annual Cost of Operation and Maintenance

Maintenance.

Annual maintenance costs were assumed to be three percent of the total mechanical and electrical capital cost (unless otherwise noted) which excludes the annual costs of the ponds.

Reagents.

The following prices were used to estimate annual costs of chemicals:

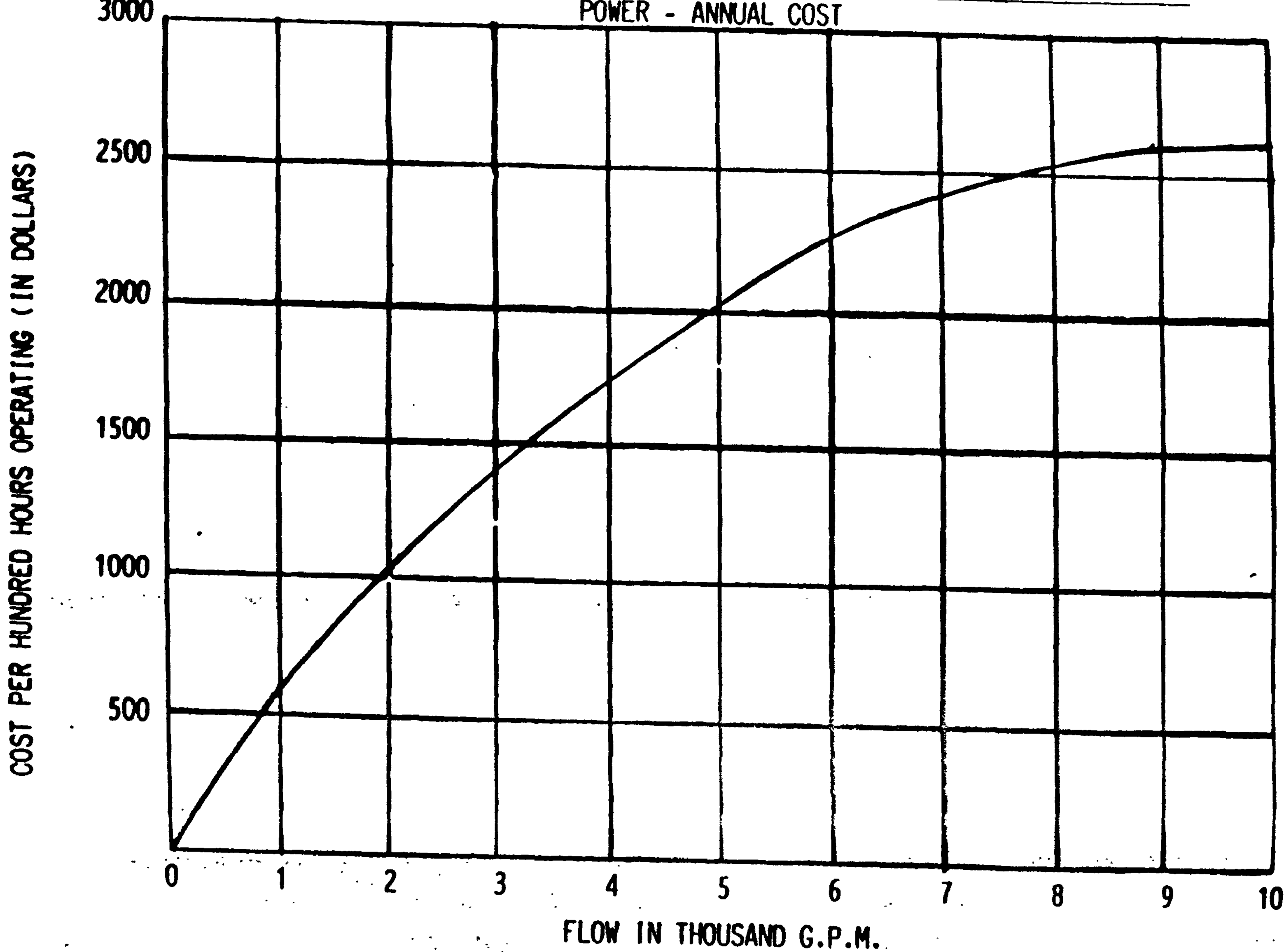
Polyelectrolyte	$2.50/lb delivered

A dosage of 2 mg/l was assumed in calculating the annual cost for chemicals. This assumption is based on the settling tests performed during the 1983 and 1984 treatability studies.

Annual Cost of Energy

The energy cost required for wastewater treatment is the cost of fuel to drive the required engines. Fuel cost at $1.75 per gallon, which includes delivery, was used to estimate costs.

FIGURE IX-5. PLACER MINING - WASTEWATER TREATMENT OPTIONS - COSTING STUDY
POWER - ANNUAL COST



Facilities were assumed to operate 10 hours per day, 65 days per year for mines smaller than 700 yd^3/day, 75 days per year for mines 700 to 1250 yd^3/day, and 85 days per year for large mines over 1250 yd^3/day where we had no actual operating data available. Figure IX-5 is a plot of flow rate versus cost per hundred hours per year of operation.

TREATMENT PROCESS COSTS

Primary Settling

Capital Costs

The required sizes of primary settling ponds were determined by hydraulic loading and design data obtained during field settling tests. Primary settling ponds were sized for each option based on one-hour and six-hour detention times. All pond volumes include volume for flow including 20 percent for freeboard and volume for sediment storage. In all cases, the depth of ponds was assumed as 12 feet. It was also assumed that a new pond would be built when the water depth above the sediment reached a minimum of 3 feet. A sediment density of 50 percent was used for design purposes.

The wastewater was assumed to flow to and from the ponds by gravity. In all options having primary and secondary ponds, it was assumed the four primary ponds would be constructed each mining season at different locations and that the spent ponds would not be refilled. For the two options that have only primary ponds, it was assumed that one pond would be constructed each mining season. Figure IX-6 is a plot of flow rate versus pond excavation volumes. Figure IX-7 is a plot of flow rate versus time of excavation, and Figure IX-8 is a plot of flow rate versus pond excavation cost. The curves are calculated using a D-8 at the capacity and cost as presented above based upon 65 days of sluicing time.

Ponds having a three-hour detention time were also costed since this detention time would produce an effluent close to that of a six-hour detention pond. As can be seen from Figure IX-8, the difference in cost for the six-hour and three-hour ponds is very small and is within the cost-estimating accuracy. Therefore, the six-hour settling ponds were utilized when preparing the cost estimates.

Annual Costs.

Since the ponds will only be constructed for one mining season, the annual amortized cost was assumed to be the construction cost for each pond.

Secondary Settling

Capital Costs.

The required sizes of secondary settling ponds were determined by hydraulic loadings and data obtained during field settling tests. Secondary settling ponds were sized for six hours of detention time based on 100 percent and 20 percent of the total flow. The 20 percent values reflect the amount of water that would be discharged under the 80 percent recycle options.

FIGURE IX-6. PLACER MINING - WASTEWATER TREATMENT OPTIONS - COSTING STUDY

EXCAVATION VOLUME FOR PRIMARY SETTLING PONDS

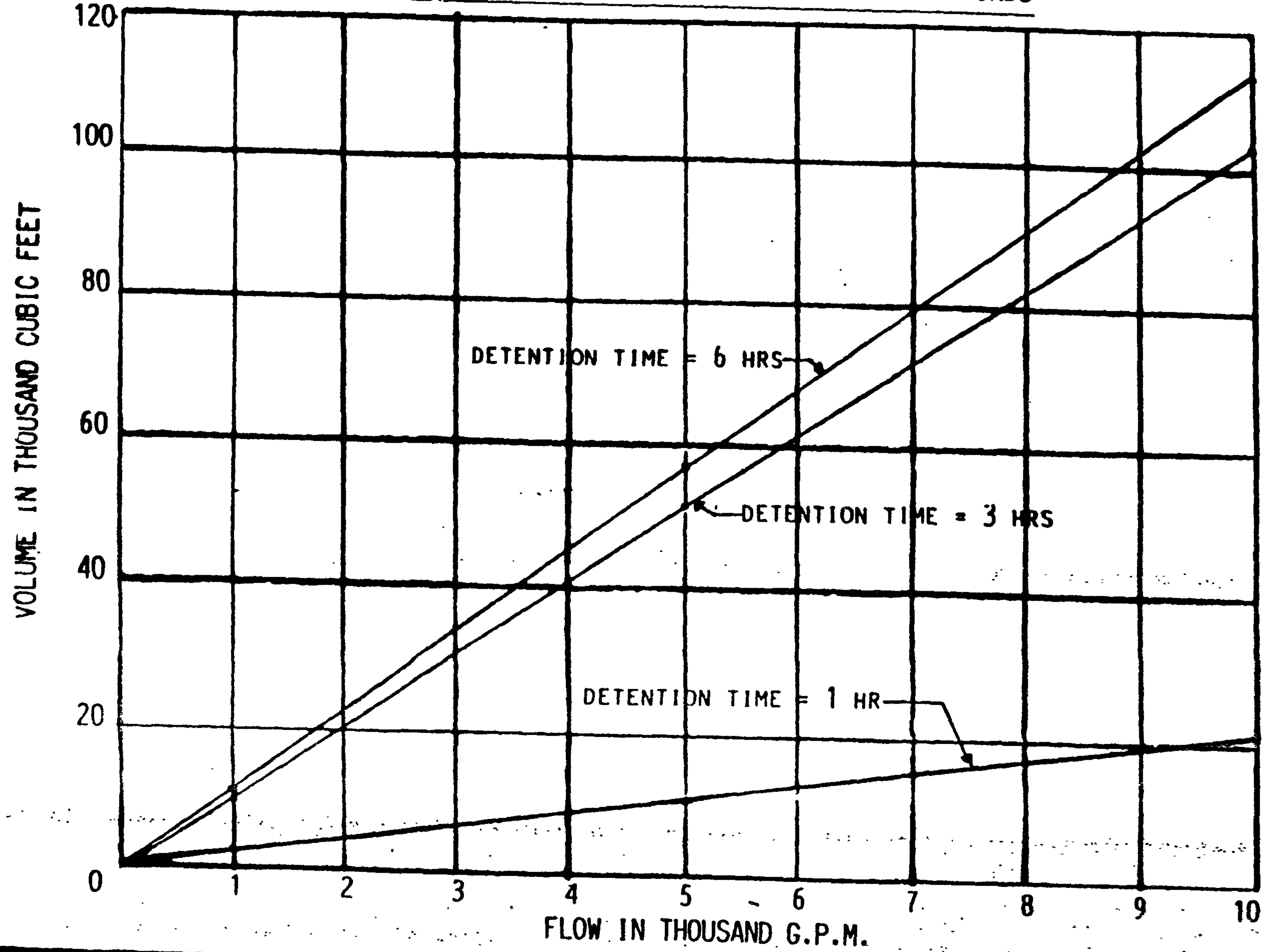


FIGURE IX-7. PLACER MINING - WASTEWATER TREATMENT OPTIONS - COSTING STUDY

EXCAVATION FOR PONDS - CAPITAL COST FOR PRIMARY AND SECONDARY SETTLING

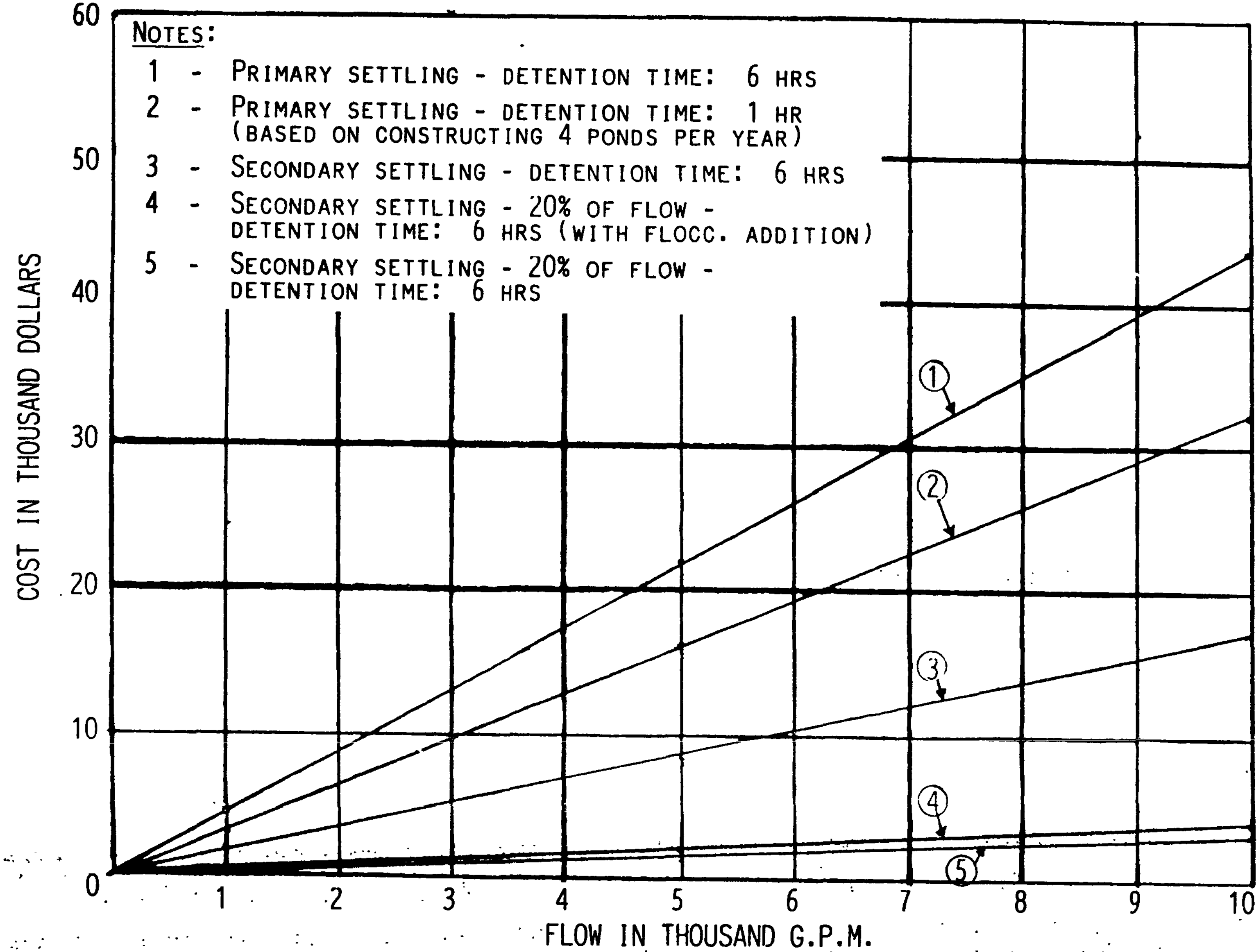
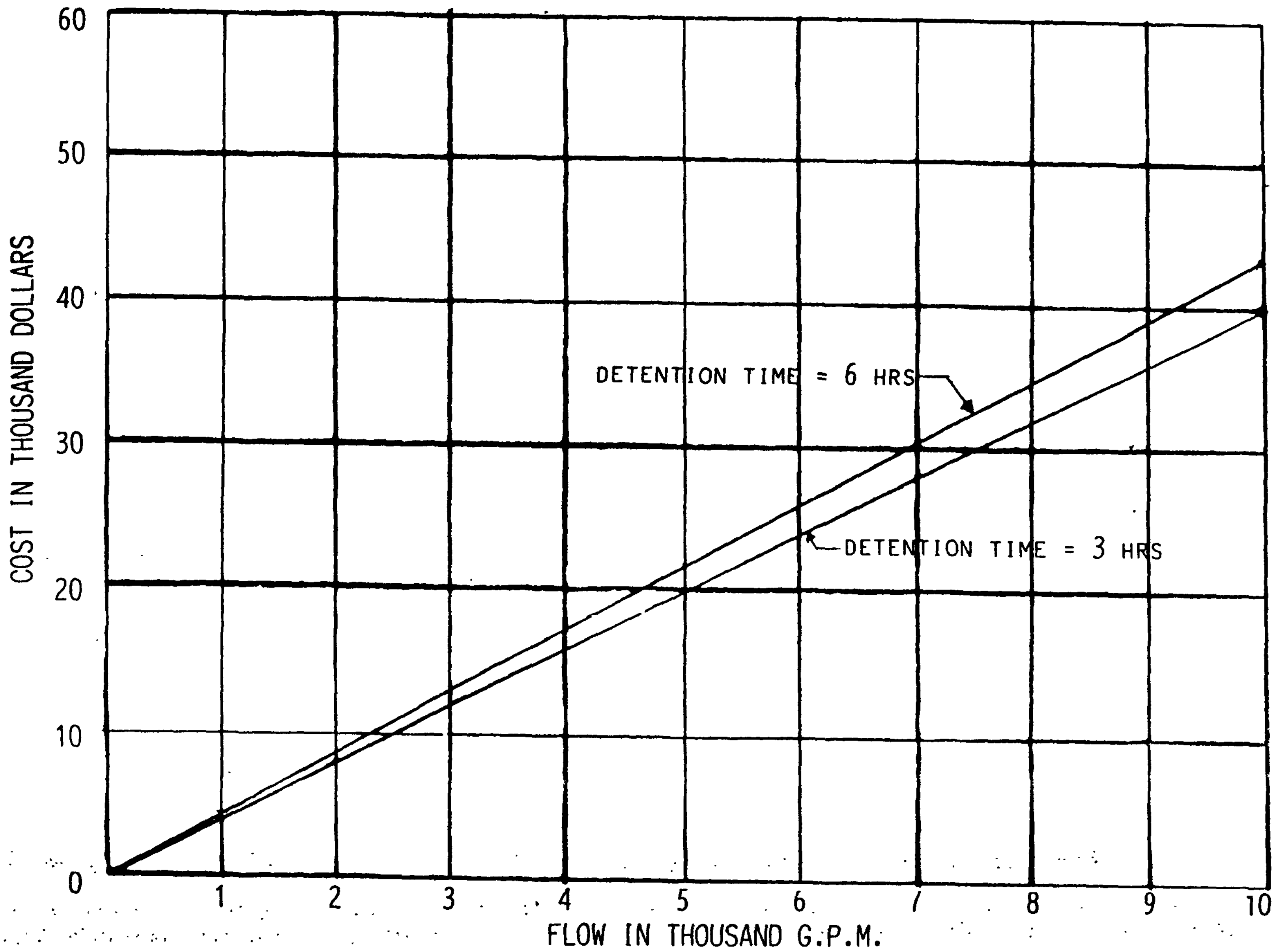


FIGURE IX-8. PLACER MINING - WASTEWATER TREATMENT OPTIONS - COSTING STUDY

EXCAVATION FOR PONDS - CAPITAL COST FOR PONDS HAVING 3 HOURS AND 6 HOURS DETENTION TIME



All pond volumes allow for a safety factor and sediment storage. In all cases, the water depth was assumed to be 12 feet plus 20 percent of flow volume for freeboard, which includes the volume require for sludge storage.

The wastewater was assumed to flow to and from the ponds by gravity. One secondary pond would be constructed during the mining season. Figure IX-9 is a plot of flow rate versus the required volume of excavation for the secondary ponds. The cost of excavation for secondary ponds are presented in Figures IX-7.

Annual Costs.

Since the ponds will only be constructed for one mining season, the annual amortized cost was assumed to be the total construction cost for each pond.

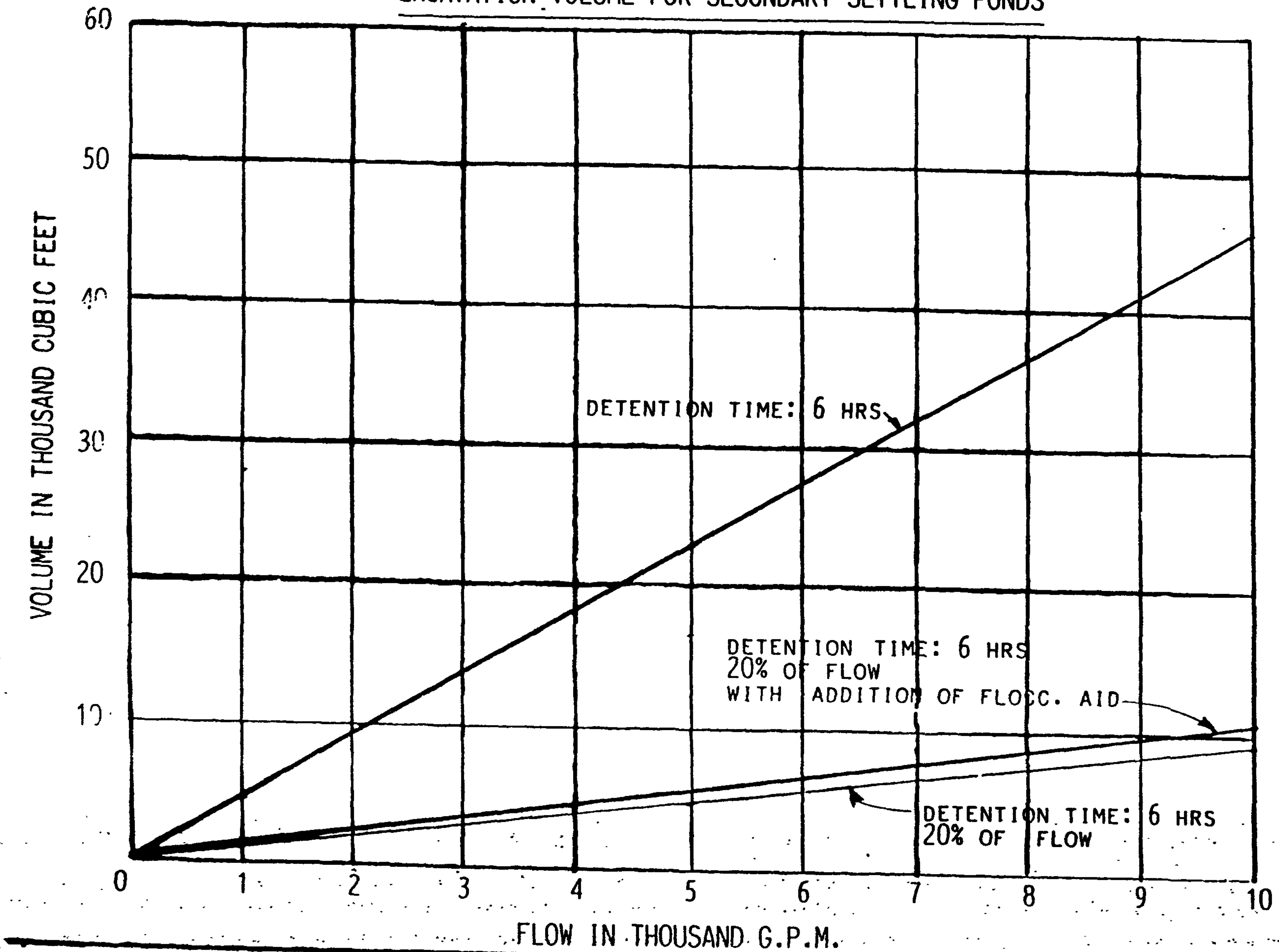
Piping

Capital Costs.

Piping is required after the primary pond whether or not a secondary pond is used. Figure IX-4 shows a typical layout of a placer mine treatment system with the assumed pipe lengths shown. The length of pipe from one end of the primary pond to the other will depend upon the flow rate which dictates the pond size.

FIGURE IX-9 PLACER MINING - WASTEWATER TREATMENT OPTIONS - COSTING STUDY

EXCAVATION VOLUME FOR SECONDARY SETTLING PONDS



In addition, if recycle is practiced, piping will be required from the recycle pumps to the sluice. This length of pipe is also dependent on the flow rate and, in turn, the primary pond size.

Prices for aluminum piping were obtained from manufacturers and 60 percent was added for transportation to the site and installation. The pipe costs per thousand feet for various diameters would be as follows:

4" - $2,900

6" - $5,400

8" - $8,500

10" - $10,700

12" - $13,200

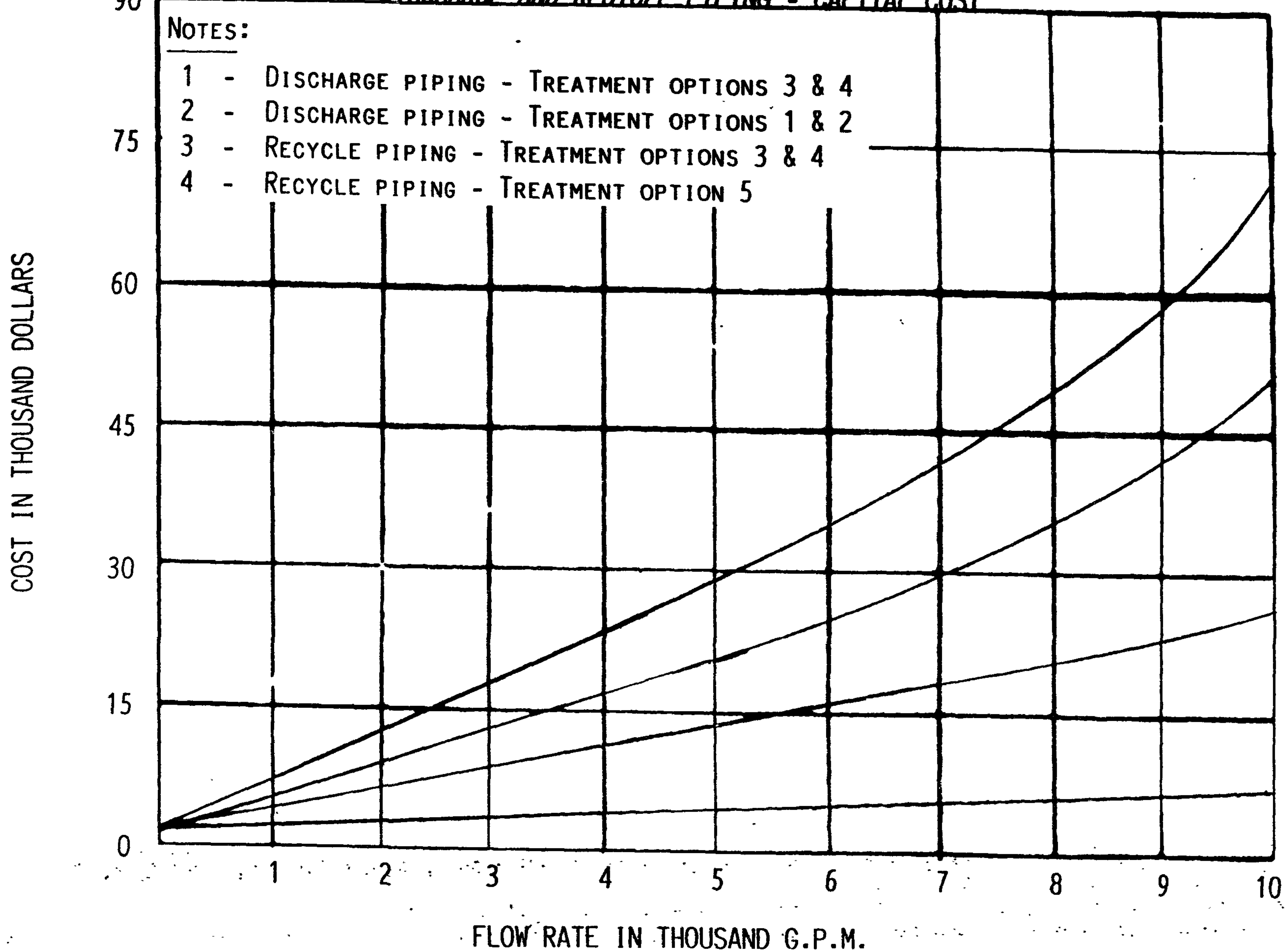
The piping required at a mining site is for discharge piping and recycle piping. A 500 foot length of pipe was utilized for discharge for all mines costed. The length of recycle piping depends upon the length of pond which is dictated by flow rate. To the length of pipe required by pond sizing, a distance of 300 feet was added for the distance between the pond and sluice. The cost for piping at various flows is presented in Figure IX-10.

Annual Costs.

Annual costs for piping systems were assumed to include the following: (1) amortization calculated at 15 percent annual interest over 5 years for equipment (CRF = 0.29832), and (2) annual maintenance at 3 percent of total capital costs.

FIGURE IX-10. PLACER MINING - WASTEWATER TREATMENT OPTIONS - COSTING STUDY

DISCHARGE AND RECYCLE PIPING - CAPITAL COST



Flocculant Addition

Capital Costs.

Capital costs were estimated for flocculation systems consisting of a metering pump mounted on a drum of diluted polyelectrolyte.

A single-sized system was used for all mine sites which includes the flocculant supply system and generator to run the system. This system has an installed cost of $3,000. A flocculant dosage of 2 parts per million was used.

Local electrical and piping connections were included in the cost estimates.

Annual Costs.

Amortization of capital cost for flocculation systems assumed a 15 percent annual interest rate with life expectancies of five years for construcion (CRF = 0.29832). Additional costs were estimated as follows: annual maintenance was assumed to be three percent of capital cost; chemicals were costed at $2.50 per pound for polymer. The cost of chemicals per 100 hours of operation versus flow rates is plotted on Figure IX-11. This figure indicates the cost for several chemical dosages.

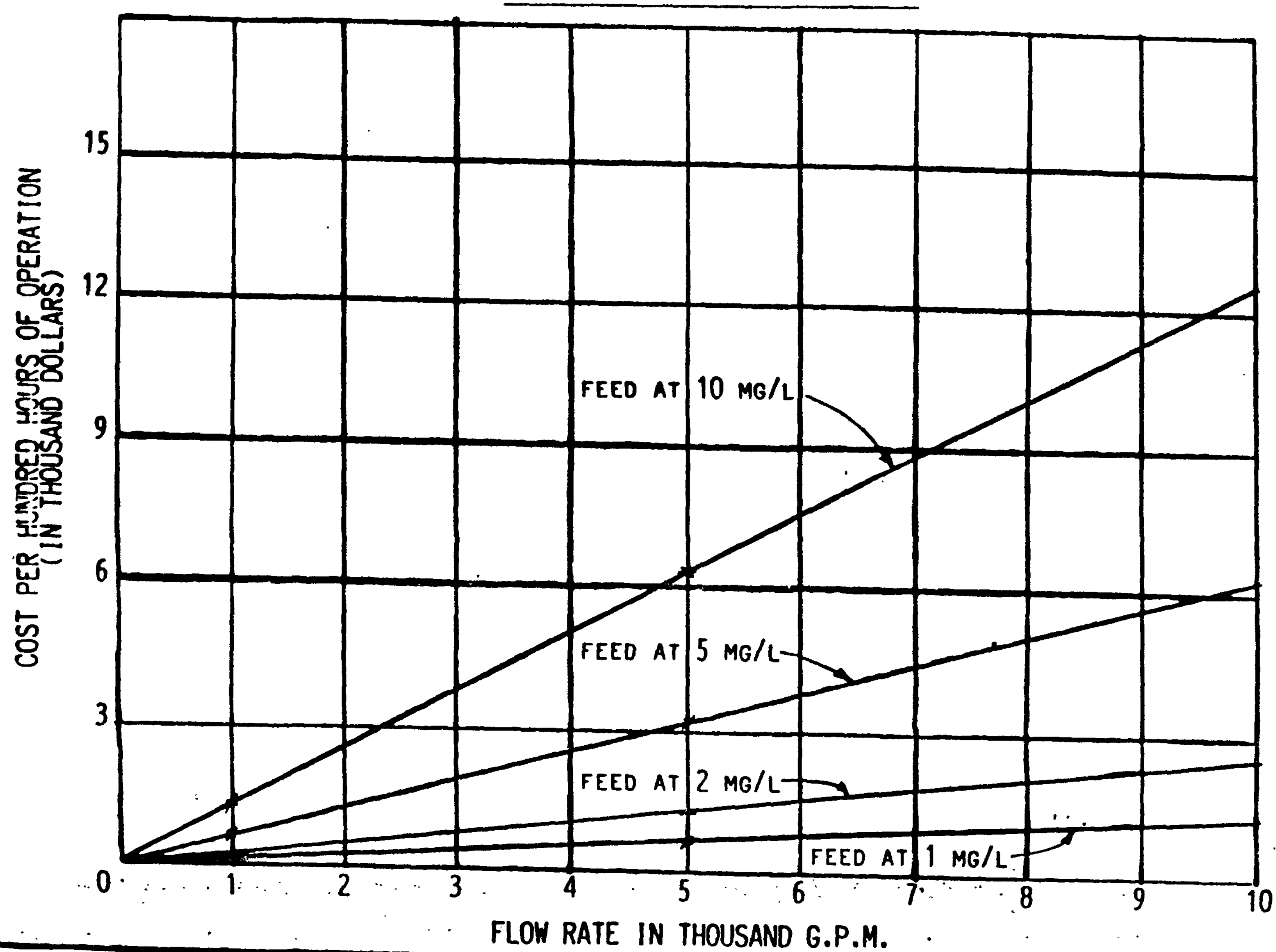
Recycle

Capital Costs.

Cost estimates were prepared for installation of systems to provide for 80 and 100 percent recycle of wastewater. Recycle is

FIGURE IX-11. PLACER MINING - WASTEWATER TREATMENT OPTIONS - COSTING STUDY

POLYELECTROLYTE - ANNUAL COST



accomplished by pumping the primary pond effluent wastewater back to the sluicing operations for reuse. Any quantity greater than the recycle rate would overflow the primary pond and flow to a secondary pond. In preparing the cost estimates, 50 percent recycle was also costed. Due to the accuracy of the cost estimating, the difference in cost for the equipment to recycle 50 percent or more of the flow is minimal; therefore, the costing for 80 or 100 percent recycle can be utilized for any recycle percentage above 50.

Recycle pumps are horizontal, centrifugal-type pumps complete with diesel engines. The pumps are normally supplied as a package which includes the pump, engine, and drive and are skid-mounted. The estimated cost includes pump piping and valves.

Pumping equipment costs were based on vendor quotations. Local piping, valves, and fittings were costed based on vendor definitions and costing methodology in Reference 1.

Pumping equipment selection was based on hydraulic flow requirements assuming a 75 foot total dynamic head requirement.

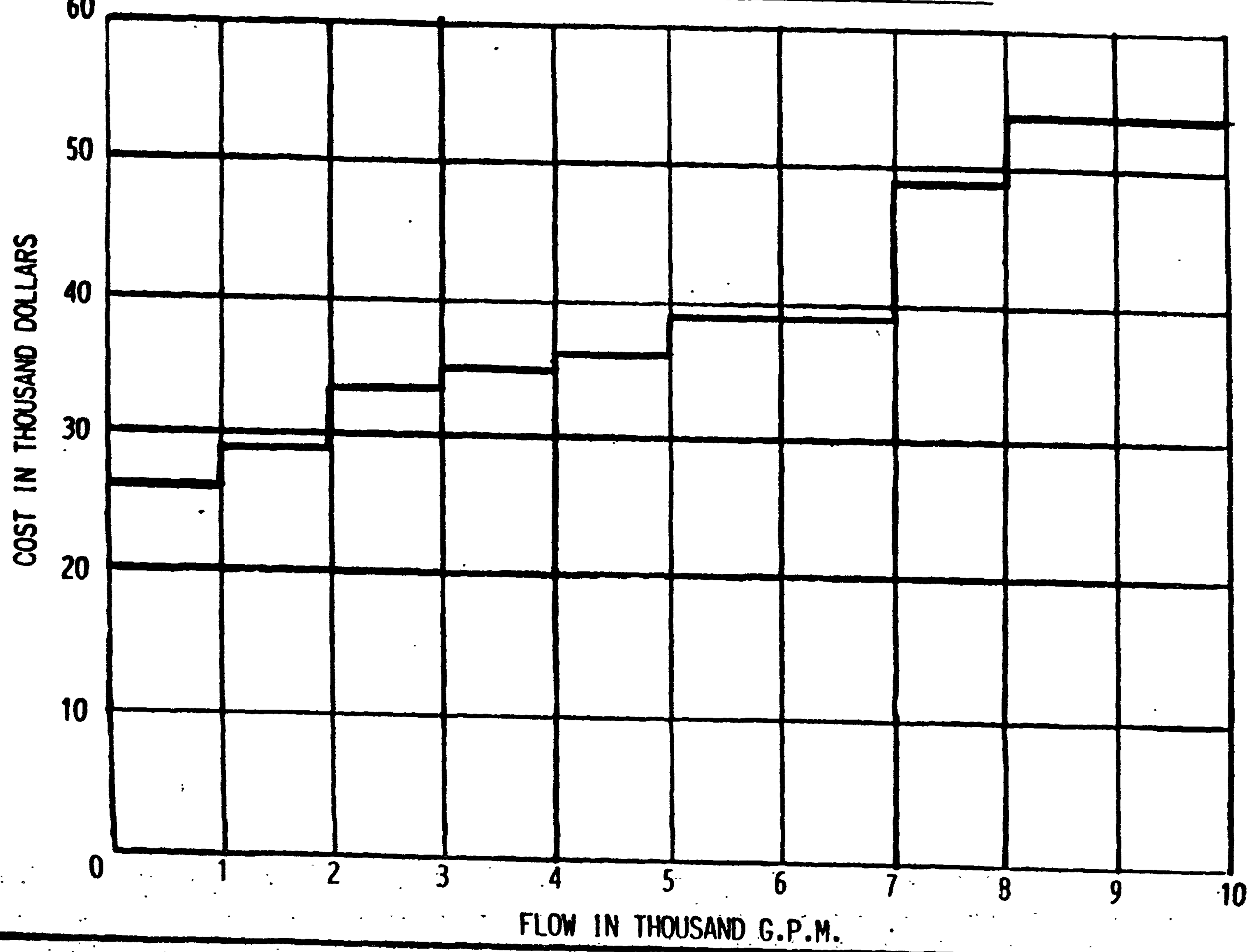
Total capital cost estimates include pumps, diesel engine drivers, piping, valves, fittings, installation, and engineering and contingencies (at 20 percent). Capital cost expressed as a function of hydraulic flow rate is plotted in Figure IX-12.

Annual Costs.

Annual costs for wastewater recycle systems were assumed to

FIGURE IX-12. PLACER MINING - WASTEWATER TREATMENT OPTIONS - COSTING STUDY

PUMPS AND DIESEL ENGINES - CAPITAL COST



include the following: (1) amortization calculated at 15 percent annual interest over 5 years for equipment (CRF = 0.29832), (2) annual maintenance at 3 percent of total capital costs, and (3) fuel computed at $1.75 per gallon.

Construction Time

Due to the relatively short operating period per year available at many sites, time required to construct the wastewater treatment facilities can reduce the total available time for mining. Therefore, estimates were also prepared on the time required to construct and install the various facilities.

Pond Construction.

The hours required to construct the ponds were based on equipment (D-6, D-7, D-8, and D-9 as appropriate) with variable capacities. This capacity was determined by contacting the equipment manufacturer.

Movement of Recirculation Pump.

Field observations indicate a three-hour period is needed to move a recycle pump from one location to another.

Pipelines.

A seven-hour period was estimated to adjust the pipeline to a new primary pond location.

Example of Cost Estimating for Placer Mine Site

The following is the method that can be utilized to determine the estimated cost for the treatment at a mine site using the Figures presented in this section. It should be noted that the cost estimates prepared for mine sites presented later in this section utilized actual calculations and not the Figures. For the purpose of this example Model Mine number 4 was utilized. This model has a sluice flow of 6,000 gpm and considers that the sluice is operated 850 hours per year handling 153,000 cubic yards of pay dirt.

Option 1

The option consists of a single settling pond (primary) with a six-hour detention time and discharge piping of 500 feet.

Cost Estimate:

A. Capital Cost

Primary Pond - From Figure IX-7	$27,000
Piping - Discharge - From Figure IX-10	15,500
Total Capital Cost	$42,500

B. Annual Operating Cost

Primary Pond Construction	$27,000
Amortization of Piping (15,500 x .29832)	4,623
O & M for Piping (15,500 x .03)	465
Total Annual Cost	$32,088

C. Hours to Construct (12 hrs/day)

	Pond Construction - Using D-9 500 cy/hr	168 hrs
	Installation of Piping	20 hrs
	Total Hours	188
	Total Man-Days	15.7
D.	Cost per Cubic Yard Mined (32,088 + 153,000)	$0.21

Option 2

This option consists of a primary settling pond for one-hour detention, followed by a secondary settling pond having a six-hour detention time and discharge piping of 500 feet. The primary pond will be constructed four times in a mining season.

Cost Estimate:

A.	Capital Cost	
	Primary Pond - From Figure IX-7	$19,500
	Secondary Pond - From Figure IX-7	11,000
	Piping - Discharge - From Figure IX-10	15,500
	Total Capital Cost	$42,500
B.	Annual Operating Cost	
	Primary Pond Construction	$19,500
	Secondary Pond Construction	11,000
	Amortization of Piping (15,500 x .29832)	4,623
	O & M for Piping (15,500 x .03	465
	Total Annual Cost	$35,588
C.	Hours to Construct (12 hrs/day)	
	Primary Pond - Using D-9 500 cy/hr	124 hrs

Secondary Pond - Using D-9 500 cy/hr	78 hrs
Installation of Piping	20 hrs
Total Hours	222
Total Man-Days	18.5

D. Cost per Cubic Yard Mined (35,588 + 153,000)

Option 3

This option consists of a primary settling pond having one-hour detention time followed by 80 percent recycle and secondary settling of the remaining 20 percent of the flow. The system requires a recycle pump, recycle piping and 500 feet of discharge pipe. The option considers the construction of the primary pond four times during the mining season.

Cost Estimate:

A. Capital Cost

Primary Pond - From Figure IX-7	$19,500
Secondary Pond - From Figure IX-7	2,500
Piping - Discharge - From Figure IX-10	4,000
Piping - Recycle - From Figure IX-10	22,000
Recycle Pumps - 80% Flow - From Figure IX-12	36,000
Total Capital Cost	$85,000

B. Annual Operating

Primary Pond Construction	$19,000
Secondary Pond Construction	2,500
Power Cost - From Figure IX-5 (80% of Flow)	17,000
Amortization of Equipment (62,000 X .29832)	18,500
O&M for Equipment (62,000 x .03)	1,860
Total Annual Cost	$59,360

C. Hours to Construct (12 hrs/day)

Primary Pond - Using D-2 500 cy/hr	124 hrs
Secondary Pond - Using D-9 500 cy/hr	61 hrs
Equipment Installation (Pipe and Pumps)	70 hrs
Total Hours	255
Total Man-Days	21.3

D. Cost per Cubic Yard Mined (59,360 - 153,000) $0.39

Option 4

This option consists of a primary settling pond having on detention time which is constructed four times during the season. Eighty percent of the effluent from the primary pond recycled to use on the sluice and the remaining twenty percent of the flow is treated in a secondary pond having a detention time of six hours before discharge. Polyelectrolyte is added to the water entering the secondary pond. This option requires recycle pumps, recycle piping and 500 ft of discharge pipe.

Cost Estimate

A. Capital Cost

Primary Pond - From Figure IX-7	$19,500
Secondary Pond - From Figure IX-7	3,500
Piping - Discharge - From Figure IX-10	4,000
Piping - Recycle - From Figure IX-10	22,000
Recycle Pumps - 80% Flow - From Figure IX-12	36,000
Polyelectrolyte System	3,000
Total Capital Cost	$88,000

B. Annual Operating Cost

Primary Pond Construction	$19,500
Secondary Pond Construction	3,500
Power Cost - From Figure IX-5 (80% of Flow)	17,000
Polyelectrolyte at 2 mg/l - From Figure IX-11 (20% of Flow)	2,000
Amortization of Equipment (65,000 x .29832)	19,390
O & M for Equipment (65,000 x .03)	1,950
Total Annual Cost	$63,340

C. Hours to Construct (12 hrs/day)

Primary Pond - Using D-9 500 cy/hr	124 hrs
Secondary Pond - Using D-9 500 cy/hr	61 hrs
Equipment Installation (Pipe, Pump, etc.)	74 hrs
Total Hours	259
Total Man-Days	21.6

D. Cost per Cubic Yard Mined (63,340 + 153,000) $0.41

Option 5

This option consists of a single primary settling pond with a six-hour detention time followed by recycle of 100% of process water. The system requires pond, recycle pumps and recycle piping.

Cost Estimate

A. Capital Cost

Primary Pond - From Figure IX-7	$27,000
Piping - Recycle - From Figure IX-10	38,000
Recycle Pump - From Figure IX-12	39,000
Total Capital Cost	$104,000

B. Annual Operating Cost

Primary Pond Construction	$27,000
Power Cost - From Figure IX-5	19,550
Amortization of Equipment (77,000 x .29832)	22,970
O&M for Equipment (77,000 x .03)	2,310
Total Annual Cost	$71,830

C. Hours to Construct (12 hr/day)

Primary Pond - Using D-9 500 cy/hr	168 hrs
Equipment Installation (Piping and Pump)	59 hrs
Total Hours	227
Total Man-Days	18.7

D. Cost per Cubic Yard Mined (71,830 + 153,000) $0.47

Treatment Costs for Various Options for the Placer Mining Industry

Table IX 1 projects the construction days required, annual costs, and cost per cubic yard mined for 10 mines. The costs were computed using actual data on construction days obtained at the mines if actual data were available. The following is a list of mines costed using data obtained at the mine for sluicing time, yardage mined and flow. The data for solids concentrations were also obtained at the mine site during treatability testing at the mines listed below.

4169 4248

U.S. ENVIRONMENTAL PROTECTION AGENCY - INDUSTRIAL TECHNOLOGY DIVISION
ENERGY AND MINING BRANCH
PLACER MINING WASTEWATER TREATMENT - COSTING STUDY - TEN MINES TESTED

MINE CODE	PRODUCTION (CY/YR)	WATER USE (GPM)	WATER USE (GAL/CY)	SEE NOTES	OPTIONS 1	OPTIONS 2	OPTIONS 3	OPTIONS 4	OPTIONS 5	REMARKS
4169	122000	5800	2970	a.	25.2	27.5	24.9	26.2	26.8	NO CLASSIFICATION
				b.	37	40	69	75	86	
				c.	$0.31	$0.33	$0.57	$0.67	$0.71	
4173	480000	8750	3500	a.	69.6	71.7	60.3	63.9	71.3	NO CLASSIFICATION
				b.	156	160	185	207	229	
				c.	$0.32	$0.33	$0.39	$0.43	$0.48	
4180	7000	1500	926	a.	5.6	6.3	9.1	9.6	7.3	CLASSIFICATION W/VIBR. SCREEN
				b.	7	8	21	23	23	
				c.	$0.10	$0.11	$0.30	$0.32	$0.32	
4244	39000	5000	1330	a.	4.4	5.6	8.2	8.6	6.1	NO CLASSIFICATION
				b.	10	12	24	25	26	
				c.	$0.24	$0.31	$0.61	$0.65	$0.66	
4247	375000	1400	450	a.	10.8	11.1	13.2	14	12.5	CLASSIFICATION WITH SCREEN
				b.	22	22	40	43	47	
				c.	$0.06	$0.06	$0.11	$0.12	$0.13	
4248	60000	1000	600	a.	6.3	6.6	9.5	10	7.9	CLASSIFICATION WITH GRIZZLY
				b.	8	8	18	20	20	
				c.	$0.13	$0.14	$0.30	$0.33	$0.33	
4249	190000	1000	316	a.	4.8	4.9	8.3	8.8	6.4	CLASSIFICATION
				b.	8	9	20	22	23	
				c.	$0.04	$0.05	$0.11	$0.12	$0.12	
4250	126000	1850	793	a.	14.8	15.5	16.4	17.3	16.4	CLASSIFICATION WITH TROMMEL
				b.	20	21	34	37	40	
				c.	$0.16	$0.17	$0.27	$0.29	$0.31	

NOTES:

a. WATER FACILITIES CONSTRUCTION DAYS REQUIRED BASED ON MINE DAILY WORKING HRS.
b. ANNUAL COST ($1000).
c. COST/CUBIC YARD MINED.
COSTS BASED ON LAST QUARTER 1984 - ENR-CCI = 4161.
COST OF TRANSPORTATION OF RENTED EARTH MOVING EQUIPMENT FROM SOURCE TO MINING SITE NOT INCLUDED.

OPTIONS:

1. PRIMARY SETTLING
2. PRIMARY SETTLING, SECONDARY SETTLING
3. PRIMARY SETTLING, 80% RECYCLE, SECONDARY SETTLING
4. PRIMARY SETTLING, 80% RECYCLE, FLOCCULANT ADDITION, SECONDARY SETTLING
5. PRIMARY SETTLING, 100% RECYCLE

U.S. ENVIRONMENTAL PROTECTION AGENCY - INDUSTRIAL TECHNOLOGY DIVISION
ENERGY AND MINING BRANCH
PLACER MINING WASTEWATER TREATMENT - COSTING STUDY - TEN MINES TESTED

TABLE IX-1
PAGE 2 OF 2

MINE CODE	PRODUCTION (CY/YR)	WATER USE (GPM)	WATER USE (GAL/CY)	SEE NOTES	OPTIONS 1	2	3	4	5	REMARKS
4251	84000	750	450	a.	4.3	4.6	7.9	8.4	6.0	
				b.	5	5	16	17	17	CLASSIFICATION
				c.	$0.06	$0.06	$0.19	$0.21	$0.21	
4252	8000	2200	7920	a.	8.1	10.6	11.2	11.7	9.8	
				b.	8	10	21	23	22	NO CLASSIFICATION
				c.	$0.96	$1.23	$2.54	$2.74	$2.82	
*4252	8000	555	3000	a.	3.3	3.9	7.2	7.5	5	
				b.	8	9	19	20	20	CLASSIFICATION WITH GRIZZLY
				c.	$1.05	$1.12	$2.39	$2.53	$2.47	AND DOUBLE-DECK VIBRATING SCREEN

NOTES:

a. WATER FACILITIES CONSTRUCTION DAYS REQUIRED BASED ON MINE DAILY WORKING HRS.
b. ANNUAL COST ($1000).
c. COST/CUBIC YARD MINED.
COSTS BASED ON LAST QUARTER 1984 - ENR-CCI = 4161.
COST OF TRANSPORTATION OF RENTED EARTH MOVING EQUIPMENT FROM SOURCE TO MINING SITE NOT INCLUDED.

OPTIONS:

1. PRIMARY SETTLING
2. PRIMARY SETTLING, SECONDARY SETTLING
3. PRIMARY SETTLING, 80% RECYCLE, SECONDARY SETTLING
4. PRIMARY SETTLING, 80% RECYCLE, FLOCCULANT ADDITION, SECONDARY SETTLING
5. PRIMARY SETTLING, 100% RECYCLE

4173	4249
4180	4250
4244	4251
4247	4252

Table IX-2 presents a summary of the cost estimates showing maximum, minimum, and average cost for annual operation and cubic yards mined.

To determine the effect on the water treatment system including a classification step for a mine that is not presently classifying, mine number 4252 was used. For this mine, it was assumed that a classification system would include a grizzly and a double deck vibrating screen. The water flow after the installation of a classification system at mine 4252 was assumed to be 2000 gallons per cubic yard sluiced.

This flow is based on data from mines using classification systems obtained during the 1983 and 1984 field studies and discussions with personnel knowledgeable in the placer mining industry. The cost estimates for this mine with and without the classification system are presented on Table IX-1 (page 2). A comparison of the two costs indicates a reduced operating cost for wastewater treatment when a classification system is added to the mining equipment because of a reduction in the amount of water necessary to sluice a given amount of ore.

TABLE IX-2

U.S. ENVIRONMENTAL PROTECTION AGENCY
INDUSTRIAL TECHNOLOGY DIVISION
ENERGY AND MINING BRANCH

ALASKAN PLACER MINING INDUSTRY
WASTEWATER TREATMENT COSTS

	OPTIONS				
	1	2	3	4	5
ANNUAL COSTS					
Maximum ($1000)	156	160	185	207	229
Minimum ($1000)	5	5	16	17	17
Average ($1000)	26.3	27.6	42.5	46.6	50.3
COSTS/CU.YD.					
Maximum	1.05	1.23	2.54	2.74	2.82
Minimum	0.04	0.05	0.11	0.12	0.12
Average	0.31	0.35	0.71	0.78	0.60

Table IX-3 projects the construction days required, annual costs, and cost per cubic yard mined for 4 model mines. The models, classification, cubic yards sluiced per hour, and days of operation assumed are as follows:

Model	Mine Size	yd^3/hr sluiced	Days Operating
1	Extra small	25	65
2	Small	50	65
3	Medium	100	75
4	Large	180	85

The costs were computed utilizing the above data and assuming 10 hours per day for operation and a water use rate of 2,000 gallons per cubic yard sluiced. Table IX-4 presents a summary of the model mines cost estimates showing maximum, minimum, and average cost for annual operation and cubic yards mined.

Cost estimates were not prepared for placer mining operations which use dredges. There is basically no cost associated with pollution control systems since most dredging operations approach zero discharge of process wastewater from the recovery process by the nature of the mining method (See Section III).

U.S. ENVIRONMENTAL PROTECTION AGENCY - INDUSTRIAL TECHNOLOGY DIVISION
ENERGY AND MINING BRANCH
PLACER MINING WASTEWATER TREATMENT - COSTING STUDY - MODEL MINES

TABLE IX-3

MINE CODE	PRODUCTION (CY/YR)	WATER USE (GPM)	(GAL/CY)	SEE NOTES	OPTIONS 1	2	3	4	5	REMARKS
MODEL 1	16250	833	2000	a.	9.4	10.5	12.1	12.8	11.1	CLASSIFIED AS EXTRA SMALL
				b.	8	9	18	20	20	SIZE MINE - MINE MODEL HAS
				c.	$0.49	$0.55	$1.12	$1.22	$1.24	CLASSIFICATION EQUIPMENT
MODEL 2	32500	1667	2000	a.	9.4	10.3	12.0	12.7	11.1	CLASSIFIED AS SMALL SIZE MINE -
				b.	10	11	23	24	25	MINE MODEL HAS CLASSIFICATION
				c.	$0.31	$0.35	$0.70	$0.75	$0.77	EQUIPMENT
MODEL 3	75000	3333	2000	a.	13.3	14.7	15.3	16.1	15.0	CLASSIFIED AS MEDIUM SIZE MINE -
				b.	18	20	35	37	42	MINE MODEL HAS CLASSIFICATION
				c.	$0.24	$0.26	$0.46	$0.50	$0.56	EQUIPMENT
MODEL 4	153000	6000	2000	a.	15.7	18.5	21.3	17.5	18.9	CLASSIFIED AS LARGE MINE -
				b.	32	36	53	57	70	MINE MODEL HAS CLASSIFICATON
				c.	$0.21	$0.23	$0.34	$0.37	$0.45	EQUIPMENT

NOTES:

a. WATER FACILITIES CONSTRUCTION DAYS REQUIRED BASED ON MINE DAILY WORKING HRS.
b. ANNUAL COST ($1000).
c. COST/CUBIC YARD MINED.
COSTS BASED ON LAST QUARTER 1984-ENR-CCI=4161
COST OF TRANSPORTATION OF RENTED EARTH MOVING EQUIPMENT FROM SOURCE TO MINING SITE NOT INCLUDED.

OPTIONS:

1. PRIMARY SETTLING
2. PRIMARY SETTLING, SECONDARY SETTLING
3. PRIMARY SETTLING, 80% RECYCLE, SECONDARY SETTLING
4. PRIMARY SETTLING, 80% RECYCLE, FLOCCULANT ADDITION, SECONDARY SETTLING
5. PRIMARY SETTLING, 100% RECYCLE

TABLE IX-4

U.S. ENVIRONMENTAL PROTECTION AGENCY
INDUSTRIAL TECHNOLOGY DIVISION
ENERGY AND MINING BRANCH

ALASKAN PLACER MINING INDUSTRY
WASTEWATER TREATMENT COSTS - MODEL MINES

	OPTIONS 1	2	3	4	5
ANNUAL COSTS					
Maximum ($1000)	32	36	59	63	72
Minimum ($1000)	8	9	18	20	20
Average ($1000)	17.0	19.0	33.8	36	39.8
COSTS/CU.YD.					
Maximum	0.49	0.55	1.12	1.22	1.24
Minimum	0.21	0.23	0.39	0.37	0.47
Average	0.31	0.35	0.67	0.71	0.76

REFERENCES

1. Means Construction Data - 1984, 42nd Annual Edition.

2. USEPA Municipal Environmental Research Laboratory, "Estimating Water Treatment Costs," EPA-600/2-79-162.

3. Kohlmann Ruggiero Engineers, P.C., "Treatability Testing of Placer Gold Mine Sluice Waters in Alaska, U.S.," Prepared for EPA Industrial Technology Division, January 1985.

4. Kohlmann Ruggiero Engineers, P.C., "1984 Alaskan Placer Mining Study and Testing Report", Proposed for EPA Industrial Technology Division, Washington, D.C., January 31, 1985.

5. Caterpillar Tractor Co., "Caterpillar Performance Handbook, 1984," revised edition.

SECTION X

BEST PRACTICABLE TECHNOLOGY (BPT)

This section identifies the effluent characteristics attainable through the application of the best practicable control technology currently available (BPT). See Section 301(b)(1)(A) of the Clean Water Act. BPT reflects the existing performance by plants of various sizes, ages, and processes within the gold placer mining industry. Particular consideration is given to the treatment already in place.

BPT limitations for eleven subcategories of the ore mining industry were promulgated in 1978 and were upheld in the courts. See Kennecott Copper Corp. v. EPA, 612 F.2d 1232 (10th Cir. 1979). Effluent limitations for the gold placer mine industry were reserved until additional information could be developed. While it is now long after the 1977 date to comply with BPT under the Clean Water Act, EPA is proposing BPT because current treatment at most existing placer mines is inadequate to establish a baseline for limitations, including BCT and BAT.

The factors considered in identifying BPT include: 1) the total cost of applying the technology in relation to the effluent reduction benefits to be achieved from such application; 2) the size and age of equipment and facilities involved; 3) the processes employed; (4) nonwater quality environmental impacts, (including energy requirements), and (5) other factors the Administrator considers appropriate. These factors are considered below. The Act does not require or permit consideration of water quality problems attributable to particular point sources or industries, or water quality improvements in particular water bodies in setting technology-based effluent limitations guidelines. Accordingly, water quality considerations are not the basis for selecting the proposed BPT. See Weyerhaeuser Company v. Costle, 590 F.2d 1011 (D.C. Cir. 1976).

In general, the BPT level represents the average of the best existing performances of plants of various ages, sizes, processes or other common characteristics. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. Limitations based on transfer technology must be supported by a conclusion that the technology is, indeed, transferable and a reasonable prediction that it will be capable of achieving the prescribed effluent limitations See Tanners' Council of America v. Train, 540 F. 2d 1188 (4th Cir. 1976). BPT focuses on end-of-pipe treatment rather than process changes or internal controls, except where such are common industry practice.

The Agency studied the gold placer mining industry to identify the processes used and the wastewaters generated by mining and beneficiation.

As discussed in Section VIII, the control and treatment technologies available to gold placer mines include both in-process and end-of-pipe technologies. Based on the pollutants found in the wastewater discharge, described in Section VI, and the pollutants selected for control, See Section VII, the following three technologies were considered as possible bases for BPT.

1. Simple Settling - Settling ponds are installed as a single large pond but are often used in a multiple arrangement of two or more ponds in series. Simple settling removes solids found in wastewater and the ponds in series further reduce settleable solids[1] and total suspended solids (TSS)[2] loadings in each of the sequential ponds. The principal involved is to retain the wastewater long enough to allow the solids (particulates) to settle while keeping the velocity of the flow to a minimum approaching quiescent settling conditions. Sludge storage is critical and must be considered in the design and construction of a pond.

[1]Settleable solids is the particulate material which will settle in one hour expressed in militers per liter (ml/l) as determined using an Imhoff cone and the method described for Settleable Solids in 209E Standard Methods for Examination of Water and Wastewater, 16th Edition.

[2]Total Suspended Solids (TSS) is the residue retained on a standard glass-fiber filter after filtration of a well-mixed water sample expressed in milligrams per liter (mg/l) using the method described for Total Suspended Solids Dried at 103°-105° in 209C Standard Methods for Examination of Water and Wastewater, 16th Edition.

Virtually all commercial gold placer mines operating in 1984 and 1985 had settling ponds of varying numbers, sizes, and efficiencies. The effluent limitations contained in NPDES permits for placer mines were based on the use of settling ponds; as a result, the technology is available and in use by the industry. However, sampling data and other information on existing ponds indicate that most ponds are inadequately designed, constructed, or maintained to consistantly produce an acceptable effluent quality or concentration of solids (settleable solids and TSS). In Section IX of this document, treatment facilities to control solids with simple settling technology are designed and costed to provide 6 hours of settling in well designed, constructed, and operated settling ponds which reduce the flow velocity to a minimum and have sufficient volume for sludge to preclude remixing or cutting of solids from the sludge back into the effluent. (The reasons for selecting a 6-hour settling period are discussed below). As discussed in Section VI and Table VI-1, the long term achievable levels for solids based on 1984 data from existing treatment at placer mines is less than 0.2 ml/l settleable solids and less than 2000 mg/l TSS. Field treatability tests indicate settleable solids are reduced to less than 0.2 ml/l with about 3 hours quiescent settling as discussed in <u>1984 Alaskan Placer Mining Study and Testing Report</u>, January 31, 1985. A general engineering design concept is that doubling quiescent settling time in settling tests will provide a retention time in an actual pond with a generous margin of reliability. Finally, Discharge Monitoring

Reports (DMR) from mines which reported to Region X in 1984 revealed over 2600 individual grab samples with settleable solids at 0.2 ml/l or less.

2. <u>Recycle of Process Wastewater</u> - Recycle of process wastewater from simple settling ponds is discussed in Section VIII. As we discussed there, high rate recycle of over 50 percent is practiced by commercial placer mines of all sizes, i.e., production capacity, and in all mining districts for which we have data. Recyling only requires the addition of a pump at the settling pond(s) and piping back to the gold recovery process.

In Section VIII, three different recycle options were considered: 80 percent recycle from primary settling followed by secondary settling of the 20 percent blowdown, 80 percent recycle and flocculant addition to the 20 percent blowdown, and 100 percent recycle from primary settling. Less than 80 percent recycle was not considered because while the reduction in the mass of pollutants is a direct function of the percent recycle, the cost of recycle of 80 percent or more is approximately the same as the cost of 50 percent recycle. Flocculant addition and the attainable limitations using flocculants are discussed below. The attainable effluent limitations for discharge of blowdown from an 80 percent recycle system are the same as for simple settling, 0.2 ml/l settleable solids and 2000 mg/l TSS, but the mass of pollutants discharged is 80% less than the mass of pollutants from once-through simple settling. The effluent limitation based on 100 percent recycle is no discharge of process wastewater.

3. Coagulation and Flocculation

The use of flocculants is also discussed in Section VIII. Coagulation and flocculation is not used by existing gold placer mines, but is used in wastewater treatment facilities in many industrial categories, by many mines and mills in other subcategories of the ore industry, and by coal mines and coal preparation plants. Flocculant addition and coagulation increases the size of particles for settling by forming flocs of individual particles that act as a simple particle which settle faster because of the increased weight and size over the individual particles. Pilot testing of the use of flocculants was conducted at placer mines which indicate that attainable effluent limitations for coagulation and flocculation are zero settleable solids and less than 100 mg/l TSS.

Specialized Definitions for Gold Placer Mines:

The proposed effluent limitations guidelines are for facilities discharging wastewater from mines that produce gold or gold bearing ones from gold placer deposits and the beneficiation processes to recover gold or gold bearing ore which use gravity separation methods. The proposal does not apply to gold mines extracting ores (hard rock ores and mines) other than placer deposits nor to the gold ore mills associated with hard rock mines regardless of the extraction process used in the mills. The proposal does not apply to the wastewater from gold or gold ore extraction processes from gold placer deposits that use cyanide or other chemicals for leaching gold or to extraction processes that use froth flotation methods. These effluents are regulated in the 1982 rulemaking for ore mining.

The data and information contained in this document apply primarily to the process wastewater discharges from the beneficiation process. The proposed effluent limitations guidelines limit this process wastewater. However, other wastewater such as mine drainage and groundwater infiltration is often commingled with the process wastewater. The effluent discharge of the commingled wastewater is also limited as discussed in "Specialized Provisions for Gold Placer Mines," below.

Because the considerations for defining effluent limitations and standards for gold placer mines differ from other industries, including the rest of the ore mining category in 40 CFR 440, EPA is proposing definitions which would apply only to gold placer mines. All other definitions in the general regulations (40 CFR Part 401) and the ore mining regulation (40 CFR Part 440) apply.

(1) Gold placer deposit means an ore consisting of metallic gold-bearing gravels, which may be: residual, from weathering of rocks in-situ; river gravels in active streams; river gravels in abandoned and often buried channels; alluvial fans; sea-beaches; and sea-beaches now elevated and inland.

(2) Gravity separation methods means the treatment of mineral particles which exploits differences between their

specific gravities. The separation is usually performed by means of sluices, jigs, classifiers, spirals, hydrocyclones, and shaking tables.

(3) Process wastewater means all water used in and resulting from the beneficiation process, including but not limited to, the water used to move the pay dirt or ore to and through the beneficiation process, the water used to aid in classification or screening, the water used in the gravity separation methods, and the precipitation on and runoff from the beneficiation process area.

(4) Beneficiation process means the dressing or processing of ores for the purpose of (i) regulating the size of the ore or product, i.e., classification or screening; (ii) removing unwanted constituents of the ore, and (iii) improving the quality, purity, assay grade of a desired product, i.e., by gravity separation methods.

(5) Beneficiation process area means the combined areas of land used to stockpile pay dirt or ore immediately before the beneficiation process, stockpile the tailings immediately after the beneficiation process, including the area of land (i.e., drainage below the sluice) from the stockpiled tailings to the treatment system, and the area of the treatment system, e.g., holding pond(s) or settling pond(s).

(6) Groundwater infiltration means that water which enters the treatment facility as a result of the interception of natural springs, aquifers, and other seepage or run-off which percolates

into the ground and seeps into the treatment facility's pond or wastewater holding facility.

The effluent limitations guidelines and standards for all ore mine and dressing facilities are applicable to point sources discharges from active mines and active mills and beneficiation, and not applicable to closed, or abandoned mines and mills, or discharges from mine areas being reclaimed, or point or non point sources from areas outside of the mine area. Specific definitions for ore mining and dressing promulgated in 40 CFR 440 which are pertinent to gold placer mines are discussed below.

(1) Mine is an active mining area, including all land and property placed under, or above the surface of such land, used in or resulting from the work of extracting metal ore or minerals from their natural deposits by any means or method, including secondary recovery of metal ore from refuse or other storage piles, wastes, or rock dumps and mill tailings derived from the mining, cleaning, or concentration of metal ores.

(2) Active mining area is a place where activity related to the extraction, removal, or recovery of metal ore is being conducted, except, with respect to surface mines, any area of land on or in which grading has been completed to return the earth to desired contour and reclamation work has begun.

(3) Mine drainage means any water drained, pumped, or siphoned from a mine.

Summary of Proposed BPT Effluent Limitations Guidelines

As discussed in Section IV, for the purpose of developing effluent limitations guidelines and standards, gold placer mining is defined as a separate subcategory in the Ore mining and dressing point source category. The gold placer mining subcategory is broken down further according to the size of the facility (capacity to process ore) and type of mining process. The basis for breakdown by size is the potential economic impact to small commercial mines and large commercial mines.

As discussed in Section IV, the proposal does not cover mines that process less than 20 cubic yards of ore per day (yd^3/day), or to dredges which operate in open water, e.g., open marine waters, bays, or major rivers. At the present time, EPA does not believe such limitations are warranted. These small mines are generally intermittent, "non-commercial" operations. The Agency believes that because of the diversity among these operations and the nature and volume of their discharge compared to "commercial mines," the preferable approach is to develop effluent limitations and standards for these facilities in the permit process based on the permit writer's best professional judgment. The dredges in open waters are not covered because the Agency has no information as to number, location, or applicable technologies for these facilities. Permits for these operations would likewise be based on the permit writer's best professional judgment.

The rest of the gold placer mine industry has been subcategorized into three groups:

1. All mines using all mining methods with a beneficiation process capacity of 20 to 500 yd^3/day.

2. All mines using all mining methods with a beneficiation process capacity of over 500 yd^3/day (except large dredges with capacity of over 4000 yd^3/day).

3. Large Dredges which process more than 4000 yd^3/day.

Proposed BPT effluent limitations for the first two groups i.e., all mining methods with beneficiation capacity of over 20 yd^3/day except large dredges, are based on simple settling technology (option 1) with limitations on settleable solids and TSS. While many mines with capacities of 20 to 500 yd^3/day were identified in the economic analysis document as possible base line closures, or potentially not profitable before any costs of water pollution control were imposed on the model mines, simple settling is essentially the only end-of-pipe practicable technology available for raw discharge. Raw discharge is not consistent with the objective of the Act which is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Ponds (simple settling) are presently the standard practice of the industry because existing permits limits are based on this technology. The limitations on settleable solids and TSS can be attained at existing mines with careful to construction and maintenance of settling facilities as discussed in Section VIII. The size of the ponds to provide retention to attain the limitations combined with the relief provision for precipitation as discussed below, are reasonable. The limitations for TSS are proposed as 2000 mg/l monthly average, based on a typical monitoring frequency for TSS of one sample per month. In earlier development documents for ore mining and dressing and in the preambles to regulations for the industry, EPA identified settleable solids as the primary pollutant regulated to control solids from placer mines because the analysis is relatively easy to perform and unlike TSS does not require storage and transit to a laboratory. On the other hand, TSS analysis must be performed in a laboratory. EPA recognizes it is often not feasible for remote placer mines to sample, properly preserve the sample, and deliver the sample for TSS analysis to a laboratory on a frequent basis. However, sampling once every 30 days for TSS will generally require only 3 or 4 samples per mine per mining season. In light of the heavy solids load in placer mining wastewater, EPA believes it is reasonable to require regulation of TSS, and in turn monitoring for TSS, for placer mines.

BPT limitations for large dredges (over 4000 yd^3/day) is proposed to be no discharge of process wastewater based on the existing practice at these large dredges which requires high rate recycle approaching 100 percent recycle as part of the mining system. At least 3 operating dredges for which EPA has data are not discharging process wastewater (100% recycle) within the definitions and provisions discussed below. No discharge is practicable and requires a minimum investment and modification to processes at existing large dredges which are not already meeting the no discharge of process wastewater standard.

The cost/benefit inquiry for BPT is a limited balancing, committed to EPA's discretion, which does not require the Agency to quantify benefits in monetary terms. See, e.g., American Iron and Steel Institute v. EPA, 526 F.2d 1027 (3rd Cir. 1975). In balancing costs in relation to effluent reduction benefits, EPA considers the volume and nature of existing discharges, the volume and nature of discharges expected after application of BPT, the general environmental effects of the pollutants, and the cost and economic impacts of the required pollution control level.

Raw wastewater from the beneficiation process at commercial size placer mines (processing more than 20 yd^3/day, all methods) is described in Section VIII of this document and, based on 1984 data, averaged 50 ml/l settleable solids and 30,000 mg/l TSS. The beneficiation processes at these mines produce over 16,000 million pounds per year of water born solids (TSS) in the extraction process. As discussed in the technical memorandum "Placer Mining Industry Contaminants Removed by Wastewater Treatment", Kohlmann Ruggiero Engineers, November 1984, implementation of limitations on solids at the proposed BPT levels would reduce solids by over 93 percent as compared to the untreated effluent. The cost of this reduction as determined from the model costs in Section IX of this document is $6.9 million/year assuming no treatment facilities are presently in place (or new construction must replace treatment facilities). The pollutant removed is solids (settleable solids and TSS); the effect of solids on the environment is discussed in Section VII of this document. The economic impact on the industry is discussed in detail in the Economic Analysis of Proposed Effluent Limitations and Standards for the Gold Placer Mining Industry. EPA believes the benefit of the proposed BPT effluent limitations justify the cost of implementation.

EPA has considered the nonwater quality environmental impact (including energy requirements) of the proposed BPT effluent limitations. EPA believes the proposed BPT regulation best serves competing national goals where the elimination or reduction of one form of pollution may aggravate other environmental problems. The implementation of treatment to meet BPT effluent limitations will not create any additional air pollution emissions. Considering the solid waste generation of the mining and beneficiation of gold placer deposits where often 5 to 6 tons of overburden (solid waste) is removed to mine one ton of paydirt, where beneficiation to recover the gold often leaves over 98% of the ore as solid waste or tailings, the solid waste generation or the sludge left by BPT is inappreciable. Imposition of the proposed BPT and the settling ponds to obtain the limitations will require some land area for the ponds, but the land will normally be available in the area left from mining. BPT will require a small increase in energy consumption to provide fuel for the construction or mining equipment used to build and maintain the ponds and other earthen structures for wastewater treatment. Gravity flow is normally used to convey the process wastewater to and through treatment and discharge;

therefore no energy is required for pumping at commercial mines except large dredges. Large dredges require pumps as part of their mining and beneficiation process and no additional pumps are required.

The proposed BPT limitations are summarized below.

Best Practicable Technology (BPT) for Gold Placer Mines

Subcategory	Effluent Characteristics	Effluent Limitations	
		Instantaneous Maximum	Monthly Average
Mines with beneficiation capacity of 20 to 500 yd^3/day of paydirt (all mining methods)	Settleable Solids TSS	0.2	 2000 mg/l
Mines with beneficiation capacity of over 500 yd^3/day of paydirt (all mining methods except large dredges with capacity of over 4000 yd^3/day)	Settleable Solids TSS	0.2 ml/l	 2000 mg/l
Large Dredges with beneficiation capacity of over 4000 yd^3/day of paydirt	No Discharge of Process Wastewater		

Specialized Provisions for Gold Placer Mines

The 1982 regulation for the ore mining and dressing industry has specialized provisions for combined (commingled) waste streams, as well as a storm exemption. The proposed regulation for gold placer mines includes similar provisions, with certain changes necessary to accommodate the particular considerations for gold placer mining. The following provisions are proposed for gold placer mines.

(1) <u>Combined Waste Streams</u>: Where process wastewater is commingled with mine drainage or groundwater infiltration, this combined waste stream may be discharged if the concentration of each pollutant or pollutant property does not exceed the effluent limitations applicable to mines processing 20 to 500 yd^3/day. However, the volume of commingled wastewater that may be discharged does not include the flow or volume of process wastewater where the effluent limitation for the beneficiation process is no discharge of process wastewater.

(2) <u>Storm Exemption for Facilities Not Subject to Effluent Limitations Guidelines and Standards Requiring No Discharge of Process Wastewater:</u> If, as a result of precipitation (rainfall or snowmelt), a source with an allowable discharge has an overflow or excess discharge of effluent which exceeds the limitations or standards, the source may qualify for an exemption from such limitations and standards with respect to such discharge if the following three conditions are met:

(i) The treatment system is designed, constructed, and maintained to contain or treat the maximum volume of untreated process wastewater which would be discharged by the beneficiation process during a 6-hour operating period without an increase in volume from precipitation or groundwater infiltration, plus the maximum volume of runoff resulting from a 5-year, 6-hour precipitation event. In computing the maximum volume of water which would result from a 5-year, 6-hour precipitation event, the operator must include the volume which would result from all areas contributing runoff to the individual treatment facility, i.e., all runoff that is not diverted from the active mining area and all runoff which is allowed to commingle with the influent to the treatment system.

(ii) The operator takes all reasonable steps to maintain treatment of the wastewater and minimize the amount of overflow.

(iii) The operator complies with the notification requirements of the National Pollutant Discharge Elimination System (NPDES) regulations contained in 40 CFR 122 §122.41 (m) and (n). The storm exemption is designed to provide an affirmative defense to an enforcement action. Therefore, the operator has the burden of demonstrating to the appropriate authority that the above conditions have been met.

(3) Storm Exemption for Facilities Subject to Effluent Limitations Guidelines and Standards Requiring No Discharge of Process Wastewater: If, as a result of precipitation (rainfall or snowmelt), a source which is subject to effluent limitations guidelines and standards requiring no discharge of process wastewater has an overflow or discharge which violates the limitations or standards, the source may quality for an exemption from such limitations or standards with respect to such discharge if the following conditions are met:

(i) The treatment system is designed, constructed, and maintained to contain the maximum volume of process wastewater stored, contained, and used or recycled by the beneficiation process during normal operating conditions without an increase in volume from precipitation or groundwater infiltration plus the maximum volume of wastewater resulting from a 5-year, 6-hour precipitation event. In computing the maximum volume of wastewater which would result from a 5-year, 6-hour precipitation event, the operator must include the volume which would result from all areas contributing runoff from the beneficiation process area, i.e., all runoff that is not diverted from the treatment system for the beneficiation process.

(ii) The operator takes all reasonable steps to minimize the overflow or excess discharge.

(iii) The operator complies with the notification requirements of the National Pollutant Discharge Elimination System (NPDES) regulations contained in 40 CFR Part 122 §122.41 (m) and (n). The storm exemption is designed to provide an affirmative defense to an enforcement action. Therefore, the operator has the burden of demonstrating to the appropriate authority that the above conditions have been met.

(4) Groundwater infiltration provision: In the event a source which is subject to no discharge of process wastewater effluent limitations guidelines and standards can demonstrate that groundwater infiltration contributes an uncontrollable amount of water to the treatment system's impoundment or wastewater holding facility, the permitting authority may allow the discharge of a volume of water equivalent to the amount of

groundwater infiltration. This discharge shall not exceed the effluent limitations applicable to a mines with beneficiation capacity in the range of 20 yd^3/day to 500 yd^3 of pay dirt or ore per day.

Guidance for Implementing the Specialized Provisions for Gold Placer Mines

Following is guidance for implementation of the special provisions above to assist permit writers who may include these provisons in NPDES permits and mine operators who wish to design, construct, and maintain their treatment facilities to quality for these provisions.

Storm Exemption to Establish an Upset to the Treatment System

1. The exemption is available only if it is included in the operator's permit. Many existing permits have exemptions or relief clauses stating requirements other than those set forth above. Such relief clauses remain binding unless and until this proposed regulation is issued as a final regulations and the storm exemption is incorporated into the operator's permit.

2. The storm provision is an affirmative defense to an enforcement action. Therefore, if this provision appears in the final regulation, there is no need for the permitting authority to evaluate each settling pond or treatment facility permitted at that time.

3. Relief can be granted to ore process wastewater discharges and combined waste streams.

4. The relief only applies to the increase in flow caused by precipitation on the facility and surface runoff.

5. Relief is granted as an exemption to the requirements for normal operating conditions when there is an overflow, increase in volume of discharge, or discharge from a by-pass system caused by precipitation.

6. Relief can be granted for discharges during and immediately after any precipitation or snowmelt. The intensity of the event is <u>not</u> specified.

7. The provision does not grant, nor is it intended to imply, the option of ceasing or reducing efforts to contain or treat the runoff resulting from a precipitation event or snowmelt, regardless of the intensity of the precipitation. The operator must continue to operate the treatment facility to the best of the operator's ability during and after any precipitation.

8. Relief can be granted from all effluent limitations and standards, i.e., in BPT, BAT, BCT, and NSPS.

9. In general, the relief is intended for discharges from tailings ponds, settling ponds, holding basins, lagoons, etc., that are associated with and part of treatment facilities. The relief will most often be based on the construction and maintenance of these settling facilities to "contain" a volume of water.

10. The term "contain" for facilities which are allowed to discharge must be considered in conjunction with the term "treat" discussed in paragraph 11 below. The containment requirement is intended to insure that the facility has sufficient capacity to provide 6 hours of settling time for the volume resulting from a 5 year, 6 hour precipitation event. This is the settling time required to "treat" influent so that it meets the daily effluent limitations and standards. The theory is that a settling facility with sufficient volume to contain the runoff from a 5-year, 6-hour rainfall plus 6-hours discharge of normal process wastewater and normal combined waste streams (e.g., without an increase in volume from precipitation) can provide a minimum 6-hour retention time for settling of the wastewaters even if the pond is full at the time the storm occurs. The water entering the pond as a result of the storm is assumed to follow a last-in, last-out principle. Because of this, the "contain" and "maintain" requirement for facilities which are allowed to discharge does not require providing for draw down of the pool level during dry periods. The volume can be determined from the top of the stage of the highest dewatering device to the bottom of the pond at the time of the precipitation event. There is no requirement that relief be based on the facility being emptied of wastewater prior to the rainfall or snowmelt upon which the exemption is provided. The term "contain" for facilities which are allowed to discharge means the wastewater facility's holding pond or settling pond was designed to include the volume of water that would result from a 5-year, 6-hour rainfall.

11. The term "treat" applies to facilities which are allowed to discharge and means the wastewater facility was designed, constructed, and maintained to meet the daily maximum effluent limitations for the maximum flow volume in a 6-hour period. The operator has the option to "treat" the flow volume of water that would result from a 5 year, 6 hour rainfall in order to qualify for the storm water exemption. To compute the maximum flow volume, the operator includes the maximum flow of wastewater including mine drainage and groundwater infiltration during normal operating conditions without an increase in volume from precipitation plus the maximum flow that would result from a 5-year, 6-hour rainfall. The maximum flow from a 5-year, 6-hour rainfall can be determined from the Water Shed Storm Hydrograph, Penn State Urban Runoff Model, or similar models.

12. The term "treat" offers to the operator alternatives to the simple settling provided by settling ponds upon which effluent limitations are based. Examples of alternatives are: 1) clarifiers designed and operated to "treat" the maximum flow volume, but which would not have the actual volume to provide an actual 6-hour retention time; and 2) flocculants to aid settling and, if properly used, allow a smaller settling pond to obtain the same results as a larger settling pond, e.g., 6-hour retention of the wastewater.

13. The term "maintain" is intended to be synonymous with "operate." The facility must be operated at the time of the precipitation event to contain or treat the specified volume of

wastewater. Specifically, in making a determination of the ability of a facility to contain a volume of wastewater or to provide 6-hours of retention of wastewater to treat a volume or flow, sediment and sludge must not be permitted to accumulate to such an extent that the facility cannot hold the volume of wastewater resulting from 6-hours of normal process wastewater discharge and normal combined waste streams plus the volume resulting from a 5-year, 6-hour rainfall. That is, sediment and sludge must be removed as required to maintain the specific volume of wastewater required for the exemption, or the embankment must be build up or graded to maintain a specific volume of wastewater required, or a new settling pond must be built and used.

14. The term "contain" for facilities treating only process wastewater subject to no discharge means the wastewater facility is designed, constructed, and maintained to hold, without a point source discharge, the volume of water that would result from a 5-year, 6- hour rainfall, in addition to the normal amount of water which would be in the wastewater facility for recycle and reuse to the beneficiation process, e.g., without an increase in volume from precipitation. The operator treating only process wastewater must provide for freeboard under normal operating conditions equivalent to the volume that would result from a 5-year, 6-hour rainfall on the beneficiation process area (including the ponds).

15. The storm provision for no discharge of process wastewater must be considered in conjunction with the combined

waste stream provision which would allow a discharge from a treatment system treating (1) process wastewater with a no discharge limitation and (2) commingled mine drainage and ground water infiltration. The volume allowed to be discharged would be the volume attributable to the mine drainage and groundwater infiltration. The storm provision for facilities treating these combined waste streams would be based upon the sum of the elements or volumes to: (1) "contain" the process wastewater subject to no discharge and runoff from the beneficiation area as discussed in 14 above to determine a volume, to which would be added the volume required to (2) contain or treat the volume of mine drainage and groundwater infiltration (combined waste streams) allowed to be discharged as discussed in 10 and 11 above.

Mine Drainage from Active Mining Areas of Gold Placer Mines

1. "Active mine areas" include the excavations in mines; refuse, middling, and tailings areas; tailings ponds, holding and settling basins; and other areas ancillary to a mine. Active mine areas do not include areas unaffected by mining or beneficiation of pay dirt.

2. "Mine drainage" includes all water which contacts an "active mining area" and which naturally flows into a "point source" - a discernible, confined, and discrete convenience - or is collected in, or channeled or diverted to a "point source," i.e., settling ponds.

3. Water which contacts an "active mining area" and either does not flow, or is not channeled by the operator, to a point source, is considered nonpoint source runoff, and the proposed regulations do not require the mine operator to collect and treat such runoff. The proposed regulations require the placer mine operator to treat runoff which contacts an active mining area and is discharged from, or collected in a point source, and is commingled in a "combined waste stream."

4. When an existing mine is permanently closed, effluent limitations and standards of performance for the ore mining and dressing point source category, including placer mines, are no longer directly applicable.

5. Mine drainage handling is a part of most methods and systems used to mine or extract ore. At many ore mines, mine drainage is handled and treated to meet specific effluent limitations and standards for mine drainage both during the periods the mine is actually working and also during idle periods when the mine is not actually working, i.e., weekends, vacation periods, strike periods, idle days, idle shifts, and temporary closures of the mine. Mine drainage handling is often required full-time to maintain the mine and treatment of this mine drainage is also required full-time to meet effluent limitations and standards for mine drainage discharges. This mine drainage from a mine when it is not actually working is still considered to be from an "active mining area." However, gold placer mines differ from other metal mines and other hard rock gold mines in that most gold placer mines are seasonal and operate only in the

summer, or less than 4 months a year. Also, operating data on gold placer mines indicate most placer mines operate one shift per day for about 10 hours. Finally, specific limitations and standards for mine drainage from gold placer mines are not proposed, although limitations and standards for mine drainage are included to the extent that mine drainage is commingled in combined waste streams. Therefore, limitations and standards for mine drainage, e.g., combined waste streams, are applicable only when mine drainage is commingled with process wastewater. Process wastewater is considered to be discharged from the time the beneficiation process is started until the time the volume of combined wastewater would be discharged, calculated on last in, last out considerations, e.g., retention time in the settling pond.

6. The proposed effluent limitations guidelines and standards for gold placer mines are not applicable during the off season. They are applicable from the time the beneficiation process is first started in a calender year to the time the beneficiation process is last loaded and used in a calender year, e.g., the mining season.

7. While the proposed effluent limitations guidelines and standards are applicable to process wastewater and combined waste streams during the mining season, other "point source discharges" during the mining season, i.e., segregated mine drainage and mine camp runoff and sewage, may be subject to separate permit limitations; as well as "point source discharges" before and

after the mining season, i.e., mine drainage, construction runoff and mine camp discharges. Limitations for these discharges would be determined based on best professional judgement by the permitting authority.

Guidance to Determine Process Capacity

1. The proposed effluent limitations guidelines and standards are directly applicable to mines with a beneficiation process with the capacity to process more than 20 yd^3 of pay dirt per day. In the course of developing effluent limitations guidelines and standards for gold placer mines, EPA established three groups in the gold placer mining subcategory: (1) all mines with a beneficiation process with the capacity to process more than 20 yd^3 and less than 500 yd^3 of pay dirt per day; (2) all mines with a beneficiation process with a capacity to process more than 500 yd^3 of pay dirt per day, except large dredges; and large dredges with a beneficiation process with a capacity to process more than 4000 yd^3 of pay dirt per day.

2. The pay dirt processed is measured as "bank run" pay dirt which is the volume of pay dirt as measured in place in its natural state and before extraction or mining and before the swell in volume that occurs when compacted material in place is broken and stacked; i.e., in a stockpile.

3. Applications for NPDES permits are usually made and the permits for a given mining season written before the start of the mining season. Therefore, determinations as to permit conditions

and whether effluent limitations guidelines and standards are even applicable to a specific gold placer mine's discharge must be made before the mining and processing that determine the mine's size begins. A mine's size therefore must be determined based on information supplied by the mine operator as part of the permit application.

4. Many permits are a reissue of an existing permit to the same mine operator who uses the same equipment as used previously at essentially the same location to mine and process pay dirt. For these permits which are reissued, the mine operator may use data and information from the previous season or year to determine the mine's size of 1 to 20 yd^3/day, 20 to 500 yd^3/day, over 500 yd^3/day, and for dredges over 4000 yd^3/day. However, should the status and operation of the mine be scheduled for a change, i.e., from prospecting and exploration to production status or from low production to a higher production with additional equipment, the mine operator must notify the permitting agency of this forecast or anticipated increase in pay dirt mined and processed. The mine operator would make an estimate of the amount of bank run pay dirt that will be mined in the coming season as discussed below.

5. Many permit applications will be made by operators planning to mine during the next season for the first time in an area that was mined by a different operator the previous season, by mine operators who are increasing production as mentioned in 4 above, and by mine operators who are opening new mines which are

"new sources" or "new discharges" (as defined in the NPDES regulations, 40 CFR Part 122). For these permits, the mine operator must provide the best estimate of the mine's size, e.g., capacity to process pay dirt.

6. The capacity to process pay dirt used to determine a mine's size (yd^3/day) is based on the average amount of paydirt moved through the benefication process (i.e., sluice) in a calendar day (24-hour period) whether the working day is one or more shifts. For reissue of an existing permit for an existing mine as discussed in 4, the mine operator would divide the total bank run material (yd^3) mined in a year or season by the number of days the beneficiation process was operated. EPA believes most mines have records or logs of the amount of paydirt processed in a season or can estimate the amount processed with reasonable accuracy and similarly, have records or logs of the number of days per season the gold recovery process was operated. Since permit conditions will be based on a mine's size when the proposed regulations are promulgated, most mine operators will have the opportunity to establish and keep records of pay dirt processed and the number of days the mine processes the pay dirt.

7. For permit applications discussed in 5, estimates of capacity to process pay dirt are also based on the average amount of pay dirt moved through the benefication process in a calendar day. While the permit applicant cannot base the application on personal experience mining at the location, if the same or similar equipment, i.e., handbook capacity, is used, then the information from the previous operator can be used to determine

the capacity in yd^3/day. For mines that are increasing production, going from prospecting or assessment to production, or are new sources or new dischargers, EPA believes that most miners make an assessment as to the viability of investing money and time in the venture, at least to the extent of estimating how much pay dirt they will process and how many days their sluice will operate. These estimates are acceptable for the purpose of determining the mine size.

8. EPA believes that only a very few gold placer mines will be in a range of production where exactly 500 yd^3/day capacity will be a critical issue. The vast majority of the mines making application for permits will be obviously larger or smaller than 500 yd^3/day. For example, based on data for 1984 permits, less than 9 percent of the applications were for mines with capacities of 400 to 600 yd^3/day. EPA believes that this magnitude of production and range will continue for mines. However, for those few mines where the production rate is critical and the capacity of the beneficiation process approaches very closely the 20 yd^3/day or the 500 yd^3/day cutoff, the permitting authority may request periodic or mid-season reporting of paydirt processed and days the beneficiation process was operated to determine the production rate, and issue or change permit limitations accordingly.

9. At the end of the mining season or at the end of the year when the final DMR is submitted, the operator should indicate the actual capacity of the beneficiation process for

that season or year.

10. EPA recognizes that the information and data submitted by a mine operator on how much paydirt will be processed during a season or calendar year are the mine operator's good faith estimates based on the operators professional judgment and experience in mining and operating gold placer mines or are based on the judgment of a mining professional, i.e., mining consultant or professional mining engineer, who is familar with the mine. EPA does not believe that exactly 500 yd^3/day will be critical for most mines as discussed in 8 above. However, statements of estimates and reported production (yd^3/day) must be made in good faith because the data will be used to determine what group of mines (larger or smaller than 500 yd^3/day) the operation belongs in and what effluent limitations and standards apply. The statements made in a NPDES permit application are subject to Title 18, U.S.C. E 1001 which states that "Whoever, in any matter within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or makes any false, fictitious or fraudulent statements or representations, or makes or uses any false writing or document knowing the same to contain any false, fictitious or fraudulent statement or entry, will be fined not more than $10,000 or imprisoned not more than five years, or both."

SECTION XI

BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY (BCT)

Section 301(b)(2)(E) of the Act requires categories and classes of point sources, other than publicly-owned treatment works, to achieve effluent limitations that require the application of the best conventional pollutant control technology (BCT) for control of conventional pollutants as identified in Section 304(a)(4). The pollutants that have been defined as conventional by the Agency, at this time, are biochemical oxygen demand, suspended solids, fecal coliform, oil and grease, and pH. BCT is not an additional limitation; rather, it replaces BAT for the control of conventional pollutants.

Section 304(b)(4)(B) of the Act requires that, in setting BCT, EPA must consider: the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impacts (including energy requirements), and other factors the Administrator deems important. Candidate technologies must also pass a two-part test of "cost reasonableness" as discussed below.

A. Candidate Technologies

As discussed in Section VIII, four treatment options were considered for placer mines using three treatment technologies: simple settling, recycle of process wastewater at 80 percent and

100 percent, and coagulation and flocculation of the 20 percent blowdown from 80 percent recycle. For the purpose of developing effluent limitations, EPA considered each of these treatment options in light of the Section 301(b)(4)(B) factors listed above for each of the three segments of the gold placer mining subcategory.

Wastewater pollutant levels and pollutant concentrations achievable by each option were determined using the same information and data discussed in Section X for achievable BPT limitations. Recycle of 80 percent and 100 percent are add-on technology to BPT which would require additional equipment including pumps and piping to meet the more stringent limitations. Flocculant addition is an add-on to the 80 percent recycle option that would require still more additional equipment and supplies such as mixers, metering devices, and the flocculants themselves to further treat the 20 percent blowdown from 80 percent recycle. In increasing order of cost to implement, and pounds of solids removed, the options are: 80 percent recycle, 80 percent recycle with flocculant addition to the 20 percent blowdown, and 100 percent recycle.

Of the three add-on options, 100 percent recycle obviously offers the largest removal of pollutants. Also, as discussed below, this technology would pass the two part "cost-reasonableness" test for BCT for all mines with beneficiation capacity over 20 yd^3/day (all mining methods, including dredges).

1. Gold Recovery with the 100 Percent Recycle Option

A repeated concern of industry commenter's is that recycle of wash water reduces gold recovery in a sluice because of the higher concentrations of TSS found in recycled wastewater compared to once-through wash water. However, no conclusive data have been offered by the industry to quantify any loss or, if there is a loss, what TSS concentration starts to effect a loss. Lacking any hard and verifiable data from industry, EPA decided to conduct its own tests to obtain data on the effect of recycle on gold recovery. As discussed in Section VIII of this document, EPA funded studies to ascertain if a loss of recoverable gold occurred in a pilot-scale sluice when the TSS concentration in the wash water was varied from almost zero to about 200,000 mg/l. The results of the tests provide EPA the only hard and verifiable data on the effect of TSS concentration on gold recovery.

These tests indicate that over 99 percent of the gold is effectively recovered regardless of the TSS concentration in the wash water, e.g., recycle does not affect the recovery of gold in the size range of +100 mesh. The tests also indicate there may be some migration of the recovered gold down the sluice to lower riffles as the TSS concentration increases, but settling of the recycle water for 6 hours would reduce the TSS concentration to less than 2000 mg/l and in turn, reduce any migration. EPA therefore believes that 100 percent recycle of process wastewater will not materially effect gold recovery in a sluice.

Based on the 1984 total production of the industry (yd^3/day of pay dirt processed), over 20 percent of the production is processed with wash water that is 90 percent to 100 percent recycled as discussed in Section VIII. Also, recycle (generally because of a shortage of water) is employed in most mining districts for which we have information, indicating that pumping and powering of the pumps is a viable process change, even in remote locations.

2. Mines with Processing Capacity of 20 to 500 yd^3/Day

As discussed in Section IV of this document, the mines with processing capacity of less than 500 yd^3/day are identified in the Economic Development Document as generally not viable operations under the assumptions employed to estimate cost items for water pollution control, operating and mining expenses, and income from gold recovered. Therefore, the subcategory for mines with beneficiation capacity of 20 to 500 yd^3/day (all mining methods except dredges) was established to address the economic considerations. While 80 percent recycle, with and without flocculant addition to the blowdown, are technologies that are less costly than 100 percent recycle, implementation of these technologies is economically unachievable for this segment of the industry which is projected to be unprofitable in the baseline, i.e., before any water pollution control costs were imposed.

Given the general implications of the economic analysis, EPA is proposing no more stringent limitations for BCT than BPT limitations for mines in this group. For the reasons discussed in Section VII, EPA is regulating TSS at BCT. Based on the technology selected for this group of mines, i.e., simple settling, the BCT limitation on TSS is 2000 mg/l monthly average. As with the BPT limitations for TSS, EPA is recommending that NPDES permit monitoring requirements consist of one sample and analysis per month which EPA believes is a reasonable requirement for placer mines, considering their remote locations.

3. Mines with Processing Capacity of Over 500 yd^3/Day

No discharge of process wastewater is proposed for mines with beneficiation capacity of over 500 yd^3/day of pay dirt (all methods). A no discharge requirement passes the cost-reasonableness test discussed below and is economically achievable for large mines. Just as most mines with benefication capacity of less than 500 yd^3/day (all mining methods) are projected to be unprofitable, most mines above this size are projected to be financially healthy and capable of installing additional treatment to simple settling upon which BPT was based, including the pumps, piping, and ancillary equipment to obtain no discharge of process wastewater through 100 percent recycle.

4. Large Dredges with Processing Capacity of Over 4000 yd^3/Day

For large dredges (larger than 4000 yd^3/day), EPA is proposing BCT limitations equal to the BPT limitations i.e., no discharge of process wastewater. Therefore, there is no incremental cost to go from BPT to BCT. EPA has identified no more stringent technologies to control process wastewaters from these large dredges and BCT can not be less stringent than BPT.

B. BCT Cost Test

In addition to other factors specified in Section 304(b)(4)(B), EPA assesses BCT limitations in light of a two-part "cost-reasonableness" test. The first test compares the cost for private industry to reduce its conventional pollutants with the costs to publicly owned treatment works for similar levels of reduction in their discharge of these pollutants. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA evaluates both tests as measures of "reasonableness". In no case may BCT be less stringent than BPT.

EPA published its methodology for carrying out the BCT analysis on August 29, 1979 (44 FR 50372). In American Paper Institute v. EPA, 660 F.2d 954 (4th Cir. 1981), the Court of Appeals ordered EPA to correct data errors underlying EPA's calculation of the first test, and to apply the second cost test. (EPA had argued that a second cost test was not required). On October 29, 1982, the Agency proposed a revised BCT methodology (47 FR 49176). EPA also published a notice of data availability on September 20, 1984 (49 FR 37046).

The BCT cost reasonableness analysis for the placer Gold Mining Industry is discussed in the study entitled "Cost Effectiveness Analysis of Proposed EFfluent Limitations and Standards for the Placer Gold Mining Industry" which is included in the record of the rulemaking. In this report, EPA first evaluated the cost per pound of solids (TSS) removed incrementally by each treatment option above the previous option for a sample of 10 representative placer mines. Annual treatment costs for each option in addition to the cost per pound of solids removal were estimated using data obtained at the 10 mine sites during treatability tests performed in 1984 (See Section VII and "1984 Alaskan Placer Mining Study and Testing Report," Kohlmann Ruggiero Engineers, January 1985). EPA also analyzed the cost per "pound equivalent" (i.e.; pounds of toxic pollutants weighted by a measure of their toxicity) removed at the 10 mines. The results presented in the report indicate all of the options considered were extremely "cost-effective" in terms of their removal efficiency for toxic pollutants and total solids.

For the purpose of performing the aforementioned BCT cost-reasonableness tests however, EPA calculated estimates of the aggregate or industry-wide cost of solids removed by the recommended BPT and BCT options. To arrive at these overall cost per pound figures, EPA utilized the model mine framework developed for its analysis of the economic impacts of this regulation (See Economic Impact Analysis, EPA 440/02-85-026, August 1985). The cost per pound incurred by the entire industry at BPT is approximately $0.00062, while the cost for large mines only (i.e.; those processing 500 cubic yards of material per day or more) is $0.00058. Small commercial mines (i.e.; those processing between 20-500 cubic yards per day) would incur an aggregate cost per pound of approximately $0.00061 at BPT. At the more stringent technology (100% recycle of process wastewater) recommended for BCT, the cost per pound of solids removed beyond BPT is $0.002 for large mines. The cost at BCT for small mines is also in this range, but no more stringent technology beyond BPT is recommended for these mines since it is believed that many are unprofitable under current economic conditions.

EPA considers the above cost figures to be one cent per pound removed since the actual estimated values are reasonable by any interpretation and because no smaller unit of currency exists; i.e., there is no other meaningful denomination. Therefore, when rounded to a cost, both of the BCT cost-reasonableness tests are "passed," and the candidate technology for BCT for both large and small mines is cost reasonable. See the aforementioned cost-effectiveness study for further details.

C. Summary of Proposed BCT Limitations

The proposed BCT limitations are summarized below:

Best Conventional Pollutant Control Technology

Subcategory	Effluent Limitation
Mines With Beneficiation Capacity of 20 to 500 yd^3/day of Paydirt (all Mining Methods)	TSS - 2000 mg/l Monthly Average
Mines With Beneficiation Capacity of over 500 yd^3/day of Paydirt (all Mining Methods Except Dredges with beneficiation capacity of over 4000 yd^3/day of paydirt)	No discharge of Process Wastewater
Large Dredges With Beneficiation Capacity of over 4000 yd^3/day of Paydirt	No Discharge of Process Wastewater

Specialized Definitions and Provision

The specialized definitions, commingled wastestream provisions, and storm exemption discussed in Section X for BPT are also proposed to be applicable to BCT.

SECTION XII

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

This section identifies effluent limitations based on best available technology economically achievable (BAT). See Section 301(b)(2)(A) of the Clean Water Act. These limitations are based on the best control and treatment technology employed by a sepecific point source within the point source category or subcategory, or by another industry where it is readily transferable. Emphasis is placed on additional treatment techniques applied at the end of the treatment systems currently employed for BPT, as well as improvements in process control and treatment technology optimization.

Input to BAT selection includes all materials discussed and referenced in this document. As discussed in Section VII, ten sampling and analysis programs were conducted to evaluate the presence/absence of toxic pollutants. A series of pilot-scale treatability studies was performed at several locations within the industry to evaluate BAT alternative.

Consideration was also given to:

1. Age and size of facilities and equipment involdved
2. Process(es employed
3. In-process control and process changes

4. Cost of achieving the effluent reduction by application of the alternative control or treatment technologies

5. Nonwater quality environmental impacts (including energy requirements)

In general, the BAT technology level represents the best economically achievable performance of plants of various ages, sizes, processes, or other shared characteristics. Those categories whose existing performance is uniformly inadequate may require a transfer of BAT from a different category. BAT may include feasible process changes or internal controls, even when not in common industry practice.

This level of technology also considers those plant processes and control and treatment technologies which at pilot-plant and other levels have demonstrated both technological performance and economic viability at a level sufficient to justify investigation.

The Agency has reviewed a variety of technology options and evaluated the available possiblities to ensure that the most effective and beneficial technologies were used as the basis of BAT. EPA examined technology alternatives which could be applied to placer mining BAT options and which would represent substantial progress toward prevention of environmental pollution above and beyond progress achievable by BPT.

The Clean Water Act requires consideration of costs in BAT selection, but does not require a balancing of costs against effluent reduction benefits (see Weyerhaeuser v. Costle, 11 ERC

2129 (DC Cir. 1978)). In developing the proposed BAT, however, EPA has given substantial weight to the reasonableness of costs and reduction of discharged pollutants. The Agency has considered the volume and nature of discharge before and after application of BAT alternatives, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels. The options presented represent a range of costs so as to assure that affordable alternatives remain after the economic analysis. The rationale for the Agency's selection of BAT effluent limitations is summarized below.

EPA considered the same treatment and control options discussed in Section VIII which were considered for BPT as the technology options for BAT: simple settling, recycle of process wastewater at 80 percent, recycle of process wastewater at 100 percent, and coagulation and flocculation of the 20 percent blowdown from 80 percent recycle. For each of the subcategories set out in Section IV, EPA reviewed the various BAT factors listed above to determine whether different BAT effluent limitations guidelines for certain groups of gold placer mines might be appropriate.

As discussed in Section VIII, although the regulation for gold placer mines is not being issue under a schedule established in the NRDC Settlement Agreement, EPA has decided to apply the criteria for regulating (or in the alternative excluding from regulation) toxic pollutants and subcategories established in Paragraph 8 of the Decree. Data collected by EPA from individual mines within the industry were used in deciding which specific toxic pollutants would be regulated.

Paragraph 8(a)(iii) of the Settlement Agreement allows the Administrator to exclude from regulation toxic pollutants not detectable by analytical methods developed under Section 304(h) of the Clean Water Act or other stat-of-the-art methods. This provision also applies to pollutants below EPA's nominal detection limit. In addition, Paragraph 8(a)(ii) allows the exclusion of pollutants that were detected in amounts too small to be effectively reduced by technologies known to the Administrator. One hundred and nine toxic organics, cyanide and eleven toxic metals are excluded from regulation under these provisions.

Paragraph 8(a) (iii) also allows the Administrator to exclude from regulation pollutants detected in the effluent of only a small number of sources within the category and uniquely related to those sources. The toxic organic pollitant methylene chloride was detected in the effluent at three mines during the screen sampling program and Bis(2-Ethylhexyl)Phthalate was found at one mine. These two organics are attributed to sample and laboratory contamination. Methylene chloride and Bis(2-Ethylhexyl)Phthalate are therefore excluded under this provision.

Paragraph 8(a) (iii) of the Settlement Agreement also allows the Administrator to exclude from regulation pollutants that are effectively controlled by the technology upon which other effluent limitations guidelines and standards are based. As described more fully in Section VII and Section XI, EPA has determined that solids, primarily the solids put into suspension by the benefication process at placer mines, are the principal pollutant in the wastewater from placer mines and, furthermore, that limiting the discharge of solids controls other pollutants which are found in the solid form. Therefore, the Agency is basing limitations more stringent than BPT on the control of solids: TSS, a conventional pollutant controlled under BCT, and settleable solids, a non-conventional pollutant controlled under BAT. The Agency believes that arsenic and mercury found in discharges from placer mines are adequately controlled by the incidental removal associated with the control and removal of settleable solids and TSS found in the discharges. If TSS are controlled to meet the BCT limitations, and settleable solids are controlled to meet the BAT limitations, any arsenic and mercury in the discharge would be reduced to levels that would be proposed if arsenic and mercury were controlled directly e.g., the concentrations promulgated to control arsenic and mercury in the ore mining and dressing point source category regulation. See 40 CFR Part 440.

The 1982 final effluent limitations guidelines and standards for ore mining and dressing excluded the toxic pollutant asbestos from direct effluent limitations because effluent limitations on solids (TSS) effectively controlled the discharge of asbestos (chrysotile). Asbestos was found in all raw waste discharges and all effluent from all ore mines and mills where an analysis was made for asbestos (88 samples representing 23 mine/mill facilities). EPA found a high degree of correlation between solids and chrysotile asbestos in the raw wastewater and treated wastewater and concluded that settling tehnology was so successful at removing solids, an effluent limitation on asbestos was not appropriate inlight of the correlation with solids and the expense of monitoring specifically for asbestos. The Agency believes that efflunet limitations on solids in the discharge from gold placer mines would also control the discharge of asbestos.

Turbidity has been the subject of some controversy as to what achievable levels can be obtained by various treatment technologies and what levels of turbidity are acceptable water quality for various uses. Turbidity is not a toxic pollutant; rather, turbidity is a nonconventional pollutant which can be controlled by direct BAT limitations on the levels of turbidity that may be discharged or by indirect control through limitations on other pollutant parameters, i.e., solids. As discussed in Section VII, turbidity is a measure of the light scattering properties of water. Turbidity levels are a function of and the result of suspended solids in water; the mass, size, shape, and refractive index of the solids in the water affect the measured turbidity. Since turbidity is a function of solids levels, EPA is proposing BAT effluent limitations on settleable solids, a nonconventional pollutant.

For each of the gold placer mining subcategories, the Agency has not identified any technology more stringent than those proposed here for BAT which are attainable and economically achievable within the Act. The Act does not permit consideration of water quality problems attributable to a point source or industry or water quality improvements in particular water bodies in setting technology-based effluent limitations guidelines. Water quality considerations are not and can not be the basis for selecting BAT. See Weyerhauser Company v. Costle, 590 F. 2d 1011 (D.C. Cir. 1976). Effluent limitations on turbidity may be included in NPDES permits if necessary to meet state water quality standards.

For large dredges and mines with beneficiation process capacity larger than 500 yd^3/day (all mining methods), EPA is proposing no discharge of process wastewater based on total recycle of process wastewater as the BAT effluent limitation guideline. These effluent limitations are the same as the BCT effluent limitations. EPA is not proposing any more stringent limitations because we have not identified any more stringent technologies to control process wastewater pollutants from these groups of gold placer mines.

For mines with beneficiation process capacity of 20 to 500 yd^3/day (all mining methods) EPA is proposing BAT effluent limitations on settleable solids (SS) based on simple settling technology equal to BPT and BCT limitations on SS. EPA is not proposing BAT effluent limitations guidelines for these smaller mines based on partial (80 percent) or total (100 percent) recycle because, as discussed in Section IX and in the Economic Impact Analysis, effluent limitations based on these technologies would not be economically achievable for this group of mines.

EPA is not proposing BAT effluent limitations based on coagulation and flocculation of the blowdown from partial recycle because technical questions remain to be resolved regarding the use of flocculants on the wastewater discharges from gold placer mines (as discussed in Section VIII) and the economic impact on these smaller mines of partial recycle is not economically achievable.

The proposed BAT effluent limitations are summarized below:

Best Available Technology Economically Achievable

Subcategory	Effluent Limitations
Mines with Benefication Capacity of 20 to 500 yd^3/day of Paydirt (all mining methods)	Settleable Solids - 0.2 ml/l Instantaneous Maximum
Mines with Benefication Capacity of over 500 yd^3/day of Paydirt, (all mining methods except Large Dredges with capacity of over 4000 yd^3/day of paydirt)	No Discharge of Process Wastewater
Large Dredges with Benefication Capacity of over 4000 yd^3/day of Paydirt	No Discharge of Process Wastewater

Specialized Definitions and Provisions

The specialized definitions, provisions for commingled waste streams and the storm exemption discussed in Section X for are also applicable to BAT effluent limitations guidelines.

Engineering Aspects of Best Available Technology Economically Achievable

The implementation of technology to attain BAT effluent limitations will not create any additional air pollution emissions. The amount of solid waste generated by the technology for BAT limitations is negligible compared to the amount generated by mining and processing. Land requirements for settling ponds at mines processing less than 500 yd^3/day (all methods) and at large dredges are no more than the requirements for BPT. For mines processing more than 500 yd^3/day (all methods except large dredges), there is a small increase in anticipated land requirements. However, land already mined will generally be available.

Recycling of process wastewater may have a short-term impact on water use downstream from the mine on a stream with limited flow. However, this short-term impact will most often be negligible because once the amount necessary for recycling is removed, the remaining flow, as well as subsequent flow, will continue downstream. In addition, flow will be higher quality, i.e., it will not contain pollutants from placer mining. It is not intended that mines upstream deny water to downstream users impounding excess water above the amount used in the process or allowed by their water right.

Recycle of process wastewater at mines with a benefecation process capacity of over 500 yd^3/day will create in increase in energy consumption for power to drive recycle pumps. At many mines, gravity flow is used to bring water to the benefecation process and these mines will require the addition of a pump and a means to drive the pump. Most mines do not have electricity available for such pumps and EPA believes the mines will probably purchase a form of skidmounted diesel or gasoline direct drive engine/pump. In determining the cost to implement the no discharge of process wastewater requirement by recycle, EPA included the cost to purchase a skid-mounted unit and the fuel to run the unit. However, in actual practice, EPA has observed that many mines are already using pumps to supply wash water either one time through or recycled process wastewater. These mines with pumps to supply wash water will have little if any increase in energy consumption to recycle 100 percent of the process wastewater.

There will also be an increase in energy consumption to provide power for the equipment to build and maintain the wastewater treatment facilities (settling and holding ponds). However, in determining the cost to implement the technology for sample settling or recycle, EPA used the value of the equipment and labor time of the equipment already at the mine and the equipment operators already at the mine. The equipment time for building and maintaining ponds is a small part of the total equipment hours available in a mining season; the energy consumption to build and maintain ponds is negigible compared to the total energy requirement for mining in a season. For example, the mine represented by Model B in Section IX would use about 225 machine/operator days to mine and process in a season and about 15 machine/operator days to build and maintain a 100 percent process wastewater recycle facility.

The largest impact on mines processing more than 20 yd^3/day (all mining methods except large dredges) is the cost to meet the design, construction, and operation requirements of a proper treatment system, e.g., to meet the requirements of the storm exemption, consisting of settling ponds for mines processing less than 500 yd^3/day and holding ponds for recycle of process wastewater for mines processing more than 500 yd^3/day. The construction and operation of facilities that will quality for the strom exemption is discussed in Section X. Most mines for which EPA has data and information on existing ponds will have to construct and maintain larger ponds with better construction and design than are presently being used. Attention to detail will be required to address such factors as: surface areas of the pond, rate of flow through the pond, eliminating short circuiting of flow across the pond, and entrace and exit effects of the effluent. A number of handbooks are available to assist the mine operator in the design, construction, and maintainance of ponds, including "Placer Mining Settling Pond Design Handbook," January 1983, States of Alaska Department of Environmental Conservation. The use of the concepts depicted in such handbooks will greatly facilitate the mine operator complying in with the BAT effluent limitations.

As discussed above, the Clean Water Act does not require a balancing of costs against effluent reduction benefits. However, included in the record supporting the proposed regulation, is the Agency's report "Cost Effectiveness Analysis of Proposed EFfluent Limitations for the Placer Gold Mining Industry" which calculates two measures of effectiveness of the proposed regulation: pounds of TSS removed as discussed in Section XI and pounds of priority (toxic) pollutants removed weighted by an estimate of their toxicity, e.g., pound-equivalents removed. Non-regulated pollutants, i.e., arsenic and mercury, are included when they are removed incidently as a result of a particular treatment technology. The cost-effectiveness in terms of pound equivalent removed for sample mines with beneficiation capacity of over 500 yd^3/day (all mining methods except large dredges) which is the group of placer mines with BAT more stringent than BPT is acceptable and justifies the approximate $212 per pound equivalent removed. In addition for all estimated mines in this group, the cost per pound of solids removed in BPT to BAT is less than $0.002 or over a million tons of solids at a cost of about $3,300,000.

SECTION XIII

NEW SOURCE PERFORMANCE STANDARDS (NSPS)

The basis for new source performance standards (NSPS) under Section 306 of the Act is best available demonstrated technology. New facilities have the opportunity to implement the best and most efficient ore mining and milling processes and wastewater technologies. Congress, therefore, directed EPA to consider the best demonstreated process changes and end-of-pipe treatment technologies capable of reducing pollution to the maximum extent feasible.

EPA proposed that new source gold placer mines achieve new source performance standards that are equivalent to the effluent limitations guidelines proposed for BCT and BAT. The general wastewater characteristics costs to treat and percentage of pollutant removals from new sources are expected to be similar to existing sources.

These performance standards would apply to process wastewater as defined in the specialized definition discussed in Section X. The combined (commingled) waste stream provision and storm exemption which apply to BPT and BAT also apply to NSPS. See Section X.

EPA is unable to identify any more stringent limitations for mines with beneficiation capacity of over 500 yd^3/day than the no discharge requirement. For beneficiation processes of less than 500 yd^3/day, EPA is not proposing any more stringent limitations for new sources than what is required for existing sources. EPA expects that the financial condition of new source mines smaller than 500 yd^3/day will be similar to existing mines of this size and that more stringent standards may prevent new people from entering the placer mining industry, i.e., it may pose a barrier to entry. Since the new source standards are equivalent to the existing source standards, these proposed NSPS will not pose a barrier to entry.

New Source Performance Standards

Subcategory	Effluent Limitation
Mines With Beneficiation Capacity of 20 to 500 yd^3/day of Paydirt (all mining methods)	Settleable Solids - 0.2 ml/l Instantaneous Maximum TSS - 2000 mg/l Monthly Average
Mines With Beneficiation Capacity of over 500 yd^3/day of Paydirt (all mining methods except Large Dredges with Capacity of over 4000 yd^3/day of paydirt)	No Discharge of Process Wastewater
Large Dredges With Beneficiation Capacity of over 4000 yd^3/day of Paydirt	No Discharge of Process Wastewater

SECTION XIV

PRETREATMENT STANDARDS

Section 307(b) of the Act requires EPA to promulgate pretreatment standards for both existing sources (PSES) and new sources (NSPS) of pollution which discharge their wastes into publicly owned treatment works (POTWs). These pretreatment standards are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTWs. In addition, these standards must require pretreatment of pollutants, such as certain metals, that limit POTW sludge management alternatives. The legislative history of the Act indicates that pretreatment standards are to be technology-based and, with respect to toxic pollutants, analogous to BAT.

EPA did not propose pretreatment standards for existing sources (PSES) or new sources (PSNS) in the ore mining and dressing point source category in the 1982 rulemaking nor is it proposing such standards for the gold placer mine subcategory since there are no known or anticipated discharges to publicly owned treatment works (POTWs).

☆U.S. GOVERNMENT PRINTING OFFICE 1985 491 191 46106