Clean-up Strategy, Risk Assessment and Analysis of Accidental Pollution at Roşia Montană

CONCLUSION

Under all conditions, the risk of an accident is extremely small. The scale of toxic discharge of a plausible accident is limited and temporary. Under most conditions, even in the event of such an accident, the river water quality remains superior to both surface and drinking water standards even at the point of discharge into the river. In all cases, these safe conditions are re-established hundreds of kilometres before the discharged water reaches the Hungarian border. The risk analysis establishes that any more damaging case is unrealistic. The very low risk of accidents and the definite environmental benefits of the clean-up combine to suggest an overall beneficial environmental outcome from the project.

EXECUTIVE SUMMARY

The impact of the development of a gold mine at Roşia Montană, Romania, as proposed by Gabriel Resources, has been closely re-examined in order to:

- quantify the beneficial effect of the proposed clean-up of the currently continuing pollution from the site caused by the abandoned historic mining operations; and,
- assess the risks of an accident and its consequences for the river system from the site of the mine through to the Hungarian border 595 km downstream.

To do these evaluations, RMGC requested Professor Paul Whitehead of University of Reading in UK and Professor Steven Chapra of Tufts University, Boston, USA to undertake river flow and water quality modelling studies, and the Norwegian Geotechnical Institute (NGI) to undertake an event tree hazard analysis of the TMF. Mr. Patrick Corser, P.E. and Mining Sector Leader, MWH, contributed his expertise to both aspects of this work, along with advice from cyanide experts. The joint conclusions of this work are:

- the proposed clean-up would achieve an almost complete removal of the current and constant pollution coming from the site, a definite environmental benefit of the project;
- the probability of an accident resulting in a toxic discharge is very small (1 chance in 1 million years). The scale of a discharge from an accident would not cause the water, even in the immediate vicinity, to exceed the regulated standard set for safe surface or drinking water - except in the circumstance of a low water flow condition in the river

system. Such combined set of conditions was evaluated to have a much lower probability (1 chance in 4 million years). In that event, the water would have, temporarily and to a limited extent, cyanide concentration levels in excess of the regulated water standard over a distance of some 80 km downstream.

The cyanide concentration in these circumstances is not dangerous to human, animal, bird and most aquatic life. Only the most vulnerable of fish species (the river trout) – and only the most vulnerable individual specimens, rather than this entire species in the river or in the area – would potentially be affected. This is because of the limited level of toxic materials that would be discharged by an accident and the limited duration of exposure as the wave of contaminated water passes. As cyanides are not bio-accumulated, once the contaminated water passes, any adsorbed toxins will quickly be excreted or oxidised by partially affected organisms such that they will make a rapid and full recovery in a short time.

In most water flow conditions, the dilution and dispersion in the river would reduce the toxic concentration immediately at the point of discharge into the river to a level that complies with the regulated standards;

- these remote and limited impacts from an accident are based on the worst case assumption that the discharge is not contained within the industrial area nor diluted by emergency procedures, both of which are possible mitigating measures; and,
- given the very robust design, large capacity and the conservative operating criteria of the containment facilities, any worse discharge is unrealistic. The event tree analyses show that the probability of non-performance of the TMF is about 100 times lower than the probability of failure for containment dams, based on the performance observed for dams around the world.

The following table summarizes the key conclusions:

Event	**High Flow river conditions**	**Low Flow river conditions**
Overtopping of the dam due to extreme rain or snow melt - two 1 in 10,000 yr rainfall in 24 hours followed by 1 in 10 yr flood (probability of occurrence less than 1 in 100 million years)	No breach of water standards	Not considered. Extreme rainfall and low flow condition in river would not occur at same time.
Dam breach caused by large earthquake or other triggers (probability of occurrence 1 in 1 million years)	No breach of water standards	Standards exceeded for 80 km downstream, only for extreme concurrence of events (probability of occurrence of 1 in 4 million years). • Temporary and limited consequences • potentially mitigated
Environmental Impact Assessment (EIA) hypothetical dam breach cases – unrealistic. (probability of occurrence 1 in 100 million years or less)	Not realistic Theoretically exceeds standards	Not realistic Theoretically exceeds standards

Background

The Roşia Montană mine site is located in the Apuseni Mountains, which are part of the Carpathian Mountains in Transylvania, Romania. The Roșia Montană catchments drain into the Abrud and Aries River system which subsequently becomes the Mures River and this river flows into Hungary over 595 km downstream of the mine site. There has been pollution at the Roşia Montană mine in Romania since Roman times and the current plans to redevelop the old and abandoned mine site and bring a new mine into operation have been controversial.

RMGC addressed earlier in the EIA document the beneficial effects of extensive plans for a clean-up of the legacy of 2000 years of mining at this location. This clean-up is an inherent part of the mine development project – a known positive environmental consequence of the proposed development.

The key water pollution environmental question concerning the future impact of the Roşia Montană development is the potential impact of accidental pollution events on the downstream water quality.

The Hungarian authorities, concerned about the risk assessment methodology used in the EIA, suggested that a site and design-specific quantitative event tree analysis of the hazard associated with a Tailing Management Facility (TMF) accident would be a more reliable method than the qualitative analysis presented in the EIA. RMGC therefore requested that the Norwegian Geotechnical Institute (NGI) perform an event tree hazard analysis of the TMF. The Hungarian authorities also requested a new water quality study using a classical dispersion model approach that also builds in the dilution effects from incoming tributaries and the pollution degradation effects. RMGC requested Professor Paul Whitehead of University of Reading in UK and Professor Steven Chapra of Tufts University in Boston, USA, to undertake the dispersion model studies. Mr. Patrick Corser, P.E., Mining Sector Leader, MWH, a mining and dam design engineer collaborated in both aspects of the analyses, along with advice from cyanide experts.

Model Development

In order to investigate the cleanup of metals from the mine and the potential impacts of accidental pollution on the river system downstream, two models have been developed. The first is an extension of the INCA (Integrated Catchment) Model to incorporate a range of metals leaching from the old mine. The INCA model has been developed by Professor Whitehead over 12 years as part of two European Projects (see www.eurolimpacs.ucl.ac.uk and www.reading.ac.uk/INCA), with over 50 papers published in the international literature based on this model. The model simulates water flow and water quality in catchments, and is a daily, process based model. The model also incorporates the key factors that control water movement and chemical changes in rivers. It has been used widely across Europe to assess catchments and river systems subject to pollution, environmental change, climate change, land use change and mining development. The model also incorporates the dilution effects of inflowing water from tributaries and streams joining the main river. The model has been calibrated against actual past experience and data to confirm its accuracy and has been applied to the full river system downstream of the Roşia Montană project, down as far as the Hungarian Border at Nadlac on the Mures River.

In order to investigate the accidental discharge of pollutants, such as cyanide (CN), from the site, a new version of the classical dispersion model has been developed by Professor Steven Chapra and Professor Paul Whitehead. This model was developed to incorporate not only dispersion processes but also the dilution effects of inflowing water from tributaries and streams joining the main river, as well as the chemical decay processes that affect cyanide in river systems. This model has also been developed as part of a large European Project (see www.eurolimpacs.ucl.ac.uk).

These two models have been used in the analysis reported here to assess firstly the beneficial aspects of the metal clean up operation which has been planned as part of the mine development and, secondly, to evaluate the potential impacts of cyanide releases from the TMF dam in the event of a breach caused by extreme seismic, and/or weather events, or for example a natural terrain slide in the valley slopes.

Mine Restoration and Clean-up Strategy

The INCA model has been applied to the catchments at Roşia Montană and the river system downstream. The model simulates the day to day variations in flow and water quality, including key metals such as cadmium, lead, zinc, mercury, arsenic, copper, chromium and manganese. The model incorporates the key processes affecting flow and water quality in the river system and simulates current pollution moving down the river system.

As part of the mine development, it is proposed to clean up the currently abandoned open pits at Roşia Montană. This would be effective at removing the large sources of acid and metal contaminated waters that currently pollute the rivers systems downstream.

Important considerations concerning water quality are:

i. the upstream water quality, including contaminants entering the river upstream of Roşia Montană, but unrelated to it;
ii. the pollutants added to the river system currently from the abandoned open pit mines at Roşia Montană;
iii. the commitment by the mining project to clean-up the current Roşia Montană pollutants – involving the removal of almost all the pollutants currently entering the river system at Roşia Montană; and producing a large percentage reduction of the current overall river pollution.

With respect to the current pollutants from Roşia Montană, as shown in Table 1 below, the clean-up technology would reduce the metals to low concentrations and remove a very large percentage of the metals currently draining from Roşia Montană.

Table 1: Chemistry concentrations after clean-up and the percentage reductions achieved the clean water targets in mine discharge concentration.

Selection of Metals Requiring treatment	Post Treatment Concentrations (mg/l)	Percentage Reduction in Concentrations
Cadmium	0.05	82.7
Zinc	0.05	99.8
Arsenic	0.10	72.0
Copper	0.02	99.1
Chromium	0.10	95.8
Manganese	0.30	94.3

The effects of these metal concentration reductions at Roşia Montană on the river downstream can be calculated using the model. The model calculates that the clean up will significantly reduce the concentrations of key metals such as cadmium, zinc, arsenic, copper, manganese and chromium and also the loads of metals being transported down the river. The load estimates at Roşia Montană, Turda (80 km downstream) and at the Hungarian border are given in Table 2 for the current situation and in Table 3 assuming the clean up operation. The loads of metals are significantly reduced, as illustrated by the high percentage reductions shown in Table 4 below.

Table 2: Current Mean Daily Metal Loads (kg/day) along the River System

Metal Loads	Roşia Montană (kg/day)	Turda (kg/day)	Nadlac (kg/day)
Cadmium	0.85	0.72	0.69
Zinc	104.8	88.60	69.9
Arsenic	0.85	0.72	0.56
Copper	11.5	9.90	7.90
Chromium	5.8	4.89	3.86
Manganese	14.1	11.90	9.30

Table 3: Calculated Metal Loads (kg/day) assuming Collection and Treatment as Committed by the Mining Project

Metal Loads	Roşia Montană R (kg/day)	Turda (kg/day)	Nadlac (kg/day)
Cadmium	0.18	0.13	0.10
Zinc	7.90	6.20	4.40
Arsenic	0.30	0.22	0.15
Copper	5.80	4.50	3.20
Chromium	0.73	0.56	0.39
Manganese	0.86	0.63	0.42

Table 4: Percentage metal load reductions in the river system overall assuming collection and treatment as proposed at Roșia Montană, but with other sources of such pollution continuing

Metals	Roşia Montană (%)	Turda (%)	Nadlac (%)
Cadmium	79.3	81.9	85.5
Zinc	92.5	93.0	93.6
Arsenic	64.5	69.4	73.2
Copper	49.5	54.5	59.4
Chromium	87.4	88.5	89.9
Manganese	93.9	94.7	95.5

Conclusions on Clean-up

Modern environmental management can go a long way to restoring river systems and this is the fundamental principle behind the European Water Framework Directive. Restoring rivers to an adequate water quality with the subsequent improvement in aquatic ecology is the clear objective of such legislation.

The proposed cleanup and restoration operation at Roşia Montană will result in almost complete removal of pollutants (a reduction in concentration from 72% to 99.8% of the different metals) originating at the Roşia Montană site as seen in Table 1 above. This will produce significant benefits to the river system downstream, including at the Hungarian border, significantly lowering metal concentrations and restoring water quality and ecology that have probably been damaged for over 2000 years.

Dam Performance at Roșia Montană and Potential Impact on Rivers Downstream

A dam breach, releasing tailings and water from the dam and the secondary containment dam over a period of time, is an event that could have an impact on the river system downstream, if the volume of water and tailings released is very large.

The hazard associated with dam breach and overtopping, with the release of tailings and water, was the subject of a thorough event tree hazard study by NGI. The results have been reconfirmed with the dam designers, cyanide process experts and water study experts. The hazards associated with all aspects of the site, construction, operation and post-closure relevant for a well-functioning TMF were identified. The potential conditions and triggers of accidents, and failure modes were evaluated, and combinations thereof were evaluated cumulatively, including:

<u>Triggers</u>

- Extreme rainfall and/or snowmelt
- Earthquake shaking
- Landslide in natural slopes near dam abutment
- Failure of waste stockpile into reservoir

<u>Failures modes</u>

- Foundation failure
- Dam slope instability
- Unravelling of downstream toe and slope
- Dam abutment failure followed by embankment failure
- Dam overtopping or excessive leakage under TMF
- Crest settlement or collapse

<u>Conditions affecting performance of TMF</u>

- Construction deficiencies
- Insufficient quality control
- Unforeseen construction schedule change.

As part of the environmental impact assessment process, "worst case" scenarios were studied, involving a discharge of pollutants from the TMF into the river. Two broad types of situations were addressed in the EIA study:

- Firstly, the question was raised whether an event such as the Baia Mare failure in 2000 could occur at Roşia Montană, if a very high precipitation and snow melt raised the water level in the TMF and if water overflowed the crest of the dam (UNEP 2000, Cyanide Spill at Baia Mare Romania, Report of the UNEP/OCHA Assessment Mission, Geneva). In the Baia Mare case, the dam was built of cyclone tailings (i.e. silt and sand) and the water flowing over the crest also eroded the dam and resulted in a large release. In Roşia Montană, the TMF dam will be built of rockfill and would not be subject to being washed away by a volume of water that would overtop the dam. In addition, the Roşia Montană TMF dam will have an emergency spillway (non-existent at Baia Mare) to control any excess water released, in the unlikely event that a discharge was to occur.

- The second type of situations addressed is associated with a breach in the TMF dam, involving a sudden release of tailings material and associated water release.

Section A below presents the potential pollution for an extreme overtopping event and Section B addresses the case of dam breach. The discharge volumes and the initial cyanide concentrations were estimated by MWH, along with advice from cyanide experts. The hazard analysis was done by NGI using an event tree approach. A special workshop in Bucharest brought together experts on tailings dams and on risk analysis to assess the probabilities.

A. Rainfall/Snow Melt Induced Dam Overtopping Event

The design of the TMF has been sized to accommodate, in addition to the tailings and water effluents of the processing plant operations, a very large rain storm/snow melt event. The design criteria specify that the TMF will have capacity to store two Probable Maximum Flood (PMF) events and still have the additional capacity of one meter of freeboard. The two PMF volumes are generated from the runoff of a Probable Maximum Precipitation (PMP) event - which amounts to two 1 in 10,000 year rainfall events occurring within the same 24 hour period. In the unlikely event of a larger runoff, the excess water would be discharged from the emergency spillway in a controlled manner that would not endanger the structural stability of the dam. The spillway is designed to pass a 1 in 10 year flood event that is assumed to occur immediately after the two PMP events; the 1 in 10 year flood is assumed, for study purposes, to be discharged through the spillway despite the remaining capacity of the one meter of freeboard. The probability of an overtopping type release of water is extremely low, due to the capacity and design criteria of the Roşia Montană TMF rockfill dam.

The volume flowing through the spillway would be that introduced by a 1 in 10 year flood (i.e. ignoring conservatively the extra freeboard capacity). A flow of 2.3 m^3/second was estimated for 12 hours, cumulatively amounting to a volume of 100,000 m^3, which volume is assumed to reach the river.

The estimated probability of occurrence for two 1 in 10,000 year rainfall events occurring within the same 24 hour period is 1 in 100 million years. The probability is even lower for a sequence including, in addition, a 1 in 10 year flood. These probabilities place these events beyond realistic scenarios.

The river dispersion analyses evaluated the situation under both low flow and high river flow conditions, in which contaminated waters escape, via the emergency spillway, from the industrial zone of the project without treatment. It is difficult to conceive that the water volumes giving rise to an overtopping event could occur concurrently with a low river flow condition. For illustrative purposes, Figure 1 below presents a typical example of the calculated cyanide concentration downstream under a high flow condition in the river system**.** The results of the study indicate that the peak cyanide concentrations at the Hungarian border are low, and well below the Hungarian cyanide river water standard of 0.1 mg/l Total CN and the drinking water standard of 0.05mg/l Total CN. Furthermore, neither surface nor drinking water standards are exceeded at any point along the river, even including the immediate point of discharge into the river at Abrud.

Table 5 shows numerically the calculated peak cyanide concentrations in the river at the Corna valley TMF site and downstream of the Corna valley for high flow conditions. In order to analyze the worst impact, conditions in the 17th year of operation were assumed, when the tailings contained behind the dam are at their highest level, The model calculates the peak concentrations and allows for the dispersion in the river as well as dilution from inflowing streams and tributaries. The model conservatively assumes a minimal loss of cyanide due to volatilization (or evaporation) and degradation, which are all natural processes normally occurring and reducing concentrations in the river. For weak acid dissociable (WAD) a decay rate of 0.1 per day is assumed. For strong acid dissociable (SAD), a very conservative decay rate of zero under all conditions is assumed. (Based on the tests done with samples of the materials from the site, WAD was estimated on average to be 60% of the total and SAD 40% of the Total cyanide on which the standards are based).

Figure 1 Cyanide concentration (mg/l) calculation of a dam overflow event entering the Mures River System under high-flow conditions at 17th year volumes (Assumed overflow volume released from Corna dam 2.3 m^3 per second for 12 hours, cumulatively 100,000 m^3)

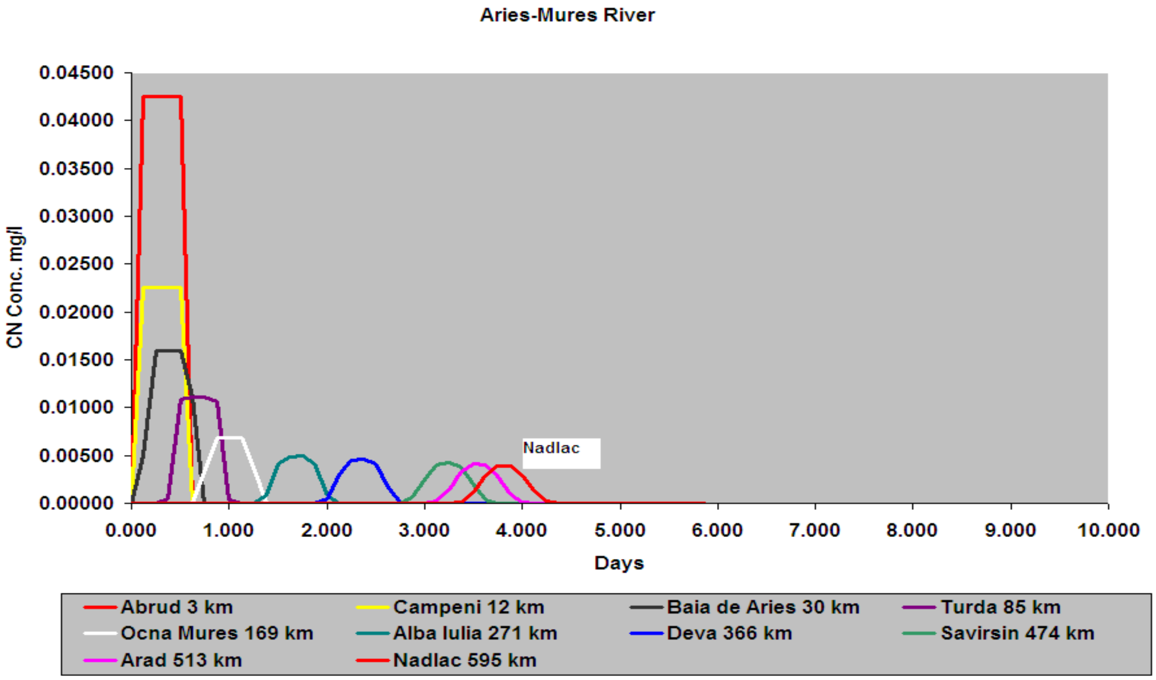
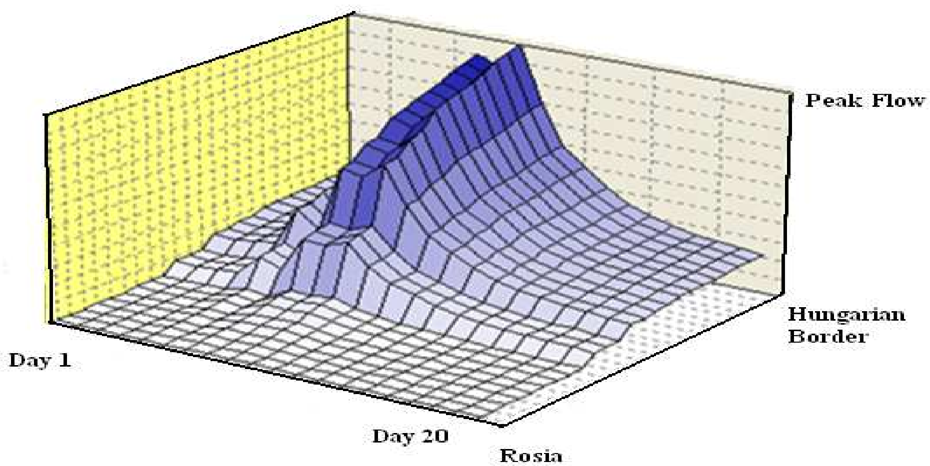


Table 5: Calculated Peak cyanide concentrations (mg/l) assuming a worst case rainfall event followed by a flood under high flow conditions at 17th year volumes.

Reach	Travel Time days	Peak Total CN conc. mg/l
Abrud	0.1	0.045
Campeni	0.1	0.023
Baia de Aries	0.5	0.016
Turda	0.5	0.011
Ocna Mures	0.7	0.007
Albalulia	1.0	0.005
Deva	1.7	0.005
Savirsin	2.4	0.004
Arad	3.2	0.004
Nadlac	3.8	0.004

Figure 2: A typical storm event on the Aries- Mures river system from Roșia Montană down to the Hungarian border showing flows over a 20 day period in February 2004. The flows increase down the river system as tributaries join the main river and these higher flows provide dilution



The cyanide concentrations from the site to the border are below the river water standard and the drinking water standard – and the risk probabilities are less than 1 in 100 million years, something that makes the prospect of an overtopping event so remote that it is considered meaningless.

This analysis illustrates that, in the case of a severe rainfall (and/or snow melt) event - even if the designed capacity of the dam would fail to contain the rain water - the overflow would not produce cyanide concentrations in Hungary that are even remotely close to the levels of pollution observed in the Baia Mare event. The concentrations after the Baia Mare event were, at the Hungarian border, 200 times the surface water standard and 400 times the drinking water standard. An extremely improbable spill at Roşia Montană would not exceed the regulated acceptable cyanide levels anywhere in Romania or at the Hungarian border for either the surface or drinking water standards.

B. Dam Breach Scenarios

Two categories of conditions were considered for a dam breach. The first were the extreme scenarios outlined in the EIA for a dam breach. However, as discussed below, after close review, these scenarios were considered to be too extreme to be plausible. The second category modelled scenarios with extremely low probability of occurrence, but considered more plausible than the scenarios in the first category. Each category is discussed in more detail below

B.1 Dam Breach Conditions Considered in the EIA

The cases reported in the EIA (see EIA Report, Part 7 Risks, page 120 of 205), considered releases of 7.8 million m^3 of tailings, with 3.8 million m^3 of water; and of 27.7 million m^3 of tailings, with 5.9 million m^3 of water over 24 hours. These releases would require so large a removal of the dam - amounting to 60 meters of height and 390 meters of width – that it was considered impossible for this to occur to a rock fill dam built with a downstream slope of 3 horizontal to 1 vertical.

The hazard analyses done with the help of additional experts on tailings dams and risk assessment at the Bucharest workshop, and using the event tree approach, replace the earlier extreme scenarios of dam breach suggested in the EIA Report. The probability of occurrence for the earlier extreme dam break scenarios were found to be too small (less than once in 100 million years) to be considered realistic scenarios. Scenarios with higher probability of occurrence were determined and considered in the event tree analyses.

Regardless of the fact that the more extreme cases have an extremely low probability of occurrence, to the point of being unrealistic, the water quality impacts were analyzed. The results indicate that, in the first case, as the wave of contaminated material passes, the water at the Hungarian border reaches above the surface water standards (i.e. to be at 0.76 mg/l Total Cyanide against a surface water standard of 0.1 mg/l Total). In the second even more extreme case, the water reaches 1.08 mg/l Total Cyanide. These cases are for low flow conditions, the worst case from an impact point of view. These large releases of water are considered completely unrealistic because of the extremely low probability of occurrence. The cyanide toxicity discussion set out later in this report note the very limited damage consequences of even this level of toxicity.

B.2 Low Probability, but More Plausible, Scenarios

The risk associated with more plausible scenarios causing environmental consequences was considered by NGI. The highest hazard (probability of occurrence) associated with plausible non-performance of the dam was determined to be one in one million years. The event tree analyses show that the probability of non-performance of the TMF is about 100 times lower than the probability of failure for containment dams, based on the performance observed for dams around the world

The physical impacts due to these scenarios were estimated by the experts at the hazard workshop to be a crest deformation of approximately 5 to 8 meters over a length of the dam crest that ranged between 100 to 200 m. The volume of tailings released was conservatively estimated at a range of approximately 125,000 m^3 to 250,000 m^3, with a release of approximately 13,000 m^3 to 26,000 m^3 of contaminated water over 24 hours. This event would result in a tailings and water release that is approximately 100 times less than the two extreme scenarios considered in the EIA.

The dam breach scenario was considered during the late years of operation when the TMF is at its highest volume. During the early years of development of the TMF, the hazard analyses showed that any water escaping from the dam (again with a very low probability of occurrence) would be contained within the zone between the secondary containment dam (SCD) and the toe of the TMF dam and not reach the river.

On the basis of the hazard analyses run by NGI in cooperation with several international dam and risk experts, the dam breach and overflow scenarios during the final years of operation of the TMF might result in, quoting the risk expert report, “some material damage and some contamination to the vicinity downstream of the TMF”, but not more. No flooding above the river bed will occur. The tailing themselves might travel a distance of a few hundred meters from the TMF dam, well short of any danger to surrounding properties and people.

The results of modelling for the high flow and low flow conditions are shown in Tables 6 and 7 and in Figures 3 and 4. Modelling results for both cases indicate that the downstream water quality criteria will most frequently be met for river standards and for drinking water standards, even at the immediate vicinity of the site. However, under low flow conditions, there may be a short term exceedence of standards for a distance of 80 km from the site. It should be emphasized that these simultaneous conditions of a dam breach and low flow have a considerably lower probability of occurrence, being one chance in four million years. The lower probability is due to the low flow conditions having been observed to occur statistically during 3 out of 12 months in a year.

The small risk of this impact is again of a limited extent and is temporary. The impact should be weighed against the benefit of the immediate and assured clean-up of the current actual and constant heavy metals pollution.

The impacts from this type of dam breach that have been discussed above do not address some of the project features that could reduce the impacts. Specifically, the model does not consider the potential to capture some of this discharge flow in the SCD and the semi-passive treatment lagoons that will be constructed directly below the SCD. The SCD will have a capacity of 53,000 m^3. The lagoons are planned to extend for a distance of approximately 500 meters beyond the SCD and have an extra capacity of about 33,000 m^3 above their operating capacity. These two facilities will not be full during normal operating conditions and could mitigate, or even contain, the impact of the release of tailings and water. Further, the possibility of utilizing nearby, downstream reservoir facilities with a capacity to hold 10 million m^3 of water to promptly dilute any spill as an emergency response measure that would eliminate any exceedence of standards, even in the immediate vicinity of the site, is under investigation.

The following results in Tables 6 and 7 and Figures 3 and 4 do not include any of the above mitigations.

Table 6: Travel times and Peak concentrations for Case where 26,000 m^3, released over 24 hours, with a Total Cyanide concentration in the TMF reclaim pond of 5mg/l, under high flow conditions.

Station	Travel Time days	Peak Total CN conc. mg/l
Abrud	0.14	0.0090
Campeni	0.22	0.0046
Baiade Aries	1.04	0.0032
Turda	1.16	0.0023
Ocna mures	1.32	0.0014
Albalulia	1.71	0.0010
Deva	2.28	0.0009
Savirsin	3.11	0.0009
Arad	3.40	0.0009
Nadlac	3.65	0.0008

Figure 3: Cyanide concentrations for Case where 26,000 m^3 released over 24 hours, with a Total Cyanide concentration in the TMF reclaim pond of 5mg/l, under high flow conditions.

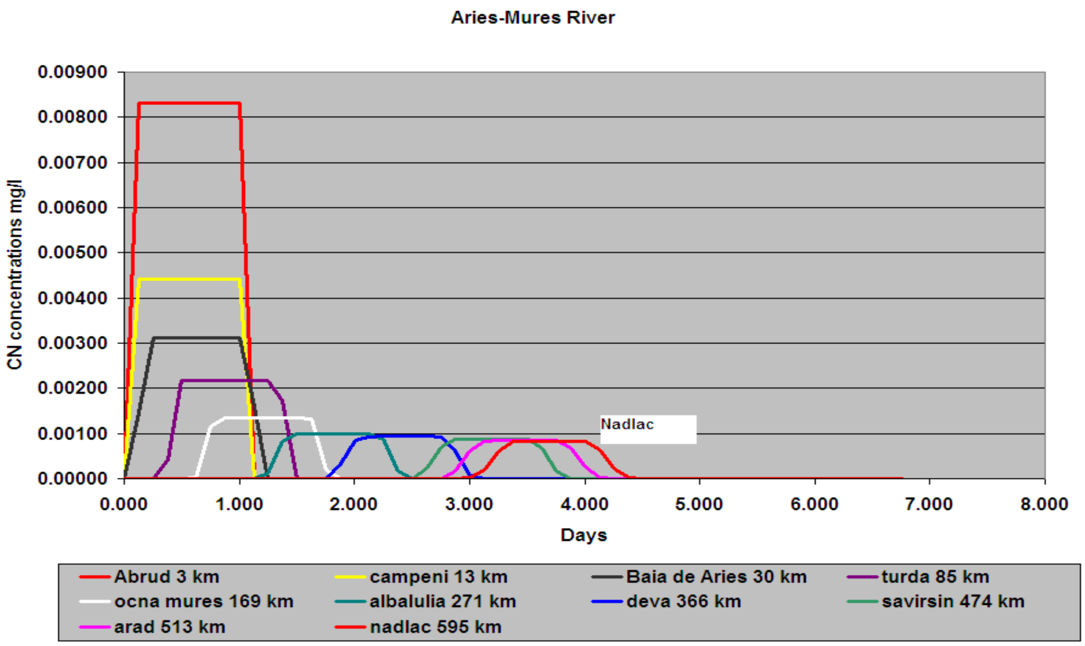
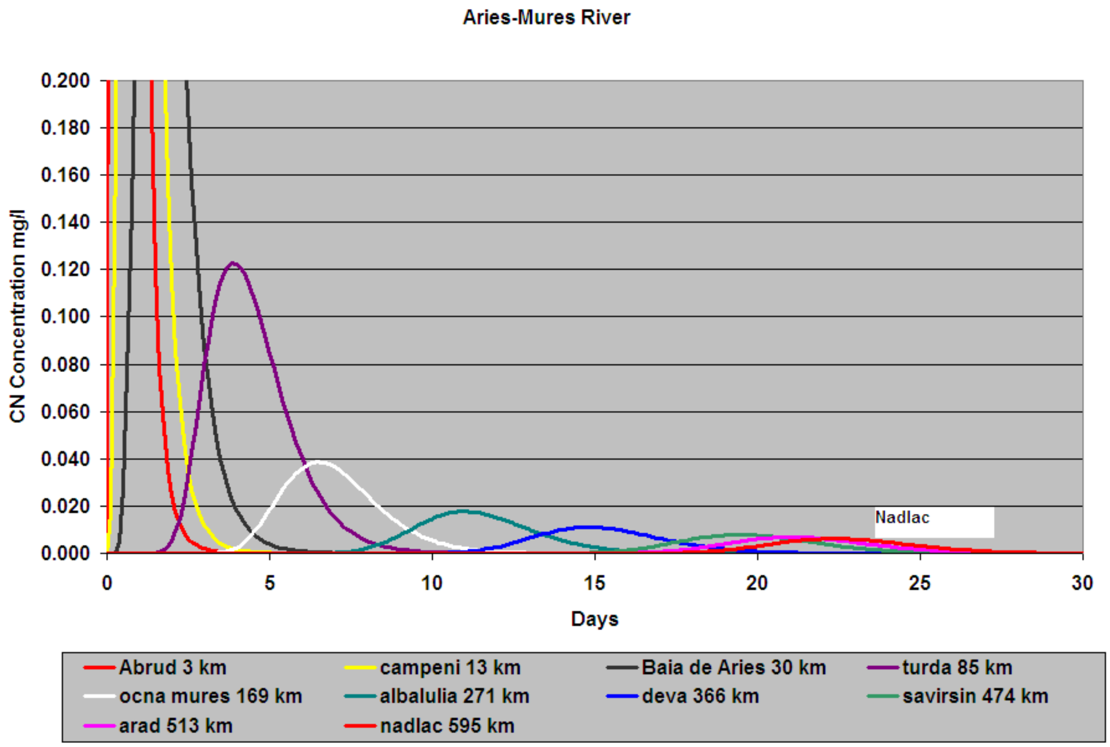


Table 7: Travel times and Peak concentrations for Case where 26,000 m^3 is released over 24 hours with a Total Cyanide concentration in the TMF reclaim pond of 5mg/l, under low flow conditions.

Station	Travel Time Days	Peak Total CN conc. mg/l
Abrud	1.00	1.6817
campeni	1.08	0.8853
Baiade Aries	1.49	0.5296
Turda	3.80	0.1475
Ocna mures	6.37	0.0448
albalulia	10.78	0.0192
Deva	14.55	0.0117
Savirsin	19.11	0.0081
Arad	20.66	0.0070
Nadlac	21.97	0.0063

Figure 4: Cyanide concentrations for Case where 26,000 m^3 is released over 24 hours with a Total Cyanide concentration in the TMF reclaim pond of 5mg/l, under low flow conditions. (Note Scale has been reduced to show the concentrations in the lower reaches of the river)



Cyanide Toxicity discussion

The toxicity of cyanide depends on many factors that cannot be determined directly from the "total cyanide" measurement. It is ultimately the "free cyanide" and those cyanide compounds that can readily release free cyanide (weak acid dissociable cyanides) that determine the toxicity to life forms. The ambient conditions of pH, temperature, light and factors affecting volatilization and oxidation also impact the level of this toxic constituent element.

Nevertheless, the peak cyanide levels (determined by worst case scenarios and at the worst location, being the immediate vicinity of the site) as a result of the tailings/water discharge of the magnitude and duration caused by the accident conditions assessed are:

- far below a concentration and/or duration that can affect human, bird or non-aquatic life forms;
- for animals and birds, considered safe at cyanide concentrations well above those in the fenced off tailings pond– and virtually unaffected at the worst levels modelled for accidental discharge in the river;
- safe for aquatic plant life, which is also able to withstand far greater concentrations and durations of exposure than those involved in the cyanide levels projected for the river, even under the most adverse discharge conditions modelled;

- of a concentration that may influence the most sensitive of invertebrate aquatic life forms however the duration of exposure is such that minor if any impact would be expected; and,
- of a more variable significance for fish – which are the most vulnerable vertebrate life form because of the acute sensitivity of some species and the duration of their exposure to the toxic water by virtue of living in the medium. Even fish, however – and even the most vulnerable of the species (river trout) - require a minimum level of cyanide concentration and some minimum duration of exposure before the weakest specimens of this least resistant species would experience loss of life.

The conditions post accident at their worst might threaten the weakest fish specimens of the most susceptible species – but the limited concentration and temporary exposure is such that only the weakest specimens would succumb. The limited duration is such as to make even that a less than certain outcome. Certainly there would not be a significant depletion of numbers of even the most susceptible species; so that they would remain represented in the watercourses.

It is, perhaps, noteworthy that, while it is intended that the clean-up of the current acid rock drainage pollution would permit the restoration of aquatic life, there is currently no material aquatic life that can survive in the current acid and heavy metal contaminated water conditions in the river within at least some 40 kilometres of the site.

Conclusions on Hazards Associated with Potential River Pollutions

Accidental pollution could occur if unusually intense rainfall and/or a large earthquake caused an overtopping or a breach in the dam at Roşia Montană. A massive rainfall event of two 1 in 10,000 year rainfall occurring within 24 hours followed by a 1 in 10 year flood that could result in discharge from the TMF facility, was determined to have an extremely low probability of occurrence (less than 1 in 100 million years). This is considered an unrealistic scenario. However, an analysis of the water quality impacts from such an extreme rainfall scenario was conducted. The dispersion analysis indicated that there would be no exceedence of water quality standards at the Hungarian border and an upstream exceedence only in the case of a low water flow conditions, an even less realistic combination of adverse conditions.

NGI determined that the probability of the dam breach scenarios originally outlined in the EIA document was extremely low (once in 100 million years or even lower). The massive breach was considered as entirely unrealistic. However, the water quality impacts were studied for such unrealistic cases. The analyses determined that water quality standards were slightly and temporarily exceeded at the Hungarian border.

For other more plausible dam breach scenarios, event tree hazard analyses were run. In the quantitative assessment, the total probabilities, including all potential modes of failure and all triggers resulted in a probability of occurrence of 1 in a million years or less. The analyses show that the probability of non-performance of the TMF is about 100 times lower than the probability of failure for containment dams, based on the performance observed for dams around the world. The physical impacts of even a once in a million year type of event were considerably smaller than assumed in the EIA. Given the much smaller volumes of material released (approximately 100 times less than the EIA cases), the results of the analyses indicated that there will be either no damage, if the tailing and water are contained in the semi-passive containment ponds; or that there may be some limited impacts for a temporary period in the vicinity immediately downstream of the Corna valley, but only for the scenario of low flow conditions.

As for the prospects of damaging environmental consequences, the cyanide concentration in the circumstances of the exceedences of regulatory standards for water quality is not dangerous to human, animal, bird and most aquatic life. Only the most vulnerable of fish species and only the most vulnerable individual specimens would potentially be affected.

In no case will there be adverse impacts anywhere close to the Hungarian border.

OVERALL CONCLUSIONS

In summary, given the design features of the Roşia Montană TMF and the established design and operating criteria for the facility, the plausible dam breach or overtopping scenarios did not result in any impacts to water quality at the Hungarian border and only under the worst low flow conditions resulted in only limited impacts directly downstream of the secondary containment dam in the Corna valley. The environmental damage consequences of such an impact would be minor. This confirms the robust design for the Roşia Montană TMF.

The low probability hazards must also be considered in light of the immediate and definitive benefits of the river clean-up resulting from the removal of current pollution from the proposed mine site by the project.

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