HydroMet
CORPORATION LIMITED

A.B.N. 71 002 802 646

SUCCESSFUL PROJECTS IN WASTE RECYCLING AND ENVIRONMENTALLY ACCEPTABLE DISPOSAL (THE HYDROMET STORY)

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ABSTRACT

Hydrometallurgical treatment of industrial wastes has been developed by Hydromet Corporation to initially extract contained elements and produce a value added product. This process now allows the company to treat a range of wastes generated both within Australia and overseas. The processes used have been developed in liaison with government regulators and the company now has a well established reputation with major industrial companies.

INTRODUCTION

Over the past 10 years Hydromet has undertaken a range of waste handling projects that have exclusively used hydrometalurgical techniques to treat and provide satisfactory disposal options for difficult hazardous industrial wastes. The company attempts as a first priority in assessing potential treatment options to recover target metals from wastes or residues and to produce value added chemicals for sale. Following recovery of selected elements the remaining residues are immobilised prior to sending to landfill. This approach results in much less bulk to landfill, which is often not the case for simpler encapsulation methods.

This hydrometallurgical approach has been developed over a number of years and in a number of different projects, and was the result of a need to diversify the approach to enable a waste treatment project to be continued. Close

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liaison with government regulators was required to achieve this first off technology.

Hydromet has extended the concept to treating smelter streams that contain precious metals plus other associated elements. The company toll treats these residues, recovers selected chemicals for sale, and returns the precious metals to the smelter.

The experience and technical expertise gained has allowed the company to diversify its metallurgical treatment processes to the current situation where an extensive range of processes are either currently underway or in the final planning stages.

These projects include:

- treating EAF steel dusts to extract zinc,
- treating overseas smelter residues and product streams to extract selenium,
- recovering acid from refinery waste oils,
- treating spent catalysts,
- immobilising mercury-contaminated wastes,
- immobilising recycled battery lead slags prior to landfill disposal,
- treating water treatment plant sludges.

This important technology development expertise required to deal with these difficult and often hazardous waste streams has been provided by a small dedicated team of metallurgical and chemistry and industry professionals led by Technical and founding Director Dr Lakshman Jayaweera. All laboratory and pilot scale testwork is carried out at either our Unanderra or Newcastle processing facilities.

HYDROMET'S BACKGROUND IN WASTE TREATMENT TECHNOLOGY

For those unfamiliar with Hydromet, its business and background in the waste recycling industry, our brief history is as follows:

- Hydromet is a Public Listed Company on the ASX and has approximately 3,000 shareholders. The company was listed on the ASX in 1992.

- Hydromet has been the pioneer in the development of hydrometallurgical techniques to treat a range of metal bearing residues to recover the recycle targeted metals from the waste and to produce metal chemicals for sale to a range of applications both within Australia and overseas.

- The company has three licensed waste treatment facilities at:
  - Unanderra near Wollongong
  - Tomago near Newcastle in NSW
  - Onsite at the Pasminco Hobart smelter in Tasmania

- The principal project in the early years of the company's growth was the treatment of a 24,000 tonne stockpile of Zinc, Copper, Lead and Cadmium bearing baghouse dust at the Unanderra site. This dust was accumulated over 20 years of smelter operation at the Southern Copper site at Port Kembla in NSW (now Port Kembla Copper). The project was based on the recovery of zinc as zinc sulphate by leaching, with placement of the leach residue containing 30% lead to Pasminco's Cockle Creek smelter in Newcastle for lead recovery through the smelter. This successful recycling option to the Cockle Creek smelter of the lead residue ceased in 1996 when the Pasminco group rationalized residue treatment at their various sites, and began treating their own internally generated residues at Cockle Creek.

THE DEVELOPMENT OF TECHNOLOGY

With a very successful zinc sulphate business, but without a satisfactory lead disposal route, Hydromet conducted a worldwide search in an effort to place the lead as feed to another smelter, which proved unsuccessful.

The company then embarked on a research program to establish the potential for chemical fixation of the residue and whether an immobilisation technique was already in existence. With no approved technique available, the company set out to develop an immobilisation technique to meet EPA and landfill disposal criteria to allow its environmentally acceptable disposal.

The research and development work and defining of the final process took 3 years to complete, from laboratory to pilot scale, and a further 1-year to obtain NSW EPA approval of the immobilisation process.

The process is, as far as Hydromet can ascertain, a world first for immobilisation of lead residue of this type.

The process chemistry involved the addition of chemical reagents to convert all of the metal constituents such as lead, arsenic and cadmium and other traces of heavy metals into extremely insoluble compounds. The solution was then buffered to ensure the long-term stability of the end product.

Whilst Hydromet recognized that stabilization could be achieved adequately with a variety of compounds, the particular compound utilised in our proprietary stabilisation methods was considered the most desirable as its solubility in water is much greater, thus ensuring a much faster reaction rate.

Basically the stabilising ions generated in solution react with any dissolved metals to form a variety of inert metal compounds. An additional benefit is the achievement of homogeneous mixing in a slurry environment, which optimizes solid surface exposure for dissolution and reaction, and is clearly superior to direct solid phase reaction by the less efficient dry mixing of reagents.

This project has been the catalyst for Hydromet to utilise immobilisation technology to treat a number of hazardous wastes that previously had provided generators and waste handlers with enormous problems in providing satisfactory disposal routes. The confidence gained from the lead immobilisation project has allowed the company to explore further treatment options.

Products produced and sold from processing of metal bearing wastes by Hydromet so far include:

- Zinc Sulfate
- Lead Nitrate
- Copper Sulfate
- Cobalt Sulfate
- Manganese Sulfate
- Tin Hydrate
- Selenium Oxide.

WORKING WITH THE REGULATORS

Approval of the Hydromet lead process came only after a rigorous review and assessment by the NSW EPA Hazardous Substance Regulation branch and Policy Division.

The company worked closely with this division in developing the immobilisation technique, as this particular project was unique in the amount of contaminant elements, the quantity of waste involved and its environmental significance.

There was a requirement that exhaustive testwork be undertaken and ultimately required submission of a comprehensive and precise commissioning report. This report had to include substantial scientific and analytical data to demonstrate that the final treated material met strict Non - Liquid Waste TCLP and MEP classification disposal criteria.

The division also included site visits to examine equipment installation and random sampling/analysis of the final treated waste from the plant.

Final EPA approval of this immobilisation technique and support for the project was a watershed for the company. It allowed for other projects similar to this to be approached with confidence, both from the company and its clients.

ENVIRONMENTAL REGULATIONS AND THEIR IMPACT ON WASTE TREATMENT

As stated previously, Hydromet works in close liaison with the local EPA and NSW EPA Hazardous Substance Sydney branch in developing solutions to various waste streams for their clients. In developing these solutions, current legislation provides the framework for compliance and ultimate approval for each separate process.

Notably, the Protection of the Environment Operations Act 1997,and Waste Regulation 1996 form the framework under which Hydromet's industrial operations and waste activities are licensed. Similarly the Environmental Guidelines Assessment, Classification and Management of Liquid and Non-liquid Wastes provided by NSW EPA defines the criteria to be met in the disposal of wastes. The guidelines outline Toxicity Characteristic Leaching Procedure (TCLP), Specific Contaminant Concentration (SCC) limits under which wastes are classified for either solid or liquid waste disposal.

Accountability for waste management as a licensed Waste Facility also requires compliance with the Waste Tracking regulations which control movements of wastes in and out of the facility and to ultimate recycle of disposal destination. Hydromet complies with this tracking and reporting procedure in the conduct of its waste operations at Unanderra and Newcastle.

It is these guidelines objectives which then underpin the development of an immobilisation process for assessment and approval by the EPA.

Clients experiencing waste problems with either existing stocks or processes generating wastes approach Hydromet seeking solutions to those problems to dispose of the stockpile or an ongoing treatment option for existing production activities generating unavoidable wastes.

HYDROMET'S WASTE EVALUATION, TREATMENT AND/OR DISPOSAL PROCEDURE

The following process is adopted in reviewing a typical waste treatment option for a generator:

1. The waste or residue is evaluated in our laboratories to establish their contaminants and levels of each contaminant within the waste material.

2. Where a recovery/recycle option is possible the targeted metal is examined in terms of its suitability to chemical leaching (separation) from the waste stream and to further value adding to produce a final saleable chemical product. Refer to **figure 1** for a simple outline of a typical recovery/value added process utilised by Hydromet.

3. Where recovery and or treatment involves a residue immobilisation requirement, further laboratory work is carried out to establish a formulation to immobilise the remaining contaminants rendering them acceptable for landfill disposal, usually in the solid waste class. EPA approval will be required for immobilisation and landfill disposal.

4. Mass balance, energy requirements and solid waste/effluent streams are established and confirmed.

5. Once sufficient laboratory work has established a bench scale process, pilot plant testwork is carried out to confirm laboratory results, determine necessary modifications whether to the technical and or plant configuration and economics of the proposed process.

6. A project model, including commercial evaluation is prepared for consideration and, if acceptable, a proposal is prepared for the client outlining:

    - The extent of our findings
    - The process planned for the waste treatment
    - EPA approval considerations and timeframe where appropriate
    - A cost indication to carry out the work
    - Final destination of the treated/recovered/immobilised waste
    - Where treatment is agreed, we usually recommend a plant scale trial for a nominated quantity (from 1 to 100 + tonnes) depending on the waste and timing, again to confirm earlier results.

Typical Recovery Route

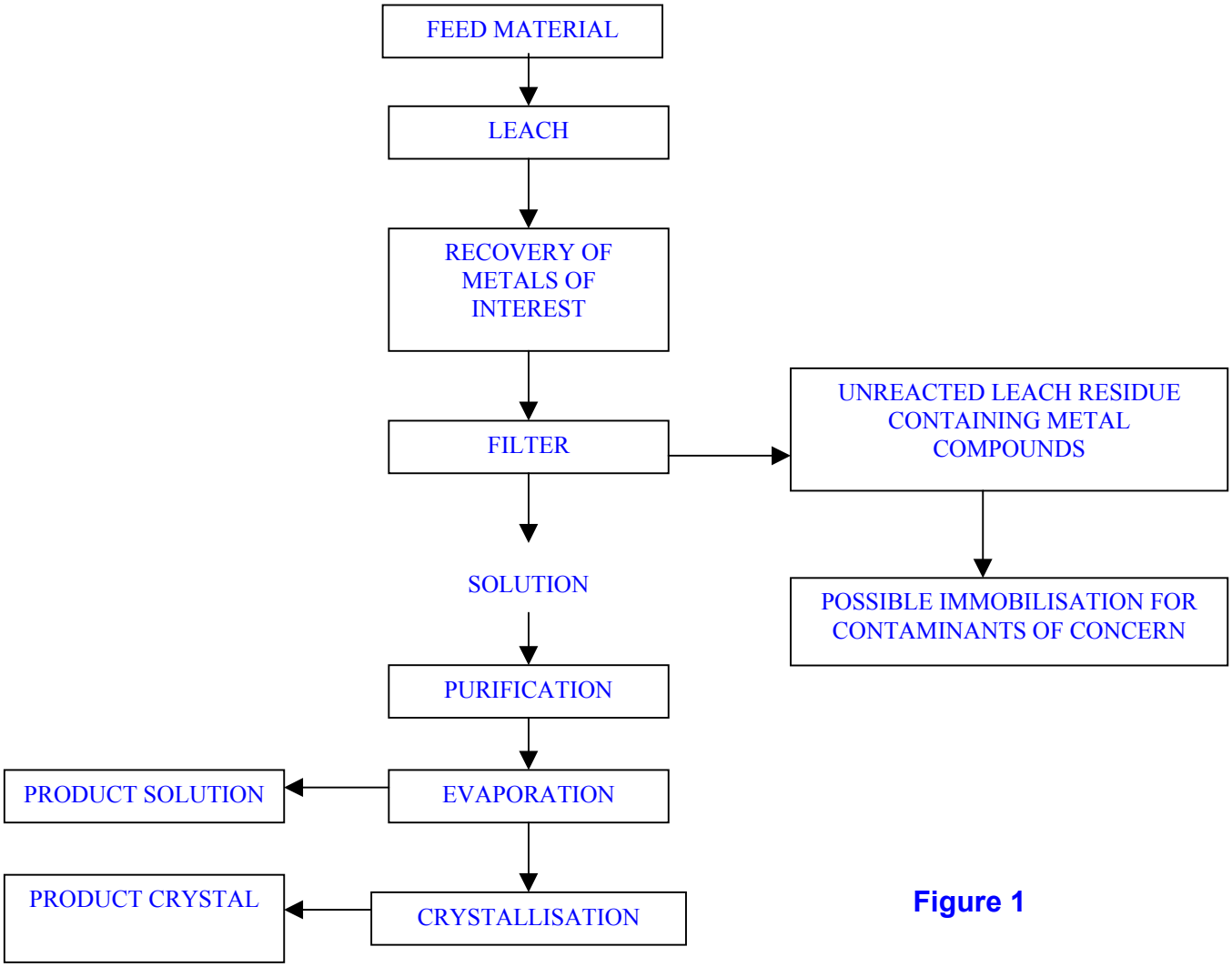

Figure 1

WASTE IMMOBILISATION PROCEDURE

Where either technical and or economic reasons prevent a recycle route or immobilisation is considered the only option, laboratory development work is carried out to establish:

- Contaminants and levels present in the waste requiring immobilisation
- The chemical formulation required to fix the contaminants in the residue

Once sufficient bench scale test work confirms a basic process, optimisation of the proposed formulation is performed. A plant pilot scale evaluation is again conducted for technical and economic purposes.

When the process is defined a treatability study is prepared for NSW EPA to enable their independent assessment of the proposed treatment process the

equipment designed to carry out the immobilisation and the supporting scientific data provided to confirm the residue is effectively fixed. Supporting data will include independent NATA analytical information confirming TCLP and sometimes MEP (Multiple Extraction Procedure) results. The study must demonstrate long term stability of the treated waste. These results will determine ultimate waste classification for landfill purposes. The submission may be extensive depending on the process and will also include provision of:

- Reasons for immobilisation versus re-use or recycle
- Full process description
- Process flow sheets
- Mass balance defined
- Extensive analytical and scientific data proving immobilisation and compliance with TCLP/MEP criteria
- An independent experts report supporting the chemistry and findings of the study (in the case of the lead project)
- Equipment list
- HAZOP and HAZAN assessments of the proposed process
- Standard Operating Procedures of the proposed process
- OH&S, Environmental and Risk Assessments where appropriate
- QA procedure utilised
- Waste tracking and licensed landfill operator to be used for final disposal of immobilised waste. The landfill must be licensed to receive the particular final immobilised residue.

Refer to **figure 2** for a basic immobilisation process flowsheet.

The cost to immobilise a waste will vary according to the formulation utilised, the quantity to be treated, the complexity of plant required and a number of other factors. Final landfill charges and transport must also be taken into account. Total processing costs may be offset to some extent by the value of metal recovered and its ability to be recycled.
The timeframe to complete development work, conduct plant trials and obtain EPA approval will depend on the particular waste requiring treatment and the time necessary for the EPA in its review procedure.

Typical Immobilisation Route

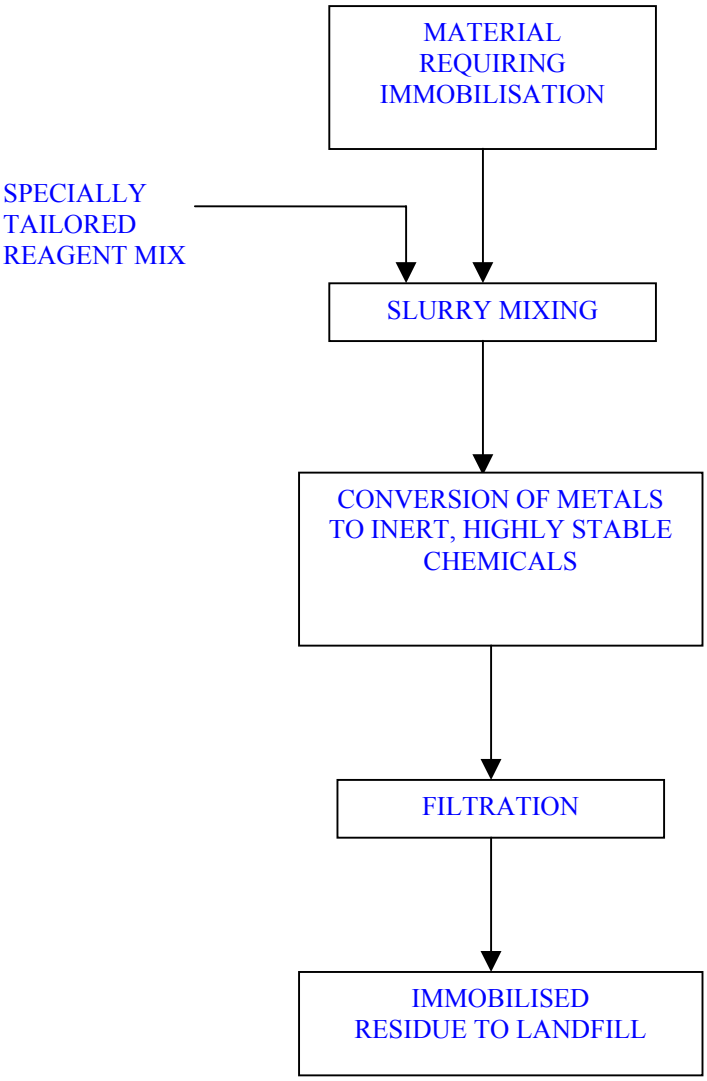

Figure 2

SUCCESSFUL WASTE PROJECTS CARRIED OUT BY HYDROMET

By following the procedures outlined above, Hydromet has been given approval for a number of projects, which include:

- Treating zinc rich dust from the Onesteel electric arc furnace operation at Rooty Hill, NSW. The company leaches the dust to form zinc sulphate products, which are sold into the agricultural industry. The remaining leach residue, containing predominately iron, is immobilised and disposed into landfill. The process is outlined below in **figure 3**.

EAF Dust Treatment Process

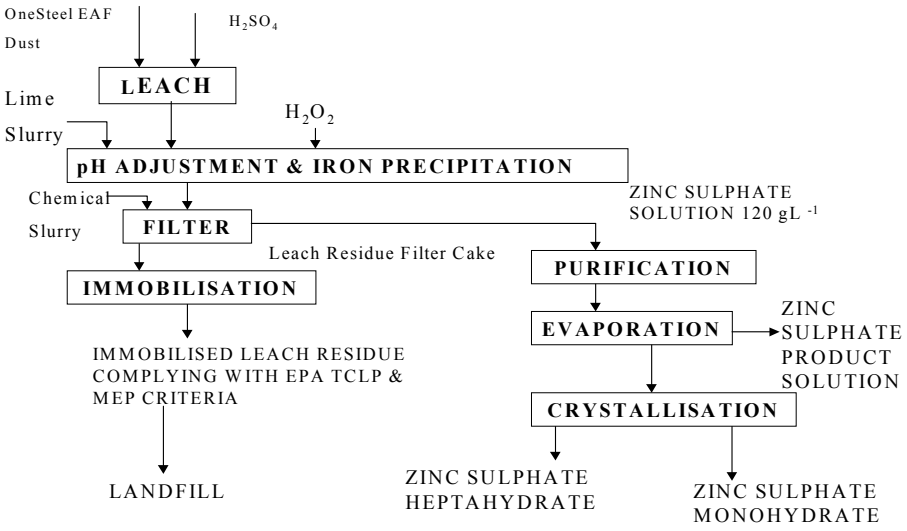

Figure 3

- Processing Tin sludge from BHP's Port Kembla steelworks to immobilise the residue prior to disposal to landfill.

- Providing manganese residue filtration and immobilisation at our Risdon, Tasmania facility on behalf of Pasminco.

- Conducting precious metals recovery at our Newcastle facility on behalf of Falconbridge Norway from a selenium rich smelter residue. In this application the company has developed technology to treat residues containing valuable precious metals, previously not possible. The company extracts the selenium from the residue, producing a saleable selenium product, with the precious metal concentrated by up to 5 times returned to the smelter for recovery. This is shown in **figure 4**.

Falconbridge Precious Metals Process

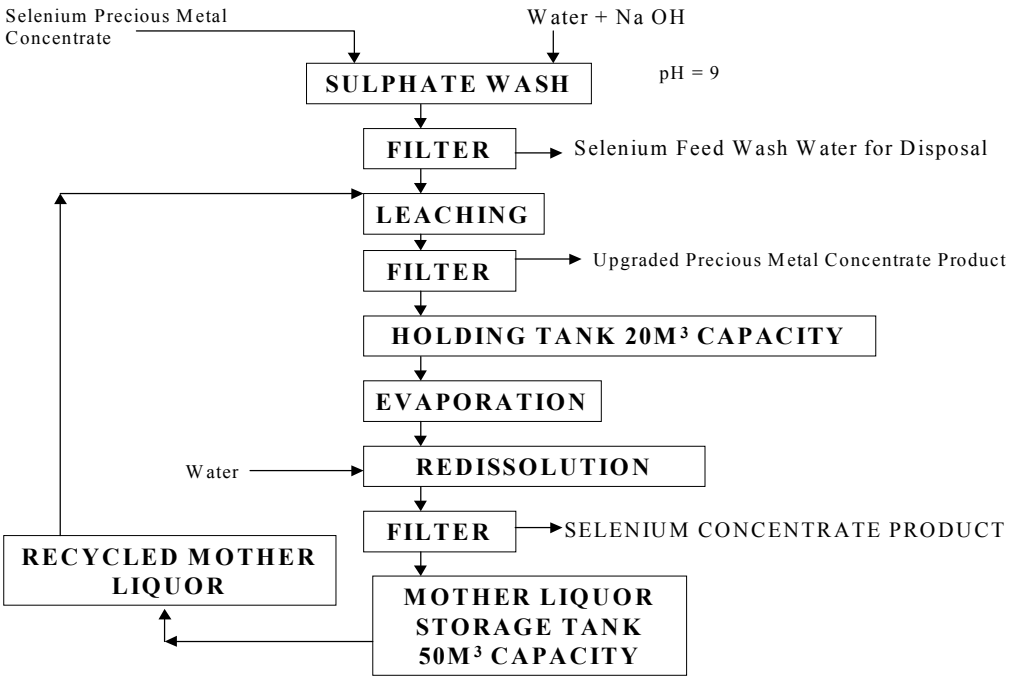

Figure 4

- Preparing to immobilise spent hydrotreating catalyst from a major oil refinery

- Preparing to immobilise and dispose of lead contaminated slag from a battery recycling operation.

- Immobilising mercury-contaminated residues and materials generated in a local sulphuric acid manufacturer.

- Separating red oil from spent sulphuric acid generated in an oil refinery. The project is currently under an R&D grant evaluation. The basis of this project is to recover the spent acid and utilise it in the production of zinc sulphate at the Unanderra site. This will eliminate the need for the current disposal method, which has greenhouse gas generated wastes.

- Removing copper, tellurium and bismuth compounds from precious metal residues at the Tomago site and returning the precious metal to the overseas generator for further recovery.

- Treating selenium/precious metal product at our Tomago site for selenium recovery and returning the precious metal concentrate to the overseas smelter.

Other major projects completed include:

- Immobilised 16,000 tonnes of lead residue as outlined above under contract to Rio Tinto.

- Treatment of 850 tonnes of lead bearing garnet, a by-product of sandblasting of the Sydney Harbour Bridge. This project was carried out in 1999 and resulted in our process separating lead from the garnet. The recovered lead was onsold to a secondary lead smelter for recovery and the residual clean garnet disposed to landfill.

- Processing of 400 tonnes of cobalt bearing residue to recover cobalt as Cobalt Oxide for sale to an overseas smelter.

- Processing of a range of Copper, Zinc, and Nickel bearing wastes to produce metal chemicals and provide a disposal solution for these clients.

- Production of Manganese chemicals from manganese residue.

- Production of Selenium products from smelter residues.

- Treatment of over 300 tonnes of Arsenic residue from an acid plant.

Hydromet's client list includes :

- Rio Tinto
- BHP
- Falconbridge Norway
- Caltex
- Queensland Nickel
- RTA New South Wales.
- Pasminco
- Onesteel
- Port Kembla Copper
- Exide Technologies.
- Shell
- Incitec
- Kennecott Copper (Utah USA)

CONCLUSION

Hydromet has successfully developed hydrometallurgical techniques to treat a range of industrial wastes. The techniques have expanded to include straight immobilisation of residues to leaching and recovery of value added chemical products. Treatment of overseas precious metal residues has seen the company extend its client base, and has become a well-recognised international company, known for its innovative technology in treating a range of residues.

With the continuing drive for cleaner waste disposal routes and ones that will ensure no long term consequences, Hydromet feels it provides an environmentally acceptable solution to hazardous industrial waste that is not only accepted, but supported by the environmental regulators. To ensure long-term sustainability, the company has extended its hydrometallurgical processes to include treatment of selenium rich residues from both local and overseas smelters, whereby precious metal components are concentrated and returned for further recovery while the selenium is recovered as a saleable product.