Newmont's Boddington Gold Mine tailings pipelines. Hydraulic design issues and comparisons with operating data

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Abstract
The design of the tailings disposal system at Newmont's recently commissioned 100,000 tonnes of ore per day Boddington Gold Mine included some unique challenges. Laboratory tests revealed the tailings settled rapidly, forming a very compact bed. This required special considerations for restart after an emergency shutdown and provisions for dumping the slurry from the pipelines if necessary. The design required uninterrupted deposition of tailings into the 15 km^2 dam concurrent with ongoing activities inside the dam such as mining, HDPE lining, wall construction and pipe relocation. Methods for managing slack flow in the dam distribution pipelines were also required. Design issues are discussed and some initial operating data presented.

1. INTRODUCTION

Newmont's recently commissioned Boddington Gold Mine south of Perth, Western Australia, is one of the largest gold/copper mines in the world, with a design capacity of 100,000 tonnes of ore per day and expected gold production of up to one million ounces of gold and copper production of up to seven million pounds per annum.

The original Boddington Gold Mine treated over 100 million tonnes of oxide ores during a 14 year period from 1987 until the mine's temporary closure in 2001. The new mine and processing facility treats the basement material which underlies the original oxide deposit and produced its first copper concentrate in September 2009.

The basement ore is particularly hard and abrasive, which resulted in a unique flowsheet and design considerations being developed. This included a comminution circuit that utilises two-stage crushing followed by High Pressure Grinding Rolls (HPGRs) and ball mills. Unlike the ground product from SAG/ball milling, the Boddington HPGR/ball mill product includes a portion of sharp and angular particles that are not normally found in tailings slurries.

The four large ball mills grind the crushed ore to approximately 80 percent passing (P_{80}) 150 micron prior to a flotation circuit. The flotation circuit produces a copper/gold concentrate which is filtered and trucked to port for sale to overseas smelters. The flotation tailings are thickened to 60-65% concentration by weight (%w/w) before passing through two large leach/carbon-in-leach (CIL) trains. Gold in solution is recovered from this process to produce gold dore bullion on site.

Tailings from the leach/CIL trains is transported by two 4.75 km long HDPE-lined steel pipelines which rise 60 m to a booster station at the Residue Disposal Area (RDA). Two stages of Weir Warman 16/14 pumps arranged in a parallel duty/standby configuration are used to transport tailings to the booster station.

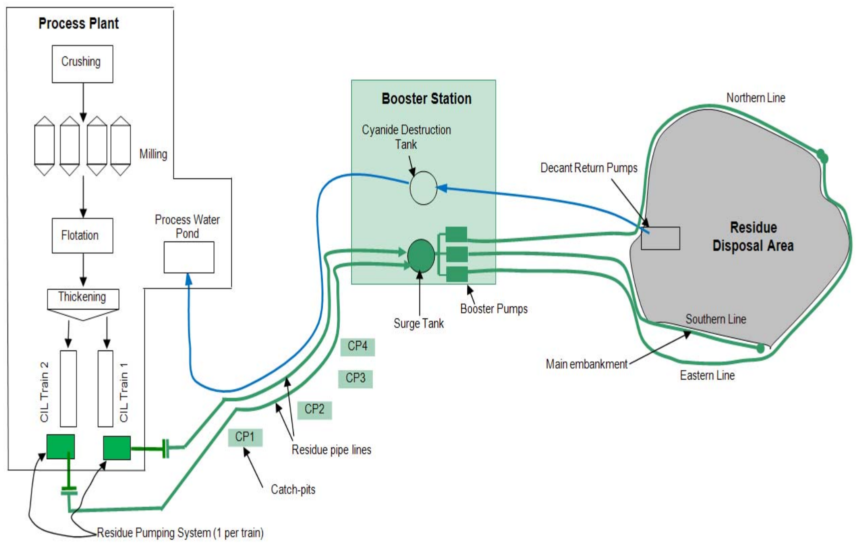
Caros acid is added to the tailings in a large surge tank at the booster station to destroy the weak acid dissociable (WAD) cyanide before being distributed around the 15 km^2 RDA. The RDA is almost continuously being mined or under some form of construction so considerable flexibility had to be provided in the distribution system. Three distribution lines were therefore provided (two duty / one standby) to allow for these activities. Single stage Weir Warman 16/14 pumps distribute the tailings and second stages will be added as the height of the dam rises. Ceramic chokes have been installed in the early years to prevent slack flow on steep down slopes.

The tailings disposal system is designed to transport up to 5258 tph of dry solids. At this maximum solids throughput, the total slurry flow rate from the plant to the booster station ranges from 4688 m^3/h at 65%w/w to 6160 m^3/h at 55%w/w. To assist in water management within the RDA, additional decant water can be added at the booster station to reduce the slurry density to 50%w/w, increasing the maximum flow rate to the RDA to 7115 m^3/h. Figure 1 shows a flow schematic of the tailings system.

The tailings samples used for design were relatively coarse, with a P_{80} of 150 micron which made rheological testing difficult. Also the particles were of sharp angular shape and the slurry settled to a hard packed bed rapidly. As a result, special consideration was given in the design for restarting after an unplanned shutdown and to provide containment for dumping the slurry if necessary. The twin pipelines to the booster station are subject to significant transient pressures if an emergency shutdown occurs, and a surge analysis also formed part of the design.

Design pipeline hydraulics are compared with some measured data. Since commissioning of the plant in September 2009, the particle size of the tailings during the ramp up period has been finer than design, with a typical P_{80} of 110 micron. The rheology of the finer tailings is compared with the design rheology and the hydraulic consequences discussed.

Figure 1 Schematic of Tailings System



2. LABORATORY TESTING TO DETERMINE DESIGN PARAMETERS

2.1 Sample Preparation

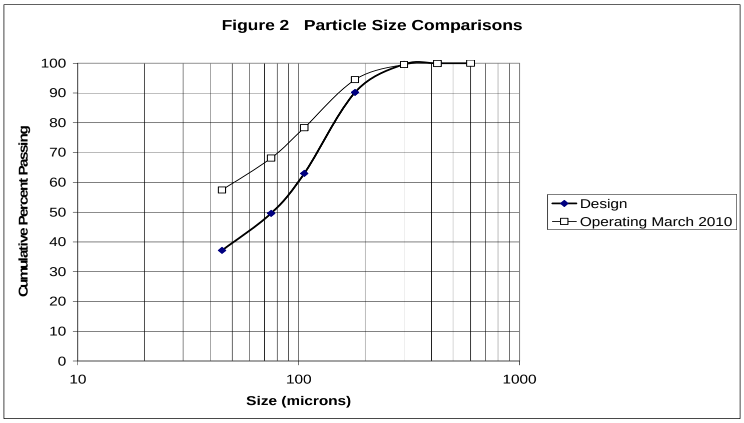
A total of twenty 0.5 kg separate samples in dry form were received at Slurry Systems' laboratory for testing. The dry samples were combined and mixed thoroughly by hand. Local tap water was then added to form a 73%w/w concentration base sample. The gold recovery process occurs at high pH and lime was added to the sample to raise the pH to 10.8. During agitation at 73%w/w concentration the base slurry formed a thick homogeneous slurry from which representative sub-samples could be removed as required for testing. When agitation of the base sample ceased, the solids settled within minutes to form a dense bed which required chipping with a spoon to remix.

Sub-samples of dry solids were sent to the University of Newcastle for scanning electron microscope examination. These revealed the particles were very angular with sharp edges, sometimes with a length to breadth ratio of 2 or 3. The angular shape of the particles explained why the slurry settled to such a compact bed.

2.2 Solids SG and Particle Size

The solids SG of two representative dry sub-samples were determined using an Air Comparison Pycnometer. The determined solids SG was 2.79. Subsequent SG tests on a range of samples by Newmont indicated an average solids SG of 2.83 which was used for the hydraulic design.

Particle size was determined by wet screening. Figure 2 compares the design particle size distribution (P_{80} = 150 micron) with the size distribution from samples taken during operation between 1st and 8th of March 2010 (P_{80} = 112 micron). The particle size distribution has been consistently lower than design during ramp up of the operation.



2.3 Tailings Slurry Rheology

Rheology tests were conducted using a Contraves Rheomat 115 narrow gap, rotational viscometer with a bob diameter of 45.62 mm and a cup diameter of 48.20 mm giving a diameter ratio of 0.9465. Samples were screened to remove any trace plus 850 micron particles which might jam in the 1.29 mm gap between the bob and cup. The viscometer data was analysed in terms of the Bingham plastic model. A straight line was fitted to the high shear rate data and extrapolated to the shear stress axis to give the Bingham yield stress. The slope of the line represents the plastic viscosity. In determining the Bingham parameters, the shear rate applicable to a Newtonian fluid as provided by the instrument manufacturer was used, with no attempt to determine the true shear rate. This simplification is justified by the narrow gap and high diameter ratio. The Bingham parameters determined by this approach have been found to give good pressure gradient and transition velocity predictions compared with test loop and pipeline data for many different types of slurry.

It was noted in Section 2.1 how the slurry settled to a very compact bed. This made rheology testing very difficult and the testing needed to be done as quickly as possible to minimise settling in the viscometer. Because of these difficulties, rheology tests were conducted on two separate sub-samples. Figure 3 shows shear stress versus shear rate plots for the tests on the first sub-sample with the fitted Bingham plastic lines indicated.

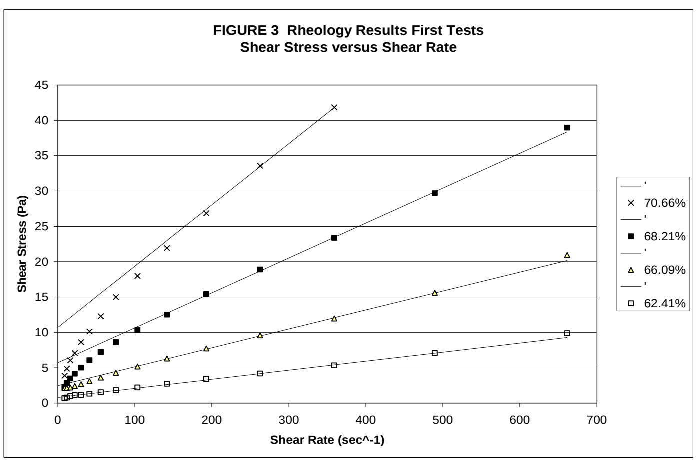


Figure 4 shows the yield stress versus concentration for the two sub samples. Because of the difficulties with rapid settling during testing, all except one of the tests were conducted at concentrations above 65%w/w. As a result, although the intended operating range was between 55%w/w and 65%w/w concentration, only one of the data points is in this range. An exponential trend line was fitted to the two sets of design data combined allowing extrapolation to the lower concentrations of interest. The yield stress design equation is given as Equation 1 with yield stress (τ_y) in Pascals and concentration (Cw) in weight percent.

$$\tau_y = 2.307x10^{-9}\ e^{0.3124\ Cw} \qquad \text{(Equation 1)}$$

Also shown in Figure 4 is yield stress data obtained for the operating sample obtained in March 2010. The operating yield stress is approximately double the design yield stress. The higher operating yield stress is consistent with the finer particle size of the March 2010 sample shown in Figure 2.

Figure 5 shows the plastic viscosity versus concentration. As is typically the case with most types of slurry, variations in particle size have less influence on the plastic viscosity than on the yield stress.

Figure 4 Yield Stress Comparisons

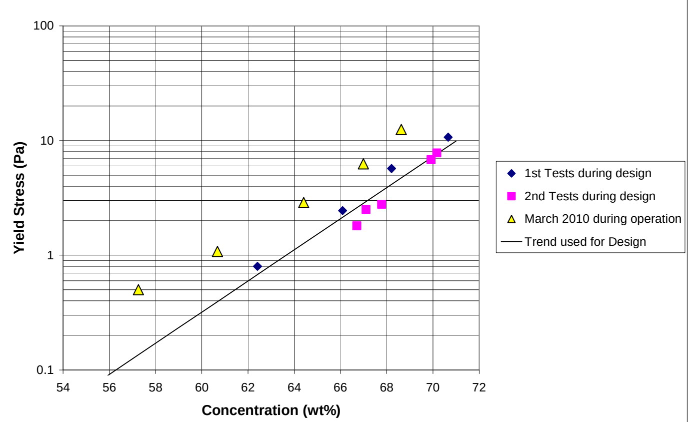
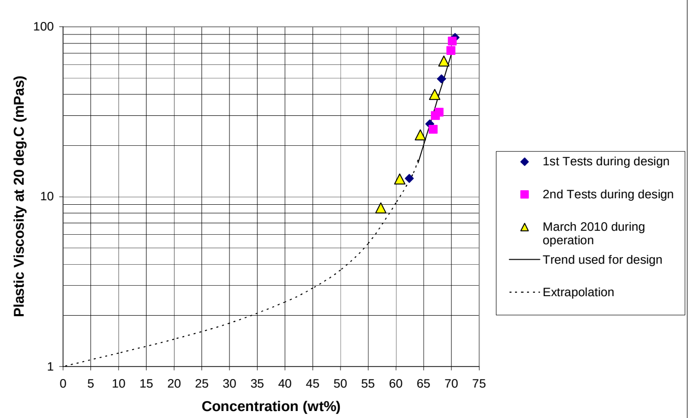


Figure 5 Plastic Viscosity versus Concentration



2.4 Settling Tests and Consequences for Restart

Laboratory settling tests revealed Boddington tailings settled fast, typically reaching equilibrium conditions within about 25 minutes. Tests were conducted in 109mm diameter clear plastic jars at initial concentrations of 45%w/w, 50%w/w, 55%w/w, 60%w/w and 65%w/w. Jars were used rather than measuring cylinders to facilitate sampling of the settled mixtures. The initial slurry height in each test was 140 mm. Each test was conducted over a period of 45 minutes.

At the end of the 45 minute settling period, the settled slurry was vertically probed using a 10 mm diameter wooden rod. The probing consists of pushing the rod vertically down in the centre of the jar. The settled slurry is not otherwise disturbed. This is a qualitative test used to gauge ease of restart after pipeline shutdown. In the case of a fine particle slurry which has settled homogeneously, the probe requires almost no force to reach the bottom of the container and there is no detectable difference in apparent consistency between top and bottom.

Probing of the settled Boddington slurries gave a significantly different result. In all cases the top third of the slurry was relatively easy to probe but thereafter became increasingly difficult. For 45%w/w and 50%w/w initial concentrations, probing the bottom third was similar to probing a wet beach sand deposit. For the higher concentrations it was increasingly difficult to force the probe through the bottom third of the settled slurry and in the case of the 65%w/w initial concentration it required almost maximum possible physical force.

During the probing it was obvious that there was a high proportion of very fine particles in the top third, especially at the lower initial concentrations. As the initial concentration increases more fines are locked in with the coarser material in the lower portion of the settled bed. With fines occupying the interstices between the coarser particles the settled mixture becomes very compacted. The degree of compaction is increased by the sharp edged, angular nature of the particles.

The conclusion from probing the settled slurries was that for all concentrations, restart of the pipeline would involve initial movement of the water layer with rapid remixing of the top one third or one half of the settled slurry. Resuspension of the lower half of the settled slurry in the pipeline would take longer due to the compacted nature of the solids component.

Slurry taken during operation in March 2010 displayed significantly different settling characteristics than the sample used for design. The March 2010 slurry formed a soft settled bed which could be readily resuspended. This is supported by the operational experience to date where pipeline settling and restart has not been an issue. There are a number of factors that may influence this discrepancy in slurry characteristics such as over grinding but these have not been explored fully in this paper.

3. DUAL PIPELINES TO THE BOOSTER STATION

3.1 Throughput

Each leach/CIL train has a dedicated pipeline which transports tailings to the booster station. Each of these pipelines is required to transport between 1577 tph and 2629 tph of dry solids. The design solids concentration ranges from 55%w/w to 65%w/w giving a minimum flow rate of 1407 m^3/h (1577 tph at 65%w/w solids) and a maximum flow rate of 3080 m^3/h (2629 tph at 55%w/w solids). The nominal dry throughput is 2,103 tph at 60.3%w/w solids giving a flow rate of 2,128 m^3/h.

3.2 Selection of Pipe

The tailings contain residual cyanide from the gold recovery process and are at a pH of approximately 10. The pipelines traverse environmentally sensitive native forest areas and meet the following key environmental design criteria:

- The pipelines are HDPE lined steel which provide both protection from corrosion and abrasion as well as double containment. Leak detection ports with pressure gauges are provided for regular monitoring. Wear plugs are also provided at regular intervals to monitor liner condition.
- The pipelines are located in a lined corridor that drains to four lined catch-pits. The catch-pits are fitted with sump pumps and are sized to contain pipe failure along with rainfall events. The catch-pits are fitted with level detection for alarming as well as close circuit television cameras (CCTV).

Based on the required range of flow rates and the need to operate above the deposition velocity at the minimum flow rate, a DN650 steel pipe (OD 660 mm) was selected. The original pipe selection was 7.9 mm but standard weight 9.5 mm pipe proved cheaper and was installed. The internal diameter of the steel pipe is 641 mm. Wear criteria dictated that a 24 mm thick HDPE liner was required giving a pipe ID of 593 mm.

Based on the pressure requirements, an API 5L Grade B steel pipe was selected with a conservative design factor of 0.60 giving a maximum pressure rating of 4160 kPa. This equates to a slurry head of 246 m for 65% concentration slurry and 273 m for 55% concentration slurry. The HDPE lined steel pipe is flanged at intervals of between 200 and 330m (depending on site topography) using ANSI Class 300 flanges (pressure rating 5102 kPa).

3.3 Predicted Liner Wear Rate

At the nominal 2128 m^3/h flow rate, the velocity in the 593 mm ID lined pipe is 2.14 m/s. Based on the particle size, a design wear rate of 0.46 mm per year was applied giving a liner wall thickness loss of 9.2 mm over 20 years. The 24 mm liner specified provides an additional margin of safety for wear.

Liner thickness testing after 8 months of operation has shown negligible wear of the liner. However, during this period the particle size has been finer than design as seen in Figure 2.

3.4 Predicted Deposit Velocity and Head Loss Gradients

The predicted deposit velocities are 1.07 m/s at 65%w/w, 1.39 m/s at 60.3 %w/w, and 1.66 m/s at 55%w/w. Design deposit velocities were increased by 10% due to sections of the pipe sloping upwards at up to 15%. The minimum operating flow rate of 1407 m^3/h (at 65%w/w) gives a minimum velocity of 1.42 m/s compared with the design deposit velocity of 1.18 m/s. Based on the particle size, solids SG and rheology, the predicted head loss gradients range from 3.07 m slurry/km to 10.5 m slurry/km. A pipe roughness of 0.01 mm was assumed.

3.5 Hydraulic Gradient Lines and Pumps

Figure 6 shows typical Hydraulic Gradient Lines (HGLs) for slurry at 55%w/w concentration (highest pump head). Two stages of Weir Warman 16/14 pumps with 1200 kW drives arranged in a parallel duty/standby configuration are used. The second stage pumps are driven by variable speed drives.

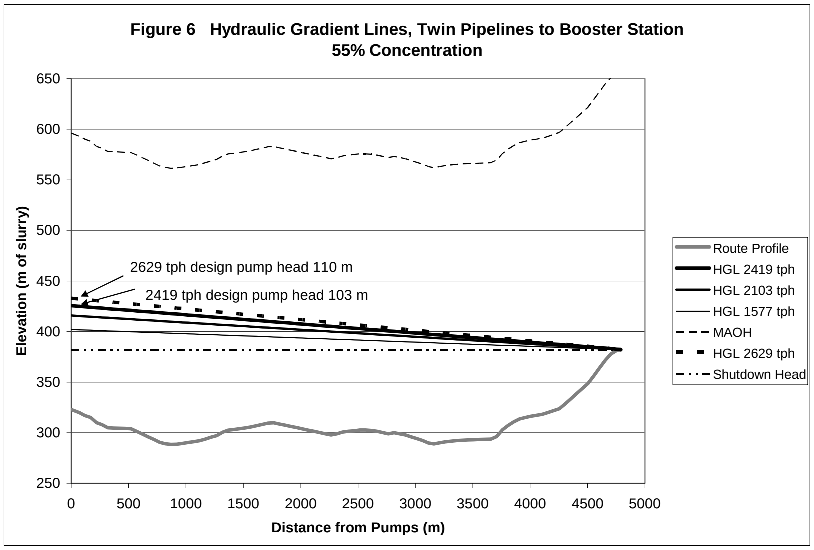
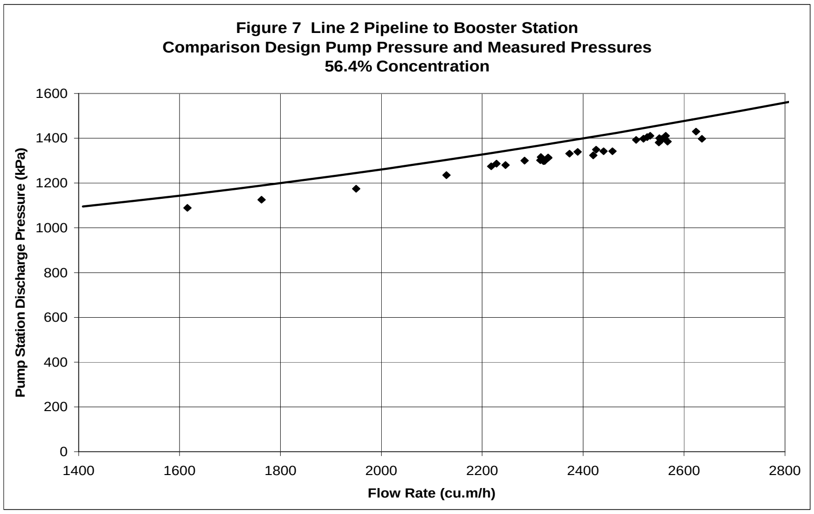


Figure 7 compares the predicted design pump discharge pressure with measured pressures. The measured pressures are approximately 5% below the predicted pressure, confirming the design calculations.

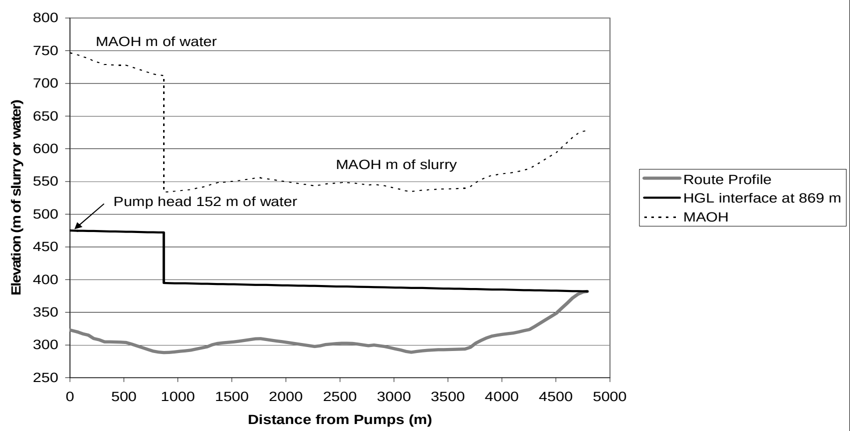


3.6 Pipeline Flushing

Due to constraints within the plant, the maximum flushing water flow rate available during the design phase was 1500 m^3/h which equates to a velocity of 1.51 m/s. Figure 8 shows the HGL when flushing 65%w/w slurry with the water/slurry interface at the low point 889 m from the pumps. The interface at this position gives the highest required pump head of 152 m of water. The two pumps in series provide a total of 110 m head with the remaining 42 m head supplied by the process water system pressure.

Due to the additional 42 m of head required, flushing water from the process water system is injected directly into the suction of the first stage pump. A control valve in the flushing water line automatically maintains a minimum flow of 1500 m^3/hr in the pipelines, even when operating under reduced feed conditions. Despite some early control logic issues, this system works well. The line is completely flushed for one hour before it is shutdown.

Figure 8 HGL with Flushing Interface at 889 m
1500 cu.m/h , Concentration 65%



3.7 Restart after Emergency Shutdown and Pipeline Draining

Normally the pipeline is flushed prior to shutdown as indicated in Figure 8. However an unscheduled shutdown such as a power failure will result in slurry settling in the pipeline. As described in Section 2.4, the tailings settle rapidly to form a compact settled bed and there were concerns that resuspension of the bed may prove difficult when flow is resumed.

The conclusions from the settling tests were that the top portion of the settled bed would resuspend relatively easily whilst the bottom portion (about half the pipe cross section) may be more difficult to resuspend. To date there have been no issues with regard to resuspending solids following an unscheduled shutdown. However, as the plant is still being ramped up and grind size is significantly less than the design of 150 micron, the system has not been fully tested.

In the event of a prolonged power outage or pipeline maintenance, the pipeline can be gravity drained to four catch pits provided at low points at 400 m, 800 m, 2250 m and 3200 m from the pumps. A hydraulic analysis was conducted of the likely slurry settled solids volumes resulting from opening drain valves at these four low points. For draining of both pipelines the analysis indicated required catch pit volumes ranging from 200 m^3 at Chn 400 m to 1300 m^3 at Chn 3200 m with settled solids comprising 100 m^3 and 800 m^3 respectively. The predicted volume of settled solids at the Chn 3200 m catch pit is a greater proportion of the slurry volume because of the higher drainage velocities achieved down the steep slope from the booster station that would resuspend additional solids. The catch pits include a concrete section with a ramp to allow settled solids to be recovered by front end loader. The concrete section overflows to either a HDPE or clay lined liquid containment section.

3.8 Surge Analysis

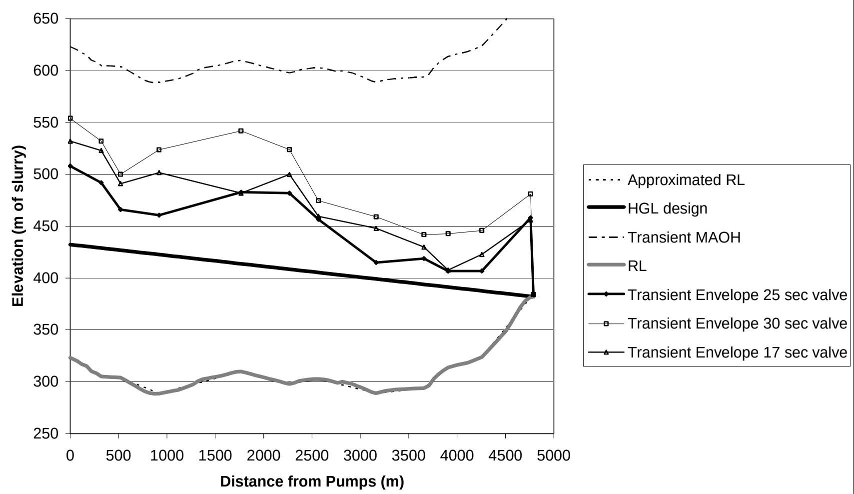
The pipelines to the booster station are large diameter with relatively high velocities and significant static head. Surge pressures following an emergency shutdown were expected to be significant. A surge analysis was conducted during the design phase using SURGE 5.1 software from the University of Kentucky.

The combined moment of inertia of the two pumps and motors in series is 1320 kgm^2. The acoustic velocities (a_0) used in the analysis are based on a_0 for water in the particular pipe size multiplied by 0.937 to account for the effect of the solids in the slurry. The 0.937 factor was derived following the method outlined in Section 1-3 of Wylie and Streeter (Ref. 1) for the solids volume concentration of 0.30 and assuming a bulk modulus of elasticity of the solids of 20×10^9 Pa. The resulting a_0 was also decreased by 10% to allow for the dampening effect of the HDPE liner. The adopted a_0 for the DN650 steel pipe with 24 mm HDPE liner was 913 m/s.

The slurry pipeline code allows for the maximum allowable operating head (MAOH) of steel pipe to be 10% higher than the steady state value under transient conditions giving a transient MAOH of 300 m slurry at 55%w/w concentration. For the surge analysis the route profile has been approximated by 12 straight line portions as indicated by the dashed route profile in Figure 9. (Note: RL = Relative Level).

Simulations were run for the maximum 3080 m^3/h flow rate at 55%w/w concentration. The initial simulation using a check valve at the pump station discharge indicated the check valve closed 22 seconds after an emergency shutdown. Following this initial simulation run, the check valve was replaced with a simulated actuated gate valve. Simulations were run with valve closure times of 17, 25 and 30 seconds after an emergency shutdown. Figure 9 shows the predicted maximum transient head envelope following an emergency shutdown for each of these closure times. The transient head at a particular location fluctuates with the maximum value during the 75 second simulation period within the envelope shown.

Figure 9 HDPE Lined Steel Pipeline to Booster Station
Maximum Transient Head Envelopes Following Power Failure
Flow Rate 3080 cu.m/h at 55% Concentration



A valve close time of 25 seconds after an emergency shutdown gave the lowest transient heads with the maximum transient head at pump discharge of 185 m (2820 kPa) compared with the steady state head of 110 m. For all three valve close times the transient head envelope is below the transient 300 m MAOH for the pipe shown and also below the ANSI Class 300 flange head rating of 335 m at 55%w/w concentration. In order to provide further protection of the pipeline, hydraulically actuated knife gate valves (complete with accumulator in case of power failures) were installed. Burst discs were also installed downstream of the discharge valve.

A pressure transmitter will be installed on the downstream side of the pump discharge valve. At present a pressure transmitter is located on the upstream side of the discharge valve and so does not measure transient pressures on the downstream side of the valve when it is closed. Hence verification of the transient pressure analysis is not available at present.

During commissioning when pumping water, a power failure occurred without the discharge valve closing allowing the installed pressure transmitter to measure the transient pressure. Preliminary evidence from these transient pressure measurements indicate the acoustic velocity is significantly less than the assumed design value of 974 m/s for water in the HDPE lined steel pipe. The measured peak to peak transient pressure time was 90 seconds translating to an acoustic velocity of 220 m/s. This lower acoustic velocity is what would be expected from the HDPE liner alone. The reasons for this are currently unknown. However, installation of the additional pressure transmitter should allow more comprehensive analysis.

4. DISTRIBUTION PIPELINES

4.1 General

The dual pipelines from the plant discharge into a common agitated surge tank at the booster station. Tailings from this tank is distributed around the RDA via the Southern, Northern and Eastern distribution pipelines. Each pipeline increases in length and is relocated several times throughput its lifetime. During normal operation, two distribution pipelines are operating with the third available for use when relocation (during dam construction activities) or maintenance is required. The three pipelines distribute tailings around the perimeter of the RDA through spigots located at 60 m intervals. At any one time discharge from each pipeline is from six spigots. Because the RDA is a natural valley rather than a flat paddock area, careful distribution of tailings is required to prevent some deposition areas becoming isolated, creating localised ponds and preventing the supernatant water flowing to the decant pumps. Decant water can be added to the residue surge tank to dilute the discharge tailings when required to assist with the site water balance.

At the start of mine operation the RDA valley floor was approximately 80 m below the booster station. Eventually, the top of the tailings will be slightly below the level of the booster station. A plan of the distribution pipelines in the RDA is shown in Figure 10.

4.2 Southern Distribution Pipeline – Illustration of Slack Flow Issues

A single Weir Warman 16/14 pump driven by a 1200 kW variable speed motor feeds the Southern distribution pipeline. At the start of operations, the Southern distribution pipeline was 2800 m long with the first 1250 m comprising 800 OD HDPE PN18.5 pipe with 710 OD PN10 pipe thereafter. A choke station is located at Chn 300. The chokes are required in the early years to prevent slack flow in the steep downwards section of sloping pipe immediately after the booster station.

The choke station, as installed, consists of three 230 mm ID ceramic chokes and one 261 mm ID ceramic choke in series, each installed in a 6 m long DN650 steel spool lined with 35 mm rubber. A single 307 mm ID choke is also installed at the exit of the pump station. The purpose of this choke is to ensure that there is always a positive discharge head generated for the variable speed pump to control the flow rate.

Figure 10 Typical Distribution Pipeline Layout

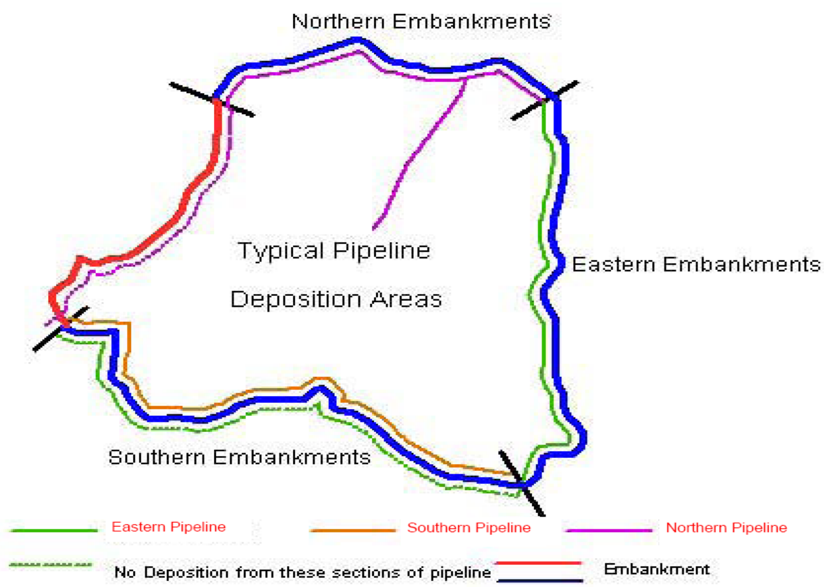


Figure 11 shows the Year 1 Southern distribution pipeline HGLs for various throughputs based on the original design when discharging through the near spigots. Figure 11 serves to illustrate the complexities associated with avoidance of slack flow in the early years. Without the additional head dissipated by the chokes, the HGLs would intersect the ground profile at around Chn 200 on the steep down slope from the booster station resulting in slack (open channel) flow over most of the steep slope section. The slope is approximately 10% and the slack flow velocity is predicted to be around 8 m/s, causing rapid wear of the bottom of the PN18.5 HDPE pipe.

The chokes prevent slack flow but cause their own limitations on operation. With the choke setup shown in Figure 11, the maximum available pump head of 65 m occurs at a flow rate of 3350 m^3/h which equates to the maximum 2629 tph at 52%w/w concentration. The HGL shown for the normal 2103 tph at 60.3%w/w concentration indicates a pump head of 5 m and slack flow is only just prevented downstream of the booster station. For the 3 Mills 1577 tph operation at 60.3%w/w concentration HGL shown, slack flow is not prevented and for this solids throughput the concentration would need to be reduced to 50%w/w to increase the flow rate to 2135 m^3/h to prevent slack flow.

In order to counter this effect, a pressure transmitter was installed in the discharge piping from the booster station. If slack flow occurs the pressure transmitter will indicate a vacuum. The concentration can then be reduced by the addition of water to increase the flow rate sufficiently until the pressure transmitter reads a positive pressure.

Figure 11 Southern Distribution Pipeline HGL and MAOH Year 1
Discharge at Nearest Spigots
Maximum Flow Limited to 3350 cu.m/h

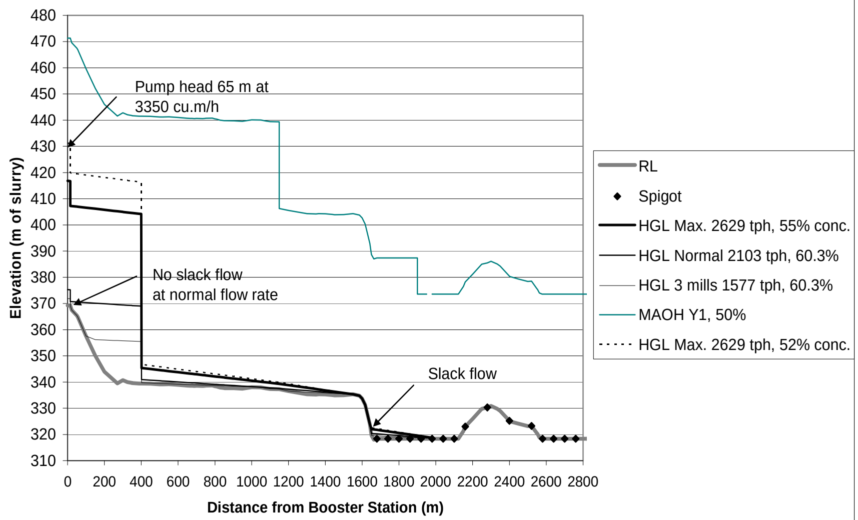


Figure 11 shows that slack flow exists downstream of Chn 1600 where the pipeline drops down to cross the top of the main dam embankment. However, this slack flow region will disappear within two years once the height of the embankment is increased by 15 m. The high wear rates in the pipeline can be tolerated for this short period.

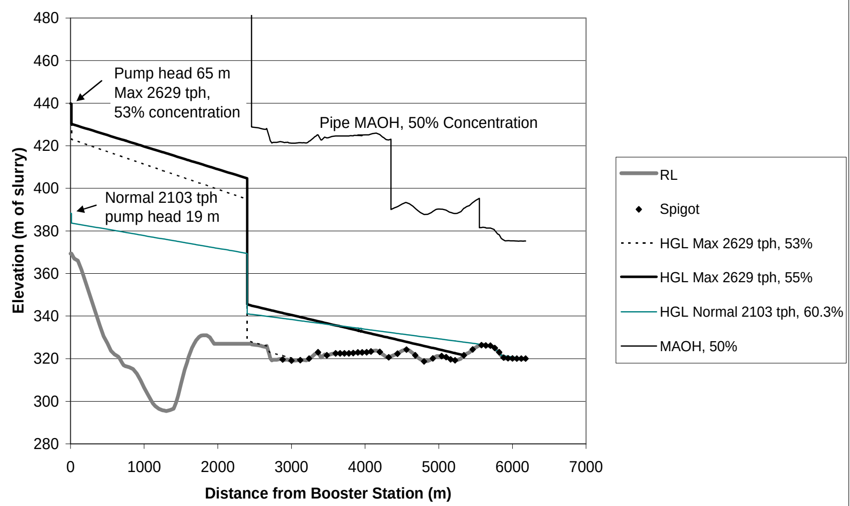
Figure 11 applies to Year 1 operation. In subsequent years, the discharge elevations increase and chokes are progressively removed. By Year 18 the pipeline length has been extended to 5200 m and the elevation at the far discharge is slightly higher than the booster station and therefore chokes are not required.

4.3 Eastern Distribution Pipeline

The Southern distribution pipeline discussed above traverses the main embankment and its operation will be periodically interrupted as the embankment is progressively raised. The Eastern distribution pipeline overcomes this problem by crossing the valley below the main Southern embankment allowing it to continue operating when the embankment is being raised. Because of the high pipeline pressures in the valley section, and the environmentally sensitive nature of the area, the Eastern distribution pipeline includes a section of HDPE lined steel pipe. At the start of operations the pipeline consisted of HDPE lined steel pipe to Chn 2450, followed by PN18.5 pipe to Chn 4650, PN12.5 pipe to Chn 5750 and PN10 to the end of the pipeline at Chn 6350. A choke station consisting of four chokes was installed at Chn 2450 at the end of the HDPE lined steel pipe section. The Eastern distribution pipeline has a single Weir Warman 16/14 pump driven by a 1200 kW variable speed motor with provision for a second stage pump to be installed at a later date.

The chokes prevent slack flow downstream of the booster station in a similar manner as the Southern distribution pipeline described in Section 4.2. Figure 12 shows HGLs for three different flow rates discharging to three different locations. As was the case with the Southern distribution pipeline, chokes are progressively removed from the pipeline as the discharge elevation increases. By Year 18 the Eastern distribution pipeline is 9000 m long and discharges at a similar elevation as the booster station.

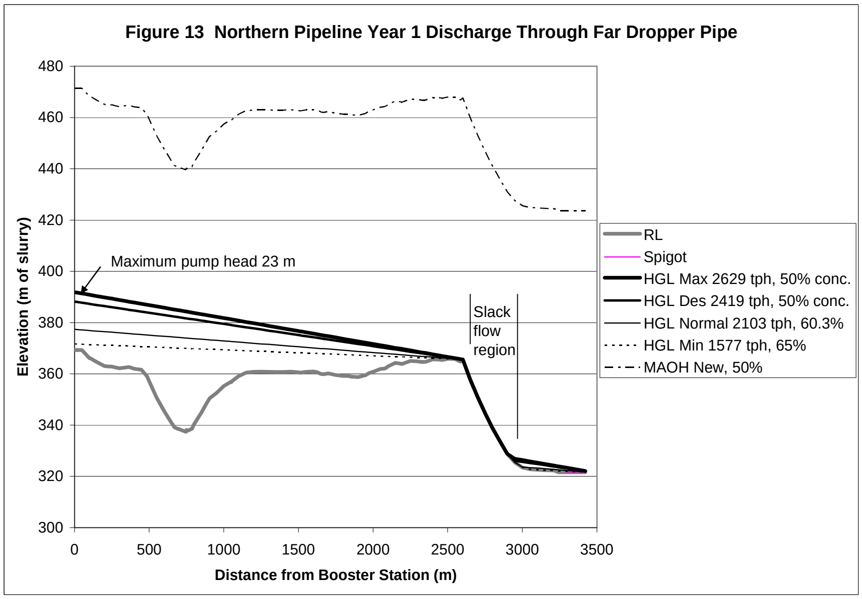
Figure 12 Eastern Distribution Pipeline HGLs and MAOH Year 1
Various Discharge Points



4.4 Northern Distribution Pipeline

At the start of operations the Northern distribution pipeline consisted of 3500 m of PN18.5 pipe. Additional lengths of PN12.5 and PN10 pipe will be progressively added over the mine life. Unlike the other two distribution pipelines, the Northern distribution pipeline does not fall steeply from the booster station but follows a route along a ridge line before dropping into the deposition area as indicated in Figure 13. The tailings are distributed from six spigots on a tee section at the end of the pipeline.

No chokes are installed in the Northern distribution pipeline. In Year 1, slack flow will occur in the dropper pipe as indicated in Figure 13. However, by Year 2 the pipeline length will be extended to Chn 5800 and much of the slack flow region in the dropper pipe will become pressurised. As the deposit elevation increases in later years the dropper pipe will eventually be fully pressurised during operation.



5. CONCLUSIONS

The tailings pumping system at Newmont's Boddington Gold Mine has been described and major design issues discussed. The mine has been in operation since September 2009 and the system has met design expectations.

6. REFERENCES

Wylie, E.B and Streeter, V.L., "Fluid Transients", Feb Press, Ann Arbor, Michigan, 1993