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A water audit of Newmont's Tanami Goldmine Operation, N.T. Australia

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Water auditing and water efficient practices are evolving as the quantitative tools for water balance reporting in the mining and minerals processing sector. This paper was written to describe the process of water auditing in a gold mining environment. It will contribute towards building an appropriate water management framework for The Cooperative Research Centre (CRC) for sustainable resource processing (CSRP). The research assists with the assessment of water balances in mining and hydrometallurgical processes and provides, on the ground, steady-state data for ongoing probabilistic modeling underway at most of Newmont's gold mine operations. Five Newmont case study mine sites including the Tanami Granites Goldmine are central to this PhD water project study. The function of the Tanami-Granites water audit exercise was to measure a controlled flow of various water quality types and set a framework to establish further research for water efficiencies and water conservation in mining.

Introduction

The aim of this paper is to generate a portable and transferable framework of water auditing measures. The auditing methods promoted in this paper will underpin the delivery of a self-managed system of quantifying mine-water sources and usage. This is supported by a quantitative analysis of fit for purpose water use that represents a quality assessment on various water uses and suitability. The water audit domain is represented by four water sources and water outflow from two discharge outlets. The general aim of this paper lays the groundwork for the application of materials and methods required for water auditing in hydrometallurgy and mining. The specific objectives include:

- Developing a pre-audit water circuit schematic
- Outlining the materials and methods required to conduct a mine site water audit
- Describing the operation of ultrasonic testing equipment
- Conducting a water audit and formulating a results table
- Provide a site water quality analysis and non-audit water flow data to format a results table
- Describe the process of data logging water flows and produce a line graph for analysis
- Contribute to a generic water quality and percentage usage table
- Tabulate a step-by-step framework of a water audit procedure
- Develop a water management strategy.

This paper generates a background of water use data that will provide water security when operating a remote area goldmine in a water scarce desert region. It will establish the framework of a water management strategy required for site-wide water uses while maintaining sustainable water stocks.

Background and site description

The Granites Tanami Operation sits within the Killi-Killi geological formation where gold mineralisation occurs along the 'Tanami Corridor' in quartz veins within turbiditic sediments. Throughout this recent geological formation (Wygralak 2005), siltstones and sandstone dominate the geology with banded iron and dolerite sills intruding the upper sediments. Much weathering has occurred and the topography is subdued, consisting of flat to undulating sand plains and broad drainage depressions associated with palaeochannels (NTG 2005). There is a general lack of well-defined surface drainage channels however; palaeo-alluvial valley sediments provide a shallow overland flow of rain-driven water, generally moving in a southward direction (Wygralak 2005). The average annual rainfall is 475mm of which 90% falls between November to April and provides an aquifer recharge necessary to sustain the 1500 Mega-Litres (ML) of bore-water abstracted for the Tanami operations (Newmont 2009).

Process description

The unit operations included a three phase gold-ore crushing system installation (CSI), a ball mill, hydro-cyclones, an underflow stream reporting to spiral concentrators, an overflow stream reporting to a carbon in leach process (CIL), a reverse osmosis filtration system and final concentration of gold and silver in the acid washing and elution process. Unit operations are highlighted and water quality is classified within the framework of a water audit process (Sturman 2004). Approximately 3.0 Mega-Tonnes per Annum (MTPA) of gold ore is extracted of which ~0.2 MTPA is stockpiled waste material and 2.8 MTPA is process/treated. Bore water is abstracted and is classed as either fresh (<1 500 mg/L total dissolved solids -

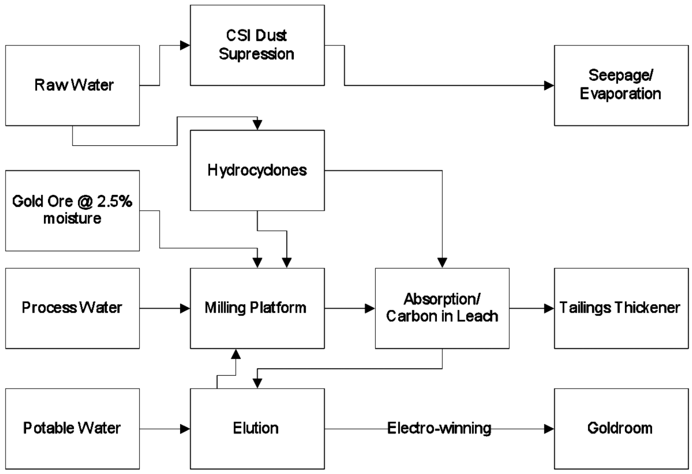

Figure 1. Granites goldmine water audit domain

Table I
Granites water audit: audit preparation materials and methods

Equipment	Process water	Raw water	Potable (RO)	Tails water
Ultrasonic thickness gauge	Measure pipe wall thickness	Measure pipe wall thickness	Measure pipe wall thickness	Measure pipe wall thickness
Electronic calipers	Measure pipe outside diameter	Measure pipe outside diameter	Measure pipe outside diameter	Measure pipe outside diameter
Sandpaper/cleaning cloth/ coupler gel	Prepare pipe wall for transducers	Prepare pipe wall for transducers	Prepare pipe wall for transducers	Prepare pipe wall for transducers
Ultrasonic Meter	Calibrate to pipe specifications	Calibrate to pipe specifications	Calibrate to pipe specifications	Calibrate to pipe specifications
Magnetic clamp-on or electrical tie-on HM transducers HS transducers	Monitor and record main supply flow rate	Monitor and record main supply and CSI flow rates	Monitor and record RO supply to elution flow rate	Monitor and record tails thickener overflow to process water flow rate
Aqua conductivity meter/ beaker	Collect sample and record TDS	Collect sample and record TDS	Collect sample and record TDS	Collect sample and record TDS
pH meter/beaker	Collect sample and record pH	Collect sample and record pH	Collect sample and record pH	Collect sample and record pH
Laptop computer Hoboware software program Pendant data logger			Attach data logger to (meter) for RO water supply-underground mine services	

TDS) or brackish (1 500 to 15 000 mg/L TDS) water of which fresh water makes up 1.5% of the total water usage volume. The Granites Gold Plant CSI blends and processes soft oxide material and harder underground ore, a Ball Mill that grinds the crushed ore with a water feed rate of approximately 350 wet tonnes per hour. The feed-water is sourced from either (raw) brackish borewater or tailings decant return water, otherwise referred to as process-water. Course ground material is recycled back into the mill to allow for regrinding and acceptable passing grades for reporting to the hydro-cyclones that separate various grades of material. This results in concentrated product spilling to an underflow stream from one of the cyclones leading to the gravity circuit. The overflow slurry enters the CIL circuit consisting of 4 leach tanks and 7 absorption tanks. The gravity circuit is made up of spirals, tables and an Acacia Reactor to produce concentrated (pregnant) eluate for electrowinning. From the CIL circuit, acid washing and elution further concentrate gold and silver in solution. This is recovered in stainless steel cathodes attached to anodes and the process of electrowinning. Barren slurry from the CIL process reports to the tails thickener and barren eluate is re-used and pumped to milling (Newmont 2009).

The water audit domain is contained within the prescribed unit operations (Figure 1). The water audit boundary also includes the potable water outflow from the potable water tank facility. Potable water supplied from storage is required for elution and the final stages of gold recovery. A simplified diagram was compiled to highlight the water audit domain (Figure 1).

As specified, the water audit domain was bounded by the supply side of water storage vessels and input of moisture contained in crushed gold ore. The discharge side of the domain included raw water pumped to the CSI for dust suppression and spent tailings pumped from CIL to the inlet side of the tails thickener. Within the audit boundary, water has several functions including dust suppression, rheology (transport of slurry), re-used water (barren eluate) cycled back into milling and process water used for plant and equipment wash-downs which is collected at sump points and pumped back into the system. During the audit very little evaporation occurred within the domain and minimal water was lost to ground. Therefore water movement and monitoring was kept to a controlled process of direct measurement other than ore moisture inputs and water calculated within the solids flux of discharged slurry (Newmont 2009).

Methodology

The water audit

The water audit team consisted of the water auditor (author), a graduate metallurgist and a process operator. The audit was initiated by a synchronized recording of meter readings at a set time on day one of the exercise. The readings were transferred onto an excel spreadsheet used to document all parameters within the water audit domain. The configuration of flow meters, pipe-work, valves and pumps varied considerably from one unit operation to another (see Table I). This included meter types, flow measurement, flow rates, pipe material, pipe specifications, valves and pumping regimes. For example; process water is measured in m^3/hr and raw water is monitored in L/s. Other variations throughout the water circuit included potable water pumped via a Grundfos centrifugal pump servicing either small bore polyethylene or carbon steel pipes. Water meters ranged from radio-active densimeters (tails-slurry) and rotary turbine loggers (small bore) to electro-magnetic-flow (magflow) meters for larger water transfer pipes. Magflow meters are displayed electronically and totalised at base-stations around site. During the water auditing period an ultrasonic meter (see Figure 2) was employed to assess the accuracy of on-site water metering within the audit domain. The water audit meter calibration exercise commenced by using an ultrasonic thickness gauge and electronic calipers to measure water pipe wall thicknesses and outside diameters respectively. Where pipe outside diameter (OD) exceeded 120 mm a tape measure was used to measure OD and information was gathered from pipe suppliers and site project records to confirm pipe specifications where possible.

A water pipe's sound fluid velocity was measured through a transducer array that was clamped on after pipe dimensions were fed into the hand held meter to set the calibrations for accurately recording the water flow- rate. Once the data was displayed on the ultrasonic meter screen a comparison was recorded from the site water meter being tested. In some instances mechanical barrel type meters displayed a totaliser function rather than a water flow rate display. To compensate for this, a time interval stopwatch over the number of litres counted was used to calculate and compare L/s or kL/hr flow rates. Table I describes the materials and methods used in the water-audit.

The transducers came in two sets; one labeled HS was for small-bore pipes up to 120mm outside diameter. The HM unit clamped on (magnetically) to pipes ranging from 120mm to 500mm OD (Figure. 2). Electrical tie straps were used to secure transducers on polyethylene pipes. Once pipe

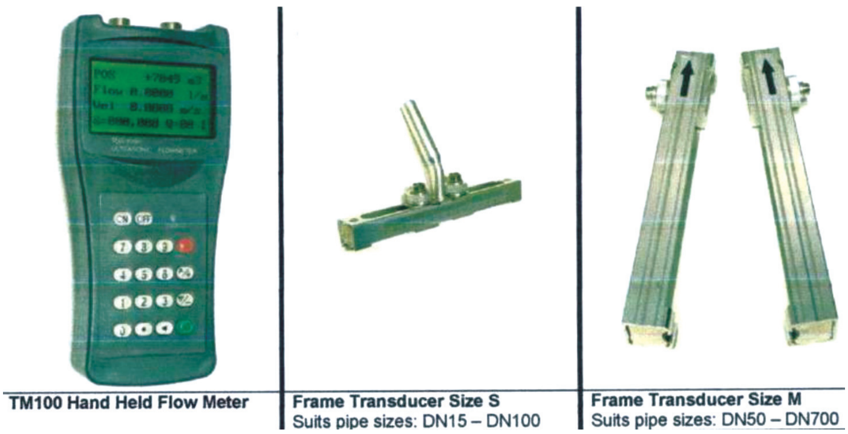

Figure 2. Ultrasonic meter and transducers

Table II
TM-100 Ultrasonic clamp-on water meter - audit preparation

Water type Audit	Unit operation	Pipe material	Pipe outside diameter- Electronic calipers	Pipe wall thickness- Ultrasonic gauge	Transducer spacing- (large HM) (small HS)	Meter type
Process	Milling/CIL	Carbon steel	250 mm	9 mm	HM-237 mm	ABB magflow
Raw	CSI	Polyethylene	90 mm	8 mm	HS-71 mm	Elster bulk flow
Potable	Elution	Carbon steel	90 mm	5.4 mm	HS-87 mm	DaviesShephard
Raw	Hydrocyclones	Carbon steel	200 mm	9 mm	HM-188 mm	ABB magflow
Non-audit	--------	-------	-------	-------	-------	----------
Potable	RO to decline DBS M26	PVC	20 mm	1 mm	HS-1 mm	Elster volumetric
Bore-water	Jumbuck Bore	Polyethylene	110 mm	11 mm	HS-92 mm	ABB telemetric
Seepage recovery	Bunkers TSF Bore M3	Carbon steel	60 mm	3.7 mm	HS-39 mm	Elster bulk flow
Raw	Raw bleed to process water	Polyethylene	100 mm	5.8 mm	HS-79.2 mm	Not metered
Raw	To RO	Polyethylene	90 mm	4 mm	HS-69 mm	Elster bulk flow
Potable	RO product	Carbon steel	60 mm	3.3 mm	HS-50 mm	DaviesShephard
Decant	Bunkers to PW	Polyethylene	225 mm	4 mm	HM-175 mm	ABB magflow

specifications had been entered into the ultrasonic meter the transducer spacing figure was calculated and displayed on the menu list. Other factors to be entered were pipe material; carbon steel, PVC or polyethylene, fluid type, pipe-liner (yes/no) and flow rate (kL/hr, L/m or L/s). The signal detection (sound fluid velocity) was either weak or strong depending on the degree of transducer contact. This was improved by pipe wall preparation including the use of sand paper to clear debris, a clean wiping cloth to remove residues and a thick application of coupler gel.

The measurement of water quality was recorded by a conductivity and pH test kit and carried out on potable, raw and process water. Process water included the make-up of tailings storage facilities (TSF) decant return-water and tails thickener water overflow. Raw water make-up consisted of various bore water locations pumped in to the main raw water holding tank. Reverse osmosis (RO) filtration draws water off the raw water tank and processes potable water at an efficiency of approximately 50%. The waste brine water off RO filtration reports to the process water tank and RO product water is stored in the potable water tank. The audit concluded by recording all water meter readings on a set time after five days of operations. The exercise was finalized by calculating the differences of meter readings of inflows of water tabulated against outflows of water.

Results

The Tanami/Granites water audit revealed several anomalies that affected the outcome of the water audit and these issues are discussed along with the data that was recorded during the auditing exercise. Results outlined are the water audit findings including a comparative graph of flow rate calibration using a hand-held ultrasonic meter, a water audit results table, a non-audit table of water flow-rates and water quality and record of potable water used at the Dead Bullock Soak underground services in the Callie Pit. A water classification table is represented as a summary of all of the mine site case studies and a comparison is tabled as to the range of water quality present at the Tanami/Granites operation. The gold mining operation has been producing gold for twenty years and is now one of Australia's biggest gold producers (Newmont 2009). Due to changes in company ownership and restructuring of water services over the years there is a lack of archival data relating to pipe specifications and historic record of water sources, uses and discharges. During the water audit exercise an ultrasonic meter was deployed as a means to calibrate pipe specifications, non-metered flows and key metering points around site. The ultrasonic meter or hand held computer receives all water flow characteristics via clamp-on transducers once pipe dimensions and corresponding transducer spacing have been recorded and applied. Apart from the lack of site data, several obstacles relating to calibrating flow-rates in carbon steel and old polyethylene pipe-work were experienced. The aim of the calibration exercise was to highlight areas deficient in water flow-rate accuracy as a means to report areas needing attention. These locations were revealed as a result of repetitive measuring and attempts to calibrate particularly process water and bore-water delivery/discharge pipe-work and meters.

Accuracy of measurements

The site recognizes that over time, carbon steel pipe-work accumulates salt build-up on the inside of the pipe walls. The accumulated calcite forms a substrate inside the pipe that counters the effectiveness of ultrasonic wavelengths reporting water flows to set parameters for display and measurement of water movement. Furthermore, old polyethylene pipe- work on site has been degraded by years of exposure to sunlight and mechanically impacted by continual moving and restructuring of the water delivery and discharge circuits. Therefore, the ultrasonic measurement of pipe wall thickness and lack of site data on old polyethylene pipe work proved to be a barrier to measurement of water flow compared to calibrating in-situ water meters attached to dated polyethylene pipe work. In these identified problem areas of the water audit domain the greatest differences of flow measurements were recorded. That is, the greatest margin of error in process water transfers and site meter read-outs compared to the ultrasonic metering data. Figure 3 highlights these differences whereas potable and raw water flow rate testing was accurate to within 2%.

The calibration exercise is a necessary support function of a mine water audit. A water audit can be conducted over short term durations however, a five day period was recognised as a suitable timeframe to ensure the water audit calibration exercise could be completed along with water quality analysis during the water audit process. The build-up of calcite material from saline water in pipe work and meters affected the accuracy of ultrasonic measurement. Therefore adjustments were made to pipe wall thickness inputs to the ultrasonic meter to allow for calcite build-up. The water auditor overcame this obstacle and continued obtaining sets of data that were maintained while auditing site-metered flow rates of feed and discharge water. Further testing and analysis should be carried out on plant-meter accuracy prior to any structural changes to the water circuit to ensure water flow measurement precision.

The water audit ceased prematurely due to an unscheduled mill shut down for maintenance and repairs. The water audit was due to be closed off four hours later than the 'shut' although this did not affect the ability of the auditor to record flow rates and finalise the water audit with all resources on hand. The auditor concluded the water audit by utilising mine staff in order to record flow rates at key points in a synchronised procedure. Plant meter totaliser displays were recorded, ore moisture through-put and barren slurry (solids) discharge water analysis was retrieved from the site laboratory. A theoretical water audit closure was achieved however; the results were not conclusive due to several barriers experienced during the exercise. From the outset is was assumed that within the water audit domain a closed water circuit consisting of

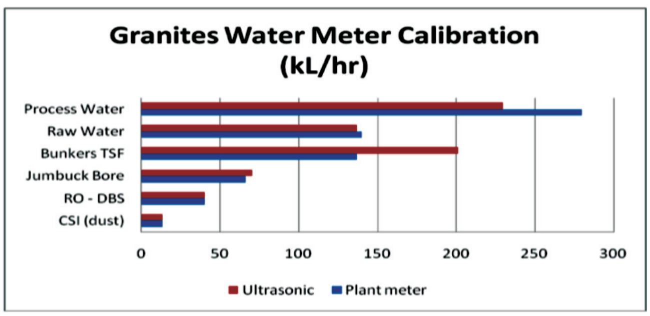

Figure 3. Plant meters vs. ultrasonic meter

Table III
Water audit domain results

Tanami/Granites Water Audit Results (10.00 hrs -27/11 to 06.30 hrs -02/12) 2008								
Inflow	Meter	Pipe	OD	WT	Plant Flowrate	Ultrasonic Meter	% Diff.	Usage kL
Process	Magflow	Steel	250 mm	9 mm	280 kL/hr	230 kL/hr	22%	34408
Raw	Magflow	Steel	200 mm	9 mm	39 l/s	38 l/s	2%	11975
Potable	Magflow	Steel	90 mm	5.4 mm	Totalized	48 l/m	-------	307
Ore H_2O	--------	------	--------	--------	2.5% of solids flux	--------	-------	1043
							Totalised water use (kL)	47733
Outflow								
Raw CSI	Turbine	Poly	90 mm	8 mm	3.5 l/s	3.57 l/s	2%	1815
CIL discharge	-------	Steel	300 mm	12 mm	47.9% of solids flux	--------	--------	45733
							Totalised water discharge (kL)	47548
							Net Gain (kL) = % Gain/Loss	185 +0.4%

Table IV
Water classification, analysis and flow rate measurement

Water Location	Water type	TDS mg/l	pH	Flow rate
Potable (RO) water tank	Fresh	243	7.11	-
Process water tank	Brackish	4826	7.18	-
Raw water pump	Brackish	3194	7.17	39 l/second
CSI w/down	Brackish raw	3256	7.21	220 l/minute
CSI w/shop	Potable	179	7.18	8 l/ minute
Admin. Int (fountain)	Filtered fresh	198	-	6 l/ minute
Admin. Ext	Filtered fresh	195	-	20 l/ minute
Mill w/down	Brackish process	4838	7.24	200 l/ minute
Mill safety shower	Fresh	198	7.22	20 l/ minute
Mill crib-room	Filtered fresh	179	7.1	12 l/ minute

milling, concentration, leaching, absorption and elution had little to zero water losses. Therefore, in areas that could not be audited and for example; the CIL barren slurry discharge to the tailings thickener were established from laboratory analysis of the solids fluxes.

A framework was established to lay the groundwork for future water audits including meter calibration, water quality analysis and the categorisation of water used for various unit operations in mining processes (Sturman 2004). Table IV contributes to the overall water audit function and towards building a framework that can be adapted to future mine site water audits in order to establish fit for purpose mine water usage. (see Table V).

Table III includes ultrasonic meter results that can be corroborated with the meter calibration results in Figure 3. The greatest margin of 22% is indicated with process water flows and even though raw water had the same metering and steel pipe work, a 2% error margin in most calibrations confirms the effectiveness of an ultrasonic metering application for site-meter calibration. The potable water feed to elution was measured by an electro-magnetic flow-meter (magflow) that displayed a totalised figure whereas process and raw water meters displayed kL/hr and L/s respectively. Therefore, the potable feed could not be compared using the ultrasonic meter. In Table III a gain of 0.4% indicates water closure where -/+ 10% is generally an acceptable error margin to achieve water audit closure (Sturman 2004). However, the result is an assumption based on the fact that during the audit procedure, no water was lost. This was based on communication with staff and checking through daily reporting logs to confirm all water remained within the water flow circuit over the water audit duration. During the water audit a number of non-audit water outlets were examined both for water quality and flow rate measurement. For water quality, pH and salinity (TDS) were tested using a hand held conductivity meter. The flow rates were calculated using a water measuring cup, existing plant meters or the ultrasonic meter.

Table IV is a snapshot of water values and classifications that when analysed can be incorporated into the overall water hierarchy of water use across the 5 Newmont case study mine sites displayed in Table V. These and other considerations relating to water efficiencies leading to water conservation will be explored further in the summary section of the Tanami/Granites water audit paper.

Finally, a separate component of the water audit exercise was implementing the use of a data logging device on the potable water supply meter at the Callie Decline, Dead Bullock Soak (DBS). It must be noted that out of all the metering locations, the reverse osmosis RO (potable) supply line for drinking water to the decline had the only meter suitable to fit a logging device to it. The decline is located 40 km from the Tanami Granites Goldmine operation. The extracted gold ore from DBS is transported by haul-pack trucks along a sealed road that links the two facilities.

The pendant data logger recorded flow volumes via a t-probe that tabulated 1 pulsed reading for every 5 litres of water flowing past the data-logger transponder. The data is

Table V
Hierarchical water classification

Water source	TDS	Mine function	Approximate usage	Classification
Potable	< 1,500 mg/l	Accom ops Elution	1%	Scheme
Bore potable	< 1,500 mg/l	Accom ops		
RO Elution	5%	Fresh Filtered		
Bore brackish	1,500 to 15,000 mg/l	Hydrocyclones	20%	Raw
Barren Eluate	<15,000 mg/l	Sag Ball mills	Up to 6 cycles of re use	Re-used Process
Meteoric	Variable	Tailings dam		
Water storage	Variable	Raw		
Tailings decant	15,000 to 35,000 mg/l	Sag Ball mills	Up to 60% of raw water inflow	Recycled Process
Bore saline	<35,000 mg/l	SAG Ball mills Dust control	20%	Process
Paleo channel	35,000 to 120,000 mg/l	Dust control	Variable	Non Process
Hyper saline				
Treated wastewater	<15,000 mg/l	Revegetation Tailings dam	< 1%	Recycled

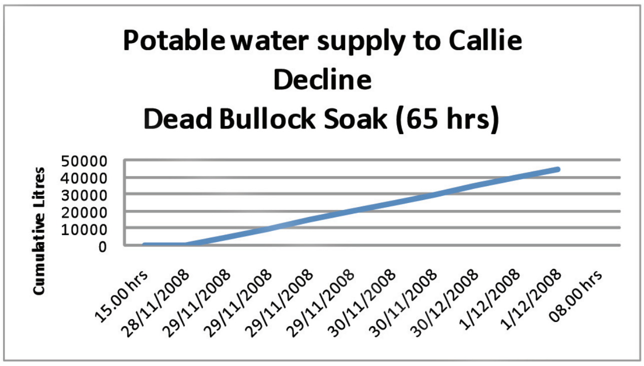

Figure 4. Data logging using Hoboware programme

recorded by the pendant device and at the end of the trial it was de-activated and removed from the in-line meter. The data was then loaded into a laptop via an attached base station. The software program stores and displays water flow volumes and trends. In this case, Figure 4 highlights the total volume of potable water that was pumped to the decline, and over the 65 hour logging period a flow rate of 11.5 L/m was calculated. The benefit of logging a water supply assists with the evaluation of water requirements during a fixed time of observation. Considering the fact that no more than 100 personnel were underground on any one shift, the findings highlighted a possible loss of water downstream due to an obvious oversupply of water for personal use.

Discussion

As mentioned the Tanami/Granites operation has been running for 20 years and many structural changes have occurred (Newmont 2009). This includes water delivery circuits that have been interrupted and re-routed or blocked off where no flow is present. In most mine sites, water circuits are constructed to ensure water either returns to its holding reservoir or is delivered on demand at appropriate outlets. This is especially critical to enabling fresh ambient water to be delivered for human consumption whether it is for drinking, showering or safety wash-down and flushing stations. During the water analysis and flow measurement exercise several anomalies were discovered. Even though the results indicate even distribution of TDS and pH according to the water type, turbid water was present at the CSI workshop and safety wash stations sprayed hot water heated by water standing in the delivery pipe. Therefore, active flowing water circuits are required for delivery of potable water to drinking and safety wash-down outlets.

In Table V the water classifications are a guide to applying varying water qualities to unit operations while conducting either a controlled (contained) or site-wide water audit. Raw water quality differs considerably between one Newmont mine site to another and in some cases not much separates the quality of raw water compared to process water. In the case of Tanami/Granites, the pressure on bore water abstraction can be alleviated, by increasing the flow of discharged treated wastewater from village accommodation into tailings storage. Further water conservation could include an increase in tails thickener overflow back into the milling circuit. Overall mine water quality is maintained through increased storm water collection and greater settling and clarifying of TSF water.

Table V is a generic classification of water types and 'fit for purpose' use in the utilisation of water for human consumption, dust control and hydrometallurgical processes across the 5 case study mine sites. Water quality of water sources and uses within the scope of the Tanami/Granites water audit were included into the overall water hierarchy framework detailed in Table V. That is, results based data from Table IV collated into the overall water hierarchy of generic minewater use.

Table VI represents a procedural framework of a developmental process towards water auditing within a mine site's environmental program. It contributes towards a water accounting process that is both transferable and transparent in its content and applicable to a gold mining operation. Evidence supporting a water audit closure is revealed in a results outcome based report and underpins a guarantee that minimal water losses are incurred through an accountable raft of data and findings. A diagrammatic overview is produced and summarised by a final phase of water audit reporting. This may include reporting via a feedback mechanism and liaison with the water audit team followed up by a summary and recommendations of water efficiencies and conservation. The final outcome is a presentation of findings and appropriate closure format directed to the client/auditee. This would include a water management strategy that underpins a reporting mechanism towards continuous improvement in water allocation compliance and water use analysis. This results section has provided an insight into the processes of water auditing and water quality analysis. It contributes to the delivery of a

Table VI
FRAMEWORK - Water audit processes and activities

Water audit steps	1	2	3	4
Preparation	Initial site visit and data collation exercise	Prepare site wide water schematic and *Contents list	Calibrate all testing equipment	Arrange drug alc. screening, flights and accom.
*Contents List	Identify audit participants	Site (domain) description	Identify water sources/sinks	Prepare and send water audit brief
Site arrival pre-audit setup	Locate accom. and commence site induction process	Meet with water audit participants and identify various roles	Prepare strategy for temporal spatial water audit process	Undergo site wide entry permit process
Commence water audit	Synchronize and record water audit meter readings with team	Prepare excel spreadsheet for data entry	Identify and monitor unit operations	Measure and record tank reservoir capacities
Meter calibration	Locate and fix pendant data loggers to turbine meters	Locate and prepare all ultrasonic meter testing sites	Input pipe specifications, set transducer spacings	Clamp on or tie on transducers and record flow-rates
Water quality	Log in all water quality testing sites	Test and record water types for turbity, pH, temp. and TDS	Measure and record flow rates for non water audit quality testing sites	Produce site water classification table
Achieve water audit closure and prepare audit process review	Synchronize and record all water audit meter readings with team	Summarize and calculate water flow volumes from excel spreadsheet	Identify water audit barriers and challenges for reportingtable mechanism	Produce water audit closure and process review
Water management strategy	Collate all qualitative and quantitative data	Outline water efficiency strategies	Summarize water audit process and steps for continuous improvement	Produce paper / ppt for mine site feedback mechanism

portable and transferable data set representing the methods and processes of water auditing in a remote mining location. It will be taken up by Newmont Mining Corporation and the Centre for Sustainable Resource Processing to further the research into water efficiencies in mining cycles leading to overall water conservation.

Water management strategy

Meteoric inflow and groundwater flows are monitored in terms of providing make-up water such as seepage recovery and decant return at Tanami/Granites for the duration of mine operations. Therefore, strategies are in place to manage Newmont's environmental program which includes water use for specific mine and metallurgical processes (Newmont 2009). They include the provision of a site-wide water balance to make available effective monitoring of water flows based on establishing best practice towards operational goals in water management. The inclusion of key performance indicators, to be put in place, define and measure progress towards mine water usage and management ultimately achieving environmentally sound water recycling and reuse. Ongoing monitoring programs help provide information towards this operational goal. The scope of Newmont's environmental program underlines the need to proactively manage impacted water through the agency of a site-wide water balance and a site-wide planning tool. Some examples of a strategic approach include the boosting of non-process water influxes via the use of treated wastewater from village accommodation and greater control over storm water catchment and prevention of evaporation from process water reservoirs. Continuous improvement via a water management strategy is applied to water auditing and accountability for ongoing operations and water quality leading to mine closure.

Conclusion

The water audit of the Tanami Granites goldmine was a controlled exercise to determine water use and water quality in one section of the overall mine lease area. The water audit was concluded by measuring the inflow of water against the outflow of water within a specified domain. The water auditing procedure was governed by a specified aim and set of objectives. Initially a water circuit schematic was designed to highlight the water audit domain within the overall goldmine site. The description of the methodology followed that described the materials and methods including a meter flow-rate calibration exercise using ultrasonic testing equipment. The water audit process was described and the results were tabled to provide a clear indication of the number of unit operations and the ensuing water balance results. The water audit also included the results of a data logging exercise that highlighted the loss of potable water as a result of unaccounted for water usage underground. Site water quality testing and results contributed to a generic mine water quality assessment table for all of Newmont's mining operations. Finally, a water audit procedural table was drafted to contribute towards a water auditing framework underpinned by a water management strategy. This was developed as a reporting mechanism of the site's overall environmental performance in water sources, usage and re-use.

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A mine site I visited last year (2008) was experiencing a very dry winter and groundwater reserves were being affected. This particular mine had a large workforce of around 500 employees and contractors and after completing a water audit of the mine village I noticed the efficiency of the waste water treatment plant (WTP) and that clean treated water was being disposed of in a nearby sink (wetland). I suggested the mine run a discharge line from the WTP to the tailings facility to boost the decant reserves increasing the water supply in the process water circuit. Currently up to 3 000 kL per month is being reclaimed from the WTP as a result of my recommendations and has had a very positive impact on lessening the water demand and abstraction on local aquifers.