canada/yukon subsidiary
agreement on mineral resources

Program 3 Placer Mining

PLACER MINING WASTEWATER TREATMENT TECHNOLOGY

Sigma Resource Consultants Ltd.

Canada

Yukon

DEPARTMENT OF INDIAN AFFAIRS
AND
NORTHERN DEVELOPMENT

PLACER MINING SETTLING PONDS

VOLUME TWO
DEMONSTRATION PROJECT METHODOLOGY

SRCL S3487
MARCH 1986

SIGMA RESOURCE CONSULTANTS LTD

CONTENTS

1. INTRODUCTION

This report is Volume Two of a study on placer mining settling pond design. The first volume, **Design Principles**, reviewed methods and criteria for settling pond design and identified field research needs. This volume outlines the methodology for a demonstration project intended to generate required settling pond design data.

The general objectives of the demonstration project are: 1) to refine the settling pond design methods outlined in Volume One; and 2) to demonstrate construction and operation of a settling pond system designed in accordance with proposed criteria. The detailed objectives of the demonstration project, as recommended in Volume One, can be summarized as follows:

1) Evaluate various sampling strategies to obtain representative paydirt samples.

2) Evaluate proposed methods for estimating fine sediment storage volumes.

3) Evaluate pre-settling ponds that can be cleaned by conventional earthmoving equipment;

4) Determine the minimum hydraulic retention time for effective settleable solids removal.

5) Investigate the influence of varying length to width ratios and pond inlet berms on settling pond performance.

6) Evaluate and refine the use of a settling pond system model based on discrete settling and ideal settling basin theory for estimating pond effluent suspended solids.

7) Evaluate the use of settling tests for estimating pond effluent suspended solids.

8) Evaluate the use of total recycle as a waste treatment method.

9) Assess the actual costs of providing effective settling pond treatment with and without total recycle at an operating mine.

10) Demonstrate design, construction and operation of a settling pond system designed in accordance with proposed criteria.

Study Approach

These objectives can be best achieved by detailed field studies and monitoring at a single "primary" mining operation plus limited data collection at several additional "secondary" sites. The primary site would serve as the demonstration site and would in turn provide data required to evaluate the factors which affect settling pond performance. Visits to several secondary sites would provide sufficient data to apply and test the proposed settling pond design procedure for different types of mining operations.

Report Outline

The technical methodology is outlined in Section 2. Section 3 describes site requirements and give examples of mining operations that could meet these criteria. A workable administrative frame-work is critical to the demonstration project's success. Possible forms of contractual agreements between the Government, Mine Operator and Consultant are discussed.

A project schedule and cost estimate are given in Sections 4 and 5. The final section summarizes the major recommendations.

2. METHODOLOGY

2.1 PAY GRAVEL SAMPLING

Pay gravel grain size distribution data are essential in order to estimate settling pond sediment storage requirements, and to predict effluent suspended solids concentrations when using methods based on sedimentation theory. Wide variations in size distribution have been observed between different placer deposits as well as within single deposits.

Research Objective: - to determine the number of pay gravel samples required to generate grain size distribution data that are representative for a single operation over one mining season.

Methodology: - collect eight weekly pay gravel samples during active mining using proposed sampling methods;

- determine grain size distributions using procedures outlined in Section 4.1.1 of Volume One;

- complete statistical analyses of the data, describing the relationship between the number of samples collected and corresponding variations in estimated sediment storage volumes and effluent suspended solids.

Comments: - quantitative data is required to provide an example of size distribution variations, regardless of the fact that the results may be site specific;

- the data is also required to complete the materials balance computations necessary to address other research objectives.

2.2 SEDIMENT VOLUME ESTIMATES

A key settling pond design specification is a storage volume requirement for one season's sediment production.

Research Objective: - to evaluate the accuracy of sediment volume estimates calculated by the proposed pond sizing methods.

Methodology: - apply the methods described in Section 4 of Volume One at the primary study site

- complete cross-section surveys of each cut plus tailings piles and ponds; determine actual volumes for pay material, coarse tailings, sand tailings and sediment accumulation in ponds;

- determine pond sediment dry density and determine the grain size of the sediment samples to verify dry density estimates predicted by equation 14 in Volume One.

Comments: - the observations should be made before and after each cut is mined, which would result in two or three sets of measurements over an eight week period;

- sampling of sediment for dry density determinations will require specialized equipment.

2.3 PRE-SETTLING POND EVALUATION

Construction and operation of a pre-settling pond has been proposed as a practicable method for extending main settling pond life.

Research Objective: - to evaluate pre-settling pond geometry and sediment removal efficiency based on the design specification listed below.

Methodology:

- construct a pre-settling pond with an overflow rate of 7.5 $m^3/hr/m^2$ (2.6 $Igpm/ft^2$) and a depth of 0.7 m;
- estimate the actual mass and volume accumulation rates of material trapped;
- determine the maximum water and sediment depths that can be handled by dozers and loaders, and document any changes in required machine maintenance;
- reconstruct and enlarge the pre-settling pond to increase settling effectiveness;
- evaluate the relationship between pre-settling pond size and main settling pond life.

Comment:

- the reconstructed pond design should provide for regular cleaning of the pond with conventional equipment.

2.4 RETENTION TIME FOR SETTLEABLE SOLIDS REMOVAL MAIN SETTLING POND

A review of available limited data indicates that approximately 5 hours theoretical retention time (ie. the pond water volume divided by the pond influent flowrate) is required to achieve a settleable solids level of 0.2 ml/L. This criterion should be confirmed by field measurements.

Research Objective:

- to determine the minimum theoretical hydraulic retention time for effective settleable solids removal.

Methodology:

- monitor main pond settleable solids levels at the primary study site and/or at the secondary sites; when a level of 0.2 ml/L is reached, determine the pond water volume by cross-section survey (soundings from a small boat);

- measure pond influent flowrate and compute the theoretical retention time;

- make a note of any additional factors that could be affecting settleable solids removal (eg. shallow pond depth and scouring near the pond outlet).

Comment: - monitoring and measurement of at least three operating ponds as described above is recommended to observe possible site specific variations.

2.5 EFFECTS OF POND GEOMETRY AND APPURTENANCES MAIN SETTLING POND

Settling pond performance can be enhanced by maximizing the flow path length between the inlet and outlet plus by providing uniform distribution of the influent over the pond width. However, the potential benefits from modifications to pond geometry have not been quantified for full scale ponds.

Research Objective: - to investigate the effects of pond length to width ratios and pond inlet berms on settling pond performance.

Methodology: - construct the main settling pond at the primary study site with a length to width ratio of about 5:1;

- conduct a tracer study and cross-section surveys of the new pond to determine the dead space fraction (see Section 3.1, Volume One);

- compare the measured dead space fr [illegible] with the preliminary estimates given in Section 3.1, Volu[illegible];

- construct a permeab[illegible]ck inlet berm to reduce inlet velocity and improve [illegible]istribution;

- repeat the tracer tests to determine the effect, if any, of the berm on actual pond retention time and dead space fraction;

- conduct an additional tracer test and cross-section surveys on a settling pond with a less favourable length to width ratio at one of the secondary study sites;

- compare the measured dead space fraction from the secondary site with the demonstration pond results and the preliminary estimates given in Section 3.1, Volume One;

- summarize the observed effects of length to width ratios and inlet berms on pond performance.

Comments:

- the focus of this work is to check the effect of changes to length to width ratios on shortcircuiting as predicted by the theoretical pond model;

- the preferred tracer test would probably utilize "step test" injection of Rhodamine WT dye monitored by a fluorometer equipped with a strip chart recorder. To reduce turbidity, pay material would not be processed for the duration of the test. Background theory for calculation of mean residence time and dead space fraction using tracer tests is given by Griffin and Barfield (1983) and Levenspiel (1972).

2.6 EFFLUENT SUSPENDED SOLIDS ESTIMATES BASED ON THE THEORETICAL SETTLING POND MODEL

A method for predicting effluent suspended solids based on grain size data, flowrates, feed rates and sedimentation theory was developed in Volume One.

The calculation assumes that "steady state" conditions are reached following continuous sluicing for a period longer than the retention time of the pond system (refer to Section 4.4.3 Volume One). However, this assumption would not necessarily be valid for smaller operations operating only one shift per day. Thus the research methodology outlined below addresses non-steady state as well as steady state conditions.

Research Objective: - to assess and refine the proposed method for estimating effluent suspended solids

Methodology: Part One - Steady State Conditions

- estimate effluent suspended solids by applying the method described in Section 4 of Volume One; complete estimates for the primary study site plus a minimum of four secondary sites with single pass flow through sedimentation ponds;

- compare actual measured effluent quality with effluent quality predicted by the method;

- determine actual grain size distributions of pond influent and effluent suspended solids by the Bottom Withdrawal Tube method (see Appendix I) and compare measured and predicted grain size distributions;

- analyze the results, including water and materials balance calculations for the primary site, and, if appropriate, modify the method to improve the predictive accuracy.

Part Two - Non-Steady State Conditions

- develop a correction factor formula to adjust the predicted effluent suspended solids levels to account for the hours of continuous sluicing per day in relation to the theoretical pond retention time, and also to account for residual suspended solids levels from the previous day's sluicing;

- measure hourly effluent suspended solids levels at the primary study site and sluice continuously until maximum 'steady state' effluent suspended solids levels are achieved (up to approximately 20 hours, depending on pond retention time), stop sluicing and continue hourly measurements of residual suspended solids levels in the pond for several hours;

- measure the theoretical pond retention time by cross-section survey.

Comment:

- the correction factor formula would be developed from materials balance and sedimentation theory, then checked with the field data;

- the purpose is to provide more accurate effluent quality estimates for smaller operations utilizing only 1 shift per day; the formula would also provide an indication of how effluent quality might deteriorate as the pond volume was reduced by sediment accumulation.

2.7 EFFLUENT SUSPENDED SOLIDS ESTIMATES BASED ON SETTLING TESTS

Settling tests with simulated or actual wastewater samples may provide reasonably accurate estimates of effluent suspended solids.

Research Objective:

- to evaluate the relative accuracy of effluent suspended solids estimates based on settling tests with simulated wastewaters and with actual wastewaters; and to evaluate the effects of settling vessel size on test results.

Methodology:

- conduct settling tests, using 2 m high x 150 mm diameter plexiglass columns, with simulated and actual wastewaters at the primary and secondary study sites; measure pond volumes; compute theoretical retention times; and estimate effluent suspended solids (see Section 4.1.1 Volume One);

- analyze and compare the grain size distributions of the actual and simulated wastewaters tested (use the BW Tube grain size analysis method, Appendix I);

- compare estimates of pond effluent quality with actual effluent quality;

- conduct "duplicate" settling tests using 1000 ml cylinders; compare the 1000 ml cylinder results with results from the column tests making sure that the wastewater sample sediment concentration and grain size distribution for comparative tests are equivalent.

Comment: - the above work will define the usefulness and limitations of settling tests and will result in recommendations for a standardized settling test procedure.

2.8 TOTAL RECYCLE

Total recycle and elimination of a surface discharge is a potential method for meeting stringent effluent standards. The work proposed for this demonstration project would be completed without the use of flocculants and should complement the 1986 flocculant studies proposed by others.

Research Objective: - to operate a total recycle system at a Yukon placer mine as a wastewater treatment method and to develop methods and additional criteria for designing ponds to facilitate total recycle without chemical flocculation.

Methodology: - convert the flow through pond system to a total recycle system by installing an intake, pump and piping to recycle process water from the main settling pond;

- reduce the potential for surface runoff entering the pond system by ditching and drainage;

- operate the system for at least three weeks;

- monitor system performance and variables including:
  - material feed rate and particle size
  - rate of buildup of suspended solids in process water
  - process water suspended solids grain size (BWT method) and specific gravity (hydrometer)
  - hours sluiced per day
  - pond volume
  - pond influent flowrate

- observe and document the sediment removal performance of the pond at high suspended solids levels and evaluate the application of the basic theoretical settling pond model to predicting recycle pond performance;

- develop a predictive model for estimating the rate of buildup of suspended solids as a function of system variables.

Comment: - the settling pond layout at the primary site will have to be designed to facilitate the recycle demonstration.

2.9 WASTE TREATMENT COSTS

The costs of providing effective settling pond treatment at placer mines is highly site specific. As discussed in Section 7 of Volume One, an assessment of industry-wide waste treatment costs to meet a given set of effluent standards would require the preparation of detailed waste treatment designs for a large proportion of the industry. In spite of the limitations of studying a single site, detailed monitoring of the primary site waste treatment costs would provide useful data for subsequent cost assessments.

The demonstration mine activities that relate to direct control of erosion and fine sediment losses should be included in the cost accounting. These items would include:

- surface runoff and erosion control work
- stream diversions and flood protection
- pre-settling pond construction and clean out
- settling pond construction
- pumping, piping and site work to facilitate total recycle
- data collection, design and monitoring

Detailed monitoring of machine hours, labour and capital costs for each item should be conducted throughout the project. Care will be required to separate standard waste treatment costs from the costs of performing the research experiments. Unit costs for machine and labour time proposed by the Klondike Placer Miners Association (Wright Engineers, 1986) could be utilized in calculating project costs.

The recycle data required to prepare an estimate for annual recycle costs would include:

- equipment costs
- construction and installation costs
- operating and maintenance costs
- potential costs attributed to lost gold production either by additional "downtime" due to recycle, or by reduced gold recovery.

Conclusive data on the effects of recycle on fine gold recovery would not be practicable to obtain, however any observations on changes in the sluicing operation, such as washing effectiveness, should be recorded.

2.10 SUMMARY OF TECHNICAL PROGRAM

The research and demonstration activities to be completed at the primary and secondary sites are summarized briefly below.

Primary Site

- data collection for design of pond and stream diversion
- construction of pond and stream diversion
- evaluation of pay gravel sampling methods
- evaluation of sediment volume estimates
- optimization of pre-settling pond geometry
- determinationn of retention time for settleable solids removal
- evaluation of effects of pond geometry and appurtenances
- evaluation of effluent suspended solids estimates based on the theoretical pond model
- evaluation of effluent suspended solids estimates based on settling tests
- evaluation of total recycle
- detailed monitoring of pond performance and costs.

Secondary Sites

- determination of retention time for settleable solids removal (at least two sites)
- evaluation of effects of pond geometry and appurtenances (at least one site)
- evaluation of effluent suspended solids estimates based on the theoretical pond model (at least four sites)
- evaluation of effluent suspended solids estimates based on settling tests (at least four sites).

3. SITE REQUIREMENTS

3.1 SITE SELECTION CRITERIA

The primary study site should be a mining operation with the following characteristics:

1) a defined mining plan and layout that includes daily sluicing for at least 80 days (the dependability of continuous sluicing is of paramount importance);

2) adequate land area for construction of a single main settling pond (approximately 2 to 4 acres) within relatively close proximity to the mining and sluicing operation (approximately 500 feet) (ie. relatively easy to convert to recycle);

3) stream diversion either not necessary, feasible to construct, or feasible to upgrade;

4) a dependable, relatively clean water supply presently without recycle; (the use of a pump system that could be moved for recycle could result in project cost savings).

5) process water flow rate and average material feed rate in the ranges of 1500 - 3000 Igpm and 75 - 150 yds^3/hr;

6) accessible by road;

7) no groundsluicing or hydraulic stripping;

8) a co-operative mine operator who would be compensated for work performed.

The above criteria have been specified to facilitate accomplishment of the research program. The location of the site in the Klondike area within easy access of a large number of miners would enhance the demonstration value of the project.

The criteria for selection of the four (or more) secondary study sites are as follows:

1) an operating mine (actively sluicing);

2) a settling pond system capable of meeting a settleable solids objective of 0.2 ml/L or better;

3) no recycle;

4) preferably at least one site for each type of deposit class (ie. gulch, narrow valley - low bench, broad valley and high bench);

5) a co-operative mine operator (there would generally be minimal disruption to these operations).

3.2 PROJECT ADMINISTRATION AND SITE SELECTION

A number of possible administrative arrangements for the settling pond demonstration project could be considered as outlined below. It is also recommended that the Klondike Placer Miners Association be consulted as to possible alternative arrangements and be involved in the site selection process. The possible arrangements include:

1) government operated demonstration mine;

2) a privately operated demonstration mine that can be studied with minimal interference to the operation;

3) a privately operated site that requires modifications to provide a pond system suitable for achieving the research objectives; the modifications would be paid for by government contract.

The government operated demonstration mine concept apparently is not a viable alternative for 1986. Item 2) above, the "minimal interference" concept, would be an arrangement similar to the 1984 Flocculant Demonstration Project completed at the Airgold site by Stanley Associates (1985). However, it is unlikely that a miner has in place, or will build a settling pond system to meet project requirements as well as providing additional assistance without compensation.

It is proposed that the mine operator be directly compensated for the required work according to a formal government contract. This could be set up in a form similar to a typical construction contract. This arrangement would ensure that the mine operator at the primary site is fully co-operative and motivated towards achieving the project objectives.

The scope of work would include erosion control works, stream diversion and flood protection construction, pre-settling pond construction and cleanout, main settling pond construction, recycle system set up and operation, and supply of materials, equipment and labour. Payment would be based on a schedule of lump sum items to construct and maintain works in accordance with specifications. Payment for additional miscellaneous work could be based on hourly rates for equipment and labour.

Payment for possible lost gold production due to "down time" could be based on previous production experience and an appropriate formula. Alternatively, it is suggested that compensation for lost revenues could be provided indirectly through the lump sum prices.

Construction inspection and contract administration services would be required. It is proposed that the engineering consultant hired [illegible] -omplete the research work would also provide these services.

Site Selection Procedure

The suggested procedure for site selection can be outlined as follows:

1. Prepare an outline of site criteria, scope of work, general contract provisions and procedure for awarding contract.

2. Contact potential operators.

3. Meet with interested operators and select the three best sites.

4. Select the project engineering consultant. Initial work should include preliminary site design and quantity estimates for the three sites to support price negotiations.

5. Negotiate the terms of an agreement with each of the three operators based on the preliminary site designs and quantity estimates.

6. Select the best site.

7. Proceed with the detailed design, construction and research program.

The prices for the site contract work to be performed by the mine operator should be negotiated considering the following points:

- the mine operator is already required by the Water Board to provide a settling pond with an effluent "objective" of 0.2 ml/L settleable solids;

- the project will provide the operator with free engineering and testing that would be of benefit in meeting effluent standards in future years.

The total value of the contract with the operator should therefore be sufficient to cover his expected additional costs to build and maintain the ponds to proposed specifications, to set up the recycle system for temporary operation and to compensate for any lost revenues due to reduced sluicing time.

3.3 POTENTIAL SITES

Given the available data in previous reports and government publications, it is not possible to provide an extensive list of potential sites. It is suggested that the field personnel in the various government departments in the Yukon (including the Yukon Water Board) that are most familiar with the placer operations, could compile lists of operations that meet project criteria. Contact with the mine operators would then be necessary to determine their plans for 1986 and their possible interest in providing either the primary or secondary study sites.

A few example operations from previous mining seasons that apparently met the proposed criteria are as follows:

Example of Primary Site:

- Airgold Ltd., Dominion Creek (Stanley, 1985)

Examples of Secondary Sites:

- Yukon Jack Mines, Dominion Creek (Stanley, 1985).
- K Djukastein, Revenue Creek (Reid Crowther, 1984).
- Bardusan Placers, Johnson Creek (Reid Crowther, 1984).
- Bleiler Placer, Highet Creek (Reid Crowther, 1984).
- Sites studied by Weagle (1984), except for #8, #9 and #14, which utilized recycle (assuming additional pond capacity would be provided).

4. SCHEDULE

A proposed project schedule is outlined in Figure 1. It is recommended that the core field program at the primary study site be conducted over an eight week period in July, August and September, which would cover more than 50% of the potential operating season. The proposed research at the secondary sites would be conducted during this same period.

Lead time is required to collect field data, complete detailed pond design and construct the pond system. The primary site operator should therefore be selected before the end of May, at the latest, in order to have sufficient time to complete the program before freeze up.

SIGMA GROUP
PROJECT SCHEDULE

PLACER MINING SETTLING POND DEMONSTRATION PROJECT

Job Number 3487
DATE MARCH 1986

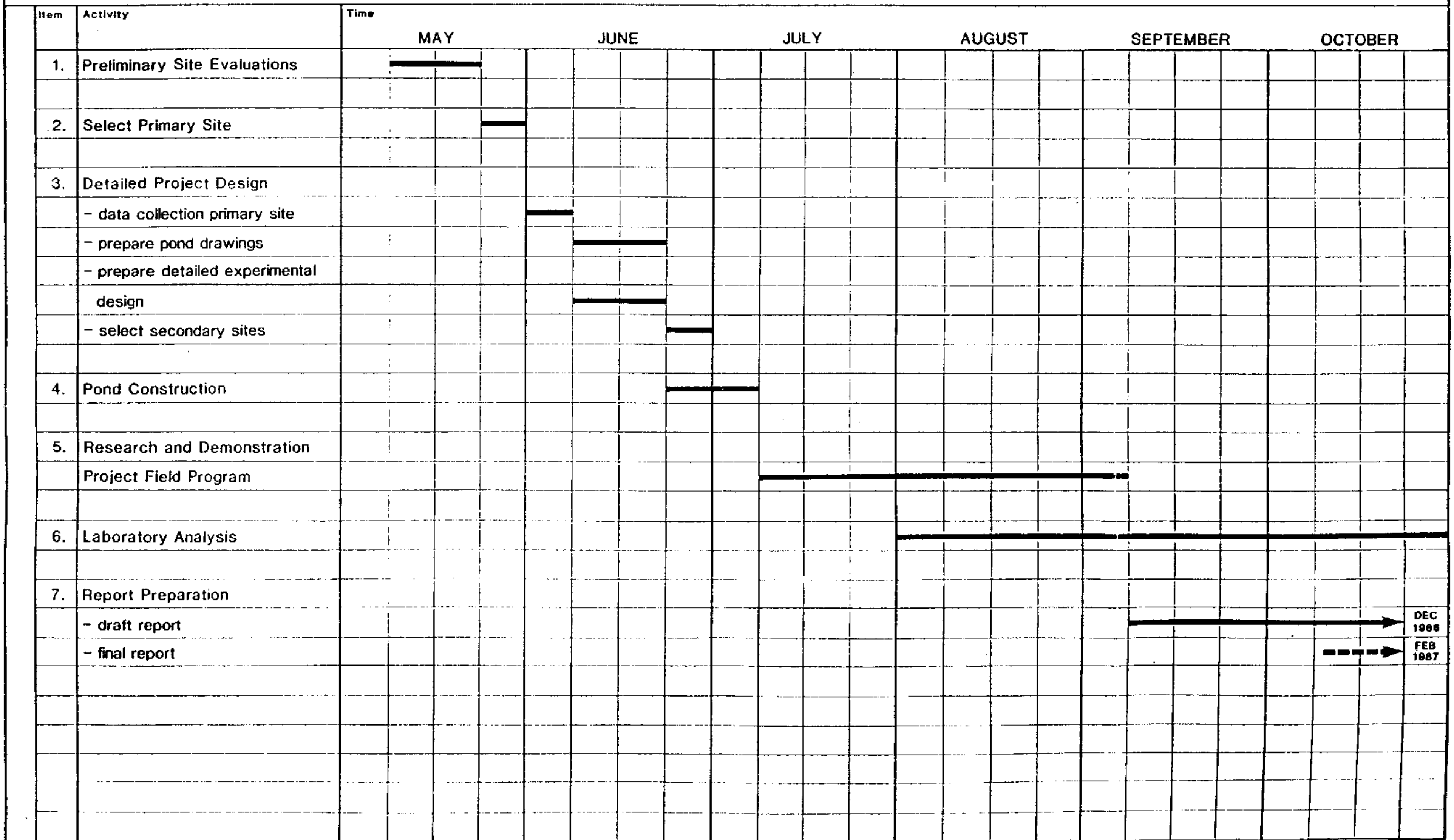

FIGURE 1

5. COST ESTIMATE

The costs of demonstration site construction and operation and the required consulting engineering services are estimated below. Additional government personnel time and expenses will be required for site selection and project administration.

5.1 POND CONSTRUCTION AND OPERATION

The actual value of the primary site contract will depend on site specific factors and the negotiated prices. The estimate presented below is based on the hypothetical example discussed in Section 4, Volume One and is therefore a rough figure for planning purposes; actual costs may be significantly different.

	Item	Quantity		Estimated Cost
1.	Stream diversion improvement and erosion control works	site specific	(allow)	$ 5,000
2.	Pre-settling pond construction and clean out of fine sand	4800 m^3		6,000
3.	Excavation of Settling Pond (includes embankment construction)	17,000 m^3 (total pond volume)		22,000
4.	Primary spillway, emergency spillway and rock inlet berm	site specific	(allow)	5,000
5.	Recycle System Costs (approx 20 days) - short term lease and installation of pump set, piping and intake works, or move existing pump system - fuel costs and maintenance - additional "down time" due to recycle	site specific	(allow)	7,000
		TOTAL		**$ 45,000**

5.2 DESIGN, FIELD PROGRAM AND REPORT PR_PARATION

An engineering consulting firm, or possibly government technical staff, would be required to design and conduct the project. The completion of the core field program, comprised of the research and demonstration site work described in section 2, would be sufficiently demanding to fully utilize a two person field team (professional engineer and technologist) over an eight week period.

Personnel and expenses costs for the project are estimated below:

Personnel

	Item	Personnel	Days	Estimated Cost
1.	Preliminary site evaluations, designs and quantity estimates	PE Tech	12 10	$ 4,800 2,400
2.	Detailed data collection, site design and construction supervision	PE Tech	18 25	7,200 6,000
3.	Research and Demonstration Program	PE Tech	40 40	16,000 9,600
4.	Analysis and Report Preparation	PE Tech	50 40	20,000 9,600
5.	Additional personnel including: review by senior staff, drafting and word processing			8,400
		Total		**$ 84,000**

Expenses

	Item	Estimated Cost
1.	Airfare, vehicle, accommodation and meals	$ 20,000
2.	Sampling and testing equipment	3,000
3.	Laboratory Analyses - sieve and hydrometer grain size - BW Tube grain size - suspended solids - freight	8,000
4.	Office Expenses	1,500
	Total Expenses	**$ 32,500**

5.3 COST SUMMARY

The total cost of the project is estimated to be approximately $178,000 as summarized below:

Item		Estimated Cost
1. Pond Construction and Operation		$ 45,000
2. Personnel		84,000
3. Expenses		32,500
	Subtotal	$ 161,500
	10% Contingency	16,150
	TOTAL	**$ 177,650**

A major cost saving could be realized if a suitable primary study site could be found that required only minimal work to modify an existing settling pond system.

6. RECOMMENDATIONS

This report outlines the required field study methodology to refine and evaluate proposed criteria and procedures for settling pond design, [illegible] and estimating effluent suspended solids. Major recommendations can be summarized as follows:

1) The research and demonstration project should be completed at a primary demonstration mine site plus at four (or more) secondary sites covering a range of placer mining conditions.

2) The primary demonstration site work should include detailed monitoring and analysis of the factors affecting settling pond performance, evaluation of the proposed methods for estimating effluent quality, evaluation of total recycle, and documentation of waste treatment costs.

3) The secondary site work should include further evaluation of the proposed methods for estimating effluent quality plus collection of additional data on the effects of settling pond geometry and retention time on settling pond performance.

4) The core field program should be at least 8 weeks long (including 3 weeks for operation of a total recycle system) and be completed by a two person study team comprised of a professional engineer and a technologist.

5) The primary demonstration site will likely require a significant amount of construction work to meet project specifications with respect to stream diversion, and settling pond construction and operation. To ensure the project's success, the mine operator should be compensated in accordance with a government contract for supervised work performed.

6) The site selection process and contacts with potentially interested mine operators should be initiated **as soon as possible** to allow completion of the project in 1986.

REFERENCES

AMERICAN SOCIETY OF CIVIL ENGINEERS,.1975. **Sedimentation Engineering.** ASCE Manual on Engineering Practice No. 54, V A Vanoni, editor, ASCE, New York.

GRIFFIN, M L and B J BARFIELD. 1983. **Model Studies of the Dead Storage within Sediment Ponds.** 1983 Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation, University of Kentucky, Lexington.

LEVENSPIEL, O. 1972. **Chemical Reaction Engineering,** 2nd ed., Wiley, New York.

REID CROWTHER & PARTNERS LTD and BETHELL MANAGEMENT. 1984. **A Study of the Potential Use of Polyacrylamide Flocculants in The Yukon Placer Mining Industry.** Prep. for: Arctic Land Use Research Program, DIAND, Whitehorse, Yukon.

STANLEY ASSOCIATES ENGINEERING LTD and CANVIRO CONSULTANTS LTD. 1985. **Development and Demonstration of Treatment Technology for the Placer Mining Industry.** Prep. for Environment Canada, Whitehorse, Yukon.

WEAGLE, K. 1984. **Treatment of Placer Mining Effluents Using Settling Ponds.** Volume 1 - Technical Report, Prep. for Government of Yukon.

WRIGHT ENGINEERS LIMITED. 1986. **Materials Handling Technology.** Draft prep. for DIAND, Whitehorse, Yukon, (in preparation).

APPENDIX I

THE BOTTOM WITHDRAWAL TUBE METHOD

OF GRAIN SIZE ANALYSIS

THE BOTTOM WITHDRAWAL TUBE METHOD OF GRAIN SIZE ANALYSIS

INTRODUCTION

The theoretical procedure for estimating pond effluent quality outlined in Volume One of this study predicts pond effluent suspended solids based on the estimated particle size distribution of the pond influent suspended solids and ideal settling basin theory. In this procedure, the influent particle size distribution is calculated from grain size analysis data for the pay material. To evaluate the validity of the calculations, measurement of actual pond influent suspended solids particle size distributions is necessary. Grain size measurements of simulated and actual wastewaters used for settling tests will also help to interpret settling test results.

The available methods of grain size analyis for liquid suspensions of silt and clay include the hydrometer, pipet and BW Tube methods (ASCE, 1975). All of these methods are based on the principle of determining a theoretical particle diameter distribution from measured sediment fall velocities. For the expected concentration range of about 500 mg/L to 20,000 mg/L suspended solids, the BW Tube method is recommended.

DESCRIPTION

The bottom withdrawal tube is a glass tube marked with a volumetric scale and has a quick-acting outlet at the lower end. The sample is uniformly dispersed in the tube and then placed in an upright position into a mounting rack. Draughts of known volume are drawn from the bottom at known time intervals, placed into evaporating dishes, oven dried and weighed. When the sediment weight of each fraction has been determined, the particle-size distribution can be computed.

The analysis is time consuming (8 hours/sample) and therefore a laboratory requires several tubes to analyze a number of samples efficiently. A detailed laboratory manual procedure has been prepared by the Sediment Survey Section, Inland Waters Directorate, Vancouver, BC. Samples should be prepared without deflocculant addition, without mechanical mixing and with native creek water (if dilution is necessary).

ANALYSIS COSTS

Discussions with Mr B Tassoni of the Sediment Survey Section, Inland Waters Directorate, Vancouver, BC, indicate that completion of the required analyses at the Environment Canada laboratory in Vancouver would likely be less costly than at a commercial laboratory. The lab presently performs sediment grain size analyses for hydrometric stations in the Yukon for DIAND under a cost recovery agreement. The required placer mining demonstration project related analyses, estimated to number about 70 samples, could probably be completed under a similar arrangement for a cost of $20/sample. However, depending on laboratory work load, the bulk of the tests may take up to 2 to 3 months to complete. It is recommended that DIAND personnel set up a suitable arrangement with the Environment Canada laboratory to perform the required BW tube analyses for the Placer Mining Settling Pond Demonstration Project.