ALEXCO

To: Dan Cornett, Access Mining Consultants

From: Brad Thrall, Alexco Resource Corp.

Date: January 11, 2006

cc: Jonathan Clegg, Western Silver Corp.

Re: Technical Design Memorandum - Carmacks Copper Project
Solution Storage/Events Pond Sizing

Background

Additional information has been requested by the Responsible Authorities as part of the environmental assessment for the Carmacks Copper Project. In particular, Western Silver Corporation has proposed a number of solution management provisions in its June 2005 Environmental Assessment Report for the Carmacks Copper Project. These provisions include complete pad draindown in the first year, 48 hours of draindown capacity at the design flowrate, and other climate events and pond volume design considerations. This report provides additional technical support information and more importantly includes relevant operating data from the Alexco Resource Corp. Brewery Creek Mine. All of the information referenced from the Brewery Creek Mine is available in public Water Board reports filed under Alexco's Water Use License QZ96-007.

Reference to actual Brewery Creek data is relevant to the Carmacks Copper project in that the Brewery Creek operation is a similar northern heap leach operation and is the best industry example for assessing heap draindown characteristics expected for the Carmacks Copper Project. Given the similarities between the Carmacks Copper Project and the Brewery Creek Mine in terms of climate, design pumping capacities and heap size, the use of this actual Brewery Creek data is pertinent and applicable in confirming design criteria and assumptions for the Carmacks Project.

Solution Storage/Events Pond Sizing

Western Silver Corporation has proposed an events pond with a capacity of approximately 160,000 m^3 to store the following combinations of events:

- The operating solution volume, plus;
- Excess runoff inflows from the critical duration of 100-yr return period event occurring at the most critical point in time, plus;
- An allowance for heap draindown as follows:
    - During the first year of operation, 100% of the total potential heap draindown volume, or

- During subsequent years of operation, 48 hours of draindown at the full rate of solution application, and
- Redundant systems

The design heap solution application flowrate for the Carmacks Copper Project is 540 m^3/hr. Assuming a constant flow rate throughout the entire 48 hours, this portion of the pond capacity requirement is 25,920 m^3.

48-hour draindown capacity and time

The primary reasons for proposing the 48-hour design criteria for Carmacks Copper are to provide directly measurable inputs for determining the design volume rather than using % moisture values, as well as providing adequate capacity and time for personnel to respond to any upset conditions causing the draindown event such as power outages, pump failure, etc.

Actual operating experience over an 8-year period at the Brewery Creek Mine has demonstrated that during heap draindown events, the flowrate from the heap does not stay constant but instead decreases dramatically during the initial 48-hour period. The actual draindown data collected at the Brewery Creek Mine is summarized in Table 1. The Brewery Creek heap underwent a planned full scale heap draindown event during the decommissioning and closure phase. This took place in September 2002. At the time of the draindown, the heap was in full solution recirculating mode and had in excess of 5,500,000 tonnes of spent ore under active irrigation. The full height of the Brewery Creek heap at this time was approximately 28 meters. Mine staff took the opportunity to measure the draindown event and gathered actual operating data for flowrate versus time.

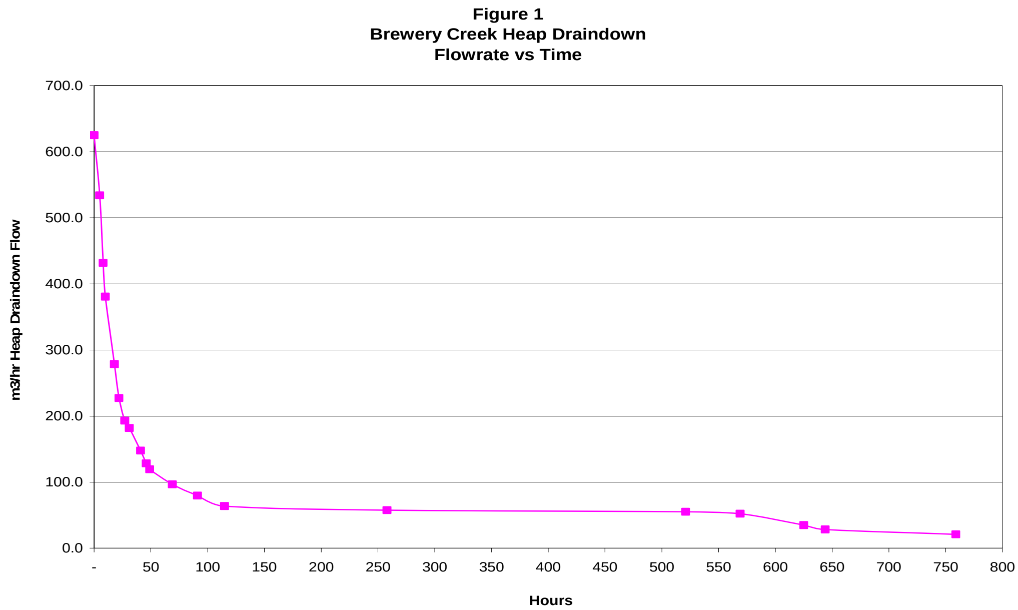
Actual heap effluent flowrates were measured at select time intervals during the draindown event. These flowrates were measured using a combination of the flowmeter installed in the effluent line and the water elevation in surveyed pond volumes.

Table 1
Brewery Creek Mine
Draindown Event Summary Data

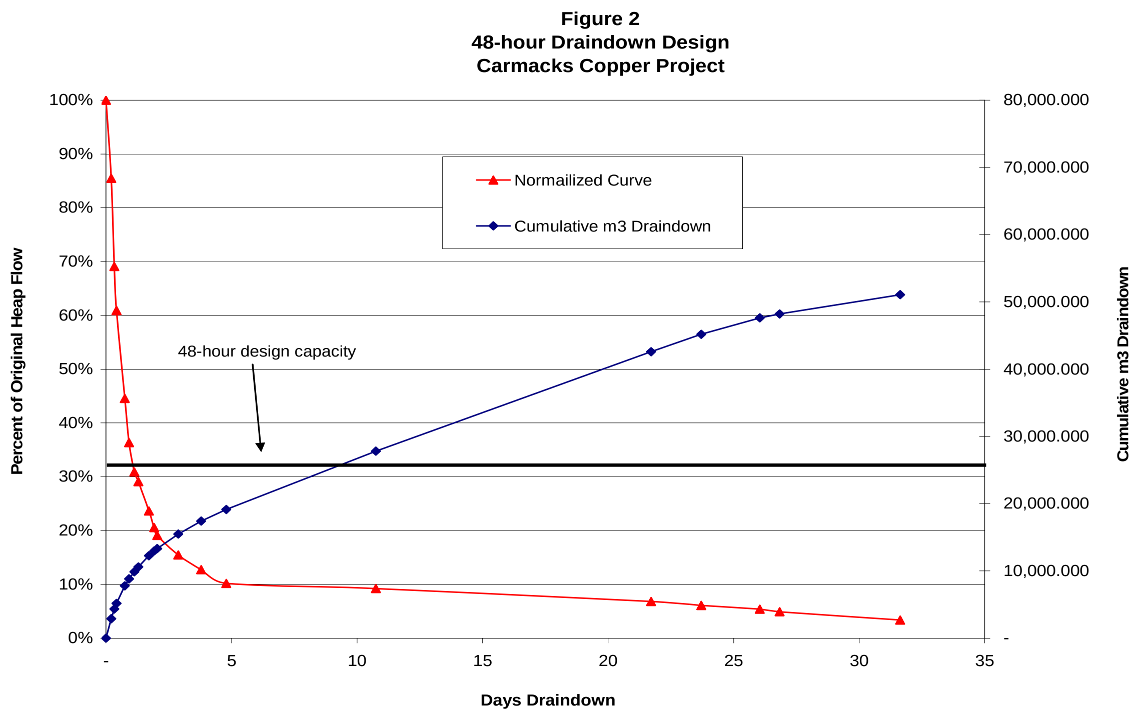
Tonnes Under Irrigation 5,521,000
Total Heap Area ha 32.9

Date	Time	Cumulative Hours	Cumulative Days	Heap Effluent m3/hr	% of Original Flow	Cum M3	% of Total	Draindown M%
4-Sep-02	2:15:00 PM	0.0	0.0	625.0	100%	-	0%	0
4-Sep-02	7:15:00 PM	5.0	0.2	534.1	85%	2,898	5.7%	0.05%
4-Sep-02	10:15:00 PM	8.0	0.3	431.8	69%	4,347	8.5%	0.08%
5-Sep-02	12:15:00 PM	10.0	0.4	380.7	61%	5,159	10.1%	0.09%
5-Sep-02	8:15:00 AM	18.0	0.8	278.4	45%	7,795	15.3%	0.14%
5-Sep-02	12:15:00 PM	22.0	0.9	227.3	36%	8,807	17.2%	0.16%
5-Sep-02	5:15:00 PM	27.0	1.1	193.2	31%	9,858	19.3%	0.17%
5-Sep-02	9:15:00 PM	31.0	1.3	181.8	29%	10,608	20.8%	0.19%
6-Sep-02	7:15:00 AM	41.0	1.7	147.7	24%	12,256	24.0%	0.22%
6-Sep-02	12:15:00 PM	46.0	1.9	128.4	21%	12,946	25.3%	0.23%
6-Sep-02	3:15:00 PM	49.0	2.0	119.3	19%	13,318	26.1%	0.24%
7-Sep-02	11:15:00 AM	69.0	2.9	96.6	15%	15,477	30.3%	0.27%
8-Sep-02	9:15:00 AM	91.0	3.8	79.5	13%	17,414	34.1%	0.31%
9-Sep-02	9:15:00 AM	115.0	4.8	63.6	10%	19,132	37.5%	0.34%
15-Sep-05	8:00:00 AM	258.0	10.8	57.5	9%	27,794	54.4%	0.49%
26-Sep-02	7:00:00 AM	521.0	21.7	55.1	9%	42,601	83.4%	0.75%
28-Jun-02	7:00:00 AM	569.0	23.7	52.3	8%	45,178	88.5%	0.80%
30-Sep-02	5:00:00 PM	625.0	26.0	35.0	6%	47,623	93.2%	0.84%
1-Oct-02	12:00:00 PM	644.0	26.8	28.4	5%	48,225	94.4%	0.85%
6-Oct-02	7:00:00 AM	759.0	31.6	21.1	3%	51,071	100.0%	0.90%

The draindown flowrate (m^3/hr) for Brewery Creek as a function of time is shown in Figure 1.



A normalized curve was developed from the Brewery Creek draindown curve and applied to the design flowrate of 540 m^3/hr for Carmacks Copper. The draindown curve for Carmacks Copper as a function of percent of the original flow versus time is presented in Figure 2.



Two significant points are evident from Figure 1 and 2. First, after 48 hours of heap draindown, the actual flowrate in the heap effluent at Brewery Creek was approximately 19% of the original flow. By applying this same factor to the Carmacks Copper design flowrate of 540 m^3/hr, the actual flowrate after 48 hours of draindown at Carmacks Copper would be approximately 103

m^3/hr rather than 540 m^3/hr. More importantly, the total volume drained from the heap after 48 hours would be approximately 13,300 m^3 compared to the design capacity of 26,000 m^3. By applying the curve from the actual Brewery Creek data, there would be approximately 10 days of capacity in the proposed 48-hour design criteria rather than only 2 days. This is significant when assessing whether there would be adequate time available to respond to any upset conditions such as power outages and pump failures.

In a draindown study of 37 heaps, (Kampf, Salazar and Tyler 2002) the draindown data and rates showed a rapid decline in drainage rates characteristic of gravity-dominated flow through the most conductive pathways in the ore. Just after rinsing stopped, drainage rates decayed rapidly over periods of days to weeks. The actual experience at Brewery Creek and the expected performance of the Carmacks Copper heap is consistent with the results of this large study.

The 48 hour design criteria proposed for the Carmacks Copper project (26,000 m^3), based on actual representative heap draindown, translates into an actual capacity of 10 days and provides more than adequate response time to ensure continued solution management on the heap.

Total Draindown %

The total draindown moisture percent is an input to the waterbalance model necessary for determining the ultimate volume of leach solution draining from the heap as well as sizing the required solution pond capacity for the first year.

Three column draindown tests have been conducted on Carmacks Copper ore. The results of these tests are summarized in Table 2.

Table 2

Carmacks Copper Project

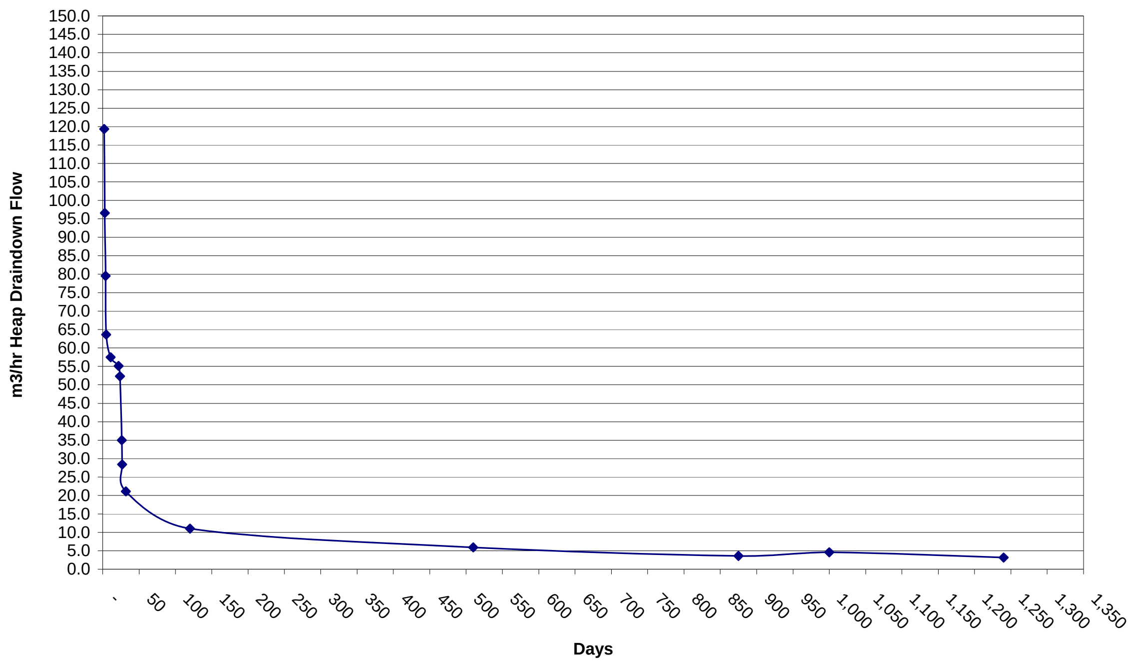
Column Draindown Testwork Summary

Test ID	Date	Crush Size inches	Column Charge kg.	Residual %M	Hold-up %M	Draindown %M
Test A	Feb-01	ROM	8795.0		10.2%	1.8%
Column C-1	Feb-01	- 3/4	164.2	10.8%	14.8%	4.2%
Column C-2	Feb-01	- 3/4	164.2	10.8%	14.8%	3.5%

The results of Columns C-1 and C-2 closely represent the proposed crush size of the Carmacks project (1”). The average draindown moisture percent for ¾” crushed material was 3.85%. This is higher than the ROM material which is to be expected.

By comparison, the column leach tests for Brewery Creek predicted a draindown moisture of 2.1% which was subsequently adjusted upwards to 3.0% for sake of conservatism. The final draindown moisture percent for the Brewery Creek heap based on actual heap draindown data is estimated to be approximately 1.5%. The difficulty in determining the actual heap draindown moisture percent in the Brewery Creek heap (and any heap for that matter) is due to the curve shown in Figure 3. After nearly 3 ½ years since the Brewery Creek heap was shutdown and allowed to drain freely, there is still approximately 2.5 m^3/hr flowing from the heap. This is consistent with long-term estimates for the Brewery Creek heap once a storage and release cover was constructed. However, over this 3½ year period, in excess of 350,000 m^3 of precipitation has fallen over the surface area of the heap. Accurately determining the longterm draindown volume and how much of the 2.5 m^3/hr of heap flow is attributed to original "draindown" versus how much is from the 350,000 m^3 of precipitation is not straightforward. The question is when did the heap draindown curve cross over from original heap draindown to normal and ongoing precipitation and infiltration?

Figure 3
Brewery Creek Heap Longterm Draindown Flow
Flowrate vs Time



The rational for designing pond storage capacity for a complete pad draindown is to provide considerable time (months to year) to intervene and re-establish flow. Experience at numerous heap leach operations, including the Brewery Creek heap, shows that this is not the case and the majority of heap draindown volumes occurs relatively quickly within a matter of 2-3 weeks (Kampf, Salazar and Tyler 2002), (Brewery Creek actual 2002-2005). Industry best practice for preventing uncontrolled draindown and potential release of solution is to prevent the draindown from occurring in the first place by providing an ability to always pump solution to a heap, regardless of any plausible scenario leading to a draindown (i.e. catastrophic fire). This is the rational for proposing backup and contingency pumping systems as a more appropriate measure rather than complete pad draindown capacity. Complete pad draindown design volumes lead to difficulty in assessing the true moisture % value and consequently drives an overly conservative and punitive pond volume design criteria.

The operating experience at Brewery Creek demonstrated that the heap flow decreased dramatically during the first few days but then reached a steadily decreasing linear trend after the next month and longer. When the Brewery Creek heap was shutdown in September 2002, the recirculating flow was over 600 m^3/hr. Following the shutdown of the Brewery Creek heap in 2002, the flowrate from the heap was approximately 11 m^3/hr after 120 days (November 2002). At the end of 2003, the flowrate from the heap was measured at 5.9 m^3/hr. For 2004, the end of year flowrate was 3.6 m^3/hr and at the end of 2005, the flowrate from the heap is approximately 2.3 m^3/hr.

Based on the experience at Brewery Creek, the column draindown moistures significantly overpredicted the actual draindown of the heap. The experience indicates that the columns over predicted by a factor of at least 25 - 30%. This is primarily due to column wall effects where solution short circuits the material. Based on this and the column data for a Carmacks draindown of 3.8% (Table 2) for crushed material, it is recommended that a draindown value of 3.0% be used for Carmacks Copper heap water balance modeling.

Verification of Operating Parameters

Verification of the critical heap operating parameters can be done through calibration and additional data collection during the period of active mining and processing operations.

Representative samples of crushed ore will be available at the crushing plant. Routine column leaching tests of these samples can be completed on an ongoing basis during operations. This is a normal routine testing program conducted at most heap leach operations. As part of this program, dry ore moisture, makeup moisture and draindown volumes can be collected on a monthly basis and used to calibrate and verify the input parameters to the water balance model.

Larger samples can also be collected on the heap itself from recently stacked material as well active areas within the heap. These larger samples can be used to determine ore moisture parameters and compared to the column database for additional data verification.

The data collected from these ongoing programs can be used to verify the water balance model. Actual pond volumes and pumping flowrates are updated along with actual tonnes of ore under irrigation. Model results compared to actual results allow calibration of the most critical parameters and a more confident model is developed with time. This was the experience at the Brewery Creek Mine and will be used at Carmacks Copper.

Events Leading to Draindown

There are a number of possible events that could lead to an unplanned draindown of the recirculating solution in the heap system. This section describes the possible “mechanical” failure events that could lead to an unplanned draindown event and the time required to respond to these events. The possible mechanical failure events that could lead to an unplanned draindown include:

- Solution Distribution Pump Failure
- Power Outage and Failure
- Broken Solution Distribution Pipeline
- Frozen Solution Distribution Pipeline
- Major Process Building Fire

Each of these possible failure modes has a potential risk and associated probability of occurring. The likelihood of the failure mode can be classified using a 5-tier system ranging from Not Likely to Expected. Accepted Failure Modes & Effects Analysis (FMEA) risk assessment approaches use a typical scale as summarized below:

Likelihood Category	Probability of Occurrence
Not Likely	< 0.1% chance of occurrence
Low	0.1 – 1% chance of occurrence
Moderate	1 – 10% chance of occurrence
High	10 – 50% chance of occurrence
Expected	> 50% chance of occurrence

The likelihood of the described failure modes is estimated based on operational experience at other similar heap leach operations, most notably the Brewery Creek Mine.

Solution Distribution Pump Failure

Solution to the Carmacks heap will be supplied by a single 4-stage vertical pump rated at 450 kw with an identical spare backup installed. The nominal flowrate to the heap is 540 m^3/hr. Mechanical failure of the primary solution pump would result in temporary loss of solution flow to the heap. The response to this event would be to start the secondary or backup pump and reestablish solution recirculation to the heap. Mechanical failure of the primary solution pump is considered Moderate (10% chance of occurrence). If properly maintained, pumps such as these will operate without failure for many years, beyond the operational life of the mine. If the pump does fail however, the backup or secondary pump can be started within a matter of 5-10 minutes. The primary and secondary backup pumps will be isolated from each other both mechanically and electrically so a failure of the primary pump will not effect the operation of the backup pump.

The secondary or backup pump will be operated and maintained as part of a standard preventative maintenance program. This program will include periodic running and operation of the secondary pump, usually every week. It is also normal to rotate the operation of these two pumps. The simultaneous failure of both the primary and secondary pump is considered Not Likely (0.1% chance of occurrence). If the primary pump failed and it was necessary to operate on the secondary pump, the primary pump would be removed and sent out for repair. Depending on the level of repairs required, the pump would likely be offsite for a matter of 2-3 weeks. In this event, the contingency pumping system (CPS) would serve as the secondary or backup pump.

Power Outage

Diesel generators will supply power to the process facilities as well as the entire operation. The power generation plant will consist of 5 (ea) diesel generating units, each with a minimum continuous operation rating of 1,650 kw. The power required for the primary solution pump to the heap is 450 kw. Under normal plant operating conditions, only one of the 5 generators is required for operating the pumping and process equipment. The other generators are dedicated to the crushing plant. Since the process operation only requires one generator, there is effectively 4 backup units available to maintain pumping capability. Under a worse case scenario, the crushing plant can be shut down temporarily or throughput reduced to supply ample power to the process operation in the event of a failure of one of the generators. The risk for heap draindown attributed to loss of generating capacity is considered Not Likely (0.1%).Sizing

Broken Solution Distribution Pipeline

If one of the main solution distribution pipelines were to unexpectedly break, pumping of solution to the heap would have to be suspended temporarily until the line was repaired. The smaller sub headers are isolated from the main distribution line. If one of these lines were to break, the operator would simply close the isolation valve and pumping would continue uninterrupted.

If the main line were to break, the line would be shutdown and repaired. The mine will carry sufficient spares in inventory to repair possible breaks or leaks in the pipeline. In the case of the Brewery Creek operation, the main line never experienced any operational failure during its entire 6 year service life. If repairs were required, the system would only be shutdown for a matter of hours. Repairs could certainly be made well within the timeframe of 10 days provided by the 48-hour heap draindown design criteria.

The likelihood of a broken solution line creating a short term heap draindown is Moderate (10% chance of occurring).

Frozen Solution Distribution Line

This scenario is similar to the broken pipeline in that it would lead to a temporary loss of solution recirculation. The primary cause of frozen lines is a loss or reduction in flow during extremely cold temperatures. As long as solution velocity is maintained, the experience at Brewery Creek indicates that freezing of main solution lines was not a concern and did not occur. Similar to the broken lines, smaller feed headers will be isolated with valves. The smaller lines are more prone to freezing. These lines can be isolated and replaced if necessary. Drip emitters will be used for irrigating the heap in the winter months. The drip emitters will be buried beneath the surface of the heap approximately 1.0 – 1.5 meters. The experience at Brewery Creek is that this was sufficient to prevent any widespread freezing of drip emitter lines.

Repairs could certainly be made well within the timeframe of 10 days provided by the 48-hour heap draindown design criteria. The likelihood of a short term draindown of the heap solution due to frozen solution lines is Moderate (10% chance of occurring).

Major Process Building Fire

If a catastrophic failure of all of the pumping and power generation systems occurred from an event such as a major fire, the heap would draindown the majority of its solution if pumping capability were not reestablished. The time required to replace primary pumping and power generation systems from a major fire would likely take at least 3-4 weeks if not longer. As shown in the Brewery Creek draindown curve and actual operating experience, most of the draindown occurs in the first 30 days. In this catastrophic scenario, a separate and isolated contingency pumping system (CPS) would be necessary to re-establish flow to the heap. The likelihood of a major building fire is considered Unlikely (0.1% chance of occurring).

Operating Redundancies

The operating redundancies designed into the Carmacks processing system have been described in the various system failure scenarios. The following summarizes the operating redundancies built into the system:

1. Identical backup solution pump capable of supplying 100% of the heap flow;
2. Excessive diesel generating capacity in the event a primary generator fails. The Carmacks process will have 5 generators rated at 1,650 kw. Only one of these generators is required to run the 450 kw primary solution pump.
3. Contingency pumping system (diesel powered pump) located outside and away from the SX/EW and power plant. The CPS would not be effected by a major fire and would be already piped into the main solution distribution line and available for use within a matter of minutes. A CPS consists of a diesel powered pump already connected into the main solution distribution line and isolated by valves. The CPS would be in place and ready

for operation during the most critical design period which is the spring of the year when the 100-yr snowpack would potentially occur. The CPS would be located sufficiently away from the main process building so it would not be affected by a major fire.

In addition, standard operating procedures and training programs would be in place to ensure rapid response measures were taken by operating personnel to initiate the contingency measures.

Effects from Operational Changes

Changes in operational conditions may have any effect on the overall heap water balance. Some of the possible operational changes that may take place and their anticipated effect on the water balance are summarized. The key potential changes in operations include:

- Increase or decrease in production rates
- Shorter or longer production season
- Change in ore crush size
- Change in leaching kinetics

Increase or decrease in production rates

The planned production rate of ore stacked on the Carmacks Copper leach pad is nominally 9,800 tonnes per day. If the daily production rate is increased, a higher rate of make-up water will be required to place this ore under leach. Conversely, if the daily production rate of ore is decreased, a lower rate of makeup water will be required. Throughout the production season, daily production rates will inevitably change. Operational changes caused by weather, equipment availability and material handling characteristics will effect the daily throughput of ore. Often times, the actual daily ore production rate will either exceed or be lower than the planned production rate. These normal fluctuations in operational productivity are not likely to cause material changes in the amount of ore stacked to the leach pad in the short term.

In the longer term, if the planned seasonal production rate of 1,970,000 tonnes of ore stacked on the leach pad is materially higher or lower, then the overall amount of fresh water required will change. By way of example, assuming the fresh water makeup requirement is 10% of the amount of ore stacked, an increase of 10% ore production in a season would require approximately 19,700 m^3 more makeup solution. If the annual ore production rate falls short of target by 10%, the seasonal impact of fresh makeup solution would be a decrease of approximately 19,700 m^3. It is important to note that not all of the solution required to begin leaching of newly stacked ore comes from fresh water. A significant portion comes from draindown moisture of older ore as leaching ceases from other areas of the leach pad. This is reflected in the overall water balance model.

Shorter or longer production season

Some of the anticipated runoff from snow on the leach pad during spring freshet is retained by dry ore placed on the heap during the spring of the year. A delay in startup and ore stacking in the spring of the year would cause less solution being retained from this dry ore. Similar to the production rate example, there would be no material change in the water balance at the end of the year as long as the planned production rate for the year is achieved.

A shorter production season would presumably result in less ore stacked on the leach pad. This would likewise result in less ore requiring solution make up and a lower requirement for makeup water. Less ore stacked on the leach pad on a seasonal basis does not however directly translate into more solution volume in the event pond. Other factors such as precipitation, evaporation, pumping rates, etc all influence the amount of solution in inventory at the end of each year.

Change in ore crush size

The planned crush size for Carmacks ore is 25 mm (1”). A coarser crush size will likely result in less makeup water requirements due to less fines in the stacked ore. As Table 2 shows, the difference between makeup requirements between ROM and ¾” crush size is over 4%. The other effect of crush size on the water balance is the draindown moisture %. Generally, a coarser crush size will result in a lower draindown moisture % because there is less operating moisture in the ore to begin with.

Change in leaching kinetics

A change in leaching kinetics (rate at which copper leaches) could impact the water balance through the time ore must remain under leach to obtain the ultimate recovery. If the leaching kinetics are longer than anticipated, more ore may have to remain under leach for a longer period which could result in a higher overall amount of ore under leach. This may have an impact through a higher draindown volume. This amount is fixed however because there is a fixed pumping rate and therefore a fixed or finite amount of ore that can be leached at one time.

Conclusion

- 48 hours of draindown capacity (25,920 m3) at the design flowrate of 540 m3/hr equates to 10 days of actual draindown capacity;
- The proposed redundant heap operating systems proposed for Carmacks Copper are equal to if not greater than industry best practices. By implementing the proposed redundant systems, the probability of a complete pad draindown due to mechanical failure is very unlikely;
- Based on the actual operating experience at the Brewery Creek Mine and a review of the Carmacks Copper heap operating design and solution management systems, the proposed solution management design criteria are appropriate.