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CINOLA GOLD PROJECT

STAGE II REPORT

RESPONSE TO GOVERNMENT COMMENTS

CITY RESOURCES (CANADA) LIMITED

CINOLA GOLD PROJECT

STAGE II REVIEW

RESPONSE TO GOVERNMENT COMMENTS

Submitted by:

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF APPENDICES

RESPONSE TO ENVIRONMENT CANADA

RESPONSE TO B.C. MINISTRY OF ENVIRONMENT

RESPONSE TO MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES

INTRODUCTION

INTRODUCTION

1.0 PROJECT PROPOSAL AND RESPONSE DOCUMENT

City Resources (Canada) Limited is proposing to develop the Cinola Gold Project on the Queen Charlotte Islands of British Columbia. The project, which includes an open pit mine and processing plant for producing doré gold, will be located on Graham Island, 18 km south of Port Clements. A total of $24.8 \cdot 10^6$ tonnes of ore will be mined, requiring the removal of approximately $51.3 \cdot 10^6$ tonnes of waste rock. The design rate of production is set at $2.1 \cdot 10^6$ tonnes/a of ore and on average it is necessary to mine and remove $4.3 \cdot 10^6$ tonnes/a of waste and overburden.

Construction is scheduled to begin September 1989. Full operation will commence January 1, 1991, and continue for 12 years or more depending on the gold grades found below the presently designed pit limit. The project will employ a maximum of 314 people during construction and approximately 200 people during operation

The proponent, City Resources (Canada) Limited (hereinafter referred to as City Resources), was established in 1986 through the joining and restructuring of Consolidated Cinola Ltd. and City Resources (Asia) Limited, a subsidiary of City Resources Limited of Australia. City Resources

(Canada) Limited, , was established with the primary objective of bringing the Cinola Gold Project into operation.

In June 1988, City Resources submitted a six-volume Stage II Report to the Mine Development Steering Committee (MDSC). This report, addressing the project description, site environment, socio-economic implications, environmental management plans and impact assessment, incorporated the findings of an 18 month data collection and experimental program to develop comprehensive environmental protection plans. A Stage II Addendum Report was submitted in August 1988, presenting results of further testing programs. All relevant government agencies have reviewed the Stage II Reports in detail and their comments have been documented in a series of letters and compendiums published in fall - winter 1988.

This report, entitled "Response to Government Comments", provides a thorough and systematic response to those review agencies requesting additional information and clarification prior to issuing a decision on Approval-in-Principle for the Cinola Gold Project. Specifically, the objectives of this document are:

- to clarify and expand on certain aspects of project description and operation which were presented in the Stage II Report;

- to update the project description presenting refinements which have been incorporated in response to ongoing engineering design, feasibility assessment and government suggestions for contingency design;

- to present the results of environmental studies which were in progress during and after the Stage II submissions;

- to reassess project effects incorporating assumptions as requested by the review agencies; and

- to describe environmental contingency plans as requested by the review agencies.

The following sections review events leading to submission of this document, provide a project design update and describe the organization and contents of this response document.

2.0 BACKGROUND

2.1 Stage II Report

The Stage II Report was submitted to the MDSC on June 13, 1988. The report consisted of six volumes and appendices as follows:

Volume 1	Executive Summary
Volume II	Project and Facilities Description, plus Appendices;
Volume III	Baseline Environmental Description, plus Appendices;
Volume IV	Environmental Impact Assessment and Management Programs, plus Appendices;
Volume V	Environmental Research and Special Studies, plus Appendices; and
Volume VI	Socio-Economic and Community Impact Assessment.

The Stage II Report included a comprehensive assessment of the environmental impacts of the project, including the potential for acid mine drainage at the project site. In addition, the report detailed management plans to control and to mitigate the effects of acid generation. Other items included compilation of the available baseline data; thorough documentation of the metallurgy and treatment of process tailings; and assessment of the implications of the project regarding mercury, arsenic, and cyanide in the environment, and their effects on fish and migrating birds in the Yakoun River basin. Reclamation and abandonment plans were also provided.

2.2 Stage II Addendum Report

The Stage II Addendum Report was submitted on September 2, 1988. The Addendum Report presented the results of test work that were not available for inclusion in the Stage II Report. The testing programs included:

(a) pilot scale mill process tests and characterization of mill effluent;

(b) tests to characterize the pilot mill tailings;

(c) waste rock liming tests; and

(d) additional treatment tests of acidic water.

In addition the Addendum Report presented environmental management options for various scenarios for temporary or early closure of the property.

2.3 Feasibility Study

The Feasibility Study is presently in the last stages of preparation and should be available within a couple of weeks of the distribution of this document. It is planned to have a copy of the document and the necessary backup given to the Mineral Resources

Division of the Ministry of Energy, Mines and Petroleum Resources, so that they can review the work.

An addendum to the Feasibility Study is currently being prepared that will show the costs of environmental management which have been included in the study. This addendum volume will be completed within the month and a copy will also be given to the Mineral Resources Division, so as to facilitate this aspect of their review of the total document.

2.4 Review Workshops

During the Stage II review process a number of information exchange meetings and workshops were held with relevant review agencies. The subject, dates and participants of the major workshops were as follows:

- Stage II Workshop-Vancouver, July 29, 1988
    - MDSC - Victoria
    - Ministry of Environment - Victoria
    - Environment Canada - Vancouver
    - Fisheries and Oceans - Vancouver
    - Indian and Northern Affairs - Vancouver
    - Ministry of Native Affairs - Victoria
    - Rescan Environmental Services
    - City Resources and consultants
- Stage II Workshop - Smithers, August 10, 1988
    - Ministry of Environment - Victoria
    - Ministry of Environment - Smithers

- Water Management - Smithers
- Waste Management - Smithers
- Fisheries and Oceans - Vancouver
- Fisheries and Oceans - Prince Rupert
- Ministry of Health - Terrace
- Ministry of Lands - Smithers
- City Resources and consultants.

o Hydrology and Water Quality Workshop - Smithers, September 30, 1988

- Ministry of Environment - Victoria
- Ministry of Environment - Smithers
- Water Management - Smithers
- Waste Management - Smithers
- Steffen Robertson and Kirsten (B.C.) Inc.
- Norecol Environmental Consultants Ltd.

o Stage II Addendum Workshop - Vancouver, October 7, 1988

- MDSC - Victoria
- Ministry of Environment - Victoria
- Ministry of Environment - Smithers
- Ministry of Energy Mines and Petroleum Resources - Smithers
- Fisheries and Oceans - Vancouver
- Fisheries and Oceans - Prince Rupert
- Environmental Protection - Vancouver
- Environment Canada - Vancouver
- Indian and Northern Affairs - Vancouver
- B.C. Native Affairs - Vancouver
- City Resources and consultants

- Socio Economic Workshop - Victoria, October 19, 1988
  - MDSC - Victoria
  - Ministry of Health - Victoria
  - Social Services and Housing - Victoria
  - Ministry of Regional Development - Victoria
  - Ministry of Municipal Affairs - Victoria
  - Ministry of Energy, Mines and Petroleum Resources - Victoria
  - Ministry of Native Affairs - Victoria
  - Indian and Northern Affairs - Vancouver
  - City Resources and consultants

- Fish Habitat Compensation Planning Workshop - Vancouver, October 20, 1988
  - Fisheries and Oceans - Prince Rupert
  - Norecol Environmental Consultants Ltd.

- Cyanide Degradation and Metals Mobilization in Pit Back Fill Workshop - Vancouver, October 28, 1988
  - Environmental Protection - Vancouver
  - Environment Canada - Vancouver
  - Adrian Smith Consulting
  - Norecol Environmental Consultants Ltd.

- Groundwater Workshop - Vancouver, October, 1988
  - Environment Canada - Vancouver
  - Adrian Brown Consultants
  - Steffen, Robertson and Kirsten (B.C.) Inc.

- High West Water Management Workshop - Vancouver, December 1, 1988

    - Environmental Protection - Vancouver
    - Fisheries and Oceans - Vancouver
    - Ministry of Environment - Victoria
    - Water Management - Smithers
    - Steffen, Robertson and Kirsten (B.C.) Inc.
    - Norecol Environmental Consultants Ltd.

  Mercury Methylation and Nutrient Workshop Vancouver, December 1-2, 1988

    - Environmental Protection - Vancouver
    - Environment Canada - Saskatoon
    - Ministry of Environment - Victoria
    - Ministry of Environment - Smithers
    - Fisheries and Oceans - Vancouver
    - City Resources and consultants

- Fish Habitat Compensation Planning Workshop - Vancouver, February 17, 1989

    - Fisheries and Oceans - Vancouver
    - Norecol Environmental Consultants Ltd.

In addition, several site visits were held with interested agency representatives and meetings were held with individual agencies to address specific topics.

2.5 Public Information

City Resources (Canada) Limited has maintained a project information office in Port Clements throughout the Stage II Study and review period. In addition, following Stage II submission, a series of public meetings were held in the Queen Charlottes as well as open houses at Terrace and Prince Rupert as follows:

o	22 July 1988	Open House at Prince Rupert
o	5 August 1988	Questions and Answers Meeting - Port Clements
o	13 August 1988	Technical Workshop - Port Clements
o	16 August 1988	Questions and Answers Meeting - New Masset
o	23 August 1988	Questions and Answers Meeting - Queen Charlotte City
o	27 August 1988	Technical Workshop - Queen Charlotte City
o	30 August 1988	Questions and Answers Meeting - Sandspit
o	19 September 1988	Open House at Terrace

A series of site tours has been conducted for local schools and interest groups.

2.6 Government Comments

Written comments pertaining to the Cinola Gold Project Stage II Report were received by MDSC from the following agencies:

- o Environment Canada/Fisheries and Oceans Canada (October 31, 1988)
- o Ministry of Environment (November 3, 1988)
- o Ministry of Energy, Mines and Petroleum Resources (December 9, 1988)
- o Ministry of Native Affairs (November 21, 1988)
- o Village of Masset (September 13, 1988)
- o Village of Port Clements (November 22, 1988)
- o Ministry of Municipal Affairs (October 5, 1988)
- o Ministry of Health (September 9 and 15, 1988)
- o Ministry of Social Services and Housing (October 12, 1988)

The latter three agencies have supported the granting of Stage II Approval-in-Principle to the Cinola Gold Project. The Ministry of Native Affairs and the villages of Masset and Port Clements have supported the employment opportunities provided by the project as long as environmental protection and adequate community planning and infrastructure can be provided. Environment Canada (EC), Fisheries and Oceans Canada (DFO), Ministry of Environment (MOE) and Ministry of Energy, Mines and Petroleum Resources (MEMPR) have specified additional information that would be required prior to a decision on Stage II Approval-in-Principle. Their information requirements are described in the following submissions:

- Environment Canada/Fisheries and Oceans Canada - letter to R.C. Crook (MDSC), October 31, 1988 and "A Compendium of DOE/DFO Comments on the Cinola Gold Project Stage II Report" submitted to MDSC on November 23, 1988.

- B.C. Ministry of Environment - John Dick memorandum to R.L. Crook (MDSC), November 3, 1988, with attached Appendices 1, 2, 3 and 4.

- B.C. Ministry of Energy, Mines and Petroleum Resources - Norman Ringstad letter to R. Crook (MDSC), December 9, 1988, with attached "Cinola Gold Project, Engineering and Inspection Branch, Stage II Submission - Initial Review".

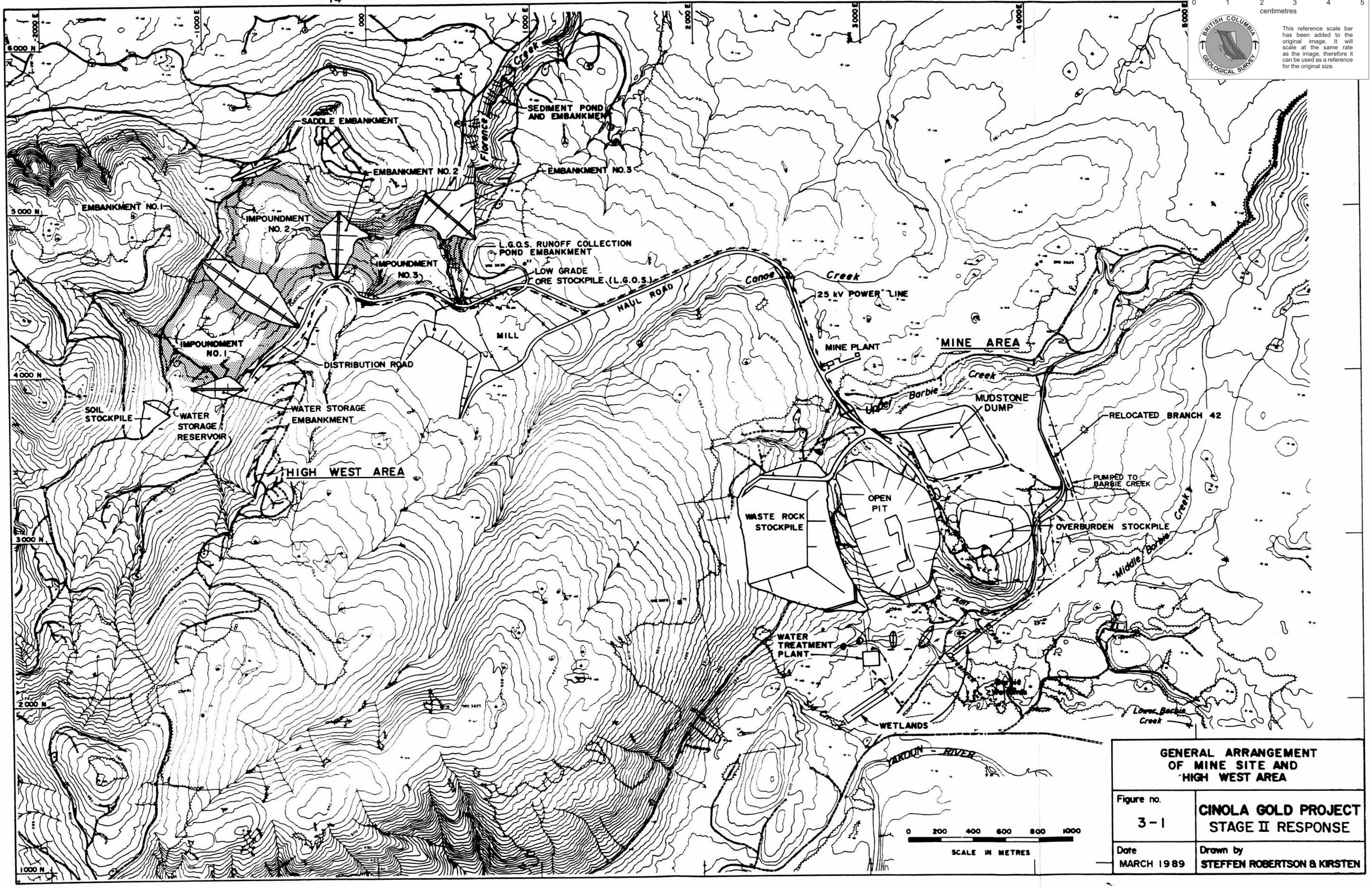
This response document specifically addresses government comments and requests for clarification contained in the submission from the above three agency/groups.

3.0 PROJECT DESIGN UPDATE

A number of changes to the project design have been made between the submission of the Stage II Report and completion of the Feasibility Study. These changes primarily reflect refinements of the design as the detailed engineering progresses. In addition, some changes have been made in response to project review comments. These design modifications will have the effect both of optimizing the project and ensuring that it can be managed practically and acceptably, from an environmental point of view, under a wide range of operating conditions. Aspects of the project which have been modified are outlined below and discussed in more detail as appropriate in subsequent sections of the report. Figure 3-1 shows the updated general arrangement of the mine and High West areas.

3.1 Fuel for Power Generation

At the time the Stage II Report was being prepared, an assured source of heavy fuel could not be confirmed; therefore, the report was prepared and the impact assessment completed on the assumption that light fuel would be used. Since then, a dependable source of heavy fuel has been located, and all costing and design for the Feasibility Study has been carried out on the assumption that heavy fuel would be used. The shipment and transportation of the fuel will be more costly, but the overall cost of operation will be significantly lower. Low sulphur fuel would be purchased so that the emissions of SO_2 will remain low. Projected ranges of NO_x and SO_x concentrations in emissions are within Pollution Control objective levels, with the



GENERAL ARRANGEMENT OF MINE SITE AND HIGH WEST AREA

Figure no. 3-1	CINOLA GOLD PROJECT STAGE II RESPONSE
Date MARCH 1989	Drawn by STEFFEN ROBERTSON & KIRSTEN

inches 0 1 2
0 1 2 3 4 5 centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
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exception of the upper value for NO_x which approximates the upper value in the objectives range. Acid deposition has been modelled using the projected range of emissions with heavy fuel showing that the deposition rates would be below the draft deposition guidelines and, therefore, environmentally acceptable. Appendix 3.1-1 discusses modelling data of emissions from the power plant. City Resources proposes, as a contingency, to investigate the potential for scrubbing the flue gases for SO_x and NO_x which could then be used in the process plant. This would minimize concentrations in emissions with the side benefit of lowering project requirements for sulphuric acid and ammonia.

3.2 Provision of Quicklime for the Process Plant

It had been assumed, at the time of Stage II Report preparation, that quicklime for the process would be obtained from kilns located in the Prince Rupert-Terrace area. In the preparation of the Feasibility Study it was determined that transporting limestone to Graham Island and establishing a lime kiln at the Ferguson Bay laydown area would be more practical and cost effective as well as eliminating the need for sea transport of quicklime . The kiln will be a standard package type plant having the necessary specifications so as to meet all pollution control objectives. It will be operated by a contractor and the contract will stipulate proper environmental management procedures. Operation of the kiln at Ferguson Bay will have the additional benefit of providing employment for the residents of Port Clements. (Refer to Section 10a of the response to MEMPR for further details on the lime kiln facility.)

3.3 Marine Docking Facility

The design shown in the Stage II Report has been amended with the assistance and input of MacMillan Bloedel. The Stage II design, with the docking facility on the inside of the existing breakwater, resulted in some encroachment on the MacMillan Bloedel booming area. The new design has located the facility just outside of the existing breakwater. The relocation was to minimize the risk of conflicts between barge traffic and log sorting and loading operations. An access causeway and breakwater extension to the east of the existing breakwater will provide a protected slip for the docking facility.

In the new location, the majority of filling and dredging will be in subtidal areas such that there will be less disturbance of intertidal plant communities important to anadromous fisheries (Refer to Section I-8a of the response to EC for further details.)

3.4 Plant and Low Grade Ore Stockpile Sites

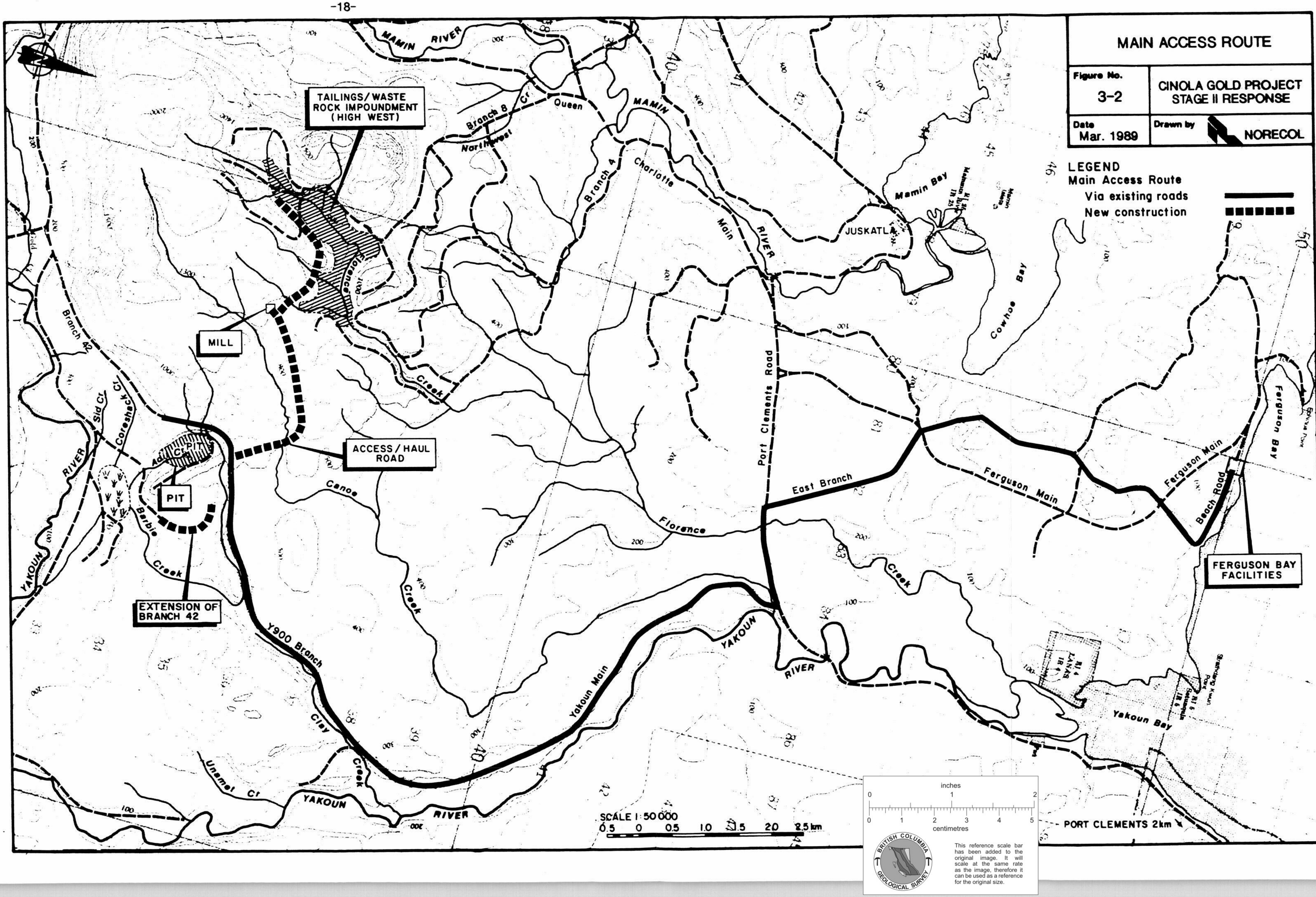
The conceptual layout of the plant facilities presented in the Stage II Report was reviewed during the Feasibility Study to ensure that the locations were optimal with respect to construction, operation and environmental considerations. As a result, the plant and the stockpile locations were shifted and now approximate the location suggested by certain reviewing agencies. (Refer to Section 5a of the response to MEMPR for further details.)

3.5 Access Roads

There have been some minor changes made to the road layout as part of the Feasibility Study. Part of these changes are related to the changes to the plant layout described above. The other changes have come about as a consequence of the discussions that City Resources has had with MacMillan Bloedel. MacMillan Bloedel wishes to eliminate the potential for conflicts on their central haul roads and therefore would like to limit, as much as possible, the use of Ferguson Main for project-related traffic. They have suggested, and City Resources has agreed, that City Resources rehabilitate and use the Bay Road, which parallels the Ferguson Main for the majority of the route. One other minor change has been made to the road system in the mine area at the request of MacMillan Bloedel. This change was made to eliminate a permanent crossing of Barbie Creek on a route which linked the relocated Branch 42 with the Y-900 Branch. Figure 3-2 illustrates the modified access route location.

3.6 Mine Water Management

The design of the mine water treatment plant presented in the Stage II Report was based on the objective that the volume of treated plant inflow could fluctuate widely. The mine water management plan has been subsequently refined based on the objective of minimizing day to day fluctuations in treatment plant inflow so as to maximise the quality of the effluent. The capacity of the associated storage and settling ponds was enlarged, to provide the necessary



MAIN ACCESS ROUTE
Figure No.
3-2
CINOLA GOLD PROJECT
STAGE II RESPONSE
Date
Mar. 1989
Drawn by
NORECOL
LEGEND
Main Access Route
Via existing roads
New construction
TAILINGS/WASTE ROCK IMPOUNDMENT (HIGH WEST)
MILL
ACCESS/HAUL ROAD
PIT
EXTENSION OF BRANCH 42
FERGUSON BAY FACILITIES
MAMIN RIVER
Branch 8
Northwest Cr
Queen
Branch 4
Charlotte
Main
RIVER
JUSKATLA
Mamin Bay
Cowhoe Bay
Branch 42
Sid Cr
Coreshack Cr
YAKOUN RIVER
Barbie Creek
Canoe
Florence
Creek
Port Clements Road
East Branch
Ferguson Main
Beach Road
Ferguson Bay
Y900 Branch
Clay Creek
Yakoun Main
YAKOUN RIVER
Yakoun Bay
Unamel Cr
SCALE 1:50 000
0.5 0 0.5 1.0 1.5 2.0 2.5 km
PORT CLEMENTS 2km
inches
0 1 2
0 1 2 3 4 5
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
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flexibility to control flows through the system. (Refer to Section I-3.d of the response to EC and corresponding Appendix I-3-1 for a detailed description of the modified mine area water management plan.)

3.7 Construction Camp Location

It was indicated in the Stage II Report that the construction camp would be located in the Village of Port Clements. In the Feasibility Study the camp has been relocated to a site near the plant. The latter location is preferred for the following reasons:

- The siting of a temporary construction camp in Port Clements may result in disturbance of the existing residential area. This is a concern which has been raised by several residents.

- The location of the camp close to the construction area will make for better control of the workforce.

- The construction costs are minimized due to the minimal travel time involved.

- Since vehicular traffic will be controlled, potential traffic conflicts on logging roads are reduced.

3.8 Tailings Impoundment Areas

At the time that the Stage II Report was issued the site geotechnical test work that had been completed in the High West area was only preliminary and certain conservative assumptions were incorporated into the tailings embankment designs. The slopes that were used in the Stage II design were very flat based on conservative assumptions concerning the quality of rock available to construct the shells of the dams. Subsequent test work has demonstrated that the available rock is of good quality, so that it is possible to steepen the slopes of the dams.

4.0 REPORT ORGANIZATION

Responses to the Stage II review comments of EC/DFO, MOE, and MEMPR, respectively, are provided in each of three major report sections as indicated by the tab dividers. The organization (topic, section numbering, etc.) of each section of the response document duplicates the organization and numbering of the government comments documents. This was done for ease of reference and to ensure that all concerns, in particular those pertaining to completion of the Stage II review, were thoroughly and systematically addressed. Because the government review comments from each agency use different numbering systems, the format of each response section is different as described in the following sections.

4.1 Response to Environment Canada/Fisheries and Oceans Canada

The organization of the Environment Canada section of the response report parallels the organization of the M. Ito letter of October 31, 1988. This letter summarizes items to be addressed prior to a Stage II Approval-in-Principle decision, including requirements for further project information and impact analysis (Section I), environmental protection commitments required of the proponent (Section II) and additions to contingency plans for project operations and design (Section III). No responses are required to Section IV of the letter which outlines issues to be addressed by government.

Responses are supplied for each topic designated by a, b, c, etc. under numbered sub-headings (1, 2, 3, etc.). Each topic statement from the letter is reiterated in this report, followed by a full response. The topics outlined in the letter reflect more detailed discussions which are provided in the associated Compendium document. The responses to each topic therefore endeavour to address all relevant comments in the Compendium.

In some cases, comments have been made in the Compendium which require a response but which are not directly referred to in the letter. In these cases, the Compendium comment is reiterated and fully referenced in the report and a specific response provided. These comments/responses may be provided under appropriate topics as identified in the letter [for example, responses to specific Compendium comments are provided under the existing topic I-1a) Barbie Creek Fish Habitat and Spawning Areas]. If the compendium comment does not pertain to an existing topic as identified in the letter, a new topic has been added under an appropriate numbered subheading [for example, responses to specific Compendium comments are provided under subheading I-8. Fish Habitat Compensation/Mitigation under the new topic c) Miscellaneous comments - compendium only].

Each topic presented in the M.Ito letter is identified in the Table of Contents. To find a response to a specific comment from the letter refer to the corresponding section, subheading and topic in the response document. To find responses to comments from the Compendium refer to appropriate topics or subheadings as indicated in the Table of Contents.

4.2 Ministry of Environment

Responses in the MOE section of the report directly parallel the organization of comments supplied in the J. Dick letter of November 3, 1988. The comments and responses in the report use the same numbering system that was used in the letter except that letters are used to identify topics which are indicated by an asterisk in the letter. The major sections of the MOE response include information requirements to be addressed at Stage II (Section 1) and corporate commitments required at Stage II (Section 2). No responses are required for a third section of the MOE letter which identifies government commitments.

Topics identified in the MOE letter are supported by more detailed discussion in the appendices to the letter. Responses to the topics in the letter endeavour also to address any additional related comments in the appendices. The specific Appendix comments requiring response are reiterated with full responses provided under appropriate topics or subheadings as identified in the MOE letter and the Table of Contents of this report. MOE have requested a full response to the Stage II report review by Dr. Frank T. Caruccio (Appendix 2 of the MOE Comments). The response is provided in Appendix 1.7-1 of this document.

4.3 Ministry of Energy, Mines and Petroleum Resources

Specific items to be addressed in response to MEMPR were identified in the attachment to Norman Ringstad's letter of December 9, 1988. The attachment, which conveys the comments and information requests of the Engineering and Inspection Branch, outlines major topic areas and one or more subtopics. Some of the topics are raised in a general discussion section and some are listed specifically as Stage II concerns. In the response document, the subtopics have been extracted and reiterated along with the response. They are identified by letters (a, b, c) in the report for cross referencing purposes.

For two of the topics which appeared in the MEMPR review, 2. Tailings Impoundment and 3. Mine Plan, no further information was required for the Stage II review. Accordingly, these have been omitted from the response document.

4.4 General Format

Responses to each topic identified in the government comments start on a new page. Each response is prefaced by the appropriate Section heading, subheading and the lettered topic as listed in the Table of Contents.

The government comment pertaining to that topic is reproduced in part or in full. Then the response is provided followed by references cited where appropriate and identification of the author of the response. The latter is provided to facilitate any follow-up discussions.

Page numbers for each section of the response are prefaced with an abbreviation for the agency for ease of section identification and cross referencing between responses to each agency. When a response applies to comments from more than one agency the response is cross referenced to avoid repetition.

Some study results and design modification generated following Stage II submission are discussed in detailed stand-alone documents which have been included as appendices to this report. These Appendices are referred to as appropriate throughout the responses to various agencies. The appendices are numbered according to the report section in which they first appear. The titles of the appendix documents are provided in the Table of Contents.

RESPONSE TO ENVIRONMENT CANADA
LETTER OF OCTOBER 31, 1988 (M. ITO)
AND COMPENDIUM, November 23, 1988

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

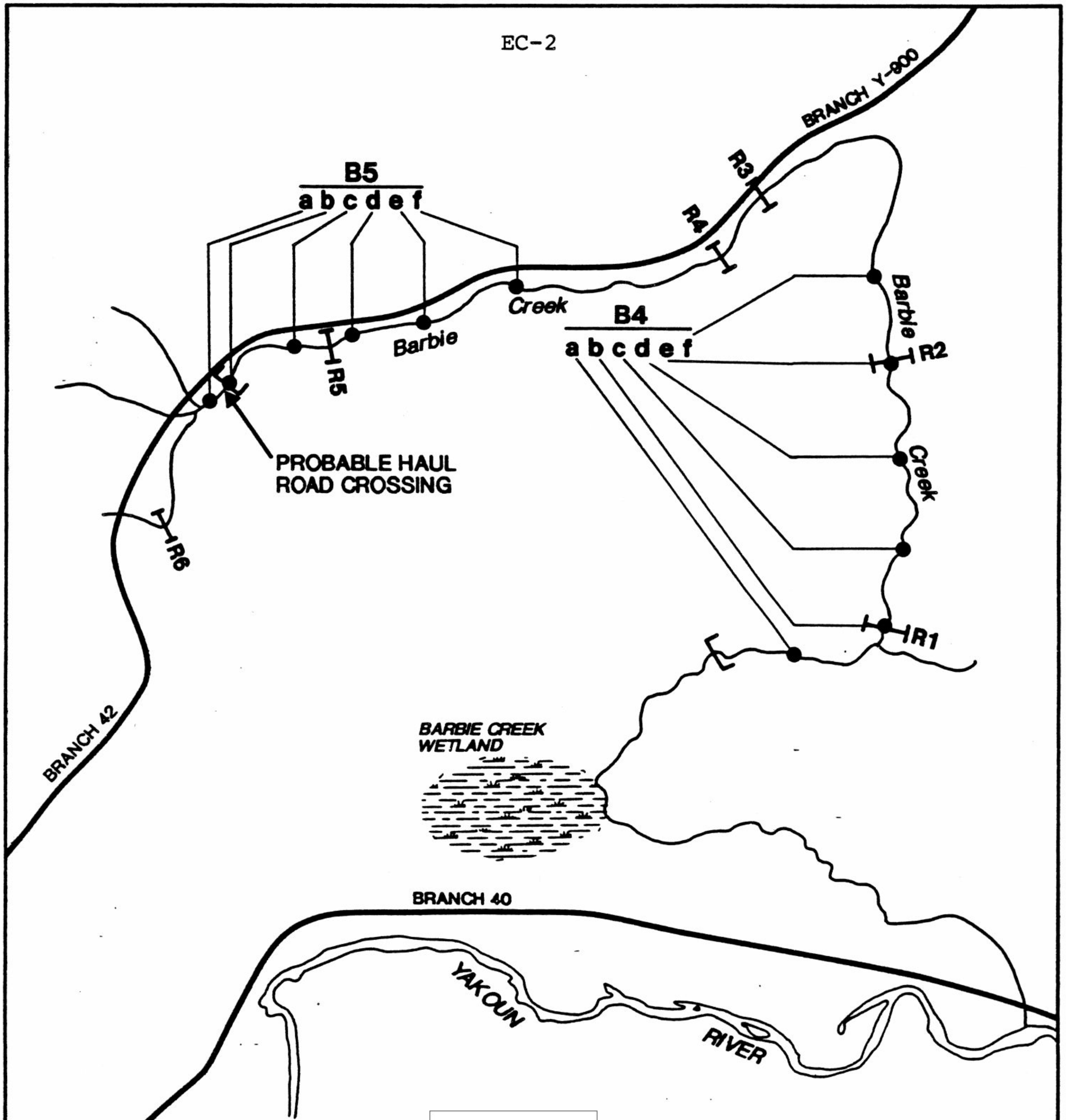
1. Baseline Environmental Conditions

Topic: a) Barbie Creek fish habitat and spawning areas

Comment: Further information on the presence of salmon (for example, coho) in upper Barbie Creek and in particular, the location of salmon spawning areas and/or salmon redds, must be undertaken in order to more fully understand the risk posed by activities and planned discharges to the system.

(The following response also addresses comments in Section 2.3.1.2.4, page 17, of the EC Compendium regarding adequacy of information on spawning habitat.)

Response: Norecol Environmental Consultants Ltd. surveyed Barbie Creek upstream of the old pilot plant (hydrology site Q8) on November 16, 1988, to document spawning salmon and redds. No redds or spawners were observed which may have been due to the considerable depth of much of the stream combined with the dark colour of the water. However, fish habitat was characterized and the spawning and rearing capabilities assessed. Based on the survey, the reach boundaries for Barbie Creek have been modified slightly (Figure I-1-1). The following paragraphs describe the fish habitat and capabilities of each reach and present fish sampling data from IEC Beak background information on juvenile fish presence. IEC Beak fish sampling sites in upper Barbie Creek are shown on Figure I-1-1, and catch data are summarized in Table I-1-1.

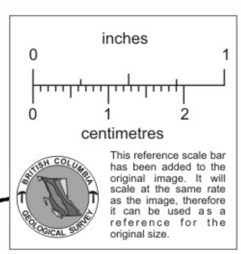


LEGEND

Indicates the Substations (a–f) That Comprise Sampling Station B5 (IEC BEAK SITES) — B5 a b c d e f

Reach Break — R6

Limit of Norecol Survey



Scale 1:20 000

0 200 400 600 800 metres

BARBIE CREEK FISH HABITAT	
Figure no. I-1-1	CINOLA GOLD PROJECT STAGE II RESPONSE
Date Mar. 1989	Drawn by NORECOL

TABLE I-1-1

IEC BEAK FISH CAPTURES IN UPPER BARBIE CREEK

IEC BEAK STATION	NORECOL REACH	METHOD[a]	EFFORT	DATE	No. CAPTURED[b] CO	DV	CT	RB
B4 a	Reach 1	MT	2 Trap Days	May 21/81	-	7	-	9
b	Reach 2	MT	2 Trap Days	May 21/81	-	9	1	5
c		MT	2 Trap Days	May 21/81	-	8	1	4
d		MT	2 Trap Days	May 21/81	-	2	-	5
e		MT	2 Trap Days	May 21/81	-	-	-	2
f	Reach 3	MT	2 Trap Days	May 23/81	1	5	-	-
		ES	Quantitative	May 23/81	55	19	2	-
B5 f	Reach 5	MT	2 Trap Days	May 27/81	4	2	-	-
e		MT	2 Trap Days	May 27/81	4	5	-	-
d		MT	2 Trap Days	May 27/81	5	4	-	-
c	Reach 6	MT	2 Trap Days	May 27/81	-	7	-	-
b		MT	2 Trap Days	May 23/81	-	9	-	-
a		MT	6 Trap Days	May 25/80	-	12	-	-
		MT	6 Trap Days	Jun 6/80	-	9	-	-
		MT	3 Trap Days	Oct 3/80	-	10	-	-
		MT	4 Trap Days	May 23/81	-	10	-	-
		MT	2 Trap Days	May 23/82	-	3	-	-
		ES	Quantitative	Oct 17/80	-	3	-	-
		ES	Quantitative	May 25/81	-	12	-	-

[a] MT - minnow trap

ES - electroshocking

[b] CO - coho salmon

DV - Dolly Varden char

CT - cutthroat trout

RB - rainbow trout

Response: **Reach 1**
(cont'd)

Reach 1 is described in detail in the Stage II Report (Volume III, pages 5-261 and 5-263) and is consistent with observations during this survey.

Reach 2

The physical characteristics of Reach 2 are consistent with the Stage II Report (Volume III, page 5-261), but the lower reach boundary has been moved about 800 m further upstream as a result of the survey. Deep (1 m) glide pools predominate in this section, and considerable fish cover is provided by large organic debris, overhang and cutbanks, indicating considerable rearing potential. Approximately 80% of the reach is suited to rearing. However, IEC Beak minnow trapping in this reach captured predominantly Dolly Varden char and rainbow trout juveniles. The absence of coho salmon juveniles cannot be explained, although trapping occurred over a short time period. Spawning habitat for anadromous fish is limited in this reach, but smaller gravels suitable for resident fish occur in about 2% of the area.

Reach 3

Reach 3 is primarily single channel, has a few side channels, and flows through coniferous forest. The reach is approximately 1.4 km in

Response: (cont'd)

length, with an average gradient of about 1.5%. Channel width is approximately 4 m. This reach is shallower than Reach 2, and pool-riffle-glide habitat occurs throughout. Small gravel bars are numerous. There is good spawning gravel for anadromous species in about 20% of the area, and this reach probably has the most productive spawning habitat in the system. It is estimated that this reach has approximately 500 m^2 of spawning area. Rearing habitat occurs in about 40% of the reach and is provided primarily by pools, cutbanks, and large organic debris. Minnow trapping and quantitative electroshocking by IEC Beak yielded 68% coho salmon, 29% Dolly varden char, and 3% cutthroat trout juveniles. Minnow trapping yielded 0.5 coho salmon/trap day and 2.5 Dolly Varden char/trap day.

Reach 4

Reach 4 is a short, bouldery section with gradients of 3 to 5%. Spawning and rearing habitat is limited in this section.

Reach 5

Reach 5 is approximately 1.5 km in length, channel width is about 3 m, and gradient is less than 1%. The north side of the valley adjacent to the stream has been logged, and the valley flat is about 20 m wide. In spite of the confined valley, the stream is placid and pool habitat predominates. Water depths range from

Response: (cont'd) 0.5 to 1 m, with substrate comprising small gravels and sediment. Most of the reach is suitable for rearing, but spawning habitat is limited by the small size of the substrate. Minnow trapping in this reach by IEC Beak yielded 54% coho salmon and 46% Dolly Varden char juveniles. Minnow trapping yielded 2.2 coho salmon/trap day and 1.8 Dolly Varden char/trap day. The presence of coho juveniles in this reach indicates that coho spawn in this area. The upstream reach boundary is probably the limit of coho migration, since no coho juveniles were captured by IEC Beak upstream of this reach.

Reach 6

Reach 6 is about 1 km in length with gradients ranging from 3 to 7%. The channel is about 2 m wide and has a stepped profile. Adjacent slopes in the lower half of the reach have been completely logged. Spawning and rearing habitat is limited. Minnow trapping and quantitative electroshocking by IEC Beak yielded only Dolly Varden char juveniles. Minnow trapping yielded 2.4 Dolly Varden char/trap day. Sampling was done in three different years (1980 to 1982) and in 1980 was carried out at three different times: in May, June, and October. In the Stage II Report, the aquatic biophysical map (Figure 5.8.5-1) incorrectly shows Dolly Varden presence as "inferred" in this reach (that is, DV in parenthesis on the reach symbol). Norecol's survey was terminated in the middle of this reach.

Response: (cont'd) Two steep headwater tributaries of Barbie Creek join Reach 6. These drainages have gradients of 13 to 20%.

The Environment Canada Compendium (Section 2.3.1.2.5) makes the following comment:

Comment: (cont'd) The [Stage II] report suggests (Volume III page 5 - 271) that the absence of coho salmon in Reach 5 could be the result of an impassible culvert.

Response: The culvert referred to is located at Branch 42 on one of these steep headwater tributaries of Barbie Creek which joins Reach 6. This stream is high gradient and is extremely unlikely to contain fish and would not be utilized by coho salmon. Extensive fish sampling by IEC Beak in the adjacent downstream reach at Site B5a yielded only Dolly Varden char (Figure I-1-1, Table I-1-1).

The Environment Canada Compendium (Section 2.3.1.2.5) makes an additional comment regarding side channel habitat in Barbie Creek:

Comment: (cont'd) There is a complete lack of information on side channel habitats for Barbie Creek. Although flow reductions on Barbie Creek are not expected to be significant (based on current model predictions) basic information on side channel habitats would be useful as an aid in monitoring habitat changes which may occur as a result of mining and we recommend that such information be provided.

Response: Norecol conducted a spawning survey in upper Barbie Creek on November 16, 1988. Very few side channels were observed in the 5.6 km of stream

Response: (cont'd) surveyed upstream of the Barbie Creek wetlands, and only about 1% of the area was occupied by side channels. In fact, stream depth throughout most of this area ranged from about 0.5 to 1 m. As flow reductions in Barbie Creek are not expected to be significant, no significant impacts are expected.

The Environment Canada Compendium (Section 2.3.1.2.5, page 17) makes the the following comment concerning fish sampling in Upper Barbie Creek:

Comment: (cont'd) It appears that neither I.E.C. Beak (Volume III, Figure 5.8.2-1) nor Norecol (Volume III, Figure 5.8.3-1) appears to have sampled fish in the upper part of reach 2 and in reach 3. We assume therefore that there are either inconsistencies in the Stage II Report or that the Report's reference to fish presence in this area is only implied.

Response: IEC Beak's sampling in this area was more widespread than indicated on Figure 5.8.2-1 in Volume III, which does not show the several sub-stations of both Sites B4 and B5 where samples were taken. The locations of the sub-stations and associated catch data are presented on Figure I-1-1 and Table I-1-1 of this document.

Response by: G. Longworth, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

2. Groundwater Assessment

Topic: a) Effect of Specogna Fault

Comment: The effect of the Specogna Fault on the hydrogeology of the area either now or after closure.

Response: The Specogna Fault and its associated (overlying) hydrothermal breccia do not now, and will not in the future, behave as a conduit to surface and groundwater flow.

The field piezometric data show that the Specogna Fault and associated breccia are indeed not acting as a conduit. If they were, water would be expected to flow through the conduit from north to south, draining water from the pit area towards the Yakoun River Flats. The groundwater levels in the pit would therefore be expected to be lowest in the vicinity of the fault and to drop as one moved from north to south. The measured groundwater levels in the vicinity of the fault are, however, higher than levels to both the east and west and generally higher than the level in Barbie Creek north of the proposed pit. The Specogna Fault and its associated breccia therefore appear to be acting as a barrier, rather than a conduit. This result is consistent with the model results provided in the Stage II Report and with the refined modelling presented in the Update Hydrogeology Report.

As shown on Table I-2-1, a total of 438 field permeability tests have been performed on the rock in the vicinity of the project.

Table I-2-1

Summary of Results of Field Packer Tests

MATERIAL	NUMBER OF TESTS	HYDRAULIC CONDUCTIVITY (m/s x 1E-08) LOW	MEAN	HIGH
Masset volcanics, sediments, and rhyolites	260	0.01	10	2000
Haida mudstone, including felsic dikes	30	0.006	1	400
Skonun sediments, unaltered and unsilicified	14	0.05	6	100
Skonun sediments, silicified and argillically altered	108	0.02	5	3000
Specogna fault material and hydrothermal breccia	16	3.0	20	200
Fluvioglacial sand and gravel, (Barbie wetlands)	6	0.3	30	500
Glacial till (High West area, northwest saddle)	4	0.2	9	90
GEOMETRIC MEAN OF ALL VALUES	438		7.4	

The geometric mean hydraulic conductivity of these tests is 7E-08 m/s. Sixteen of the tests were conducted in the fault and breccia materials to the west of the proposed pit. The geometric mean hydraulic conductivity of these materials is about 2E-07 m/s, which is essentially the same as the general country rock in this area. This finding is consistent with what is observed in the adit. Seepage from the area of the fault into the particular heading which traverses the fault appears to be similar or even less than in the other parts of the adit. Consequently, the fault material cannot be expected to act as a significantly preferential conduit.

The Specogna Fault is probably a strand of the Sandspit Fault, which was formed during the late Cretaceous period (about 60 million years ago). Mineralization of the Cinola orebody was emplaced along the Specogna Fault by hydrothermal processes between 8 million and 15 million years ago.

When any geological material is subjected to tectonic shear, its hydraulic conductivity either increases as a result of the generation of fractures or decreases as a result of the formation of gouge. These two effects offset each other. While it is generally difficult to predict what hydraulic conductivity changes will occur in the absence of field information, the extensive field data available for the Specogna Fault allow confident prediction of the effect of future tectonism. The current hydraulic conductivity of the fault is the result of the deformation of the fault during historic tectonic events in the recent to pleistocene epoch (10,000 to 2,000,000 years ago.)

Based upon the measured hydraulic conductivity in the Specogna Fault and overlying breccia, the age of the fault, and that the fault has been subjected to large earthquakes in the past 10,000 years, it can be confidently predicted that the hydraulic conductivity will not charge significantly in the next 10,000 years.

Consequently, there will be no changes to the groundwater levels and flows observed at present in the area of the Specogna Fault as a result of mining activities.

EC-12

Response by: Adrian Brown, Consulting Hydrogeologist to Steffen Robertson and Kirsten, and John Gadsby (Steffen Robertson and Kirsten)

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

2. Groundwater Assessment

Topic: b) Flow loss in Barbie and Coreshack creeks

Comment: Interpretation of stream flow monitoring to identify reaches of Barbie and Coreshack Creeks "gaining" or "losing" groundwater and how this would change as a result of mining.

Response: There will be no significant or detectable changes in the flow in Barbie Creek or Coreshack Creek due to groundwater lowering during mine operation or as a result of reclamation of the pit.

Evaluation of the impact of the proposed mining activities on flows in the adjacent creeks has proceeded from a simple practical analysis to a more sophisticated computer model. Results from both analyses are presented below.

1. Barbie Creek

The majority of flow in Barbie Creek is from surface water. Studies indicate that the average surface flows and base flows are about 10,000 and 3,300 m^3/d, respectively. The analyses performed to evaluate the significance of the impact of the project on creek flows have in general ignored the surface runoff component and considered only the portion that derives from deep groundwater.

The first step in the analysis is to calculate creek groundwater flows into the pit. Flow to the pit is essentially north-south (from Barbie Creek to the north and Barbie Wetland to the south), and takes place within a strip 400 m wide (about the width of the pit). The deepest excavation of the open pit will be at 0 m elevation (AMSL). The elevation of upper Barbie Creek (located about 300 m north of the pit) is about 160 m AMSL, and Barbie Wetland (located about 500 m south of the pit) is about 55 m AMSL. Darcy's law can be used to calculate the maximum expected groundwater flow:

$$Q = k\ i\ A$$

where: Q = volumetric flow
k = hydraulic conductivity
i = hydraulic gradient
A = flow area

The results of the calculation for groundwater flows into the open pit are presented in Table I-2-2.

Table I-2-2

Estimate of Maximum Groundwater Flow from the North and South into the Pit Using Darcy's Law

PARAMETER	FROM NORTH	FROM SOUTH
Hydraulic conductivity (effective)	9E-08 m/s	9E-08 m/s
Head loss during flow	160 m	55 m
Distance of flow	300 m	500 m
Depth of flow	300 m	300 m
Width of flow	400 m	400 m
Head gradient	0.53	0.11
Flow area	120000 m^2	120000 m^2
Volumetric flow rate	0.0058 cum/s	0.0012 cum/s
Volumetric flow rate (m^3/d)	500 cum/d	100 cum/d

The maximum groundwater inflow to the open pit from the north is therefore about 500 m^3/d and from Barbie Wetland in the south about 100 m^3/d.

A computer simulation of the impact of the pit on Barbie Creek during the greatest drawdown (200 m) was performed. In order to maximize computed flows from the creek, the analysis assumed that the pit was at its full depth for the entire period of operation (about 12 years) and that flows in the system had reached equilibrium. In this analysis, flow to the pit is 672 m^3/d, close to the total of 600 m^3/d calculated above. The reduction in flow in the upper reaches of Barbie Creek (taken at a downstream point, which includes all of the influence of the pit) was computed to be 504 m^3/d, almost exactly the amount calculated in the simple evaluation. The percentage reduction in baseflow at that location was found to be 8.5%; the reduction in average flow was found to be 3%. These changes are small compared with natural fluctuations in stream flow.

2. Coreshack Creek

Coreshack Creek flows over Haida mudstone over its full distance until it reaches the Barbie Wetlands. The Haida mudstone is of very low hydraulic conductivity, and only minimal flow could pass through it. Accordingly, any drawdown that occurs as a result of mining would not on its own detectably influence the flow of this creek. Mining will reduce some of the catchment that currently feeds Coreshack Creek, however, and this accounts for most of the calculated reduction in flow of 435 m^3/d.

Response by: Adrian Brown, Consulting Hydrogeologist to Steffen Robertson and Kirsten

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

2. Groundwater Assessment

Topic: c) Transient simulation groundwater model

Comment: The use of a transient simulation groundwater model changes the interpretation of the mine area hydrology for premining, operation, and post-mining conditions.

Response: Steady state results were used in Stage II because there is almost no difference between transient and steady state model results. In general the impacts at steady state are greater than the impacts during transient stages, (see appendix I-2-1).

The Cinola Gold Project groundwater hydrology is dominated by the high precipitation in the site area. As a result, the surface is saturated for much of the year. All streams flow throughout the year, and the extent of groundwater dewatering effects in the unconfined aquifer formed by the bedrock surrounding the open pit is reduced significantly. This is distinct from the confined aquifer situation more commonly encountered in groundwater resource evaluations, where the aquifer is often separated from the infiltration of precipitation by low permeability layers. In the confined aquifer situation, the transient effects of dewatering may linger for years and therefore may require transient analysis for evaluation.

The use of transient modelling to evaluate the environmental impact of mining would in all but one case be unconservative. The exception is when evaluating the rate of re-equilibration of the groundwater system after mine backfilling. A transient refill analysis has therefore been performed.

A simple analysis shows the reason for the lack of significance of transient effects. Groundwater inflow to the open pit is about 600 m^3/d. This is equivalent to the infiltration that occurs over an area of about 30 ha. This infiltration takes place over a few hundred metres around the pit perimeter, so that the transient effects are very quickly swamped by the infiltration.

The example analyzed to demonstrate this effect is the recharge of the aquifer following refilling of the pit. Pit backfilling is expected to be done within 24 months after closure of mining. In addition to water taken from impoundment no. 3 to the open pit, water used during backfilling operations will come from runoff, precipitation, and direct discharge. Groundwater flow is a relatively small component. In the worst transient case, recharge is due only to groundwater inflow, but recharge still develops quickly. The transient state analyses show that, of the maximum 200 m drawdown in the pit, after one month the drawdown is 180 m, after one year it is not less than 90 m, and at steady state it is 80 m (as the final reclaimed surface is lower than the original surface). During this process the groundwater system around the pit reaches a steady state in less than 18 months. Thus the entire system reaches steady state quickly, and the "transient" behaviour of the groundwater system within the pit is primarily controlled by the rate of filling of the pit, not the groundwater system itself.

Response by: Adrian Brown, Consulting Hydrogeologist to Steffen Robertson and Kirsten

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

2. Groundwater Assessment

Topic: d) Saturation of pit backfill

Comment: Verification that potentially acid generating waste rock backfilled in the pit will become fully saturated (i.e., underwater).

Response: The material used to backfill the pit will remain saturated at all times after initial resaturation, under all circumstances. The high degree of confidence in this statement results from the following factors:

1. In all locations the maximum backfill elevation will be below the current water table. This means that under all future conditions, groundwater will flow to the reclaimed pit from the sides and bottom, regardless of the permeability of the backfill material.

2. The available infiltration (about 0.75 m/a) will be augmented by runoff from the surrounding pit walls, direct precipitation, and the groundwater seepage noted above. The cumulative effect of this input water will be the creation and sustenance of a wetland on the reclaimed pit surface in perpetuity.

3. Material will become segregated during backfilling, with the coarse materials falling to the base of the pile and the fines remaining on top. This will create a thick,

low permeability cap on the backfill that will further assist retention of water on the surface.

4. All analyses performed on the system (Stage II Report and Update Hydrogeology Report) indicate that it is essentially impossible to develop a scenario wherein any part of the backfill would desaturate. The only scenario that would result in desaturation is the extreme condition where a completely impermeable cover is placed over all of the backfill, which would create pore tension in a small zone near the south end of the pit. This situation could not occur with the low permeability cap described in 3. above.

Groundwater table diagrams for both the open pit and reclaimed system are included in the Update Hydrogeology Report. As indicated, the reclaimed system groundwater levels will follow the original topography, as the reclaimed surface will be flat. Water flowing from north to south across the reclaimed pit surface will cause an increase in the water table immediately to the south of the pit, thus improving the ability of this area to resist any incipient acidification.

Response by: Adrian Brown, Consulting Hydrogeologist to Steffen Robertson and Kirsten

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: a) Acid-base accounting for Haida mudstone

Comment: Additional acid-base accounting of the Haida mudstone, rhyolite, and west wall of the pit must be obtained since those units have been assumed to be non-acid generating, but data indicate some acid generating potential. The material management and water management plans may require modification pending those results (see also Environment Canada Compendium, Section 4.1.1 p.35-36).

Response: An additional 79 samples of mudstone and rhyolite have been collected from core drilled in and around the proposed west wall. These samples were taken from cores drilled between the years 1977 and 1988 and were selected to provide a three-dimensional profile of acid-base-accounting characteristics around the proposed west wall.

The four objectives of the study were:

- o to obtain acid-base accounting analyses for sub-groups of mudstone and rhyolite which have been characterized only to a limited extent;

- o to obtain a wide spatial distribution of data points, both horizontally and vertically (2-D), along the west side of the pit with some additional distribution through the wall into the unsheared mudstone (limited 3-D);

Response: (cont'd)

- o to emphasize sample collection of mudstone sub-groups 1b and 1c and rhyolite sub-group 3a which comprise most of the waste rock volume in these groups; and

- o to obtain several acid-base accounting analyses over short intervals of core in order to define natural variability at "one" point.

The details of this study are contained in Appendix I-3-1, "Acid-base Accounting Characteristics of Cinola Mudstone and Rhyolite in the Proposed Pit Area".

The results of the analyses indicated that acid-base-accounting parameters of large, mineable blocks of mudstone and rhyolite are spatially correlated. For example, net acid production is predicted not to develop in the mineable blocks of the largest mudstone sub-group, Mudstone 1b, located at depth across the fault zone, but is expected in this mudstone from shallower depths. For the largest rhyolite sub-group, Rhyolite 3a, net acid production is not expected from mineable blocks on the north side of the fault zone at any depth. These spatial relationships will permit the segregation of mineable blocks of each sub-group on the basis of potential for net acidity.

The first concern regarding potentially acidic mudstone and rhyolite is the pH of drainage water

Response: (cont'd) from over the west pit wall. Based on pit wall locations presented in the Feasibility Report for the Cinola Gold Project for Mine Years 3, 7, and 12, there are zones on the west pit wall which are expected to consistently result in some net acidity throughout the mine life based on the material having negative net neutralization potentials. The modified mine area water management plan (Appendix 1.1-1 addresses the potential requirement to treat this drainage water. It is likely that the mining sequence will change so that the west pit wall is initially established and maintained west of the Specogna Fault. This would result in decreasing rates of acid generation from the wall through time so that pH-neutral runoff could be expected after several years of exposure as demonstrated in the waste rock pad experiments.

The second concern regarding potentially acidic mudstone and rhyolite is the dump in which the material will be stored. This dump as presented in the Stage II Report is predicted to have an average net neutralization potential of -13.6 tonnes of $CaCO_3$ equivalent / 1000 tonnes of rock. This value is more positive than the critical value of -15 t $CaCO_3$ / 1000 t below which Cinola rock consistently generates net acidity (for further discussion of the "cutoff" value for net neutralization potential at Cinola refer to responses to Compendium comments below). However, due to the closeness of the values, the waste-management plan has been adjusted to allow selected mineable blocks of all

Response: (cont'd) sub-groups of mudstone and rhyolite (that is, acid generating blocks) to be transported to the High West impoundments to be deposited underwater to assure that the mudstone-rhyolite dump remains pH-neutral.

The impoundments will accept up to 9,400,000 tonnes of mudstone and rhyolite without major adjustments (refer to discussion in response to E C , Section III-2a) and the transportation to the impoundments of all blocks with a net neutralization potential more negative than the critical value of -15 t $CaCO_3$ / 1000 t will total 3,800,000 tonnes. This will lead to a non-acid-generating mudstone-rhyolite dump because (1) only blocks with a net neutralization potential more positive that -15 t $CaCO_3$ / 1000 t will report to the dump and (2) the average net neutralization potential of the dump is predicted to be +1 t $CaCO_3$ / 1000 t. The additional disposal of mudstone and rhyolite in the impoundments is not expected to change the assessment of the physical and geochemical impacts as presented in the Stage II Report (refer to E C Section III-2a).

In their Compendium document, Environment Canada requested several analyses pertaining to and clarifying interpretation of acid-base accounting data. These comments are addressed as follows:

Comment: The proponent used a "cutoff" net neutralization potential of 5 tonnes/1 000 tones to categorize a sample as "potentially" or "not potentially"

Comment: (cont'd) acid producing. This value was developed in the Appalachian coal fields of the U.S.A. and is related to the acid potential of soils in the region. It is not appropriate for the prediction of AMD (Environment Canada Compendium, Section 4.1.1, p. 35).

Response: Norecol compared kinetic test results of ABA to determine the cutoff value of Net Neutralization Potential (NNP) for net acid generation specific to Cinola rock types. Based on data from humidity cells, column experiments, and waste rock pads (Stage II Report, Volume V Appendices), there are 55 comparisons of NNP to kinetic test results. Values of NNP ranged from -190.0 to +180.0 t Ca CO_3/1000 t of rock, with four values in the range of -10 to -20 t $CaCO_3$/1000 t. Of the 55 comparisons, 46 produced acidic drainage, and the corresponding values of NNP wee -15.2 to -190.0 t $CaCO_3$/1000 t. Of the 55 comparisons, 9 produced neutral drainage, and the corresponding values of NNP were -72.9 to +180.0 t Ca CO_3/1000 t, including two values of -10.9 and -18.1. These comparisons suggest that any value of NNP more positive than -15 t $CaCO_3$/1000 t will not produce acidic drainage, whereas any value of NNP more negative than -15 t $CaCO_3$/1000 t will usually produce acidic drainage. This "cutoff" value -15 t $CaCO_3$/1000 t of rock is more appropriate for the Cinola site than the conservative cutoff value of -5 t $CaCO_3$/1000 t, which was used in the Stage II Report.

Comment (cont'd) The coefficient of variation for acid producing humidity cells was lower for both average and maximum sulphate production related to surface

Comment (cont'd)

area compared to weight. Relating sulphate production to both surface area and percent sulphur increased the coefficient of variation for average sulphate production, but reduced the coefficient for maximum production. Therefore, if maximum sulphate production rates are required for any calculations, relations to both surface area and percent sulphur may be appropriate (Environment Canada Compendium, Section 4.1.2, p. 38).

Response:

For clarification, Norecol compared average and peak rates of acid generation in kinetic tests to %S. The major Cinola rock types are Haida mudstone, Skonun sediments, rhyolite, multiphase breccia, and argillically altered rock. Acid-base accounting (ABA) indicated each of these groups had distinctive means and ranges in ABA characteristics including total sulphur (Stage II Report, Volume V, Table 3.2.4-1). Furthermore, kinetic tests demonstrated distinctive differences in the rates of acid generation. These include high initial acid release from argillically altered rock as a consequence of highly reactive sulphide, and consistently low rates of acid generation with neutral-pH drainage from mudstone as a consequence of the carbonate control of acid generation. As a result, it is reasonable to expect a relationship between total sulphur and the rate of acid generation, but this relationship should not necessarily be interpreted as cause-and-effect.

The relationship between mean rates of acid generation vs. %S has been quantitatively

Response (cont'd)

examined and is best described by a polynomial equation in the range of 0 to 6%. The best-fit equation is:

MEAN RATE (mg SO_4/100 g/wk) = -4.504 + 12.73 (%S) + 8.737 $(\%S)^2$

with a correlation coefficient (r) of 0.845.

The relationship of peak rates of acid generation vs. %S can similarly be described in the range of 0 to 6% S:

PEAK RATE (mg so_4/100 g/wk) = -22.863 + 47.283 (%S) + 14.595 $(\%S)^2$

with a correlation coefficient (r) of 0.711.

These correlation coefficients generally suggest that 71% (r^2) of variations in mean rates and 50% (r^2) of variations in peak rates can be explained by variations in total sulphur. As explained above, these weak correlations do not suggest a cause-and-effect relationship, indicating that sulphur content is not a critical parameter for the calculation of sulphate production rates.

Response by: Kevin Morin, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: b) Pit water ditch system

Comment: The operation of a parallel ditch collection system within the open pit needs to be described in more detail because failure of the ditch system would significantly increase flows to the treatment plant.

Response: This comment is no longer applicable as separation of pit water is not required under the modified mine area water management plan (refer to Appendix 1.1-1).

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: c) Large-scale limestone addition

Comment: The proposed large-scale test of limestone addition to waste rock should begin as soon as possible in order to better define the amount of limestone required under field conditions to minimize acid generation in the waste rock stockpile. Results obtained at the time of the approval-in-principle decision should be integrated into the environmental control plan for the project.

Response: As part of Stage II studies, the rate and quantity of acid drainage were defined for the major rock types at the site. The studies included acid-base accounting, humidity cells, leach columns, on-site weathering pads, on-site barrels with mixtures of waste rock and limestone, and laboratory-based columns with mixtures of waste rock and limestone (Volume V and Addendum). All of these tests provided results that could be compiled into a consistent set of data to demonstrate conceptually and practically the amount of limestone required for pH control. The results were consistent with principles of geochemistry and acid generation.

Two non-ideal complexities not fully dealt with in the Stage II Report were limestone blinding and large-scale effects (only limited data from the limestone barrels, columns and the waste rock pads exists). Limestone blinding, or encapsulation, occurs during the neutralization of acidic water when iron hydroxides, gypsum,

Response: (cont'd)

and other minerals precipitate from the water and encapsulate the limestone. In effect, this prevents the remaining limestone from dissolving and neutralizing additional acidic water. The method proposed in Stage II for minimizing encapsulation is to grind the limestone to a fine grain size to maximize its reactivity and spatial distribution which would increase the quantity of precipitates required for encapsulation.

Large-scale complexities include barometric pumping of air into and out of large rock piles, which can only be examined in large-scale tests. Such factors may result in a requirement for additional limestone, but the amount is not expected to be significant. Nor will these factors affect or alter the conceptual understanding of acid generation and control in the stockpile as defined in the Stage II Report. The Feasibility Report has allowed for three times the calculated requirements for lime to be available on site for the purpose of acid generation control. This amount will more than adequately address any additional requirements.

Stage III tests are intended to examine encapsulation and large-scale effects in greater detail and will include a large-scale, on-site rock stockpile with added limestone to evaluate the non-ideal complexities under on-site conditions and to refine limestone placement

Response: (cont'd) procedures. The large-scale tests would be initiated after approval-in-principal.

Response by: Kevin Morin, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: d) Verification of water treatment plant operation

Comment: The performance claims of the water treatment plant must be verified as some other similar operating systems do not achieve the levels projected for the Cinola plant. Solutions to possible operational problems such as excessive scaling must be addressed. In addition, the ability of the plant to address mine operational changes requires further evaluation.

Response: The performance expectations are based on two main factors:

a) The water treatment plant is one of four components of the water treatment system, which includes settlings ponds, the treatment plant, the monitoring and equalization ponds, and the wetlands.

b) The design of the plant incorporates a modern high density sludge system to control scaling, as well as a monitoring/maintenance system to ensure that objectives will be met.

The first part of the water treatment system is the very large settling pond MSSP3, which will significantly smooth out fluctuations in the quantity and chemistry of the influent flow to the plant. This will allow the plant to operate with a constant influent.

Within the treatment plant the principal factor known to cause excursions in effluent quality is scaling of the pH probes. The incorporation of a high density sludge recycle system (HDS) is expected to substantially reduce scaling problems (the HDS system was introduced in the Feasibility Study). The HDS system will provide seed crystals in the lime mixing tank, which will result in gypsum crystal growth on the seeds rather than on the process equipment. In addition, pH probes will be ultrasonically cleaned while in the mixing tank and regularly (2-6 hours) removed for cleaning. A microprocessor will monitor the pH probes and shut down the influent to the plant if a problem develops. The combination of these features is expected to minimize excursions.

The equalization pond has been modified to a two-pond system. The first pond will be a monitoring pond. The second, larger pond will equalize small-scale fluctuations in effluent quality. If problems develop in the plant they will be detected at the monitoring pond, and the plant will be shut down until the problem is corrected. The water in the monitoring pond can then be recycled to MSSP3, if this is found to be necessary. The two-pond system will ensure that large-scale fluctuations in effluent quality are detected, in the first pond without affecting the main second pond. Small-scale fluctuations will be smoothed out in the second pond before discharge.

The constructed wetlands are an additional safety factor in the design of the water treatment system. Removal of any suspended particulates, and possibly, but not necessarily, dissolved metals or nitrates will occur in the wetlands.

The combination of water treatment system components will ensure a consistent high quality effluent at the discharge point.

Details of the water treatment system are presented in Appendix I-1-1.

Response by: J. Cronin, J. Brodie, Steffen Robertson and Kirsten

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: e) Duration of pit backfill period

Comment: Rock exposed during backfilling of the pit may generate AMD until flooded. The time of exposure of this rock in the pit needs to be minimized through changes to the backfilling/flooding plan. [This assumes fresh fines will be formed (EC Compendium, Section 4.4.1 p.51)]. (The response to this comment also addresses B.C. MOE comments in Appendix 1, Section 4.2, p. 15.)

Response: Rock in the stockpile will be exposed to years of weathering during operation, and most of the rock will thus generate relatively little acidity after backfill to the pit. However, there are concerns that handling of the rock will expose some fresh sulphide minerals, which, although of limited quantity, will then engage in full acid generation. If this occurs, the acid generation will likely follow the trend defined by testwork in Volume V of the Stage II Report (Section 3.7.2) which is characterized by an initially high rate of acid generation for six months followed by a sharp decrease to a relatively low rate. Based on this trend, 70% of the total acid will be generated in the first 12 months following exposure of fresh sulphide minerals during backfilling and 80% will be generated in 16 months. For this reason, Response: (cont'd) decreasing the period to submerge the backfill from more than three years to less than two years will result in a minor benefit. Furthermore, an exposure period of more than one year is not critical to the required limestone addition nor to cumulative acid generation. Nevertheless contingency measures are available to increase the rate of submergence of waste rock in the backfilled pit as described in the response to MOE (Section 1.3a).

Response by: Kevin Morin, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: f) Mobilization of metal salts at neutral pH

Comment: Metal salts formed in the waste rock stockpile could be mobilized even at neutral pH. The possible concentration of metals at neutral pH in both the reclaimed pit and tailings pond requires further assessment. The movement of groundwater within the backfilled pit also needs to be defined in order to assess the significance of metal mobility. (The response to this comment also addresses comments in B.C. MOE Appendix 1, Section 4.2, p. 15.)

Response: Chemical equilibrium is an ideal concept indicating there is only one possible concentration of a metal under a unique set of conditions, primarily pH. In such an ideal state, the dissolving limestone in the stockpile will create a pH of 7, for example, which will cause metals to precipitate out of the water to an equilibrium level. As long as the pH remains at 7, there will be no further precipitation or dissolution. When the rock is backfilled to the pit or disposed of in the tailings impoundment, and aqueous pH in the pit is maintained at 7, for example, there will be no dissolution or precipitation beyond that necessary to maintain the equilibrium concentration at which the "metal salts" were formed. In this ideal state, there will be no "mobilization" of the precipitated minerals.

From a practical viewpoint, chemical equilibrium is not always attained in an aqueous system. For this reason, Volume V, Section 4, of the Stage II Report and Section 6 of the Addendum

Response: (cont'd)

explicitly compared metal concentrations vs. pH from short-term leach tests, long-term leach tests, humidity cells, column experiments, waste rock pads, and limestone columns with waste rock, overburden, and tailings under various flushing rates, temperatures, and ionic strengths. At near-neutral pH, all of these experiments yielded similar aqueous concentrations of a particular metal, indicating that chemical equilibrium is essentially attained at near-neutral pH.

In order to provide quantitative water quality impact predictions for the Stage II Report, data from the limestone columns (Stage II Addendum Report), the experiment that most closely simulates pit backfill conditions was used to represent the anticipated aqueous metal levels in the backfilled pit. Metal levels in this and other experiments varied to a relatively minor extent from week to week because of such processes as depletion of metals from the samples, variable temperatures, and minor fluctuations in pH. The relatively minor nature of the fluctuations in the metal levels justifies the use of long-term mean concentrations for quantitative predictions, particularly in zones of slow-moving groundwater such as are predicted in the backfill and in the tailings impoundment, where residence times are long and concentrations can be expected to stabilize near the mean concentration.

Response: (cont'd)

In spite of this evidence, further tests are planned for Stage III. These tests will involve the leaching at neutral and alkaline pH of rock that has accumulated "metal salts" for a longer period of time than was available at Stage II. According to chemical equilibrium theory, the concentration of "metal salts" will have no effect on aqueous concentrations beyond their equilibrium concentration. Nevertheless, the data will be evaluated to determine if chemical equilibrium levels defined in the Stage II tests are again attained.

In the event that Stage III testwork indicates the potential for higher metal levels than those predicted in previous experiments, there are contingency plans to control metal chemistry. For example, the stockpile rock can be sprayed and coated with lime or another compound to stabilize the salts during backfilling. Additionally, dissolved compounds such as lime can be added to the backfill porewater to limit aqueous mobilization. Controlling the pit water at a higher pH would assist in precipitation of the metals presenting the greatest concern.

Response by: Kevin Morin, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: g) Acid generation at expected oxygen content and flushing rates

Comment: Estimates of sulphide mineral oxidation and attendant acid and metal release must be recalculated based on expected oxygen contents and water flushing rates since those factors would control the rate of acid generation in the backfilled pit and tailings impoundment.

Response: The assumption that oxygen content and flushing rate control the rate of acid generation ignores many other factors that can limit acid generation (for example, grain size, encapsulation, temperature) (refer to Stage II Report, Volume 2, Section V). In particular, the consumption of reactive sulphide minerals over time leads to a decrease in the rate of acid generation until only the coarse-grained minerals with negligible susceptibility to oxidation remain. Nevertheless, as requested, we have calculated the rate of acid generation in a saturated, oxygen-limited system as defined below.

Water exposed to the atmosphere is capable of absorbing approximately 10 mg/L of oxygen. If this oxygenated water then moves into submerged acid-generating rock, the 10 mg/L provides the only source of the required oxygen. As a result, acid generation can only proceed until the 10 mg/L is consumed. Based on the standard geochemical equation of pyrite oxidation with oxygen (Stage II Report, Volume V, Section 2.2, Equation 5), 10 mg/L of oxygen can result in up

Response: (cont'd)

to 16 mg/L of sulphate and up to 33 mg/L of acidity, calculated as $CaCO_3$ equivalent. In general, whenever alkalinity of the water in mg/L of $CaCO_3$ exceeds the acidity from acid generation (33 mg/L $CaCO_3$ equivalent), pH will remain near neutral values. If the acidity surpasses alkalinity, acidic drainage will develop.

The limestone calculations in Volume IV for the pit backfill were based on the length of time during which acid generation is predicted to exceed the natural alkalinity of the groundwater (60 to 180 mg/L as $CaCO_3$) assuming an unlimited supply of oxygen. The predictions indicated 1310 t of $CaCO_3$ were required for the initial 25 (at 180 mg/L) to 110 (at 60 mg/L) years when natural alkalinity would be exceeded. However, based on the oxygen-limited system (33 mg/L of acidity as $CaCO_3$ equivalent), acid generation would never exceed the natural alkalinity even at a minimum of 60 mg/L $CaCO_3$ and, consequently, no limestone would be required after submergence of the backfill. Because the pH is controlled, aqueous metal concentrations are expected to remain at minimal levels as defined in Section 4 of Volume V of the Stage II Report.

The limestone calculations in Volume IV for the tailings impoundments were based on the length of time during which acid generation in the argillically altered and the potentially acid

Response: (cont'd) generating rock used to construct the causeway in the impoundment is predicted to exceed the natural alkalinity of the groundwater (60 to 180 mg/L as $CaCO_3$) assuming no oxygen depletion. The predictions indicated that mixing of 3 to 9% of the tailings with rock in each impoundment was required for the tens to hundreds of years when natural alkalinity would be exceeded. However, based on the oxygen-limited system (33 mg/L of acidity), acid generation would never exceed the natural alkalinity of the groundwater and, consequently, no mixing with tailings would be required for pH control. Because the pH is controlled, aqueous metal concentrations are expected to remain at the minimal levels defined in Section 4 of Volume V.

These scenarios assume the only available source of oxygen is the dissolved oxygen carried by the water moving through rock and tailings. This scenario may not be applicable to the Cinola Gold project for two major reasons. First, before the rock is submerged, water has drained from crevices and fractures and has been replaced with air. As a result, the fractures contain an additional source of oxygen until the air is displaced or dissolved, potentially leading to an initially high rate of acid generation which is more consistent with the predictions in Stage II (Section 3.7, Volume V). Second, the rate of acid generation decreases through time due to the oxidation and removal of finer-grained sulfide and the slower

Response: (cont'd) oxidation rate of coarser sulfide. As a result, the rate of oxidation will fall below the level where all dissolved oxygen is consumed so that oxygen concentration will no longer be the limiting control on acid generation. Therefore, acid generation is more complex than simply "oxygen contents and water flushing rate" and the detailed experiments and predictions in Volume IV and V are considered valid. Further confirmation of predictions will be gathered during Stage III testwork.

Response by: Kevin Morin, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: h) Groundwater pH

Comment: Predictions of pH and metal mobility are based in part on assumed pH and alkalinity of groundwater. The pH and alkalinity of the upwelling groundwater expected to enter the backfilled pit and tailings impoundment must be verified.

Response: Predictions of the existing groundwater quality, based upon available data for the mine and High West areas, are discussed in the Stage II Report, Volume III, Section 5.5.6. It would appear from this work that although some assumptions have been made in the High West area, they are probably conservative, and the actual results are likely to be better than the assumed values.

Nevertheless, as discussed in the Stage II Report, Volume IV, Section 5.1.4, groundwater wells will be established in the vicinity of the embankments in the High West impoundment area, waste rock stockpile, and pit as part of the Stage III studies.

These wells will be drilled using an air rotary drill rig in order that groundwater samples free of drilling fines can be obtained. The wells will be pump tested to provide further data on in-situ hydraulic conductivities, and will be developed in such a manner as to provide long-term monitoring of groundwater quality.

Response: John Gadsby, Steffen Robertson and Kirsten.

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

3. Acid Mine Drainage Abatement

Topic: i) Leaching environments in the backfilled pit

Comment: The effect of different leaching environments in the upward and downward moving groundwater zones within the backfilled pit and reclaimed tailings impoundment must be examined further. Geochemical conditions in those two zones are different and would affect estimates of acid generation and metal mobility. (see also Environment Canada Compendium, Section 4.4.1, p.52).

Response: A zone of upward moving groundwater can be a different leaching environment with a different geochemistry than a zone of downward moving groundwater. This is a consequence of downward moving groundwater carrying constituents such as dissolved oxygen and dilute concentrations of ionic species which reflect its surface water origins, whereas upward moving groundwater from deeper flow systems will carry little oxygen and higher concentrations of aqueous species. However, from the perspective of acid generation predictions for the Cinola site, the quality of water in the two zones is actually expected to be similar for the following reasons.

In the zones of upward moving groundwater in the pit backfill and tailings impoundment, the background groundwater will have a new limited oxygen concentration and, as a result, there will be little sulphide oxidation and acid generation. (We are basing the assumption of low oxygen concentration on typical groundwater

Response: (cont'd) regimes). The upward moving groundwater will thus maintain a neutral/alkaline pH and dissolved metal levels will attain equilibrium at that pH.

In the zones of downward moving groundwater, acid generation with accompanying neutralization may initially occur at a relatively rapid rate and then decrease to a relatively minor rate through time as discussed in Section 3.7 of Volume V. The decreasing rate is primarily attributable to consumption of the most reactive sulfide, although the rate may also decline due to other factors such as the limitation of oxygen diffusion into the rock and the limitation of dissolved oxygen in water to a level of approximately 10 mg/L. For these reasons, acid generation in the zone of downward moving groundwater is expected to decrease through time. Based on studies conducted elsewhere in Canada, this temporal trend may result in a lateral zone of acid generation which migrates downward through time, decreasing in severity and in rate of migration until negligible. Because the pit backfill and tailings will contain solid limestone and dissolved alkalinity, neutral/alkaline pH values will be maintained which in turn will preserve minimum equilibrium levels of aqueous metals similar to concentrations expected in the zones of upward moving groundwater. As a result, groundwaters in the two distinct zones are expected to have little difference in aqueous

Response: (cont'd) chemical composition and pH. Nevertheless, the proposed Stage III testwork will examine further the impact of oxygen-bearing water on acid generation and water quality in the backfilled pit.

City Resources is committed to adding the required limestone to the backfill in order to maintain neutral/alkaline pH throughout the reclaimed pit. On-going testwork and Stage II experiments will permit the refinement of limestone requirements to ensure maintenance of acceptable pH and metal levels.

Response by: Kevin Morin, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

4. Mill Effluent Quality

Topic: a) Sensitivity analysis of tailings pond water balance

Comment: The plan to operate the tailings impoundment in total recycle must be achieved since contaminant levels during operation will be too high for direct discharge to the receiving environment. A sensitivity analysis of factors affecting the water balance for the tailings impoundment as required by the provincial Water Management Branch is supported. The ability to maintain total recycle given possible changes to mill operation, and to tailings and waste rock disposal must be examined in that analysis.

Response: This comment is addressed in the response to B.C. MOE Section 1.6a.

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

4. Mill Effluent Quality

Topic: b) Performance of SO_2/air and sodium sulfide treatment in series.

Comment: Performance of the SO_2/Air and sodium sulphid treatment systems operated in series was not evaluated in the Stage II Report and may be important in achieving required effluent quality. Further analysis, possibly including laboratory tests, are required to ensure the systems can achieve projected effluent quality on a consistent basis when operated in series.

Response: Our preliminary assessment on this subject is that the use of the oxidation treatment just before the sulfidization of the soluble mercury should not make the mercury precipitation process less effective. It could have little or no detrimental effect even from the economic side. Under the worst scenarios it would increase the consumption of Na_2S required to achieve the same extent of mercury precipitation.

The destruction of free and complexed cyanide is carried out by applying a strong oxidizing potential to the cyanide containing slurry. In the system adopted for Cinola, SO_2 and air are used as the oxidants and copper acts as a catalyst. The generalized reaction is:

$$CN^- + SO_2 + O_2 + H_2O \longrightarrow CNO^- + H_2SO_4$$

Response: (cont'd)

The design calls for the process to be carried out in a single agitated tank in which SO_2 and air are dispersed by sparging.

In order to improve the economics, it is necessary to keep the addition of SO_2 and air to the minimum.

It is well known that SO_2 can act both as an oxidizer and as a reducer. If SO_2 is sparged into a slurry without any air, the slurry becomes reducing.

The precipitation of mercury is accomplished through the following reaction:

$$Hg(CN)_4^{=} + Na_2S \text{ ---> } HgS + 2Na^+ + 4\ CN^-$$

One can obviously assume that if there is a large excess of oxidant, this could oxidize the Na_2S added and decrease the amount of the reagent available for the sulfidization reaction. However, the direct oxidation of sulfides with air is normally slow, specially compared to the time required for the above sulfidization reaction.

In addition, one would expect that at the output of the cyanide destruction tank, there is no remaining oxidation power left due to the reduced amount of air.

Response: (cont'd) Since there are no other interferences foreseen with the sulfidization reaction it is concluded that the worst scenario that could be expected is where additional Na_2S would have to be added to compensate for any residual oxidizers. This has no significant impact on the economics of the process.

Response by: Arnaldo Ismay, Minproc

I ISSUES TO BE ADDRESSED BY THE PROPONENT

4. Mill Effluent Quality

Topic: c) Verification of copper and cyanide degradation in tailings

Comment: The estimate of the rate of copper and cyanide degradation within the tailings pore water must be verified since significant natural reductions of contaminants following decommissioning must occur in order to meet effluent quality requirements.

Response: Section 3.7.2.2 of Volume IV of the Stage II Report discussed field evidence for degradation of cyanide and levels of soluble metals in tailings pore water at various sites worldwide. The references are provided at the end of this section.

In an attempt to verify that natural degradation did in fact take place at rates comparable to those in the quoted references (that is, a half life of six months or less), the slurry residues from the pilot plant were resampled after approximately 5 months of storage in closed buckets. It should be emphasized that when placed in storage, there was no intention of resampling for this purpose; the condition of storage cannot be considered to duplicate the conditions under which tailings would be stored in a tailings impoundment and these cannot be considered controlled tests.

The results of this resampling are unclear. While copper values in both samples were

Response: (cont'd) substantially reduced, the cyanide levels appeared to decrease in one sample and to increase in the other. The sample that showed an apparent increase in cyanide levels was that in which cyanide destruction had been carried out by the SO_2 air process. The full results of these determinations, together with the original results, are as follows:

DATE	SAMPLE	DISSOLVED Cu	TOTAL CN	W.A.D. CN	pH	SULPHATE
May 16/88	H_2O_2 kill supernatant	0.88	1.87	1.25	8.0	2438
Oct 20/88	H_2O_2 kill supernatant	0.08	0.81	0.71	8.0	1970
Oct 20/88	H_2O_2 kill pore water	0.11	0.75	0.66	8.0	-
May 16/88	SO_2/air kill supernatant	0.29	0.60	0.14	8.0	3250
Oct 25/88	SO_2/air kill supernatant	0.05	0.67	0.57	8.1	2720
Oct 25/88	SO_2/air kill pore water	0.07	1.20	0.74	8.5	-

The SO_2/air method of cyanide destruction was originally selected because of the lower total and W.A.D. cyanide levels achieved by this method. Should these results be verified during Stage III testwork, i.e. that the use of hydrogen peroxide leads to improved cyanide levels after a period of storage, City Resources will undertake

Response: (cont'd) to use the hydrogen peroxide method of cyanide destruction.

The changes in copper and cyanide in the slurry in which cyanide was killed with SO_2/air are apparently contradictory. As copper will be in solution in the form of a copper/cyanide complex, then an increase in cyanide, if that were possible, would lead to an increase in copper in solution, but this does not appear to be the case. It should be pointed out that the determination of copper at these levels is substantially more reliable than that of cyanide. This may bring into question the accuracy of the cyanide analyses in the presence of the relatively high concentration of thiocyanate found in the SO_2/air slurry. The presence of thiocyanate at concentrations several orders of magnitude greater than those of total and W.A.D. cyanide causes a chemical interference with the analytical methods for cyanide and will result in an overestimate of cyanide levels. This effect is common in the analysis of cyanide at low levels in the presence of thiocyanate and has been documented elsewhere. There is no known mechanism by which cyanide could be reformed from the products of cyanide oxidation (cyanate and thiocyanate).

If the data from the hydrogen peroxide tests are considered, then the half life of cyanide is shown to be less than six months due to natural degradation in the porewater, that is, the

Response: (cont'd) residual cyanide level is only 40% of its initial value after 5 months.

In both groups of data, there are significant reductions in copper values in the tailings slurry porewater to 13% and 24% of the original values after 5 months.

The presence of high thiocyanate levels is an aspect which City Resources plans to address in its next phase of metallurgical testwork. The loss of cyanide in the process to thiocyanate represents a high cost, and there is considerable economic incentive to reduce the loss of cyanide by this mechanism. It is currently planned to explore the prevention of thiocyanate formation by various routes such as adding a flotation or adsorption step to preferentially remove elemental sulphur. If this is successful, the tailings slurry would have significantly lower thiocyanate prior to cyanide kill than those from previous pilot plant operations. Since this will reduce chemical interference in the determination of the low cyanide levels required, it is suggested that final verification of cyanide degradation be included as part of Stage III work after slurries are obtained from future pilot plant work. Degradation with time will be determined in a series of carefully designed and controlled tests during which the slurries will be stored in a manner that will resemble conditions in a tailings impoundment.

Response: (cont'd) The current situation and proposed continued research into cyanide in mill effluent and its subsequent degradation may be summarized as follows:

1) Cyanide kill testwork will be repeated on future pilot plant effluent samples. These may be lower in thiocyanate than previous samples, but would in no case exhibit higher levels of thiocyanate than those tested previously. Subsequent testing will be carried out to determine changes in copper, total cyanide and W.A.D. cyanide with time;

2) If the current data is verified by this method, i.e., that cyanide destruction with hydrogen peroxide leads to lower copper, total cyanide and W.A.D. cyanide in the tailings pore water after storage, then City Resources will undertake to use the hydrogen peroxide kill method rather than sulphur dioxide; and

3) If this subsequent testwork, with the enhanced accuracy of cyanide determination due to lower levels of thiocyanate, shows differences between the methods of cyanide destruction in levels of copper, total and W.A.D. cyanide in mill effluent and after storage, City Resources will undertake to adopt the cyanide destruction method that appears most suitable from the results of this testwork. If the results show that

Response: (cont'd) different methods meet the required effluent levels, the most economic method will be adopted.

Response by: Adrian Smith, Adrian Smith Consulting Inc.

Reference:

Caldwell, J.A., D. Moore, and A.C.S. Smith. 1984. Impoundment design for cyanided tailings - case history of the Cannon Mine project: Conference on Cyanide and the Environment, Tucson, AZ: 249-263.

Englehardt, P.R. 1984. Long-term degradation of cyanide in an inactive leach heap: Proceedings: Conference of Cyanide and the Environment, Tucson, AZ.

Resource Recovery and Conservation Consultants (RRCC). Attenuation of Cyanide in Soils: Phase 1 Report for Dupont Company.

Smith, A.C.S., A. Dehman and R. Pullen. 1984. The effects of cyanide-bearing, gold tailings disposal on water quality in the Witwatersrand South Africa. Conference on Cyanide and the Environment, Tuscon, AZ: 221-230.

Smith, A. 1988. Testimony to Department of Health and Environmental Control, South Carolina Permit #SC0041378. Appeal Hearing. Columbia, SC., December 1987 - Ridgeway Mining Company, South Carolina.

Worsley Alumino Pty Ltd. 1986. Report on studies into cyanide decay process residues.

I ISSUES TO BE ADDRESSED BY THE PROPONENT

5. Impacts of Mercury/Nutrients

Topic: a) Quantification of mercury release and impacts

b) Effects of effluent on productivity and mercury methylation

Comment: a) Methylation/demethylation of mercury and the uptake of methylmercury currently occurs in the receiving environment adjacent to the Cinola project. The mine will cause an incremental increase in the amount of mercury in the environment and therefore there will likely be some increase in methylmercury production, particularly in Barbie and Florence Creeks. The quantity and form of mercury to be released into the receiving environment and the amount of methylation that could occur will have to be quantified with respect to potential impacts on resident fish.

b) The increase in organic matter that will result from the increase in primary productivity and the potential for this to enhance mercury methylation must be assessed. The effects of chemical changes in receiving water quality (e.g. competition for orthophosphate and availability of micronutrients) on nutrient availability and algal productivity must also be included in this assessment.

Response: The response to these two comments is given as a single response which integrates the findings of the mercury methylation and speciation study and the nutrient limitation study. These studies were completed following the submission of the Stage II and Addendum reports and full study

Response: (cont'd) reports are provided in Appendices I-5-1 and I-5-2. Relevant sections of the Appendix reports have been extracted or paraphrased and incorporated in the following response. The findings of the mercury and nutrient studies were reviewed in detail at a two day comprehensive mercury methylation workshop held between representatives of Environmental Protection, Fisheries and Oceans, B.C. Ministry of Environment and the City Resources environmental consulting team (December 1 and 2, 1988). The response reflects the observations and conclusions of that workshop.

The concerns surrounding mercury methylation at the Cinola site have arisen out of observations early in the exploration phase that mercury levels in the area of the Cinola deposit are anomalously high. In addition resident fish (cutthroat trout, Dolly Varden char, rainbow trout) samples collected by Ministry of Environment staff from the Yakoun River in October 1987 indicate fish muscle tissue mean mercury levels ranging from 0.10 to 0.31 ug/g wet weight. In a total sample of 49, no fish had tissue mercury concentrations above the criterion of 0.5 ug/g recommended by the Ministry of Health for unrestricted human consumption. However, 13 fish had mercury concentrations in excess of 0.3 mg/L, the maximum level recommended for those who consume fish on a daily basis. These observations suggest to the Ministry of Environment that mercury levels in existing resident fish stocks are of concern with respect

Response: (cont'd)

to human consumption and that any incremental increase in fish tissue mercury concentrations caused by mining activities is therefore unacceptable (B. Wilkes memo to D. Parsons, December 1, 1988). Anadromous fish species which support native domestic and commercial fisheries and a steelhead sports fishery are of minor concern with respect to metals accumulation in the project area (Environment Canada Compendium Section 8.2.7, page 90) because the greater part of their life cycle and growth takes place in the marine environment far removed from the influence of the Yakoun system.

Existing mercury levels in Florence and Barbie Creeks and those predicted for the creeks during and after mine operation are well below criteria for protection of aquatic life. Therefore, the focus of concern with respect to mercury and the Cinola Project is not toxic effects but the effect on mercury accumulation in resident fish tissue and associated health risk to humans consuming these fish.

The causes of mercury accumulation in fish are reviewed in Appendix I-5-1. In summary, mercury levels in fish tissue increase when there is an increase in methylmercury availability. In turn, methylmercury availability is regulated by the net rate of microbial mercury methylation. Methylmercury production increases when there is an increase in ionic (bioavailable) mercury or when there is an infusion of readily decomposed organic matter to the aquatic system which

Response: (cont'd) stimulates the activity of methylating bacteria without causing a corresponding increase in fish production (eg. flooding of terrestrial soils and vegetation in new impoundments). Concern for the potential effect of mine development on mercury levels in fish arises from two sources:

1) increased mercury input to surface water from disturbance of soils and acid generating rock and as a result of ore processing and tailings disposal; and

2) enhanced mercury methylation by flooding of the constructed wetlands and freshwater reservoir, and by fertilization of surface water with nitrates in drainage from blasted rock and mill tailings.

Accordingly City Resources was requested to provide a quantitative estimate of mercury input to surface waters from mining activities and to assess the impact of mining on mercury methylation and bioaccumulation in fish.

Environmental Mercury Levels

As noted in the Stage II Report (Volume III, p. 2-42) mercury levels in the Cinola deposit (x=4.6 ppm), while higher than average for non-mineralized areas, are not exceptionally high by comparison to other deposits which have been developed (refer to City Resources (Canada) Limited 1987, p. 7-10). Existing mercury levels in sediments of streams potentially affected by

Response: (cont'd) project activities are provided in the Stage II Baseline Environmental Description (Volume III, Table 5.6.4-4, p. 5-182) and in Table 2.3-3 of Appendix I-5-1. Barbie Creek, influenced by the mineralized zone, has higher sediment mercury levels (216 to 289 ng/g dry weight) than Florence Creek (165 ng/g) in the proposed tailings disposal area, although levels in both creeks are within the range of natural concentrations found in North American streams (Stage II Report, Volume III, Table 5.6.4-6, p. 5-185).

Mercury levels in water were not detectable in Barbie and Florence creeks using the standard laboratory detection limits (50 ng/L) employed in the Stage II baseline studies. Accordingly an arbitrary value of half the detection value, or 25 ng/L, was used in Stage II to characterize receiving waters and predict mercury concentration in streams during and after mine operations. As part of the post-Stage II mercury studies, specialized analytical techniques with lower detection limits (as low as 0.4 ng/L) were used to measure total and ionic mercury in streams. The results (Table 3.3-1, Appendix I-5-1) gave a mean total mercury value of 7.9 ng/L for Lower Barbie Creek and 3.7 ng/L for Florence Creek. These values are considerably lower than the assumed half detection values used to predict the total mercury loads to receiving waters in Stage II.

Natural mercury methylation and demethylation rates were also measured in study area streams as

Response: (cont'd) described in Section 2.1 of Appendix I-5-1. Sites included Middle Barbie, Barbie Wetland, Lower Barbie, Florence Creek and a control site on Gold Creek.

There was a broad range of variation in specific rates of microbial methylation and demethylation and in the methylation balance among the sites sampled. Microbial mercury methylation activity (M) was below detection in Middle Barbie Creek on both sampling dates (Table 2.3-1, Appendix I-5-1). In Lower Barbie Creek and Gold Creek, methylation activity was below detection when sampled at the end of August but was measurable later in September. Natural methylation activity in Barbie Wetland, formed by flooding of forest soils when the logging road was constructed was more than 10 times higher than at any other location (Appendix I-5-1, p. 16).

Methylation rates were not correlated with mercury concentration in sediments but were correlated with organic content of sediments. In contrast demethylation rates (D) were not correlated with methylation rates nor with organic content of sediments. The high methylation rate observed in sediments from Barbie Wetland was balanced to a large degree by the high demethylation activity there. The moderate methylation occurred in association with low demethylation rates so that net methylmercury production (M/D) in Gold Creek was secondary to that in Barbie Wetland and was much higher than in other stream sediments.

Response: (cont'd) The finding of sites like those in Barbie Wetland and Gold Creek which support significant levels of net microbial mercury methylation (high M/D) and the general similarity of mercury concentrations in juvenile coho salmon from these streams with fish from other sites in the Cinola area indicates that sites such as these undoubtedly exist in other streams of the Yakoun drainage as well as in Florence Creek. Mercury concentrations in juvenile coho salmon collected from Lower Barbie Creek immediately below Barbie Wetland, a site of high net methylmercury production, were comparable to mercury levels in juvenile coho in the upper and lower reaches of the Yakoun River, and averaged about 65% of mercury concentrations in fish from the mid Yakoun. Similarly, concentrations in Dolly Varden char from Lower Barbie were the same as in Yakoun fish and averaged 67% of levels in fish from Florence and Boucher Creeks (Stage II Report, Volume IV, Table 3.11.2-1, page 3-180). The high net methylation at the Barbie Wetland and Gold Creek sites are explained by the high organic content of the sediment. The reason for the occurrence of such sites is probably variable, ranging from low gradient reaches where organic matter can accumulate (e.g. the sampling sites at Gold Creek) to backflooded areas resulting from stream flow restrictions (e.g. Barbie Wetland). Sites such as these likely represent the dominant natural sources of methylmercury to the system.

Response: **Effects of Mine Development**
(cont'd)

High West

The effect of project development in the High West area on mercury methylation and subsequent accumulation in fish may potentially be related to:

1) Flooding of the fresh water reservoir;

2) Seepage of mercury enriched tailings porewater into Florence Creek surface waters following deactivation of impoundments; and

3) Stimulated methylation in the reclaimed impoundments due to nitrate fertilization of surface waters by tailings porewater seepage.

The Stage II Report identified mitigative measures to prevent stimulated methylation in the reservoir. These include clearing the vegetation and stripping the organic layer prior to flooding. Mineral soils from the reservoir area were tested to assess whether they would enhance microbial methylation activity or shift the methylation balance above that in the natural Florence Creek sediments. Reservoir soils were incubated in Florence Creek as described in Appendix I-5-1 and methylation and demethylation rates were measured using radioactive mercury.

The assay results indicate that the soils selected as the substrate in the water storage

Response: (cont'd) reservoir are quite acceptable for that purpose. At the time of sampling, microbial methylation activity was low but detectable in all of the sediment samples from Upper Florence Creek while methylation was below detection in three of the four reservoir soil samples (Table 2.3-7). Demethylation activity in the soils averaged about 58% of that in the stream sediments but the methylation balance (M/D) in the soils was still less than 30% of M/D in the stream sediments (Table 2.3-7).

The other way in which the project may introduce mercury to the environment in the High West area is by groundwater displacement of tailings porewater into the reclaimed impoundment and then into the Florence Creek. Measurements were made of the bioavailable or ionic mercury in the porewater from a pilot mill tailings sample that had been aged for five months and exposed to oxidizing conditions in transport and handling. (Because of the small volume of porewater available for analysis -100 mL - it was not possible to analyse for total mercury and the analytical detection limit was higher than that attainable for larger sample volumes).

The tailings porewater contained no measurable ionic mercury at a detection limit of 2.0 ng/L (Table 3.3-2, Appendix I-5-1) despite the total mercury concentration of 240 ng/L, measured in this effluent at the time it left the pilot mill (Stage II Addendum Report, p. 3-25) . Measurements of ionic mercury in tailings water

Response: (cont'd) were not made at the time the tailings were generated and, as noted previously, total mercury was not measured in this study. Therefore, it was not possible to determine if the low level of ionic mercury in the effluent is due to the tailings treatment process or is a result of aging of the tailings. Nevertheless it is apparent that, several months after production, mercury in the tailings porewater does not occur in a form that is readily available to methylating bacteria.

The results of this analysis also indicate the stability of the non-ionic mercury in the tailings porewater upon exposure to oxidizing conditions. The sample was mixed with air when the sample bottle was filled and the 100 mL sample was stored in a 500mL samples bottle for approximately 5 weeks with air in the headspace. The sample was subjected to considerable agitation in transport to the analytical laboratory and the headspace air also was deliberately exposed to room air on two occasions between collection and analysis. However, despite this exposure to oxygen, no ionic mercury was detected in the sample. The stability of the non-ionic mercury in the tailings upon exposure to oxidizing conditions suggests that mercury in the tailings pond seepage is unlikely to convert to the ionic form due to oxidation.

The lack of ionic mercury in the tailings porewater and the apparent stability of the non-ionic mercury in the porewater with exposure

Response: (cont'd) to aerobic conditions is consistent with observations made at several abandoned gold and base-metal mines in Manitoba. The tailings at these mines contain significant quantities of mercury (e.g. Sherridon Mine, 2800 ng/g) and drainage from these tailings has produced elevated concentrations of total mercury in the sediments of receiving lakes, yet mercury concentrations in fish from these lakes have not been affected. This indicates that the tailings did not represent a source of ionic mercury and that the non-ionic mercury in the tailings was stable upon exposure to oxidizing conditions. Details of these impact assessments were presented in Volume IV of the Stage II Report (pp. 3-182 and 3-183).

The effect of nitrate fertilization from project effluents on stream production was assessed using in situ algal bioassays as described in Appendix I-5-2. Concerns regarding nutrient enrichment included fish habitat degradation due to algal blooms (oxygen depletion, physical impacts on spawning gravels) and enhanced mercury methylation activity due to increased organic input to the system.

The bioassays were conducted in Florence Creek but the results are considered transferable to Barbie Creek because of similar chemical and nutrient composition of the water and similar algal communities (Appendix I-5-2 p. 7). In Florence Creek, nitrate concentrations are predicted to increase up to and at times exceed

Response: (cont'd) 1000 ug/L due to tailings porewater seepage. The bioassays showed that an increase in biomass of periphytic algae would peak at N additions $\leq$ 100 ug/L; and that additions beyond this level had no further effects on biomass accrual. This equated with a 3- to 4-fold increase in sustainable algal biomass in Florence Creek. This increase compares with the 10-fold increase in algal biomass which is typically targeted by deliberate stream fertilization programs to enhance salmonid production in coastal streams (Perrin et al. 1987, Johnston et. al. in press).

Any stimulation of mercury methylation due to this autochthanous input is expected to be offset by enhanced fisheries production. Evidence for the importance of biodilution of tissue metal levels by increased productivity is supported by comparisons of mercury concentrations in fish from eutrophic (high primary productivity) and oligotrophic (low productivity) lakes. D'Itri et al. (1971) compared mercury concentrations in rainbow trout from a eutrophic and an oligotrophic lake in Northern Michigan. The fish were stocked in the lakes at the same time and consequently were the same age when sampled. Mercury concentrations in fish from the eutrophic lake were less than half the levels in fish from the oligotrophic lake. Fish from the eutrophic lake weighed twice as much and were 27% longer than fish from the oligotophic lake. Similarly, enclosure experiments have been conducted to examine the effect of increased primary

Response: productivity on mercury concentrations in fish.
(cont'd) Hecky et al. (1987) found that a doubling of primary productivity had no effect on mercury levels and that the addition of organic matter which stimulated fish growth could actually reduce mercury concentrations in fish. Jackson (1988) and Ramsey and Ramlal (1987) found high rates of microbial methylmercury production in sediments from eutrophic East Mynorski Lake in northern Manitoba, yet mercury concentrations in forage fish from the lake were not elevated (Bodaly et. al. 1987).

In summary the soils of the freshwater reservoir and the inorganic tailings solids are not expected to stimulate mercury methylation rates above the background rates observed in Florence Creek sediments. Based on analysis of pilot mill samples, tailings porewater is not expected to contribute significant concentrations of ionic mercury to Florence Creek. This is consistent with observations at other mines where drainage from tailings containing mercury has not resulted in enhanced mercury accumulation in fish from downstream lakes. Nitrate levels in porewater may increase primary productivity up to 5 times natural levels. This is expected to have a slightly beneficial effect on fish production with no significant effect on mercury accumulation in fish tissue.

In the worst case, if methylation rates increased in the reclaimed water reservoir and tailings impoundment, it is unlikely that significant

Response: (cont'd) resident fish populations would be affected. It is not anticipated that fish populations will establish in the impoundment area as Embankment #3 will block upstream mitigation and there is a lack of suitable spawning habitat in the upper Florence basin.

Mine Area

The effect of project development in the mine area on mercury accumulation in fish may potentially be related to:

1) Flooding of soils by the construction of wetland treatment systems;

2) Discharge of ionic mercury with drainage from the waste rock and effluent from the water treatment plant; and

3) Stimulated mercury methylation due to nitrate and phosphate fertilization of lower Barbie Creek with treatment plant effluent.

In order to test the potential for stimulated mercury methylation in soils flooded by the constructed wetlands, several candidate soils for construction of the wetland were incubated in Barbie Wetland and their methylation rates compared with those of natural Barbie Wetland and Barbie Creek sediments. These test soils were taken from the proposed sites of Mine Site Wetlands 1 (MSW1), Mines Site Wetlands 2 (MSW2-P) the mudstone dump and the pit.

Response: (cont'd) Results of the methylation bioassays are reported in detail in Appendix I-5-1 Section 2.3.4.

None of the soil-types tested stimulated microbial methylation activity or shifted the methylation balance above that in natural Barbie wetland sediments (Tables 2.3-8). All soils except those from the proposed mudstone dump site exhibited methylation rates below natural Barbie Creek sediments. Methylation activity was below detection in test-soils from MSW1, MSW2-P, and the pit but was measurable in the mudstone soils. Demethylation activity was consistently low in all four test-soils (Table 2.3-8). The occurrence of relatively high methylation activity in the mudstone soils in conjunction with the low demethylation activity resulted in a methylation balance for the mudstone soils that was at the high end of the natural range; comparable to that measured in Gold Creek (Tables 2.3-1 and 2.3-8; Appendix I-5-1).

From the standpoint of minimizing net microbial methylation in the constructed wetlands, any of the test-soils from MSW1, MSW2, or the pit area would be suitable since none supported measurable microbial methylation and the substrate for the constructed wetland would therefore not represent a source of methylmercury to receiving waters. Soils from the area of the proposed mudstone dump would be the least attractive choice of the types tested.

Response: (cont'd) The microbial methylation balance (M/D) in the submerged soils was directly correlated with initial organic content of the soil but independent of the final organic content (Table 2.3-9; Appendix I-5-1). Similarly, methylating activity (M) was weakly correlated with initial organic content but was independent of the final organic content (Table 2.3-9). Apparently the terrestrial organic matter in the soils from the proposed location of the mudstone dump was more available to the methylating bacteria than the fine organics which settled onto the soils while they incubated in the wetlands. This may indicate that terrestrial organic matter stimulates the activity of methylating bacteria more than autochthonous organic matter.

The regression analysis also showed a lack of correlation between methylation activity in the soils and either the initial or final concentration of total mercury (Table 2.3-9; Appendix I-5-1). This finding is consistent with the results of work in northern reservoirs, where microbial methylation activity is unaffected by the introduction of inorganic mercury in unaltered native soils. While previous studies have shown that total mercury concentrations of up to 460 ng/g in soils did not stimulate microbial methylation (Ramsey 1987), the results of this study indicate that total mercury concentrations up to about 550 ng/g have no effect on methylation rates.

Response: (cont'd)

The potential for increased mercury methylation and bioaccumulation in lower Barbie Creek due to drainage from the waste rock stockpile and effluent from the water treatment plant was assessed by measuring the bioavailable or ionic mercury in drainage from the limed columns, which were designed to simulate the limed waste rock stockpile.

Concentrations of total and ionic mercury in drainage from limestone column 3 were low and within the range of concentrations in receiving waters (Appendix I-5-I, Tables 3.3-1 and 3.3-2). The net contribution of the limestone column to total mercury in the leachate was only 1.8 ng L^{-1}; a concentration which is lower than any measured in the streams. Although the majority (67%) of the total mercury leached from the column was ionic, that contribution (1.2 ng L^{-1}) was comparable to natural concentrations measured in Florence Creek (Table 3.3-1). The lime mixed with the waste rock appears to effectively neutralize the acidity and at the same time remove mercury from solution before it can leave the column.

Based on the results of this study, the lime that will be added in the water treatment plant should also be expected to greatly reduce mercury concentrations in effluents before discharge to the environment. Analyses of effluent from the bench scale test of the water treatment process employed detection limits of 100 to 300 ng

Response: (cont'd) L^{-1}. Concentrations in effluent were always below detection and the results of this study suggest that concentrations may be as much as a factor of 100 lower than these limits. Effluent from the Stage III pilot scale test of the water treatment process will be analysed using the methods employed in this study in order to test that assumption.

An additional concern was raised regarding the effect of nutrient inputs to Barbie Creek and implications to accumulation of organic matter and mercury methylation in the creek. Nutrient inputs are expected from leaching of blasting residue (nitrates) and phosphorus from waste rock piles and the pit walls. The effects of predicted nutrient additions to algal accrual in receiving waters was tested using in situ algal bioassays. As noted previously, the bioassays were conducted in Florence Creek, but the results are considered transferable to Barbie Creek as the water chemistry and algal community composition in the two creeks are similar.

The results of the bioassays showed that nitrogen limited biomass accrual was saturated at $\leq$ 100 ug N/L; however, predicted phosphorus additions of 2 ug/L did not result in additional growth of periphytic algae. The lack of response with phosphorus additions was attributed to possible complexing of phosphates by humates in the receiving waters making them unavailable for plant uptake or growth limitation caused by some

Response: (cont'd) other micronutrient. The net result of combined nitrogen and phosphorus equated to a 3 to 4 fold increase in algal biomass in the receiving stream. As noted previously, this compares with a 10-fold increase which is the objective of stream fertilization studies to enhance fisheries production.

It is anticipated that stimulatory effects, if any, on mercury methylation will be counter balanced by increased fish production as discussed under High West impacts.

In the worst case, mercury methylation and bioaccumulation in lower Barbie Creek is of concern primarily with respect to cutthroat trout and Dolly Varden char which reside in this reach. These fish are not harvested for human consumption. Mercury methylation in lower Barbie Creek will not affect mercury levels in adult anadromous fish which originate from this reach.

Response by: Liz Neil, Norecol; Doug Ramsey. Aggasiz North; Chris Perrin, Limnotek.

References:

Bodaly, R.A., N.E. Strange, R.E. Hecky, R.J.P. Fudge, and C. Anema. 1987. Mercury content of soil, lake sediment, vegetation, and forage fish in the area of the Churchill River diversion, Manitoba, 1981-82. Can. Data Rep. Fish. Aquat. Sci. 610:iv+33p.

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D'Itri., F.M., C.S. Annett, A.W. Fast. 1971. Comparison of mercury levels in an oligotrophic and a eutrophic lake. Jour. Mar. Technol. Soc. 5(6): 10-14.

Hecky, R.E., R.A. Bodaly, N.E. Strange, D.J. Ramsey, C. Anema, and R.J.P. Fudge. 1987. Mercury bioaccumulation in yellow perch in limnocorrals simulating the effects of reservoir formation. Can. Data Rep. Fish. Aquat. Sci. 628:v+158 p.

Jackson, T.A. 1988. The mercury problem in recently formed reservoirs of northern Manitoba (Canada): effects of impoundment and other factors on the production of methylmercury by microorganisms in sediments. Can. J. Fish. Aquat. Sci. 45:97-121.

Johnston, N.T., G.J. Perrin, P.A. Slaney, and B.R. Ward (in press). Increased periphyton standing crop, invertebrate abundance and juvenile salmonid growth by stream fertilization. Can. J. Fish. Sci.

Perrin, C.J., M.L. Bothwell, and P.A. Slaney. 1987. Experimental enrichment of a coastal stream in British Columbia; effects of organic and inorganic additions on autotrophic periphyton production. Can. J. Fish. Aquat. Sci. 38:137-145.

Ramsey, D.J. 1987. Measurements of methylation balance in the Little Jackfish River System, Ontario. Prepared by Ontario Hydro, Environmental Studies and Assessments Department, Toronto, Ontario.

References: (cont'd)

Ramsey, D.J., and P.S. Ramlal. 1987. Measurements of mercury methylation balance in relation to concentrations of total mercury in northern Manitoba reservoirs and their use in predicting the duration of fish mercury problems in new reservoirs. Summary report of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion, Technical Appendix 12. Winnipeg, MB.

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

5. Impacts of Mercury/Nutrients

Topic: c) Wetland construction and effects on mercury methylation

Comment: Additional details on the design and construction of the wetland treatment schemes must be provided to verify performance claims. These should include assessment of bottom substrate and plant species and their capability to survive under the conditions expected in the wetland. The potential for increased methylation of mercury in the wetlands, including those constructed for abandonment, must also be assessed.

Response: The wetland treatment systems design criteria provided in the Stage II Report (Volume IV Appendix 2.2.2-1) were aimed at achieving the specific treatment functions of a) nitrate removal from pit and waste rock drainage water at the mine site and b) copper removal at the tailings impoundments after closure. The rationale for the selected design criteria has been presented in the Stage II Report. A review of the design including impoundment geometry, hydraulics, planting substrate and vegetation is provided below. The wetland construction schedule is described in Section 1.4d) of the responses to the MOE.

Geometry and hydraulics

Treatment efficiency in the wetlands is optimized by maximizing the contact of the water with the plant/soil environment. In general terms, this applies to both nitrate and copper

Response: (cont'd)

removal. Thus it is important to ensure even flow distribution, avoid short circuiting and maintain low flow velocities. Flow distribution is achieved with a manifold inlet to distribute the incoming water throughout the width of the wetland channel, and with baffles that provide a channel length to width ratio of >10:1. The vegetation in the wetland also contributes to flow dispersal. Low flow velocity is achieved by constructing the wetland soil surface with a nearly flat slope. A completely flat bottom gradient is ideal but impractical to achieve; however, a slope of up to 2% can be tolerated. A slope of 0.5% at the Cinola minesite wetlands is realistic. Detailed designs of outlet/depth control structures are presently being evaluated by SRK and Norecol

Planting substrate

The Stage II Report, Appendix 2.2.2-1, Table 4, indicated that a sandy loam with a moderate organic content is ideal for planting wetland vegetation. However, mercury methylation studies have indicated that mineral soils (<20% organic matter) are preferred from the standpoint of minimizing potential for mercury methylation. In practice, wetland vegetation can be expected to grow on almost any substrate except perhaps a heavy clay or densely consolidated material. Dense stands of the rush <u>Juncus</u> sp. are already present on the existing pilot mill tailings pond at Cinola, having

Response: (cont'd)

colonized the site naturally. Soils from the proposed constructed wetlands area or the pit area will likely be used for wetland construction. Soils from the area of mudstone dump area are considered inappropriate based on the results of mercury methylation bioassays.

Availability of Wetland Vegetation

It was not known at the time of the Stage II Report submission, whether the preferred wetland plants (cattail _Typha_ sp. and bulrush _Scirpus_ sp.) are available near the the project area or on the Queen Charlotte Islands. Since that time, additional information on wetland plant species distribution on the Queen Charlotte Islands has been obtained from the botanical literature. The cattail, _Typha_ sp., does not appear to occur on the Charlottes (Calder and Taylor 1968); however the bulrush, _Scirpus lacustris_, does occur. Among the smaller species, several forms of rushes, _Juncus_ sp., sedges, _Carex_ sp., and cottongrass, _Eriophorum_ sp., as well as many other potentially useful species are available. Species selection will be finalized in Stage III following identification of potential donor sites and small scale testing.

The capability of the plants to survive under conditions expected in the wetland has been addressed in part in the Stage II report (Volume

Response: (cont'd)

IV, Appendix 2.2.2-1). During the Stage II Report review, elevated pH and sulphate concentrations were identified as potential concerns. These concerns are addressed in greater detail below.

Plant adaptability to alkalkine pH

Both acidic and alkaline pH conditions can be buffered in aquatic plant systems. Seidel (1976, cited in Appendix 2.2.2-1) report plant growth in waters with pH ranging from 11.6 to 4.3 units. Stephenson et al. (1980, also cited in the appendix) report growth of cattails, nutsedge and bulrush at pH above 9 units. Seidel (1976) reports that established wetlands can be exposed to strongly alkaline industrial wastewaters (pH 11.6-12.0) and be effective in reducing the effluent pH to circum-neutral levels.

Transplanting success and regrowth rate after transplanting will be greater in propagules that originate from a site in which the pH is similar to that of the new site. Thus, if pH at the new site during the regrowth period is expected to be around 6-8, transplants from practically any natural site should take successfully. Delaying plant exposure to elevated pH until after the wetland vegetation is established (at least one full growing season after transplanting) should be an adequate means of preventing pH shock.

Response: (cont'd)

Transplanting propagules from pH 6-8 environment to a pH 10-11 environment directly is not advisable.

The optimum pH for nitrification/dentrification, which is an important N removal pathway in the wetlands is around seven units. Note that pH entering the wetlands in the mine site is projected to be in the range of 6 to 8.5 units. Effluent from the lime treatment system will have a high buffering capacity, and the pH consequently is expected to remain in the circum-neutral range. For these reasons, pH is unlikely to pose a problem to the nitrogen removal processes in the mine site wetlands.

Plant adaptability to elevated sulphate concentrations

Plant response to elevated sulphate concentrations is addressed in detail in Section 1.4 of the responses to the MOE comments. The available information indicates that wetland vegetation can tolerate sulphate concentrations in excess of those anticipated in the treatment plant effluent at Cinola. Field tests during Stage III will confirm which of the locally available species are suitable.

Potential for increased methylation of mercury in the wetlands

The potential for stimulation of methylmercury production above natural levels by substrate

Response: (cont'd)

soils in the constructed wetlands was assessed following submission of the Stage II Report (Agassiz North Associates 1988; see Appendix I-5-1) and is discussed in detail in E C Sections I-5a and b and III-3a. In summary only soil from the area of the proposed mudstone dump site was found to produce measurable net methylation activity. However, the methylation balance for the soils from the area of the mudstone dump was just 60% of that in natural Barbie Wetland sediments. Soils with potential for stimulation of mercury will not be used in the construction of the wetlands. If necessary, the wetlands will also be harvested to reduce accumulation of organic matter.

Response by: Alan Whitehead, Norecol

References:

Calder, J.A. and R.L. Taylor, 1968. Flora of the Queen Charlotte Islands, Part 1: Systematics of the Vascular Plants. Monograph No.4 Part 1, Research Branch, Canada Department of Agriculture. Ottawa, Ontario, pp.69-82.

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

6. Impact Assessment

Topic: a) Effects of effluent discharge to Barbie Creek

Comment: Barbie Creek on occasion exhibits extremely low flows which results in minimal dilution being available for mine discharges. We are concerned that the concentrations of contaminants in Barbie Creek predicted by the proponent will not adequately provide for the protection of fish and fish habitat. Moreover, there are uncertainties in predicting contaminant loading and resulting impacts. Accordingly, we recommend the proponent assess alternative disposal locations and/or schemes for the proposed release of effluent from the water treatment plant. However, if the proponent wishes to pursue the discharge of the effluent to Barbie Creek then further investigations of the effects of the discharge would be required. These assessments would include a more detailed examination of the effects of a range of effluent constituents, effluent and receiving water variability and would consider all life history stages of salmonids (that is, spawning, incubation, rearing, smoltification, migratory behaviour).

Response: Since discharge to Barbie Creek is still planned, additional assessments of impacts on water quality have been made. However, before these assessments are presented, it is necessary to describe modifications to the basic water quality predictions for Coreshack and Barbie creeks (Stage II Report, Volume IV, Tables 2.2.2-6 and 3.6.2-2 and Stage II Addendum Tables 8.3-1 and 8.3-2).

The mine area water management plan has been modified (Appendix 1.1-1) as the result of

Response: (cont'd) additional acid-base accounting tests which suggest that some of the mudstone on the west pit wall will be acid generating (refer to EC Section I-3a and Appendix I-3-1). Consequently, runoff from the west pit wall will be processed in the water treatment plant. This change will result in greater volumes of effluent discharged from the treatment plant to Barbie Creek via Wetland MSW1 and reduced volumes of effluent discharged from Settling Pond MSSP4 to Coreshack Creek. In addition, since acid-generating mudstones will be transported to High West, the volume of the mudstone dump will be reduced, resulting in proportionately less runoff from the dump and more runoff from the area surrounding the dump being discharged via Wetland MSW2 to middle Barbie Creek. Contingency plans for dealing with greater than expected effluent volumes or poorer than expected effluent quality include use of effluent for freshwater makeup at the mill, storage of effluent in High West and/or discharge to other water bodies. The reader should refer to Appendix 1.1-1 for details of these plans.

The effects of the changes in effluent volumes have been modelled using the same spreadsheets that calculated the expected water quality presented in the Stage II Report and the Stage II Addendum. Except for the altered effluent volumes, basic assumptions remained the same as those described in the previous reports, but revised estimates of the clean flows in Barbie and Coreshack creeks (Appendix 1.5-2) were used

Response: (cont'd) in the calculations. The mean values representing background water quality were not changed fromthe previous reports, as the inclusion of (c nt'd) additional monitoring data caused only minor alterations to the calculated means. However, based on recent low level determinations of mercury in receiving waters (Appendix I-5-1), a background mercury concentration of 7.9 ng/L was used.

New water quality predictions are given in Tables I.6-1 to I.6-4. Table I.6-1 shows the expected water quality of middle Barbie Creek after mixing with effluent from Wetland MSW2. Table I.6-2 shows the expected effect of discharges from settling ponds MSSP1 (waste rock stockpile cover runoff) and MSSP4 (intercepted groundwater) on Coreshack Creek. Table I.6-3 shows the effect of discharging effluent from the water treatment plant plus the waste rock stockpile underdrain via Wetland MSW1 into the clean flow component of lower Barbie Creek. Table I.6-4 represents the cumulative effects of all these discharges on lower Barbie Creek.

Although the values presented in these tables have changed somewhat from predictions given in the Stage II Report and the Stage II Addendum, the basic conclusions remain unaltered. MOE criteria will not be exceeded in Barbie Creek for any parameter except iron and aluminum. Iron and aluminum concentrations, which under baseline conditions exceeded their respective criteria, will increase by less than 10%. Copper concentrations will remain well below criteria based on the predicted hardness. Mercury

TABLE I.6-1

Expected Water Quality of Middle Barbie Creek After Mixing with Discharge from Wetland MSW2, Predicted by Norecol for the Cinola Gold Project

PARAMETER	MUDSTONE RUNOFF CONCENTRATION	OVERBURDEN RUNOFF CONCENTRATION	AVERAGE BACKGROUND CONCENTRATION	CONCENTRATIONS IN BARBIE CREEK, YEAR 7											
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Barbie Creek Flow Rate (m3/s)				0.25	0.23	0.19	0.14	0.068	0.051	0.051	0.057	0.11	0.24	0.31	0.28
Overburden Stockpile Discharge Rate (m3/s)				0.0068	0.0067	0.0038	0.0045	0.0025	0.0024	0.0027	0.0021	0.0046	0.0076	0.0084	0.0065
Mudstone Dump Discharge Rate (m3/s)				0.014	0.014	0.0081	0.0094	0.0053	0.0051	0.0056	0.0045	0.010	0.016	0.018	0.014
Clean Runoff Discharge Rate (m3/s)				0.023	0.023	0.013	0.015	0.0084	0.0078	0.0086	0.0068	0.016	0.027	0.029	0.021
Wetland MSW2 Discharge Rate (m3/s)				0.045	0.044	0.025	0.029	0.016	0.015	0.017	0.013	0.030	0.050	0.055	0.041
Hardness (mg CaCO3/L)	74	1	12	15	15	14	15	16	16	17	16	16	15	15	14
Sulphate (mg/L)	42	2	3	5	5	4	5	5	6	6	5	6	5	5	5
Total Metals (mg/L):															
As	0.010	0.001	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003
Cu	0.006	0.0002	0.0009	0.0011	0.0011	0.0010	0.0011	0.0012	0.0012	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011
Fe	1.3	0.046	1.44	1.40	1.40	1.41	1.39	1.39	1.38	1.37	1.39	1.38	1.39	1.40	1.41
Hg (ug/L)	0.11	0.05	0.0079	0.014	0.014	0.012	0.015	0.016	0.017	0.018	0.016	0.016	0.015	0.014	0.013
Zn	0.030	0.0005	0.0040	0.0052	0.0053	0.0049	0.0054	0.0056	0.0059	0.0060	0.0056	0.0057	0.0054	0.0052	0.0051

continued...

TABLE I.6-1 (concluded)

Expected Water Quality of Middle Barbie Creek After Mixing with Discharge from Wetland MSW2, Predicted by Norecol for the Cinola Gold Project

PARAMETER	MUDSTONE RUNOFF CONCENTRATION	OVERBURDEN RUNOFF CONCENTRATION	AVERAGE BACKGROUND CONCENTRATION	CONCENTRATIONS IN BARBIE CREEK, YEAR 12											
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Barbie Creek Flow Rate (m3/s)				0.25	0.22	0.19	0.14	0.067	0.051	0.051	0.057	0.11	0.23	0.31	0.27
Overburden Stockpile Discharge Rate (m3/s)				0.0068	0.0067	0.0038	0.0045	0.0025	0.0024	0.0027	0.0021	0.0046	0.0076	0.0084	0.0065
Mudstone Dump Discharge Rate (m3/s)				0.014	0.014	0.0081	0.0094	0.0053	0.0051	0.0056	0.0045	0.010	0.016	0.018	0.014
Clean Runoff Discharge Rate (m3/s)				0.024	0.024	0.014	0.016	0.0086	0.0079	0.0087	0.0069	0.016	0.027	0.030	0.021
Wetland MSW2 Discharge Rate (m3/s)				0.045	0.044	0.025	0.029	0.016	0.015	0.017	0.014	0.030	0.051	0.056	0.041
Hardness (mg CaCO3/L)	74	1	12	15	15	14	15	16	16	17	16	16	15	15	14
Sulphate (mg/L)	42	2	3	5	5	4	5	5	6	6	5	6	5	5	5
Total Metals (mg/L):															
As	0.010	0.001	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003
Cu	0.006	0.0002	0.0009	0.0011	0.0011	0.0010	0.0011	0.0012	0.0012	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011
Fe	1.3	0.046	1.44	1.40	1.40	1.41	1.39	1.39	1.38	1.37	1.39	1.38	1.39	1.40	1.41
Hg (ug/L)	0.11	0.05	0.0079	0.014	0.014	0.012	0.015	0.016	0.017	0.018	0.016	0.016	0.015	0.014	0.013
Zn	0.030	0.0005	0.0040	0.0052	0.0053	0.0049	0.0054	0.0056	0.0059	0.0060	0.0056	0.0057	0.0054	0.0052	0.0051

TABLE I.6-2

Expected Water Quality of Coreshack Creek After Mixing with Runoff from the Waste Rock Stockpile Surface And Groundwater Intercepted at the Pit, Predicted by Norecol for the Cinola Gold Project

PARAMETER	MUDSTONE RUNOFF CONCENTRATION	INTERCEPTED GROUNDWATER CONCENTRATION	CORESHACK CREEK BACKGROUND CONCENTRATION	CONCENTRATIONS IN RECEIVING WATER, YEAR 7 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Coreshack Creek Flow Rate (m3/s)				0.043	0.038	0.032	0.023	0.011	0.0086	0.0086	0.0096	0.018	0.040	0.053	0.046
Clean Water a Discharge Rate (m3/s)				0.0061	0.0061	0.0034	0.0038	0.0020	0.0017	0.0019	0.0014	0.0037	0.0068	0.0076	0.0060
WRS Mudstone Cap Discharge Rate (m3/s)				0.020	0.019	0.011	0.013	0.0073	0.0069	0.0076	0.0061	0.013	0.022	0.024	0.019
Groundwater Discharge Rate (m3/s)				0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078
Hardness (mg CaCO3/L)	74	62	12	33	34	32	37	42	45	45	43	40	35	32	32
Sulphate (mg/L)	42	48	3	18	18	17	21	25	28	28	27	23	19	17	17
Total Metals (mg/L):															
As	0.010	0.008	0.003	0.005	0.006	0.005	0.006	0.006	0.007	0.007	0.006	0.006	0.006	0.005	0.005
Cu	0.006	0.0016	0.0009	0.0023	0.0023	0.0020	0.0024	0.0024	0.0025	0.0026	0.0024	0.0026	0.0024	0.0023	0.0021
Fe	1.3	0.6900	1.65	1.46	1.45	1.44	1.40	1.30	1.26	1.26	1.26	1.37	1.45	1.48	1.47
Hg (ug/L)	0.11	0.10	0.0079	0.043	0.046	0.042	0.050	0.059	0.065	0.066	0.062	0.056	0.047	0.042	0.041
Zn	0.030	0.060	0.0031	0.016	0.017	0.017	0.020	0.026	0.028	0.028	0.028	0.022	0.017	0.015	0.015

a Local inflow to settling ponds MSSP1 AND MSSP4 assumed to have Coreshack Creek background water quality

continued...

TABLE I.6-2 (concluded)

Expected Water Quality of Coreshack Creek After Mixing with Runoff from the Waste Rock Stockpile Surface
And Groundwater Intercepted at the Pit, Predicted by Norecol for the Cinola Gold Project

PARAMETER	MUDSTONE RUNOFF CONCENTRATION	INTERCEPTED GROUNDWATER CONCENTRATION	CORESHACK CREEK BACKGROUND CONCENTRATION	CONCENTRATIONS IN RECEIVING WATER, YEAR 12											
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Coreshack Creek Flow Rate (m3/s)				0.042	0.037	0.032	0.023	0.011	0.0084	0.0084	0.0094	0.018	0.039	0.052	0.045
Clean Water a Discharge Rate (m3/s)				0.0019	0.0019	0.0009	0.0010	0.0003	0.0001	0.0001	0.0000	0.0009	0.0020	0.0023	0.0019
WRS Mudstone Cap Discharge Rate (m3/s)				0.032	0.031	0.018	0.021	0.012	0.011	0.013	0.010	0.022	0.036	0.040	0.031
Groundwater Discharge Rate (m3/s)				0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Hardness (mg CaCO3/L)	74	62	12	42	44	40	46	51	54	54	52	50	44	41	40
Sulphate (mg/L)	42	48	3	24	25	24	28	32	35	35	34	30	26	23	23
Total Metals (mg/L):															
As	0.010	0.008	0.003	0.006	0.007	0.006	0.007	0.007	0.007	0.008	0.007	0.007	0.007	0.006	0.006
Cu	0.006	0.002	0.0009	0.0028	0.0029	0.0025	0.0029	0.0028	0.0029	0.0030	0.0027	0.0031	0.0030	0.0028	0.0027
Fe	1.30	0.69	1.65	1.37	1.36	1.34	1.29	1.17	1.13	1.14	1.14	1.26	1.36	1.39	1.38
Hg (ug/L)	0.11	0.10	0.0079	0.059	0.061	0.057	0.067	0.075	0.080	0.081	0.077	0.072	0.063	0.058	0.056
Zn	0.030	0.060	0.0031	0.022	0.023	0.023	0.027	0.033	0.036	0.036	0.035	0.029	0.023	0.021	0.021

a Local inflow to settling ponds MSSP1 AND MSSP4 assumed to have Coreshack Creek background water quality

TABLE I.6-3

Expected Water Quality of Barbie Creek Receiving Discharge From Wetland MSW1
Assuming that West Pit Wall Drainage is Processed in Water Treatment Plant

PARAMETER	WASTE ROCK UNDERDRAIN EFFLUENT CONCENTRATION	LIME TREATMENT EFFLUENT CONCENTRATION	BARBIE CREEK AVERAGE BACKGROUND CONCENTRATION	MOE RECEIVING WATER CRITERIA	CONCENTRATIONS IN RECEIVING WATERS, YEAR 7 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie at Branch 40A Flow Rate (m3/s)					0.44	0.39	0.33	0.24	0.12	0.088	0.088	0.098	0.19	0.40	0.54	0.47
Clean Water a Discharge Rate (m3/s)					0.00046	0.00046	0.00023	0.00023	0.00012	0.00000	0.00000	0.00000	0.00023	0.00046	0.00058	0.00046
Lime Treatment Discharge Rate (m3/s)					0.037	0.036	0.024	0.027	0.019	0.018	0.019	0.017	0.027	0.041	0.041	0.039
WRS Underdrain Discharge Rate (m3/s)					0.0075	0.0074	0.0051	0.0057	0.0041	0.0039	0.0042	0.0037	0.0058	0.0082	0.0089	0.0073
Dilutions					9.8	8.8	11.2	7.3	5.1	4.0	3.8	4.8	5.6	8.3	10.9	10.2
Hardness (mg CaCO3/L)	234	2050	12	-	172	189	153	220	292	352	368	307	271	199	156	168
Total Phosphorus (mg/L)	0.053	0.006	0.036	-	0.034	0.034	0.034	0.033	0.032	0.032	0.032	0.032	0.033	0.034	0.034	0.034
Total Metals (mg/L)																
Al (dissolved)	0.27	0.45	0.36	0.03	0.37	0.37	0.36	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.36	0.37
As	0.006	0.02	0.003	0.05	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.005	0.005	0.005	0.004	0.004
Cd	0.0003	0.0004	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
Cr	0.0004	0.003	0.0005	0.002	0.0007	0.0007	0.0007	0.0007	0.0008	0.0009	0.0009	0.0009	0.0008	0.0007	0.0007	0.0007
Cu	0.013	0.02	0.0009	0.002	0.0025	0.0027	0.0023	0.0030	0.0038	0.0044	0.0046	0.0039	0.0036	0.0028	0.0024	0.0025
Fe	0.098	3.00	1.65	0.30	1.73	1.74	1.72	1.75	1.79	1.82	1.82	1.79	1.78	1.75	1.72	1.73
Hg (ug/L)	0.05	0.20	0.0079	0.1	0.023	0.025	0.022	0.028	0.035	0.041	0.042	0.036	0.033	0.026	0.022	0.023
Mn	0.166	0.30	0.21	0.05	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.21
Pb	0.0011	0.002	0.0005	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	0.036	0.036	0.001	0.05	0.004	0.005	0.004	0.005	0.007	0.008	0.008	0.007	0.006	0.005	0.004	0.004
Zn	0.0178	0.03	0.0031	0.03	0.0054	0.0057	0.0052	0.0061	0.0072	0.0080	0.0083	0.0074	0.0069	0.0058	0.0052	0.0054

a Quality assumed to be same as Barbie Creek background

continued...

TABLE I.6-3 (concluded)

Expected Water Quality of Barbie Creek Receiving Discharge From Wetland MSW1
Assuming that West Pit Wall Drainage is Processed in Water Treatment Plant

PARAMETER	WASTE ROCK UNDERDRAIN EFFLUENT CONCENTRATION	LIME TREATMENT EFFLUENT CONCENTRATION	BARBIE CREEK AVERAGE BACKGROUND CONCENTRATION	MOE RECEIVING WATER CRITERIA	CONCENTRATIONS IN RECEIVING WATERS, YEAR 12											
					JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie at Branch 40A Flow Rate (m3/s)					0.43	0.38	0.32	0.23	0.11	0.087	0.087	0.096	0.18	0.40	0.53	0.47
Clean Water a Discharge Rate (m3/s)					0.00046	0.00046	0.00023	0.00023	0.00012	0.00000	0.00000	0.00000	0.00023	0.00046	0.00058	0.00046
Lime Treatment Discharge Rate (m3/s)					0.041	0.041	0.041	0.041	0.026	0.025	0.026	0.024	0.035	0.041	0.041	0.041
WRS Underdrain Discharge Rate (m3/s)					0.0076	0.0076	0.0052	0.0057	0.0041	0.0039	0.0042	0.0037	0.0058	0.0084	0.0090	0.0074
Dilutions					9.0	7.9	7.1	5.1	3.8	3.0	2.9	3.5	4.5	8.1	10.7	9.7
Hardness (mg CaCO3/L)	234	2050	12	-	188	208	238	311	382	462	475	411	336	201	157	176
Total Phosphorus (mg/L)	0.053	0.006	0.036	-	0.034	0.033	0.033	0.032	0.031	0.030	0.030	0.031	0.032	0.034	0.034	0.034
Total Metals (mg/L)																
Al (dissolved)	0.27	0.45	0.36	0.03	0.37	0.37	0.37	0.37	0.37	0.38	0.38	0.37	0.37	0.37	0.36	0.37
As	0.006	0.02	0.003	0.05	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.006	0.006	0.005	0.004	0.004
Cd	0.0003	0.0004	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
Cr	0.0004	0.003	0.0005	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cu	0.013	0.02	0.0009	0.002	0.0027	0.0029	0.0031	0.0039	0.0046	0.0054	0.0056	0.0049	0.0042	0.0028	0.0024	0.0025
Fe	0.098	3.00	1.65	0.30	1.74	1.75	1.78	1.82	1.85	1.89	1.90	1.87	1.82	1.75	1.72	1.74
Hg (ug/L)	0.05	0.20	0.0079	0.1	0.025	0.027	0.029	0.037	0.043	0.051	0.052	0.046	0.039	0.026	0.022	0.024
Mn	0.166	0.30	0.21	0.05	0.21	0.21	0.22	0.22	0.22	0.23	0.23	0.22	0.22	0.21	0.21	0.21
Pb	0.0011	0.002	0.0005	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	0.036	0.036	0.001	0.05	0.005	0.005	0.005	0.007	0.008	0.010	0.010	0.009	0.007	0.005	0.004	0.004
Zn	0.0178	0.03	0.0031	0.03	0.006	0.006	0.006	0.007	0.008	0.009	0.010	0.009	0.008	0.006	0.005	0.005

a Quality assumed to be same as Barbie Creek background

TABLE 1.6-4

Expected Water Quality of Barbie Creek after Mixing with All Minesite Discharges,
Assuming that West Pit Wall Drainage is Processed in the Water Treatment Plant,
Predicted by Norecol for the Cinola Gold Project

PARAMETER	BARBIE CREEK BACKGROUND CONCENTRATION	CONCENTRATION IN RECEIVING WATER, YEAR 7											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie Creek Flow Rate (m3/s)		0.39	0.35	0.30	0.21	0.10	0.079	0.079	0.088	0.17	0.36	0.49	0.42
Wetland MSW2 Discharge Rate (m3/s)		0.045	0.044	0.025	0.029	0.016	0.015	0.017	0.013	0.030	0.050	0.055	0.041
Coreshack Creek Discharge Rate (m3/s)		0.076	0.071	0.055	0.048	0.028	0.025	0.026	0.025	0.043	0.076	0.093	0.079
Wetland MSW1 Discharge Rate (m3/s)		0.044	0.044	0.029	0.033	0.023	0.022	0.023	0.020	0.033	0.049	0.049	0.046
Hardness (mg CaCO3/L)	12	154	167	141	191	249	283	292	256	226	174	140	153
Sulphate (mg/L)	3	126	137	114	158	208	238	245	214	188	143	114	125
Total Metals (mg/L):													
As	0.003	0.005	0.005	0.004	0.005	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005
Cu	0.0009	0.0026	0.0028	0.0024	0.0030	0.0037	0.0041	0.0042	0.0037	0.0035	0.0029	0.0025	0.0026
Fe	1.65	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.65	1.67
Hg (ug/L)	0.0079	0.029	0.031	0.027	0.034	0.042	0.048	0.049	0.044	0.040	0.032	0.028	0.028
Zn	0.0031	0.0076	0.0080	0.0073	0.0089	0.011	0.012	0.013	0.012	0.010	0.0081	0.0072	0.0073

continued...

TABLE I.6-4 (concluded)

Expected Water Quality of Barbie Creek after Mixing with All Minesite Discharges,
Assuming that West Pit Wall Drainage is Processed in the Water Treatment Plant,
Predicted by Norecol for the Cinola Gold Project

PARAMETER	BARBIE CREEK BACKGROUND CONCENTRATION	CONCENTRATION IN RECEIVING WATER, YEAR 12											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie Creek Flow Rate (m3/s)		0.39	0.34	0.29	0.21	0.10	0.078	0.078	0.087	0.17	0.36	0.48	0.42
Wetland MSW2 Discharge Rate (m3/s)		0.045	0.044	0.025	0.029	0.016	0.015	0.017	0.014	0.030	0.051	0.056	0.041
Coreshack Creek Discharge Rate (m3/s)		0.090	0.085	0.065	0.059	0.038	0.034	0.035	0.034	0.055	0.091	0.11	0.092
Wetland MSW1 Discharge Rate (m3/s)		0.048	0.048	0.046	0.046	0.023	0.029	0.030	0.028	0.041	0.049	0.049	0.048
Hardness (mg CaCO3/L)	12	165	180	212	262	252	354	360	327	271	172	140	158
Sulphate (mg/L)	3	135	148	177	219	210	300	305	276	227	141	113	129
Total Metals (mg/L):													
As	0.003	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.006	0.005	0.005	0.005
Cu	0.0009	0.0028	0.0030	0.0031	0.0038	0.0037	0.0048	0.0049	0.0045	0.0040	0.0029	0.0026	0.0027
Fe	1.65	1.65	1.65	1.69	1.68	1.63	1.67	1.67	1.67	1.66	1.64	1.63	1.65
Hg (ug/L)	0.0079	0.033	0.035	0.036	0.044	0.048	0.059	0.061	0.055	0.048	0.035	0.031	0.032
Zn	0.0031	0.0089	0.0094	0.0094	0.0113	0.014	0.016	0.016	0.015	0.012	0.0094	0.0083	0.0085

Response: (cont'd) concentrations will not approach the 0.1 ug/L criterion even during summer low flows.

During 1:10 year 7-day low flow conditions there will be no impact on Barbie Creek because all runoff from the pit, and if necessary from the waste rock stockpile, will be collected and stored in MSSP3. This water will not be processed and discharged until stream flows increase (Appendix 1.1-1).

In addition to the basic predictions just described, several other scenarios have been considered. These cases include increased quantities of treated water, higher background concentrations of metals and other parameters, and poorer effluent quality.

The water management plan (Appendix 1.1-1) takes into account the need to process, discharge and/or store higher than normal volumes of water which arise from above average precipitation. The effect of the higher discharge rate necessitated by above average October precipitation in year 7 has been modelled and is presented in Table I.6-5. Receiving water concentrations reached under this scenario are not as high as those predicted during year 12 under average precipitation conditions. Above average precipitation in October of year 12 would not affect receiving water quality, as all excess treatment plant effluent would transported to Impoundment No. 3 rather than discharged.

TABLE I.6-5

Effect of Contingency Plans for a Wet October on Expected Water Quality of Barbie Creek, Predicted by Norecol for the Cinola Gold Project

PARAMETER	BARBIE CREEK BACKGROUND CONCENTRATION	CONCENTRATION IN RECEIVING WATER, YEAR 7											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie Creek Flow Rate (m3/s)		0.39	0.35	0.30	0.21	0.10	0.079	0.079	0.088	0.17	0.36	0.49	0.42
Wetland MSW2 Discharge Rate (m3/s)		0.045	0.044	0.025	0.029	0.016	0.015	0.017	0.013	0.030	0.050	0.055	0.041
Coreshack Creek Discharge Rate (m3/s)		0.076	0.071	0.055	0.048	0.028	0.025	0.026	0.025	0.043	0.076	0.093	0.079
Wetland MSW1 Discharge Rate (m3/s)		0.048	0.048	0.044	0.033	0.023	0.022	0.023	0.020	0.033	0.049	0.049	0.048
Hardness (mg CaCO3/L)	12	166	182	208	191	249	283	292	256	226	174	140	158
Sulphate (mg/L)	3	136	150	173	158	208	238	245	214	188	143	114	129
Total Metals (mg/L):													
As	0.003	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005
Cu	0.0009	0.0027	0.0029	0.0030	0.0030	0.0037	0.0041	0.0042	0.0037	0.0035	0.0029	0.0025	0.0026
Fe	1.65	1.67	1.67	1.70	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.65	1.67
Hg (ug/L)	0.0079	0.030	0.032	0.033	0.034	0.042	0.048	0.049	0.044	0.040	0.032	0.028	0.029
Zn	0.0031	0.0077	0.0081	0.0081	0.0089	0.011	0.012	0.013	0.012	0.010	0.0081	0.0072	0.0074

Response: (cont'd) Higher treatment plant effluent volumes could also arise if it became necessary to treat water from the waste rock stockpile underdrain. Various contingencies to address this scenario are presented in the response to EC comment III-1a including storage in High West and treatment of the stockpile drainage. The effects on receiving water quality of treating all mine area discharge including the stockpile drainage have been calculated. For these calculations, the monthly discharge rates for treated water have been increased to the values shown in Appendix 1.1-1, and flows from the waste rock stockpile underdrain have been decreased to zero. The resulting predictions (Tables I.6-6) do not differ substantially from predictions given in Tables I.6-3 and I.6-4.

To assess the effect of background variability in a range of effluent constituents, the predicted receiving water quality presented in Table I.6-3 was recalculated using background concentrations equal to the baseline mean plus two standard deviations. Monitoring data collected through August 1988 were used for these calculations. The mercury concentration was set at twice the measured level or 15.8 ng/L.

The results of this assessment (Table I.6-7) are not substantially different from the values given in Table I.6-3. The higher background concentrations of aluminum, iron, and phosphorus are much higher than both the mean levels and the

TABLE I.6-6

Expected Year 7 Water Quality of Barbie Creek after Mixing with All Minesite Discharges,
Assuming Treatment of all Minesite Discharges, Predicted by Norecol for the Cinola Gold Project

PARAMETER	BARBIE CREEK BACKGROUND CONCENTRATION	CONCENTRATION IN RECEIVING WATER, YEAR 7 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie Creek Flow Rate (m3/s)		0.39	0.35	0.30	0.21	0.10	0.079	0.079	0.088	0.17	0.36	0.49	0.42
Wetland MSW2 Discharge Rate (m3/s)		0.045	0.044	0.025	0.029	0.016	0.015	0.017	0.013	0.030	0.050	0.055	0.041
Coreshack Creek Discharge Rate (m3/s)		0.076	0.071	0.055	0.048	0.028	0.025	0.026	0.025	0.043	0.076	0.093	0.079
Wetland MSW1 Discharge Rate (m3/s)		0.041	0.041	0.041	0.041	0.023	0.022	0.023	0.020	0.033	0.041	0.041	0.041
Hardness (mg CaCO3/L)	12	165	181	214	267	293	334	344	302	266	173	139	157
Sulphate (mg/L)	3	136	150	179	225	248	283	292	256	224	143	113	129
Total Metals (mg/L):													
As	0.003	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.006	0.006	0.005	0.005	0.005
Cu	0.0009	0.0026	0.0027	0.0030	0.0036	0.0038	0.0043	0.0044	0.0039	0.0036	0.0027	0.0023	0.0025
Fe	1.65	1.69	1.69	1.73	1.74	1.73	1.74	1.74	1.73	1.72	1.68	1.67	1.69
Hg (ug/L)	0.0079	0.030	0.032	0.033	0.041	0.046	0.052	0.053	0.047	0.043	0.032	0.027	0.029
Zn	0.0031	0.0076	0.008	0.0081	0.010	0.011	0.013	0.013	0.012	0.010	0.008	0.0071	0.0073

continued...

TABLE I.6-6 (concluded)

Expected Year 12 Water Quality of Barbie Creek after Mixing with All Minesite Discharges,
Assuming Treatment of all Minesite Discharges, Predicted by Norecol for the Cinola Gold Project

PARAMETER	BARBIE CREEK BACKGROUND CONCENTRATION	CONCENTRATION IN RECEIVING WATER, YEAR 12 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie Creek Flow Rate (m3/s)		0.39	0.34	0.29	0.21	0.10	0.078	0.078	0.087	0.17	0.36	0.48	0.42
Wetland MSW2 Discharge Rate (m3/s)		0.045	0.044	0.025	0.029	0.016	0.015	0.017	0.014	0.030	0.051	0.056	0.041
Coreshack Creek Discharge Rate (m3/s)		0.090	0.085	0.065	0.059	0.038	0.034	0.035	0.034	0.055	0.091	0.11	0.092
Wetland MSW1 Discharge Rate (m3/s)		0.041	0.041	0.041	0.041	0.023	0.029	0.030	0.028	0.041	0.041	0.041	0.041
Hardness (mg CaCO3/L)	12	164	180	212	262	283	400	407	368	304	172	139	157
Sulphate (mg/L)	3	135	148	177	221	239	341	347	313	257	141	113	129
Total Metals (mg/L):													
As	0.003	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.006	0.005	0.005	0.005
Cu	0.0009	0.0027	0.0028	0.0030	0.0036	0.0039	0.0050	0.0051	0.0046	0.0041	0.0028	0.0024	0.0026
Fe	1.65	1.67	1.67	1.71	1.71	1.68	1.74	1.74	1.73	1.72	1.66	1.65	1.67
Hg (ug/L)	0.0079	0.033	0.035	0.036	0.044	0.050	0.063	0.065	0.058	0.051	0.035	0.030	0.031
Zn	0.0031	0.0087	0.009	0.0093	0.011	0.014	0.016	0.016	0.015	0.013	0.009	0.0082	0.0084

TABLE I.6-7

WATER QUALITY OF BARBIE CREEK ASSUMING BACKGROUND WATER QUALITY EQUAL TO MEAN PLUS TWO STANDARD DEVIATIONS (a) PREDICTED BY NORECOL FOR THE CINOLA GOLD PROJECT

PARAMETER	WASTE ROCK UNDERDRAIN EFFLUENT CONCENTRATION	LIME TREATMENT EFFLUENT CONCENTRATION	BARBIE CREEK BACKGROUND CONCENTRATION	MOE RECEIVING WATER CRITERIA	CONCENTRATIONS IN RECEIVING WATERS, YEAR 7: JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie at Branch 40A																
Flow Rate (m3/s)					0.44	0.39	0.33	0.24	0.12	0.088	0.088	0.10	0.19	0.40	0.54	0.47
Clean Water b																
Discharge Rate (m3/s)					0.00046	0.00046	0.00023	0.00023	0.00012	0.00000	0.00000	0.00000	0.00023	0.00046	0.00058	0.00046
Lime Treatment																
Discharge Rate (m3/s)					0.037	0.036	0.024	0.027	0.019	0.018	0.019	0.017	0.027	0.041	0.041	0.039
WRS Underdrain																
Discharge Rate (m3/s)					0.0075	0.0074	0.0051	0.0057	0.0041	0.0039	0.0042	0.0037	0.0058	0.0082	0.0089	0.0073
Dilutions					9.8	8.8	11.2	7.3	5.1	4.0	3.8	4.8	5.6	8.3	10.9	10.2
Hardness (mg CaCO3/L)	234	2050	19	-	178	195	160	226	297	357	373	313	277	205	162	175
Total Phosphorus (mg P/L)	0.053	0.006	0.078	-	0.072	0.071	0.073	0.070	0.068	0.065	0.065	0.067	0.068	0.071	0.073	0.072
Total Metals (mg/L)																
Al (dissolved)	0.27	0.45	0.57	0.03	0.56	0.55	0.56	0.55	0.55	0.54	0.54	0.54	0.55	0.55	0.56	0.56
As	0.006	0.02	0.012	0.05	0.013	0.013	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.012	0.013
Cd	0.0003	0.0004	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
Cr	0.0004	0.003	0.0005	0.002	0.0007	0.0007	0.0007	0.0007	0.0008	0.0009	0.0009	0.0009	0.0008	0.0007	0.0007	0.0007
Cu	0.013	0.02	0.0015	0.002	0.0031	0.0033	0.0029	0.0036	0.0043	0.0049	0.0051	0.0045	0.0041	0.0034	0.0029	0.0031
Fe	0.098	3.00	5.16	0.30	4.91	4.89	4.94	4.84	4.72	4.63	4.60	4.70	4.76	4.87	4.93	4.93
Hg (ug/L)	0.05	0.20	0.0158	0.1	0.030	0.032	0.029	0.035	0.041	0.047	0.048	0.043	0.040	0.033	0.029	0.030
Mn	0.166	0.30	0.56	0.05	0.53	0.53	0.54	0.53	0.51	0.50	0.50	0.51	0.52	0.53	0.54	0.53
Pb	0.0011	0.002	0.0005	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	0.036	0.036	0.001	0.05	0.004	0.005	0.004	0.005	0.007	0.008	0.008	0.007	0.006	0.005	0.004	0.004
Zn	0.0178	0.03	0.0060	0.03	0.0080	0.0082	0.0078	0.0086	0.0096	0.0103	0.0105	0.0098	0.0093	0.0084	0.0078	0.0080

a Based on monitoring data throughout August 1988

b Quality assumed to be the same as Barbie Creek background

continued...

EC-102

TABLE I.6-7 (concluded)

WATER QUALITY OF BARBIE CREEK ASSUMING BACKGROUND WATER QUALITY EQUAL TO MEAN PLUS TWO STANDARD DEVIATIONS (a) PREDICTED BY NORECOL FOR THE CINOLA GOLD PROJECT

PARAMETER	WASTE ROCK UNDERDRAIN EFFLUENT CONCENTRATION	LIME TREATMENT EFFLUENT CONCENTRATION	BARBIE CREEK BACKGROUND CONCENTRATION	MOE RECEIVING WATER CRITERIA	CONCENTRATIONS IN RECEIVING WATERS, YEAR 12											
					JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lower Barbie at Branch 40A Flow Rate (m3/s)					0.43	0.38	0.32	0.23	0.11	0.087	0.087	0.10	0.18	0.40	0.53	0.47
Clean Water b Discharge Rate (m3/s)					0.00046	0.00046	0.00023	0.00023	0.00012	0.00000	0.00000	0.00000	0.00023	0.00046	0.00058	0.00046
Lime Treatment Discharge Rate (m3/s)					0.041	0.041	0.041	0.041	0.026	0.025	0.026	0.024	0.035	0.041	0.041	0.041
WRS Underdrain Discharge Rate (m3/s)					0.0076	0.0076	0.0052	0.0057	0.0041	0.0039	0.0042	0.0037	0.0058	0.0084	0.0090	0.0074
Dilutions					9.0	7.9	7.1	5.1	3.8	3.0	2.9	3.5	4.5	8.1	10.7	9.7
Hardness (mg CaCO3/L)	234	2050	19	-	194	215	244	317	388	467	481	416	342	207	164	182
Total Phosphorus (mg P/L)	0.053	0.006	0.078	-	0.072	0.071	0.070	0.067	0.064	0.062	0.061	0.063	0.066	0.071	0.073	0.072
Total Metals (mg/L)																
Al (dissolved)	0.27	0.45	0.57	0.03	0.56	0.55	0.55	0.55	0.54	0.53	0.53	0.54	0.54	0.55	0.56	0.56
As	0.006	0.02	0.012	0.05	0.013	0.013	0.013	0.013	0.013	0.014	0.014	0.013	0.013	0.013	0.012	0.013
Cd	0.0003	0.0004	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
Cr	0.0004	0.003	0.0005	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cu	0.013	0.02	0.0015	0.002	0.0032	0.0035	0.0037	0.0044	0.0051	0.0059	0.0060	0.0054	0.0047	0.0034	0.0030	0.0031
Fe	0.098	3.00	5.16	0.30	4.90	4.87	4.85	4.74	4.63	4.52	4.50	4.59	4.69	4.87	4.93	4.92
Hg (ug/L)	0.05	0.20	0.0158	0.1	0.032	0.034	0.036	0.043	0.050	0.057	0.058	0.052	0.045	0.033	0.029	0.031
Mn	0.166	0.30	0.56	0.05	0.53	0.53	0.53	0.51	0.50	0.49	0.49	0.50	0.51	0.53	0.54	0.53
Pb	0.0011	0.002	0.0005	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	0.036	0.036	0.001	0.05	0.005	0.005	0.005	0.007	0.008	0.010	0.010	0.009	0.007	0.005	0.004	0.004
Zn	0.0178	0.03	0.0060	0.03	0.008	0.008	0.009	0.010	0.011	0.012	0.012	0.011	0.010	0.008	0.008	0.008

a Based on monitoring data throughout August 1988
b Quality assumed to be the same as Barbie Creek background

Response: (cont'd) effluent concentrations; thus, with respect to these parameters Barbie Creek is actually diluted by the discharge. Predicted levels of copper and mercury are still well below receiving water criteria.

The water treatment plant and the effluent monitoring pond are designed so that poor quality effluent, arising from an upset in the plant,will not be discharged. This water will be pumped to MSSP3 for retreatment. The equalization pond and wetlands can also be used to intercept any poor quality effluent for retreatment prior to discharge. Therefore it is not expected that poor quality water will be discharged to Barbie Creek. Contingency options for discharge in the event of poorer than expected effluent quality as a normal condition are discussed in Appendix 1.1-1.

Discharges from the water treatment plant to Barbie Creek will have no impact on the Yakoun River. For example, all of the effluent produced (including treatment of the waste rock stockpile runoff) in a year with higher than normal precipitation could be assimilated by the Yakoun River, even if the effluent were of poorer-than-expected quality.

The impact of discharges from the water treatment plant on downstream water quality in the Yakoun River has been assessed using calculations similar to those used for Barbie Creek (as

Response: (cont'd) presented in Tables I.6-3 and I.6-7). Flows in the Yakoun River at Sid Creek and water quality of the Yakoun River at Site Q10 were substituted for the Barbie Creek flows and water quality. The measured mercury level in Florence Creek was used to represent background, since no low level mercury determinations have been done on Yakoun River water. The expected effluent quality was taken from data supplied by Environment Canada for operating water treatment plants.

Table I.6-8 shows that the water quality of the Yakoun River is unaffected. Concentrations of aluminum and iron, the two metals which currently exceed receiving water criteria, will not change measurably. All other parameters will meet receiving water criteria, and any alterations in water quality will be difficult to distinguish from background variability.

Effects of predicted water quality changes on salmonids are discussed in the response to MOE comment 1.4a.

Response by: Annette Smith, Norecol

Reference:

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Report. Volume IV. Environmental Impact Assessment and Management Programs. pp. 3-90 to 3-93.

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Addendum Report. pp. 7-16 and 8-13.

TABLE I.6-8

Expected Downstream Water Quality in the Yakoun River Assuming Worst Case Water Treatment Plant Discharge to Barbie Creek, Predicted by Norecol for the Cinola Gold Project a

PARAMETER	LIME TREATMENT EFFLUENT CONCENTRATION	YAKOUN RIVER BACKGROUND CONCENTRATION	MOE RECEIVING WATER CRITERIA	CONCENTRATIONS IN RECEIVING WATER, YEAR 7											
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Yakoun River at Sid Creek Flow Rate (m3/s)				36.2	35.9	24.8	23.5	15.1	10.6	6.2	6.1	16.2	42.6	44.6	38.1
Lime Treatment Discharge Rate (m3/s)				0.041	0.041	0.041	0.041	0.041	0.041	0.029	0.020	0.033	0.041	0.041	0.041
Dilutions				895	886	612	580	373	261	216	297	485	1051	1100	942
Hardness (mg CaCO3/L)	1500	13	-	15	15	15	16	17	19	20	18	16	14	14	15
Sulphate (mg/L)	1500	1.0	-	3	3	3	4	5	7	8	6	4	2	2	3
Total Metals (mg/L):															
Al (dissolved)	0.2	0.10	0.05	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
As	0.02	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cd	0.0025	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Co	0.1	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001
Cr	0.01	0.0005	0.002	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Cu	0.05	0.0006	0.002	0.0007	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0007	0.0006	0.0006	0.0007
Fe	0.25	0.31	0.3	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Hg (ug/L)	0.2	0.0037	0.1	0.0039	0.0039	0.0040	0.0040	0.0042	0.0044	0.0046	0.0044	0.0041	0.0039	0.0039	0.0039
Mn	0.1	0.03	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Ni	0.02	0.001	0.025	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Pb	0.01	0.0005	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zn	0.01	0.0012	0.03	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012

a Poorer than expected effluent quality, treatment of waste rock stockpile runoff, above average October precipitation, all processed water discharged to Barbie Creek

continued...

TABLE I.6-8 (concluded)

Expected Downstream Water Quality in the Yakoun River Assuming Worst Case Water Treatment Plant Discharge to Barbie Creek, Predicted by Norecol for the Cinola Gold Project a

PARAMETER	LIME TREATMENT EFFLUENT CONCENTRATION	YAKOUN RIVER BACKGROUND CONCENTRATION	MOE RECEIVING WATER CRITERIA	CONCENTRATIONS IN RECEIVING WATER, YEAR 12											
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Yakoun River at Sid Creek Flow Rate (m3/s)				36.2	35.9	24.8	23.5	15.1	10.6	6.2	6.1	16.2	42.6	44.6	38.1
Lime Treatment Discharge Rate (m3/s)				0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
Dilutions				895	886	612	580	373	261	153	150	399	1051	1100	942
Hardness (mg CaCO3/L)	1500	13	-	15	15	15	16	17	19	23	23	17	14	14	15
Sulphate (mg/L)	1500	1.0	-	3	3	3	4	5	7	11	11	5	2	2	3
Total Metals (mg/L):															
Al (dissolved)	0.2	0.10	0.05	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
As	0.02	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cd	0.0025	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Co	0.1	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001
Cr	0.01	0.0005	0.002	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005
Cu	0.05	0.0006	0.002	0.0007	0.0007	0.0007	0.0007	0.0007	0.0008	0.0009	0.0009	0.0007	0.0006	0.0006	0.0007
Fe	0.25	0.31	0.3	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Hg (ug/L)	0.2	0.0037	0.1	0.0039	0.0039	0.0040	0.0040	0.0042	0.0044	0.0050	0.0050	0.0042	0.0039	0.0039	0.0039
Mn	0.1	0.03	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Ni	0.02	0.001	0.025	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Pb	0.01	0.0005	0.003	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zn	0.01	0.0012	0.03	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0013	0.0013	0.0012	0.0012	0.0012	0.0012

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

6. Impact Assessment

Topic: b) Water Quality Impacts on Florence Creek

Comment: In general, the water quality impacts on Florence Creek are not expected to be significant (with the possible exception of mercury) provided all of the assumptions and predictions as outlined in the Stage II are correct. A revised impact assessment would be required however, if those assumptions and predictions are modified as a result of further studies identified elsewhere in this letter (e.g. if loading of cyanide and copper to the environment were increased as discussed in 4(c).

Response: The assumptions concerning copper and cyanide loadings have not changed since submission of the Stage II Report (refer to MOE Section 1.6c). However, the assumption of constant water quality in the reclaimed impoundments from month to month has been revised to examine the effect of seepage buildup in the impoundment during summer months when there is no surface discharge. In addition average Florence Creek background mercury concentration has been revised from half detection (25 mg/L) used in Stage II to 3.7 mg/L based on recent low level mercury measurements (Appendix I-5-1). New predictions based on variable water quality from the reclaimed impoundments and revised values for background mercury levels are given in the response to MOE comment 1.4c.

Response by: Annette Smith, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

7. Hydrology/Physical Impacts

Topic: a) Flow reduction and gravel recruitment in Florence Creek

Comment: There are a number of surface water flow related activities which could adversely affect fish populations. The most significant of these is the proposal to fill the freshwater reservoir in a single season as this could significantly reduce flows in Florence Creek at the falls (5R Figure 5.8.5-1, Volume III). Methods to mitigate potential impacts of this flow reduction must be developed. In order to assess the impacts of reservoir filling and to develop necessary mitigation, as a minimum, areas of critical fish passage will have to be identified.

Response: The Stage II Report suggested that mean monthly streamflows in Florence Creek could be reduced by 30% when the reservoir is being filled. These reductions would be limited to a period when flows are normally high (October through March) and would be monitored to ensure minimum flows are maintained in Florence Creek. The report also stated that guidelines for determining minimum flow requirements in the creek would be completed during Stage III.

Since submission of the Stage II Report, project engineers have further refined the water balance associated with the High West area and have revised the sequence of reservoir filling with the specific intent of eliminating potential effects on fish resources. On December 1, 1988 representatives of Norecol and SRK met with representatives of EC and MOE to discuss the

Response: (cont'd)

revised plans for filling the reservoir and the consequences to fish habitats downstream.

This revised plan extends the period for filling the reservoir during high flow periods over two years. The result would be a maximum flow reduction of 18% in Florence Creek near the Branch 4 road crossing, during the filling period compared to a 30% reduction over one winter as predicted in the previous plans.

During normal periods of low flow (May through September), the procedures for augmenting flows in the creek by diverting flow from the reservoir would be implemented, if necessary, as described in the Stage II submission.

As long as flows are reduced by less than 18% during periods of normally high flow, we do not anticipate any effects on the fish migration or spawning, including any effects associated with possible dewatering of side channels and exposure of instream barriers in the channel.

If reservoir filling coincides with an abnormally dry fall and winter (less than a 10% probability), it will be feasible to minimize flows to the reservoir and extend the overall reservoir filling period for up to three or four years so as to maintain minimum flow requirements in Florence Creek at all times. If this is necessary, a further contingency can be implemented to reduce freshwater make-up requirements by recycling make-up water from the mine area water treatment plant.

Response: (cont'd) As indicated in the Stage II submission, an assessment of minimum flow requirements will be completed in consultation with DFO during the Stage III process.

Comment: (cont'd) There is also a concern that development of the impoundment on the headwaters of Florence Creek could affect gravel recruitment in downstream salmon spawning areas. Although the company referenced this in the Stage II Report, further assessment is required.

Response: With respect to effects on gravel recruitment, the Stage II Report referred to field observations and analysis of aerial photographs, which indicated that the most active input of granular material to Florence Creek appears to occur downstream of the proposed impoundment. Therefore, no impacts on gravel spawning areas downstream are expected during any phase of the project or following mine closure.

To evaluate further the above mentioned concern, Norecol retained the services of a fluvial geomorphologist, D.L. Hogan & Associates Ltd., to examine air photographs of the Florence Creek watershed and evaluate the degree of concern associated with possible reductions in gravel recruitment to fish spawning reaches downstream of the impoundments. As indicated in the Stage II document, salmon and trout spawning habitats begin approximately 1.5 km below the lower impoundment (Impoundment 3), and extend

Response: (cont'd) downstream approximately 1 to 2 km below the Branch 4 road crossing.

The air photo analysis by Mr. Hogan is provided in Appendix I-7-1, and indicates that approximately 20% of the watershed will be segregated from the downstream area by construction of the High West impoundments. Potential changes downstream of the impoundments include downcutting of the channel and some coarsening of bed materials.

Based on the air photo analysis several factors were identified that are expected to limit the effect of the impoundments on sediment supply to downstream reaches of Florence Creek. These factors include the following:

- Despite the observation of some gravel bars and channel widening in the upper watershed channels, these channels generally appear to be sediment supply limited and may not contribute significant quantities of sediment to the downstream mainstem areas.

  For example, the headwater channels are probably similar to the upper channels in Florence Tributary (described in the Stage II report), characterized by very stable channel features, such as moss-covered riffles anchored by debris and cobbles, as well as very cohesive banks.

Response: (cont'd)

- Significant sources of sediment exist downstream of the impoundments, including gullies visible in the canyon area below the lower impoundment and extending downstream to the salmon and trout spawning reaches. These sources may be more significant to downstream sediment supply than the apparently more stable upstream areas.

- The canyon area immediately below the impoundments and upstream of the important fish habitats will probably act to limit the extent of channel changes downstream as a result of the bedrock controlling features. For example, they will act to limit the degree of channel downcutting and to facilitate sediment transport through the canyon to downstream areas.

- Fish spawning reaches commence at least 1.5 km below the impoundments and based on the factors outlined above, may not be significantly affected.

Given the complexity of factors that affect sediment supply and transport in the system, the conclusions of the preliminary evaluation based on air photos will have to be verified by field surveys. These surveys will include a more detailed examination of the Florence Creek mainstem extending from several kilometers downstream of the impoundments to the headwater areas. In addition, a monitoring program will

Response: (cont'd) will also be established to provide a means of assessing changes in gravel quality within the spawning reach downstream of the canyon areas. Details of this program would be established during the Stage III process.

Response by: Morris Zallen/Stan Woods, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

8. Fish Habitat Compensation/Mitigation

Topic: a) Compensation Proposal for Ferguson Bay

Comment: Compensation for fish habitat loss resulting from filling at the proposed dock facility is to be developed at Stage III. Consultations with DFO and resolution of necessary mitigation and/or compensation are required prior to approval-in- principle. As part of these consultations, the proponent must provide rationale for selection of the Ferguson Bay site and details of impacts on fish and fish habitat, and the compensation proposal.

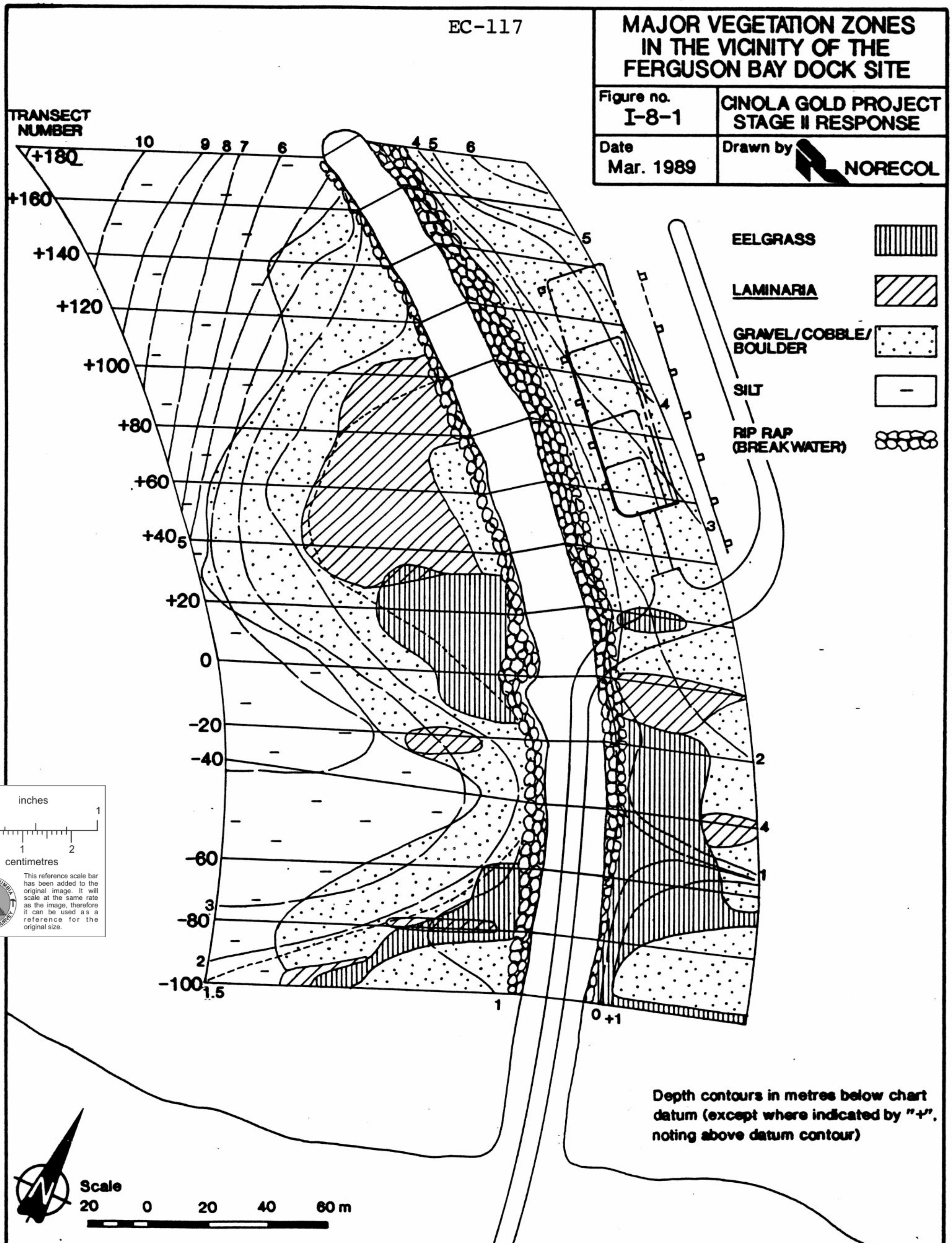
Response: Norecol began consultation with DFO (Mr. G. Caw) regarding proposed mitigation and compensation proposals for the Ferguson Bay dock site, and has provided DFO with (1) a summary of results from a field survey of Ferguson Bay completed in October 1988, and (2) a report summarizing factors that led to the decision to locate the dock facility in Ferguson Bay (Appendix I-8-1).

The field trip report summarized more detailed investigations of fish habitat characteristics in the vicinity of the proposed dock site, based on systematic SCUBA dive transects, and included a map of habitat zones near the existing breakwater in the bay and selected photographs depicting conditions in each of these zones. In particular, eelgrass beds and other habitats both inside and outside of the existing breakwater were mapped and described.

Response: (cont'd) The report summarizing the evaluation of alternative dock site locations presented information on five potential areas on Graham Island that were considered as potential dock sites. The evaluation process incorporated information on economic, logistic and general environmental factors that led to the selection of the Ferguson Bay location.

Since the above documents were submitted to DFO, the specific location of the proposed dock site was moved from inside the breakwater to a location on the outside of the breakwater. This relocation was necessitated because of a recent decision by MacMillan Bloedel, the operators of the log dump in Ferguson Bay, not to permit barge docking within the area that they presently use for log handling. Figure I-8-1 indicates the new location of the proposed dock in relation to the habitat information collected from previous site surveys.

The new design has not been finalized, and therefore the specific location along the breakwater and the configuration of the structure are still subject to minor changes. The new design will include a causeway to allow trucks to safely back-up to the dock ramp, as well as a breakwater to protect the immediate area of barge mooring. The configuration shown in Figure I-8-1 indicates that the barge mooring area extends over bottom areas that probably


EC-117
MAJOR VEGETATION ZONES IN THE VICINITY OF THE FERGUSON BAY DOCK SITE
Figure no. I-8-1
CINOLA GOLD PROJECT STAGE II RESPONSE
Date Mar. 1989
Drawn by NORECOL
TRANSECT NUMBER
EELGRASS
LAMINARIA
GRAVEL/COBBLE/BOULDER
SILT
RIP RAP (BREAKWATER)
Depth contours in metres below chart datum (except where indicated by "+", noting above datum contour)
Scale 20 0 20 40 60 m
inches 0 1
centimetres 0 1 2
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

Response: (cont'd)

possess epibenthic and infaunal organisms, but are generally devoid of macroscopic benthic vegetation, considered to be the most important areas for fish rearing. In addition, the area where the proposed breakwater occurs extends over bottom depths greater than 3 m below the 0 m tide level (Chart Datum), and therefore will cover bottom that is also probably devoid of macroscopic vegetation, although these areas were not examined in previous habitat surveys. The proposed causeway extension, as presently designed, will cover a small area of eelgrass (Zostera).

Given the new location and configuration of the proposed dock site, some additional studies will be required to confirm the potential effects of this structure on fish habitats in the area. The following approach will be taken in re-assessing these new plans:

- The mapped area of benthic habitats on the outside of the breakwater will have to be extended to incorporate the area of the proposed breakwater;

- Physical oceanographic conditions at the site will have to be assessed to determine whether alteration of shoreline processes will affect the existing eelgrass bed located shoreward of the proposed structure.

Response: (cont'd)

- The dock site design will then be finalized to minimize or eliminate any of the above mentioned direct or indirect losses of bottom habitats that are important fish habitats, including areas that possess kelp or eelgrass.

- Finally, an assessment will be made summarizing the effects of the new dock site location and configuration on benthic habitat areas, including specific plans for compensation of any losses of eelgrass or other important benthic habitats. Compensation plans will be made in accordance with current DFO policy for "no net loss" of important fish producing habitats.

It is anticipated that all of the above study requirements and details of habitat compensation, if necessary, will be completed during the Stage III process, and incorporated in the final dock design. In summary, the new dock location will have a minimal effect on existing intertidal habitats. Appropriate compensation plans will be developed in on going consultation with DFO and there are ample opportunities for developing compensation habitat in the immediate vicinity of the proposed dock.

Response by: Morris Zallen, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

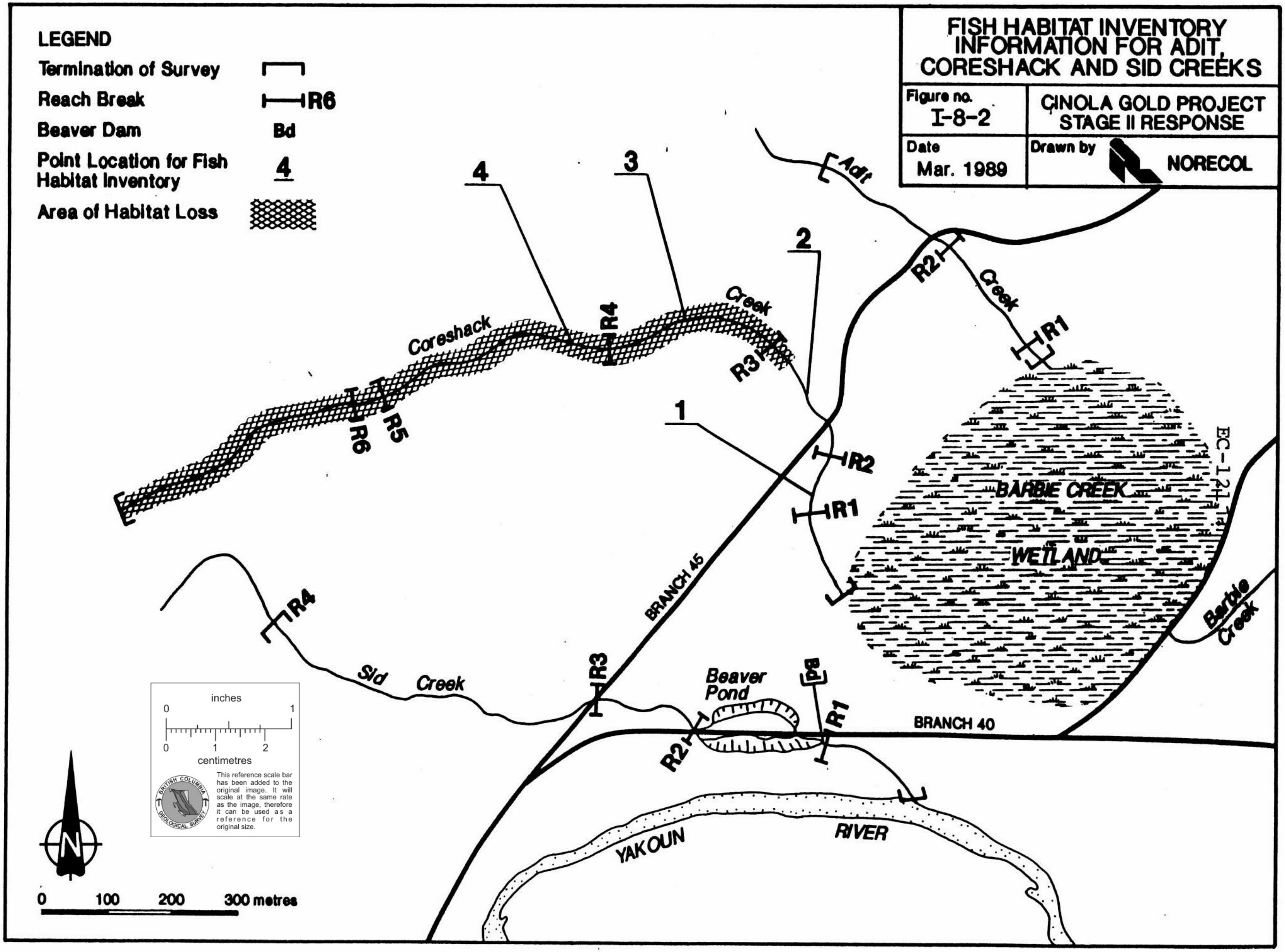
8. Fish Habitat Compensation/Mitigation

Topic: b) Fish utilization in Adit and Coreshack creeks

Comment: Contrary to the Stage II Report, recent DFO fish sampling data indicate the presences of coho and cutthroat, as well as Dolly Varden in Coreshack Creek. In light of potential effects, further information on fish and fish habitat in upper Coreshack Creek is required due to the possibility of mitigation and/or compensation. (The answer below also addresses background discussion and comments in the E C Compendium, Section 2.3.1.2.4, p. 16).

Response: Norecol documented fish habitat in Coreshack Creek on November 17, 1988. The survey was intended to provide a sufficient level of detail for compensation/mitigation considerations. Fish habitat was documented using DFO/MOEP stream survey forms and photographs; reaches were delineated, and potential spawning and rearing habitat in each reach was estimated. DFO/MOEP forms are given in Appendix I-8-2. Figure I-8-2 shows the reach boundaries and the area of stream that will be lost due to construction of the settling ponds.

The following sections describe the fish habitat and capabilities of the reaches identified in Figure I-8-2:


FISH HABITAT INVENTORY INFORMATION FOR ADIT, CORESHACK AND SID CREEKS
Figure no. I-8-2
ÇINOLA GOLD PROJECT STAGE II RESPONSE
Date Mar. 1989
Drawn by NORECOL
LEGEND
Termination of Survey
Reach Break R6
Beaver Dam Bd
Point Location for Fish Habitat Inventory 4
Area of Habitat Loss
Adit
Creek
Coreshack
Creek
R1
R2
R3
R4
R5
R6
1
2
3
4
BARBIE CREEK WETLAND
Barbie Creek
BRANCH 45
BRANCH 40
Sid Creek
Beaver Pond
Bd
YAKOUN RIVER
inches
0
1
centimetres
2
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY
N
0 100 200 300 metres
EC-121

Response: (cont'd)

Reach 1

This reach has a low gradient, diffuse channel and is transitional between the more discrete channel upstream and the Barbie Creek wetland downstream. Channel widths and depths are highly variable and pool habitat predominates. Moderate crown cover is provided by alder trees and small debris is the predominant fish cover. No spawning habitat occurs in this reach as the substrate is silt. Rearing habitat occurs in about 50% of the reach.

Reach 2

This reach is about 0.10 km in length and has a low gradient (0.5%), straight, unconfined channel with an average width of 2.3 m and an average depth of 15 cm. Crown cover is moderate and comprised of coniferous and deciduous vegetation. Good spawning gravel for anadromous species occurs in about 40% of the reach (about 88 m^2) and 30% of the area is suitable for rearing.

Reach 3

This reach is about 0.19 km in length. The channel has a stepped profile controlled by large organic debris and gradient is about 2.5%. Average channel width is 2.6 m and average riffle depths are about 15 cm. Shallow riffles predominate, but a few plunge pools

Response: (cont'd)

controlled by debris are scattered throughout. The channel is confined in a narrow valley. A few small gravel bars are present, but no side channels are present. Spawning habitat is limited to less than 10% of the reach, but a pair of pink salmon have been observed spawning just upstream of Branch 45 on one occasion by Cinola personnel. Rearing habitat occurs in about 30% of the reach and is provided primarily by small plunge pools, organic debris and cutbanks.

Reach 4

This reach is 0.25 km in length. Average channel width and average wetted width are both 1.7 m and average depth is about 40 cm. Pool and glide habitat predominates and the channel is confined by low, stable banks vegetated with grasses and small conifers. The lack of bars and side channels indicate the reach is laterally stable. Crown cover is limited since most large trees have been logged. Substrate is comprised mainly of silts and organic debris and gravels are highly sedimented. Consequently spawning habitat is very limited (about 2% of the reach) . Rearing habitat is extensive and occupies over 80% of the reach. Rearing cover is provided mainly by deep pools, large organic debris from logging, and cutbanks.

Response: (cont'd)

Reach 5

This reach is 0.36 km in length. Average width is 1.3 m and average depth is about 15 cm and gradient is 1.5%. Shallow pool-riffle-glide habitat occurs throughout. Substrate is mostly small gravels with silt in some of the larger pools. Most pools do not exceed 0.6 m in depth. The channel is occasionally confined and dense crown cover is provided by small coniferous trees. A few small gravel bars and side channels were observed in the reach. Due to the small size of the stream in this reach, it appears best suited to resident fish populations. Spawning habitat occupies about 20% of the reach, but only about 1% has potential to be utilized by anadromous species. Rearing habitat occurs in about 10% of the reach. Most fish cover is provided by small organic debris and pools.

Reach 6

This reach is a short, bouldery, stepped section with a gradient in excess of 10%. Spawning and rearing habitat is extremely limited in this reach.

Reach 7

This reach is a headwater section with no perceived fisheries values. The channel is less than 0.5 m wide and substrate is silt and organics.

Response: (cont'd)

Some fish habitat will be lost in Coreshack Creek as a result of the settling pond construction. The affected area will be the upstream 50 m of Reach 3 and all reaches upstream of this point. Reaches 4 and 5 would support resident fish and probably anadromous fish, but there is no fish habitat potential upstream of Reach 5. The total estimated loss of potential spawning habitat in Reaches 3, 4, and 5 is 104 m^2, and the total potential loss of rearing habitat for the same area is estimated at 410 m^2 . These estimates are considered very conservative and probably overestimate the potential spawning and rearing area for salmon.

The proponent commits to compensation and/or mitigation for this habitat loss according to the Department of Fisheries and Oceans (DFO) established policy of "no net loss" of productive fish habitat. Preliminary fisheries surveys in the immediate vicinity of Coreshack Creek indicate that Sid Creek (Figure I-8-2) may present the best opportunity for enhancement to compensate for habitat loss in Coreshack Creek. Sid Creek was found to be utilized by coho salmon, rainbow/steelhead trout, and Dolly Varden char juveniles during a fish sampling program in mid-January 1988. Relatively high densities of juveniles were captured in a large beaver pond adjacent to Branch 40, and potential spawning habitat for anadromous and resident fish was documented between Branch 40 and Branch

Response: (cont'd) 45 (Figure I-8-2). The beaver pond could be increased in area to provide additional spawning habitat, and the section of stream between Branch 40 and Branch 45 has potential for improvement of spawning habitat. This system will require more study to assess adequately the limiting factors and enhancement potential before definitive plans can be formulated.

Wayne Knapp and Greg Caw (DFO) has been contacted in regard to the proponent's commitment and the potential for Sid Creek as a compensation alternative. Meetings were held between Norecol and DFO in February to initiate discussion on the compensation/mitigation issues.

Comment: (cont'd) Similarly, the lower reaches of Adit and Coreshack creeks will be adversely affected, therefore, additional fish utilization (that is, spawning or redd identification) is needed. (The response below also addresses comments in the Environment Canada Compendium, Section 2.3.1.2.3, p. 14-15).

Response: Norecol surveyed Adit Creek on November 15, 1988, and Coreshack Creek on November 17, 1988, to document coho salmon spawners and redds. No redds or spawners were observed in either system. In Coreshack Creek 88 m^2 of good spawning habitat was found in Reach 2, and small areas (4 m^2) of gravel suitable for salmon spawning were observed just upstream and 380 m upstream of Branch 45. In lower Adit Creek spawning habitat is extremely limited, and the gravel available is highly sedimented and

Response: (cont'd) discoloured. The overall evaluation of these drainages suggests a few spawning pairs may utilize Coreshack Creek, whereas spawning probably does not occur in Adit Creek.

Response by: G. Longworth, Norecol

I. ISSUES TO BE ADDRESSED BY THE PROPONENT

8. Fish Habitat Compensation/Mitigation

Topic: c) Miscellaneous comments - Compendium only

A number of comments concerning fish habitat and habitat use for streams in the mine and High West areas appeared in the EC Compendium but were not reflected in the covering letter. Responses to these comments are provided below.

Comment: Comparisons between coho densities in Florence and Barbie creeks, as well as other systems on the Charlottes may not be valid because different sized study sections were established. Coho densities in Florence Creek were underestimated, since visual observations of fry densities by DFO staff on the Charlottes were among the highest they have seen (paraphrased from Environment Canada Compendium, Section 2.3.1.1, p. 12-13).

Response: As indicated in the detailed comments from EP/DFO, Norecol did use different sized study sections in Barbie and Florence creeks during quantitative sampling for fish densities. On Barbie Creek 100 m sections were sampled, compared to 50 m sections on Florence Creek.

Barbie Creek was the first stream sampled in this program, and 100 m sections were initially established to ensure that enough fish would be captured to provide relatively precise estimates of coho and trout densities. It became apparent during the program, however, that captures were sufficiently high in the streams that smaller study sections would be adequate to sample fish populations in these streams.

Response: (cont'd)

As outlined in the Stage II Report (Volume III, 5.8.3.1, p. 5-216), Norecol followed established methods for sampling fish populations, which included a determination that the study sections encompassed the different types of habitat observed within the reach being sampled.

On this basis, Norecol believes that comparisons of fish densities between the various sample sites are realistic and reflect conditions present within the reaches sampled. Further, the Stage II Report provided comparisons with other data on the Queen Charlotte Islands to place the information from the Cinola Gold Project area in perspective relative to comparable sampling from other coastal streams in the region. Norecol does not believe that these comparisons are unreasonable. However, Norecol did not intend to imply either that juvenile populations are always lower than other streams in the Charlottes or that salmon in Florence Creek are "not abundant".

Nevertheless, Norecol would place more confidence in estimates of fish densities derived from the quantitative sampling rather than from visual estimates of fish densities, since subjective observation can be misleading. Perhaps the visual observations of high fry densities reflect the time of year observations were made. For example, the numbers of fry present in the creek shallows during the early summer may well appear to be higher than if

Response: (cont'd) observations are made later in the summer, after juveniles disperse to various areas for rearing. As we indicated, our sampling program was carried out during the late summer (August).

Comment: (cont'd) Fish data collected for Sid, Coreshack, Florence, Clay, Boucher, and Northwest creeks between December and February may underestimate fish populations (paraphrased from Environment Canada Compendium, Section 2.3.1.1, p. 13).

Response: Norecol agrees that winter is not the best period to sample fish to obtain general information on fish presence and habitat utilization. Nevertheless, Clay Creek and Northwest Creek are unaffected by the proposed development. Boucher Creek also is not expected to be affected by the development, based on estimates of groundwater seepage to the headwaters of the creek. Sid Creek will similarly be virtually unaffected by the development, with the exception of very minor reductions in flow.

Florence Creek has been sampled on numerous occasions, including quantitative sampling during the summer in addition to the above-mentioned winter samples.

In our view, Coreshack Creek was the only creek where additional information on fish habitats would be required, and on this basis Norecol completed a sampling program to assess habitats and fish presence in this creek. Details of this program are provided earlier in this response, under Topic b) Fish utilization in Adit and Coreshack creeks.

Topic: Construction windows

Comment: (cont'd) More site-specific life history timing would be useful for determining construction windows. (paraphrased from Environment Canada Compendium, Section 2.3.1.1, p. 13).

Response: Norecol believes there is adequate information to determine a construction window based on life history information for the major species on the Queen Charlotte Islands, and it is unlikely to be substantially different for the Cinola area.

Norecol fully expects the construction window to which the proponent will be required to adhere will be determined by and in consultation with relevant DFO/MOE personnel during the Stage III process.

Topic: Impacts on Boucher Creek fisheries

Comment: (cont'd) There is limited fisheries information on Boucher Creek, and it is unclear how far up the system anadromous fish migrate. However, the Stage II information is acceptable, provided that predictions regarding seepage quantity and quality are accurate (paraphrased from Environment Canada Compendium, Section 2.3.1.2.1, p. 13).

Response: Pilot scale simulations of the mill process and operating data from other facilities were used to estimate seepage quality for the purposes of the Stage II study. This is information is considered appropriate for a Stage II assessment. In addition, predictions of seepage quality and water quality management plans will be refined on the basis of further pilot mill and related environmental testwork proposed for Stage III.

Topic: Habitat use in Canoe Creek

Comment: (cont'd) IEC Beak caught coho juveniles upstream of a falls, 7.5 km from the mouth of the creek, which were identified as impassable by Norecol. The commitment to collecting additional information for the creek is unclear (paraphrased from Environment Canada Compendium, Section 2.3.1.2.6, p. 18).

Response: This area of Canoe Creek is currently inaccessible. The presence of a falls was based on information provided by mine personnel who may have been referring to a falls known to occur near the headwaters of Canoe Creek. There are no mapped features to indicate a falls at the location shown, therefore the mapped location may be in error.

Nevertheless, additional studies of Canoe Creek will be completed in association with assessing fish habitats in the vicinity of the proposed haul road. These studies will be completed when ground access to the site is possible, during Stage III. At that time, the presence of coho in this portion of the creek can be confirmed.

Topic: Further assessment of Florence Creek

Comment: (cont'd) More documentation of life stages below the Branch 4 crossing is required to assess the potential effects of flow reductions during reservoir filling. In particular, (1) spawning areas should be documented where greatest flow alterations will occur, (2) potential obstructions to migration at low flow need to be identified, (3) side channels need to be documented (paraphrased from Environment Canada Compendium, Section 2.3.1.2.7, p. 18-19).

Response: As indicated in Section I.7.a) of this response document, Norecol have developed a revised plan for filling the reservoir, which includes provision for filling over a two-year period. This revised plan will significantly improve the anticipated reductions in mean monthly flow during the winter (high flow) period. The maximum reduction in mean monthly flows during this period are now anticipated to be 18%, compared to earlier estimates of 30%. In the event of an abnormally dry period during filling, flows can be diverted back to the creek for flow augmentation and to maintain a minimum flow level. On this basis, Norecol do not foresee any impact on fish passage or spawning in Florence Creek.

Nevertheless, a subsequent study of minimum flow requirements for maintaining fish passage to the spawning areas in upper Florence Creek (near the Branch 4 road crossing) will be completed during Stage III to ensure that, in the unlikely event of a dry fall/winter period, flows can be diverted from the reservoir to provide water adequate for fish passage and spawning. Requirements for minimum flow would be determined in consultation with DFO.

Norecol has identified in the Stage II Report that spawning areas in Florence Creek most likely to be affected by flow reductions extend from the first set of falls on the creek (above the Branch 4 road crossing) downstream to several hundred metres below the Branch 4 crossing.

Comment: (cont'd) Existing data on juvenile rearing requirements during summer low flows is adequate only if Norecol can confirm the ability to augment flow during the summer.

Response: Water management plans still provide for the ability to augment flows in Florence Creek as necessary to provide for no net loss of habitat. In addition, contingency plans for mine water management include use of effluent from the mine area treatment plant in place of freshwater make-up to the mill. This would reduce the requirement for freshwater to less than 200 m^3/day and reduce requirements for extraction from Florence Creek accordingly.

Topic: Effects on streams discharging to Ferguson Bay

Comment: Information is required on spawning and rearing in the unnamed creek which enters Ferguson Bay (paraphrased from Environment Canada Compendium, Section 2.3.2, p. 20).

Response: The unnamed creek lies outside the area that will be affected by project developments, and Norecol does not believe that further information is required for this unnamed creek. Norecol indicated in the Stage II Report that salmon are present in Ferguson Bay and stated that "individuals of all five Pacific salmon species, as well as trout and Dolly Varden char, should be present. In addition to salmonids from the Yakoun system, juveniles from other systems might use Ferguson Bay. For example, the small creek entering Ferguson Bay supports a small population of coho salmon and possibly other salmonids...". On this basis, Norecol

Response: (cont'd) have always maintained that the bay itself contains important salmonid habitats that should either be preserved or compensated for in the design of the proposed dock site.

Comment: (cont'd) The consultant misinterpreted V. Fradette regarding commercial fishing in Masset Inlet. Commercial net fisheries occur in Yakoun Bay and Port Clements.

Response: Norecol staff spoke to Mr. Fradette on several occasions about commercial fishing activities in Masset Inlet, with the specific intention of learning whether any commercial fishing was done in the vicinity of Yakoun Bay and Port Clements. The information contained in the Stage II Report was obtained directly from those conversations. However, even if commercial fishing occurs at some future date, the Cinola project will not affect the fisheries in these areas.

Response by: Morris Zallen, Norecol

II. COMMITMENTS REQUIRED FROM THE PROPONENT

1. Baseline Environmental Conditions

Topic: a) Yakoun Estuary

Comment: Further baseline sampling for background levels of metals in estuarine sediments and biota (that is, eelgrass, algae, and marsh grasses, invertebrates, and small fish such as sculpins, flatfish and sticklebacks) which are eaten by birds are required. Tissue analysis for heavy metals is also needed on a representative sample of waterfowl (dabbling and diving ducks) likely to be consumed by humans. This is required to assess any potential impacts on bird populations from the operation.

Response: The request for tissue analysis to assess heavy metal levels in waterfowl assumed that the effects of mine-related metals additions will be measurable. Because of the potentially wide range used by waterfowl and the resultant natural variability in metal concentrations in tissue it is considered unlikely that tissue analysis will measure the effects of mining on waterfowl. Measurement of metals in sediment accumulation zones and plants or biota which are relatively stationary (invertebrates, territorial fish) in the estuary, and which are consumed by waterfowl, would provide an early indication of the potential effect of mining operations on birds. Further discussion regarding monitoring of metals in the Yakoun Estuary will be held with Environment Canada during Stage III.

Response by: Liz Neil, Norecol

II. COMMITMENTS REQUIRED FROM THE PROPONENT

2. Acid Mine Drainage Abatement

Topic: a) Tailings/waste rock mixing experiment

Comment: Experiments to determine an optimum mixing strategy for potentially acid generating materials and tailings are required to ensure neutral pH conditions are maintained in the tailings impoundment (see also Environment Canada Compendium, Section 4.2.3, p.44-45).

Response: As part of the Stage III work, experimental tests will be conducted to ensure the mixing strategy will maintain neutral or alkaline pH conditions in the impoundment system. These tests will consist of laboratory experiments with various proportions of tailings and acid-generating/ acid-releasing rock. These tests will indicate the reactivity of the geochemical processes in the materials as well as the optimum proportion and thoroughness of mixing required to prevent the development of acidic conditions. Larger-scale field tests will be conducted to assure proper mixing and that large-scale mixing behaves as predicted by the laboratory experiments.

Response by: Kevin Morin, Norecol

II. COMMITMENTS REQUIRED FROM THE PROPONENT

2. Acid Mine Drainage Abatement

Topic: b) Pilot scale wetland

Comment: Pilot scale testing of metal removal in the wetlands is needed to optimize the effectiveness of this treatment system (this could be incorporated in studies planned by the proponent to examine nutrient removal).

Response: Testing of metals and nutrient removal in constructed wetlands under Cinola conditions will be carried out in conjunction with the pilot scale field study mentioned above. The study will be carried out after substrate and vegetation tests in temporary sub-units of one of the two mine site wetlands. The latter tests will assess transplanting methods and adaptability of wetland species to mine wastewater. It should be noted, however, that the wetlands are provided primarily for nutrient removal during the summer low flow period, when projected nitrate-N concentrations leaving the water treatment facility may exceed receiving water criteria (10 mg N/L). Metals removal is an incidental benefit of these wetlands.

Response by: Alan Whitehead, Norecol

II. COMMITMENTS REQUIRED FROM THE PROPONENT

3. Mercury/Nutrients

Topic: a) Metal levels in adult coho

Comment: It is not anticipated that predicted increases in methyl mercury production will result in a significant increase in levels of mercury in adult salmon. However, in light of the importance of salmon to commercial, sport and native fisheries, additional adult coho sampling must be conducted in order to establish baseline conditions.

Response: City Resources has conducted a large number of studies in order to quantify potential effects of project operations on mercury methylation rates. Mercury speciation studies on receiving waters and simulated effluents indicate that project-related contributions of ionic mercury will be extremely low - in the order of natural background levels. Nutrient bioassays suggest that contributions of organic matter resulting from project-related nutrient inputs will be small and that these inputs will be in a form which can contribute to fish production.

All of these these studies indicate that the potential for effects of the project on mercury accumulation in fish is negligible. City Resources agrees that there will be no measureable effect on adult salmon which in any event will be in the sea for the greater part of their growth cycle. In this respect, the request for baseline data on adult coho is considered redundant as there will be no

Response: (cont'd) basis for effects monitoring. However, City Resources is willing to discuss the rationale, design and possible implementation of a limited program with the agencies during Stage III.

Response by: Liz Neil, Norecol

II. COMMITMENTS REQUIRED FROM THE PROPONENT

3. Mercury/Nutrients

Topic: b) Seasonal in-situ algal bioassay

Comment: In-situ algal bioassays must be repeated at other times of the year, and in Barbie Creek, to confirm the extrapolation of preliminary conclusions to other seasons.

Response: During Stage II in-situ algal bioassays were confined to Florence Creek because channel morphometry and flows in Barbie Creek precluded use of the standard in-stream apparatus for this experiment. Further it was determined that algal communities and background nutrients levels were similar in Barbie and Florence Creek. On this basis it was reasonably assumed that the response of algal communities to nutrient additions in Florence Creek would be comparable to the response of algae in Barbie Creek. Based on current concerns regarding potential micronutrient limitation and effects of pH changes on phosphate availability, site specific tests in Barbie Creek have been requested.

In-situ algal bioassays could be conducted in water from Barbie Creek by using a trough apparatus on the bank and a pump to supply a continuous flow of water from the creek to the trough. While feasible the experiment would entail overcoming logistical problems such as provision of power for continuous pumping and risks such as loss of experimental results in the event of pump failure. The potential success of this experiment will be improved if it is

Response: (cont'd) conducted in conjunction with other test programs during Stage III when the area will be more closely monitored. The design of the apparatus and the experiment would be developed during Stage III and reviewed with relevant agencies prior to implementation.

The requirement for seasonal bioassays has been reviewed in the light of results of the Stage II nutrient studies. Florence Creek was found to be nitrogen limited. In-situ bioassays in Florence Creek indicated that phosphorus additions did not cause an increase in algal biomass due possibly to complexing of phosphates by humates or other micronutrient limitations. Seasonality in terms of periphyton growth is dependent on nutrient availability at different times of the year and other seasonal factors such as temperature and flow. The expected concentrations of nitrogen in receiving waters during operation will result in saturation of nitrogen limited periphyton accrual at all times of the year. In a nitrogen replete system physical factors will play the main role in controlling seasonality in periphyton accrual.

Accordingly, the greatest impact of mine related nutrient input is expected to occur in the late spring or summer. High flows and lower temperatures are likely to limit biomass accrual at other times of the year. Therefore, it is recommended that any further tests in Barbie and Florence Creek focus on the spring/summer season

Response: to quantify algal biomass accrual under what is
(cont'd) probably the worst case condition.

Prepared by: Liz Neil, Norecol

II. COMMITMENTS REQUIRED FROM THE PROPONENT

3. Mercury/Nutrients

Topic: c) Algal bioassays with simulated effluent

Comment: Further algal bioassays may be required in Barbie Creek with nitrogen, phosphorus, and simulated effluent from the waste treatment plant to assess the effect of all chemical additions, if no other alternative disposal scheme for the water treatment plant effluent is pursued.

Response: Stage II nutrient bioassays indicated that nitrogen-limited algal growth was saturated at approximately 100 mg N/L and that no further accrual was stimulated by additions of phosphorus in combination with nitrogen. It was suggested that the lack of response with phosphorus addition, when nitrogen was no longer limiting, may be due to complexing of phosphate by humates making it unavailable for plant uptake, or to growth limitation by some other micronutrient.

The concern was raised that changes in pH and input of various elements as a result of the water treatment plant effluent may result in increased phosphorus availability or supply of limiting micronutrients in Barbie Creek. This would result in an increase in accrual rates over those observed during the in-situ bioassay.

In order to test the effect of treatment plant effluents on algal accrual in Barbie Creek it has been recommended that bioassays be conducted using simulated treatment plant effluent. Such work will not be possible until the pilot scale

Response: (cont'd) water treatment plant is in operation during Stage III. The requirements and scope for any additional work will be reviewed with the agencies in Stage III.

Prepared by: Liz Neil, Norecol

II. COMMITMENTS REQUIRED FROM THE PROPONENT

4. Spills/Contingency

Topic: a) Consultation with relevant agencies

Comment: Significant risks to valuable fishery resources are posed by the transport of hazardous materials to the barge site in Ferguson Bay. Consultations and discussions are required between the proponent, their carrier, the Canadian Coast Guard, the Department of Public Works, and other agencies to review methods to reduce the risk of spills during barge transport and off-loading for the Cinola project.

Response: City Resources will commit to working closely with the interested government agencies when developing the Cinola transportation plans and the spill response contingencies. In the first instance, they will develop their plans for road and dock construction and spill response and clean-up in cooperation with their own consultants and MacMillan Bloedel. The planning work and proposed construction will then be reviewed, to ensure its acceptability, with relevant agencies including:

- o Canadian Coast Guard (Navigable Water Protection)
- o Transport Canada (Transport Dangerous Goods)
- o Ministry of Environment (Waste Management Branch)
- o Ministry of Transportation and Highways (Road Safety)

Response: (cont'd) Following on this work, City will then review the proposed plans with any other agencies who express an interest in the matter. The agencies could include:

- o Fisheries and Oceans Canada
- o Water Management Branch
- o Environmental Protection Service.

In addition, City Resources personnel and/or carriers contracted by City Resources will be fully trained and equipped to comply with all relevant regulations and procedures pertaining to the transportation of dangerous goods.

Response by: Peter Cowdery, City Resources

III. ADDITIONS TO THE PROPONENT'S CONTINGENCY PLANS

1. Acid Mine Drainage Abatement

Topic: a) Treatment of waste rock stockpile drainage

Comment: It is likely that the waste rock stockpile underdrain will at times become contaminated due to acid formation in the stockpile. The ability to treat the underdrain in the water treatment plant must be included in the waste management plan.

Response: The calculated flows from the underdrain in the waste rock stockpile range from a minimum of 320 m^3/d to a maximum of 1200 m^3/d. The acid abatement program proposed for the waste rock stockpile is designed to prevent the water draining to pond MSSP2 from becoming acidic.

Both water quantity and quality will be monitored in pond MSSP2 to ensure that the water is acceptable for discharge to the environment. In the event that pH measurements in pond MSSP2 drop beneath an acceptable lower limit (pH = 6.0), suggesting that the acid abatement measures in the waste rock stockpile are not as effective as planned, one or all of the following contingency plans will be implemented.

1. Treating settling pond MSSP2 with lime.

2. Applying limestone into trenches excavated below the toe of the slope to intercept the drainage water.

3. Increasing the pH of the water draining through the waste rock stockpile by:

- increasing the amount of limestone added into the waste rock stockpile during its construction, both by mixing and as an additional cover layer; and

- adding hydrated lime into the waste rock stockpile uphill of the toe drain.

If it is found necessary to add lime to the water in pond MSSP2, the water will be re-circulated into the waste rock stockpile at the active face. Re-circulating the water will provide residence time for the precipitates to settle out and remain within the stockpile and that potential "hot spots" will be flushed out. The effectiveness of the contingent re-circulation procedure will be tested as part of the large scale liming test of waste rock storage, during the Stage III studies.

In the event that the re-circulated water is still unacceptable for discharge to the environment, the ultimate contingency will be to process the water through the water treatment plant, or in the event that the plant capacity will be exceeded, the water will be pumped to and stored in the active High West impoundment pond. The pond water in this active impoundment will be highly alkaline, and therefore any acidic water from pond MSSP2 will be immediately neutralized. The contingency plan for the mine area water treatment system is discussed in more detail in Appendix I-3-1.

These contingency plans will be evaluated further during the Stage III design work. A factor of prime importance in providing an effective environmental water management plan is the minimization of the volume of acidic water that has to be treated. It is therefore important to ensure that the water collected in pond MSSP2 does not require treatment other than settling.

Response by: J.W. Gadsby
Steffen Robertson & Kirsten

III. ADDITIONS TO THE PROPONENT'S CONTINGENCY PLANS

1. Acid Mine Drainage Abatement

Topic: b) Lime additions to tailings impoundment

Comment: The possible need for lime and limestone additions to maintain neutral pH in the area of the tailings impoundment where tailings and argillically altered rock are to be mixed needs to be assessed.

Response: Based on acid-base accounting tests reported in the Stage II Report, the tailings contain 20.7 tonnes of $CaCO_3$ (limestone) / 1000 tonnes of tailings as indicated by neutralization potential. This $CaCO_3$ is derived from the addition of limestone and lime in the mill circuit. In other words, as these tailings are placed in an impoundment, limestone is also being added to the impoundment. For this reason, the need for limestone addition to the impoundments has been addressed and is the basis for the waste-management plan presented in Section 2.1.3.3 of Volume IV. This plan calls for approximately 0.1-03 tonnes of tailings to be mixed with each tonne of rock in order to maintain a high pH. Because a maximum of a few million tonnes of waste rock will be placed in each impoundment, less than a million tonnes of tailings is required for mixing compared to a total tailings volume of about 8 000 000 tonnes in each impoundment. In fact, the calculated percentages of tailings in each impoundment that are required for pH control are: 3% in Impoundment 1, 9% in Impoundment 2, and 4% in

Response: (cont'd) Impoundment 3 (Section 2.1.3.3, Volume IV). These relatively small percentages provide a relatively large factor of safety so that the $CaCO_3$ content of tailings could safely decrease in an ideal situation by a factor of 10 to 30 or the volume of waste rock could increase safely in an ideal situation by a factor of 10 to 30. In any case, because the $CaCO_3$ content of the tailings originates in the mill-circuit addition of limestone and lime, the $CaCO_3$ content can be regulated at the mill as necessary.

Response by: Kevin Morin, Norecol

III. ADDITIONS TO THE PROPONENT'S CONTINGENCY PLANS

1. Acid Mine Drainage Abatement

Topic: c) Water treatment plant capacity

Comment: The need to increase the capacity of the water treatment plant to accommodate additional drainages or provision of a mobile treatment system must be developed since several pond discharges have at least some potential to become contaminated with metals based on current information.

Response: The two areas of the mine water treatment system that will or may produce acidic water containing metals are the open pit and the waste rock stockpile. Water from these areas will be received by ponds MSSP3 and MSSP2.

All runoff water from the open pit is assumed to be acidic. The water is collected in pond MSSP3 and processed through the water treatment plant before being discharged to the environment. The water balance assumes that runoff from the pit walls will remain acidic throughout the entire life of the mine. This is a conservative assumption, as no allowance has been made for acid burnoff from the pit walls. The test work clearly indicates that the sulphides will burn off with time. Provision will be made in the second half of the mine life to route water from the upper part of the pit walls, over a limestone bed, to either pond MSSP2 or a new pond, thereby reducing the volume of water required to be processed through the water treatment plant.

Since submission of the Stage II Report, the capacity of pond MSSP3 has been increased from 75,000 m^3 to 254,000 m^3. This increased capacity provides additional environmental protection by allowing for containment of runoff from high precipitation events, which can then be processed through the water treatment plant at a later date.

Water from the underdrain of the waste rock stockpile will be collected in pond MSSP2. As a result of the acid abatement design for the waste rock stockpile, the water in pond MSSP2 should not be acidic. The water is to be passed through wetland MSW1 for removal of nitrates before being discharged to the environment. Contingency plans for additional treatment of the water in pond MSSP2 and the waste rock stockpile are discussed in response to question EC-III-1a.

Settling ponds MSSP1, 5,6, and 7 receive runoff water from areas that contain no acid generating rock. All ponds will be monitored regularly. As discussed below, provision will be made to add lime and flocculants to these ponds before the water is discharged to the wetlands and/or the environment.

Ponds MSSP1 and MSSP7 will receive runoff from the surface of the waste rock stockpile. The water collected in the ponds will contain sediments, but it will not be acidic. If found necessary, flocculants will be added to ponds MSSP1 and MSSP7.

Pond MSSP6 will receive runoff from the overburden and mudstone dumps. This water will contain sediments and possible nitrates. The runoff water will not be acidic, as any potentially acid generating mudstone will be taken to the High West impoundment for permanent storage underwater. Water from pond MSSP6 will be passed through wetland MSW2 for removal of nitrates before being discharged to the environment. If found necessary, lime can be added to the pond to increase the pH and flocculants can be added to reduce sediment levels in the discharged water.

Pond MSSP5 will receive runoff water from the haul road to the waste rock stockpile. The water will contain only sediments. Any waste rock that drops off the trucks will be removed by the maintenance crew and placed in the waste rock stockpile. If found necessary, lime and flocculants can be added to ensure the water is acceptable for discharge to the environment.

Response by: J.W. Gadsby, Steffen Robertson & Kirsten

III. ADDITIONS TO THE PROPONENT'S CONTINGENCY PLANS

1. Acid Mine Drainage Abatement

Topic: d) Lime to control pH in the pit backfill

Comment: The quantity of lime and limestone that may be required to maintain the pit water quality at, or slightly above, neutral pH during backfilling needs to be evaluated.

Response: In Volume IV, Section 2.1.2.2, of the Stage II Report, the limestone requirement to neutralize acidity during backfilling is calculated to be 3520 t of $CaCO_3$. This calculation is based on the conservative assumption that 440,000 m^3 of water will have an extreme acidity of 8000 mg/L as $CaCO_3$, or that all of the water in the pit (approximately 4,400,000 m^3) will have an acidity of 800 mg/L.

The conservative calculation does not take into account the limestone remaining in the stockpile, the alkalinity in the inflowing groundwater, and the alkalinity in Impoundment No. 3 decant. Consequently, it is reasonable that a maximum of only five to ten thousand tonnes of limestone may be required to neutralize pit water during backfilling. This quantity is well within the supply and handling plans of the mine which will have a stockpile of 15,000 t and a grinding and handling capacity of 100,000 tpy.

Response by: Kevin Morin, Norecol

References:

III. ADDITIONS TO THE PROPONENT'S CONTINGENCY PLANS

1. Acid Mine Drainage

Topic: e) Water treatment after closure

Comment: The contingency to treat pit water and tailings pond supernatant after abandonment, possibly for one pore volume exchange, must be discussed with agencies and then detailed and costed by the proponent.

Response: 1. Backfilled Pit

The purpose of the proposed backfill plan is to ensure that the rock mass is not acid generating and that the pore water is alkaline after completion of the backfilling operations. During the operation of the mine, drainage water from the waste rock stockpile will be collected in pond MSSP2, and the water quality will be monitored before discharge to the environment. Hence, the effectiveness of the acid abatement measures incorporated in the design and construction will be well demonstrated and metal chemistry well defined. As a consequence, the condition of the waste rock will be known immediately prior to backfilling in the pit. Through monitoring, the quality of water collected in the pit will also be known prior to backfilling.

If the monitoring data indicate that "hot spots" may have occurred in the waste rock stockpile, the contingency plans for backfilling would include:

- raising the pH of the water in the pit by the addition of limestone, which would be mixed in the same manner as when constructing the original stockpile;

- sluicing supernatant water pumped from impoundment no. 3 to the pit over the unsubmerged waste rock as it is being backfilled to flush out "hot spots";

- adding more lime to the water from impoundment no. 3 as necessary to maintain the alkalinity of the water pool in the pit;

- using hydraulic monitoring to recirculate the pit water and sluice the rock backfill as it is end-dumped;

- end-dumping the waste rock in two lifts to ensure that the rock is quickly immersed in a high pH water; and/or

- providing one or two deep injection well pipes at either end of the pit as it is backfilled.

In the event that the contingency plans fail and the water running over the spillway is found to be environmentally unacceptable then all that will be required is to dam the spillway temporarily and add lime to the pond as is now done to the existing pilot mill decant pond. The pore water can be monitored and treated if necessary by pumping up from one injection well, adding lime to the pump discharge, and reinjecting down the other well. This procedure can be readily handled by a member of the power plant crew who will continue to be on site and available after the mining is completed. This procedure makes the treatment less dependent on the weather and rainfall.

The method of treatment suggested in the question would involve dealing with some 4.4 million m^3 of water. To treat this volume would require that pit water be extracted at a rate not greater than the natural inflow in order to ensure that the backfill remains saturated. At the calculated average pit refill rate of 1850 m^3/d, treatment of the entire pore volume of pit water will take a minimum of 6.5 years. It is not believed that this method of processing the pit water is the most desirable environmental solution.

See also response to question EC-III-1A.

Response: 2. High West Tailings Impoundment System

The impact assessment for Florence Creek on closure of mining assumes that pore water discharged to the surface of the reclaimed tailings impoundment will have the quality of mill effluent and that plug displacement will occur, i.e. no allowance was made for mixing of pore water and groundwater.

The tailings impoundments will be located in the Florence Creek Valley. The depth of tailings will therefore be shallow at the edges, probably about 5 m ranging to a maximum depth of 60 m in the centre of the impoundment (range of 40 to 60 m). Tailings will be deposited from the sides of each impoundment. Consequently the coarse fraction and more permeable portion of the tails will be deposited along the edges and the fine portion (less permeable) in the centre. The rock shells at the embankments will be more permeable than the tailing fines. The perimeter of each impoundment will therefore, consist of a zone of more permeable material than the centre.

The assumption that pore water displacement is equivalent to mill effluent quality is highly conservative for the following reasons:

1) During the four years of tailings deposition in each impoundment, the tailings around the perimeter will be exposed to precipitation and runoff, consequently the mill effluent pore water in the perimeter zones will be practically flushed out and recirculated by the time the impoundment will be reclaimed.

2) During the operational period, flows of groundwater into the impoundment will occur more readily around the sides where the higher permeability materials occur (tailings and rock shells). Mill effluent pore water at the sides of the impoundment will therefore be replaced by groundwater, probably before reclamation occurs.

3) After closure of mining, the upward flows of groundwater directly to the surface of the impoundment will continue through the previously established drainage paths in the more permeable perimeter zones.

4) In the centre of the impoundment where the tailings deposits will be deepest, and of extremely low permeability, the volume of upward groundwater flows will be very small. Consequently, the rate at which pore water will be displaced from the central area will be minimal.

The net effect of the above factors will be that the quality of displaced pore water after closure of mining will be significantly better than mill effluent.

During operations, the tailings deposition procedures, groundwater flows and the system chemistry will be monitored. Results from the monitoring will be used to quantify further seepage volumes and water quality. The need for a water treatment plant to treat the supernatant in the impoundments will be evaluated early in the mine life based on the results of monitoring Impoundment No. 1.

Response by: J.W. Gadsby, Steffen Robertson & Kirsten

III. ADDITIONS TO PROPONENT'S CONTINGENCY PLANS

2. Mill Effluent Quality

Topic: a) Additional waste rock disposal in tailings impoundments

Comment: The potential for additional quantities of acid releasing rock to be placed in the impoundmentts and the effects upon the water balance and pond chemistry must be examined.

Response: There will be little effect on the High West tailings impoundments as a result of the disposal of additional acid generating waste rock.

The storage capacity of the present three-pond system as presented in the Stage II Report is 27.5 x 10^6 m^3. As discussed in the Stage II Report, Volume II, Section 6.5.2 a conservative contingency of 5% of the total volume of tailings and waste rock was included in the design. In addition to this contingency, if the saddle embankment and embankment nos. 2 and 3 are raised by 10 m to accommodate waste to elevations 295 m and 285 m in impoundments nos. 2 and 3, respectively, the total storage capacity is increased to approximately 33 x 10^6 m^3. This additional volume of 5.5 x 10^6 m^3 would accommodate about 9.4 x 10^6 t of waste rock.

Recent studies show that approximately 3.7 x 10^6 t of mudstone may be acid generating. This is equivalent to approximately 1.4 x 10^6 m^3. This potentially acid generating mudstone will be stored underwater in the High West impoundments, thereby reducing the reserve storage capacity to 4.1×10^6 m^3.

Additional storage capacity is available in the High West system by increasing the height of the embankments and by utilizing the area upstream of the water storage dam. The water storage reservoir could be used for underwater storage of acid generating waste rock (minimum capacity 1.1×10^6 m^3, or approximately 2×10^6 tonnes).

In order to increase the storage capacity, it will be necessary to increase the volume of material in the embankments and modify the locations of the diversion ditches.

Placing additional waste rock into the impoundments will not affect the water balance. The water balance is an account of inflows and outflows. Changing the tonnage of waste rock placed in the High West impoundment system does not alter the inflows or outflows of water. Increasing the storage capacity of the impoundments does not change the design philosophy of the High West system.

From a water quality perspective, each impoundment could hold more than 10 times more acid-releasing rock than currently proposed with no significant impact on quality. This is based on calculations in Volume IV, Section 2.1.3.3, which indicate that the neutralization potential and alkaline nature of the tailings are sufficiently high that only 3 to 9% of the tailings volume will be needed for mixing with rock at current predicted volumes.

EC-164

Response by: John Gadsby/John Barton-Bridges, Steffen Robertson and Kirsten, and Kevin Morin, Norecol.

III. ADDITIONS TO THE PROPONENT'S CONTINGENCY PLANS

2. Mill Effluent Quality

Topic: b) Tailings impoundment supernatant treatment at closure

Comment: The tailings impoundment supernatant may require treatment immediately at closure and after abandonment due to elevated levels of cyanide and copper arising from mill effluent quality. Plans must be developed for this treatment scheme.

Response As discussed in the response to E C comment I-4c there has been no change in assumptions with regard to cyanide degradation and copper reductions in the tailings mass over time. In addition, predictions of tailings supernatant quality are considered conservative as described in E C section III-1e. For these reasons a requirement to treat the supernatant at closure is highly unlikely. Nevertheless the water treatment plant will remain in place after closure and can be recommissioned if required. On going operation of the power plant after closure will provide the funds and manpower to permit on going operation if necessary.

Response by: Elizabeth Neil, Norecol

III. ADDITIONS TO THE PROPONENT'S CONTINGENCY PLANS

3. Mercury

Topic: a) Abatement of mercury methylation

Comment: Plans to abate any significant increase in methylation of mercury that may occur as a result of mine operation must be formulated.

Response: Project design and contingency plans for abatement of potential mercury methylation have focussed on control of the two principal causative factors:

- o potential increases in ionic inorganic mercury;
- o potential increases in organic matter which may stimulate the activity of mercury methylating bacteria without a corresponding increase in overall system productivity.

The sites of potential concern with respect to project activities include:

- o the constructed wetlands in the mine area water management system;
- o Barbie Creek downstream of the treatment plant effluents;
- o the freshwater reservoir; and
- o the reclaimed impoundments.

Response: (cont'd)

Methylmercury production in the constructed wetlands may be stimulated by inputs of ionic mercury from waste rock drainage and in water treatment plant effluents, or by organic matter in the substrate soils used for wetlands construction. Mercury speciation and methylation bioassays conducted during Stage II (Appendix I-5-1) indicated that judicious selection of substrate soils for construction of the wetland will provide effective control of mercury methylation from this potential source of stimulation (refer to response to EC Section I-5 a) and b). In addition it was shown that lime treatment of leachate (simulated waste rock drainage) yields concentrations of ionic mercury which are comparable to natural concentrations in receiving waters; therefore water treatment plant effluent is not expected to produce increased levels of ionic mercury in the wetlands. Consequently, no stimulation of methylation above natural levels is expected from this source.

Inflows to the wetland will be closely monitored and tested for total and ionic mercury. If necessary, inflow waters can be treated by liming in the sedimentation ponds which collect drainage water immediately upstream of the wetlands. Organic matter accumulation in the wetlands can be minimized by harvesting of vegetation.

Response: (cont'd)

As all project-related discharges to Barbie Creek will be made via constructed wetland systems, controls on mercury input to the wetland systems (discussed above) will also serve to protect Barbie Creek. Some additional concern has been expressed regarding the effect of nutrient enrichment in lower Barbie due to treatment plant effluents, causing increased algal growth and accumulation of organic matter and stimulation of methylating bacteria. Nutrient bioassays have predicted a five-fold increase in accrual of algal biomass (Appendix I-5-2), approximately half the value targeted by stream fertilization programs to increase fish production. The increased production caused by mine-related nutrient input is expected to be reflected in increased fish production which will counteract potentially enhanced methylation by biodilution (refer to E C Section I-5a and Appendix I-5-1). Nevertheless, water and fish will be carefully monitored in lower Barbie to assess potential effects.

The primary concern with respect to increased methylation is mercury accumulation in resident fish which inhabit the lower two kilometers of Barbie Creek. Exposure of juvenile anadromous species in this reach will not affect mercury levels in adult fish which return to the sea for the majority of their growing period. Resident fish are not currently harvested in the lower Barbie Creek area and, if increased mercury accumulation is observed in resident fish, it

Response: (cont'd)

will be readily feasible to control fishing in the vicinity of this exposure. However, mine activities are not expected to stimulate methyl mercury production above the natural rates observed in Barbie Wetlands and Gold Creek and which can be expected in other similar drainages.

The potential for stimulated mercury methylation in the High West area relates to flooding of soils in the freshwater reservoir and potential effects of organic accumulation in the reclaimed impoundments. The impact of mercury methylation in this system would be confined again to resident fish populations which establish in the High West following reclamation.

Organic soils will be stripped from the basin of the freshwater reservoir so as to minimize the potential for methylation. Methylation bioassays conducted on the subsoils of the reservoir confirm that these soils will not support elevated methylation rates (Appendix I-5-1). Organic accumulation in the reservoir will be gradual; no sudden influxes of organic carbon are expected that will upset the balance of bacterial methylation in relation to overall system productivity.

In the reclaimed impoundments a potential source of mercury is seepage of tailings porewater into the surface water. As indicated by mercury speciation analyses, bioavailable mercury in the

Response: (cont'd)

tailings pore water is very low (refer to E C Section I-5a and Appendix I-5-1), probably as a result of the neutralization step and sodium sulphide addition in the mill process and the resulting alkaline pH of the porewater. Therefore contributions of ionic mercury from porewater seepage are not expected to cause a significant increase over baseline levels. Tailings water will be carefully monitored during operation for total and ionic mercury. The sequential deactivation and reclamation of impoundments will allow monitoring and testing to design the optimal deactivation and closure program. Contingency plans which are available in the event of unexpected methylation activity following deactivation and closure are discussed under reclamation below.

Various reclamation scenarios are possible following deactivation. These scenarios may have different implications to organic accumulation and potential effects on methylation rates. The Stage II Report indicated that impoundments would be reclaimed to wetland systems for polishing of seepage inflows after closure. Pilot scale wetlands to be developed during Stage III will provide insights as to the implications of reclamation to wetlands and effects on mercury methylation. Reclamation plans will be modified and refined based on these findings. Contingencies which may potentially be activated with respect to reclamation of deactivated impoundments include,

Response: (cont'd)

reclamation of impoundments as ponds/lakes with limited peripheral wetland development (possibly incorporating peat filters) at the outflows of the impoundments, incorporation of limed trenches at the impoundment outlets, segregation of tailings solids from methylating bacteria (which are active in surface sediments only) by spigoting a layer of ground waste rock and/or lime on the tailings surface prior to reclamation, etc. Again, monitoring of the pilot wetlands and the first of the reclaimed impoundments will provide information which will be used to refine the reclamation design for successive downstream impoundments.

Response by: Liz Neil, Norecol

RESPONSE TO B.C. MINISTRY OF ENVIRONMENT
LETTER AND APPENDICES
JOHN DICK, NOVEMBER 3, 1988

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.1 Project Planning

Topic: a) Requirement for advanced design

Comment: Conceptual planning for key project components will need to be backed up within near final level of detailed design at Stage II.

Response: There are several levels of design for a facility or plant and descriptions of four common stages have been given here.

The first is conceptual, where although the feasibility of the design is assured, there are little or no details available as to the mechanics of the plant. This stage is generally completed and used for the Pre-Feasibility Studies. The second level is the one where sufficient work has been done so that drawings can be prepared. These drawings therefore, form the basis of reasonably accurate estimates of costs for the plant. This stage normally represents the level of detail that is used in a Feasibility Study. A third level is what has been termed basic engineering. This is where the majority of the design problems are solved and cost estimates can be prepared to a fair degree of detail. A fourth and final stage is where detail designs are completed and the ensuing drawings are suitable for construction and detailed budgets. After approximately half of the third stage has been completed, work on the last stage will be started and thereafter progress on the two stages will generally

Response: (cont'd) proceed in parallel. The detailed design work will normally be carried out as part of the Stage III phase. The third stage must be completed for permitting and bidding. The fourth must evidently be completed for the start of construction.

All designs for the Plant Facilities in the Stage II Report were essentially at the second, or Feasibility Study stage. Minor modifications were incorporated into the designs used in the Feasibility Study, but the conceptual foundation of the facilities has not been changed. Nevertheless, the designs cannot be considered "Near Final". Using the definitions provided above, this type of design could only be provided after the basic engineering had been completed.

It would seem to be unrealistic and unnecessary to request this level of detail to allow an Approval-in-Principal to be given. The work necessary to complete basic engineering is extensive and when completed the facility will still operate within the parameters set at the conceptual stage. What will likely happen is that the design will be improved, as more engineering is carried out, resulting in the facility operating better than originally conceived.

Response by: Peter Cowdery, City Resources

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.1 Project Planning

Topic: b) Review of the feasibility study

Comment: The company must demonstrate that it can afford to develop the project to the standards of the proposed design over a range of economic conditions. The ministry will ask to review the feasibility study in confidence with MEMPR to ensure that adequate, near final designs and contingency plans have been incorporated in the assessment.

Response: City Resources believes that although a review of the Feasibility Study is a legitimate part of the Approval-in-Principle process, it would be unrealistic and counter-productive to allow all those agencies who might wish to see the material to have access to this report. The reasons for this belief are given below.

The Feasibility Study is a complex highly technical document, which is designed to provide sufficient information to financial houses and their technical advisors, so that they can evaluate the economic attractiveness of the project. Costing, though done in some detail, is compressed and extensively summarized. This means that it will take time to identify the individual costs and extract them from the mass of estimating that is included. In some cases the identification of particular cost items would require the aid of the estimators themselves to pull the cost out of a totalled amount.

Response: (cont'd)

The main reason for reviewing the Feasibility Study must be to ensure that there are no discrepancies that could adversely affect the estimated environmental impact between this study and the Stage II Report. A review of this type would not involve a review of the costing and should be comparatively easy to complete, but the other reasons given for the review are of more concern.

These reasons include the evaluation of the validity of the costs, a determination of whether or not the project is economically attractive and if the proposed environmental work and monitoring could affect the viability of the project. These evaluations would be difficult, if not impossible to carry out for those agencies who did not have experienced mine project estimators and engineering staff. The question of viability and economic attractiveness is a matter of judgement, which can only be decided by financial institutions and/or joint venture partners.

City Resources therefore considers that the best way for the government to review the study is for one agency alone to do the work and to work closely with City Resources and its consultants in carrying out the work. It is understood that the arrangements made by the Chief Mine Inspector of the MEMPR have been found satisfactory to the interested agencies. City Resources has committed to expedite this one

Response: (cont'd) review by preparing a short addendum volume which will set out the costs of the various environmental measures that are being taken. The addendum will also include an opinion on the sensitivity of these measures to the economic viability of the Project.

Response by: Peter Cowdery, City Resources

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.2 Environmental Supervision

Topic: a) Environmental supervision during and after operation

Comment: The Cinola Project will require a level of ongoing operational environmental management that is unprecedented for a mining project in British Columbia. Great attention to detail in every aspect of mine development will be essential to ensure fail-safe operation of facilities. City Resources must ensure adequate environmental supervision of this project during the construction and operation stages, and provide for inspection and maintenance at closure in perpetuity. Details of these plans are to be provided at Stage II for the review and approval of the MDSC.

While commending the company for developing a mineplan based on requirements for closure, we have problems with an abandonment plan based on engineered structures that are required to remain in place forever. We wonder if the company has realized that such structures, particularly in an area of high rainfall and frequent seismic activity, will require regular inspection and maintenance and that it will be the company's responsibility to ensure that these are provided in perpetuity.

Response: This comment is addressed in the response to MOE, Section 2 c) and d) as well as the response to MEMPR. Section 9a).

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.3 Pit Abandonment Plans

Topic: a) Verification and contingency planning for flooding of the backfilled pit

Comment: The proposed pit reclamation plan calls for 2 years for backfilling and 42 months for flooding. This is a significant time for exposure. Can it be reduced?

Answer: Flooding of the open pit can easily be accelerated in order to reduce the complete backfilling period from 42 months to 24 months. The flooding rate used in design to fill the total void space in the rock backfill of an estimated 4,410,000 m^3 was based on the following inflows to the pit: groundwater and precipitation (minus evaporation), which provide 3020 m^3/d, and a total of 550,000 m^3 of water from impoundment no. 3.

The mine water treatment plant will be shut down at this time and the accumulated water from all the ponds will be directed to the pit. As a consequence, additional water would become available from other sources such as MSSP2, providing an average flow of 550 m^3/d, and MSSP1, which could contribute the average winter flow (September to April), 2549 m^3/d. With these two additional sources the average infill rate would increase such that the flooding period would reduce to approximately 24 months. In addition there will be approximately 1.7×10^6 m^3 of water in the water storage reservoir that could be made available if required.

MOE-8

The exposure time of the waste rock could be reduced further by delaying the start of backfilling for 6 to 12 months to allow the pit to become partially filled. It is important, however, to avoid ultimately overfilling the pit, i.e., adding more water than is required to fill the pore spaces of waste rock.

Abatement of acid generation from the effects of limestone addition in the waste rock stockpile will continue during the backfilling period. In construction of the waste rock stockpile, it is planned to include three times the quantity of limestone required to control acid generation. Therefore, it is expected that a significant quantity of limestone will remain in the waste rock when it is backfilled to the pit.

As discussed in response to Question EC-I-2d, the backfilled pit will remain fully saturated in perpetuity.

Response by: J. Brodie, Steffen Robertson and Kirsten

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.3 Pit Abandonment Plans (continued)

Topic: a) Verification and contingency planning for flooding the backfilled pit

Additional comments in Appendix 1 pertain to the duration of the pit backfilling and submergence period and the implications for acid generation and the mobilization of metal salts on the backfill.

Comment: Filling time (42 months) is approximately twice the time it takes to backfill the waste rock (24 months), so there could be significant acid generated in the pit while it fills with water, causing further deterioration of pit water quality (Appendix 1, Section 4.2, p. 15).

Response: A complete response to this comment is provided in Section I-3e of the response to Environment Canada.

Comment: (cont'd) It should be recognized that acid generation, without the removal of metal salts, will likely have been going on in the stockpile since its initiation. Dumping waste rock into the pit will release these salts. Pit water quality may therefore be much poorer than anticipated (Appendix 1, Section 4.2, p. 15).

Response: This comment is fully addressed in Section I-3f of the response to Environment Canada.

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.3 Pit Abandonment Plans

Topic: b) Effect of seismic activity on the Specogna Fault

Comment: The impacts of repeated seismic events on the integrity of the pit embankment and spillway, on the Specogna Fault, and on the maintenance of the water cover over potentially acid-generating waste rock over the long-term after abandonment must be evaluated.

Response: The Queen Charlotte Islands and BC/Alaska coastline are well recognized as areas of high seismic activity. The Pacific Geoscience Centre catalogue of seismic events indicates that from 1899 to the present day more than 30 earthquakes with epicentres less than 100 km from the Cinola site have occurred. Magnitudes of these earthquake range from 3.7 to 8.0. As discussed in the response to Question MOE-1.1.6, all earth and rockfill structures will be designed to withstand the shaking induced by a maximum credible earthquake (magnitude 8.6 Richter Scale) along the Queen Charlotte Fault, which is a minimum distance of 65 km west of the Cinola site.

The Specogna Fault is not a causitive or principal fault in this region, and there is no evidence of geologically recent movement. It is believed that the hydraulic conductivity of the fault has probably decreased in geologic time. There is no evidence to indicate that groundwater levels in the Specogna Fault have dropped as a result of earthquake activity in the past 100 years. Hence, we do not believe future earthquakes will affect the integrity of the fault.

The pit embankment will not cross the Specogna Fault. The surface trace of the fault lies approximately 75 m west of the proposed embankment location.

The spillway for discharge of surface water off the reclaimed pit to Adit Creek will be excavated in rock. The rock spillway would be stable during earthquakes and will be designed to pass the probable maximum flood.

Retention of water within the backfilled pit is discussed in section MOE-1.1.3 of these responses.

Response by: John Gadsby, Steffen Robertson and Kirsten

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.4 Water Quality

Topic: a) Water quality impacts in Barbie Creek for the 7-day, 1:10 year low flow and a range of pH conditions

Comment: The anticipated quality of water in Barbie Creek during operation and at abandonment must be verified, particularly with respect to 7-day, 1:10 year low flow conditions . . . Verification of anticipated effluent qualities at a range of final pH levels from the water treatment plant is therefore required.

Response: In low flow conditions there will not be any discharge from the water treatment plant via Wetland MSW1 to Barbie Creek during the operating period. Runoff from the pit and, if necessary, from the waste rock stockpile will be stored in settling pond MMSP3 for processing and discharge during higher flows. In addition, contingency plans have been designed to deal with poorer than expected effluent quality (Appendix 1.1-1). Therefore, variations in effluent quality and the 7-day, 1:10-year low flow will not pose concerns for water quality and do not need to be assessed.

However, the water quality of Barbie Creek at closure (Stage II Report, Volume IV, Table 3.6.2-7) has been reassessed for the 7-day, 1:10-year low flow. Assumptions for the calculations were the same as those used in the Stage II report, except that mean values for the April to September Barbie Creek water samples were used to represent background water quality

Response: (cont'd) rather than overall mean values. In addition, based on recent low level analyses (Appendix I-5-1), a background mercury concentration of 7.9 ng/L was used.

As described in the Stage II Report (Volume IV, Section 2.2.2), the reclaimed pit discharges via Adit Creek to Barbie Creek. In the Adit Creek drainage there will be no surface runoff during extremely low flows, and groundwater will supply any flow in the creek. For this reason the water quality of Adit Creek is assumed to be almost the same as that of the pit backfill (Table 1.4-1). After mixing with Adit Creek, the water quality of Barbie Creek will meet MOE receiving water criteria (Table 1.4-2) for all parameters.

Comment: (cont'd) The significance of the anticipated major changes in water quality (pH, hardness, SO_4, nutrients and metals) on fish habitats and populations, particularly with respect to migratory behaviour, should be understood.

Elevated sulphate and hardness levels in Barbie Creek are not expected to have adverse effects on fish habitats, populations, or migratory behaviour.

Since biologically-available heavy metals in Barbie Creek will be below concentrations that might affect upstream migrant fish, concerns are primarily related to a consideration of possible effects on fish movement due to artificially-

TABLE 1.4-1

Expected Quality of Outflow from the Reclaimed Pit (Adit Creek) During the 1:10-Year, 7-Day Low Flow, Predicted by Norecol For the Cinola Gold Project

PARAMETER	PIT BACKFILL CONCENTRATION	ADIT CREEK a APR - SEPT BACKGROUND CONCENTRATION	1:10-YEAR 7-DAY LOW FLOW CONCENTRATION
Adit Creek Flow Rate (m3/s)			0.00013
Groundwater to Pit Seepage Rate (m3/s)			0.0032
Dilution			0.04
Hardness (mg CaCO3/L)	234	14	225
Sulphate (mg/L)	150	5	144
Nitrate (mg N/L) (HiWest)	15.7	0.010	15.1
Total Phosphorus (mg P/L)	0.053	0.052	0.053
Orthophosphate (mg P/L)	0.0047	0.001	0.005
Total Cyanide (mg/L) (HiWest)	0.0005	0.0005	0.0005
WAD Cyanide (mg/L) (HiWest)	0.0005	0.0005	0.0005
Total Metals (mg/L):			
Ag	0.0002	0.0001	0.0002
Al (dissolved)	0.27	0.46	0.28
As	0.006	0.004	0.006
Ba	0.03	0.016	0.029
Cd	0.0003	0.0001	0.0003
Co	0.007	0.002	0.007
Cr	0.0004	0.001	0.0004
Cu	0.013	0.0010	0.013
Fe	0.098	1.90	0.17
Hg (ug/L)	0.05	0.0079	0.049
Mn	0.166	0.17	0.17
Mo	0.03	0.0025	0.029
Ni	0.0076	0.001	0.007
Pb	0.0011	0.0005	0.001
Sb	0.036	0.001	0.035
Se	0.004	0.0005	0.004
Zn	0.0178	0.0045	0.017

a Middle Barbie Creek (Q8) baseline water quality used to represent Adit Creek

TABLE 1.4-2

Expected Water Quality of Barbie Creek at Closure During the 1:10-Year, 7-Day Low Flow, Predicted by Norecol For the Cinola Gold Project

PARAMETER	PIT OUTFLOW (ADIT CREEK) CONCENTRATION	LOWER BARBIE CREEK APR - SEPT BACKGROUND CONCENTRATION	1:10-YEAR 7-DAY LOW FLOW CONCENTRATION	MOE RECEIVING WATER CRITERIA a CONCENTRATION
Lower Barbie Creek Flow Rate (m^3/s)			0.0097	
Pit Water (Adit Creek) Discharge Rate (m^3/s)			0.0033	
Groundwater Discharge Rate (m^3/s)			0.00023	
Dilution			2.9	
Hardness (mg $CaCO_3$/L)	225	14	68	-
Sulphate (mg/L)	144	2	38	-
Nitrate (mg N/L)	15.1	0.028	4.15	10
Total Phosphorus (mg P/L)	0.053	0.052	0.052	-
Orthosphosphate (mg P/L)	0.005	0.001	0.0019	-
Total Cyanide (mg/L)	0.0005	0.0005	0.0005	-
WAD Cyanide (mg/L)	0.0005	0.0005	0.0005	0.01
Total Metals (mg/L):				
Ag	0.0002	0.0001	0.0001	0.0001
Al (dissolved)	0.28	0.35	0.33	0.04 b
As	0.006	0.005	0.005	0.05
Ba	0.029	0.008	0.013	5.0
Cd	0.0003	0.0001	0.0001	0.0008
Co	0.007	0.001	0.002	0.05
Cr	0.0004	0.0005	0.0005	0.002
Cu	0.013	0.0008	0.0038	0.0053 c
Fe	0.17	2.55	1.94	0.3
Hg (ug/L)	0.049	0.0079	0.031	0.1
Mn	0.17	0.28	0.25	0.1
Mo	0.029	0.005	0.011	2.0
Ni	0.007	0.001	0.003	0.065
Pb	0.001	0.0005	0.001	0.016
Sb	0.035	0.001	0.010	0.05
Se	0.004	0.0005	0.001	0.001
Zn	0.017	0.0032	0.0068	0.03

a Maximum acceptable concentration at predicted hardness (where applicable)

b Criterion for median background pH = 5.7

c Criterion for hardness of 35 mg $CaCO_3$/L, which is the average expected hardness for 30 days containing the 1:10-year, 7-day low flow (based on measured flows from July 1987)

Response: (cont'd)

elevated calcium and sulphate levels. Literature and professional judgement shows that calcium and sulphate ions are both relatively innocuous to fish and neither has been reported to cause avoidance responses at the concentrations anticipated in Barbie Creek. Thus there is no evidence which suggests that the passage of fish migrating up Barbie Creek to the spawning grounds would be impeded by the expected water quality conditions.

Even under extreme 10-year low flow conditions when sulphate levels in Barbie Creek are projected to reach 500 mg/L (Stage II Addendum, Appendix 8.3-1), adverse effects on fish behaviour or homing ability are not anticipated. Neutral sulphate salts (e.g. sodium sulphate, calcium sulphate, magnesium sulphate) are relatively innocuous to salmonid fish and require strengths of several thousand mg/L before toxicity is evidenced. No studies could be found which showed avoidance responses of fish to elevated sulphate levels.

The question of artificially-elevated water hardness adversely affecting the homing ability of returning adult salmonids has been addressed by contacting experts in that field. The Scandinavian experiences to date with lakes, rivers and streams limed to counteract acidic conditions due to acid rain indicate improved returns of migrant salmon following liming (Andersson et al. 1984, Per Ostensson 1985).

Response: (cont'd)

Fisheries scientists in eastern Canada are now liming acid streams in attempts to recover salmon runs endangered by acid rain (Watt 1986; W. Watt and W. White, DFO Halifax, pers. comm.); similar liming projects are also underway in northern Ontario (J. Munro and G. Booth, Ontario Ministry of Environment, pers. comm.) and being considered for British Columbia waterbodies where acidic water conditions due to acid rain are threatening certain salmon runs (K. Hyatt, DFO Nanaimo, pers. comm.).

The consensus of opinion from all informed persons contacted by phone is that liming of soft, low pH water to increase pH is proving beneficial to the salmonid populations inhabiting the limed waterbodies or those downstream of treatment. Beneficial effects include enhanced numbers of rearing juveniles, and consequent improvements in numbers of downstream migrants (smolts) and returning adults. From this experience, we can be confident that this degree of liming is not harmful to the fishery (and is indeed beneficial due to counteracting natural acid conditions).

Productive salmonid fisheries (including those with migrant species) exist in locations where water hardness is very high. For instance, chalk rivers (flowing through limestone deposits) in England can support a good fishery (I. Birtwell, DFO West Vancouver, pers. comm.). In addition, the mitigating effect of water

Response: (cont'd) hardness on heavy metal toxicity to fish increases progressively with increasing hardness values up to 500 mg/L (Sprague 1985). This mitigatory influence is recognized by incorporating hardness values in the definition of receiving water criteria for various metals. At metal hardness levels predicted for Barbie Creek during operation, receiving waters consistently meet criteria for protection of aquatic life - including rearing and migrating salmon.

The other issue which has been raised is whether the elevated hardness predicted for Barbie Creek downstream of the treatment plant might interfere with the normal homing response of fish to chemical cues which were imprinted during their stream rearing or downstream migration. Potential sources of concern include:

a) an adverse effect on the performance of the olfactory sensory system due to high calcium in solution;

b) binding of calcium with trace organic substances responsible for olfactory excitation and homing;

c) masking (by high calcium in solution) of those trace organic constituents responsible for imprinting and upstream migration of salmonids.

Response: (cont'd)

A recent phone conversation was held with Dr. Kjell Doving (Dept. of Zoophysiology University of Oslo, Norway). (Dr. Doving and colleagues are actively involved in research projects associated with salmon olfaction and migrant behaviour in response to water chemistry). Dr. Doving did not anticipate any problem in the functioning of the fishes' olfactory sensory system due to high calcium concentrations (high water hardness). Calcium is necessary for proper functioning, and calcium deficiency rather than excess would pose a problem.

With respect to high lime additions masking sensory cues or otherwise adsorbing to the trace organics to which fish have been imprinted, Doving commented that "The probability of calcium binding these molecules is very little." He stated that the olfactory response was triggered by amphoteric substances, and he would not expect calcium to mask these substances.

To conclude, based on the professional judgement of prominent workers in this area, the artificial elevation of hardness in lower Barbie Creek water up to maximum predicted values of 500 mg/L is not expected to cause an impact on returning adult salmonids. Exposure of returning adult salmon to this 10-year extreme low flow may be an unlikely event due to the timing of extreme low flow versus that for the normal seasonal migration of coho salmon. Extreme low

Response: (cont'd)

flows are expected to occur during summer months and are extremely unlikely after mid September. Coho migration in Barbie Creek commences in October. The hardness values predicted for the Yakoun River (normal seasonal values of 14-20 mg/L upon complete mixing with downstream Barbie Creek water containing limed minewater) indicate no adverse effects on salmonids due to increased hardness within this waterbody.

Further, changes in water quality should have no adverse effects on downstream migrants, since predicted heavy metals are below those that would cause an adverse effect (e.g. avoidance, stress, etc.). Migrant smolts are euryhaline and naturally encounter an appreciable variation in salinity during their residence in estuaries. Further, their urge to move downstream (when the biological clock says "go") is quite strong - and most likely unaffected by the differences in water hardness they would encounter while moving down Barbie Creek and into the Yakoun River.

The question is best viewed with respect to expected conductivity changes in Barbie Creek due to the addition and mixing of the limed minewater. Under extreme (10-year) low flow conditions, a maximum conductivity of approximately 800 micromhos/cm is predicted for lower Barbie Creek water (following mixing of

Response: (cont'd) the treated minewater). In terms of fish osmoregulation, this is equivalent to a salinity value of less than 1 part per thousand (o/oo). Thus, no osmoregulatory shock or adverse effect on exposed smolts could be attributed to this ionic (salt) strength. Assuming that the extreme elevation in conductivity for downstream Barbie Creek water results primarily from Ca++, Na+, SO_4^{-2} and NO_3-, no barrier to downstream movement of migrant smolts would be anticipated due to these ions.

Response by: Don McLeay, D. McLeay and Associates
Annette Smith, Norecol

References:

Andersson, B.I., I. Alenas and H. Hultberg. 1984. Liming of a small acidified river (River Anrasean) in southwestern Sweden, promoting successful reproduction of sea trout (*Salmo trutta*). 27 p. Inst. Freshwater Res. Report NO. 61 National Swedish Board of Fisheries. Drottningholm.

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Report. Volume IV. Environmental Impact Assessment and Management Programs. pp. 2-51

Per Ostensson. 1985. An example of a successful restoration of an acidified stream through continuous liming - the River Fyllea in Sweden. Paper presented at the International Symposium on Acid Precipitation, Sept. 15-20, 1985. Muskoka, Ontario

References: (cont'd)

Sprague, J. B. 1985. Factors that modify toxicity, Chapter 6, p. 124-163.

In G.M. Rand and S.R. Petrocelli (eds) Fundamentals of Aquatic Toxicology. Methods and Applications. McGraw Hill.

Watt, W.D. 1986. The case for liming some Nova Scotia salmon rivers. Water, Air and Soil Pollut. 31: 775-789.

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.4 Water Quality

Topic: b) Mercury levels in Barbie and Florence creeks during the 7-day, 1:10-year low flow

Comment: The potential for mercury to exceed receiving water quality objectives in Florence Creek and the Barbie Creek system must be investigated more closely, particularly under 7-day, 1:10-year low flow conditions.

Response: Mercury levels predicted for the 7-day, 1:10 year low flow conditions are discussed in the responses to MOE comments 1.4a and 1.4c. The predictions given in these responses are conservative because of the relatively high mercury levels assumed in the effluents. The mercury concentration in pit backfill was assumed to be 0.05 ug/L (the analytical detection limit) based on undetectable mercury concentrations in leachate from the limed columns experiment (Stage II Report, Table 2.2.2-2). Recent low level mercury measurements (Appendix 1.5-1) on leachate from the limed columns have indicated a much lower concentration, 1.8 ng/L. Similarly, the mercury level in tailings porewater seeping into the reclaimed impoundments was assumed to be 0.24 ug/L based on total mercury measured in the pilot mill effluent (Stage II Addendum, Table 8.2-1). Low level total mercury determinations were not done on tailings porewater, but the recent studies showed undetectable (<0.2 ng/L)

Response: (cont'd) levels of ionic mercury, the form which would be available for methylation (Appendix I-5-1).

Response by: Annette Smith, Norecol

References:

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Report. Volume IV. Environmental Impact Assessment and Management Programs. p. 2-45

City Resources (Canada) Limited. 1988. Cinola Gold Project Stage II Addendum Report. p. 8-4.

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.4 Water Quality

Topic: c) Water quality impacts in Florence Creek for the 7-day, 1:10 year low flow and a range of mill effluent quality conditions

Comment: The potential for unacceptable changes in water quality in Florence Creek during operation and after operations have ceased should be examined more closely, particularly with respect to nutrients and metals. Predictions of water quality impacts should be verified using a realistic excursion envelope for mill effluent quality based upon operating experience from other mines and using 7-day, 1:10 year low flow conditions. (An additional comment in Appendix 4 requests that these predictions be presented in a summary table).

Response: Since there will be no discharges from active impoundments, variations in mill effluent quality will have no impact on Florence Creek. In addition because of the recycling of supernatant and constant mixing of tailings as they are spigotted into the impoundments, short term variations in tailings quality are expected to be well attenuated in the impoundment and will have a negligible effect on pore water quality.

The pilot mill effluent quality used for predicting impacts of discharges from reclaimed impoundments (Stage II Addendum, Table 8.2-1) is considered the best available estimate of effluent quality but is a worst case estimate of tailings pore water seeping into the reclaimed impoundments because it assumes plug displacement. Further, since there will be no

Response: (cont'd) discharges from the reclaimed impoundments during dry periods, the 7-day, 1:10-year low flow is not expected to present a concern during operation. Therefore, additional water quality predictions for the 7-day, 1:10-year low flow are made only for closure when discharges from the reclaimed impoundments will occur. The mill effluent quality described in the Stage II Report is used for these predictions.

Table 8.2-5 (Stage II Addendum) showing water quality of Florence Creek at closure has been updated using the 7-day, 1:10 year low flow (Table 1.4-3). Receiving water criteria are met for most parameters, including copper and mercury. However, the predictions suggest that silver and aluminum will slightly exceed MOE criteria. The predicted silver concentration is an artifact of the assumed background concentration (half the detection limit or 0.0001 mg/L), which is equal to the criterion. The aluminum concentration is predicted to increase by more than 10% but will remain within the range of background variability described in the Stage II Report (Volume III Appendix 5.5.4-1, Table 9B); therefore this change will be difficult to demonstrate. Further, as noted in the Stage II Addendum, some removal of aluminum in the pond/wetland is likely.

Table 1.4-3 also suggests that during the low flow event, nitrate would exceed 10 mg/L. However, this prediction does not take into account any nitrate removal in the pond/wetland.

TABLE 1.4-3

Water Quality of Florence Creek at Closure during the 1:10 Year 7-Day Low Flow, Predicted by Norecol for the Cinola Gold Project

PARAMETER	GROUNDWATER EFFLUENT CONCENTRATION a	SURFACE EFFLUENT CONCENTRATION b	FLORENCE CREEK APR - SEPT BACKGROUND CONCENTRATION	1:10-YEAR 7-DAY LOW FLOW CONCENTRATION	MOE RECEIVING WATER CRITERIA CONCENTRATION c
Florence Creek Flow Rate (m3/s)				0.02	
Surface Effluent Discharge Rate (m3/s)				0.0015	
Groundwater Effluent Discharge Rate (m3/s)				0.00022	
Dilution				10.6	
Hardness (mg CaCO3/L)	1629	1629	11	150	-
Sulfate (mg/L)	3250	3250	1	280	-
Nitrate (mg N/L)	295	295	0.010	25.4 d	10
Total Phosphorus (mg P/L)	0.50	0.50	0.036	0.076	-
Total Cyanide (mg/L)	0.14	0.001	0.0005	0.001	-
WAD Cyanide (mg/L)	0.083	0.001	0.0005	0.001	0.01
Total Metals (mg/L)					
Ag	0.0020	0.0020	0.0001	0.0003	0.0001
Al (dissolved)	1.4	1.4	0.26	0.36	0.1
As	0.13	0.13	0.001	0.012	0.05
Ba	0.05	0.05	0.006	0.010	5.0
Cd	0.001	0.001	0.0001	0.0002	0.0013
Co	0.52	0.52	0.001	0.046	0.05
Cr	0.017	0.017	0.0005	0.002	0.002
Cu	0.05	0.05	0.0006	0.0049	0.0083 e
Fe	0.07	0.07	0.49	0.45	0.3
Hg (ug/L)	0.24	0.24	0.0037	0.024	0.1
Mn	0.02	0.02	0.030	0.029	0.1
Mo	0.13	0.13	0.0025	0.013	2.0
Ni	0.08	0.08	0.001	0.008	0.11
Pb	0.02	0.02	0.0005	0.002	0.035
Sb	0.10	0.10	0.001	0.010	0.05
Se	0.006	0.006	0.0005	0.001	0.001
Zn	0.02	0.02	0.0008	0.0024	0.03

a Pore water seepage from reclaimed Impoundment No. 3; assumes 1 year (2 half-lives) of cyanide degradation/copper precipitation

b Pore water displaced to surface of reclaimed Impoundments Nos. 1 and 2; assumes that after at least 10 half-lives cyanide has degraded to the analytical detection limit

c Maximum acceptable concentration at predicted hardness (where applicable)

d Conservatively assuming 80% wetland efficiency, NO3 would be 7.7 mg N/L

e Criterion for hardness of 67 mg CaCO3/L, which is the average expected hardness for 30-days containing a 1:10 year, 7-day low flow (based on measured flows from July 1987)

MOE-27

Response: (cont'd) A 7-day, 1:10 year low flow would occur during the summer, when nitrate removal efficiency is highest. If a conservative 80% removal efficiency is assumed, the expected nitrate concentration in Florence Creek is 7.7 mg/L.

The mercury concentration during a 1:10-year 7-day low flow has been predicted using an average Florence Creek background mercury concentration of 3.7 ng/L based on recent low level mercury measurements (Appendix I-5-1). The predicted mercury level in receiving water is 0.024 ug/L, well below the criterion of 0.1 ug/L.

As noted earlier the 7-day, 1:10-year low flow is not considered to be the limiting flow condition during operation because there are no discharges from the active impoundment during operation and because there are no surface discharges from the reclaimed impoundments during the low flow months. Since seepage in the impoundments will continue at a constant rate in all months, the worst case to occur during operation will likely result from the initial discharge of the reclaimed impoundments following accumulation of seepage over the summer months. This case was assessed in the Stage II Report (Volume IV, Tables 3.6.3-1 and 3.6.3-2). However, the assessment assumed that, except for the increased concentrations discharged in September, the water quality of the reclaimed impoundments would remain constant throughout the year. It was subsequently

Response: (cont'd) determined that because inflows from precipitation and runoff, as well as outflows, vary from month to month, the quality of the supernatant would change with time. Accordingly, monthly quality of the reclaimed impoundments was determined and used to predict water quality in Florence Creek during years 6 (following deactivation and reclamation of Impoundment No. 2) and 10 (following deactivation and reclamation of Impoundment No. 3). Assumptions used to predict monthly water quality are outlined below:

- o Figure 1.4-1 schematically illustrates the water balance assumed;

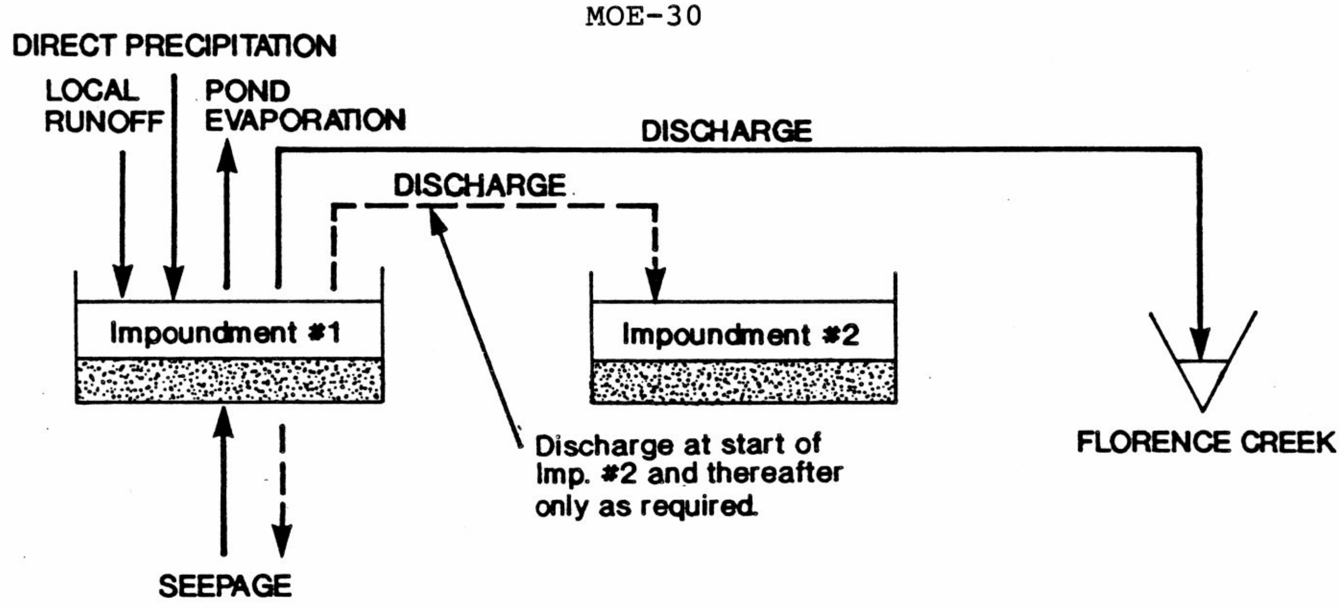
- o Mass balance equations were used to calculate resultant water quality in the ponds;

- o The first two years after reclamation were modelled for each impoundment. Predictions for the second years (year 6 in Impoundment No. 1 and year 10 in Impoundment No. 2) are presented in Tables 1.4-4 and 1.4-5;

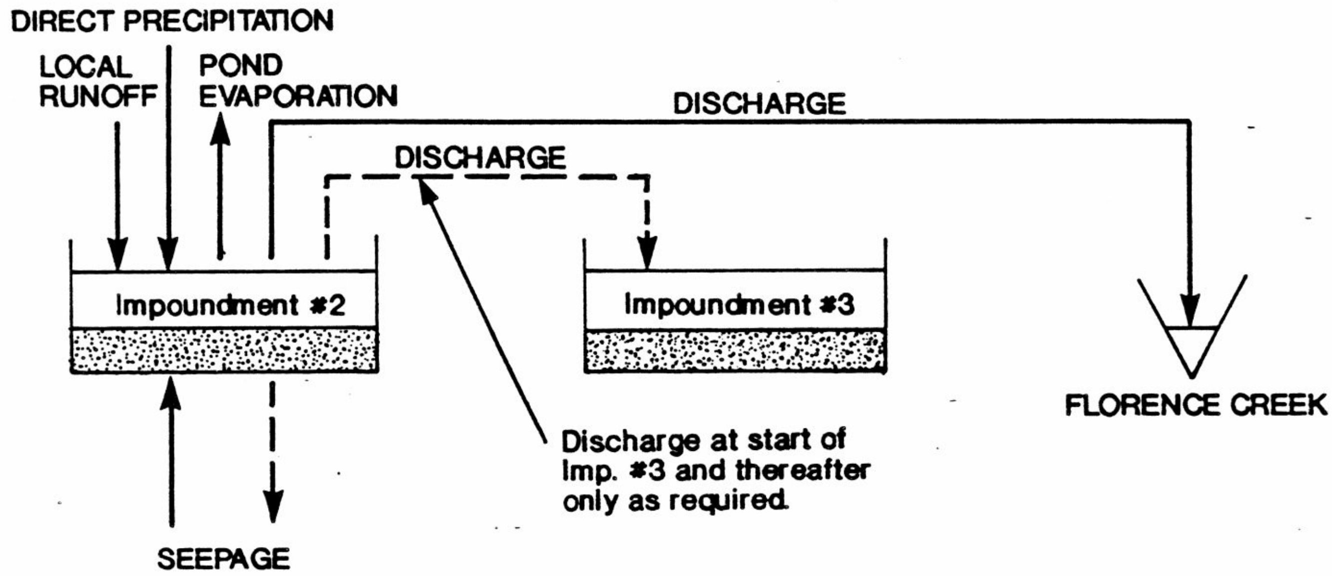
- o The mass balance equation for January of the first year was:

  Seepage In = V1
  Seepage Water Quality = Q1
  Precipitation + runoff - evaporation = V2
  Florence Creek Background Water Quality = Q2
  Resultant pond volume = V3
  Resultant quality in pond = Q3

$$Q3 = \frac{V1Q1 + V2Q2}{V3}$$



IMPOUNDMENT #1 RECLAIMED



IMPOUNDMENT #2 RECLAIMED

WATER FLOW SCHEMATICS FOR RECLAIMED IMPOUNDMENTS	
Figure no. 1.4-1	CINOLA GOLD PROJECT STAGE II RESPONSE
Date Mar. 1989	Drawn by NORECOL

TABLE 1.4-4

Expected End of Month Quality in Reclaimed Impoundment No. 1,
Predicted by Norecol for the Cinola Gold Project

PARAMETER a	FLORENCE CREEK BACKGROUND CONCENTRATION	TAILINGS POREWATER CONCENTRATION	CONCENTRATION IN RECLAIMED IMPOUNDMENT, YEAR 6 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Direct Precipitation (1000 m3/d)			2.72	3.01	1.81	2.22	1.41	1.09	1.01	0.98	2.16	3.74	3.38	3.27
Local Runoff (1000 m3/d)			0.24	0.27	0.16	0.20	0.13	0.10	0.09	0.09	0.19	0.34	0.30	0.29
Pond Evaporation (1000 m3/d)			0.16	0.22	0.33	0.52	0.83	1.13	1.31	1.23	0.92	0.55	0.27	0.15
Seepage In (1000 m3/d)			0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
Seepage Out (1000 m3/d)			0.024	0.024	0.024	0.024	0.024	0.024	0.023	0.023	0.023	0.023	0.023	0.022
Discharge to Imp #2 (1000 m3/d)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Discharge to Creek (1000 m3/d)			2.84	3.10	1.69	1.95	0.75	0.11	0.00	0.00	1.18	3.57	3.46	3.46
Water in Pond (Million m3)			0.114	0.114	0.114	0.114	0.114	0.114	0.109	0.105	0.114	0.114	0.114	0.114
Hardness (mg CaCO3/L)	10	1629	45	42	50	53	70	97	133	170	142	88	62	48
Sulfate (mg/L)	0.5	3250	88	81	98	104	137	190	262	335	280	173	121	94
Sodium (mg/L)	5.93	2200	60	55	67	71	93	129	178	228	191	118	83	64
Nitrate (mg N/L)	0.014	295	7.95	7.36	8.86	9.41	12.4	17.2	23.8	30.4	25.4	15.7	11.0	8.55
Total Phosphorus (mg P/L)	0.029	0.50	0.016	0.015	0.018	0.019	0.024	0.033	0.045	0.057	0.048	0.030	0.022	0.017
Total Cyanide (mg/L)	0.0005	0.54	0.015	0.014	0.016	0.017	0.023	0.032	0.044	0.056	0.047	0.029	0.020	0.016
WAD Cyanide (mg/L)	0.0005	0.33	0.0089	0.0083	0.010	0.011	0.014	0.019	0.027	0.034	0.029	0.018	0.012	0.0096
Total Metals (mg/L):														
Ag	0.0001	0.0020	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
Al (dissolved)	0.27	1.4	0.06	0.06	0.07	0.07	0.09	0.12	0.16	0.19	0.17	0.11	0.08	0.07
As	0.001	0.13	0.004	0.003	0.004	0.004	0.006	0.008	0.011	0.014	0.011	0.007	0.005	0.004
Ba	0.005	0.05	0.002	0.002	0.002	0.002	0.003	0.004	0.005	0.006	0.005	0.003	0.002	0.002
Cd	0.0001	0.001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000
Co	0.001	0.52	0.014	0.013	0.016	0.017	0.022	0.031	0.042	0.054	0.045	0.028	0.020	0.015
Cr	0.0005	0.017	0.0005	0.0005	0.0006	0.0006	0.0008	0.0011	0.0014	0.0018	0.0016	0.0010	0.0007	0.0005
Cu	0.0006	0.1000	0.0028	0.0026	0.0031	0.0032	0.0043	0.0059	0.0082	0.0104	0.0087	0.0054	0.0038	0.0030
Fe	0.45	0.07	0.04	0.04	0.04	0.04	0.05	0.06	0.08	0.09	0.08	0.06	0.05	0.05
Hg (ug/L)	0.0037	0.24	0.007	0.006	0.008	0.008	0.010	0.015	0.020	0.025	0.021	0.013	0.009	0.007
Mn	0.023	0.02	0.003	0.003	0.003	0.003	0.003	0.004	0.005	0.006	0.006	0.004	0.003	0.003
Mo	0.0025	0.13	0.0037	0.0035	0.0041	0.0044	0.0057	0.0079	0.011	0.014	0.012	0.0072	0.0051	0.0040
Ni	0.001	0.08	0.002	0.002	0.002	0.003	0.003	0.005	0.007	0.008	0.007	0.004	0.003	0.002
Pb	0.0005	0.02	0.0006	0.0005	0.0006	0.0007	0.0009	0.0012	0.0017	0.0022	0.0018	0.0011	0.0008	0.0006
Sb	0.001	0.10	0.003	0.003	0.003	0.003	0.004	0.006	0.008	0.010	0.009	0.005	0.004	0.003
Se	0.0005	0.006	0.0002	0.0002	0.0002	0.0002	0.0003	0.0004	0.0006	0.0007	0.0006	0.0004	0.0003	0.0002
Zn	0.0008	0.02	0.0006	0.0006	0.0007	0.0007	0.0009	0.0013	0.0017	0.0022	0.0019	0.0012	0.0008	0.0007

a Impoundment water balance from Cinola Stage II Volume II Appendicies, Appendix 6.8.1-1

MOE-31

TABLE 1.4-5

Expected End of Month Water Quality in Reclaimed Impoundment No. 2,
Predicted by Norecol for the Cinola Gold Project

PARAMETER a	FLORENCE CREEK BACKGROUND CONCENTRATION	TAILINGS POREWATER CONCENTRATION	CONCENTRATION IN RECLAIMED IMPOUNDMENT, YEAR 10 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Direct Precipitation (1000 m3/d) b			2.51	2.78	1.67	2.05	1.30	1.01	0.93	0.91	1.99	3.45	3.12	3.02
Local Runoff (1000 m3/d)			0.68	0.76	0.46	0.56	0.35	0.27	0.25	0.25	0.54	0.94	0.85	0.82
Pond Evaporation (1000 m3/d)			0.15	0.21	0.30	0.48	0.77	1.04	1.21	1.14	0.85	0.51	0.25	0.14
Seepage In (1000 m3/d)			0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
Seepage to Saddle (1000 m3/d)			0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Seepage Out (1000 m3/d)			0.015	0.014	0.014	0.014	0.013	0.013	0.013	0.013	0.012	0.012	0.012	0.012
Discharge to Imp #3 (1000 m3/d)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Discharge to Creek (1000 m3/d)			3.08	3.37	1.87	2.17	0.93	0.28	0.02	0.06	1.73	3.92	3.76	3.75
Water in Pond (Million m3)			0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
Hardness (mg CaCO3/L)	10	1629	34	32	39	41	54	73	98	122	101	62	45	36
Sulfate (mg/L)	0.5	3250	63	60	73	77	102	140	189	234	194	118	84	66
Sodium (mg/L)	5.93	2200	44	42	50	54	70	96	130	161	134	82	58	46
Nitrate (mg N/L)	0.014	295	5.75	5.39	6.59	6.99	9.22	12.7	17.1	21.2	17.6	10.7	7.59	6.02
Total Phosphorus (mg P/L)	0.029	0.50	0.016	0.016	0.018	0.019	0.023	0.031	0.040	0.049	0.041	0.027	0.021	0.017
Total Cyanide (mg/L)	0.0005	0.54	0.011	0.010	0.012	0.013	0.017	0.023	0.031	0.039	0.032	0.020	0.014	0.011
WAD Cyanide (mg/L)	0.0005	0.33	0.0065	0.0061	0.0075	0.0079	0.010	0.014	0.019	0.024	0.020	0.012	0.0086	0.0069
Total Metals (mg/L):														
Ag	0.0001	0.0020	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
Al (dissolved)	0.27	1.4	0.09	0.09	0.09	0.10	0.12	0.14	0.18	0.22	0.19	0.13	0.11	0.09
As	0.001	0.13	0.003	0.003	0.003	0.003	0.004	0.006	0.008	0.010	0.008	0.005	0.004	0.003
Ba	0.005	0.05	0.002	0.002	0.002	0.002	0.003	0.004	0.005	0.006	0.005	0.004	0.003	0.002
Cd	0.0001	0.001	0.00004	0.00004	0.00005	0.00005	0.00006	0.00007	0.00010	0.00012	0.00010	0.00007	0.00005	0.00004
Co	0.001	0.52	0.010	0.010	0.012	0.013	0.017	0.023	0.031	0.038	0.031	0.019	0.014	0.011
Cr	0.0005	0.017	0.0004	0.0004	0.0005	0.0005	0.0007	0.0009	0.0012	0.0014	0.0012	0.0008	0.0006	0.0005
Cu	0.0006	0.10	0.0021	0.0020	0.0024	0.0025	0.0033	0.0045	0.0060	0.0075	0.0062	0.0038	0.0027	0.0022
Fe	0.45	0.07	0.11	0.10	0.11	0.11	0.12	0.14	0.17	0.20	0.18	0.14	0.12	0.11
Hg (ug/L)	0.025	0.24	0.010	0.010	0.011	0.012	0.014	0.018	0.023	0.028	0.024	0.017	0.013	0.011
Mn	0.023	0.02	0.006	0.006	0.006	0.006	0.007	0.008	0.010	0.012	0.010	0.008	0.007	0.006
Mo	0.0025	0.13	0.0031	0.0029	0.0035	0.0037	0.0047	0.0064	0.0085	0.0105	0.0088	0.0055	0.0040	0.0033
Ni	0.001	0.08	0.002	0.002	0.002	0.002	0.003	0.004	0.005	0.006	0.005	0.003	0.002	0.002
Pb	0.0005	0.02	0.0005	0.0005	0.0006	0.0006	0.0008	0.0010	0.0013	0.0017	0.0014	0.0009	0.0006	0.0005
Sb	0.001	0.10	0.002	0.002	0.002	0.003	0.003	0.005	0.006	0.008	0.006	0.004	0.003	0.002
Se	0.0005	0.006	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0005	0.0007	0.0006	0.0004	0.0003	0.0002
Zn	0.0008	0.02	0.0006	0.0005	0.0006	0.0007	0.0008	0.0011	0.0015	0.0018	0.0015	0.0010	0.0007	0.0006

a Impoundment water balance from Cinola Stage II Volume II Appendicies, Appendix 6.8.1-1

b Assumed to be deionized water

MOE-32

Response: (cont'd)

- The mass balance equation for other months through the end of year two was:

  V1, V2, Q1, Q2 as above
  Resultant Water Quality in Pond from Previous Month = Q3
  Resultant Pond Volume from Previous Month = Volume in Pond for that month = V3
  Resultant Volume in Pond for Current Month = sum of inputs - sum of outflows added to V3 as per schematic = V4
  Resultant Water Quality in Pond for Current Month = Q4

  $$Q4 = \frac{V1Q1 + V2Q2 + V3Q3}{V4}$$

- Physical parameters were derived from the impoundment water balance presented in the Stage II Report, Volume II Appendix 6.8.1-1;

- To maintain consistency with the Stage II Report, clean water inflow, that is runoff, was taken to have Florence Creek background water quality; precipitation was assumed to be de-ionized water.

- Pond seepage water quality was assumed to be pilot mill effluent quality as per the Stage II Addendum Report; and

- To maintain consistency with the Stage II Report, seepage out of the impoundments in the Florence Creek system was not included in calculations; seepage from impoundment 2 through the Saddle Embankment to Boucher Creek was included.

Response: (cont'd)

- In the months of July and August for Impoundment No. 1 and in July for Impoundment No. 2 evaporation exceeds precipitation plus runoff. Volumes were taken to be zero for mass balance calculations for those months.

The quality of the reclaimed impoundments presented in Tables 1.4-4 and 1.4-5 represents end-of-month quality. It is necessary to predict a mean monthly quality to be discharged into the mean monthly flows. The mean quality for any month is the average of the end-of-month qualities for that month and the previous month (Tables 1.4-6 and 1.4-7).

Monthly water quality predictions for Florence Creek during year 6 (Impoundment No. 1 reclaimed) and year 10 (Impoundment Nos. 1 and 2 reclaimed) are presented in Tables 1.4-8 and 1.4-9. Changes from the predictions given in the Addendum report are minor, except that it is necessary to assume some cyanide degradation and copper precipitation in order to meet receiving water criteria in September of year 10.

As suspected the September water quality is very likely the worst case to be encountered during operation because seepage accumulates in the impoundments over the summer with reduced dilution by precipitation. If the impoundment water is discharged in early fall the assimilative capacity of Florence Creek may be insufficient to receive an uncontrolled

TABLE 1.4-6

Expected Mean Monthly Water Quality in Reclaimed Impoundment No.1,
Predicted by Norecol for the Cinola Gold Project

	CONCENTRATION IN RECLAIMED IMPOUNDMENT, YEAR 6											
PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Hardness (mg $CaCO_3$/L)	46	43	46	51	61	83	115	151	156	115	75	55
Sulfate (mg/L)	91	84	89	101	120	163	226	299	308	226	147	108
Sodium (mg/L)	62	58	61	69	82	111	154	203	209	154	100	74
Nitrate (mg N/L)	8.25	7.66	8.11	9.14	10.9	14.8	20.5	27.1	27.9	20.6	13.4	9.8
Total Phosphorus (mg P/L)	0.017	0.016	0.016	0.018	0.021	0.029	0.039	0.051	0.053	0.039	0.026	0.020
Total Cyanide (mg/L)	0.015	0.014	0.015	0.017	0.020	0.027	0.038	0.050	0.051	0.038	0.025	0.018
WAD Cyanide (mg/L)	0.009	0.009	0.009	0.010	0.012	0.017	0.023	0.030	0.031	0.023	0.015	0.011
Total Metals (mg/L):												
Ag	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001
Al (dissolved)	0.064	0.060	0.062	0.068	0.079	0.10	0.14	0.18	0.18	0.14	0.096	0.074
As	0.004	0.003	0.004	0.004	0.005	0.007	0.009	0.012	0.013	0.009	0.006	0.004
Ba	0.002	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.006	0.004	0.003	0.002
Cd	0.000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Co	0.015	0.014	0.014	0.016	0.019	0.026	0.036	0.048	0.049	0.036	0.024	0.017
Cr	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001
Cu	0.0029	0.0027	0.0028	0.0032	0.0038	0.0051	0.0070	0.0093	0.0096	0.0071	0.0046	0.0034
Fe	0.044	0.042	0.042	0.044	0.048	0.056	0.069	0.085	0.087	0.073	0.058	0.049
Hg (ug/L)	0.007	0.007	0.007	0.008	0.009	0.012	0.017	0.023	0.023	0.017	0.011	0.008
Mn	0.003	0.003	0.003	0.003	0.003	0.004	0.005	0.006	0.006	0.005	0.004	0.003
Mo	0.004	0.004	0.004	0.004	0.005	0.007	0.009	0.012	0.013	0.009	0.006	0.005
Ni	0.002	0.002	0.002	0.003	0.003	0.004	0.006	0.008	0.008	0.006	0.004	0.003
Pb	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001
Sb	0.003	0.003	0.003	0.003	0.004	0.005	0.007	0.009	0.010	0.007	0.005	0.003
Se	0.0002	0.0002	0.0002	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0005	0.0003	0.0003
Zn	0.0006	0.0006	0.0006	0.0007	0.0008	0.0011	0.0015	0.0020	0.0020	0.0015	0.0010	0.0007

TABLE 1.4-7

Expected Mean Monthly Water Quality in Reclaimed Impoundment No. 2,
Predicted by Norecol for the Cinola Gold Project

CONCENTRATION IN RECLAIMED IMPOUNDMENT, YEAR 10

PARAMETER a	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Hardness (mg CaCO3/L)	35	33	35	40	47	63	86	110	111	82	53	40
Sulfate (mg/L)	65	61	66	75	89	121	164	211	214	156	101	75
Sodium (mg/L)	45	43	46	52	62	83	113	145	147	108	70	52
Nitrate (mg N/L)	5.88	5.57	5.99	6.79	8.10	10.9	14.9	19.2	19.4	14.2	9.15	6.81
Total Phosphorus (mg P/L)	0.017	0.016	0.017	0.018	0.021	0.027	0.035	0.044	0.045	0.034	0.024	0.019
Total Cyanide (mg/L)	0.011	0.010	0.011	0.013	0.015	0.020	0.027	0.035	0.036	0.026	0.017	0.013
WAD Cyanide (mg/L)	0.007	0.006	0.007	0.008	0.009	0.012	0.017	0.022	0.022	0.016	0.010	0.008
Total Metals (mg/L):												
Ag	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001
Al (dissolved)	0.09	0.09	0.09	0.10	0.11	0.13	0.16	0.20	0.20	0.16	0.12	0.10
As	0.003	0.003	0.003	0.003	0.004	0.005	0.007	0.009	0.009	0.007	0.004	0.003
Ba	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.005	0.006	0.004	0.003	0.003
Cd	0.00004	0.00004	0.00004	0.00005	0.00005	0.00007	0.00009	0.00011	0.00011	0.00008	0.00006	0.00005
Co	0.011	0.010	0.011	0.012	0.015	0.020	0.027	0.034	0.035	0.025	0.016	0.012
Cr	0.0005	0.0004	0.0005	0.0005	0.0006	0.0008	0.0010	0.0013	0.0013	0.0010	0.0007	0.0005
Cu	0.0021	0.0020	0.0022	0.0024	0.0029	0.0039	0.0053	0.0067	0.0068	0.0050	0.0033	0.0025
Fe	0.11	0.10	0.11	0.11	0.12	0.13	0.16	0.19	0.19	0.16	0.13	0.12
Hg (ug/L)	0.011	0.010	0.011	0.011	0.013	0.016	0.021	0.026	0.026	0.020	0.015	0.012
Mn	0.006	0.006	0.006	0.006	0.006	0.008	0.009	0.011	0.011	0.009	0.007	0.006
Mo	0.003	0.003	0.003	0.004	0.004	0.006	0.007	0.009	0.010	0.007	0.005	0.004
Ni	0.002	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.006	0.004	0.003	0.002
Pb	0.001	0.0005	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001
Sb	0.002	0.002	0.002	0.003	0.003	0.004	0.005	0.007	0.007	0.005	0.003	0.003
Se	0.0002	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0006	0.0006	0.0005	0.0003	0.0003
Zn	0.0006	0.0006	0.0006	0.0006	0.0007	0.0010	0.0013	0.0016	0.0016	0.0012	0.0009	0.0007

TABLE 1.4-8

Expected Water Quality of Florence Creek After Reclamation of Impoundment No.1,
Based on Mean Monthly Quality in the Reclaimed Impoundment,
Predicted by Norecol for the Cinola Gold Project

PARAMETER	FLORENCE CREEK BACKGROUND CONCENTRATION	CONCENTRATIONS IN RECEIVING WATERS, YEAR 6											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Florence Creek Flow Rate (m3/s)		0.48	0.43	0.47	0.36	0.21	0.10	0.15	0.15	0.17	0.74	0.65	0.49
Impoundment No. 1 Discharge Rate (m3/s)		0.033	0.036	0.020	0.023	0.009	0.001	0.000	0.000	0.014	0.041	0.040	0.040
Hardness (mg CaCO3/L)	10	12	13	11	13	12	11	10	10	22	16	14	14
Sulfate (mg/L)	0.5	7	7	4	7	5	3	1	1	25	13	10	9
Sodium (mg/L)	5.93	9.77	10.2	8.22	9.9	9.1	7.3	5.9	5.9	22.3	14.2	11.7	11.5
Nitrate (mg N/L)	0.014	0.58	0.65	0.35	0.59	0.46	0.20	0.014	0.014	2.3	1.2	0.84	0.81
Total Phosphorus (mg P/L)	0.029	0.028	0.028	0.028	0.028	0.029	0.029	0.029	0.029	0.031	0.030	0.029	0.028
Total Cyanide (mg/L)	0.0005	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.005	0.003	0.002	0.002
WAD Cyanide (mg/L)	0.0005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.002	0.001	0.001
Total Metals (mg/L):													
Ag	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Al (dissolved)	0.27	0.25	0.25	0.26	0.25	0.26	0.26	0.27	0.27	0.26	0.26	0.26	0.25
As	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001
Ba	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Cd	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Co	0.001	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.005	0.003	0.002	0.002
Cr	0.0005	0.001	0.0005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cu	0.0006	0.0008	0.0008	0.0007	0.0008	0.0007	0.0007	0.0006	0.0006	0.0013	0.0010	0.0009	0.0008
Fe	0.45	0.42	0.41	0.43	0.42	0.43	0.44	0.45	0.45	0.42	0.43	0.42	0.42
Hg (ug/L)	0.0037	0.0039	0.0039	0.0038	0.0040	0.0039	0.0038	0.0037	0.0037	0.0053	0.0045	0.0042	0.0041
Mn	0.023	0.022	0.021	0.022	0.022	0.022	0.023	0.023	0.023	0.022	0.022	0.022	0.022
Mo	0.0025	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Pb	0.0005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Se	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zn	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0008	0.0008	0.0008

TABLE 1.4-9

Expected Water Quality of Florence Creek After Reclamation of Impoundment Nos. 1 and 2,
Based on Mean Monthly Water Quality in the Reclaimed Impoundments,
Predicted by Norecol for the Cinola Gold Project

PARAMETER	FLORENCE CREEK BACKGROUND CONCENTRATION	CONCENTRATION IN RECEIVING WATER, YEAR 10											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Florence Creek Flow Rate (m3/s)		0.48	0.43	0.47	0.36	0.21	0.10	0.15	0.15	0.17	0.74	0.65	0.49
Impoundment No. 1 Discharge Rate (m3/s)		0.033	0.036	0.020	0.023	0.009	0.001	0.000	0.000	0.014	0.041	0.040	0.040
Impoundment No. 2 Discharge Rate (m3/s)		0.036	0.039	0.022	0.025	0.011	0.0032	0.0002	0.0007	0.020	0.045	0.044	0.043
Hardness (mg CaCO3/L)	10	14	15	13	15	14	13	10	10	34	20	17	16
Sulfate (mg/L)	0.5	11	13	7	12	10	6	1	1	51	23	16	16
Sodium (mg/L)	5.93	13	14	10	13	12	10	6	7	39	20	16	16
Nitrate (mg N/L)	0.014	1.02	1.16	0.628	1.06	0.885	0.556	0.037	0.103	4.58	2.03	1.45	1.42
Total Phosphorus (mg P/L)	0.029	0.027	0.027	0.028	0.028	0.028	0.029	0.029	0.029	0.033	0.030	0.028	0.027
Total Cyanide (mg/L)	0.0005	0.002	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.009	0.004	0.003	0.003
WAD Cyanide (mg/L)a	0.0005	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.006	0.003	0.002	0.002
WAD Cyanide (mg/L)b	0.0005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total Metals (mg/L):													
Ag	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Al (dissolved)	0.27	0.24	0.23	0.25	0.24	0.25	0.26	0.27	0.27	0.25	0.25	0.25	0.24
As	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.002	0.002	0.002
Ba	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Cd	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Co	0.001	0.003	0.003	0.002	0.003	0.002	0.002	0.001	0.001	0.009	0.004	0.003	0.003
Cr	0.0005	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cua	0.0006	0.0009	0.0009	0.0008	0.0009	0.0009	0.0008	0.0006	0.0006	0.0021	0.0012	0.0010	0.0010
Cub	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0013	0.0009	0.0008	0.0008
Fe	0.45	0.40	0.38	0.42	0.40	0.41	0.43	0.45	0.45	0.39	0.41	0.40	0.39
Hg (ug/L)	0.0037	0.0046	0.0047	0.0042	0.0046	0.0045	0.0042	0.0037	0.0038	0.0083	0.0057	0.0051	0.0050
Mn	0.023	0.021	0.020	0.022	0.021	0.021	0.022	0.023	0.023	0.020	0.021	0.021	0.020
Mo	0.0025	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Pb	0.0005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001
Se	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zn	0.0008	0.0008	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0010	0.0009	0.0008	0.0008

a Without cyanide degradation and copper precipitation
b Assuming cyanide degradation to 0.001 mg/L in Impoundment No. 1 porewater and 0.04 mg/L in Impoundment No. 2 porewater; copper precipitation to 0.05 mg/L in porewater of both impoundments

MOE-38

Response: (cont'd) discharge. Accordingly the impoundments will be designed to allow for controlled discharge from reclaimed impoundments during operation. Discharges will be controlled at a rate such that receiving water criteria will not be exceeded.

Response by: Annette Smith and Bruce Ott, Norecol

References:

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Report. Volume II Appendices. Project and Facilities Description. Appendix 6.8.1-1, pp. 15-20 and 27-34.

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Report. Volume III Appendices. Baseline Environmental Description. Appendix 5.5.4-1, p.32.

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Report. Volume IV. Environmental Impact Assessment and Management Programs. pp. 2-75 to 2-79 and 3-99 to 3-104.

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Addendum Report. pp. 8-4 and 8-9 to 8-10.

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.4 Water Quality

Topic: d) Water quality contingency plans during start-up phase

Comment: Clarification of contingency plans for the protection of water quality during what may be a rather prolonged start-up period for "new" components, such as the constructed wetlands, should be provided.

Response: The development of the constructed wetlands will commence with the pilot scale tests and they will be fully constructed before active mining begins. The treatment plant will be constructed during year 1 of mining. Only drainage from the waste rock stockpile will flow to the wetlands (approximately 20% of the design flows); the remainder of the drainage which normally would be routed to MSW1 (treatment plant effluent) will be recycled to the mill. Similarly in year 1 only a limited area of the mudstone dump will drain to MSW2. Flows from the remaining undisturbed area will be intercepted by an interim ditching system. In all it is anticipated that the constructed wetlands would be in place for up to two years prior to receiving significant discharges. Contingency plans, in the event that the wetlands are not functional by the time nitrate removal is required, will include recycle of treated effluent for freshwater make up in the mill, storage in High West or the mine area and/or irrigation. As indicated in the Stage II Report

Response: (cont'd) (Volume II, Section 7 and Volume IV, Section 2.2.2 and Appendix 2.2.2.1), nitrate removal by the wetlands will only be required during summer. During this period, storage capacity of the minesite ponds is at its maximum and the capacity of forested areas to assimilate irrigation is also at a maximum. Water stored in the ponds during the low flow periods would be discharged during a subsequent storm event. In case of prolonged drought coinciding with total depletion of storage capacity, the water would be disposed of by various means including recycle to the mill, storage in High West and upland irrigation.

Response by: Alan Whitehead, Norecol

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.4 Water Quality

Topic: e) Miscellaneous comments - Appendices only

A number of comments concerning water quality appeared in Appendix 1 but were not reflected in the summary letter. Responses to these comments are provided below.

Comment: Tables 8.3-1A, 8.3-1B, and 8.3-2 in the Addendum Report show concentrations of copper predicted to be found in Barbie Creek under conditions represented by mean monthly flows. Copper in Barbie Creek is predicted to be up to 9.5 ug/L under 1-in-10 year average June low flows (Addendum, Appendix 8.3-1, 8-13 to 15). The Ministry believes that while monthly mean flows can be utilized to provide a useful indication of water quality, the Ministry requires predictions of water quality to be obtained by using he 7-day, 1:10-year low flow estimate. City Resources has already been asked to re-run the spreadsheets for anticipated Barbie Creek water quality using this approach (Appendix 4).

These predictions assume a mean background copper concentration of 0.9 ug/L. Background copper concentrations in Barbie Creek (Upper, Middle, and Lower Barbie Creek stations - Vol. III, Appendix 5.5.4-1, p. 11-20) ranged up to 1.9 ug/L, and thus the predictions could be 1.0 ug/L higher (i.e. 10.5 and 6.7 ug/L) if the maximum background and low flows coincided.

In 1987, low flows, as low as 0.003 m^3/s, were measured in Barbie Creek. This is 1/20th of the estimated June flow in Barbie Creek after closure of 0.06 m^3/s used in Table 8.3-2 of the Addendum. During very low flow years, it is expected that the effluent from the wetland would also be smaller than average, so that the concentration in Barbie Creek would not be 20 times higher. However, because of considerably attenuated flows through the treatment system, Comment (cont'd) higher than proportional discharges are to be expected and considerably higher concentrations than those indicated will occur.

Response: Operation of the treatment plant and equalization pond during low flows is described in detail in Appendix 1.1-1, Section 7.0 and 8.0. During summer low flows, treatment plant effluent will not be delivered to the wetland. The discharge during this period from the constructed wetland below the treatment plant will therefore be negligible. In the event of prolonged drought, the wetland will be irrigated to maintain the vegetation, using water from the equalization pond.

Water treatment capability in the wetlands generally increases during summer. Warm temperatures accelerate biological activity and favour removal of solutes from the water by vegetation and micro-organisms. Water flow through the wetlands is reduced during the summer, increasing the retention time in the wetlands also increasing treatment effectiveness. In addition, evapotranspiration increases during summer, reducing effluent volumes. Because of the positive effects of these factors on effluent quality, there would appear to be no basis for concern even if discharges were necessary during summer low flows. This issue will be assessed as well during test work in Stage III.

Response by: Alan Whitehead, Norecol

Comment: (cont'd)

We recommend that sulphate toxicity be investigated further with regard to the effects on invertebrates, macrophytes, and periphyton in Barbie Creek, and the viability of the macrophytes in the proposed artificial wetlands (SO_4 toxicity to aquatic vegetation in the wetlands was not considered in Vol. IV, Appendix 2.2.2-1, p. 10). A literature review should be conducted initially, with any further investigation to be based on the findings of the review. The Ministry does not have criteria for sulphate for aquatic life, but a brief literature review revealed some rather disturbing information:

- o 250 to 500 mg/L Na_2SO_4 (170 to 340 mg/L SO_4) had a "detrimental effect" on planktonic crustaceans and molluscs after a few days.
- o 60 to 275 mg/L dissolved SO_4 drastically reduced the diversity of submerged and floating macrophyte species. (The elevated SO_4 was due to smelters and thus the possibility that other toxicants such as SO_2 or metals may have been responsible for the apparent effect of SO_4 needs to be checked.)
- o 95% of good game fish waters in the U.S. had <90 mg/L SO_4.

(All of the above information is from the National Research Council of Canada 1977)[6] (Appendix I, Section 3.4, p.15).

Response:

Wetland systems are already being used to treat acid mine drainage in North America. Many of these systems receive waters containing elevated metals and sulphate concentrations. Cottongrass in the wetland receiving acid drainage from Mount Washington Mine on Vancouver Island is tolerating influent SO_4 levels of 90 to 310 mg/L (Ferguson 1986). Sedge in a wetland at Dunka Mine in Minnesota tolerates 370 to

Response: (cont'd) 2600 mg/L SO_4 from stockpile drainage (Eger and Lapakko 1988). Cattail in a constructed wetland at a coal mine in Pennsylvania tolerates influent SO_4 levels averaging 2050 mg/L (and influent pH of 2.9) (Hedin et al. 1988). Sulphate concentrations of 575 to 900 mg/L are reported in a volunteer cattail wetland at an abandoned coal mine in Indiana (Mitsch et al. 1985). The evidence from these reports indicates that the SO_4 levels of 1500 - 2500 mg/l predicted from Cinola would not have a significant effect on the vegetation and on treatment function of the Cinola wetlands.

Further discussion regarding the effects of sulphate levels on aquatic life is provided in MOE Section 1.4a. In addition, in situ algal bioassays using simulated plant effluent will provide a direct indication of potential effects of sulphate on periphyton.

Response by: Alan Whitehead, Norecol

References:

Mitsch W.J., M.A. Cardamone, J.R. Taylor, and P.R. Hill. 1985. pp. 121-137 in: Wetlands and Water Management on Mined Lands. R.P. Brooks, D.E. Samuel and J.B. Hill (eds.). Proceedings of a Conference, October 23-25, 1985. The Pennsylvania State University. 393p.

Eger, P. and K. Lapakko. 1988. Nickel and copper removal from mine drainage by a natural wetland. pp.301-309 in: Mine Drainage and Surface Reclamation, Volume I: Mine Water and Mine Waste. Bureau of Mines Information Circular IC/9183, U.S. Dept. of the Interior. 413p.

References: (cont'd)

Hedin, R.S., D.M. Hyman and R.W. Hammack. 1988. Implications of sulfate reduction and pyrite formation processes for water quality in a constructed wetland: preliminary observations. pp.382-388 in: Mine Drainage and Surface Reclamation, Volume I: Mine Water and Mine Waste. Bureau of Mines Information Circular IC/9183, U.S. Dept. of the Interior. 413p.

Ferguson, K.D. 1986. Preliminary Evaluation of Wetland Treatment at Mount Washington. Letter from Conservation and Protection, Environment Canada, to L. Erickson, Waste Management Branch, B.C. Ministry of Environment. November 17, 1986.p. 21, section 6.3

Comment: (cont'd)

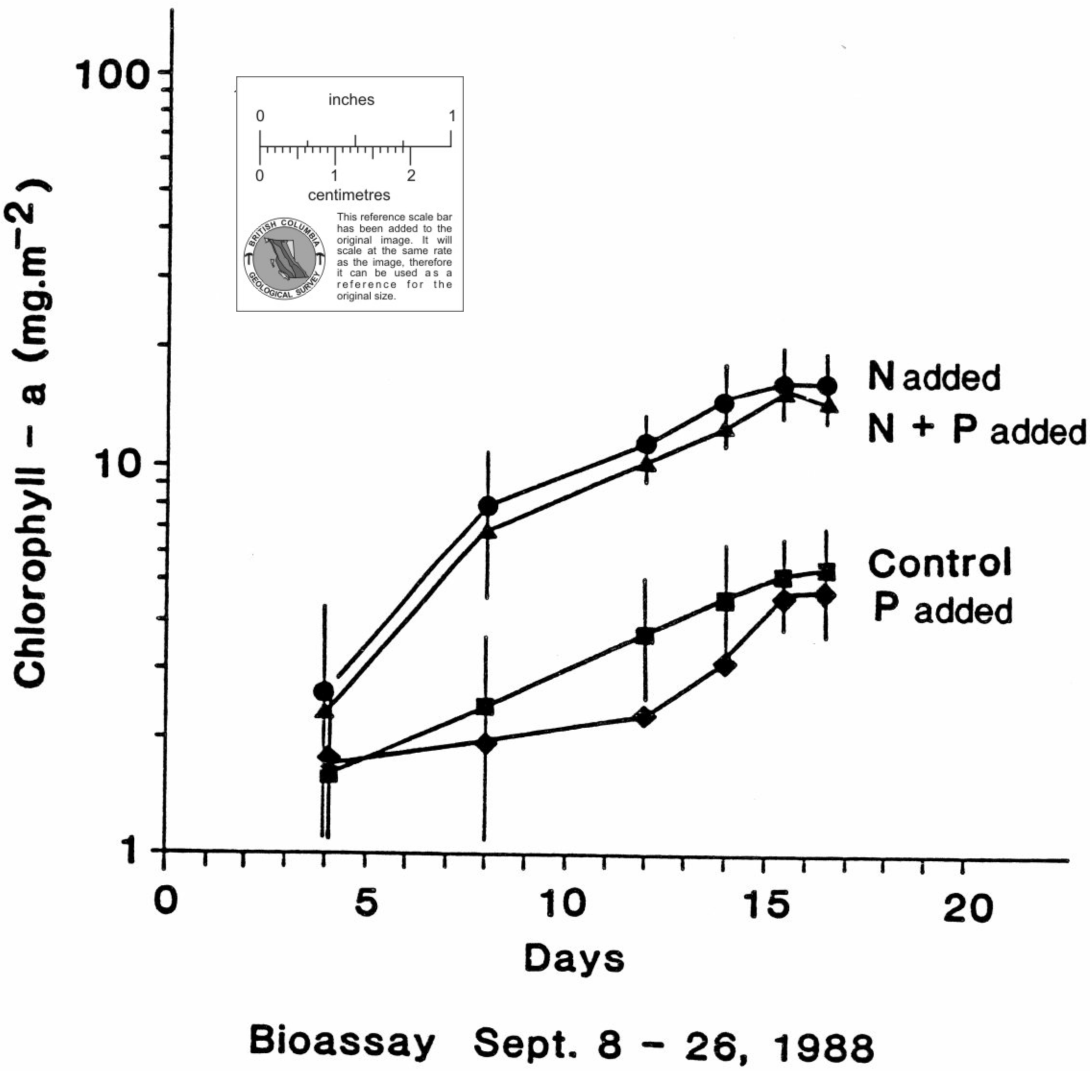
Nitrate levels in Florence Creek are predicted to increase about 100 times over the background level. The Stage II Report indicates that since these systems are phosphorus-limited, increased levels of nitrate will not affect stream productivity. As discussed above for Barbie Creek, however, some of the total phosphorus may be bioavailable and more ortho-phosphorus would be produced if reducing conditions developed in the wetlands. Groundwater collected in 1980-81 (Volume III, Table 5.5.6-2,) contained up to 1.2 mg/L ortho-phosphorus. Both total and dissolved phosphorus can be high in groundwater in the proposed impoundment area (Table 5.5.6-7).

We feel it is inappropriate to conclude that ortho-P levels are consistently low enough to make surface waters phosphorous-limited. Apart from the biology of the N-P relationship, we face the reality that the mill effluent discharge will have a nitrate level of about 295 mg/L when our effluent objective is 10 to 25 mg/L. This could be a problem. Projected nitrate increases in Florence Creek are up to 100 times over background. Basically we would need to make a decision to permit Nitrate over our effluent objectives, and then allow such a large increase in the receiving environment (Appendix 1, Section 6.3, p. 21).

Response: Sensitivity of periphyton biomass in Florence and Barbie creeks to increases in phosphorus (P) and nitrogen (N) was examined by Limnotek (Perrin 1988). The study findings indicated periphyton accrual (measured as chlorophyll-a in mg/m^2) responded to N additions and N plus P additions; however, there was no difference in response between the control (no nutrient additions) and P addition treatments (Figure 1.4-2). Thus, the creek periphyton communities were determined to be limited primarily by N rather than P. The lack of any response to P additions suggested that periphyton accrual in Florence Creek was limited by other factors, possibly including complexing of bio-available P by absorption on humate substrates or by micronutrients.

The bioassay suggested that increased N concentrations in Florence Creek and increased N plus P concentrations in Barbie Creek, that are expected from the Cinola Mine development, will approximately double periphyton growth rates and increase sustainable biomass by an average of 4 times over present levels. These amounts are less than half of those used during intentional fertilization for salmonid enhancement. Oxygen deficits in spawning gravels are not expected to occur from the Cinola development even if biomass accruals were greater than levels predicted in the bioassay.

Response by: Alan Whitehead, Norecol



Source: Perrin 1988

Figure 1.4-2 Periphyton accrual curves at highest N and P concentrations tested in the bioassay.

References:

Mitsch, W.J. and J.G. Gosselink. 1986. Wetlands. Van Nostrand Reinhold Co. New York. 539 p.

Norecol Environmental Consultants Ltd. 1985. Phosphorus from Operating Coal Mines. Report prepared for Environmental Protection Service, Mining, Mineral and Metallurgical Process Division, Hull, Quebec. June 1985.

Perrin, C.J. 1988. A Test of Nutrient Limitation in Streams Draining the Cinola Development, Queen Charlotte Islands. Limnotek Research and Development Inc. Report submitted to Norecol Environmental Consultants Ltd. December 1988. 23 p.

Comment: (cont'd)

The settling ponds which do not flow to wetlands discharge into the Barbie Creek system directly. These are MSSP1, MSSP8, and MSSP7. A contingency plan is needed to accommodate the situation where these discharges cannot meet permit limits (for example, the addition of chemical vlocculants).

Since they all flow to Barbie Creek, discharges from these ponds will have a cumulative effect. In the case of suspended solids, the overall allowable increase in Barbie Creek would be 10 mg/L over background, according to our criteria. Each of the discharges could only contribute a portion of this increase. The same applies to the nutrients, etc. We request that these relationships be modelled in the spreadsheets for Barbie Creek and submitted for our examination at Stage II.

Response: (cont'd)

All settling ponds will be sized and operated to meet discharge criteria. If for any reason required sediment levels could not be met based on settling pond retention alone, flocculants would be employed. Cumulative sediment concentrations were calculated from the same spreadsheets used to predict other cumulative impacts on Barbie Creek (Stage II Report, Volume IV, Table 3.6.2-5 and Addendum Report, Table 8.3-2). The spreadsheets were modified to include the discharges from settling ponds MSSP7 and MSSP8 to upper Barbie Creek (flow rates given in Stage II Report, Volume II Appendix 6.2-1). Where appropriate, flows were modified to reflect treatment of runoff from the west pit wall. The background sediment concentration used in the calculations was the mean value for Lower Barbie Creek (Q4), 2 mg/L (Stage II Report, Volume III, Table 5.5.4-8). Direct discharges from settling ponds and discharges from the two wetlands were assumed to equal the MOE mine effluent criterion of 25 mg/L.

The MOE receiving water criterion for suspended sediments in Barbie Creek is 12 mg/L (background plus 10 mg/L). Table 1.4-10 shows that this criterion will be met during all months. In fact, sediment levels should be lower than those predicted because sediment loadings from the various discharges will not actually be additive. Some attenuation of sediment concentrations will occur due to settling during downstream transit. In particular, settling will

TABLE 1.4-10

Final Concentrations of Sediments in Barbie Creek After Mixing With Discharges From All Minesite Settling Ponds, Predicted by Norecol for the Cinola Gold Project[a]

MONTH	YEAR 7	YEAR 12
January	7	8
February	8	8
March	6	7
April	8	9
May	10	10
June	11	11
July	11	12
August	10	10
September	10	10
October	8	9
November	7	8
December	7	7

a Assuming that each discharge contains 25 mg/L of suspended sediments and that the background concentration is 2 mg/L

Response: (cont'd) occur in the natural Barbie wetland, as indicated by the baseline data (Stage II Report, Volume III, Table 5.5.4-8) which show slightly higher suspended sediment levels in upper and middle Barbie creeks (sites Q15 and Q4) than in lower Barbie Creek (Q4).

Response by: Annette Smith, Norecol

References:

City Resources (Canada) Limited. 1988 Cinola Gold Project Stage II Report. Volume II Appendices. Appendix 6.8.1-1, pp. 55 and 58.

City Resources (Canada) Limited. 1988. Cinola Gold Project Stage II Report. Volume III. Baseline Environmental Description. p. 5-112.

City Resources (Canada) Limited. 1988. Cinola Gold Project Stage II Report. Volume IV. Environmental Impact Assessment and Management Programs. p. 3-93.

City Resources (Canada) Limited. 1988. Cinola Gold Project Stage II Addendum Report. p. 8-15.

Comment: (cont'd) The tails will contain a certain amount of mercury. Once a wetland is established on the reclaimed tails, would the organics in contact with the finely divided tailings create conditions for enhanced methylation of mercury for export to Florence Creek? It seems that all the preconditions for mercury methylation would be present (Appendix 1, Section 6.4 (4), p. 22).

MOE-53

Response: Based on mercury methylation and speciation studies (Appendix I-5-1) the potential for stimulated methylation of mercury in the High West area is minimal. Mercury speciation studies showed that ionic mercury (the form of mercury useable by methylating bacteria) in the tailings porewater was extremely low (<20 ng/L) and on the order of ionic mercury concentrations in Florence Creek (0.4-1.4 ng/L). The methylation bioassays showed that stimulated methylation was correlated with organic content of soils. The mineral soils tested showed very low net methylation rates, far lower than the natural stream sediments. The tailings will have no organic content and therefore no potential to stimulate methylation from this standpoint. In addition, it was shown by the methylation bioassay, that organic content imported to the sample during the bioassay did not cause an increase in net methylation over time. On the basis of these tests it is not anticipated that the reclaimed impoundments will provide preconditions for stimulated mercury methylation.

Response by: Liz Neil, Norecol

References:

Agassiz North Associates. 1988. Cinola Gold Project - Studies on Mercury and Mercury Methylation. Report prepared for City Resources (Canada) Ltd. December 1988. 58p.

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.5 Surface Water Hydrology

Topic: a) Flow analysis update and 7-day, 1:10-year low flow estimate

Comment: The prediction of project impacts on water quality in Florence and Barbie Creeks depends heavily on the estimates of flow within the creeks. At Stage II, the Ministry requires that flow estimates, particularly low flow be re-examined.

Response: Low flows in study area creeks were re-examined in considerable detail as discussed in Appendix 1.5-2. Sections 2.1 and 2.2 of Appendix 1.5-2 summarize estimates of the 1:10 year seven day low flows for study area creeks for the mine operation and closure phases of project development, respectively.

The estimates of the long term mean monthly flows in study area creeks have been revised (Appendix 1.5-2 Table 7) and as a consequence the estimated dry month flows in Florence and Barbie creeks have been increased. The estimated dry month runoffs in lower Barbie Creek are estimated to be 14 percent higher (from 0.57 mm/d in June to 0.65 mm/d in August) than the flow values used to evaluate the water quality of Barbie Creek in the Stage II Addendum report. For lower Florence Creek the dry month runoff is 5 percent higher (from 1.01 mm/d in June to 1.06 mm/d in August) than that reported in the Stage II Addendum report.

Response (cont'd) was presented in the Stage II Addendum report and it showed that receiving water criteria would be met.

The estimates of the long term mean monthly flows in Barbie Creek have been revised (Appendix 1.5-2 Table 7) and the estimates of the dry month flows have been increased. The revised estimates of 1:10 year dry month flows in Barbie Creek are about 14 percent higher than the flow values used to evaluate the water quality of Barbie Creek in the Stage II Addendum report, and means the conclusions of that impact assessment are conservative.

Flows in Barbie Creek during a 10 year 7 day low flow condition during the closure phase are given in Section 2.2 of Appendix 1.5-1

Comment: (cont'd) At Stage II, the Ministry requires that flow estimates, particularly low flow be re-examined. To aid in the Ministry's review of this component of the Stage II report, the company is requested to submit all precipitation and stream flow data from project sites for 1988 (up to the end of October).

Response: (cont'd) Daily precipitation data collected at project stations for the period February to December 1988 has been summarized in Appendix 1.5-2 Table 8. Study area precipitation data collected prior to this period is discussed in Section 4.4.1 of Volume III and listed in Appendix 4.4.1-2 of the Stage II report.

Response: (cont'd)

The additional precipitation data collected since February 1988 does not modify any of the conclusions of the Stage II report. During this period no extreme wet or dry periods or one day rainfalls were recorded. The greatest one day rainfalls were about 63 mm (September 29 and October 22, 1988) which are estimated to be approximately mean annual events. The driest period was 29 days long (April 11 to May 9) during which 41.2 mm of rain was recorded at the High West rain gauge (located in the upper Florence Creek drainage) and 27.9 mm of rain was recorded at the Tipping bucket rain gauge (located near the orebody). This period was definitely drier than normal for this time of the year with the recurrence interval being in the 3 to 10 year range based on information presented in Section 4.4.1 of Volume III.

Stream flow data collected from study area creeks for the period January to December 1988 have been tabulated and summarized in Appendix 1.5-2 Tables 2 and 3. Revisions to the stage-discharge relationships also allowed some gaps in the daily discharge data for December 1986, 1987 and January 1988 reported in the Stage II report (Appendix 5.2.2-2 Volume III) to be filled. Daily discharges could be provided for dates when stage data was available but the information on the stage-discharge relationship, available at the time the Stage II report was prepared, did not allow the accurate prediction of the discharge associated with the stage data.

Response: (cont'd)

Two characteristics of the stage-discharge relationship where considered when infilling gaps in the daily discharge data contained in the Stage II report (Appendix 5.2.2.2, Volume III) and in determining the daily discharge data for 1988. First, the additional high flow stage-discharge data that has been collected for study area creeks since the writing of the Stage II report allowed the extension of these curves to higher discharges than previously possible. Second, the observation that a simple linear extrapolation of these stage-discharge relationships to higher flows would result in the underestimation of the high flows and hence an underestimation of the streams dilution capacity The underestimation of the dilution capacity of study area creeks was considered conservative because it would overemphasize the impact of any contaminate discharges to these creeks.

There are two sources of revisions to the daily discharge data for December 1986, 1987 and January 1988 listed in Appendix 1.5-2 Table 1 from the data reported in the Stage II report (Appendix 5.2.2.2 Volume III); first, the infilling of some high flow data for some study area creeks as outlined above, and second, the revision of the preliminary flow data for 1987 for the Lower Yakoun River station used in the Stage II report to the final flow data published by Environment Canada in 1988. This revision significantly increased the daily flow values

Response: (cont'd)

for the low flow period of July through October 1987, for this station, from those reported in the Stage II report.

As a consequence of updating and revising the daily discharge data for the study area streams it was necessary to update and revise the observed monthly runoff information reported in Table 5.2.4-2 of Volume III. Tables 4 and 5, Appendix 1.5-2 contain the revised listing of observed monthly runoff in gauged study area creeks. Based on these revised monthly runoff values it was possible to reevaluate and update the long term mean monthly flow estimates for study area creeks. Three sources of information were incorporated into the reevaluation of the long term mean monthly flow estimates for study area creeks:

(1) Information available for the study area creeks and also for the Water Survey of Canada station on the lower Yakoun River allowed data up to December 1988 to be incorporated in the calculations (excluding September and October 1988 because of incomplete data for the Lower Yakoun River station);

(2) The revision of the preliminary flow data for 1987 for the Lower Yakoun River station used in the Stage II report to the final flow data published by Environment Canada in 1988.

Response: (cont'd)

(3) The long term mean monthly flow estimate for the Lower Yakoun River station was calculated for the period 1962-1987 which was three years longer than the 1962-1984 period reported in the Stage II report.

The updated long term mean monthly runoff estimates for the Upper and Lower Yakoun River, Middle and Lower Barbie Creek, Adit Creek, and Lower Florence Creek stations are listed in Tables 6 and 7. Values for these creeks are a revision of values given in the Stage II report (Table 5.2.4-3, Volume III). On an annual basis all of the estimated runoffs increased except for the Upper and Lower Yakoun River stations. Mean annual runoffs for the Yakoun River stations decreased by about half a percent from the values given in the Stage II report as a result of the increase in the period of record. Generally speaking the magnitude of the changes in the long term flow estimates are small which reflects the excellent (relative to other mining projects) data base that is now available to define the flows in the key study area creeks (Barbie Creek, Florence Creek and the Yakoun River).

The increases in the estimated runoff in study area streams makes the water quality impact assessment contained in the Stage II Addendum report (which was based on the underestimation of the flows in the study area creeks) conservative because it would overemphasize the impact of any contaminate discharges to these

Response: (cont'd)

creeks. Of particular interest in this regard are the increases in the dry month runoffs in lower Barbie Creek by 14 percent (from 0.57 mm/d in June to 0.65 mm/d in August) and lower Florence Creek by 5 percent (from 1.01 mm/d in June to 1.06 mm/d in August).

Another assumption used in conducting previous water quality assessments was that runoff per unit area at the proposed compliance point near the Middle Florence Creek station would be similar to that of the Lower Florence Creek gauging station. In fact as shown in Table 6 Appendix 1.5-2 the mean monthly runoff during the low flow month of August at the Middle Florence Creek station is about 30 percent higher than that of Lower Florence Creek (1.41 mm/d versus 1.06 mm/d). In comparison to the runoff values used in the Stage II Addendum report water quality impact assessment the updated estimate would be 40 percent higher (1.41 mm/d versus 1.01 mm/d).

The estimates given in Tables 6 and 7, Appendix 1.5-2 for Upper and Middle Florence Creek, Florence Tributary, Coreshack Creek, Sid Creek, Clay Creek, Canoe Creek, and Boucher Creek have not previously been reported. As some of the monthly estimates for these stations are based on only one year of data they are considered less accurate than the estimates for the stations with longer term records which were

Response: (cont'd) reported in the Stage II report (Upper and Lower Yakoun River, Adit Creek, Lower and Middle Barbie Creek, and Lower Florence Creek.

Response by: Stan Woods, Norecol

References: City Resources (Canada) Ltd. 1988. Stage II Report, Section 4 and 5 of Volume III.

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.6 Tailings Impoundment

Topic: a) Sensitivity analysis for tailings pond water balance

Comment: The sensitivity of the water balance model for the tailings impoundment system to changes in assumptions should be determined with respect to the quality and quantity of water leaving the system and to the feasibility of the system operating as planned.

Response: A sensitivity analysis was carried out for the water balance model and reviewed at a meeting between Federal and Provincial government agencies and Steffen Robertson and Kirsten on 1 December 1988. The objectives of the water balance model, the sensitivity analysis, results, and conclusions drawn from the analysis are summarized below:

Objectives:

- to account for the inflows and outflows in the High West tailings impoundment system under a range of conditions in order to design a zero discharge system;
- to determine the volume of water that needs to be stored from the active impoundments and eventually stored in impoundment no. 3; and
- to determine the impact of the impoundment on Florence Creek stream flows and to determine fresh water supply requirements.

MOE-64

Sensitivity Analysis & Results:

The components of the water balance and their percentage of the total average daily flow are summarized below:

Water Balance Components	% of Average Daily Flow Makeup Water 12%	 16%
Precipitation		
Direct precipitation	28	26
Runoff	17	16
(runoff factor = 0.7)	45	42
Tailings Pore Water	44	41
Pond Evaporation	8	7
Net Mill Water Discharge	0	7
Other Wastes (WTP, sewage)	2	2
Groundwater Seepage	1	1
Total	100%	100%

Notes:

1) Makeup water is defined as a percentage of total mill inflows.

2) Net mill water discharge is the net flow discharged to the impoundment from the mill, i.e., the difference between mill effluent and mill effluent return. Evaporation and other losses within the mill represent 12% of total mill inflow. Therefore, in the case where mill effluent return equals mill effluent, 12% of total mill inflow is required in makeup water to balance the losses.

As noted in the tabulation, the main components of the water balance are precipitation and tailings pore water, which together account for between 83% and 99% of the total water balance flows. The precipitation component includes direct precipitation on the pond surface and local runoff within the diversion ditches. The selection of precipitation, runoff factor, and tailings pore water as parameters to be included in the sensitivity analysis was based on their relative magnitudes. The ratio of water recycled from the impoundment to the mill was included in the sensitivity analysis due to the potential variability of this parameter.

3) As discussed in the Stage II Report, the basic concept used to achieve a zero discharge system is that precipitation on an impoundment is equal to the volume of water stored in the tailings mass (i.e., pore water).

As noted in the tabulation these two values are to all intents and purposes equal.

4) A matrix of 81 possible scenarios was developed for the High West water balance by allocating three values for each of the four variables selected (see figure 1.6-1). The matrix considers variations in precipitation and run-off factor against the percentage of water recycled from the impoundment and tailings water content.

% MILL EFFLUENT RECYCLE (% MAKE-UP WATER)		TAILINGS WATER CONTENT	LOW 12 YEAR PRECIP. (1849 mm/a)			AVERAGE PRECIP. (2084 mm/a)			HIGH 12 YEAR PRECIP. (2319 mm/a)		
			RUNOFF FACTOR			RUNOFF FACTOR			RUNOFF FACTOR		
			0.6	0.7	0.8	0.6	0.7	0.8	0.6	0.7	0.8
	88 % (12 %)	50%	0.124				0.173				
		45%		(0.155)		0.191	(0.197)	0.205		(0.240)	
		40%		(0.182)			0.224 (0.223)			(0.879)	1.551
	86 % (14 %)	50%									
		45%					0.218				
		40%									
	84 % (16 %)	50%	0.164								
		45%					0.239				
		40%									3.260

NOTES:

1) Values shown above are volumes of water in Impoundment 3 (in million m^3) at the end of year 12 for different cases.
2) (0.197) Results presented in Stage II report.
3) 0.218 Results of additional analyses.
4) Percentages of mill effluent recycle and make-up water are expressed as a percentage of total mill inflow.

HIGH WEST WATER BALANCE RESULTS OF SENSITIVITY ANALYSIS

Figure no. 1.6-1	CINOLA GOLD PROJECT STAGE II RESPONSE
Date MARCH 1989	Drawn by STEFFEN ROBERTSON & KIRSTEN

5) Re-evaluation of the site hydrology indicates that the 12 year high precipitation value (2319 mm) represents a return period of between 200 to 500 years.

6) The results from the analysis are shown in Figure 1.6-1. The numerical values given on the matrix are the volumes of water accumulated in impoundment no. 3 at the end of the 12 year mining operation. For 88% mill effluent recycle, the volume of water in impoundment no. 3 at the end of year 12 will range between 124,000 m^3 and 1,551,000 m^3.

When the makeup water is 16% of (84% effluent re-cycle), the total mill requirement, the volume of water in impoundment no. 3 at the end of year 12 would be 3,260,000 m^3 for worst case assumptions of precipitation, run-off factor, and tailings density.

Conclusions:

The sensitivity analysis indicates that the volume of water in the tailings impoundment(s) is influenced most by changes in precipitation and by changes in tailings moisture content. The impoundment system is capable of containing these volumes of water, as necessary, by raising the height of embankments.

As discussed in the Stage II Report, the components of the water balance will be monitored regularly throughout the life of the mine. The actual values of accumulated water can therefore be compared to the predicted values. It is proposed that the volume of water collected in impoundment no. 3 at the end of mining be used for backfilling the open pit. If the results of on-site monitoring during the first four years of operation indicate that the accumulated volume in impoundment no. 3 will exceed the open pit capacity, a water treatment facility would be constructed at the mine to allow for the entire mill effluent flow to be recycled to the mill.

Response by: J. Barton-Bridges and J. Gadsby, Steffen Robertson and Kirsten

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.6 Tailings Impoundment

Topic: b) Seismic design of embankments and long-term maintenance

Comment: The impacts of repeated seismic activity on the integrity of tailings embankments and spillways and the maintenance of acid-generating and acid-releasing rock in an alkaline, saturated state over the long-term following abandonment will need to be assessed. Similarly, maintenance requirements of the spillways over the long-term should be identified.

Response: The seismic exposure of the Queen Charlotte Islands is fully recognized by City and its consultants. As stated in the Stage II Report, the embankments will be designed for a maximum credible earthquake of magnitude 8.6 (Richter Scale) along the Queen Charlotte Fault, which is a minimum distance of 65 km from the site. As part of the Stage III studies, the effects of lower magnitude earthquakes located at shorter distances to the site will be examined though experience indicates these effects will be less than the Stage II Design criterion.

A world-recognized engineer and authority on the aseismic design of earth structures, Professor Harry B. Seed of the University of California, has been retained by City to review the seismic design aspects of the project. Professor Seed acts as a consultant to B.C. Hydro and Power Authority on its earth dams.

MOE-70

The basic philosophy in the design and construction of aseismic earth and rockfill structures is selection and use of appropriate materials and proper construction procedures. These aspects will be addressed in the Stage III design report.

During construction, City's consultants will prepare reports on construction activities and on the monitoring that is planned to be done. The construction and reports will be reviewed by other engineers and the Dam Safety Section of the B.C. Water Management Branch.

The embankment and spillways are being designed to be as maintenance-free as possible. This will be achieved by the following means:

- excavating the spillways in rock,

- designing the spillways at embankment nos. 1, 2 and 3 to pass the maximum probable flood,

- in the case of no. 3 spillway, providing a much larger spillway excavation than required for the maximum probable flood, and

- designing the embankments to be stable even if they are overtopped during a flood event that takes place when a spillway is blocked.

The maintenance program will be defined in Stage III work.

Response by: J. Gadsby, Steffen Robertson and Kirsten

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.6 Tailings Impoundment

Topic: c) Verification of cyanide degradation and copper reductions in tailings pond water

Comment: The reliability of the 6-month estimate for the half-life of CN and Cu in the tailings impoundment requires verification at Stage II.

Response: This comment is addressed in the response to E C section I-4c.

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.7 Waste Rock Stockpile

Topic: a) Contingency for prolonged operation of the waste rock stockpile

Comment: What will be the effect on the operation of the waste rock stockpile if reclamation is postponed by underground mining?

Response: There will be no change to the concept of the operation of the waste rock stockpile if reclamation is postponed by underground mining. The AMD Abatement program in the waste rock stockpile will consist of the following measures:

- o abatement of acid generation with crushed limestone;
- o prevention of migration of water in the stockpile by covering the stockpile with a synthetic liner and mudstone; and
- o collection of the underdrain water flow and implementation as required of the contingency plans discussed in response to question EC-III-1a.

A safety factor of three has been used to determine the quantity of limestone required in the stockpile. Therefore, it is expected that at the end of open pit mining a significant quantity of limestone will remain in the stockpile and be available for continued abatement of acid generation.

MOE-73

On completion of open pit mining the synthetic cover over the waste rock stockpile will be extended over all waste rock surfaces to minimize infiltration. A small active face will be maintained for waste from the underground operation.

Runoff and effluent will be routed to MSSP1 and MSSP2, respectively. Water collected in these two ponds will be monitored to ensure it is acceptable for discharge to the environment. In the event that the water is found to be unacceptable for discharge, the contingency plans as discussed in response to question EC-III-1a will be implemented.

Response by: J. Brodie, Steffen Robertson and Kirsten

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.7 Waste Rock Stockpile

Topic: b) Feasibility and effectiveness of liming the waste rock stockpile

Several issues are raised under this topic and responses have been provided by both SRK and Norecol. Norecol has addressed the feasibility of maintaining neutral pH in the waste rock stockpile considering the potential for blinding of limestone, the validity of the calculated limestone requirement and the quality of water in the pit backfill.

The MOE comments included a review by Dr. Frank T. Caruccio of acid generation predictions and management plans presented in Stage II. Some of the concerns raised in this comment reflect Dr. Caruccio's review. A full response to Dr. Caruccio's review is provided in Appendix 1.7-1.

SRK has addressed the methods for ensuring adequate mixing of limestone and waste rock. With respect to the quantity of drainage water requiring treatment during operation, SRK has provided a detailed description of the mine area water management plan and contingency plans for treatment of various drainages in Appendix 1.1-1. The MOE comment pertaining to this topic has been subdivided with responses provided by SRK and Norecol as follows.

MOE-75

Comment: The feasibility of maintaining neutral pH within the waste rock stockpile must be re-examined ..., because oxidation of waste rock and the blinding of limestone with iron coatings are expected to occur within the pile...

Response: The maintenance of neutral pH within the stockpile and its drainage is the primary goal of the waste management plans for the stockpile. Numerous tests including acid-base accounting, humidity cells, column-leach tests, and on-site weathering pads have been evaluated in detail in order to understand the oxidation of the waste rock and associated acid generation (Volume V of the Stage II Report). Accordingly, the current level of assessment of oxidation rates is considered appropriate to address Stage II requirements. For impact assessment in Volume IV, the full, unhindered rate of acid generation was used to calculate limestone requirements, despite evidence indicating the rate will be significantly less under neutral pH conditions. Furthermore, the amount of limestone to be added to the stockpile exceeds the calculated requirement based on the unhindered rate by a factor of 3. Additionally, the on-site barrel experiments (Section 6, Addendum) suggest encapsulation may not be a problem. As a result, there is a factor of safety in the plans for maintaining neutral pH in the event that predicted oxidation rates are not accurate or limestone encapsulation is significant. Nevertheless, further testwork is planned for Stage III to refine management concepts which were demonstrated to be feasible

Response: (cont'd) in Stage I. These tests include: (1) the long-term monitoring of acid generation through the on-going weathering of waste rock pads, and (2) the neutralization of acid generation through the proper addition of limestone. The proper use of limestone will be defined through on-going monitoring of the limestone columns and the proposed large-scale tests for Stage III. These limestone tests will simulate the expected conditions in the waste rock stockpile and will therefore indicate the potential for limestone encapsulation. If encapsulation becomes a problem, additional limestone may be required to offset it. Experimental testwork would then investigate methods to minimize and/or offset encapsulation.

Comment: (cont'd) ...Furthermore, there is some doubt about the validity of assumptions used to calculate the liming requirement of the stockpile. The quantity and quality of drainage water requiring treatment during operations should be verified and the impact on pit water quality of backfilling the waste rock into the abandoned pit should be reviewed.

Response: The only major assumption in the calculation of the limestone requirement is that the weathered Waste Rock Pad 1 represents the rate of acid generation that will occur in Pad 2 five years in the future. Based on a comparison of rates between these pads and corresponding humidity cells (Volume V, Section 3.7.2), this assumption appears valid and may even overestimate the future rate of acid generation.

Response: (cont'd)

The limestone requirement for the stockpile as calculated in Volume IV is based on the assumption that full, unhindered acid generation will take place in the stockpile, although experimental testwork indicates the limestone may significantly slow the rate of acid generation. Nevertheless, sufficient limestone, calculated from unhindered rates, will be added so to ensure no net acidity in the stockpile when it is backfilled into the pit. (Contingency plans and project costing have allowed for three times the calculated requirement for limestone to be added to the stockpile to provide a margin of safety.) As a result, the rock will theoretically have no impact on pit water quality.

Realistically, handling of the rock during backfilling may expose fresh sulphide minerals, and portions of the pit walls may be acid generating, but this acidity will be neutralized by portions of the west pit wall, by limestone remaining in the stockpiled rock, and by the alkalinity of the inflowing groundwater.

In order to assure neutralization, conservative calculations for additional limestone were made, indicating over 3000 t were necessary in the short term to ensure neutralization of pit water. Calculations of residual, slow acid generation in backfill indicated that in the long term over 1000 t of $CaCO_3$ would be necessary to assure long-term neutralization.

Response: (cont'd)

However, oxygen limitation in the backfill is expected to depress the rate of acid generation to a level where inflowing groundwater will neutralize acidity without the need for additional limestone.

Based on Norecol's analysis there is no apparent reason to doubt the validity of the estimated limestone requirement. Nevertheless, large-scale liming tests proposed for Stage III will examine further the effectiveness of mixing limestone and waste rock on a scale more comparable to that of the operating mine. This work will further refine and support for the estimation of limestone requirement.

On the issue of water quality in the stockpile drainage and pit backfill, the on-going limestone columns have provided water quality data with relatively little variation for mixtures of waste rock and limestone. The drainage quality data generated by these small scale simulations are the best available to represent probable operating conditions. Water quality predictions based on these data will be further refined by proposed large-scale tests with waste rock and limestone during Stage III studies.

Response by: Kevin Morin, Norecol

Comment: (cont'd) Considering the small percentage of limestone to be added to the waste rock, how will adequate mixing be achieved? (Ref., Vol. II, p. 3-103).

Response: The abatement of acid generation will be achieved by mixing crushed limestone with the waste rock. The mix ratio will be 0.6% by weight of limestone in the waste rock. This ratio will provide a safety factor of three on the calculated quantity of limestone required for the abatement of acid generation. Thorough mixing of the limestone will be achieved with a four-step process as described below.

The first step consists of passing the trucks through a limestone addition station where the ground limestone in the form of a slurry of sand sized particles (18 mesh) with up to 40% water will be sprayed on to each truckload. The necessary amount of lime (0.65 t/truck) can be premeasured, slurried and discharged on to the rock through a set of spigots designed in such a pattern to ensure even distribution.

The second step involves dumping the waste rock from a moving truck to form a pile approximately 1 m deep. A 108 t truck will carry approximately 63 m^3 of rock. This will create a pile 5 m wide, 1 m deep, and 12-15 m long. The highest point of a pile should not exceed 2 m, as less than 5% of the waste rock is expected to be greater than 1 m in diameter.

Response: (cont'd) The third step of the process consists of pushing the waste rock to the edge of the active face. The dozer will slice narrow sections off the end of the limestone covered waste rock pile. As the dozer moves ahead the rock will pile up in front of the blade and roll laterally to the full width of the blade. Mixing will continue as the dozer moves forward to the edge of the active face.

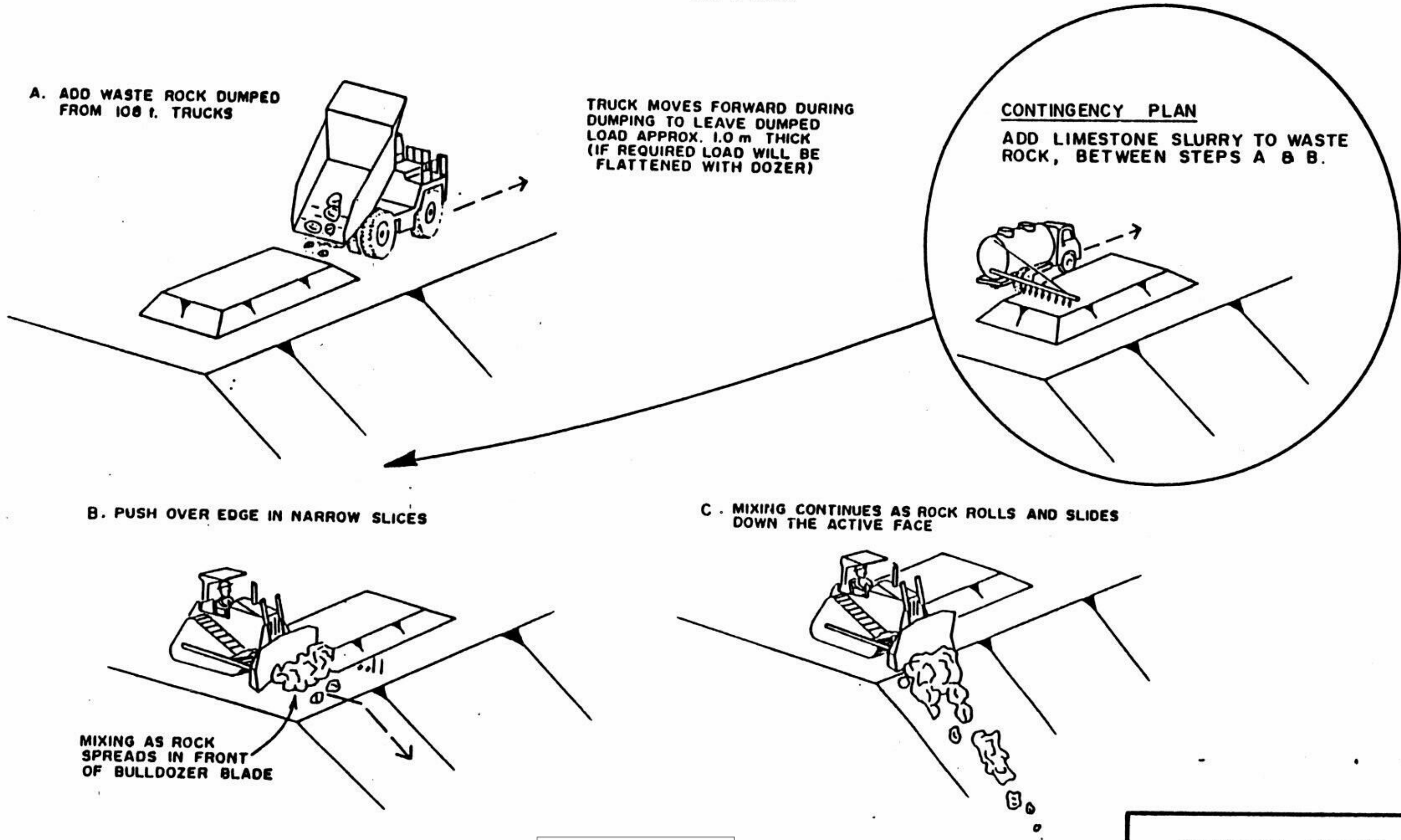
In the fourth and final step, mixing will continue as the limestone-waste rock mixture rolls and slides down the active face. The movement of rock down the slope will ensure thorough mixing.

If as part of the contingency planning it is found necessary to add more limestone to the active face, then the following procedures can be used. A dedicated tank truck, as shown in Figure 1.7-1, with a multinozzled spray boom will be used to apply the slurry to the waste rock. The pump for spraying the slurry will be geared to the truck speed to ensure uniform application as the truck passes the waste rock pile.

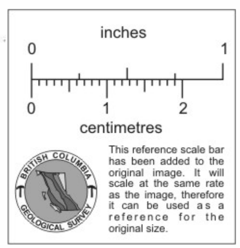
Response by; J. Brodie, Steffen Robertson and Kirsten

SCHEMATIC OF WASTE ROCK AND LIMESTONE MIXING PROCESS

NOT TO SCALE



MOE-81



WASTE ROCK STOCKPILE LIMESTONE MIXING	
Figure no. 1.7-1	CINOLA GOLD PROJECT STAGE II RESPONSE
Date MARCH 1989	Drawn by STEFFEN ROBERTSON & KIRSTEN

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.7 Waste Rock Stockpile

Topic: c) Miscellaneous comments - appendices only

Further comments regarding management of acidity in the waste rock were included in Appendix of the MOE letter as follows.

Comment: The application of the limestone to the rock as it goes into the pile will need to be constantly controlled. What are the implications if liming the pile is erratic and the dump develops hot spots? The concern here applies to closure as well as operation, because there could be a build up of "acid in waiting" in the pile which would be liberated when the rock is removed again to the pit (B.C. Ministry of Environment and Parks, Appendix 1, Section 2.2, p.3).

Response: It is not reasonable to expect consistently perfect blending of the waste rock with the limestone. Consequently, it may be prudent to expect that some "hot spots" may develop despite efforts to mix the limestone thoroughly. However, these potential hot spots are of minor concern that do not invalidate the Stage II concept for stockpile management or the proposed procedure for adding the limestone. This is apparent from an evaluation of the impacts of the hot spots under many different scenarios, as follows.

If hot spots develop in the stockpile, the resulting acidity can either migrate away from the hot spot or remain in place. If migration of acidic water occurs it will eventually encounter some limestone along its flowpath and be neutralized. The amount of waste rock in the

Response: (cont'd)

hot spots and quantity of water migrating from these areas will be very small relative to the overall amount of waste rock and water affected by addition. Sufficient limestone in the flowpath is anticipated to neutralize any acidic waters. However, in the event that some acidic water does not encounter limestone and successfully enters the underdrain, it will mix with pH-neutral or slightly alkaline water from the deep and will be neutralized. In the worst case of absolutely no neutralization, the acid water will be collected from the underdrain and directed into the settling pond. Options for treating acidic water appearing in the settling pond are presented in the response to E C comment III-1A. Accordingly, the current management concept addresses the potential for occurrence of hot spots and provides contingencies for each potential event.

In the second scenario, where the acidity accumulates at the hot spot and becomes "acid in waiting", this accumulated acidity will not dissolve any of the limestone added to the stockpile. As a result, both the acidity and the limestone added to neutralize it would remain in the stockpile until backfilled to the pit. At this point, if the acidity remains stationary, it does not represent an environmental problem. If it begins to migrate, then it will encounter the unconsumed limestone transferred with the waste rock from the stockpile or the limestone added during backfilling. In the unlikely worst case of no

Response: (cont'd) contact with limestone, the acidity would be controlled as it migrated into the pit water. The pit water will be well buffered and would neutralize this relatively small amount of accumulated acidity.

In summary, we do not anticipate the relative volume of hot spots to be significant in the proposed stockpile. The potential for hot spots has been assumed implicitly in the calculation of limestone requirements, and the management plan incorporates contingencies for this possibility including treatment in the settling pond for the stockpile and the addition of excess limestone in the pit backfill. As mentioned previously, three times the calculated requirement for limestone addition under full unhindered rates of acid generation will be available on site to provide a margin of safety for pH control.

For Stage III, large-scale on-site tests with a limed rock stockpile will be performed to determine directly the potential implications of large-scale features such as hot spots, limestone encapsulation, and oxygen transport at a scale more comparable to the proposed operating system. This information will be used to refine the waste management plan.

As mentioned previously, three times the calculated requirement for limestone additions under full unhindered rates of acid generation

Response: (cont'd) will be available on site to provide a margin of safety for pH control.

Response by: Kevin Morin, Norecol

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.8 Water Treatment Plant/Wetlands

Topic: a) Verification of treatment plant sizing

Comment: The ability of the water treatment plant to handle potential flow volumes (i.e. all pit water and all drainage from the stockpile) and qualities to meet projected standards of effluent quality under all flow conditions must be verified; a near final-level of design for this component will be required at Stage II.

Response: See response to Environment Canada comments I-3d, and III-1c and Appendix 1.1-1.

Response by: John Gadsby, Steffen Robertson and Kirsten

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.8 Water Treatment Plant/Wetlands

Topic: b) Pilot scale wetlands

Comment: As recommended in the Stage II Report, pilot scale development of the wetlands should begin immediately.

Response: A work program for the recommended immediate "pilot scale development of the wetlands" will be prepared for implementation in Stage III.

Pilot scale testing of the wetlands will be initiated upon receipt of approval-in-principle, and during the construction phase. The detailed wetland design will be finalized in Stage III; however, it is anticipated that the wetland design will include a multiple-cell arrangement to maintain the desired nearly-flat slope. This arrangement will allow the first cell constructed to serve as the pilot test site. Testing of plant species, transplant methods and wetland function will take place in this cell while the berms for the remaining cells and for the wetland below the mudstone dump area are being completed. It is anticipated that testing of vegetation adaptability to the treatment plant effluent will be carried out initially on a small scale (i.e. in pots). Pilot scale testing with treatment plant effluent will take place during the pilot scale testing of the water treatment plant

Response by: Alan Whitehead, Norecol

Various other comments pertaining to the design and testing of the constructed wetlands appeared in the MOE Appendices and are addressed below.

Comment: Storm events of varying duration will have to be analyzed and routed through the various settling and equalization ponds, as well as the wetlands. There should be sufficient pre- and post-treatment storage to absorb intense storms, to buffer treatment plant breakdowns or upsets and to provide storage during times of very low flows in receiving waters, which might cause exceedence of water quality objectives (Appendix 1, Section 2.3.1, p.6).

Response: Modifications have been made in the design of the mine site settling ponds and water treatment facility since the Stage II Report. Wetland design and operation criteria remain as described in the Stage II Report (Volume II, Section 7.3.12 and Volume IV, Section 2.2 and Appendix 2.2.2.1). Aside from direct precipitation, the wetlands will receive only effluent from the treatment plant or drainage from the mudstone dump and overburden stockpile areas. Additional information on design and operation and of the mine site ponds and water treatment plant and of the wetlands, is provided in Appendix 1.1-1, Section 9.0, of this document.

The maximum flow entering the wetland below the water treatment plant will equal the maximum effluent discharge from the plant, or 3500 m^3/d plus the drainage from the wasterock stockpile underdrain (830 m^3/d for a total flow of 4330 m^3/d). This flow is lower than the 5570 m^3/d maximum flow indicated in the

Response: (cont'd)

Stage II Report (Sections 7.3.11). As a result of the revised design, added storage capacity built in to the water treatment plant and upstream settling ponds as well as the equalization pond, will eliminate the possibility of surges. The revised system is described below.

The revised water management plan provides for additional storage in settling ponds upstream of the treatment plant as well as in an equalization pond between the treatment plant and the constructed wetland. The present design provides for storage capacities in the upstream settling ponds of:

(1) the surplus flow of the 10-year return period wet October over the average October flow;

(2) the surplus of monthly average winter flows in excess of the 3500 m^3/d treatment plant process rate;

(3) the surplus of the 100 year return period 10-day storm in excess of the 3500 m^3/d plant process rate;

(4) accumulated sediment equal to 20% of total pond capacity; and

(5) 1.0 m freeboard.

Reponse: (cont'd)

Additional details are provided in Appendix I.1-1 Sections 5.0 and 6.0. The equalization pond below the treatment plant provides an additional 20 000 m^3 storage capacity prior to entering the wetland (see Appendix 1.1-1, Section 8.0). This additional volume represents a contingency storage for treatment plant effluent. The aforementioned increased storage capacity upstream of the wetland is sufficient to mitigate storm events as well as treatment plant upsets or breakdowns.

Mitigation of water quality impacts in Barbie Creek during extreme low flows is provided by several design features of the water management plan. Mitigation is provided by the increased storage capacity mentioned above, as well as the contingency option to route water treatmentplant effluent to the mill for use as process water or to discharge to the active impoundment. The overall goal of these features is to time the releases of treated minesite drainage to coincide with the maximum flows of the receiving streams.

The wetland below the mudstone dump will receive the outflow of a settling pond, designed to remove solids from the mudstone dump runoff. The flow to this wetland will be attenuated by the settling pond. During extreme low flows in the receiving waters, there will be negligible runoff from the mudstone dump and consequently negligible discharge of wetland effluent into Barbie Creek. Storage capacity in the upstream

Response: (cont'd) settling and equalization pond will ensure sufficient flows to both wetlands during summer to sustain the wetland vegetation.

Response by: Alan Whitehead, Norecol

Comment: (cont'd) Details regarding the design of the waste rock stockpile underdrain and the transport of effluent from the two constructed wetlands to Barbie Creek will be required at Stage III (Appendix 1, Section 2.3.2, p. 6).

Response: Discharge from the wetland (MSW1), receiving effluent from the water treatment plant and drainage from waste rock stockpile underdrain, will be piped to lower Barbie Creek. Discharge from the wetland (MSW2) receiving drainage from the mudstone dump will be routed by a ditch to Barbie Creek.

Response by: Alan Whitehead, Norecol

Comment: (cont'd) At Cinola, the proposed equalization pond has capacity for storage of only 10 to 45 days influent flow, so that a plant upset could be critical in terms of the quality of the effluent being sent to the wetlands (Appendix 1, Section 2.3.3, p. 7).

Response: The treatment plant and equalization pond design have been modified as described in Appendix 1.1-1. A monitoring pond has been introduced between the water treatment plant and the equalization pond. In the event of treatment plant upset, the poor quality water will be detected in the monitoring pond and returned to

Response: (cont'd) MSSP3 for retreatment. As a result, poor quality water will not be delivered to the wetland. The revised design details of the settling ponds, treatment plant, and equalization pond are provided in Appendix 1.1-1, Sections 5.0, 6.0, 7.0 and 8.0, respectively. Prevention of potential damage to the wetlands in the event of treatment plant upset will be provided by:

1) increased storage capacity in the settling ponds receiving drainage from the pit and waste rock stockpile providing a steady flow of water to the treatment plant;

2) micro-processor monitored operation of the treatment system (three independent pH probes) controlling feed to the plant; and

3) incorporation of a 6-hour retention micro-processor-controlled monitoring pond into the equalization pond system.

In the event of a major plant upset, such as an interruption of lime addition, pH monitors in the treatment plant will signal an alarm and feed entering the treatment plant will immediately be shut off. Effluent from the treatment plant would also cease, to prevent impacts on equalization pond water quality and the wetlands. In the event of a minor upset of short duration, the pH probes will trigger an alarm, and the monitoring pond will provide a 6-hour retention period to allow the problem to

Response: (cont'd) be diagnosed and corrected before poor quality water overflows to the equalization pond. Contaminated water in the monitoring pond will be returned to MSSP3 for treatment.

Response by: Alan Whitehead, Norecol

Comment: (cont'd) We foresee a lengthy period for the establishment of the constructed wetlands, with no real guarantee that they will work, particularly if the effluent quality from them is licenced at fixed maxima which need to be met all year (Appendix 1, Section 2.3.4, p. 8).

Response: This concern is addressed by reviewing the function for which the wetlands have been designed.

The primary function of the constructed wetlands is to prevent nitrate enrichment of the receiving waters during low flows in summer. Sensitivity of the environment to nitrate enrichment is highest at this time because of increased biological activity and reduced dilution. The nitrate removal function of wetlands is not required to achieve satisfactory effluent quality during other times of year. Because nitrogen removal can take place during winter, as documented in the Stage II report (Volume IV Appendix 2.2.2-1, Table 1), design criteria for wetland operation during winter have also been provided.

Response: (cont'd) Although removal of suspended solids and metals will occur in the wetlands, this function is not necessary to meet effluent quality objectives. Establishment of a mature wetland system will take one or two full growing seasons, depending on plant vigor, weather, and soil conditions. The wetlands will be put to functional use as water treatment units only after the vegetation is successfully established. Site-specific information on wetland development will be obtained during pilot testing in Stage III. Transplanting methods will be selected once the vegetation donor sites have been identified. The methods available include plugs, root cuttings, and seed. Detailed engineering design and construction methods are now being reviewed and will be completed in Stage III. A detailed schedule for wetland development will also be established in Stage III.

Response by: Alan Whitehead, Norecol

Comment: (cont'd) The design flow through the wetlands is anticipated to be exceeded significantly in the wet months. How can they be effective when this occurs? The requirement that the physical design must withstand the 1:200 year instantaneous flow does not appear to have been evaluated to date (Appendix 1, Section 2.3.4, p. 8).

Response: The design parameters, flows and resulting hydraulic retention time (HRT) for NSW1 and MSW2 are shown in the following table.

Response:
(cont'd)

DESIGN PARAMETERS FOR MSW1 AND MSW2

	AREA	
MSW1	1.6 ha	(From Feasibility Study)
MSW2	1.1 ha	

	HRT	DEPTH
Summer	min 2 day	0.3
Winter	min 1 day	1.0

		FLOW m^3/d YEAR 3	FLOW m^3/d YEAR 7	FLOW m^3/d YEAR 12
MSW1	Summer low	1340	1760	2380
	Winter high	4220	4320	4330
MSW2	Summer low	1190	1230	1240
	Winter high	5160	5320	5360

		HRT DAYS	HRT DAYS	HRT DAYS
MSW1	Summer	3.6	2.7	2.0
	Winter	3.8	3.7	3.7
MSW2	Summer	2.8	2.7	2.7
	Winter	2.1	2.1	2.1

$$\frac{\text{Area x depth}}{\text{flow}} = \text{HRT}$$

Response: (cont'd) MSW1 will receive the outflow from the equalization pond and MSSP2. The quantity of flow will be attenuated in MSSP2 and MSSP3. The maximum flow will be the maximum from the water treatment plant of 3500 m^3/d and the maximum flow from MSSP2 will be 830 m^3/d for a total of 4330 m^3/d. Surges in flow are not expected to occur.

MSW2 will receive the outflow from MSSP6 which will attenuate the flow. However, in the event of storm runoff exceeding the capacity of MSSP6 more severe flows could result. The high velocity flow resulting from this event could cause erosion damage in the wetland. This will be prevented by regulating the flow with a weir at the inlet to the wetland. In order to prevent erosion of the wetland by high velocity flow a weir will regulate the inflow to MSW2. Flow conditions which exceed the wetland capacity will be diverted to a bypass ditch. The diverted water will go directly to the Barbie Creek tributary in which MSSP6 is located. The attenuation of flows in MSSP 2, 3 and 5 preclude the requirement for the wetlands to withstand the 1 in 200 year instantaneous flow.

Water treatment by the constructed wetlands during winter is not necessary to meet the 10 mg/L nitrate receiving water criterion. This is due to the higher dilution and assimilative capacity of the receiving environment during

Response: (cont'd) periods of high flow and to the lower biological productivity during winter due to cold temperatures. Therefore, the fact that the wetlands in the above-average wet months may be operating at flows higher than design capacity, will not be significant in terms of environmental protection.

Comment: (cont'd) Because the chemistry of the effluent will be so unlike other waters in the area, the most desirable species to plant in the wetlands may not occur naturally on the Charlottes (Appendix 1, Section 2.3.4, p. 8).

Response: The available information, on the ability of aquatic plants to tolerate non-natural water quality, suggests that most species are very adaptable. Many species of wetland vegetation, including some that are known to occur on the Queen Charlottes, have been identified as having a broad range of tolerance to water quality conditions, including pH and ionic content, as described in Volume IV of the Stage II Report (Appendix 2.2.2-1). Among the species that are known to occur on the Charlottes, information is available on the bulrush, <u>Scirpus lacustris</u>, the rushes, <u>Juncus</u> sp., sedges <u>Carex</u> sp. and cottongrass, <u>Eriophorum</u> sp. Examples of the water quality to which these species are known to be adapted, provided in Section 1.4e, indicate that the above species can tolerate sulphate (SO_4) concentrations as high as 2600 mg/L. Expected SO_4 concentrations at Cinola are 1500 to 2500 mg/L. Thus, it appears that plant adaptability to the effluent will not be a problem at Cinola.

Response: (cont'd) Testing of locally available plant species for survival in simulated effluent from the water treatment plant is planned to finalize species selection for the Cinola wetlands. This activity will be included in the pilot scale wetlands development program in Stage III. (Please refer to Section I.5.c of the responses to EC for additional information on the pilot scale studies.)

Response by: Alan Whitehead, Norecol

Comments: (cont'd) At Stage II, the proponent should develop a spreadsheet of expected discharge flow and quality from both wetlands using input variables in the Stage II report, including metals and suspended solids (Appendix 1, Section 2.3.4, p. 8).

Response: Spreadsheets for expected discharges and (nitrate) concentrations have been developed and were presented in Stage II (Volume IV, Tables 2.2.2-12 and 2.2.2-13). Spreadsheets for suspended solids and metals are not necessary to assess potential impacts on receiving waters, and have consequently not been developed. The reasoning behind this approach is as follows.

Suspended Solids

Assessment of suspended solids (SS) loading to the receiving waters at Cinola has been based on the assumption that effluent from all settling ponds will meet the 25 mg/L permit level generally applied.

Response: (cont'd)

Each wetland system in the mine site area is preceded by one or more settling ponds. Wetland MSW1 receives effluent from the water treatment facility, which includes settling basins and an equalization pond and the waste rock stockpile which is followed by a settling pond. Wetland MSW2 receives effluent from settling pond MSSP6 which treats drainage from the mudstone dump. The settling basins are currently designed to provide at least 10 hours of retention, which should ensure adequate solids removal. Consequently, water entering the wetlands will already meet the maximum permitted suspended solids levels of 25 mg/L.

Additional suspended solids removal can be expected in the wetlands. Suspended solids (SS) removal efficiencies of 40 to 93% have been recorded in constructed wetlands receiving sewage lagoon effluent (Herskowitz et al. 1987; Cooper and Boon 1987; Bavor et al. 1987). Influent SS concentrations ranging between 23 mg/L and 1000 mg/L have been reduced to levels of 4.5 to 30 mg/L in the wetland systems described. In all cases reported, wetland effluent met suspended solids standards. Preliminary results from an experimental pilot scale wetland at Quinsam Coal Mine between August and November, 1988, include effluent SS of 1.3 to 19.3 mg/L (average 9.8 mg/L) (Norecol, unpublished data). The latter results are below the expected 25 mg/L effluent SS requirement and further support the reasoning that SS releases from the constructed wetlands are not a concern.

Response: **Metals**
(cont'd)

The major concern regarding metals in mine effluent is associated with acidic drainages. All acidic waters at Cinola are to be routed through the water treatment plant for metals removal prior to release to the wetland. While the primary function of the wetland is nitrate removal, incidental removal of metals will also occur, as documented in the Stage II report (Volume IV, Appendix 2.2.2-1). Permit requirements for metals concentrations in mine site effluents are met in the current plan, even when the metals removal capacity of the constructed wetlands is not taken into account (Stage II Addendum Report, Section 8.3). Because metals removal is known to take place in such wetlands, the system provides in effect, a contingency.

The concern over potential releases of suspended solids and metals from the treatment plant to the receiving waters during lower flow periods has been addressed in Section 1.8, and Appendix 1.1-1 Sections 5.0, 6.0, 7.0 and 8.0. The proposed approach involves storing the effluent during low flow periods for either release during a subsequent higher flow period, use as process make-up water in the mill, or disposal in the tailings impoundment.

The extent to which wetlands will contribute to removal of metals and suspended solids at Cinola

Response: (cont'd) will be assessed in the pilot scale program scheduled for Stage III.

Response by: Alan Whitehead, Norecol

References:

Bavor, H.J., D.J. Roser and S. McKersie. 1987. Nutrient removal using shallow lagoon-solid matrix macrophyte systems. pp. 227-235 in:

Aquatic Plants for Wastewater Treatment and Resource Recovery. K.R. Reddy and W.H. Smith (eds.). Magnolia Publishing Inc, Orlando, Florida. 1032p.

Cooper, P.F. and A.G. Boon. 1987. The use of Phragmites for wastewater treatment by the root-zoone methods: the UK approach. pp. 153-174 in: Aquatic Plants for Wastewater Treatment and Resource Recovery. K.R. Reddy and W.H. Smith (eds.). Magnolia Publishing Inc., Orlando, Florida. 1032p.

Herskowitz, J.S. Black, and W. Lewandowski. 1987. Listowel artificial marsh treatment project. pp. 247-254 in: Aquatic Plants for Waste Treatment and Resource Recovery. K.R. Reddy and W.H. Smith (eds.). Magnolia Publishing Inc., Orlando, Florida. 1032p.

Comment: (cont'd) Design flows and anticipated effluent quality must be re-evaluated at Stage II so that the extent of changes in Barbie Creek water quality can be properly evaluated and so that the costs in the feasibility studies are based on realistic design inputs (Appendix 1, Section 2.3.4, p. 8).

Response: The system designs and revisions presented in this document have been costed in the Feasibility Study. Water quality estimates for Barbie Creek have been reassessed on the basis of the revised water balance (E C Section I-6a) and to examine the effect of the 7-day 1:10 year

Response: (cont'd) low flow condition (MOE section 1.4a). In addition, contingency plans have been developed to address various scenarios of increased flows or reduced quality of effluents (Appendix 1.1-1).

Response by: Alan Whitehead, Norecol

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.9 Milling

Topic: a) Mercury balance in the mill circuit

Comment: The mercury balance throughout the milling process needs to be clarified.

Response: The information used in predicting the mercury balance of the Cinola project has been obtained from two sources:

1. Analyses of samples removed from the pilot plant run at Hazen Research Inc. simulating the process and flowsheet proposed. (ref.1)

2. Plant data from several operating companies in the USA, South America and Papua New Guinea. (ref.2-5)

The pilot plant analyses data and the mass balances for the design conditions has been compiled to produce a predicted mercury balance for Cinola increasing the level of detail produced previously. Following this, an analysis has been made of the behaviour of mercury through the entire process. This has established the deportment of mercury in each unit operation and in all plant discharges.

Mercury Balance

During the operation of the pilot plant each unit operation of the hydrometallurgical treatment section was sampled and analyzed by

Response: (cont'd)

Norecol Environmental Consultants and by Hazen Research Inc. Average assays and concentration values were compiled and a pilot plant mercury balance is presented in Table 1.9-1. (ref.2-6) There are variations of between -9.1 and +5.3% in the balances of different unit operations. Although these would appear to be significant they should be considered typical of mercury balances carried out in other experimental tests facilities and operating plants in particular for low grade or dilute ore such as the one at Cinola.

It is worth observing that at the time of sampling the pilot plant no effort was made to obtain the samples for mercury analysis following a sequential time movement through the circuit. In other words, the samples were collected at about the same time in the nitrate oxidation and neutralization steps without allowing for progressive retention time displacement through the circuit i.e. 2 h. in leaching, 0.5 h. in each neutralization step, etc.. In addition, samples taken from the carbon in leach circuit; the cyanide destruction and the mercury sulfidization circuit may or may not have corresponded to the original sample of ore used in the mercury balance.

The average analytical values obtained at each stage of the hydrometallurgical operation have been used to prepare a predicted mercury balance

TABLE 1.9-1

Mercury Balance in the Nitrate Oxidation Process Pilot Plant

Basis: 1.00 tonne ore at 50% solids

	Mercury Analysis Solids ppb	Liquid ug/l	Solids Weight kg	Liquor Volume l	Solid mg	Mercury Liquid mg	Total mg	Mercury Dissolution %	Mercury Balance %
Ore	4344		1000	1000	4.34	0.00	4.34	0.00	
Nitrate Oxidation Product	4370	64	1032	1016	4.51	0.06	4.57	1.42	105.3
Limestone Neut. Product	4033	37	1089	1174	4.39	0.04	4.44	0.97	102.1
Lime Neut. Product	4000	2.5	1095	1267	4.38	0.00	4.38	0.07	100.9
CIL Product	2960	701	1095	1301	3.24	0.91	4.15	21.96	
CIL Carbon	35200		0.74		0.03	0.00	0.03		96.2
Cyanide destruction product (SO2)	3600	5.2	1095	1301	3.94	0.01	3.95	0.17	90.2
Mercury precipitation with Na2S (SO2)	3700	0.22	1095	1301	4.05	0.00	4.05	0.007	93.3
Mercury precipitate with Na2S (H2O2)	3300	0.32	1095	1301	3.61	0.00	3.61	0.012	83.2

MOE-105

Response: (cont'd) for Cinola. Tonnages and volumes used correspond to the design criteria of the project as used in the Feasibility Study. The results are presented in Table 1.9-2 and illustrated schematically in Figure 1.9-1..

A thickening stage after nitrate oxidation was not included in this balance since it was not used in the pilot plant runs. This does not affect the mercury balance because the oxidation leach was carried out at high percentage solids and there would not have been a significant washing/dilution effect.

As a result, the concentration of mercury in the thickener overflow can be expected to be similar to the leach solution at approximately 64 mgL^{-1}.

An analysis of the mercury distribution column in Table 1.9-2 clearly indicates that mercury is found principally in the solid phase at all stages except in the CIL cyanidation circuit. In this unit operation, up to 24% of the mercury feed was found to be in solution.

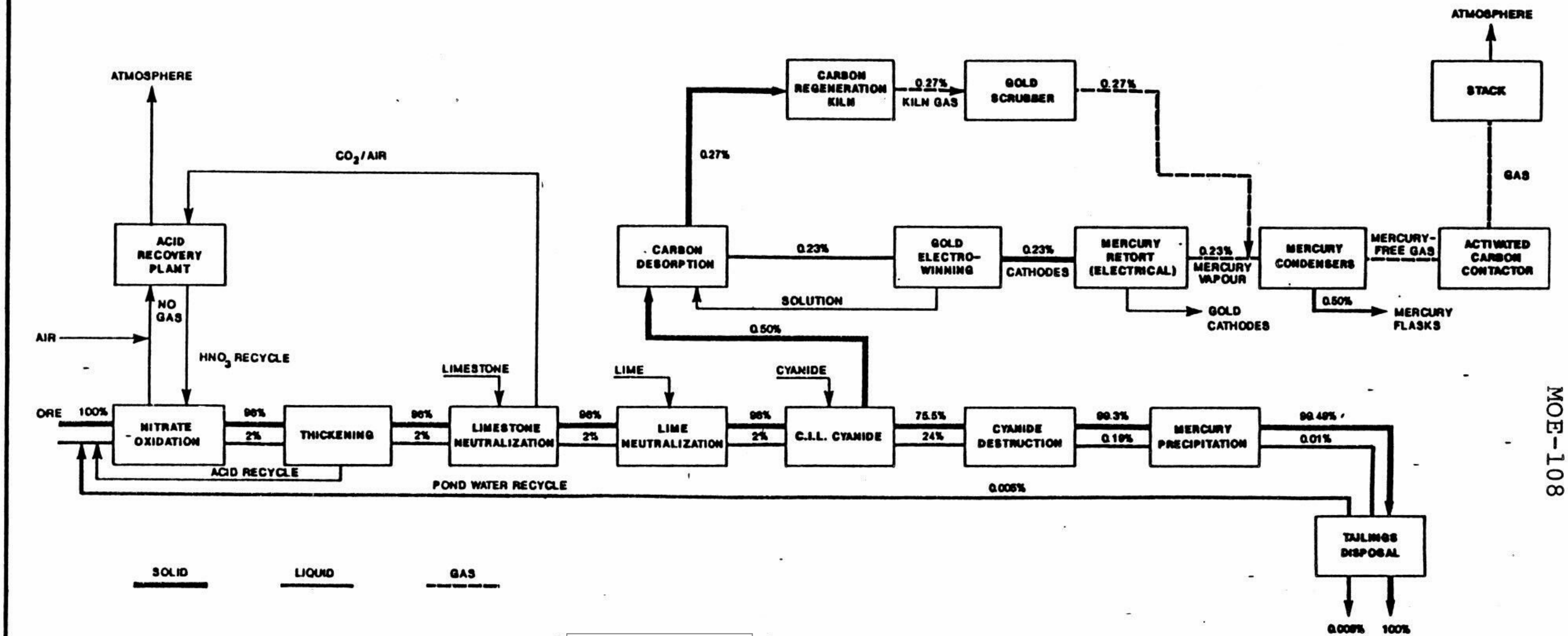
Table 1.9-2 also shows that mercury in the tailings solution contains 0.01% of the original mercury in the ore. This result was obtained at a mercury concentration of 0.22 mgL^{-1} Hg in the pilot plant in the mercury precipitation step.

The influence of cyanide destruction by oxidation with SO_2/air on the subsequent mercury precipitation as HgS has been addressed in

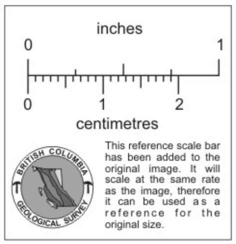
TABLE 1-9-2 MOE-107

CINOLA GOLD PROJECT
CALCULATED MERCURY BALANCE - PROCESS CIRCUIT

UNIT OPERATION	STREAM	SOLIDS		LIQUID/GAS		MERCURY		DISTRIBUTION	
		TONNAGE t/h	ASSAY ppb.	VOLUME m3/h	CONCENTRATION mg/L		g/h		%
NITRATE OXIDATION	IN ORE	262.5	4340			IN	1139.25	IN	100.00
	WATER	--		226.7	0.0		--		--
	NITRIC ACID	--		71.4	0.0		--		--
	SULPURIC ACID	--		1.9	0.0		--		--
						TOTAL	1139.25		100.00
	OUT RESIDUE	259.9	4370			OUT	1135.76	OUT	98.22
	SOLUTION	--		320.6	64		20.51		1.78
	NO gas/vapour			1791.8					
						TOTAL	1156.27 (+1.49%)		100.00
LIMESTONE NEUTRALIZATION	IN RESIDUE	259.9	4370			IN	1135.76	IN	98.18
	SOLUTION	--		320.6	64		20.51		1.77
	LIMESTONE	9.7		47.4	00		--		
						TOTAL	1156.27		100.00
	OUT RESIDUE	281.0	4033			OUT	1133.27	OUT	99.13
	SOLUTION	--		270.4	37		10.00		0.87
	CO2 gas/vapour			3122	00		--		
						TOTAL	1143.27 (-1.12%)		100.00
LIME NEUTRALIZATION	IN RESIDUE	281.0	4033			IN	1133.27	IN	--
	SOLUTION	--		270.4			10.00		--
	LIME	7.0		17.0			--		--
						TOTAL	1143.27		
	OUT RESIDUE	284.0	4000			OUT	1136.00	OUT	99.91
	SOLUTION	--		374.9	2.5		0.93		0.09
						TOTAL	1136.93 (-0.55%)		100.00
C/L CYANIDATION	IN RESIDUE	284.0	4000			IN	1136.00	IN	99.81
	SOLUTION	--		374.9	2.5		0.93		0.08
	CARBON	0.156	3500	--			0.46		0.04
	LIME/SLURRY	--		17.5	0.0		0.00		0.00
						TOTAL	1137.39		100.00
	OUT RESIDUE	284.0	2960	--		OUT	840.60	OUT	75.56
	SOLUTION	--		380.0	7.0		266.38		23.94
	CARBON	0.156	35200	--			5.49		0.49
						TOTAL	1112.47 (-2.19%)		100.00
CYANIDE DESTRUCTION	IN RESIDUE	284.0	2960	--		IN	840.60	IN	75.93
	SOLUTION	--		380.0	701		266.38		24.06
	SO2	--		0.35			--		--
	CuSO4	--		0.08			--		--
	AIR	--		386.0			--		--
	LIME/SLURRY			6.6					
						TOTAL	1106.98		100.00
	OUT RESIDUE	285.7	3600			OUT	1028.52	OUT	99.80
	SOLUTION	--		386.6	5.2		2.01		0.19
	GAS EMISSION	--		--			--		--
						TOTAL	1030.53 (-6.90%)		100.00
MERCURY PRECIPITATION	IN RESIDUE	285.7	3600			IN	1028.52	IN	99.80
	SOLUTION	--		386.6	5.2		2.01		0.19
	Na2S SOLUTION	--		0.4			0.00		--
						TOTAL	1030.52		100.00
	OUT RESIDUE	285.7	3700	--		OUT	1057.09	OUT	99.99
	SOLUTION	--		386.6	0.22		0.08		0.01
						TOTAL	1057.17 (+2.58%)		100.00



MOE-108



DISTRIBUTION OF MERCURY IN THE CINOLA GOLD PLANT	
Figure no. 1.9-1	CINOLA GOLD PROJECT STAGE II RESPONSE
Date Mar. 1989	Drawn by NORECOL

Response: (cont'd) the next section of this response (Mercury Behaviour). Since there is no reason to believe that the sulfidization reaction will be hindered; the above continuity of process unit operations and the individual mercury balances should be regarded as representative of what the plant can expect.

The mercury profile through this circuit shows that only ~ 2% mercury remains soluble at the end of the nitrate oxidation step. Soluble mercury later precipitates as a hydroxide or is adsorbed to other precipitated hydroxides when the pH is increased prior to cyanidation.

Most of the mercury is precipitated during the oxidation step. The adsorbed mercury, and the less stable hydroxides and oxisulfate compounds redissolve during the cyanidation leach and the mercury is complexed with the cyanide ions. Only 2% of the dissolved mercury is then adsorbed to the coarse activated carbon in the CIL circuit.

Once the cyanide is destroyed, mercury again re-precipitates as a hydroxide and finally upon the addition of sodium sulfide, the remaining soluble mercury precipitates down to a concentration of 0.2 mgL^{-1}.

It has been decided that when the next pilot plant is run, a sampling - mercury balance campaign will be undertaken with all the unit operations functioning in sequence and the sample removal will be carried out following a time span as expected through the process.

Response by: Arnaldo Ismay, Minproc

References:

1. Hazen Research Inc., July 22, 1988, Pilot Testing of the Nitrate Oxidation Process on Cinola Ore.

2. Willmont, C. February 8,1989, Paradise Peak, Nevada, personal communication.

3. Eisele,Judy, USBM February 10, 1989, Reno, Nevada.

4. Sandberg,R., USBM February 10, 1989, Salt Lake.

5. Zarate, G.C., CIM Conference on Impurity and Disposal, Vancouver 1985, Copper and mercury behaviour in cyanidation of gold and silver minerals.

6. Gertenbach D., August 30, 1988, Hazen Research Inc., letter to Kevin Foo, Minproc.

Response: **Mercury Deportment in the Process**
(cont'd)

Introduction

The average mercury content of the Cinola ore is 5 ppm, with analyses ranging between 2 and 10 ppm. This concentration is low compared to many gold deposits in Nevada (where the average content is 20-50 ppm.) and is similar to several large deposits under development: i.e. Porgera in Papua - New Guinea.

Response: (cont'd) While the content is low, the significant mercury concentration in waters close to the mine site and the enormous effort put in to this project in evaluating the impact of plant discharges on the environment, warrants an analysis of how mercury behaves through the entire process plant and in what forms and concentrations it exists in the tailings, gas emissions and plant products.

The following is an attempt to characterize the nature of the mercury in each stage; define what chemical reactions it undergoes and what products are formed, and establish what the stability of each of these products is.

Mercury Behaviour

Several mineralogical studies have been carried out to determine the occurrence of mercury in the Cinola ore. To do this, a scanning electron microscope was used provided with an energy dispersion analyzer. Samples would then be scanned to detect a region of high mercury concentration and then this region would be analyzed for other elements to determine their association. XRD analysis was then carried out to determine the correct compound. (ref.1) Several ore samples and samples prepared by selective digestion (to obtain a higher mercury concentration) were analyzed. The ore chips used were greater then 1 mm. in diameter.

Response: (cont'd) Only mercury sulfide as cinnabar has been properly identified by this method in the ore samples. This mineral was observed to be coating certain surfaces of quartz particles in micron and submicron films.

It was not possible to detect any mercury containing spots on examination of the ore after it had been leached and the mercury re-precipitated. This may be explained by the fact that the newly formed mercury compounds were precipitated as dispersed particles in concentrations lower than detectable with the available technique.

One must assume that given the fact that mercury exists as a sulfide compound and that the occurrence is as fine coatings on well exposed coarse particles, all of it is oxidized and leached from the matrix minerals during the oxidative nitric acid leaching.

However, mercury does not remain soluble in significant concentrations in an acid environment, particularly at 85 C. It is therefore reasonable to expect that most of the mercury re-precipitates immediately either as mercury jarosite Hg 0.5 Fe_3 $(SO_4)_2$ $(OH)_6$ or as mercury oxysulfate $HgSO_4$ 2HgO. This assumption is based on the experience that exists in producing synthetic mercury jarosite. (ref.2) In contrast to the method used for making other alkaline metal or ammonium jarosite compounds

Response: (cont'd) which consists of preparing a metal sulfate solution in an acidified ferric sulfate solution, and heating this solution to precipitate the corresponding jarosite, the production of lead or mercury jarosite is complicated by the extremely low solubility of these metals and consequently metal nitrate solutions must be prepared and added to a reactor containing acid ferric sulfate solutions at a slow and steady rate, where the lead or mercury jarosite and oxysulfate are immediately precipitated.

The chemistry of iron precipitation as jarosite compounds, which are hydrated ferric sulfate compounds, has been extensively studied and there are many publications on this subject (ref.3.4). Iron is removed from acid solutions as hydronium jarosite without the addition of alkali, by the reaction:

$$3Fe_2(SO_4)_3 + 14\ H_2O \longrightarrow 2(H_3O) \cdot Fe_3(SO_4)_2\ (OH)_6 + 5H_2SO_4$$

However, the reaction is slow and incomplete except at high temperatures.

In the presence of alkali metals or ammonium, jarosite will precipitate by the general reaction:

$$M_2SO_4 + 3Fe_2(SO_4)_3 + H_2O \longrightarrow 2M\ Fe_3(SO_4)_2\ (OH)_6 + 6H_2SO_4.$$

Response: Where M can be:
(cont'd)

H_3O^+, Na^+, K^+, Rb^+, Ag^+, NH_4^+, 1^+, $1/2Pb^{2+}$ or $1/2\ Hg^{2+}$.

The most common jarosites are those formed with potassium, sodium or hydronium. These all have natural mineral counterparts. Mercury can substitute any alkaline metal found in larger concentrations and form mercury jarosite. It is most likely that in the reactions with the Cinola ore a solid solution of several jarosite compounds is formed primarily involving hydronium H_3O^+ and mercury.

All jarosites are extremely stable compounds. This is evidenced by the fact that several hydrometallurgical processes must first dissolve all the iron in the ore or concentrate in order to extract the valuable metal products such as zinc, copper and uranium because iron and these metals are bonded chemically. Then the solubilized iron must be precipitated, washed and impounded as a certain type of jarosite compound. Jarosites have also the advantage that they scavenge and remove certain impurities either by incorporation into their compound or by adsorption. The most common impurities that are removed from solution are arsenic, selenium, germanium, etc..

Response: (cont'd) Two cases in Canada that use the disposal method are the zinc plants of Zinc Electrolitique du Canada in Valleyfield, Quebec and Kidd Creek Mines in Timmins, Ontario. The operations dispose of 1500 and 600 tonnes/day of jarosite respectively to unlined ponds that are close to populated areas. The operations have been carrying out this practice since the early 1970's without any signs of redissolution of the jarosite compounds.

Jarosites are most stable in acid conditions but although it is possible to decompose jarosite under alkaline conditions, this needs high temperatures and long periods of time (i.e. 85 - 95 C for 8-16 h.). The Cinola process flowsheet does not have these conditions, and consequently the mercury jarosite formed during the nitrate oxidation step can be expected to remain stable throughout the entire process. If it decomposes in the tailing ponds under the alkaline conditions of the cyanide plant impoundment, this reaction could only happen at an extremely slow rate and the solubilized mercury would immediately reprecipitate as mercury hydroxide.

It is possible that some of the iron could also precipitate as goethite FeO.OH. This compound is also stable but in contrast to jarosite it does not incorporate other metals into its structure. Metals that are found co-precipitated with goethite are normally bound by adsorption only and can be redissolved if a suitable complexing

Response: (cont'd) agent is found. If any mercury were to be removed from solution by goethite it is likely that it would be extracted and redissolved in the cyanidation leaching and would act similarly to the mercury oxysulfate as discussed next.

The formation of mercury oxisulfate is less understood and we believe that it is this compound which dissolves during the cyanidation leaching and allows any mercury to appear in solution. Some mercury may also be de-sorbed from precipitated hydroxide such as goethite. Mercury however stays in solution at this point of the circuit only because it is complexed with cyanide ions in the same way that gold and silver are dissolved.

As has been explained in the material balance section, some of the mercury that dissolves during cyanidation is adsorbed on to the coarse activated carbon used for gold recovery from solution. To do this, it must compete with gold and silver cyanide complexes. There is some evidence that mercury cyanide adsorption is faster than gold but that the gold cyanide adsorption is stronger than mercury and consequently gold displaces mercury off the carbon as it progresses through the carbon in the leach circuit (CIL).

There has been no evidence of this phenomena in the continuous CIL tests carried out in the pilot plant at Hazen Research. The concentration of Hg

Response: (cont'd) was quite constant throughout the tanks in this circuit at ~700 ppm. Since at all times in the CIL circuit there was a surplus concentration of cyanide, and the gold extraction reached its maximum in about the fourth tank of the 10 tank circuit, it is reasonable to assume that all the dissolvable mercury from the precipitates in the oxidation step was extracted and that all the remaining mercury in solids can be considered refractory or stable.

The unit operation that follows the CIL cyanidation step is the destruction of cyanide which is accomplished by the oxidation with SO_2/air. One must observe that the only parameters that change in this step is the oxidation potential since the reduction in pH is compensated by the addition of lime.

If the mercury concentration is reduced from 700 mgL^{-1} to about 5 mgL^{-1} as demonstrated in the pilot plant simply by removing the complexing agent, it is reasonable to assume that the 5 mgL^{-1} is the equilibrium concentration of mercury at the high pH of the solution in the absence of complexing agents.

The final operation in the process is the sulfidization of mercury that remains soluble to form a HgS precipitate by the reaction:

$$Hg(CN)^{=}_4 + MS \rightarrow HgS + M^{++} + 4CN^-.$$

Response: (cont'd) This reaction has been demonstrated to lower the mercury concentration in solution to below 1 mgL^{-1}. Under non-oxidizing or reducing conditions as would be expected in the pond, the mercury sulphide compound will remain stable.

Summarizing, it is reasonable to assume that all exposed mercury sulphide in the ore is oxidized in the nitrate pre-oxidation step simultaneously with the oxidation of pyrite/marcasite minerals and any other sulphide species. The oxidized mercury, because of its low solubility, precipitates as mercury jarosite and to a limited extent as mercury oxisulfate. Some mercury could be adsorbed to any goethite formed or other metal hydroxides. It is assumed that the less stable oxisulfate and the adsorbed mercury is re-leached during cyanidation together with any mercury hydroxide that precipitates when the slurry is neutralized from pH 1-2 up to pH 10.

The mercury that remains in solution as a mercury cyanide complex and is not adsorbed on the activated carbon, precipitates when cyanide is destroyed.

It is presumed that mercury at this stage precipitates as a hydroxide and that the remaining mercury in solution is precipitated as a stable mercury sulphide compound upon the addition of an excess quantity of Na_2S in solution.

Response: (cont'd) Both mercury jarosite and mercury sulfide are stable solid compounds and mercury hydroxide is stable at high pH values in the absence of complexing anions. Jarosite is known to decompose at a very slow rate in alkaline media, but the liberated mercury would immediately re-precipitate as mercury hydroxide.

One could speculate that there would be a certain advantage in having all the non stable mercury (non jarosite mercury) back in solution at the time that the Na_2S is added. However, this would require acidifying the cyanide containing slurry down to a pH in which all mercury hydroxide would dissolve, and then adding the Na_2S to sulphidize all the soluble mercury. Due to inherent complications in plant safety and the additional costs that would be involved in neutralizing to the disposal pH twice, this is not a practical solution.

It is fair to say that given our present state of knowledge; the experience of many years in the industrial disposal of jarosites compounds at much greater tonnages and the thermodynamic data available on the solubility of mercury sulphides and hydroxides at a high pH values, the only mercury from the tailings that could be dissolved in the water flows from Cinola would be at the concentration of 0.2 mgL^{-1} already attained during pilot plant testing.

Response by: Arnaldo Ismay, Minproc

References:

1. Electron Microprobe Analysis, Cannon Microprobe/SEM for Norecol, August 15, 1988.

2. J. Dutrizac and S. Kaiman, Canadian Mineralogist, Vol 14 p.151-158 (1976), Synthesis and Properties of Jarosite like Compounds.

3. The Jarosite Process, Arregui V, et. al., Lead, Zinc, Tin '80, edited by TMS. AIME, 1979.

4. Dutrizac, P., Metal Trans. 14B, 531 (1983). Factors affecting alkali jarosite precipitation, Hydrometallurgical Process Fundamentals.

A comment is made in Appendix I, Section 5.1, page 17, regarding solubility of cinnabar, as follows.

Comment: (cont'd) The solubility of cinnabar, HgS, in cold water is 8.6 ug/L. While this is a low solubility, HgS is not inert, as the report claims and the solubility noted above is 86 times greater than the current maximum aquatic life criterion. We note that mercury does not seem to be picked up in the long-term leach tests of pilot plant tailings solids (Table 3.4.2-2, Addendum). What is the explanation for Hg (as HgS) remaining below its solubility in the pore water? (Appendix 1, p.17, S.5.1).

Response: The solubility of cinnabar in water is dependent on pH, Eh, and the other ions in the water. [These dependencies as well as thermodynamics of HgS and $Hg(OH)_2$ are explained in Appendix 1.4.1.]

Response: (cont'd) The simplest explanation for the lack of the reported solubility is that the solubility of cinnabar is dependent on such aqueous conditions as pH, Eh, temperature, pre-existing sulfide concentrations, aqueous complexing, and redox reaction rates such as oxidation of aqueous sulphide to sulphate. For example, geochemical principles indicate the solubility of cinnabar is significantly less at alkaline pH than at acidic pH. Because of all of these complexities, it is not realistic to expect one solubility for cinnabar. Consequently, short-term and long-term leach tests were carried out on the Cinola tailings in order to determine mercury concentrations relevant to the specific characterictics of these tailings.

Response by: Kevin Morin, Norecol

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.9 Milling

Topic: b) Mercury and ammonia emissions

Comment: Emission rates of mercury and ammonia from the Carbon Stripping Plant, and details of stack parameters, must be provided in Stage II to enable our assessment of the impacts of these potential pollutants.

Response: **Mercury Elimination in Gases**

There are three places where mercury can be discharged in gaseous emissions. These are: (a) the stack from the nitric acid regeneration plant; (b) emission from the carbon regeneration kiln and (c) mercury retort furnace.

(a) Acid Regeneration Plant

The vapour pressure of mercury at 85 C is only 0.115 mm and given that the concentration of mercury in solution is only ~ 60 ppb, the amount of mercury vapour or carry over into the product gases of the nitrate oxidation step does not pose a significant mercury emission problem.

In addition, the basis of operation of the acid recovery plant is to use atmospheric air to oxidize the NO product gas into NO_2 prior to its absorption and regeneration of nitric acid. This atmospheric air oxidation requires large

Response: (cont'd) volumes of air, most of which is finally discharged from the nitric acid plant stack. The design air flow rate is 35000 m^3/h and consequently mercury in the emission from the acid regeneration plant will be well below the limit mercury concentration levels of 0.001 mg/m^3.

(b) Carbon Regeneration

Values obtained from publications (ref.1) and from operating plants indicates that about 20% of soluble mercury is adsorbed on activated carbon. Examination of the mercury distribution column in

Table 1-9-2 shows that in this case, based on pilot plant operation, only 2% of dissolved mercury was adsorbed on to the activated carbon in the CIL circuit. This low value could be the result of the low mercury composition in the ore and/or that the equilibrium mercury loading expected during steady state operation was not achieved due to the short experimental time run.

Even under the assumption that 20% of the dissolved mercury did adsorb on the activated carbon, this would represent an adsorption recovery of 1.4 kg/d on the activated carbon together with the recovered gold.

There is limited published information on the elution of mercury from the activated carbon and for the purpose of this analysis, the result of a single stripping test carried out at Hazen

Response: (cont'd) Research will be used. In this case 40.6% of the mercury was removed and it will be assumed that no mercury is desorbed during the acid washing steps.

In consequence the amount of mercury fed to the thermal activation step could be as high as 0.83 kg/day (1.4 kg/d x 0.59 = 0.83 kg/d). Since the volume of gases from the carbon treatment section of the activation kiln is 3080 m^3/h the concentration of mercury in this gas stream could be 16900 mg Hg/m^3 if it is assumed that all the mercury is volatilized in this unit operation.

The gas emission from the reactivation kiln is then passed through a cooler condenser where the mercury concentration is reduced to below 0.1 mg/m^3. This practice is in operation in several mills in Nevada, including Paradise Peak (ref.2) which has a mercury content ore order of magnitude higher than Cinola.

As a security precaution the cooled gas stream is contacted with activated carbon in a canister before being discharged to the stack. The contact with the activated carbon is a security measure required in the event of a malfunction of the cooling system. The capacity of achieving the target mercury concentration has been corroborated by the carbon manufacturer. (ref.3)

Response: (c) Mercury Retort Furnace
(cont'd)

Gold, silver and mercury adsorbed on the activated carbon are all redissolved during the stripping operation. Due to the electrochemical potential of Hg, this metal is electroplated preferentially to gold. It therefore is present in the stainless
wool cathode which must be melted to produce the gold bullion. Prior to smelting, the cathode is retorted in an electric furnace. In most cases it is possible to eliminate most of the mercury by holding the cathodes at a temperature of ~ 600 C. The mercury volatilizes and is transported in the retort off gas, drawn by a small vacuum through a 2 stage cooling system described in the preceding section.

References:

1. Zarante, G.C., CIM Conference on Impurity Control and Disposal, Vancouver, 1985, Copper and Mercury behaviour in cyanidation of gold and silver minerals.

2. Willmont, C., February 8, 1989, Mill Superintendent Paradise Peak; personal communication.

3. McManus, J., Calgon, December 1988, letter to A. Ismay.

Response: **Ammonia Elimination in Gases**
(cont'd)

There are only four locations that can be identified in the process which have some potential for producing NH_3 gas emissions. these are:

1. Acid plant regeneration.

2. NH_3 storage tanks and transfer facilities.

3. Cyanide destruction section.

4. Electrolysis cells/CIL adsorption circuit.

Ammonia will be used as the source of make up of the nitric acid consumed in the process. This reagent will arrive as liquefied gas in 22 ton tanker truck loads and will be stored in a cylindrical storage tank with a capacity of 68 m^3.

When required, the ammonia will be pumped from the storage tank, through the heater-evaporator and sent to the ammonia oxidation unit. This contains a platinum catalyst gauge which oxidizes the ammonia with air. The resultant gas stream is passed to the nitric acid plant where it is absorbed and converted to nitric acid. Annual consumption is estimated to be 1408 tonnes.

While ammonia gas is toxic, the techniques for handling such a gas in a safe manner are well established. These consist of a vacuum system in

Response: (cont'd) all pipe, tanks and connecting pipe areas which could leak during a malfunction. The ammonia can be scrubbed through a sulfate containing solution and be transformed to ammonia sulfate. This product can then be disposed off into the slurry which goes to the nitric acid oxidation step where it reacts with the soluble iron in solution and forms ammonium jarosite. These compounds are very stable as discussed under the section of mercury distribution.

In conclusion ammonia handling, storage and burning as described above are considered standard industrial practice with well defined control and safety procedures.

Ammonia can also be formed during the oxidation of cyanide during the cyanide destruction operation; in the adsorption circuit and in the electrolytic cell during the electrowinning of gold. In all of these locations, the reactions that occur are:

1. The oxidation of cyanide ions to CNO^-.

$$CN^- + SO_2 + O_2 + H_2O \dashrightarrow CNO^- + H_2SO_4$$

$$\text{or } CN^- + 1/2\ O_2 \xrightarrow{\text{activated carbon}} CNO^-$$

Or a much slower reaction with thiocyanate:

$$SCN^- + 4\ SO_2 + 4O_2 + 5H_2O \dashrightarrow CNO^- + {}_5H_2SO^4$$

Response: (cont'd) followed by:

2. The hydrolysis of CNO^-.

$$CNO^- + 2H_2O \xrightarrow{\text{hydrolysis}} NH_3 + HCO_3^-$$

The extent of these reactions have not been quantified but are minimal and are known to occur in every gold plant in the world.

The following measures are taken to control ammonia emissions into the work place:

1. Good ventilation in the CIL circuit tanks. These are self erected tanks open to the atmosphere and will not have accumulated ammonia gas due to the large amount of air that is sparged in the tanks.

2. No ammonia will be detected in the cyanide destruction circuit again due to the large volume of air injected in the tank.

3. The cells in the electrowinning circuit are equipped with close fitting covers and are connected to the central fume scrubbing system. All electrolysis cells and ducts are maintained under vacuum. This will ensure that if there is any opening, air will flow into the vessels, thus avoiding the escape ammonia to the work environment.

Response by: Arnaldo Ismay, Minproc

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.9 Milling

Topic: c) Hydrogen fluoride emissions

Comment: We note that fluoride will be used as a fluxing agent in the mill. Estimates of HF in any emissions should be presented and assessed at stage II, as this pollutant is very toxic.

Response: The use of fluorspar was proposed as a component of the fluxing agent for the smelting of the steel wool on which gold has been deposited by electrowinning. Fluxes are used to produce a slag which dissolves and retains iron and other impurities introduced with the steel wool cathodes that would otherwise report to the gold bullion.

The objective of adding fluorspar to the flux formula is to lower the slag viscosity. This effect is achieved using very little fluorspar, and in general no more than 0.1% of the melt weight (flux plus steelwool) is used in commercial plants. Furthermore only a minor amount of the fluorspar reacts to form HF otherwise it would not be effective in reducing slag viscosity.

The proposed flux composition is:

Component	% of Composition	Consumption tonnes/year
Silica	8.1	0.65
Sodium Nitrate	41.5	3.32
Borax	25.2	2.02
Litharge	0.1	0.01
Fluorspar	0.1	0.01
Steelwool	25.0	2

Response; (cont'd) The planned tonnage of flux to be used will result in the use of only 8 Kg/year of fluorspar added to the smelt bath. Assuming that even 50% of this product reacts to form HF gas then the daily discharge of HF (at 2 meltings/week) will be 77 g/day.

We have not been able to locate any reference citing HF emissions from the smelting operation of a gold plant. However, our opinion is that the very small amount of slag that is produced in a gold mill such as Cinola, coupled with the fact that fluorspar only represents 0.1% of the feed weight, does not represent at all an environmental problem nor a safety risk even when we agree that HF is a very toxic reagent.

We do want to stress that if the low production of HF in the emissions at Cinola is still a concern to this Ministry, City Resources would look into changing the flux formula to avoid fluorspar addition. This could theoretically be done by lowering the silicon content which could make the addition of fluorspar unnecessary.

Response by: Arnaldo Ismay, Minproc

1. INFORMATION REQUIREMENTS TO BE ADDRESSED AT STAGE II

1.10 Transportation Corridor

Topic: a) Contingency plans for road spills

Comment: Contingency plans for spills of toxic substances en route to Ferguson Bay or to the mine site should also be clarified.

Response: Potential problems associated with the transportation of supplies for the operation of the project include conflicts with other traffic or loss of vehicle control resulting in truck upsets or damage and potential spillage of toxic substances.

City Resources' contingency plan for road spills addressed prevention and response aspects as outlined below.

1) It has been recognized that the most important factor in contingency planning for the transportation of supplies is good communications. It has been estimated that the contractor who will carry out the transportation itself will probably have three trucks operating at all times and this number will include the fuel truck. There will also have to be a base operator at Ferguson Bay who will act as the coordinator. City Resources itself must have

Response: (con'd)

a receiver at the warehouse and there must also be a traffic manager at the mine. All of these operators must be in radio contact with each other at all times. It will be part of the planning for this operation to specify how often and when they are in contact.

It is evident that special care must be taken when the transport trucks reach the mine haul road to ensure that there is an orderly progression of vehicles along the road.

The contractor must carry, in addition to normal insurance, special environmental insurance which is very costly. As a consequence a responsible contractor will have every monetary incentive to maintain the safety of his operation.

2) A most important factor in minimizing the potential for accidents is the control of the speed of the vehicles. This could be done by mechanical governing of the engines, so that there is a maximum speed at which the vehicle can operate.

3) Another important factor for minimizing accidents is the quality of the route. The route as it exists now is reasonably straight with no bad bends, or grades, but it is recognized that it must be upgraded,

Response: (cont'd)

with adequate turnouts at lines of sight. It is anticipated that as part of this upgrading some curves in the road will be straightened out. The upgraded roads must also be provided with berms and suitably placed run-off lanes in those sections of the road that have significant grades.

Another aspect of upgrading that will have to be considered is the provision of adequate ditching on both sides of the road in those sections where there are no berms. The ditches must have the potential to hold the likely quantity of any substance that might be spilled. This will entail ensuring that the ditches are comparatively watertight by excavating them into till, or by applying a till lining. It will also be necessary to ensure that it is possible to control and contain flows from ditches to prevent spills from entering water courses.

The transportation contractor as well as being responsible for hauling must also grade the roads and City Resources will specify the quality of road surface that must be maintained. It is recognized that a potential source of road accidents in the Queen Charlotte Islands is the black ice that forms at times in the winter. The transportation contractor will be held responsible for frequent inspection of the

Response: (cont'd)

road surface, snow ploughing and adequate sanding of the surfaces whenever this is required.

4) City Resources will also specify the quality and amount of equipment that is to be used on the haul. The specifications will include:

- The provision of adequate spare tractors and cranes that can right any unit that has gone off the road.

- The use of tractors with adequate traction and stopping power. It may be necessary to use 6-wheel drives.

- The use of trailers with over-sized water-cooled brakes, or hydraulic brake retarders.

5) It is vital that conflicts between users of the roads be eliminated. City Resources has proposed to MacMillan Bloedel that all transportation be carried out on the cross shift to the logging operations, that is between the hours of 6.00pm and 6.00am.

In addition, City Resources would maintain an area within the limits of Port Clements, which will be used as an assembly area for visitors and employees. City Resources would run a shuttle service between the mine and this area for employees, service contractors

Response: (cont'd)

and visitors at change of shift and at regular intervals during the day.

6) It is also necessary for the success of the project that flexibility of access be maintained in case there is an accident, or breakdown which could potentially close a road for a number of hours. The discussions with MacMillan Bloedel have established that the Bay Road, which parallels the Ferguson Main, will be the route used by City Resources contractors. It follows, that in the case of an emergency or accident the Contractor will have the option of maintaining his operations by using Ferguson Main on a temporary basis.

The route that has been described in the Stage II Report is along the Yakoun main road and the Y-900 branch. This road will not be available for traffic in the first half of the construction period, because it is in this period that the haul road between the mine and the plant will be constructed and/or upgraded. As a consequence, Branch 8, which runs through the High West area will have to be sufficiently upgraded so as to serve as a temporary access route for heavy equipment. It is proposed to keep this branch maintained, so that in case of an emergency blockage of the Yakoun main route, there will be an alternative route available.

Response: (cont'd)

Passengers, visitors and service personnel will use Branch 4 during the construction period. There must be some upgrading of this road, so that it will be suitable for this function.

7) The final aspect of the transportation operation that must be considered is the problem of minimizing the consequences of an accident, when and if it happens. There are a number of parts to this problem. One of which is to ensure there is adequate help immediately available. Another, is to ensure the integrity of the load to minimize the possibility of spillage. A final part, is to ensure that there are plans in place to deal with spills when they occur.

One way to ensure that help is immediately available is to schedule those materials that have the potential to be especially hazardous, such as cyanide, explosives and concentrated acids, for transportation to the mine using escorted convoys. This will have the additional benefit of ensuring that there are no hazards on the road and that the vehicles travel at safe speeds.

The preservation of the integrity of the loads will be done in a number of ways, which will include:

Response:
(cont'd)

- o The proper design of trailer ensuring that the material specifications are more than adequate for the proposed service. The established specifications will ensure that the tanks can overturn without rupture.

- o The compartmentalizing of the trailers, so that in the case of rupture only part of the load has the potential for spillage.

- o The provision of additional liners within the body of the trailer wherever this is possible. This could entail the provision of air bags for the box trailers and flexible liners for the tanker trailers.

Spill response planning will be dealt with in a number of ways, which will include:

- o The provision of proper training for all of the crews, to ensure that they understand the nature of the loads they are transporting. There is a government requirement for training in loading and off-loading.

- o The establishment of the proper procedures for dealing with spills of the substances that are considered to be environmentally hazardous.

Response: (cont'd)

- o The provision of emergency contact people who will have expertise in dealing with the different substances. These experts will be both at the property and offsite. Employees will be instructed on accessing government emergency response centers where help and information can be obtained.

- o The provision of emergency supplies both on the trailers and at intervals along the route. These supplies could include:

  - slaked lime and/or limestone, for neutralizing acids.

  - Plastic sheeting for covering soluble substances.

  - Absorbent substances for soaking up fuels.

- o Training employees on proper deployment of equipment and supplies.

Response by: Peter Cowdery, City Resources

2. CORPORATE COMMITMENTS REQUIRED AT STAGE II

Topic: a) Near final design

Comment: A commitment that the design of project components critical to environmental protection (that is, the tailings embankments, the water collection/treatment plant/wetlands system, the pit embankment and abandonment plan) are in a near-final level of detail, and that these designs are the basis of mine feasibility studies represented at Stage II.

Response: This comment is addressed in MOE Section 1.1a

2. CORPORATE COMMITMENTS REQUIRED AT STAGE II

Topic: b) Establishment of a surveillance team

Comment: A commitment that a team comprised of representatives of the company, key agencies of government and public interest groups will be established to review and evaluate project development and monitoring results at regular intervals (perhaps quarterly, initially) and to review mine plans for the next interval. Details concerning the composition and terms of reference of this team are to be developed as a Stage II condition of approval. We would suggest that the very successful Surveillance Committee set up for the Equity Mine be used as a model.

Response: City Resources has, in their ongoing discussions with the Council of the Haida Nation, already committed to the formation of a committee which would periodically review the project with particular reference to environmental matters.

City Resources, in discussions with the Coordinator of the Health Care Society of the Queen Charlotte Islands, has already committed to the establishment of an independent environmental laboratory. The laboratory would carry out all monitoring and analysis of water quality samples taken for the project.

In keeping with these prior commitments, City Resources fully endorses the suggestion by MOE that a group such as the Surveillance Committee for Equity Mine be formed.

Response: (cont'd) It is understood that the committee formed by Equity Mines works very well and City will commit to visiting the mine and organizing a project committee for Cinola on the same lines as the one at Houston.

Response by: Peter Cowdery, City Resources

2. CORPORATE COMMITMENTS REQUIRED AT STAGE II

Topic: c) Reclamation bonding

Comment: A commitment to post an ever-increasing bond to cover not only the costs of project reclamation, as described in the Stage II Report, but also the costs of ongoing monitoring and maintenance in perpetuity after abandonment is required. The amount of this bond and its deposition could be reviewed on an annual basis by the committee noted above. Details of the initial bonding amount and a mechanism for its long-term use must be established as a Stage II condition of approval.

Response: City Resources has estimated the cost of closure and reclamation and has allowed for this activity in the Feasibility Study by setting up a fund along the same lines as that proposed by the MEMPR. The Feasibility Study is also conservative in estimating the yearly cash flows in that it does not take into account the salvage value of the plant.

More importantly, it does not take into account one of City Resources' priority short term aims, which is to reach agreement with B.C. Hydro on supplying power to Graham Island from its own power plant, by adding additional generating capacity as required.

B.C. Hydro is aware of City's intentions and has assured them that they can see no reason why this course of action should not be followed, as long as the cost of the power is competitive. The estimates shown in the Feasibility Study demonstrate that City Resources' cost for

Response: (cont'd) producing power is highly competitive and the company is confident that they will come to an acceptable agreement with B.C. Hydro. B.C. Hydro have confirmed their verbal assurance in writing and City Resources will commit to following up on this aspect of the project and to install additional generating capacity.

Once City Resources becomes a producer and seller of power to the Islands the problems associated with the short term nature of the project are minimized. The question of premature closure becomes non-existent, since any period of non-activity can be funded from the power operation and labour from the power house staff will be readily available to carry out the work. The question of funding long term monitoring can be solved by a commitment to use the profits of the power operation for this purpose, leaving any unused funds from the reclamation and salvage of the plant to cover unexpected contingencies and/or future clean up that may be required.

Insofar as making further commitments as to bonding, these are unnecessary since the MEMPR has the authority and responsibility to set the conditions and requirements for the matter. City Resources must then, as a matter of course, follow the guidelines that have been laid down by the Ministry.

Response by: Peter Cowdery, City Resources

2. CORPORATE COMMITMENTS REQUIRED AT STAGE II

Topic: d) Environmental supervision

Comment: A commitment is required to provide adequate environmental supervision at all times to ensure proper handling of materials and operation of facilities. The environmental supervisor(s) should be a member of the group noted in Section 2b).

Response: City Resources recognizes the importance of proper and adequate environmental supervision and the manning schedule which was used to develop the owners costs has provided for the almost immediate hiring of an environmental supervisor. It is intended to maintain continuity in the environmental work and there will be a period which the present environmental consultants will continue to be used on a full time basis. Their role will gradually fall back to that of a true consultant, which is that of providing advice on environmental matters.

City Resources' full time environmental staff in the operating period have been minimized since the goal is to establish an independent environmental laboratory and sampling organization.

City Resources endorses the suggestion by the MOEP that a full time member of the Agency be domiciled in the Queen Charlotte Islands. The

Response: (cont'd) duties of the staff member would include the provision of environmental inspection services to the project and to carry out any associated research.

Response by: Peter Cowdery, City Resources

2. CORPORATE COMMITMENTS REQUIRED AT STAGE II

Topic: e) Water treatment facilities after operations phase

Comment: A commitment to have water treatment facilities available after operations have ceased as a contingency in the event that some drainage waters continue to be of unacceptable quality for discharge to Florence or Barbie Creek.

Response: Yes. The need for water treatment after closure is discussed in response to E.C. comments III-1e and III-2b.

Response by: John Gadsby, Steffen, Robertson and Kirsten

The water treatment plant will remain in place as long as is necessary. During pit backfilling all water from the mine area will be directed to the pit to speed the backfilling and submergence procedure. As a result the water treatment plant will not be required, providing an opportunity to overhaul and rehabilitate the plant. It will then be fully operational if needed following closure and subject to on-going maintenance by on-site staff for the power plant.

2. CORPORATE COMMITMENTS REQUIRED AT STAGE II

Topic: f) Ongoing water quality and hydrology monitoring

Comment: A commitment to maintain operation of the existing baseline climate, hydrometric and water quality stations for the coming year at least. This program will be revised at Stage III according to operational requirements.

Response: The baseline climate, hydrology and water quality monitoring program will be maintained, with emphasis placed on drainages potentially affected by the project. Monitoring will focus on Barbie, Florence and the Yakoun drainages while hydrology and water quality stations on Gold, Clay and Canoe creeks and the Mamin River may be discontinued. Monitoring will continue throughout construction and operation, with sampling sites and frequency adjusted according to operational requirements.

Response by: Annette Smith, Norecol

2. CORPORATE COMMITMENTS REQUIRED AT STAGE II

Topic: g) Advance construction of wetlands

Comment: A commitment to begin construction an field testing of the wetlands immediately. The objective should be to have them operational at design capacity (hydrological and biological) before pit development activities begin. Contingency plans must be presented to deal with the possibility that this may not be achieved.

Response: A work program for pilot scale testing and development of the wetland systems will be prepared for implementation in Stage III, once Approval-in-Principle has been received.

The wetland construction schedule presented in the Stage II Report (Volume II, Section 3.4) has been revised. The anticipated schedule for wetland construction is to develop a pilot wetland during Stage III and expand this to full size during the preproduction period. Selection of vegetation donor sites and plant species for the pilot wetland will take place during spring and summer in Stage III. Small scale testing of selected plant species would proceed immediately, including a comparison of transplanting methods and assessment (in pots) of plant adaptability to water depths and simulated effluent quality. Transplanting of wetland vegetation using the selected methods would take place at any time during the subsequent dormant season between late fall and late spring. Development and maturation of the transplants would take place during the summer following berm construction. Preliminary

Response: (cont'd) pilot scale testing of the wetland could be initiated in later summer if vegetation development is sufficient. Otherwise, the pilot scale wetland testing program could be initiated in the early summer, the second summer after berm construction. In the event that discharge from the water treatment plant is necessary prior to the wetlands being functional, effluent could be disposed of in the tailings impoundment or used as mill process make-up water.

Response by: Alan Whitehead, Norecol

BRITISH COLUMBIA MINISTRY OF ENERGY, MINES
AND PETROLEUM RESOURCES LETTER,
N. RINGSTAD, DECEMBER 9, 1988

1. GEOLOGICAL ASSESSMENT

Stage II Concerns

Topic: a) Further evaluation of the underground resource

Comment: The Geological Survey Branch has indicated concerns, in its review, with respect to the major tonnage difference between geological and mineable reserves defined by the proponent, and questions whether the company's proposed mining plan would efficiently extract the currently mineable ore without unnecessarily sterilizing the remainder of the geological reserves (memo from P. Wilton to V. Preto, 1988-10-14). MEI shares this concern, since backfilling and flooding of the pit could potentially sterilize significant resource potential as part of efforts to ensure that the pit does not leak into the potential underground mine area and allow AMD production within the broken waste rock.

A further modelling and evaluation of both the potential ore below the open pit floor and the feasibility of mining in this area, with and without pit backfilling, is required.

Several questions were extracted from this comment as follows:

There appears to be a very large difference between the geological and the mineable reserves. What is the reason for this?

Response: The geological reserves were estimated at a very low cut-off grade with no regard for economics, and appeared, from a geological point of view, to represent the limits of significant mineralization in the deposit. When the operating costs were estimated it was apparent

Response: (cont'd)

that a much higher cut-off grade would have to be used if the project was to be mined economically. The geological cut-off grade of 0.69 g Au/t had to be raised to 1.1 g Au/t in order to make production economically attractive.

One feature of the Cinola deposit is a large preponderance of very low grade material, which means that any lowering of the cut-off grade is accompanied by a significant reduction in the average head grade.

The first line in Table 1-1, entitled "Reserve Reconciliation" shows the geological reserves as stated in the Stage II Report. Two independent mineable reserves as estimated for the Feasibility Study are shown in subsequent sections of the table.

The last part (Section C) of the table sets out the difference between the mineable and the geological reserves for both estimates. It is evident that the tonnages in the two estimates are very similar; the main difference between them arises from an assumption in the geostatistical estimate that greater mining selectivity is achievable. If the higher estimate of the remaining low grade at 0.89 g Au/t is accepted, it can be calculated that

TABLE 1-1

Reserve Reconciliation

A. W. Hill Manual Estimates

1. Estimates Included in the Stage II Report

Geological reserve (including possible) @ 0.69 g/t cut off -	43.5 x 10^6t @ 1.65 g/t
Diluted mineable reserve @ 1.1 g/t cut off -	24.8 x 10^6t @ 2.11 g/t

2. Revised Figures Developed for the Feasibility Study

Diluted mineable reserve @ 1.1 g/t cut off -	25.8 x 10^6t @ 2.17 g/t
Estimated dilution -	3.4 x 10^6t @ 0.64 g/t
- Undiluted mineable reserve @ 1.1 g/t cut off -	22.4 x 10^6t @ 2.40 g/t
- Undiluted in situ reserve @ 1.1 g/t cut off -	24.75 x 10^6t @ 2.33g/t
- Undiluted reserves outside of pit -	2.35 x 10^6t @ 1.67 g/t

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B. J. Askew Geostatistical Estimates Developed for and Included in the Feasibility Study

Diluted mineable reserves @ 1.1 g/t cut off -	25.62 x 10^6t @ 2.34 g/t
Estimated dilution -	1.82 x 10^6t @ 0.90 g/t
- Undiluted mineable reserve @ 1.1 g/t cut off -	23.80 x 10^6 @ 2.45 g/t
- Undiluted in situ reserve @ 1.1 g/t cut off -	25.0 x 10^6t @ 2.44 g/t
- Undiluted reserves outside of pit -	1.20 x 10^6t @ 2.24 g/t

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C. Low Grade Geological Reserves not Including in the Diluted Mineable Resources

1. Using W. Hill Revised Estimates	17.7 x 10^6t @ 0.89 g/t
2. Using J. Askew Estimates	17.9 x 10^6t @ 0.66 g/t

Response: (cont'd) the selling of gold price would have to be be significantly in excess of $ 478/oz in 1988 US $ before this material could be mined profitably. The calculations for this finding are shown on Table 1-2. City Resources has concluded that the remainder of the geological reserves will never be economically attractive and that the material is only interesting mineralization.

Response by: Peter Cowdery, City Resources

TABLE 1-2

Estimate of a Minimum Selling Price of Gold

A. Assumptions

1. The estimated operating costs that must be covered by the revenue are $16.51/t ($14.98/s.t.)
2. The metallurgical recovery is 90%
3. The grade of the material to be processed is 0.89 g/t (0.028 opt)
4. The value of $1.00 US is $1.20 CDN.

B. Calculation

The minimum selling price for GOLD must therefore be:

$$\frac{\$14.98}{1.2 \times 0.026 \times 0.9} = \text{US } \$\ 478/\text{oz}$$

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1. GEOLOGICAL ASSESSMENT

Stage II Concerns

Topic: b) Resource sterilization by pit backfilling

Comment: Does the current mining and reclamation plan, including the backfilling of the pit leave a significant proportion of the mineable reserves unmineable?

Response: The answer to this question must be prefaced by an explanation as to the reserve included in the Feasibility Study and why it appears to be different to that shown in the Stage II Report.

The mineable reserve included in the Stage II Report was based on a preliminary manual reserve calculation and pit design. The reserve calculation was subsequently revised for the Feasibility Study, largely because of improvements in the pit design. There were also changes to the reserve because a more specific dilution treatment was selected. It was decided that a geostatistical estimation of reserves and a computerized pit design should be developed and incorporated in the final Feasibility Study.

The first part of Table 1-1 shows the differences between the reserve included in the Stage II Report and the re-estimation. It would appear the first estimate was conservative in both quantity and grade. The amount of contained gold has increased by some 7% in the re-estimate. The second part of the table sets out the mineable reserve included in the Feasibility Study. Though the tonnages of the

Response: (cont'd)

manual and geostatistical estimates of the diluted reserves appear to be similar, the difference in the amount of contained gold is about 7%.

A mineable reserve in open pit mining includes only that part of the in-situ reserve at any particular cut-off that can be mined from an economically attractive pit. As a consequence, the reserve excludes material that is economically unattractive to process as well as material that cannot be mined economically because of the large amount of waste that would have to be removed.

Consequently, any economically attractive open pit design will necessarily leave some of the in-situ reserves unmined. In the case of the Cinola Gold Project, reserves outside of the pit for both the manual and geostatistical estimates are shown in Table 1-1. These unmined reserves total about 8% of the estimated in-situ material. The difference between the two estimates, manual and geostatistical, is about 6% in terms of contained gold. This difference can be attributed to the different extensions given by the estimators to the ore intersections found in the drill holes on the perimeter of the pit and their methods of dealing with high grade assays.

Response: (cont'd)

If it is accepted that the ultimate pit is indeed ultimate and will not be enlarged, then the only part of the reserves that will be left unmined is that low grade material that cannot be mined at a profit by underground methods. Table 1-3 is a review of the location and estimate of the amount of material that will not be mined in the present open pit design. The table can also be used to estimate the amount of mineralization that will not be found attractive to mine in a subsequent underground operation. The tonnages in the table were estimated manually, and the total lies between the independent manual and geostatistical estimates. On the other hand, the estimated grade is very close to the geostatistical estimate, but once the higher grade values are cut in a similar fashion to that used in the manual estimate, there is reasonable agreement between the grades. A set of sections showing the manual blocks and the outline of the ultimate pit are also included in this response document, as back up for Table 1-3.

It is evident that the material left in the east wall of the pit has little potential for extension to depth, and there is little chance of delineating a high grade portion for underground mining. It can be concluded that

TABLE 1-3

Unmined, Undiluted Reserves @ 0.11 g/t Cutoff

SECTION	ESTIMATED RESERVES Tns x 1000	Grade g/t	MAX DEPTH BELOW PIT	AVERAGE WIDTH M.	LOCATION WITHIN PIT	CONTINUITY AT PIT WALLS	OPEN TO DEPTH?	PROBABILITY OF H.G. ORE (+3 TO 4 g/t)
18 + 54	39	1.44	20	15	in floor	direct	no	little
18 + 14	68	1.41	70	9	in floor	likely direct	no	little
17 + 77	76	1.91	45	10	in floor	direct	no	little
17 + 40	134	2.13	90	10	in floor	50% direct - rest in FW of fault	yes	HG, in FW lenses
17 + 08	98	1.51	30	24	in floor	direct	no	little
16 + 62	206	1.54	60	18	in floor	direct	yes	some
16 + 19	152	1.85	40	15	in floor	direct	yes	some
15 + 86	17	6.42	16	15	in floor	direct	yes	some
15 + 55	-	-	-	-	-	-	yes	good
15 + 25	58	7.03	12	25	in floor	direct	yes	good
14 + 89	45	3.40	20	22	in floor	direct	yes	good
14 + 56	102	1.47	56	14	in floor	direct	yes	some
14 + 10	-	-	-	-	-	-	no	little
13 + 61	66	1.1	-	15	in E wall	probably none	yes	none
13 + 20	39	1.4	30	9	in floor	none - blocks 10 m below floor	yes	none
13 + 20	53	2.0	-	10	in E wall	direct	no	none
12 + 78	99	1.56	-	8	in E wall	direct	no	none in wall scattered lenses in pit floor
12 + 42	100	7.24	80	20	in floor	some direct - rest 20 m below floor	yes	good
12 + 42	26	1.53	-	8	in E wall	none 50 m in wall	yes	none
12 + 12	57	3.21	40	12	in floor	direct	yes	good
11 + 82	255	1.50	110	20	in floor	some direct - rest 35 m below floor	yes	little
11 + 82	16	5.17	-	14	in E wall	direct	yes?	little

continued . . .

TABLE 1-3 (concluded)

Unmined, Undiluted Reserves @ 0.11 g/t Cutoff

SECTION	ESTIMATED RESERVES Tns x 1000	Grade g/t	MAX DEPTH BELOW PIT	AVERAGE WIDTH M.	LOCATION WITHIN PIT	CONTINUITY AT PIT WALLS	OPEN TO DEPTH?	PROBABILITY OF H.G. ORE (+3 TO 4 g/t)
11 + 54	36	1.37	85	7	in floor	none - blocks 10 & 40 m below floor	yes	little
11 + 24	170	1.73	125	15	in floor	none - blocks 30 & 90 m below floor	yes?	some
10 + 91	58	1.69	130	9	in floor	none - blocks 90 m below floor	yes	little
Sub-Totals	260	1.75			Ore in E pit wall			
	1720	2.30						
TOTALS	1980	2.23						

Note:

1 By cutting high grade sections to the average grade value the mean grade can be calculated to be 1.7 g/t which corresponds to the Hill value and their approximate cutting procedure.

Response: (cont'd)

this material will not be mined and will effectively be rendered unmineable by the project. The blocks amount to some 260,000 t of low grade material and are equivalent to less than 1% of the total in-situ reserve. The ore in the floor can largely be recovered by salvage cuts into the pit bottom, and the blocks, which are open to depth, could be mined in a potential underground operation. There are a few blocks at the south end of the deposit that are significantly below the pit floor and therefore can be mined at any time in an independent underground mining operation, if they are found to be economic.

Since the majority of the reserve below the pit floor is open to depth and has a high grade core, the probability of an economic underground operation would appear to be quite high and has therefore been assessed. This assessment is attached to this response document as Appendix 1-1. This appendix concludes that a profitable underground operation could be initiated after the pit has been completed, given realistic gold prices and as long as the exploratory work indicates a reasonable degree of continuity of the type of mineralization found at the floor of the pit.

Response: (cont'd)

The style of high grade mineralization, which appears to be "en echelon" lenses of comparatively short strike length, together with the type of mining envisaged, either open blast hole or a VCR method, will ensure that mining can be carried out right up to and including the pit floor, so that a crown pillar will not be required after the operation ceases. The proposed method of access is via a ramp, and the use of trackless mining methods will ensure that underground mining can be profitable for comparatively small blocks of reserves.

It can be concluded that the in-situ reserves left unmined at the end of operations will constitute a negligible amount, perhaps 1% in the walls and possibly a similar quantity of very low grade material in the floor of the pit, and would in any case be uneconomic under foreseeable economic conditions.

Any underground mining that extends up to the floor of the pit will not alter the final backfilling operation. This operation will, however, necessarily be delayed until such mining has been completed. The only effect of the additional mining will be to increase the capacity of the excavation below the final ground water level. The initial planning for underground mining and the subsequent

Response: (cont'd) backfilling operation can be started in year 5 of production. This will make it possible to minimize the amount of waste taken to the High West site and increase the amount of waste stored on the temporary stockpile. In addition, extra limestone can be added to the temporary dump if this is found to be necessary for the period of underground mining. Operating cost savings will result from this change due to lower haulage costs and by reducing the requirement to increase the size of embankments necessary to store the tailings from the underground operation.

Comment: Can the temporary waste dump be safely left in place while the underground mining proceeds and can the pit be backfilled once the mining is complete?

Response: The temporary waste dump containing potentially acid generating waste material has been designed so as to prevent acid generation within the dump by adding sufficient limestone to the rock as it accumulates to neutralize all of the acid that could be potentially produced. It has been assumed in the Stage II Report and the Feasibility Study that the calculated theoretical amount of limestone required would be increased by three times to allow for the practical problems of mixing and construction.

Response: (cont'd)

Ongoing laboratory tests of columns, which have rock and limestone added in different amounts, appear to show that the conclusions City Resources has reached are indeed valid. Nevertheless, City Resources is proposing that large-scale field tests of the procedures be carried out as part of the Stage III work. These tests would involve using material from the Adit that is currently being stored on the old pilot mill foundations. A series of tests would be carried out using different amounts of limestone and different mixing techniques.

This test work will allow City Resources to use quantities of limestone that incorporate scale-up factors perceived to be realistic by all those concerned. The scale-up factor will always be sufficiently large to permit the stockpile to remain in place for a period that would be ample to cover any likely underground mining.

The initial information on underground mining will be available in the fifth year of operations, when only one-third of the waste will have been laid down in the stockpile. It would seem that any changes found to be necessary could be made at that time to prepare the stockpile for use over a longer period than envisaged in the Stage II Report. These changes

Response: (cont'd)

could entail the addition of greater amounts of limestone, redesigning the amount of final cover to be added, and using different methods of mixing. There would seem to be no theoretical reason why additional or different types of waste could not be added to this stockpile.

After mining operations are completed, the crown pillar between the pit bottom and the underground stopes can readily be removed by drilling from the pit floor, as part of the general pillar reclamation. On completion of the operation the only mineable ore that will not have been extracted are pillars in ore that are required for ground stability. With the strike length (maximum 150 m) and the mineable depth of zones (300 m vertical) expected at this time, this type of pillar is not expected to be necessary. If the ore zones are found to continue to depth, then it is very possible that an internal crown pillar may be left some 300 m below the pit floor, but this will not affect backfilling of the upper portion of the excavation.

As a consequence of the complete extraction of the mineable reserves and the mining widths of 12 m or more, it will be possible to effectively backfill all those underground excavations

Response: (cont'd) having continuity to the pit floor, as well as the open pit itself, in the manner described in the Stage II Report.

As noted elsewhere, the disposition of the pit waste can be amended to suit the increased size of the pit and underground excavations, once there is reasonable confidence that an underground operation will take place.

Response by: Peter Cowdery, City Resources

4. PLANT SITE LOCATION/MILLING PROCESS

Topic: a) Identification of other plants using similar mill process

Comment: The facilities proposed are not unusual, but the proposed milling process is technically more complicated than at most mills in British Columbia. Existing mills using this process should be identified, and a visit to such a plant by District Inspection staff would be valuable. Has there been any identification of similar milling plants to the one proposed, so that Agency members can visit it and see it in action?

Response: The use of nitric acid an as oxidant of refractory gold ores has not been employed at any commercial plant yet. However, there are certain similarities between the Cinola process and other refractory gold producers, and a visit to these properties may be instructive.

Two operating plants use acid media oxidation (sulfuric acid pressure leaching) to accomplish the same oxidation procedure proposed in the nitric acid process for Cinola. These are the McLaughlin plant of Homestake Mining Inc. in Lower Lake, California with a daily tonnage of 6100 t/d (3100 t/d through the oxidation plant) and the General Mining Union Corporation Ltd.(Gencor) plant at Sao Bento in Brazil which treats 6000 t/d of concentrate.

The first one has a pyritic concentrate and therefore the ore more closely resembles the mineralogy of Cinola. The latter treats an

Response: (cont'd) arsenopyrite concentrate. In addition to the pre-oxidation reaction it includes the precipitation and fixation of arsenic as ferric arsenate which is disposed of in the plant tailings.

These two plants will provide information regarding: (a) an acid circuit or chemical plant incorporated to a cyanidation mill; (b) neutralization circuits; (c) acid slurry thickening and recirculation of acid solutions; (d) scale prevention and effluent treatments similar to the Cinola project.

A third plant worth visiting is probably Sunshine Mining Co. in Kellog, Idaho. This mill treats a tetrahedrite concentrate to produce silver and copper using a batch nitric acid leach process at 150 C and processes 30 t/day of concentrate.

Although it is a small operation it presents many chemical similarities to the process for Cinola as follows. (a) the leach takes place in a nitric-sulfuric acid solution; (b) it generates NO gas which is converted to HNO_3, and (c) it involves a thickening step with a slurry containing nitrates. The discharge problems are similar in terms of NO_x concentrations. A visit to this plant would certainly provide information on how a hydrometallurgical process can be handled involving nitric acid and nitrogen oxide gases.

Response: (cont'd) Sikaman Gold Resources is presently carrying out a second pilot plant in Sudbury, Ontario (the first campaign was completed at APL Limited in Vancouver using a high temperature nitric acid leach process for the treatment of arsenical (arsenopyrite) tailings. The high temperature alternative of nitric acid leaching was adopted to avoid forming elemental sulfur from the arsenopyrite and pyrrhotite in these tailings.

This project has been handled with a fast track approach and the engineering of the high temperature nitric acid leach plant will begin in May of 1989 with a planned start up of early 1990. This mill will obviously have many aspects that are common to the Cinola project.

There is also a bioleaching plant under construction by U.S. Gold Inc. in Tonkin Springs, Nevada. This plant will treat 1500 t/d of ore in an acidified media using bacteria to oxidize or promote oxidation on the refractory sulfides. Following the bacterial oxidation step, the slurry will be neutralized and cyanided in the same way as at Cinola.

With respect to the nitric acid recovery plant section, again there is no plant that recovers NO/NO_2 gases at present as part of a nitric acid production. As explained in the Feasibility Study and the Stage II report, the principles for this technology have been known since 1940 (Lead Chamber process) but have not yet been used in

Response: (cont'd) conventional nitric acid manufacturing. The principal operation of the plant designed by Minproc uses a technology called the Fattinger process which absorbs NO/NO_2 gases into sulfuric acid and then releases the NO_2 gas by modifying the concentration and temperature of the concentrated sulfuric acid.

The same principle is used for absorbing dilute SO_2 or SO_2/NO_x gas mixtures at two Fattinger acid plants in Europe. The first is at Mines et Produits Chimique de Salsigne,Salsigne, France. This is a matte leaching plant. The second is in the HCST works, Gosler, Germany which treats a molybdenum roaster off gas.

A visit to these plants would demonstrate the operation proposed in the Cinola project, which is that NO gases can be initially oxidized in air under atmospheric pressure and that the remaining low concentration of NO_x, below 5000 ppm, can be recovered in sulfuric acid and converted to nitric acid releasing a final concentration of NO_x which is below 150 ppm. Both these operations have considerably higher demand for NO_x elimination than the Cinola plant

Response by: Arnaldo Ismay, Minproc

4. PLANT SITE LOCATION/MILLING PROCESS

Topic b) Workforce training in hazardous material handling and spill response

Comment: The metallurgical plant will require the use of a large number of chemicals that are commonly thought of as dangerous. Has there been a sufficient recognition of the need for proper training of plant personnel in the use and handling of these materials?

Mill-operating personnel must understand the nature of the process and the potential hazards associated with all of the chemicals used in the process, including the intermediate products at the various stages of the operation. Use of nitric acids, sulfuric acid, sodium cyanide, oxides of nitrogen, lime and sulphur dioxide contributes to the case for a significant training program before the operation begins. In particular, the nitric acid oxidation step, together with the regeneration process, would require circuiting of nitric acid and nitrous oxides, both of which are hazardous materials. This is a key area for continuous environmental monitoring, together with evacuation procedures and rescue training for the workforce. The application of sodium cyanide to the process is, in most modern plants, completed with minimum operator exposure. However, the potential exists for environmental problems and, as such, monitoring, training, and emergency preparedness are the most important aspects of the operation.

A significant training program for all operating and maintenance personnel will be required to ensure that the potential hazards of the process are fully understood.

Response: The company has taken all the precautions needed at this stage for creating a technically knowledgeable team that will operate the plant and maintain the highest degree of safety in working with and handling dangerous chemicals.

Response: (cont'd) It is well worth pointing out that the addition of chemical treatment plants to cyanidation mills is becoming more and more popular and that operations incorporating hydrometallurgical plants and using acid and oxidants are now running in remote and undeveloped locations. For example, Placer has now approved and is going ahead with their Porgera project in Papua New Guinea; Gencor is in its third year of operation at Sao Bento in Brazil (both companies use acid pressure leaching using high temperature autoclaves and high pressure equipment); and, CRA of Australia is going ahead with the Kelian project in Indonesia.

City Resources has recognized that special preparation will be required for all personnel even if they are recruited from other gold mills, or if they have previous experience in cyanidation processes. The initial mill managers and production superintendents will be incorporated in the early phases of development of the project. This will expose them to the combination of conventional milling practice and the new nitric acid pre-oxidation process. These individuals will in turn be in charge of training of operators when recruitment starts.

In addition, City Resources has planned for the building and operation of a pilot plant in British Columbia, to allow their operators to become familiar with the new processes.

Response: (cont'd) Operating and safety manuals will be written for each area of the Cinola project.

Some of the technical personnel to be hired will have chemical engineering and chemical plant training. They will be required for supervision of the acid regeneration plant and their experience will also be used for the less complicated areas of oxidation-leaching; chemical preparation; reagents destruction and environmental controls.

Timing and costs required for earlier than usual hiring and training has been fit into the company strategy plan and appropriate funding has been allocated in the economic analysis.

Response by: Arnaldo Ismay, Minproc

5. LOW GRADE STOCKPILE

Topic: a) Relocation of the low grade ore stockpile

Comment: The location of the low-grade stockpile as shown in the Stage II Report is poor from an environmental point of view. Has this design been changed in the Feasibility Study and if it has, is there a description plan available of the new location?

The low grade stockpile should be relocated to the east side of the tributary to Florence Creek in the same vicinity as proposed. It makes little sense to have it sitting in the creek when it could be situated beside the creek and still be conveniently accessible to the mill. This alteration would require revision of ditching, which should be favourable to the proponent. However, if relocation is not possible, the design of the tributary conveyance must receive special attention.

Response: Based on the Feasibility Study, the low grade ore stockpile has been relocated as indicated on Figure 3-1 in the Introduction. The new location provides benefits from an operating and cost point of view, and it addresses the environmental concerns expressed in this comment.

From an operations standpoint the proposed location offers the most convenient access from the mine. From a cost standpoint it allows the mill to be located with minimum earth moving and offers the best use of the water shed. Relocation to either side of the creek will result in a long stockpile area with higher operating costs. The tributary conveyance has been studied and included in the design.

Response: (cont'd)

The stockpile will be constructed on a 1-m thick basal infiltration barrier of mudstone to restrict infiltration of acidic water into the groundwater system. A cover over the stockpile will be designed to reduce the inflow of precipitation. It will consist of a 3.0-m thick layer of compacted mudstone on the top surface and a synthetic liner on the side slopes. A runoff diversion ditch designed to carry the 200-year, 24-hour storm runoff will surround the low grade ore stockpile. It will divert runoff from the mill area and the creek west of the mill around the stockpile and the collection pond.

A collection pond for poor quality water will be constructed 150 m downhill of the low grade ore stockpile. The pond will be created by a rockfill embankment with a high density polyethylene (HDPE) upstream liner.

Water management structures on the low grade ore stockpile will include the following:

a) A basal infiltration barrier;

b) A cover to reduce inflow of precipitation;

c) Runoff diversion ditches; and

d) A collection pond.

These structures are designed to control the quantity of acidic water, to prevent this water

Response: (cont'd) from entering the groundwater system, and collect and treat this water.

Response by: Arnaldo Ismay, Minproc

6. WASTE ROCK STOCKPILE/PIT BACKFILLING

General

Topic: a) Safety design of stockpile embankment

Comment: A volume of 26 million tons, piled 135 m high behind a permanent embankment of 40 m in height, is planned. Although only a stockpile, it will be a mine component for at least a decade and, as such, it should be constructed with long-term safety in mind.

The proponent's proposal for handling waste rock and reclaiming the open pit to a low-volume or entirely non-acid-generating site has been the focus of significant discussion and concern, generating the following Stage II questions and proposals for further evaluation.

There appears to be a permanent embankment incorporated into the design of the temporary waste stockpile. Has this stockpile been designed properly and is this embankment necessary?

Response: There is no embankment incorporated into the design of the waste rock stockpile. Construction of the waste rock stockpile is discussed in Section 3.6.6 of the Stage II Report. Following end dumping, the slopes are flattened to 3 horizontal to 1 horizontal so that equipment can work on this slope to place the cover. This is a flat stable slope for rock fragments.

On the other hand, before the waste rock is backfilled into the pit, an earth and rock fill embankment will be constructed to elevation 125 m at the south end of this pit. As descibed in section 3.7 of the Stage II Report, the purpose of this embankment is to maintain the

Response: (cont'd) groundwater level in the backfilled pit to elevation 123.5. The earth and rockfill embankment will be about 25 m high. It will be drained and constructed to water retaining structure standards and be able to withstand the shaking from the design earthquake.

Design details and construction specifications for this particular structure will be finalized during the Stage III design work.

Response by: John Gadsby, Steffen Robertson and Kirsten

6. WASTE ROCK STOCKPILE/PIT BACKFILLING

Stage II Concerns

Topic: b) Verification of flooding in the backfilled pit

Comment: Will the completed pit be able to accumulate and hold ground water, or is it likely that there will be known or unknown faults that will conduct water from the pit fast enough to empty it, or at least lower the level of ground water below the level of the backfilled potentially acid generating waste?

Known and unknown fault structures may be very costly or impossible to seal, resulting in long-term collection and treatment. A security deposit prior to approval to construct may have to be very substantial to guard against problems, and further evaluation of this issue is required.

Response: Numerous joints and fractures in the rocks of the deposit, patterned on a regular basis, are quite apparent from the adit excavations. There are minor joints at approximately 1 m spacing, with major joints every 20 to 30 m. It is equally apparent that all of these joints are completely filled with clays and gouge, which by simple inspection can be seen to be less permeable than the intervening rock itself.

Cross-cuts from the adit also extend into the Specogna Fault to the west and into the argillically altered material to the east. In neither case have open fractures been observed; in fact these two headings are totally dry. At the point of intersection, the fault consists of gouge and fine mudstone which, again by inspection, can be seen to be completely tight.

Response: (cont'd)

The largest proportion of groundwater in the Adit occurs at intersections of the excavation with surface drill holes and close to the portal where the clay filling has been washed out of the fractures due to the shallow depth of rock at this part of the excavation.

The extent of the surface exploratory drill holes is such that the possibility of encountering unknown faults or fractures in the pit excavation can be eliminated. No surface drill holes have been encountered where the drilling water was lost and/or passed through open fractures.

In addition to the above conclusions, which have been drawn on the basis of simple observation, SRK has carried out exhaustive test programs and analyses that essentially confirm the suitability of the pit to hold groundwater as described in the Stage II Report.

The effect of the Specogna Fault on the groundwater regime in the area of the open pit is discussed in response to EC comment I-2a and I-2d. Results of field studies are included in the updated Hydrogeology report (Appendix I-2-1).

Response: (cont'd) Field data clearly indicate that the Specogna Fault does not now and will not in the future behave as a conduit to surface and grounwater flow.

Response by: Peter Cowdery, City Resources
John Gadsby, Steffen Robertson and Kirsten

6. WASTE ROCK STOCKPILE/PIT BACKFILLING

Stage II Concerns

Topic: c) Sizing and costing of the water treatment plant

Comment: All effluent from all waste dumps, the overburden dump and the pit may have to pass through the AMD treatment plant. Lime treatment of waste rock may not work as well as expected. A rough estimate, not taking into account potential surges in flow, indicates that the plant may only handle approximately 1/3 of the flow in this scenario. A further assessment of water treatment plant design and costs is required, and the costs of very long-term treatment should be incorporated into the final feasibility assessment for this project.

Will the lime treatment of waste rock work as well as is expected and will the AMD treatment plant be capable of handling all of the run-off from the waste dumps and overburden dump as well as the water from the Pit?

Response: The plant has been designed with sufficient pit capacity and water storage ponds to be able to operate throughout the year with no discharge of any untreated water. The plant size allows for some excess capacity in the drier periods and as an ultimate contingency some drainage from the waste rock stockpile could, if it were found to be acidic, be routed through the plant (See Appendix 1.1-1). A more effective contingency would be to pump the water to the active High West impoundment. A number of contingencies have been developed to avoid this possibility. They are discussed in depth in EC Section III-1 a).

Response: (cont'd) Any requirement to treat water from the other stockpiles would seem to be unrealistic since the rocks of which they will consist have been demonstrated to be non-acid generating and, in some cases, acid consuming. It will be easy during the operating period to monitor the material placed on the dumps, and in any case, where material with the potential to generate acid is found, sufficient limestone can be added, in a similar manner to the main dump, to prevent the formation of any acidic runoff.

Consequently, the capacity of the treatment plant and system as designed would seem to be satisfactory.

The Mine Area Water Treatment System is discussed in responses to E C comments I-3d, and III-1c. Appendix 1.1-1 describes the water treatment system in detail.

Comment: (cont's) Will the costs of running the Water Treatment Plant be prohibitive in the long term?

Response: All planning to date has been intended to eliminate any long-term need to run the treatment plant. Nevertheless, it has been assumed that the water treatment plant itself would remain in place and will not be salvaged with the rest of the plant. If an apparent need to treat water from the backfilled pit should arise, it would seem far more appropriate to catch the water as it came across the spillway, Response: (cont'd) add sufficient ground limestone, and pump it back into the pit by injecting it into wells terminating below the water table.

As discussed in response to the E C comment III-1e, treating the water in the backfilled pit after closure using the plant is not considered the best environmental solution.

City could firmly commit to this course of action in the long term, since it intends to carry on producing power for Graham Island as long as possible. The kind of solution to the potential long term problem that has been described above can be carried out at a minimal marginal cost to the main ongoing power plant operation. The work would reduce the profits of the power station slightly, but would not require additional manpower and would not render the production of power uneconomical.

Response by: Peter Cowdery, City Resources
John Gadsby, Steffen Robertson and Kirsten

6. WASTE ROCK STOCKPILE/PIT BACKFILLING

Stage II Concerns

Topic: d) Waste rock disposal in the tailings impoundment

Comment: In view of the above, the proponent may be well advised to consider the cost of placing all the waste rock into the tailings impoundments. A 3:1 or greater waste-to-ore ratio would allow the tailings volume to be disposed of in the waste rock voids, and incremental additional tailings impoundment dimensions should only be slightly more expensive. Concern for AMD, the cost to collect and treat the drainage, and the amount of security, would all be reduced. Double handling of waste rock, the costs of lime for mixing with waste rock, and the amount of the security to provide for the premature closure scenario would be avoided. This approach would, of course, leave the pit walls exposed and subject to AMD production. A preventative treatment for this would have to developed. Extraction of all AMD waste rock on high walls, resloping, or other options would have to be considered.

Response: The proposed plan to backfill the pit came about only after it was recognized that long-term protection of the pit walls would be just as expensive as backfilling the pit. This was because a great deal of additional waste would have to be removed to provide assured safe foundations for the protective measures proposed, and there was little assurance that the problem of what would happen "in perpetuity" could be adequately addressed.

Response: (cont'd)

With the current knowledge of the geological setting it is unrealistic to assume that the argillically altered material, which will give rise to most of the potential long-term problems in the pit walls, can be excavated economically, as the extent of the altered rock seems to be increasing towards the east.

The unit cost of backfilling the pit has been estimated to be approximately $0.75/t, and the incremental cost of hauling and handling waste to the High West site is at least the same amount. This would mean that, because backfilling costs are delayed to the end of the project life and incremental haulage costs to High West would be incurred throughout the operation, the backfilling operation is more economical due to the time value of money alone.

Backfilling the open pit with waste rock, which in turn will be submerged under the final groundwater level is, therefore, the most desirable environmental solution.

Response by: Peter Cowdery, City Resources
John Gadsby, Steffen, Robertson and Kirsten

6. WASTE ROCK STOCKPILE/PIT BACKFILLING

Stage II Concerns

Topic: e) Metals release with soils and waste rock handling

Comment: The potential release of mercury, arsenic, and antimony during the handling of soils and waste rock is a concern which requires further assessment.

Response: These issues have been assessed in detail in Volume V, Section 4. Samples of rock and overburden have been excavated or drilled with a rotary bit, disturbed, packaged, and many shipped to Vancouver. The samples were then submitted to short-term and long-term leach tests, humidity cells, leach columns, and large-scale leach pads. All of this is considered to exceed the degree of handling anticipated during the actual mining operation. Despite this high degree of handling, concentrations of any particular metal were self-consistent at neutral and alkaline pH among all of the tests, indicating the insensitivity to handling. Therefore, the potential release of antimony (Volume V, Section 4.3.2), arsenic (Section 4.3.3), and mercury (Section 4.3.9) from rock and overburden has been characterized in detail. Nevertheless, these and other metals will continue to be monitored and assessed during all leaching experiments for Stage III.

Response: (cont'd) Long- and short-term leaching tests as well as acid-base accounting have been carried out on representative samples of the overburden. In every case this material has been shown to be innocuous. The main concern with moving it will be sedimentation, but the sediment control dams will be in place before the stripping operation is started.

Waste rock in the pit that has acid generating potential is easily identified because of its geographical position. This waste, except for the strongly altered argillic material, has been shown to take two months to develop acidic waters. The material should thus present no major problem in the pit, even when using conventional mining techniques, since it is very unlikely that any broken material would stay on the pit floor that long. In any case, all run-off from the pit will be collected and treated, so there is no possibility of uncontrolled releases of metals. Once taken from the pit, the waste will be hauled under a limestone dispensing station where a premeasured amount of limestone slurry will be sprayed on the rock. The limed waste will then be taken with no intermediate stops, to its planned disposal or storage area, again with no possibility of uncontrolled releases during operations. The strongly altered argillic material is a minor constituent of the waste rock, and when broken this material can be handled in a special campaign, which will probably be the best procedure because of its clay-like nature.

Response: (cont'd) Upon completion of mining and the start of reclamation, some areas in the temporary stockpile may be found to have developed acidity, due to poor mixing, exhaustion, or consumption of the limestone. These areas will be disturbed when transferring the waste back into the pit. It would seem very likely that the act of transferring the material will be enough to mix any acidic spots and to ensure they will come into contact with fresh limestone, thereby neutralizing the problem. Even if this does not happen in the transfer operation, the material will of necessity be mixed and neutralized when it is dumped into the pool of water in the pit. There is no possibility of uncontrolled release since the water collection system will still be in place at the time the material is being transferred. At that time, all water in the system will be pumped back to the pit so as to raise the water level in the pit concurrently with the level of backfilled material.

Response by: Kevin Morin, Norecol

6. WASTE ROCK STOCKPILE/PIT BACKFILLING

Stage II Concerns

Topic: f) Costs and water quality management for pit backfilling

Comment: The double handling of waste rock and pit backfilling has no well-established precedent in British Columbia mining operations. As such, if backfilling is a major commitment by the proponent, further details on the cost of backfilling, including a strategy for ensuring the maintenance of water quality during backfilling, is required. These costs should be incorporated into the final feasibility assessment for this project.

Response: See responses to Environment Canada comments I-2d, I-3e and III-1e. The cost aspects will be dealt with as part of the Ministries' review of the Feasibility Study.

Response by: John Gadsby, Steffen Robertson and Kirsten

7. RECLAMATION

General

Topic: a) Effect of reducing conditions in the pit backfill

Comment: As previously indicated, the pit backfilling concept depends entirely on the pit holding water to a level that submerges all acid-generating material. As such, the possibility of a fluctuating water table and the effectiveness of mixing limestone with acid-generating waste rock is a concern. The barrel experiments conducted by the consultants may be recording exactly what could occur in either the waste rock stockpile or the backfilled pit, if a fluctuating water table is encountered.

The barrel experiments showed that liming did not work as expected. Is it likely that the results of these tests will represent what will happen when the pit is backfilled?

Response: The barrel experiments conducted by the consultants appeared to exhibit some of the problems related to a fluctuating water table if one developed in the waste rock stockpile or the backfilled pit.

The waste rock stockpile has been specifically designed to be well drained (coarse rock particle size under drain) so that a water table cannot develop in the pile.

Additionally, there are important differences between the barrels and the proposed pit backfill. First, the barrels contained relatively fresh rock which was generating acidity at the full, unhindered rate in the rock

Response: (cont'd) layers between the limestone layers. The pit backfill will be composed of rock which has been weathered for up to 14 years and, as a result, the rate of acid generation will generally be negligible. Second, the barrels were open to the atmosphere and had a fluctuating water table which produced alternating reducing and oxidizing conditions in the rock mass and allowed some unoxidized ferrous iron to seep from the base of the barrels. During pit backfilling, the rock will be permanently submerged as quickly as possible by continuously raising the water table in the pit. However, unlike the barrels, all water during backfilling will remain in the pit so that any acidity caused by iron oxidation would be neutralized by limestone in the pit and backfill. Once submergence is completed, the upward moving background groundwater will be essentially devoid of oxygen and any acid generation will be negligible, unlike the barrels which were periodically drained and resubmerged.

Response by: Kevin Morin, Norecol

7. RECLAMATION

General

Topic: b) Revegetation of reclaimed areas

Comment: Will the revegetation of the wetlands and beaches around the tailings impoundments and the backfilled pit be carried out by replanting, or is it assumed that a process of natural regrowth will take place?

The proposal to enhance natural vegetation is somewhat confusing. The proponent should establish plant communities which achieve stated land use objectives, and should not expect natural revegetation to replace actual reclamation.

Response: The objectives of the reclamation plan for the tailings impoundments and the backfilled pit are to maintain potentially acid generating waste rock and the tailings in a saturated environment, to stabilize the banks and surface of the pit and impoundments, and to develop wetland communities to provide a passive treatment system for any ongoing seepage of pore water into the surface waters of the pit and impoundments. Conceptual reclamation plans in the Stage II report referred to preparation of sites to encourage natural invasion of wetland species and selective transplantings to promote establishment of wetlands. Reference is also made to planting of willow and alder in riparian and hummocky areas (Stage II Report Volume IV Section 2.5.4). This combination of active planting and natural colonization is considered an appropriate conceptual approach to reclamation. In practice, the pilot scale and constructed wetlands development and the

Response (cont'd)

sequential reclamation of the deactivated impoundments will provide considerable experience for refinement of the reclamation plans prior to closure. There is currently evidence for the effectiveness of natural recolonization by rushes (Juncus) on the pilot mill tailings on site. The pilot scale wetlands will provide valuable experience in species selection and planting techniques to optimize the effectiveness of active planting. Currently it is anticipated that a combination of the two approaches will meet the objectives of the reclamation plan. If it is found that active planting of the entire wetland area is required, allowance has been made in the feasibility assessment to address this contingency.

Response by: Liz Neil, Norecol

7. RECLAMATION

General

Topic: c) Potential for mercury methylation in reclaimed wetlands

Comment: The plan to establish wetlands on the tailings ponds is supported. However, there may be a potential problem with mercury methylation associated with the wetland organic matter. Complete flooding of the impoundment may be an alternative solution, although either a wetland or complete flooding are acceptable.

Response: For detailed discussion of potential impacts and mitigation of mercury methylation in wetlands refer to EC Sections I-5 (a and b), and III-3a and MOE Section 1.8b.

7. RECLAMATION

Stage II Concerns

Topic: d) Verification of flooding in the backfilled pit

Comments: The provision of further hydrogeological information on the pit water holding capacity is required. It is understood that the proponent's consultants are discussing this issue with federal and provincial environmental review agencies.

Response: This comment is addressed in EC Section 2 and MOE Section 1.3.

7. RECLAMATION

Stage II Concerns

Topic: e) Verification of long-term water quality management

Comments: Review of the conceptual reclamation plan by other agencies, particularly with respect to the long-term maintenance of water quality, is required.

Response: The primary objectives of long-term water quality management following closure and reclamation of the project site are to control acid generation on any exposed acid generating rock surfaces, to prevent mobilization of metals and to prevent erosion and sedimentation. The latter objective will be achieved by contouring, revegetation and provision of drainage to prevent erosion. The first two objectives are partly related. Water management for these aspects employ three main principles:

1) disposal of waste material in an alkaline environment (alkaline tailings, limed waste rock) to inhibit acid generation and to render metals insoluble;

2) underwater storage to exclude oxygen and inhibit acid generation; and

3) wetland development to provide long-term passive polishing of nutrients and metals.

In Stage II, various tests were conducted to explore the effectiveness of liming and underwater storage. In addition, simulated effluents were tested for contaminants of concern (for example, mercury, copper, cyanide, nutrients). The results of these tests demonstrated that the management principles were sound and implementable. The costs of reclamation control measures have been incorporated in the feasibility analysis.

In addition, City Resources is committed to carrying out additional major experiments during Stage III (large scale liming, metals mobilization tests, pilot scale wetlands) to further explore effectiveness of and refinements to the Stage II conceptual designs. Finally the 12 year operating period and sequential deactivation of the tailings impoundment will provide a large scale laboratory for monitoring effects and refining design for closure. Numerous contingency plans have been identified to contend with unexpected effects of project activities. These have been costed and the costs reviewed in terms of implications to project feasibility.

The approach to water and waste management design for the Cinola Gold Project has been to examine the worst case and to incorporate sufficient flexibility and contingency planning to address this situation. Future work will be aimed at strengthening predictions of project effects and refining design accordingly.

Response by: Liz Neil, Norecol

8. PREMATURE CLOSURE SCENARIO

Stage II Concerns

Topic: a) Waste handling and reclamation costs for premature closure scenarios

Comment: Have the costs of the premature closure programs been properly incorporated into the Feasibility Study?

The costs to carry out the waste handling and reclamation program for each premature closure scenario must be determined and incorporated into the final project feasibility assessment. An additional security to cover this eventuality will be required.

Response: A complete allowance for the costs of premature closure has not been built into the Feasibility Study itself, since the document is not designed to provide for early closure but to show how the operation will be economically viable over the project life, even when using very conservative assumptions as to gold price and high operating costs.

It must be recognized that once the plant is up and running, the operation will be continued as long as it makes a profit, breaks even, or even loses money. An operation can and will run at a loss for as long as the amount lost is relatively small or the period of loss is predicted to be short. Production costs have been estimated to be in the order of US$240.00/oz, whereas the most pessimistic of forecasters believe that the lowest value that gold will fall to is US$300.00/oz. In these circumstances it would seem unrealistic

Response: (cont'd) to have to take into account early closure, especially when City Resources plans to supply power from its own plant so that B.C.Hydro can close its plant in Masset. This latter circumstance means that a more likely scenario, in response to low metal prices, is temporary closure combined with environmental caretaking, which can readily be accommodated. The power plant will have to be kept running even if the gold plant is shut down for a period, so a continuing cash flow will be available to ensure that an adequate workforce can be retained for dealing with the continuing environmental costs of the plant facilities.

Nevertheless, the Feasibility Study is conservative in that the salvage value of the plant has not been taken into account and in that this value plus the reclamation fund that will have built up over the life of the project should adequately cover any contingency situation.

Response by: Peter Cowdery, City Resources

9. RECLAMATION BONDING / TRUST FUND

General

Topic a) Bonding requirements and feasibility assessment

Comment: The proponent has agreed to place a large trust fund to ensure that monies will be available for reclamation matters. The monies set aside should be considered as part of the Ministry of Energy, Mines and Petroleum Resources bonding provisions. As previously indicated, amendment of the Miners Act will be required to lay the appropriate legal framework. To assist the proponent, Mineral Royalties legislation and the federal Income Tax Act should also be amended, and efforts are currently being made to achieve this. In the event that the necessary legislative changes have not been made prior to project construction start-up, the security would have to be deposited under the present bonding format.

Response: The reclamation fund that has been included in the Feasibility Study is sufficient to carry out the type of work described in the Stage II Report. The amount of bonding and the creation of a locked tax free environmental or reclamation fund has been used in the economic analysis of the Feasibility Study. The fund was not designed to cover any potential costs such as long-term treatment and monitoring requirements.

The Feasibility Study is conservative in that no allowance has been made for the salvage value of the plant and none at all for the ongoing profits of a continuing power plant.

Response: (cont'd)

In addition to the fund, which will result in the generation of over $17 million at the end of year 12, there is the residual or salvage value of equipment and buildings which could finance the completion of any reclamation and long-term treatment costs if they exceed the estimated expenditures of $17,394,000.

The salvage value at the end of year 15 will be approximately $11,162,000. This revenue has not been used in the cash flow analysis which means that it can be considered a cushion for contingent costs or on-going monitoring and treatment.

As noted elsewhere, it is part of City's long-term plans to supply power to Graham Island after the mine and plant have closed. The power will be sold to B.C. Hydro, which in discussions with City has expressed its interest in buying power from City at an economically attractive price. The prices quoted in these discussions are well above City's cost of production, so that an economically viable operation can be assured. This long-term operation will therefore readily support the long-term monitoring and maintenance currently thought to be necessary. City will commit to placing the salvage value of the plant, other than the power station, into a trust fund. The interest from this fund should cover any possible remedial environmental work that may be required.

Response by: Peter Cowdery, City Resources

10. ANCILLARY FACILITIES

Topic: a) Dock facilities/limestone plant plans

Comment: It is understood that the Feasibility Study calls for a lime burning plant at Ferguson Bay. Is there a plan and description of the proposed plant available?

While is is expected that the WCB may look after inspection during operations, the facilities will still be approved under the MDRP. If an independent proponent is to construct and operate a limestone processing plant at the Ferguson Bay site, plans should be submitted and reviewed as part of the final Stage II review for the Cinola project.

Response: A study was commissioned by Minproc Engineering Inc. on behalf of City Resources for the installation and operation of a limestone burning facility at Ferguson Bay.

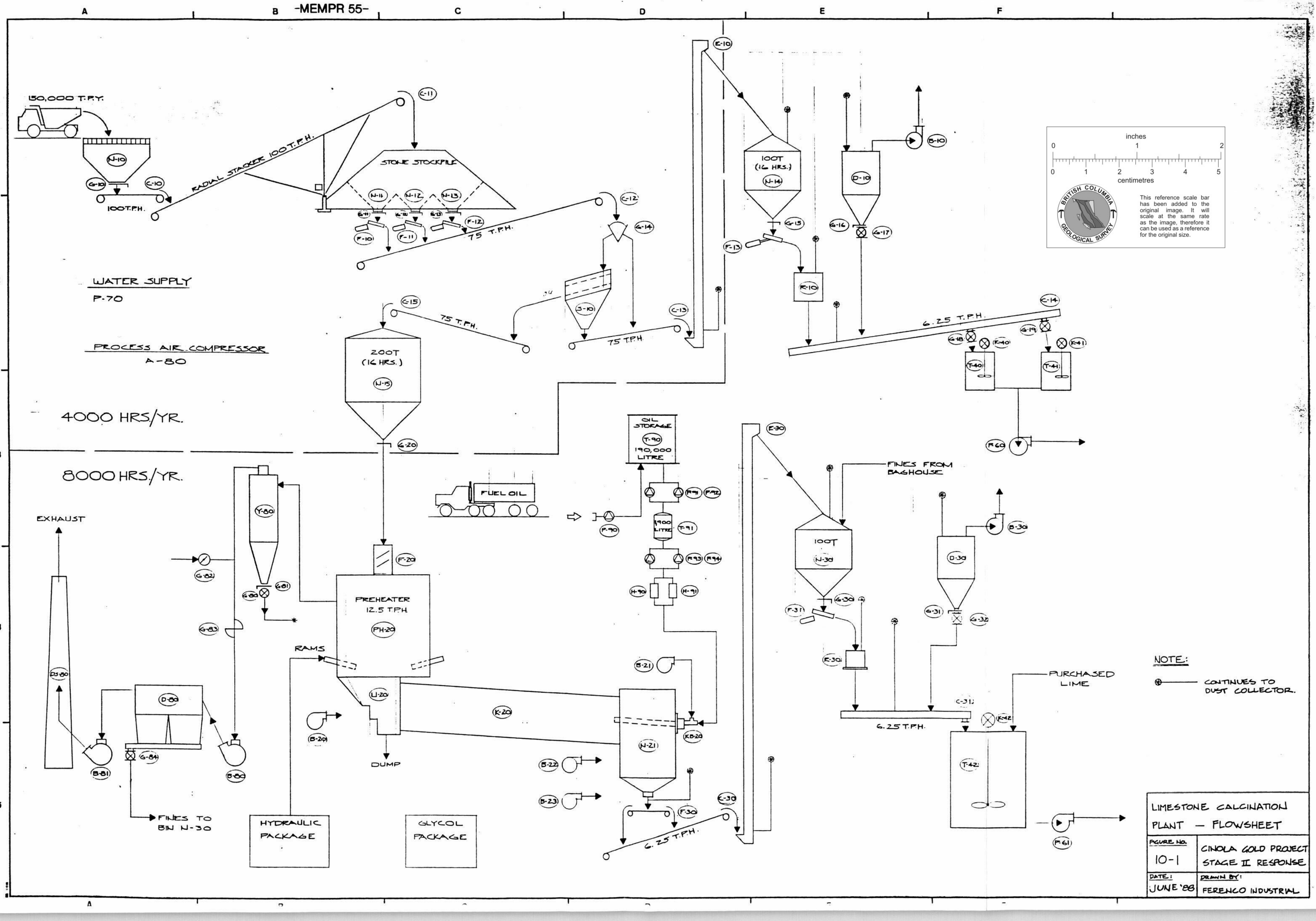
The study was assigned to Ferenco Engineering and Construction of Vancouver. Under a provision agreement for a long-term contract, City Resources would supply Ferenco with limestone (crusher run fraction) and fuel and receive from Ferenco the quicklime from a bin located in the proposed lime burning facility.

Ferenco would undertake the construction and operation of the facility while City Resources will supply the land and cover all required property taxes.

A plant flowsheet and equipment distribution sketch are provided in Figure 10-1. The

Response: (cont'd) limestone burning plant facility layout at Ferguson Bay's dock site is presented in Figure 10-2 while Figure 10-3 is a more detailed arrangement of the calcination plant facilities.

Response by: Arnaldo Ismay, Minproc


A
B
C
D
E
F
1
2
3
4
5
150,000 T.P.Y.
N-10
G-10
C-10
100 T.P.H.
RADIAL STACKER 100 T.P.H.
C-11
STONE STOCKPILE
N-11
N-12
N-13
F-10
F-11
F-12
75 T.P.H.
C-12
G-14
S-10
75 T.P.H.
C-13
C-15
75 T.P.H.
WATER SUPPLY
P-70
PROCESS AIR COMPRESSOR
A-80
4000 HRS/YR.
8000 HRS/YR.
200T
(16 HRS.)
N-15
G-20
E-10
100T
(16 HRS.)
N-14
G-15
F-13
K-10
D-10
B-10
G-16
G-17
6.25 T.P.H.
C-14
G-18
G-19
K-40
K-41
T-40
T-41
P-60
OIL STORAGE
T-90
190,000 LITRE
FUEL OIL
P-90
P-91
P-92
1900 LITRE
T-91
P-93
P-94
H-90
H-91
E-30
FINES FROM BAGHOUSE
100T
N-30
G-30
F-31
F-30
D-30
B-30
G-31
G-32
C-31
6.25 T.P.H.
PURCHASED LIME
K-42
T-42
P-61
NOTE:
CONTINUES TO DUST COLLECTOR.
EXHAUST
G-82
Y-80
G-81
G-80
G-83
PREHEATER
12.5 T.P.H
PH-20
F-20
RAMS
U-20
K-20
B-21
KB-20
N-21
B-20
DUMP
B-22
B-23
F-30
C-30
6.25 T.P.H.
DS-80
D-80
B-81
B-80
G-84
FINES TO BIN N-30
HYDRAULIC PACKAGE
GLYCOL PACKAGE
LIMESTONE CALCINATION PLANT — FLOWSHEET
FIGURE NO.
10-1
CINOLA GOLD PROJECT STAGE II RESPONSE
DATE:
JUNE '88
DRAWN BY:
FERENCO INDUSTRIAL
inches
0
1
2
centimetres
0
1
2
3
4
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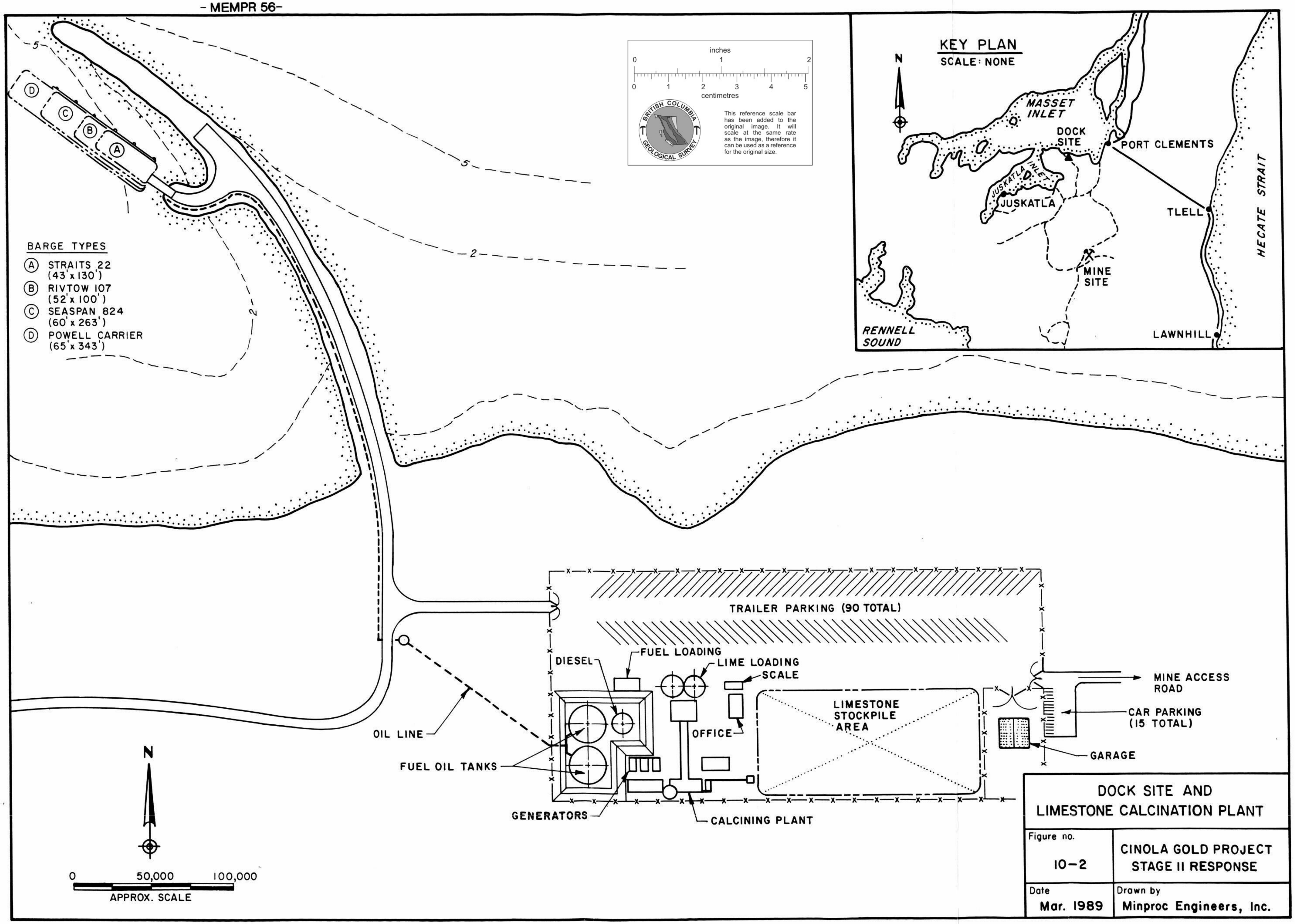
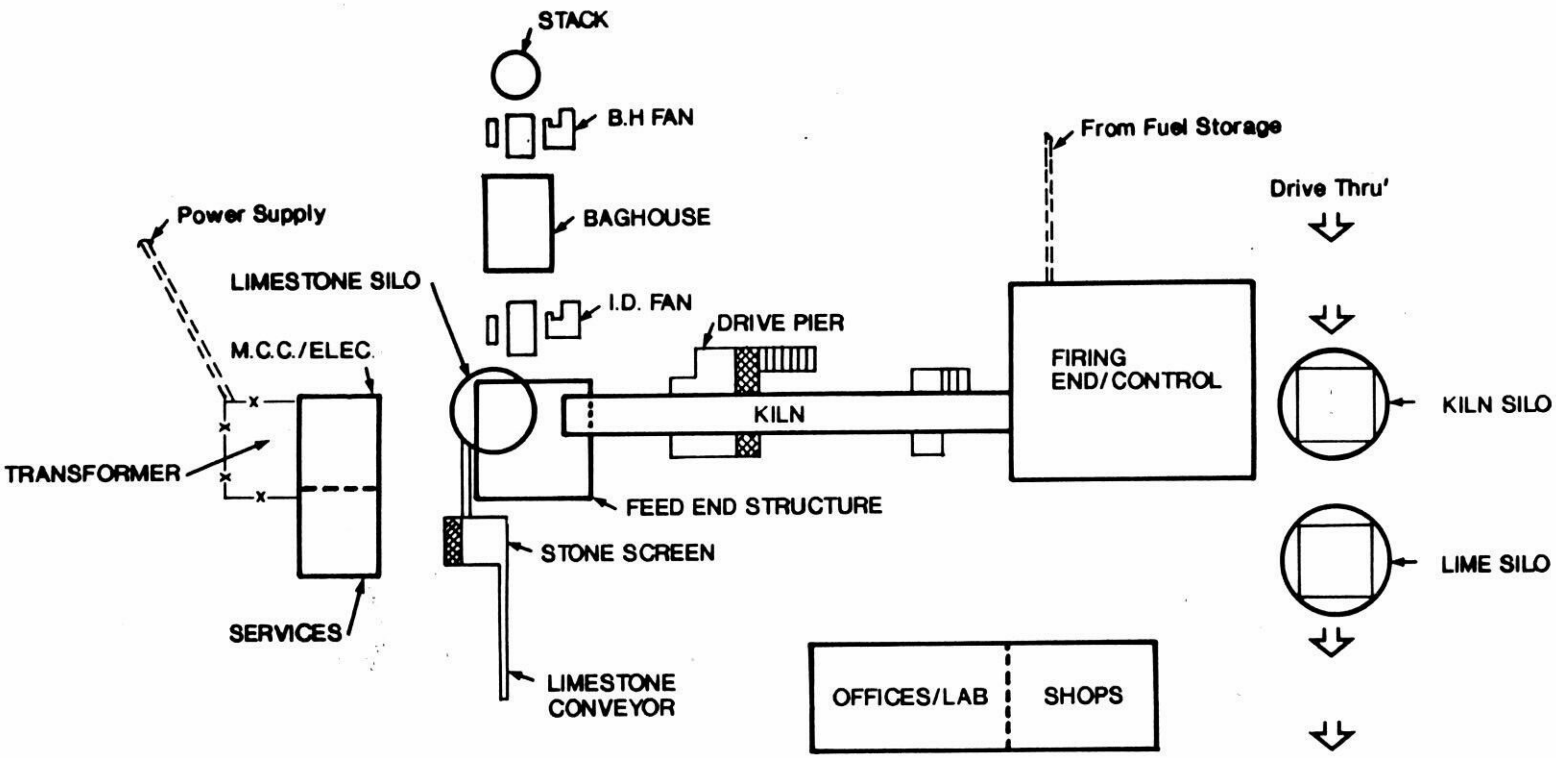
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

- MEMPR 56-


inches
0
1
2
0
1
2
3
4
5
centimetres
BRITISH COLUMBIA
GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
KEY PLAN
SCALE: NONE
N
MASSET INLET
DOCK SITE
PORT CLEMENTS
JUSKATLA INLET
JUSKATLA
TLELL
HECATE STRAIT
MINE SITE
RENNELL SOUND
LAWNHILL
BARGE TYPES
(A) STRAITS 22 (43' x 130')
(B) RIVTOW 107 (52' x 100')
(C) SEASPAN 824 (60' x 263')
(D) POWELL CARRIER (65' x 343')
5
2
TRAILER PARKING (90 TOTAL)
DIESEL
FUEL LOADING
LIME LOADING
SCALE
OFFICE
LIMESTONE STOCKPILE AREA
MINE ACCESS ROAD
CAR PARKING (15 TOTAL)
GARAGE
OIL LINE
FUEL OIL TANKS
GENERATORS
CALCINING PLANT
N
0
50,000
100,000
APPROX. SCALE
DOCK SITE AND
LIMESTONE CALCINATION PLANT
Figure no.
10-2
CINOLA GOLD PROJECT
STAGE II RESPONSE
Date
Mar. 1989
Drawn by
Minproc Engineers, Inc.



inches 0 1 2

0 1 2 3 4 5 centimetres

BRITISH COLUMBIA GEOLOGICAL SURVEY

This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

LIME PLANT ARRANGEMENT	
Figure no. 10-3	CINOLA GOLD PROJECT STAGE II RESPONSE
Date Mar. 1989	Drawn by NORECOL

MEMPR-57