INTEGRATED RISK ANALYSIS FOR INDUSTRIAL SITES WITH TAILINGS PONDS

We offer a complex integrated assessment and risk analysis, proposed by two world-leading companies in site survey and in the environmental field, developed in accordance with current regulations:

- Field survey and analysis
- Detailed topographical analysis
- Aerial imaging, hyperspectral and thermal imaging, laserscanning
- Geophysical survey
- Geotechnical analysis including slope stability analysis,
- Hydrologic and geochemical analysis
- Surface hydrology
- Toxicology
- Risk assessment
- Passive treatment methods for levees that may be structurally stable, but still have chemical related problems
- Laboratory analysis
- Statistical data processing
- Identification of hazardous substances with identification of their source
- Quantitative and qualitative testing of volume and distribution of hazardous substances
- Modelling of transport pathways, conceptual modelling and pollution scenario modelling
- Native pollution attenuation calculation
- Health and ecological risk evaluation including ADD (average daily dose) and LADD (lifetime average daily dose) toxic substances calculation
- Proposal of remediation methods
Introduction

Dear friends,

Given that your company is engaged in industrial processing of mineral raw materials and that within these technologies tailings ponds are operated, we would like to offer you a comprehensive analysis of environmental risks associated with such operations. Surely you remember the ecological disaster that happened in October 2010 in Kolontár, Hungary after the failure of a dam around a tailings pond containing caustic red alumina mud. We are convinced that similar accidents can be prevented and that areas of potential risk can be detected by using modern technologies of aerial imagery, hyperspectral imagery, thermal imagery and laser scanning in combination with ground surveys. Companies BLOM and AMEC are world leaders in their specialization and offer you highly professional services. This framework contains a brief description of these offered services.

We see great potential in the listed technologies. All combination of technologies is possible depending on the client requirement. Our engineers are ready to answer your questions and to advise for a better monitoring of industrial reservoirs.

Yours faithfully

Jan Sirotek
Director International Sales
Blom Czech Republic

Petr Vymazal
Managing director
AMEC s.r.o., Czech Rep.
TAILINGS PONDS AND OTHER LEVEES ARE FACILITIES REQUIRING RISK ANALYSIS OR INTEGRATED ENVIRONMENTAL EVALUATION

Risk can never be eliminated, but they can be managed. As environmental regulations become more rigorous, mine owners must pay extra attention to tailings disposal management, particularly in regions where water resources are limited or where social/environmental concerns dominate.

Traditional tailings management systems contain enormous amounts of water over large areas, using high dams that have, in some cases, suffered catastrophic failure. These factors have damaged the reputation of mining companies and their project.

Risk analysis can be useful under the following situations:

- if there is suspicion of possible harm to the environment or to human health;
- if there is, or is suspected to be, a serious threat to human health or environmental components,
- to prevent environmental accidents and ecological damage
- to serve as a first step in evaluating possible remediation techniques and to propose a design to reduce contamination levels.

Predominantly the consequences from tailings dam failure are:

- Flooding
- Contamination of surface water, often used for irrigation or drinking
- Contamination of underground water, often used as drinking and irrigation water
- Soil contamination
- Contamination of food chain

We can help you to solve the questions of whether the dam is stable or whether there is a seepage problem which may not be visible from the surface. In many cases of failure, the main impact is from unseen damage within the dam.

Usually the main systems affected by dam failure are the human population around the tailings dam, surface and underground water, soil and living organisms coupled with huge material and financial losses.

We are able to handle such analysis and more by using the latest available technologies, which are described later in this offer.
Sensing technology

For better evaluation of the risk analysis we can use state-of-the-art remote sensing technologies to detect potential defects of the dams and model emergency scenarios:

- Aerial laser scanning (LIDAR)
- Aerial imagery
- Oblique imagery
- Hyperspectral imagery
- Thermal imagery
- UAV imagery – PAMS

If required we can also use geophysical methods.

Blom Group has the largest and most versatile aircraft fleet in Europe and enables Blom to meet all customer needs. Blom owns a number of aircraft based throughout Europe including a Learjet, enabling the company to mobilize at short-notice to any location.

**Aircraft resources include:**

- 18 x Aircrafts for aerial survey (owned by Blom)
- 4 x Leased Helicopters
- 14 x Leased Aircrafts

**Aerial sensors**

- 10 x Large format digital survey cameras
- 13 x Large format analogue (film) cameras
- 5 x High performance (mid low to high altitude) LiDAR systems for mainly fixed wing applications.
- 5 x High performance (low to mid high) LiDAR system for Rotor wing applications.
- 1 x Multi spectral scanner (MIVIS)
3D Laser scanning technology

Laser scanning or LIDAR (Light Detection And Ranging) uses a laser beam to measure the distance to a target. The orientation of the beam is controlled as the beam scans the landscape. As it works with high frequency, it can perform acquisition of high density measurements and give an accurate 3D digital image of the documented objects and terrain in the form of a cloud of points. The cloud of points is a first raw 3D model. More elaborated 3D models are generated after post-processing and point classification. 3D models are used for volume calculation and for detection of degradation on the banks of the dams.

In the case of airborne laser scanning, the sensor is used in association with GPS technology and it is possible to geo-reference the measurements and map it on earth surface to produce a digital elevation model (DEM). DEMs are useful for building accident scenario for risk assessment.

Laser scanning can be generally characterized by the following basic features:

- Accuracy
- High density of measured points
- The short time required for the acquisition of large amounts of data
- High automation of processing of measured data

Usage

Blom proposes two acquisition methods matching with two different objectives.

For routine control of the dams, Blom recommends terrestrial laser scanning. Terrestrial laser scanning is adapted to survey small areas (less than several sq. km). It offers the smallest costs and allows producing accurate 3D models of the dams. By comparing the 3D models from different time periods (initial survey with latest survey) it is possible to detect any change with the shape of the dams or with its positioning greater than 1 cm. This technique also offers the possibility to estimate the storage capacity of the dam and to monitor the filling.
Airborne laser scanning constitutes the second acquisition method. It is recommended for modeling the industrial reservoir and the surrounding area as part of a risk assessment and the production of risk maps. This is the case when a flood can impact on a village or on a river in the surroundings.

Results and their use in site monitoring

3D modeling for change detection

Volume calculation
Maps series representing the red mud flow over the time (parts of the work of Budapest University of Technology and Economics)
Aerial imagery is the taking of photographs of the ground from an elevated position (in this case, an airplane). After geometrical correction and geographical referencing, the photography can be integrated with other geographic information into an information system; then analysis and modeling can be performed.

Orthorectified photography showing the elements for risk assessment (village of Kolontar, river, aluminium shelter and the reservoirs).

Usage

Using an aerial imagery, geographical features can be digitized and mapped. Features of interest for risk assessment are the reservoirs, the factory, the settlements and the rivers. More generally, the land use is important for risk assessment.

Another use of aerial imagery is the mapping of the industry or factory facilities. This can be required for the documentation of the site (Seveso directive) or simply useful for the management of the site.

Topographic mapping can also be realized from aerial images using stereophotogrammetry techniques. When basic topographic data is required, stereophotogrammetry can advantageously replace LiDAR survey.
Hyperspectral imaging

Hyperspectral sensors look at objects using a vast portion of the electromagnetic spectrum instead of a limited number of bands (red, green, blue and IR). Certain objects leave unique ‘fingerprints’ across the electromagnetic spectrum. These ‘fingerprints’ are known as spectral signatures and enable identification of the materials that make up a scanned object. For example, a spectral signature for oil helps petroleum geologists find new oil fields. Hyperspectral imaging can be successfully used in agriculture, mineralogy, physics, and surveillance.

Fields of application

More and more industries have to or want to demonstrate their environmental responsibility. Blom proposes to use hyperspectral imagery for environmental transparency and its documentation.

As hyperspectral technology has the capability to identify “fingerprints”, it is possible to detect and map the areas where a given chemical is or is not present in the soil.

In the case the fingerprint is negative; the imaging results can be used to demonstrate the good practices and good site management.

If the survey shows some areas are impacted, corrective measures can be taken. Using zonation maps of the impacted area (derived from the hyperspectral survey), it is possible to monitor the removal of impacted soil. After the removal, the company can prove all necessary actions were taken to insure a responsible management of the site and to reduce the environmental impact of its activities.

As a first example, hyperspectral was used for detection and zonation of soil impacted by red mud in Hungary.

As second example hyperspectral was used to detect the areas impacted by the dust coming from a red mud reservoir and transported by the wind and in Croatia.
Thermal imagery

Thermal imagery (also called thermography) uses thermal cameras to detect radiation in the infrared range of the electromagnetic spectrum (roughly 9–14 µm) and produce images of that radiation.

Results

Thermal imaging was used on the reservoir at Kolontar in Hungary. This technology was able to detect a zone of humidity on one dam. This means thermography can detect infiltration of water (not visible for a human eye) and can help to detect weaknesses in a dam structure prior to any other technique.
UAV – fast monitoring of sites

The UAV PAMS system is an ideal alternative to the aerial imagery for surveying small areas in order of few km square. PAMS can provide fully geo-referenced aerial images in RGB or in the near infrared spectrum (NIR) at high resolution between 5-10 cm/px, as well as being used for the creation of orthophotomaps these images can also be used also for generation of DTM. The biggest advantage of PAMS is its high operability, level of cost savings compared to common aerial imagery and shorter delivery time.

Usage

UAV imagery could be used everywhere where aerial images are needed but the area of interest is very small and the use of common aerial imagery is not cost effective.
Environmental assessment

Even though mainly specialized on risk assessment analysis, the world-wide experience of both companies and perfect integration of their abilities is the key to receive integrated “one stop shop” to address your pond stability concerns.

Risk analysis

Risk analysis comprehensively describes the existing and real potential risks arising from the existence of environmental pollution and provides risk management strategy, including corrective measures.

Risk analysis of contaminated areas, the risk analysis process is recommended in cases where there is suspicion of a serious threat or contamination of surface or groundwater or other negative impacts of contamination on human health or individual components of the environment may be present. But the decision on corrective action based on a clearly proven breach of legislation cannot be made. In these cases, the risk analysis has become a crucial professional basis for the process of eliminating the risks associated with contaminated sites.

Risk analysis is conceived as a complex material, usually consisting of the consecutive parts:

- Survey of the state of pollution;
- Assessment of health risks and risks for the individual components of the environment resulting from this contamination;
- Design goals and target parameters,
- Design corrective action and demonstrate how to achieve them, including a proposal of post-remediation monitoring;
- Proposal for corrective measures or comparison of alternative methods of risk reduction or elimination, or. proposal for a feasibility study to assess the best remediation technology,
- Estimate of financial costs and delays of recommended remedial action alternatives (cost-benefit analysis to the degree of risk reduction).

The aim of risk analysis is to describe in detail the existing environment and the real potential risks arising from the existence of environmental contamination and an assessment of their seriousness. Risk analysis should establish corrective actions as part of a risk management strategy.
Risks are assessed with respect to each existing, anticipated or possible way of functional use of contaminated sites and surrounding areas and the range of possible effects of migration and contamination. We assess the transfer to all parts of the environment (soil, deep geological environment, flora/fauna, surface and ground water, air etc.).

Proposed corrective actions, based on the conclusions of the risk analysis, are to be achieved within the site design parameters. The corrective actions and design parameters are usually assessed in compliance with the future usage of the land – i.e. in accordance with the land-use strategy. Design parameters of the remediation target have to be substantiated by a realistic probability of achieving them – Technical, legislative, financial and time aspects must be taken into consideration.

In addition to the land-survey techniques and geophysical methods described earlier, we also have the following specialists:

- Remediation geologist;
- Engineering geologist;
- Geochemist;
- Technologist;
- Human health specialist;
- Air pollution specialist;
- Fauna/flora specialist;
- Hydrogeologist and hydrologist;
- Other professionalist can be provided from our external specialist/foreign sister’s companies.

Our main goal is to provide to the client with an exact scope of work, which is needed for the particular case. The possibility of both companies to draw from a world-wide pool of specialists gives the opportunity to offer every service, which may be required within the mining industry.
To support the risk analysis result and to offer a complete service, we can also provide the following services:

**Geotechnical services**

Geotechnical survey can be used either as a separate survey or serve as a basis for the risk analysis. Geotechnical survey is aiming to define the weakness/changes or every nonstandard state of the dams and levees.

We offer following services:

- Detailed site investigation by experienced geologists and geotechnical engineers to determine possible potential for failure, with in situ and laboratory testing to determine the properties of the foundation materials.
- Assessing of geotechnical integrity of paste backfill;
- Review of the stability of the dam/levees (slope stability analysis);
- Settlement and Seepage analysis;
- We can propose to solve the passive treatment for those levees that may be structural stable, but still have chemical problem.

If issues of concern are found, we can help you to evaluate your risk in more detail and recommend the cost effective solutions based on our extensive experience with mines.
Blom is a leading European service provider within acquisition, processing and modeling of geographic information. Blom maintains unique European databases with collections of maps, images and models. With particular focus on online services, Blom provides data and solutions to customers in government, enterprise and consumer markets and enables partners to create applications using Blom's databases, location based services and navigation solutions. Blom has more than 1,000 employees and subsidiaries in 24 countries. The company headquarter is located in Oslo, Norway. Blom is listed on the Oslo Stock Exchange (ticker BLO).

Among the standard services and products we provide include:

- Aerial imagery
- Development of orthophotomaps
- Creation of technical and thematic maps
- Aerial laser scanning (LIDAR)
- Oblique photography
- Processing of 3D city models and visualizations
- Multispectral and thermal imaging
- Providing data and map services through online geoserver BlomURBEX
- Scanning and digitization of analog materials

This service complements the standard range of services in the field of land surveying, cadastre and terrestrial laser scanning.

Blom holds different technologies with interesting potential for monitoring the industrial sites. This document provides a comprehensive view over the technologies. It details how each technology works, how it is implemented on site, what kind of results can be expected from surveying and how the results can be exploited for the monitoring of industrial sites with reservoirs and can reinforce the safety of the site.

In 2010, BLOM developed an environment related business area, providing service to companies, state administration, regional and local government in the field of flood

---

3D laser scanning  Aerial imagery  Hyperspectral data  Thermal imaging*
management, nature protection, environmental impact assessment, as well as technical assistance for infrastructure projects financed through EU. The company employs 30 experienced staff specialized in scientific, engineering and environmental issues in the following areas:

- Environmental Impact Assessment of projects (EIA)
- Strategic Environmental Assessment of plans/programmes and strategies (SEA)
- Environmental studies,
- Hydrological and hydraulic modeling
- Development of Plans for prevention, protection and mitigation of floods effects

AMEC

AMEC s.r.o. Czech Republic, the local presence of worldwide engineering company, is an engineering and consulting company with a long experience in the field of environmental management and environmental engineering. Since its foundation in 1990 the company has successfully solved hundreds of projects in all sectors of industry, power engineering, transport, commerce, logistics, mining activity, waste economy and other areas. The company employs 15 experienced staff specialized in all relevant scientific, engineering and environmental issues, specialized in the following areas:

- Environmental Impact Assessment of projects (EIA)
- Strategic Environmental Assessment of conceptions (SEA)
- Environmental Impact Assessment of the export and investment in the country of final destination (for EGAP and Czech Export Bank)
- Consultancy support for nuclear sector - periodical safety reviews (PSR), Safety analyses report updates
- Air pollution dispersion studies, expert opinions in accordance with Clean Air Act
- Remediation and reclamation of contaminated land, applied geology and hydrogeology
- Environmental studies, biological surveys, audits and feasibility projects, risk management, noise analysis, expert opinions for the State Environmental Fund and National Property Fund etc.
- Integrated Pollution Prevention and Control (IPPC)
- Ecological management services, environmental audits
- Waste management for companies and towns
- Monitoring of landfill sites
The company operates under the ČSN EN ISO 9001:2008 quality management system and holds international accreditation by LRQA.

Since 2001 AMEC s.r.o (originally as named as INVEST project NNC, s.r.o.) is a subsidiary of British company AMEC, thus we have access to all the sources of such a diverse company when needed.

AMEC s.r.o. is an integral part of the larger AMEC, worldwide engineering company with decades of experience in mining and environmental contamination avoidance and mitigation. AMEC employs approximately 22 000 people in more than 30 countries globally.

With more than 4 000 scientists, geologist, engineers, biologists and other specialists, the success of AMEC is based upon close cooperation between the AMEC subsidiaries – sharing the experience, diversity in knowledge;

- Diversity in experience;
- Extensive experience with a variety of mining projects.

Through its worldwide offices AMEC (paired with BLOM) can provide the full range of services needed to evaluate your containment pond needs. We can perform risk analysis, geotechnical assessments, slope stability and seepage analysis, geochemical analysis, surface hydrology, toxicology etc. We can also help you manage risk in situations where ponds are structurally stable but still have chemical problems.

AMEC’s mining division has offices in nine countries on five continents. AMEC’s Paste and Tailings Group has specialists in mining tailings pond construction, maintenance and risk assessment who can be brought in when needed. In the past ten years AMEC has provided services on more than 1000 mining and metallurgical projects in nearly 80 countries.
CONTACTS

BLOM Czech Republic
Olomoucká 1158/164a
627 00 Brno
Czech Republic
Phone: +420 513 033 050
info.cz@blomasa.com
www.blomasa.com
www.blom.cz

AMEC s.r.o.
Křenová 58
602 00 Brno
Czech Republic
Phone: +420 543 428 311(2)
amec@amec.cz
www.amec.com
www.amec.cz

*The images presented in this frame offer are extracted from the database owned by Károly Róbert College which made on „Red Mud Catastrophe” event by Blom on behalf of order of Károly Róbert College.