PAPER 7

IMPROVING SULPHIDE RECOVERIES IN COMPLEX GOLD ORE BODIES USING COST EFFECTIVE PRE-CONCENTRATION BY GRAVITY

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ABSTRACT

Various full-scale test programs and installations of the InLine Pressure Jig (IPJ) have provided evidence that pre-concentration of the difficult to leach sulphide mineral through gravity can provide significant increases in economic recoveries. The continuous gravity concentrates are intensively treated either by re-grinding or Intensive Cyanidation. Data from various mine sites worldwide is presented. Treatment of complex ore bodies with this low cost methodology may render previously uneconomic ore bodies financially viable and assist in the recovery profile of transitional ore.

INTRODUCTION

The use of gravity is made extremely attractive in complex ore situations due to the low cost of operation, typically a few cents per ton operating cost and lack of chemicals.

Gold mines which suffer from poor recovery due to complex mineralogy such as Stibnite, Arsenic, Carbon, Telluride, Silver and other pacifying agents such as Iron, which can form coatings, can all benefit from the process proposed in this paper. The key issue is not overall recovery as much as one of economic recovery. The key to this is maximised recovery at the lowest possible capital and operating cost. Other options such as flotation are reviewed but are not seen in many instances to be the panacea due to issues discussed in the paper.

The use of the InLine Pressure Jig in the re-circulating load of the milling circuit is a cost effective means of recovering a sulphide/gold concentrate containing the complex mineral assemblages which require re-grinding and intensive leaching for optimised gold recovery.

The benefits of Jig Assisted Grinding (JAG) are many and the challenge over the past years has been developing, understanding, implementing and evaluating the benefits of various flowsheet models. This has involved the reconciliation of results in plant scale trials back to the original laboratory test program. The following paper outlines the insights gained in this area through extensive work carried out by many people across both laboratories and plant sites in Australia and overseas. The examples in this paper are some of the work carried out on a few selected sites but similar work has been carried out on other sites such as Penjom, Granny Smith and Agnew. This work has eventuated in several installations which we believe have great importance in the future of the gold processing industry. They will lead the way forward to the modern all-gravity plants of the future.

Compared to flotation, for the recovery of sulphides, gravity is a simple option. The simplicity generally translates to low capital and operating cost.

BENEFITS OF A JAG CIRCUIT FOR A COMPLEX GOLD FLOWSHEET

The removal of a high proportion of the complex gold sulphide gold carriers in front of the CIP/CIL circuit can significantly impact on the performance and cost of the leach circuit. Benefits include:
• Improved recoveries
• Coarser grind sizes
• Reduced cyanide
• Reduced oxygen
• Reduced residence time
• Reduced power

**FIG 1:** Simple JAG circuit showing cyclones, magnet and IPJ for complex gold and sulphide recovery.

**PROJECT EVALUATION**

A project can be evaluated based on the following criteria:

**TARGET** = RECOVERY OF THE COMPLEX MINERALS FROM THE GRINDING CIRCUIT UTILISING A JAG CIRCUIT FOR SEPARATE INTENSIVE TREATMENT AWAY FROM THE BULK OF THE ORE.

**OUTCOME** = HIGHER OVERALL GOLD RECOVERY AT A LOWER UNIT COST PER OUNCE.
In order to investigate this option it is first necessary to understand the current recovery loss in the plant or the potential loss in the case of a green field’s site. Discussion will concern operating mines in this paper although the same logic can be applied up front to a new plant installation.

It is first of all necessary to take a representative sample of the ore for this work and in many cases several samples will be required to give a spread to the work. The initial test work carried out is simply a comparison to assess the benefit of separating the complex component of the ore away from the bulk of the gangue minerals and then leaching it under intensive conditions to achieve the highest possible recovery. The ROM ore is at the same time leached under site standard conditions to fix the recovery potential base line for the ore in the normal CIP/CIL type system. The gravity tail is also leached to give the overall recovery for CIP/CIL and Gravity + Tail leaches.

<table>
<thead>
<tr>
<th></th>
<th>CIL Plant Current Recovery (%)</th>
<th>Current Gravity Recovery (%)</th>
<th>Potential Gravity Recovery (%)</th>
<th>Gravity Leach Tail Recovery (%)</th>
<th>Overall Combined Recovery (%)</th>
<th>Potential Recovery Benefit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bibiani Lab</td>
<td>80 - 85</td>
<td>40</td>
<td>70</td>
<td>87</td>
<td>90 - 95</td>
<td>10 – 15</td>
</tr>
<tr>
<td>Bibiani Plant</td>
<td>78</td>
<td>30</td>
<td>70</td>
<td>92-98</td>
<td>89</td>
<td>11</td>
</tr>
<tr>
<td>Stawell Lab</td>
<td>83</td>
<td>20</td>
<td>63 - 78</td>
<td>98</td>
<td>86</td>
<td>3</td>
</tr>
<tr>
<td>Stawell Plant</td>
<td>83-85</td>
<td>15 - 30</td>
<td>50 - 64</td>
<td>97</td>
<td>88</td>
<td>3-5</td>
</tr>
<tr>
<td>St Ives Lab</td>
<td>85</td>
<td>30</td>
<td>60</td>
<td>90</td>
<td>88-91</td>
<td>3-6</td>
</tr>
<tr>
<td>St Ives Plant</td>
<td>85</td>
<td>15</td>
<td>50</td>
<td>85</td>
<td>89</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1: Typical recovery ranges for various flowsheet options

Table 1 represents the typical range of recovery indications from both lab and plant trial information. There is a wide range of variability in the samples of these complex ore bodies and this information is a composite of results from the work carried out.

Once the potential recovery benefit is understood then the additional financial benefit can easily be predicted. It is important that a “back of the envelope” version of this be carried out early on in the process to ensure the fundamentals of the project are sound and it should also highlight the areas of sensitivity that will require more rigorous investigation.

LABORATORY TEST WORK

The Gekko Progressive Tabling (GPT) test work is carried out on a small shaking table and a yield/recovery curve is produced for each ore type. The ore is ground in a three stage process with gravity recovery carried out between stages to recover liberated gold/sulphide. This process is designed to emulate the recovery of gold/sulphides from the recirculating load of the milling circuit. In this procedure we characterise the gravity recovery potential of the ore rather than testing the efficiency of any particular process on the ore type.
**FIG 2: Typical Yield Recovery Curve**

Figure 2, above, shows the Gekko Progressive Tabling (GPT) of Bibiani ore produced in the laboratory. The star shown is the recovery achieved by heavy liquids and shows the overall potential of the ore under near perfect conditions. The chart shows gold recovery of around 75% at approx. 10% yield of the initial feed mass to concentrate.

**FIG 3: Typical Yield Grade Curve**
Figure 3, above, is the corresponding curve which shows the grade of gold in the concentrate for a given yield. As yield increases the grade decreases.

The products from this work are then taken and a composite produced at what was deemed to be the most economic recovery, at approx. 10% yield. The concentrate is then leached under intensive conditions. The gravity tail is also leached under less rigorous conditions (CIL/CIP) to establish the overall recovery from the two products. Re-grinding of the concentrates often shows positive results and again is a matter of economic recovery. Obviously from the leach results shown in Figure 4, below, the 106um grind and leach is not as desirable as the 75um grind and leach. The extra capital and operating cost of grinding to 38um was considered too high although there is some benefit in increased recovery. Very similar results were achieved from the leaching of the concentrates actually recovered on site from the IPJ trials.

![Au Leaching of Re-grind Gravity Concentrates](image)

**FIG 4: Leach Results for Bibiani**

The chart above shows the leach recoveries for Bibiani achieved at various grind sizes and reagent strengths. It is interesting to note that whilst cyanide strength increases the leach rate it does not markedly affect the overall recovery.
Concentrates from the Stawell site trial were upgraded on a table to evaluate the potential for further upgrading in the plant with a cleaner InLine Pressure Jig. The results, figure 5, show a further possibility to reduce the mass by approx. 40% without serious gold loss from the concentrate. This was carried out without any size reduction of the concentrate and it is possible that greater mass reduction could be achieved if further concentration was carried out in series with a small mill to re-grind concentrates.

**GRAVITY RECOVERY**

As the density differential of the mineral to be recovered and the gangue density converge gravity separation becomes more difficult. Generally the gravity device would be de-rated in throughput and increased in yield in order to achieve acceptable recovery. Typically the use of several stages of rougher and cleaner are utilised to achieve sufficient concentrations and recoveries. The key beneficial influences in favour of the InLine Pressure Jig (IPJ) recovering sulphide associated gold in a milling circuit is the preferential recovery of heavy mineral to the cyclone underflow that would typically ensure an initial upgrade of the sulphide in the order of 3:1 with the highest upgrade in the size fractions between 150um and 38um. The sulphide tends to report to cyclone overflow after grinding to 38um. The p80 of the sulphide would generally be 40% lower than the p80 of the gangue mineral in the cyclone overflow.
The IPJ feed grade by size curves, Figure 6, represent the cyclone underflow stream and show the increase in Sulphur grade as the cyclone preferentially recovers sulphide to the cyclone underflow rather than gangue minerals. The corresponding rise in Sulphur grade in the IPJ concentrate can be seen.

**FIG 6: Sulphur Grade by Size Fraction in the Cyclone U/F**

Due to the complexity of the balance of particle breakage and size reduction, gravity recovery efficiency and cyclone efficiency it is complex and time consuming to manually calculate the outcome of changes in conditions in the recovery circuit. Therefore the optimum operational tonnage and yield are calculated using an iterative model developed by Gekko on Limn Software. The model takes the empirical recovery curves developed by Gekko at differing feed rates, yields and feed size distributions and runs a scenario function to ascertain the optimum operating range for the IPJ in a certain ore type. As the feed sulphide particle size distribution increases so does the ability to run at a higher feed rate to the IPJ and the yield required generally reduces.

The optimal range of recovery for the IPJ lies between 1000um and 75um. A simple recovery curve shows the diminishing return as the size fractions reduce. Generally the drop off in recovery in the coarser size fraction is due to lack of mineral liberation from the gangue. The diminishing return is a function of the reduction of mineral loading in the cyclone underflow by the efficient recovery of the mineral. It is possible to reduce the cyclone underflow grade to lower than that of the feed grade if the concentrator efficiency is very high.
**FIG 7: St. Ives – Size by Size IPJ Recovery**

Figure 7, above, reveals the size by size recovery of the IPJ running at a low feed rate of approximately 7 tons per metre square of screen area.

**SITE AUDIT**

Site Audits were carried out to assess the cyclone efficiency of areas such as the cyclone which are critical to gravity recovery in the recirculating load. The site surveys at Bibiani were carried out on gold only due to ease of assay on site and this was made far more practical due to the very strong association of gold and sulphur found in the laboratory. The gold/sulphur association as seen in the chart below is very strong and was confirmed in other work.
FIG 8: Table Recovery Yield Curve for Bibiani

The yield/recovery curve for Bibiani (Figure 8) shows the close association between gold and sulphur in the ore. The other interesting point is the first point on this chart (lowest yield point) is almost always closely aligned with the maximum recovery of free gold achieved on site in a circuit that operates batch centrifugal concentrators. This is certainly the case for Bibiani as the gravity recovery throughout the whole test program over several months fluctuated around 30-40%.

The gold distribution in the cyclone underflow is seen to be 72% greater than 75um and the bulk of the gold (by association sulphide) is in the range of 75um to 1000um range. This size distribution is commonly seen in these complex gold assemblages. It must also be remembered that the size distribution in the cyclone underflow is skewed towards the fines fraction by the preferential recovery of heavy mineral to the cyclone underflow. It can be argued therefore that the feed sulphur particle size distribution is possibly even coarser than the cyclone underflow distribution.
FIG 9: Bibiani Cyclone U/F and IPJ Con Data

Figure 9, above, reveals the distribution of the gold in both the IPJ feed and the IPJ concentrate. The gold distribution in the IPJ con is in fact slightly finer than the gold in the cyclone underflow and is probably due to the lack of liberation of gold in the IPJ feed.

MAGNETICS REMOVAL FROM FEED

The IPJ relies on the differential in density of the gangue and the sulphide minerals to achieve a separation. The IPJ incorporates a bed of ragging which generally has a density between that of the mineral and the gangue, this allows the heavy mineral to “sink” through the ragging and report to concentrate and the lighter gangue minerals to “float” over the bed and report to tail. As the ragging density rises the ability for the sinks to penetrate the bed decreases and the recovery potential decreases. The density of the gangue in most applications is around 2.5 s.g. to 2.8 s.g. The density of the sulphide minerals sits between 3.0 s.g. and 4.0 s.g. which allows the recovery or separation of the gold bearing ore if desired.

In order to achieve high recoveries in the plant it is necessary to keep the bed density at the desired level. Often in the grinding circuit there is a build-up of scats or ball chips which recycle until they are removed from the system or are ground out. These steel scats have a density which is considerably higher (>6.0 s.g.) than the mineral being separated and the result is the loss of gold/sulphide to the tails.

Gekko Systems have developed their own magnetic separator to recover the steel scats from feed to the IPJ or the Spinner. This reduces the build-up of steel scats in the milling circuit. The key is to keep all steel scats, from filling the voids in the bed.
As shown in Figure 10, above, the incorporation of the magnet increased overall pass recovery for the IPJ. These recoveries were achieved without any pre-screen in front of the IPJ and the unit was accepting cyclone underflow of <18mm.

**FIG 10: Bibiani – Effect of Feed Magnet on Recovery**

JIG OPERATION / OVERVIEW

The IPJ is an effective and efficient gravity separation device that has found application in the processing of a wide range of minerals. Although based on the same principles as conventional jigs, its pressurised design and advanced control system give it many advantages such as high recovery, high unit throughput, low water consumption, close control of operating conditions, low installation cost, low operating costs and high security. The IPJ can be used either in placer deposits as the primary concentrator or in hard rock circuits to treat all or part of the cyclone underflow or mill discharge. As a result of the large combination of jig parameters and ragging types possible, the IPJ has successfully been used for a variety of minerals, including gold, sulphides, silver, native copper, tantalum, garnet and diamonds.

The IPJ is a compact, low cost continuous processing unit that requires minimal infrastructure or logistical support. As well as having a low capital cost, it has very low operating costs per tonne processed, and very low power requirements.

Increasingly the industry has recognised the benefits of using the IPJ in the treatment of complex gold ores. The IPJ operation varies from batch centrifugal concentrators (such as the Falcon Super Bowl) in that it produces a continuous concentrate discharge. This allows the IPJ to recover a higher portion of the feed to concentrate allowing the total recovery achievable by gravity to be optimised (Heins et al., 2003).
INTENSIVE CYANIDATION

Treatment of complex gold sulphide concentrates produced from higher mass pull gravity concentrators such as the IPJ allows the use a continuous Inline Leach Reactor (ILR) to maximise gravity gold recovery. The development and commercialisation of this technology has enabled the effective treatment of higher mass gravity concentrates. Advantages of this technology include significantly reduced capital outlays for Greenfield plants or plant upgrades and increased investor returns. Reduction of onsite cyanide and carbon inventories improves plant safety, materials handling and site security. By using intensive cyanidation on some complex ores the overall plant recovery can be increased. Potential also exists to increase grind size – saving energy, further reducing capital and operating costs and decreasing the environmental impact of a mill. Detoxification of cyanide before the discharge of solution to the tailings dam can reduce tailings disposal and containment requirements (Gray et al., 2003).

ISSUES WITH FLOTATION

Flotation has been used in gold plants in combination with downstream leaching for many years. However there are competing advantages and disadvantages that need to be carefully explored. There are two types of flotation that can be looked at for the purpose of gold/sulphide recovery in a gold circuit and these are Flash Flotation which runs in the cyclone underflow stream and conventional flotation which runs in the cyclone overflow stream. In the case of Stawell Gold Mine a flotation plant was installed in the cyclone overflow stream about 5 years ago and is used to recover gold/sulphide for fine grinding to increase overall recovery in the leach circuit. Some of the issues facing this technology in a gold circuit are:

- Operating cost
- Capital cost
- Effect of float residues on downstream carbon in the leach circuit.
- A relatively tight recovery / size range (poor coarse recovery)
- Poor recovery in recycled water containing cyanide residues.
- Recovery of preg robbing carbon to the high grade stream
- Complexity
- Poor recovery of complex and coated gold

The difference in operating cost between IPJ and flotation are considerable with the cost of flotation running at approx AUD$1.00 - $1.50 per ton of ore treated depending on water quality and reagent consumption versus IPJ at around $0.25 per ton treated with the major variable being number of units required rather than operating cost.

It could be argued that the combined issues related with operating flotation, especially where it is utilised to augment CIL/CIP, are considerable and in fact the overall aim of the project at Stawell was to remove the flotation from the circuit which in turn would significantly reduce the overall operating cost of the recovery plant.
FLOTATION & GRAVITY – A COMBINATION FOR NON-CIP CIRCUIT

After the above discussion it must also be stated that the combination of the IPJ and flotation in a circuit that does not have downstream CIL/CIP can be an extremely effective tool for high overall recovery as the units augment and compliment each other with a resulting very high efficiency.

SITE EXAMPLES

STAWELL

The work carried out at Stawell both in the laboratory and in the plant was extremely comprehensive. The conclusion was the project should go ahead and the table below summarises the benefit and the options. The key to the overall success of the project is the amount of preg-robbing carbon in the ore and its affect on the overall recovery. The gravity/leach circuit greatly reduces the affect of preg-robbing carbon on the overall recovery.

<table>
<thead>
<tr>
<th>Option</th>
<th>Float</th>
<th>Jig</th>
<th>ILR</th>
<th>Op Costs</th>
<th>Rec % Benefit</th>
<th>$ Benefit</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>$1.80/t</td>
<td>5.0%</td>
<td>$4.34/t</td>
<td>$2.54/t</td>
</tr>
<tr>
<td>Option 2</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>$0.80/t</td>
<td>5.0%</td>
<td>$4.34/t</td>
<td>$3.54/t</td>
</tr>
<tr>
<td>Option 3</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>$1.10/t</td>
<td>5.9%</td>
<td>$5.12/t</td>
<td>$4.02/t</td>
</tr>
<tr>
<td>Option 4</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>$2.60/t</td>
<td>6.0%+</td>
<td>$5.21/t+</td>
<td>$2.61/t+</td>
</tr>
</tbody>
</table>

Source: Stawell Gold Mine developed using current operating costs.

Table 2: Stawell – Costs vs. Benefits for Various Flowsheet Options

Table 2, above, shows that the best option from an economic point of view was to eliminate the flotation step from the system and rely on gravity (IPJ) intensive leach (ILR) and intensive leach tail re-grind and returned to the CIL circuit.

It is impossible to do justice to the work carried out at Stawell in this paper as it is worthy of a paper in its own right however the table below shows the type of work carried out to assess the overall benefit of recovery and grind size for concentrates.

<table>
<thead>
<tr>
<th>Mill Feed</th>
<th>Head Grade</th>
<th>Jig Rec.</th>
<th>Wt% Rec.</th>
<th>Lab Leaching (Recovery)</th>
<th>Tail g/t.</th>
</tr>
</thead>
<tbody>
<tr>
<td>COF</td>
<td>4.82</td>
<td>-</td>
<td>-</td>
<td>84.9%</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>2.82</td>
<td>-</td>
<td>-</td>
<td>83.6%</td>
<td>0.46</td>
</tr>
<tr>
<td>COF</td>
<td>Con p80 =</td>
<td>543</td>
<td>106</td>
<td>75</td>
<td>38</td>
</tr>
<tr>
<td>Jig Con</td>
<td>17.56</td>
<td>49%</td>
<td>13%</td>
<td>79.3% 90.9% 93.1% 94.6%</td>
<td>1.21</td>
</tr>
<tr>
<td>Overall</td>
<td>81.4% 87.2%</td>
<td>88.3%</td>
<td>89.0%</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>Benefit</td>
<td>- %</td>
<td>-3.5%</td>
<td>2.3%</td>
<td>3.4% 4.1% 3.4%</td>
<td>3.4%</td>
</tr>
<tr>
<td>- g/t</td>
<td>-0.17</td>
<td>0.11</td>
<td>0.16</td>
<td>0.20</td>
<td>0.16</td>
</tr>
</tbody>
</table>
**Table 3: Gold Leach Recovery – Central Ore no Cleaning of Concentrate**

Table 3 summarises work carried out in the lab at Stawell to determine the benefit of various grind sizes on the concentrates generated from the actual plant trials and the mill feed sample ROM leach as well as the cyclone overflow leach after gravity.

Other work carried out included:
- Size by size recovery of sulphur, arsenic and gold in the IPJ at various feed rates
- Full scale plant trials including 2 x IPJ2400 jigs taking the complete recirculating load on both Basalt and Central ore types.
- Detailed concentrate treatment evaluation
- Complete new circuit design and final costing

In light of the continuing work carried out by Gekko on other sites and the advances made in increasing recoveries with the magnet ahead of the IPJ it could be argued that the installation of the IPJ/ILR circuit at Stawell could show even higher returns than these numbers indicate.

The overall circuit was given preliminary approval by the board but was not instigated due to economic restraints at the time. Since this time the actual and predicted levels of carbon in the ore have dropped and the overall recovery benefit in light of the existing recovery data has decreased the overall benefit to the point at which it is marginal without further recovery improvements.

**BIBIANI RESULTS**

After an extensive laboratory test program and site auditing of the existing circuit it was decided to go to actual site pilot testing and that Gekko would install and commission an IPJ2400 in the cyclone underflow. The trials would be run over several months to produce an operating history and detailed metallurgical results as well as give the operators and key staff a chance to become familiar with the IPJ and get comfortable with its operation and reliability. The following curves, Figure 11, show the recovery of a single IPJ2400 in the re-circulating load. The upper curve shows the recovery/yield as modelled in the Gekko laboratory. The lower curve is the laboratory curve that has been adjusted to allow for the 30% of the free gold that is currently being recovered by the Knelson KC48 in the circuit. The large square is the recovery target for the sulphide recovery project.
**FIG 11: Bibiani – Yield Recovery Curves**

It can be seen this target is well outside the potential of the single gravity device in the circuit. However the original recovery model allows for multiple IPJ2400’s to be installed and the Gekko Predictive Model (GPM) was utilised to calculate the recovery of multiple units.

**FIG 12: Bibiani – IPJ Sulphur Recovery**

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IMPROVING SULPHIDE RECOVERIES IN COMPLEX GOLD ORE BODIES
Figure 11, above, shows the incremental increase in recovery achieved by the installation of sequential units in parallel.

In the original laboratory work carried out using GPT the gravity recovery figure of 60% of total gold was considered to be a conservative number to use as the base line calculation as it left considerable upside potential for improvement whilst providing high upside potential. The overall recovery potential seen in the lab was very high at approx. 90 -95% with the recovery of 60% of the total gold to gravity/leach. This amounts to an increase of ~10% in total recovery.

The overall economics for this project were very sound. The decision was taken however to install a flash flotation circuit in the recirculating load in place of the IPJ’s. This decision was taken from a capital and recovery basis. Laboratory flotation test work showed higher recoveries of sulphide/gold to concentrate but at higher mass recoveries than gravity. The Unit Cells were available second hand from another Ashanti site close by at no cost to the company and this tipped the scales in favour of the flotation option. It will be extremely interesting to review the recovery outcomes from the economic perspective after the installation is completed and commissioned.
ST IVES

The recovery potential for St Ives is far more difficult to summarise as there are many and variable ore bodies which make up the mineral assemblage for the site. Individual benefit work has been carried out by an independent laboratory to ascertain the benefit of separating the sulphide associated and gravity gold for re-grind and intensive leach. The results are a broad range of benefits.

Intensive full scale gravity trials were carried out with an IPJ2400 fed by the cyclone underflow and passed through a Gekko Scatex magnet for steel scat removal prior to recovery. The concentrate was then fed to an ISP30 for free gold recovery. The complete circuit is still in operation and is an ongoing source of data for further research and process improvement. The pilot circuit will run until the new plant is constructed.

The gravity circuit at St Ives in the new plant (4.5 mtpa) will incorporate both batch centrifugal concentrators for fine free gold recovery which will report to a batch InLine Leach Reactor for leaching and a series of IPJ’s to recover both free gold and sulphide for a re-grind and leach circuit.

Some of the data from this work has been invaluable in compiling a data base of recovery for later use in the Gekko Predictive Model (GPM).

FIG 13: St. Ives ILR Plant