Tailings pond rehabilitation project and effluent management system upgrade, Baldivis

Western Mining Corporation Ltd

Report and recommendation of the Environmental Protection Authority

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Summary and recommendation

In 1969, Western Mining Corporation Limited (WMC's) constructed a tailings pond in Baldivis, 7 km from the Company's Kwinana Nickel Refinery, to store solid and liquid wastes from the refinery.

In March 1979, it was discovered that the tailings pond was leaking ammonium sulphate solution to the groundwater resulting in contamination of the bottom third of the groundwater body (aquifer). It is not clear whether any subsequent environmental impacts have occurred and none has been properly identified at this time. However, this absence of obvious environmental impact could be attributed to the depth of the contamination within the aquifer and that it is overlain by a significant thickness of good quality groundwater.

The Environmental Protection Authority's concern is that the contaminated groundwater has the potential to impact on vegetation around the saline Lake Cooloongup and that use of the groundwater is currently restricted as a consequence of the contamination. Lake Cooloongup is within System 6 Recommendation area M103 and identified to be "managed priority for the conservation of flora and fauna."

Considerable effort has been expended by the proponent to determine the method and extent of remedial action. In this determination discussions took place between the proponent and several Government Agencies to ensure that the strategy developed was broadly acceptable.

The proposal has been referred to the Authority to obtain environmental approval for the chosen strategy and to cleanup the polluted base of the aquifer so that potentially unacceptable environmental impacts are prevented from occurring. As the polluted aquifer is adjacent to a System 6 reserve, it is imperative that the cleanup is performed in an orderly manner and to the satisfaction of the Environmental Protection Authority.

Currently, the proponent is recovering contaminated groundwater to manage the spread of the plume. However, at the same time it still continues to use the leaking tailings dam. In order to correct this situation the proponent proposes to:

- recover and treat liquid effluent from the tailings pond;
- stop the disposal of refinery liquid effluent to the existing tailings pond;
- increase the rate of recovery of contaminated groundwater;
- significantly upgrade its wastewater treatment plant to handle liquid effluent from the refinery and liquid effluent recovered from the tailings pond, in addition to contaminated groundwater;
- construct a new double-lined effluent disposal pond structure comprising two compartments for evaporation of effluent resulting from the upgraded wastewater treatment plant, and one compartment for intermittent disposal of solid residue if required;
- rehabilitate the existing tailings pond to ensure its structural and environmental integrity;
- continue monitoring the extent and movement of the groundwater plume and the condition of vegetation fringing Lake Cooloongup and the undertaking of necessary preventative and remedial action if required;
- maintain the above activities until the groundwater contamination plume has been satisfactorily recovered and the existing tailings pond has been rehabilitated. (WMC's commitments will apply in the event of continued operation of the nickel refinery at current production levels or an increase or decrease in production levels or closure of the refinery); and
- rehabilitate the existing leaking tailings dam.

This strategy was presented to the Authority in the proponent's Consultative Environmental Review (CER) in September 1990. The Authority released the CER for public review and comment for a four week public review period during September/October 1990.

The Authority has assessed the potential environmental impacts of the proposal described in the CER, and used additional information supplied by the proponent, the public and Government agencies to complete its Report.

The Authority's objective of the cleanup is to protect the System 6 area and beneficial uses of the groundwater in the area. Since the relationships between the contamination and potential environmental impacts are not clear at this time, the Authority cannot accept the proponent's cleanup limits as an end point to the recovery activities. They will however form the basis of the first stage to which the Authority would expect the contaminated plume to be cleaned up. The need for further cleanup activities will be reviewed based on the results of further studies and investigations.

In consultation with the Authority's officers the proponent has developed a comprehensive list of commitments covering all issues raised during the assessment of this proposal (Appendix 1).

Therefore, the Authority considers the project to be environmentally acceptable subject to the proponent being required to fulfil commitments given both in the CER and in response to the questions raised during the public review period (Appendix 2) but notes that the results from the proposed monitoring programme may indicate that additional cleanup activities are required.

Recommendation 1

The Environmental Protection Authority concludes that the proposal, as described in the Consultative Environmental Review and in the proponent's responses to questions raised during the public review period, is environmentally acceptable and recommends that the proposal could proceed subject to the commitments given by the proponent in Appendix 1 of this Report, which include:

- **rectification of groundwater pollution;**
- **liquid, slurry and solid waste management practices;**
- **remedial action around Lake Cooloongup if impacts were identified;**
- **existing tailings pond remediation and decommissioning;**
- **construction of a new tailings pond;**
- **decommissioning and rehabilitation;**
- **upgrading of wastewater treatment plant;**
- **management of new tailings dam;**
- **solid waste disposal;**
- **spillage at the plant;**
- **effluent pipeline maintenance;**
- **storage of contaminated liquids and solids in the plant;**
- **monitoring;**
- **security;**
- **weed control around tailings ponds;**
- **meeting licensing conditions;**
- **transfer of ownership; and**
- **reporting.**

The Authority considers that, following any written approval from the Minister for the Environment related to this assessment Report, the activities detailed in the proponents CER should be commenced as indicated in the proponents proposed rehabilitation plan or sooner, and that any approval for the proposal based on this assessment should be largely completed within the time period(s) identified in the proponents CER. Accordingly, if the proposal has not been substantially completed within five years of the date of this report, then such approval should lapse. After that time, further consideration of the proposal should occur only following a new referral to the Authority.

The Authority's experience is that it is common for details of a proposal to alter through the detailed design and construction phase. In many cases alterations are not environmentally significant or have a positive effect on the performance of the project. The Authority considers that such non-substantial changes, and especially those which improve environmental performance and protection, should be provided for.

1. Background

Western Mining Corporation, the proponent, operates a nickel refinery at Kwinana (Figure 1). The refinery commenced production of nickel metal in 1970.

The refining process involves oxidation of nickel concentrate in an ammonia solution which ultimately produces a solid residue waste consisting mainly of iron oxide, iron sulphides and ammonium sulphate.

In 1970 the process produced 400 tonnes per day (tpd) of solid residue, which was decreased to 20 tpd by 1985. Since 1988 solid wastes have been treated at the refinery site with a cyanide process to extract gold.

All solid and liquid waste from the process was initially disposed of as a slurry via an underground pipeline to a 30 ha tailings pond at Millar Road, Baldivis, 7 km south-east of the refinery (Figure 1) which is owned by the Industrial Lands Development Authority.

The polythene membrane lined tailings pond was constructed in a sand depression above a limestone base. In March 1979, leakage of ammonium sulphate to the base of the aquifer was detected. Since commencement of the gold extraction process in 1988, solid wastes have been railed to Kambalda for disposal with WMC's gold treatment plant residues. This has resulted in the almost complete cessation of solid waste disposal at Baldivis.

The plume associated with the contaminated groundwater has a generally higher total dissolved solids content than the surrounding groundwater (in excess of 5 g/L compared with less than 1.5 g/L). It is elongate in the north-south direction extending over approximately three kilometres. The plume has migrated only a short distance to the east from the pond, however, in the west it appears to underlie the easterly fringes of Lake Cooloongup.

The shape of the plume is considered the consequence of prevailing groundwater gradients and the nature of the aquifer within which the plume is migrating.

In 1979 WMC's commenced recovery of contaminated water through recovery bores and return of contaminated groundwater to the tailings pond. In 1981 WMC installed a reverse osmosis plant at the refinery to remove ammonium sulphate from extracted groundwater and to allow reuse of recovered water in the refinery. By the end of 1989 the reverse osmosis plant had treated 3,400 ML of groundwater and recovered 31 000 tonnes of ammonium sulphate but, over the same period, 16,500 tonnes of ammonium sulphate was estimated to have leaked from the pond.

A total of 45,000 tonnes of ammonium sulphate is currently estimated to be contained in the groundwater contamination plume. Current recovery procedures are stabilizing the plume but not significantly reducing its extent. The current reverse osmosis plant cannot directly treat plant effluent or tailings pond liquor as the concentration of salts is too high for effective operation.

2. The proposal

Western Mining Corporation proposes to resolve the on-going contamination problem resulting from the leaking tailings pond in order to ensure that it does not present an unacceptable environmental impact now or in the future.

2.1 The tailings pond

Liquor leaking from the existing tailings pond is the source of ammonium sulphate contamination in groundwater but a means of remedying the leakage is not apparent. Therefore, dewatering of the pond is an essential component for a long-term strategy to minimise potentially deleterious environmental effects

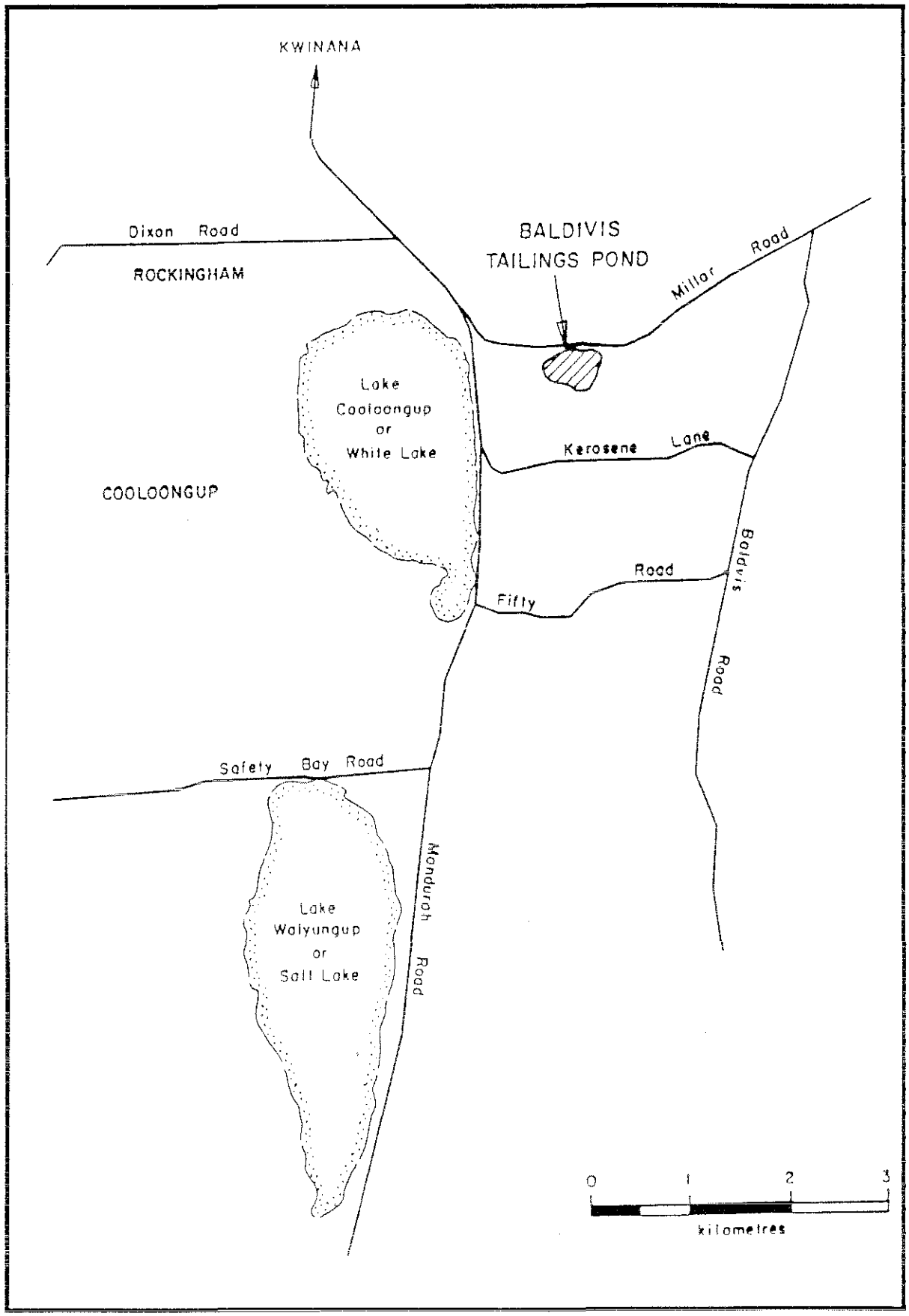

Figure 1: Tailings pond locality plan

WMC plans to dewater and rehabilitate the tailings pond and to recover contaminated groundwater in order to reduce the possibility of detrimental effects to Lake Cooloongup and fringing vegetation to the east of the lake, and to install a new effluent treatment and disposal process for the refinery.

The overall objectives of these activities is to:

(i) to reduce existing ammonium sulphate contamination in the groundwater resulting from past pond leakage; and

(ii) to ensure further contamination is eliminated.

The proponent's specific objectives are to recover contaminated groundwater, to permanently rehabilitate the existing tailings pond, to construct a new effluent pond, and to install an upgraded wastewater treatment plant to treat effluent currently produced from the refinery, liquor from the existing tailings pond and recovered contaminated groundwater.

2.2 Timing

Timing of the various elements of the strategy is indicated in Figure 2. Full operation of the upgraded effluent disposal system will take approximately two years from Ministerial approval. Dewatering of the existing tailings pond will take an additional four years and rehabilitation is expected to take a further 18 months. Groundwater recovery will continue until retraction of the contamination plume has been achieved to the satisfaction of the Environmental Protection Authority. Each of these activities has been addressed in the proponent's commitments (Appendix 1) which can be made legally binding through Ministerial Conditions under the Environmental Protection Act, 1986.

3. Potential environmental impacts assessed by the Environmental Protection Authority

3.1 Lake Cooloongup

The plume appears to currently underlie the eastern fringe of Lake Cooloongup and vegetation to the east of the lake. However, a saline plume is already thought to underlie Lake Cooloongup, possibly preventing contact between the lake water and the contamination plume.

Lake Cooloongup which dries out over summer, forms part of a north-south chain of lakes on the Swan Coastal Plain, and is of some importance for flora and fauna preservation. Vegetation surrounding the lake is predominantly open tuart (Eucalyptus gomphocephala) and paperbark (Melaleuca sp.) woodland. The area has been extensively surveyed between 1977 and 1990.

These studies concluded that whilst Lake Cooloongup is greatly enriched in nitrogen compared with other aquatic ecosystems on the Swan Coastal Plain, there is insufficient evidence to show that the high nitrogen content of the lake is related to the ammonium sulphate plume resulting from leakage from the tailings pond to the east of the lake.

3.2 Terrestrial vegetation

In addition to the possible effects to the Lake Cooloongup waterbody, concern has been expressed that the contamination plume may adversely affect vegetation fringing the eastern edge of Lake Cooloongup. The depth to groundwater near the lake is generally shallow (less than 10 m) and ammonium sulphate in groundwater at the base of this aquifer may be available to the fringing vegetation.

Figure 2: Proposed timing of activities described in CER

Although the plume may not mix with water in Lake Cooloongup itself, fringing vegetation could possibly draw on ammonium sulphate contaminated groundwater. The likelihood of adverse effects are extremely difficult to determine because of:

- the depth of the plume;
- the ammonium sulphate concentration in the plume and the variation in concentration with depth;
- the root depth of the vegetation;
- the depth from which the vegetation will draw (contaminated) groundwater; and
- the period over which (contaminated) groundwater is drawn.

The concentration of ammonium sulphate in groundwater that is likely to cause toxicity in the fringing vegetation is also unclear. However, although the data are limited, concentrations above 5-7 grams per litre are known to be toxic to most plants. At lower concentrations growth is likely to be stimulated. As mentioned above the concentration in the plume exceeds 5 grams per litre and may therefore be potentially toxic to plants.

With increasing exposure to ammonium sulphate contaminated groundwater, plant growth rates would be expected to initially increase, but in the longer term deterioration or death could occur as the concentration rose to toxic levels.

Comparative work on vegetation fringing Lake Cooloongup and that associated with Lake Clifton and Lake Haywood in the Yalgorup National Park (approximately 80 km south) have shown some deterioration in the quality of the vegetation near Lake Cooloongup, but the effects are thought to be mainly attributable to a number of factors including pests, weeds and frequency of fires, and not to the contamination plume.

4. Conclusion

It should be noted that individual aspects of this proposal that will require specific Government approval include:

- groundwater extraction, freshwater injection and access on reserve areas requires approval from the Department of Land Administration and the Department of Planning & Urban Development and, in the case of vested reserve areas, the body in which the reserve is vested and also the occupier (if applicable);
- groundwater extraction bores require licensing by the Water Authority of Western Australia;
- rehabilitation of the existing tailings pond is subject to the directions of the Minister for Resources under the Nickel Refinery (Western Mining Corporation Limited) Agreement Act 1968;
- the project site is subject to the provisions of Clause 32 of the Metropolitan Region Scheme which requires that non-rural development on land zoned Rural under the Scheme be referred to the Department of Planning and Urban Development for determination; and
- construction of the new effluent disposal pond structure requires the approval of the Environmental Protection Authority, the Minister for Resources under the Agreement Act, and the Department of Planning and Urban Development.

WMC will ensure regular consultation with the relevant local authorities; the City of Rockingham and Town of Kwinana, during the planning and implementation of the proposals described herein.

Accordingly, the Authority considers the proposal environmentally acceptable, and recommends that it could proceed. However, the Authority notes that an assessment of the adequacy of the proposed cleanup criteria must await a better understanding of the relationship between the beneficial uses of the area and the ammonium sulphate contamination. That better understanding may indicate that stricter cleanup criteria are appropriate and additional cleanup measures may be required.

Appendix 1

List of commitments made by
Western Mining Corporation Limited

9 COMMITMENTS

The proponent, Western Mining Corporation Limited (WMC) has provided the following commitments to the Environmental Protection Authority in the CER on its Tailings Bond Rehabilitation Project at Baldivis and Effluent Management System Upgrade at Baldivis and Kwinana.

9.1 General Commitments

(1) The proponent will adhere to the proposals as described in the CER and as assessed by the Environmental Protection Authority and will fulfil the commitments made therein and summarized below.

(2) The groundwater pollution resulting from the leaking tailings pond will be rectified as specified in the CER, to the satisfaction of all relevant Government agencies' including the following -

- EPA;
- Water Authority of WA;
- Department of Conservation and Land Management; and
- Mines Department.

(3) The proposed new effluent pond structure will be constructed, operated and managed to the satisfaction of -

- EPA;
- Water Authority of WA;
- Mines Department; and
- The Health Department.

(4) The proposed liquid, slurry and solid waste management practices will be carried out, where relevant, to the satisfaction of -

- Environmental Protection Authority;
- Water Authority of WA;
- Mines Department;
- The Health Department.

(5) If the EPA identifies an environmental impact on Lake Cooloongup or surrounding area resulting from polluted groundwater generated by the proponent, the proponent will take all reasonable remedial action to the satisfaction of the EPA and all other relevant Government agencies.

9.2 Existing Tailings Pond

(6) The environmental management programme will be modified where practicable to reduce the impact of pollution on the environment to the satisfaction of the EPA.

(7) The proponent will cease discharging effluent to the existing tailings pond as soon as the proposed new effluent pond structure and upgraded effluent treatment plant are commissioned. Construction and commissioning of the new effluent pond structure and upgraded effluent treatment plant will be carried out as soon as possible after all statuatory approvals have been granted, and will be to the satisfaction of the EPA.

(8) The proponent will, at least six months prior to decommissioning the existing tailings pond, prepare a decommissioning and rehabilitation plan to the satisfaction of the EPA.

(9) The proponent will commence to dewater the existing leaking tailings pond immediately after cessation of effluent disposal and at the time of commissioning the new effluent pond structure. Dewatering will be carried out as quickly as is practical and to the satisfaction of the EPA. The recovered water will be treated or disposed of to the satisfaction of the EPA.

(10) Rehabilitation of the existing tailings pond site will be carried out to the satisfaction of the EPA, Health Department, Water Authority, the Department of Resource Development and any other relevant agency.

(11) During rehabilitation, the leaking tailings pond will be stabilized to minimize leakage as far as possible, even during periods of high rainfall, and this will be done to the satisfaction of the EPA and the Water Authority of Western Australia.

9.3 Upgrading of Wastewater Treatment Plant

(12) The proponent will upgrade its reverse osmosis wastewater treatment plant to a level which will enable processing of contaminated groundwater at the treatment rates indicated in the CER. The proponent will undertake further upgrading of the wastewater treatment plant if treatment of the contaminated groundwater is not progressing at a reasonable rate to the satisfaction of the EPA.

(13) The proponent will operate and manage its wastewater treatment plant to the satisfaction of the EPA.

(14) The proponent will monitor the performance of its wastewater treatment plant so that waste recovery can be continually optimized, and this will be done to the satisfaction of the EPA.

(15) The proponent will continue to investigate new technology and improvements to improve its wastewater treatment plant to optimize recovery of pollutants and this will be done to the reasonable satisfaction of EPA.

9.4 New Effluent Pond Structure: Construction and Management

(16) The proposed new effluent pond structure will be constructed to the satisfaction of the EPA, Water Authority and the Health Department and any other relevant statutory agency.

(17) The proposed new effluent pond structure will be operated and managed to the satisfaction of the EPA, Water Authority, the Health Department and any other relevant statutory agency.

9.5 New Effluent Pond Structure: Effluent and Slurry

(18) To ensure that the final residue in the new effluent pond structure conforms to predicted specifications for future management, the plant effluent, slurry and solid residue quality and discharge rates, will be monitored to the satisfaction of the EPA. If the quality or quantity of effluent does not conform to predicted specifications and is unacceptable to the EPA, the effluent will be retreated or otherwise disposed of to EPA's satisfaction.

9.6 New Effluent Pond Structure: Leakage

(19) If leakage were detected from the proposed new effluent pond structure, EPA will be notified immediately. The proponent will take immediate action to recover leakage and mend the leak and this will be done to the satisfaction of the EPA.

9.7 New Effluent Pond Structure: Solids Buildup

(20) Solid residues building up in the new effluent pond structure over the lifetime of the ponds would be managed to the satisfaction of the EPA and Health Department.

9.8 New Effluent Pond Structure: Decommissioning and Rehabilitation

(21) The proponent will be responsible for decommissioning the new effluent pond structure and rehabilitating the site to the satisfaction of the EPA.

(22) The proponent will, at least six months prior to decommissioning the new effluent pond structure, prepare a decommissioing and rehabilitation plan to the satisfaction of the EPA.

(23) Upon decommissioning, the proponent will cease discharge to and dewater the new pond structure. This will be carried out to the satisfaction of the EPA. The recovered water, if any, will be evaporated or treated and disposed of, to the satisfaction of the EPA.

(24) Rehabilitation of the new effluent pond structure site will be carried out to the satisfaction of the EPA, Health Department, Water Authority, and any other relevant agency.

(25) During rehabilitation, the new effluent pond structure will be stabilized to prevent leakage subsequently occurring even during periods of high rainfall. This stabilization will be carried out to the satisfaction of the EPA and the Water Authority.

9.9 Solid Waste Disposal From Gold Recovery Unit

(26) The proponent will continue to transport contaminated solid waste residues, resulting from its gold recovery unit, back to its Kambalda minesite and this will be done to the satisfaction of the EPA and the Health Department. If the proponent were to change this practice and dispose of this solid waste elsewhere, it would only do so after first obtaining approval from the EPA.

9.10 Spillage at Plant

(27) Any new operations at the existing plant will be designed and operated to contain any liquid spillages and contaminated runoff within the site boundaries to the satisfaction of the EPA.

9.11 Breakage of Effluent Pipeline

(28) In the case of spillage to the environment resulting from effluent pipeline failure, the proponent will immediately inform the EPA of such spillage, immediately clean up the leakage and as soon as possible remediate any environmental impact to the satisfaction of the EPA.

9.12 Storage Facilities for Contaminated Liquids and Solids in the Plant

(29) All new facilities which are used on site to hold contaminated materials associated with polluted groundwater recovery or polluted effluent/slurry or solid waste disposal will be so designed so as to contain spillage from entering the environment. The design of containment and recovery methods to be used will be to the satisfaction of the EPA.

9.13 Monitoring

(30) Prior to construction of the new effluent pond structure, the proponent will submit and subsequently implement a monitoring programme to the satisfaction of the EPA and the Water Authority.

The monitoring programme will include -

- data outlining existing status of groundwater contamination so that a bench mark can be set to measure performance of recovery of polluted groundwater;
- proposed sampling period to determine performance in recovery of polluted groundwater;
- monitoring Cooloongup Lake environment for impacts;
- parameters to be measured;
- sampling sites and times and
- reporting times to the EPA.

(31) All samples taken in the monitoring programme will be analysed in a laboratory acceptable to the EPA.

9.14 Security

(32) The proponent will ensure that the old and new tailings ponds are fenced so as to avoid public access at all times and that this will be done to the satisfaction of the EPA.

9.15 Other Commitments

(33) The proponent will control insects and weeds around the tailings ponds (evaporation ponds) to the satisfaction of the EPA, the Health Department and the City of Rockingham.

(34) The proponent will modify its polluted groundwater recovery programme and its tailings pond management procedures, if it cannot meet licence conditions placed on it by EPA. Such modifications will be to the satisfaction of the EPA.

(35) The proponent will not transfer ownership, control or management responsibility of groundwater cleanup, tailings ponds management, solid waste disposal or tailings dams rehabilitation without prior consultation and arrangements being made which are to the satisfaction of the EPA and The Hon. Minister for Environment.

9.16 General Reporting

(36) Reports will be provided to the EPA as directed by the EPA. Reporting will include advice to the EPA on the fulfilment of any Ministerial Conditions and Commitments given by the proponent at relevant project stages and of works approval and licencing conditions.

Appendix 2

Proponents response to issues raised during the assessment process

Response to questions raised by the Environmental Protection Authority, arising from the public review of the WMC Kwinana Nickel Refinery Consultative Environmental Review on tailings pond rehabilitation and effluent management.

Question 1: Does the proponent intend to consult and take the advice of CALM regarding the decommissioning and rehabilitation of the existing tailings dam?

Response: Commitments 6 to 11 in Section 9.2 of the CER relate to decommissioning of the existing tailings dam. Specifically, Commitments 7 to 10 contain an undertaking to decommission the pond to the satisfaction of the EPA, and rehabilitate the pond to the satisfaction of the EPA, Health Department, Water Authority, Department of Resources Development and any other relevant agency. The company believes CALM to be such an agency, and will consult and take the advice, where appropriate, of CALM.

Question 2: Does the proponent intend to consult with CALM regarding monitoring of the existing contamination plume and possible impacts on Lake Cooloongup and the Leda conservation area?

Response: The company and its consultant liaised with CALM on these issues during preparation of the CER, and has committed to monitor the Lake Cooloongup environment for impacts to the satisfaction of the EPA (Commitment 30). Specific undertakings on the Cooloongup vegetation are given in Section 8.1 of the CER, and this work will be conducted in consultation with CALM.

Monitoring of the contaminant plume in the Leda locality is being conducted through sampling of bores installed for that purpose, and the company will include results obtained from this monitoring in reports to the EPA in accordance with Commitment 30. The proponent expects copies of the reports to be distributed by the EPA to relevant agencies and will consult with the EPA in conjunction with other agencies, including CALM.

Question 3: Does the proponent commit itself to recovering all groundwater which has an ammonium sulphate level equal to or greater than 2 g/L?

Response: The proponent will recover contaminated groundwater from that part of the aquifer with the highest concentration of ammonium sulphate, until:

(i) any groundwater containing ammonium sulphate at 5 g/L or above is recovered; and

(ii) the average concentration of ammonium sulphate over the aquifer thickness is less than 1.5 g/L at all monitor bore locations.

The above will be carried out unless, for a particular production bore, groundwater cannot be recovered at an ammonium sulphate concentration of at least 2 g/L, in which case the production bore would be shut down and other bores would continue to operate.

Question 4: Is the proponent willing to take advice of the Department of Mines and the Water Authority regarding freshwater injection into the contaminated aquifer?

Response: The proponent is willing to take advice from the Department of Mines, the Water Authority, and other relevant agencies regarding possible freshwater injection near the eastern edge of Lake Cooloongup, as outlined and in accordance with the undertakings given in Section 5.5 of the CER.

Question 5: Given that a cleanup criterion has been proposed and is exceeded further south of the existing monitoring programme, is the proponent prepared to extend the monitoring work so as to properly estimate the extent of the contamination?

Response: The proponent believes that the current network of monitoring bores is adequate to define the current extent and characteristics of the plume. Existing and proposed recovery bores (see CER, Figure 7) are/will be located to enable recovery of the plume as described in the CER. The proponent therefore believes that additional monitoring bores are unnecessary at this time.

Question 6: Is the proponent aware that the recovery bores will need to be licensed?

Response: The proponent is fully aware that the proposed recovery bores will need to be licensed, and will apply to WAWA for licences upon approval of the CER.

Question 7: Does the proponent believe that the contamination plume extends below the Town of Kwinana and, if so, is there any resulting environmental impact? Is it likely that an impact will occur in the future?

Response: The contaminant plume extends north of the tailings pond, and underlies part of the Leda locality in the Town of Kwinana. The proponent's response to Question 2 above indicates the monitoring being conducted on the contaminant plume. The proponent has no evidence that adverse environmental effects have been caused by the contamination plume within the area of the Town of Kwinana (see Question 16). The programme described in the CER will reduce the extent of the contaminant plume, and the concentration of ammonium sulphate in the plume, to reduce and eventually eliminate the potential risk of environmental damage. The proponent therefore believes that it is unlikely that a significant risk exists of future environmental impacts with the Town of Kwinana.

Question 8: In the event of the nickel refinery closing, does the company understand that it will have long-term responsibility for the existing tailings dam, the contaminated groundwater and the proposed tailings dam? Does the company realize that if some environmental impact occurs in the future as a result of any of its activities, it can be held responsible?

Response: The proponent fully understands the implications of the Environmental Protection Act (1986) and its responsibilities under the Act.

Question 9: Could the proponent document existing environmental impacts already occurring as a result of groundwater contamination?

Response: No adverse environmental impacts resulting from the groundwater contamination plume have been definitively documented. The company has conducted numerous studies on the contamination plume, on Lake Cooloongup, and on vegetation surrounding Lake Cooloongup (see reference list in the CER document). Currently, monitoring is being conducted on the plume and on vegetation fringing Lake Cooloongup. The CER contains undertakings on monitoring to be conducted by the company (Section 8.1), and specific commitments related to environmental impacts (Commitments 5, 30 and 31).

Question 10: Is the proponent aware of the evolution of hydrogen sulphide from the Lake Cooloongup ecosystem? If so, has contamination of the groundwater caused this problem?

Response: Wetland ecosystems such as Lake Cooloongup commonly evolve hydrogen sulphide gas from the decomposition of organic matter and from the reduction of sulphates to hydrogen sulphide. Sulphur is present in organic matter and as sulphate in natural, undisturbed systems. Systems of marine origin, such as Lake Cooloongup, may evolve considerable quantities of hydrogen sulphide. Anaerobic conditions, such as those present in wet or waterlogged areas, are conducive to hydrogen sulphide evolution. Therefore, the presence of hydrogen sulphide does not necessarily indicate a contamination problem.

The company is not aware of any substantiated evidence suggesting that the ammonium sulphate contamination plume has caused elevated levels of nitrogen or sulphur in the Lake Cooloongup ecosystem, although nitrogen levels in the lake are known to be high (see Section 1.2.3 of the CER).

Question 11: When does the refinery intend stopping discharge of ammonium sulphate solution to its leaking tailings dam?

Response: Effluent disposal to the leaking tailings pond will cease when the following has been completed:

(i) the CER is approved;

(ii) the upgraded reverse osmosis plant is operational;

(iii) the new effluent pond has been commissioned (following completion of the current design work, EPA works approval, and construction).

Question 12: Does the proponent intend to dispose of any contaminated solids to its new effluent pond?

Response: No cyanide-treated residue will be disposed of to the new effluent pond (or existing tailings pond), as specified in Commitment 26 of the CER. Disposal of solid residues not containing complexed cyanide may be disposed of in accordance with Section 5.3.2 of the CER.

Question 13: Is dilution of liquid effluent a viable option to enable direct treatment by reverse osmosis?

Response: Section 5.4.3 of the CER clearly states that (old tailings) pond liquor and refinery effluent will be able to be treated directly by the upgraded reverse osmosis plant to be installed subject to CER approval. There is therefore no necessity to dilute effluent.

Treatment of diluted or undiluted effluent is not possible with the existing treatment plant due to the presence of suspended solids in the effluent. The upgraded system will include filtration to remove suspended solids (as shown on Figure 9) prior to treatment by reverse osmosis.

Question 14: Will the resulting residues in the proposed effluent pond constitute an environmental hazard at the end of the pond or thereafter?

Response: The proponent does not believe that the residues resulting from the operation of the new effluent pond will constitute an environmental hazard for the following reasons:

(i) The new pond will be designed and constructed to an extremely high standard, as specified in Section 5.4.5 of the CER, and subject to EPA works approval. The pond will be compartmentalized and double-lined (c.f. a single, thin liner in the existing pond), with a leak recovery system installed between the two layers. Prior to construction, the area will be well prepared to minimize the risk of puncture to the liners.

(ii) At the end of the operational life of the proposed pond structure, rehabilitation to a standard approved by the EPA will be undertaken. This will involve capping of the structure with a low permeability membrane to minimize loss of salts (or any solids), if any, to the environment.

Question 15: Given that the old effluent pipeline leaked, what assurance is the proponent giving such that leaks in the new pipeline will not occur?

Response: In the CER (Section 5.4.4), the proponent has undertaken to construct at least one new polythene pipeline between the refinery and the new effluent pond. This pipeline will be constructed to a high engineering standard, minimizing the risk of rupture. The proponent cannot, however, give assurance that leaks will never occur in the new pipeline. In the event of leakage, the proponent undertakes to rectify the problem, as specified in Commitment 28.

Question 16: Is the contaminated groundwater affecting Leda nature reserve?

Response: The proponent has no evidence that the groundwater contamination plume is affecting the Leda nature reserve, nor is it aware of any evidence of adverse effects on the reserve. In addition, monitoring of the plume in the Leda locality has established that the plume is at a depth of greater than 10 m below the water table, and therefore not in direct contact with the Leda wetlands which are shallow surface expressions of groundwater (see Figure 4A in the CER). Deep-rooted vegetation at the site would therefore have access to 10 m of uncontaminated groundwater overlying the plume.

Question 17: Is the vegetation along the eastern bank of Lake Cooloongup and the south-west corner of Leda showing signs of stress associated with WMC's contamination problems?

Response: Vegetation in the Lake Cooloongup area is subject to an ongoing monitoring programme, and commitments and undertakings embodied in the CER. Leda is covered in the proponent's response to Question 16 above.

Monitoring of vegetation in the vicinity of Lake Cooloongup prior to 1990 showed no signs of stress due to the contamination plume from the leaking tailings pond. However, surveys in April and September (E M Mattiske and Associates) indicated possible stress signs in some older trees (predominantly tuart, *Eucalyptus gompho-cephala*) to the east of the lake which may be due to the effects of the contamination plume. The cause of the stress has, however, not been definitively identified, and most of the older tuarts, the younger tuarts, and other species are not showing stress symptoms.

Further monitoring of the Lake Cooloongup vicinity is subject to undertakings given in Section 8.1(ii) and (iii), and Commitment 30 in the CER.

Question 18: Does the proponent intend to cover the rehabilitated tailings dam with clay? If so, by what depth of clay?

Response: The CER describes two possible scenarios to rehabilitate the tailings pond, after removal of liquor, to provide permanent storage of the solid wastes. The objective of each is to maintain sufficient water content in the tailings to minimize

both diffusion of oxygen into the tailings (to prevent acid generation) and leakage through the tailings. Both scenarios involve capping the tailings mass with a clay layer.

Decisions on the final rehabilitation design will not be made until dewatering of the pond is nearing completion. The proponent has made a commitment (Commitment 8) to prepare a decommissioning and rehabilitation plan, to the satisfaction of the EPA, at least six months prior to decommissioning of the pond.

Although final clay layer thickness is still subject to detailed design, sufficient clay thickness to achieve moisture control within the tailings mass will be required. Preliminary work indicates that the thickness will need to be in the order of 0.5 m.

Question 19: Will the dewatering bores around the old tailings dam be left in place to aid recovery of contaminated water?

Response: Yes. Each recovery bore will be maintained until the groundwater pumped from each bore reaches the nominated end point for pumping (see Question 3).

Question 20: What will be the effect on the local vegetation of the drawdown from freshwater extraction bores?

Response: The proponent has proposed freshwater injection in the vicinity of Lake Cooloongup. The proposal would only be implemented following discussion and agreement with the relevant government authorities, and would likely be operational for short periods only, making estimates of total water use very difficult.

Water for the proposed freshwater injection system will be drawn upstream of the ammonium sulphate plume, to the east of the tailings pond (see CER, Figure 11). These bores will need to be licensed by the Water Authority of Western Australia, and hence satisfy the Authority's requirements. In any event, the amount of water drawn will be small compared to that drawn by the bores for recovery of contaminated groundwater.

Question 21: Is the proponent prepared to commit itself to rehabilitate the groundwater to the Australian standards?

Response: The proposed rehabilitation programme for groundwater described in the CER has, as its criterion for successful conclusion of the programme, levels of ammonium sulphate in groundwater which pose no practical threat to the environment, or danger for human use. Modelling work suggests that this will entail extraction and treatment of groundwater until at least 2005, and that, as recovery operations continue, the concentration of ammonium sulphate in recovered water would decrease initially, but would level out due to dilution effects and the removal of a significant portion of the contamination. Recovery of the residual plume beyond the proposed end-point is not practical and it is doubtful whether it is achievable.

Question 22: Is the groundwater contaminated with iron or other heavy metals and, if so, what is their estimated impact on the environment?

Response: The groundwater contains negligible concentrations of heavy metal. The concentration of nickel, the highest of the heavy metals, is 0.5 ppm or less from all monitoring bores, and other metals are much lower. This figure compares with nickel concentrations of 100 - 300 ppm in refinery effluent currently being discharged to the tailings pond (CER, Table 2) and potable water supply limits of 134 ppm (USEPA, 1987).

The low level of heavy metals in groundwater is due to the effect of the iron content of the solid residue (high pH) adsorbing metal ions from solution in the tailings pond, and to adsorption onto limestone in the aquifer underlying the tailings pond and in the general vicinity of Baldivis.

Appendix 3

List of organisations and members of the public that made submissions

Department of Conservation and Land Management

Town of Kwinana

Ministry of Economic Development and Trade

Health Department of Western Australia

Conservation of Kwinana's Environment

Conservation Council of Western Australia Inc.

Department of Planning and Urban development