srk news
Sustainability focus

Tools for achieving sustainability principles

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Conceptual representation of responsible mining, environmental stewardship, and land rehabilitation. Image generated using AI.

Sustainability expectations continue to influence how projects across the natural resources and infrastructure sectors are evaluated and delivered. To address these expectations, technical teams are looking for tools they can apply directly in project and operational work. This issue brings together articles focusing on some of the tools applied by SRK to achieve the sustainability objectives of our clients — these represent practical approaches used to support analysis, design, measurement, risk evaluation, and governance in real project settings.

In this issue, "tool" is used in a broad sense. Some contributions describe defined technical methods such as quantitative risk methods, modelling tools, projection inputs or analytical workflows. Others focus on structured assessment processes and governance mechanisms that help teams identify risks, compare options, and document decisions in a consistent and traceable way. Across the articles, the emphasis is on application: what the tool is, what it is used for, and how it is applied in practice.

Climate-related tools are presented through two complementary approaches. One describes global climate model outputs and data-driven methods for developing site-specific projections of precipitation, temperature extremes, and drought or wet periods to inform project planning. The other outlines a structured hazard and risk framework for evaluating climate-linked scenarios, estimating likelihood and consequence, and classifying risks to guide adaptation planning.

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Tools for achieving sustainability principles (continued)

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Christina has 20 years of experience working in the mining industry on mine water management projects. She has been involved in all aspects of planning, implementing and reporting on aquatic environment, pit lake and tailings facility projects at mine sites in British Columbia, northern Canada and internatonally. She has worked with regulators and contributed technical expertise to support clients in obtaining new permits, maintaining regulatory requirements and planning for closure.

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Tailings management is addressed through a separate set of risk and governance tools. One article explains the use of cost curves to express life-safety and consequence risk to compare different tailings facilities. Another examines risk-based tailings governance tools and the use of independent tailings review boards as oversight mechanisms to support consistency and accountability in tailings management.

A further group of articles focuses on decision-support and due-diligence tools. Multiple Accounts Analysis is presented as a structured method for comparing project alternatives. Cumulative impacts assessment is described as a tool used to evaluate combined effects beyond single-project boundaries. A collaborative human rights assessment approach is set out, involving a structured method used to identify who may be at risk, how impacts may occur, and where and when exposure may arise.

Water resource tools form another core theme. Articles describe water usage benchmarking, water stewardship approaches, and methods framing water as a material operational and sustainability factor. Technical contributions examine integrated surface water–groundwater modelling at catchment scale and the development of hydrogeological conceptual models as a foundation for water assessments, model design, and interpretation. Operational design approaches — including waste rock co-disposal — are also presented as tools with environmental performance implications in the realm of water quality.

Environmental and renewable energy projects are addressed through applied modelling and assessment tools used for siting and impact evaluation. One case study describes habitat modelling to inform design - as one of the first wind farms planned in its region, the project serves as a reference case for integrating biodiversity science into infrastructure siting through spatial analysis. Additional articles cover environmental noise software tools and visual impact assessment tools, including glare and shadow flicker modelling.

Measurement and accounting tools are addressed through an article on greenhouse gas inventory development. The contribution outlines practical challenges commonly encountered in emissions accounting — including data quality, boundary definition, and consistency across diverse operations — and describes structured calculation workflows that support standardized emission factors and alignment with established reporting frameworks.

Taken together, these articles present sustainability tools as working components of technical practice across geoscience, engineering, environmental, and social disciplines. The contributions emphasize method, transparency of assumptions, and practical application across different project stages and operating contexts. The focus throughout the issue is on how tools are applied and interpreted in practice, so their relevance can be considered in planning and operational decision-making.

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Independent review in tailings management: driving trust

AGA Brazil ITRB and site, corporate and EOR teams at a tailings facility, collaborating to strengthen safe, sustainable operations.

As tailings governance evolves from a regulatory expectation into a core pillar of corporate sustainability, mining companies are increasingly turning to Independent Tailings Review Boards (ITRBs)—not just as a Global Industry Standard on Tailings Management (GISTM) compliance mechanism, but also as a strategic tool for better technical decision-making and risk management. The value of an ITRB lies in how the board operates within the framework of the mine operation.

The ITRB model works best when the board functions as an advisor, not an auditor. At its core, effective technical review is a relationship-driven process—one built on trust, transparency, and respect for roles and expertise. The experience of AngloGold Ashanti (AGA) ITRB in Brazil illustrates how this approach works in practice.

Over three years of engagement, the ITRB for AGA Brazil—composed of representatives from SRK's Vancouver, Argentina, and Brazil offices—has developed close working relationships with site technical teams and with the Engineer of Record. These relationships do not compromise objectivity; on the contrary, they enhance the board's ability to support the teams. When those most familiar with the challenges are empowered to share their work openly, the ITRB can provide real value: identifying overlooked conditions, testing and validating assumptions, and flagging concerns in a constructive manner. Continuity is key.

This approach has led to meaningful results across AGA's Brazilian facilities. The ITRB has supported dam de-risking efforts and stability enhancement for legacy tailings facilities, as well as filtered tailings implementation for new facilities. In some cases, the board has guided more rigorous evaluations of failure modes and loading conditions that extended beyond local legislative requirements, materially improving risk understanding and mitigation.

Jurisdictions around the world are increasingly aligning with frameworks like the GISTM and Towards Sustainable Mining. But standards alone do not deliver results. How companies integrate independent review into their governance structures is critical: through mutual respect, technical engagement, and consistent dialogue.

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Michael has 15 years of experience in mine water and tailings management, specializing in risk-informed design strategies across the mining lifecycle—from scoping and permitting to operations and closure. His expertise includes tailings and water management systems, dam design and safety reviews, risk assessment, mine closure planning, hydrometeorology, climate change adaptation, and water balance and quality modeling. He also supports permitting and environmental compliance.

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In Brazil, where the memory of recent dam failures continues to shape public trust, this ITRB model is proving its worth. But the lessons apply globally: sustainable tailings management depends not just on good engineering, but on good process, robust governance, and respectful engagement.

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Enhancing tailings governance through risk-based tools

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Holly has over 10 years of international experience in mine waste management and mine closure. She specializes in the application of data science and statistical approaches to incorporate risks and uncertainties into mine waste studies and designs. Her experience includes tailings facility designs (from site-selection and alternatives assessments through to detailed design and construction oversight), dam break assessments, water balance studies, mine reclamation and closure designs, and risk assessments.

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ADAM LEIK

Adam is a senior geotechnical engineer with over eight years of experience in geotechnical and geoenvironmental projects worldwide. He specializes in mine waste management throughout all stages of the mining cycle, from conceptual design to closure, with expertise in site characterization, engineering design, numerical modelling, and risk assessment. Adam's recent work includes a portfolio-level semi-quantitative risk assessment of more than twenty tailings storage facilities.

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SRK has developed and applied a suite of risk-assessment tools that integrate with clients' existing processes. They give operators a clearer understanding of tailings storage facility (TSF) risks, a consistent way to compare facilities, and practical basis for directing time and capital to where they will reduce risk the most.

Examples include:

- A rigorous process for identifying risks and potential failure modes.
- Development of a benchmarking tool for assessing risks across TSF portfolios.
- Quantitative risk assessments (QRAs) to better characterise site-specific risks and uncertainties.

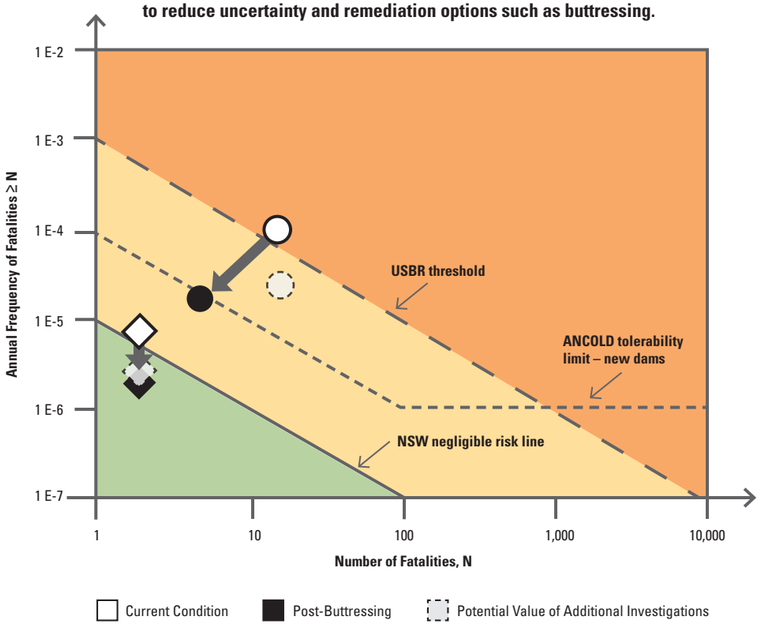
Risk Identification Process

Because many historical failures result from a combination of "unforeseen" events, often due to normalization of deviance over time, SRK conducts structured workshops where participants systematically review initiating events, hazards, and conditions, relevant or not, and explore how these could interact to cause failure. Having been applied at over 50 TSFs, this process consistently uncovers previously overlooked failure modes and hazards, providing a more comprehensive and defensible foundation for risk management.

TSF Risk Benchmarking Tool

SRK has developed a benchmarking tool that uses key performance indicators (KPIs) to estimate the probability of TSF failure. These KPIs include both quantitative inputs, such as design flows and safety factors, and qualitative inputs, such as material characterization quality. The tool is most effective when applied to a client's entire portfolio, as it generates plots comparing failure probabilities across multiple facilities and global benchmarks. The tool also converts all consequences into equivalent dollar values, allowing for a direct comparison of risks across a portfolio. This helps clients prioritize resources for maximum risk reduction, even when risks are driven by qualitative consequences such as environmental, health, or social impacts.

Example results comparing potential value of additional investigations to reduce uncertainty and remediation options such as buttressing.



Some TSFs are riskier than others; SRK's in-house tools help quantify how much riskier. Image generated with AI.

Quantitative Risk Assessments

TSFs are generally required to meet deterministic factor of safety (FOS) thresholds to be considered "safe." However, many facilities do not meet these standards and require remediation measures (e.g. buttressing). Deciding which facilities to prioritize can be challenging. QRAs consider the uncertainties underlying FOS estimates, often producing very different failure probabilities even when FOS values are identical. In one case study, the QRA results showed high value in performing additional investigations, not because they change the true underlying risks, but because they improve understanding enough to significantly reduce buttress-size requirements.

Clear communication is as important as the analysis itself. Deliverables from these tools range from detailed failure-mode registers and schematics linking monitoring activities to TSF safety, to portfolio-level visuals that are easily digestible and actionable for decision-makers. Together, these tools strengthen risk governance, improve accountability, and enable operators to demonstrate measurable progress toward sustainable tailings management.

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Multiple accounts analysis – a decision-making tool for project assessment

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Not all tailings deposition alternatives are created equal - and knowing which one is best for a project is not always straightforward given the multiple factors that need to be considered. Fluctuations in commodity prices, the need to reduce water consumption, and evolving regulatory requirements have prompted mining companies to develop adaptable tailings management alternatives. These may include new facilities, embankment raises or alternative technologies. Furthermore, the Global Industry Standard on Tailings Management publication in 2020 highlights the importance of conducting multi-criteria alternatives analyses to minimise risks to people and the environment for a facility's entire lifecycle.

To address this need holistically, the authors applied a Multiple Accounts Analysis (MAA) tool, which integrates technical, environmental, economic, and socio-economic considerations. This approach enables technical specialists to communicate key engineering factors while allowing stakeholders to provide input to the decision-making process based on their values and priorities.

An MAA involves developing a multiple accounts ledger that explicitly identifies the technical, environmental, economic and socio-economic elements that differentiate alternatives. This ledger consists of sub-accounts (evaluation criteria) and indicators (measurement criteria), which are scored and weighted to complete the evaluation. Sensitivity analyses are also conducted to evaluate the robustness of the preferred alternative. This involves considering a range of weightings that are representative of the disparity perceived by stakeholders throughout the evaluation process.

In the authors' experience, the MAA has been successfully applied across different regions, site conditions, commodities, and project stages. A structured series of workshops helps facilitators, mining personnel, and stakeholders to establish a shared understanding of each factor's relevance and provides a valuable opportunity to build consensus around the preferred tailings deposition alternative. Effective workshop facilitation can make the difference between a good and a great MAA outcome. Considering all stakeholders enables the nuances of each alternative to be truly exposed and evaluated.

The following cases illustrate the method's relevance, adaptability, and complexity:

Case A: For a lithium project in northern Argentina under extreme arid conditions, the MAA was used to select the preferred location for a ~25 km² spent brine evaporation pond and determine the optimal sequencing to accommodate forecasted production. Due to the large size of the facility, modular construction using crystallized halite extracted from the impoundment area was identified as the preferred solution. This modular construction enables subsequent cell designs to be optimized, taking advantage of increasing knowledge of the facility's performance (especially the amount of infiltration and spent brine evaporation) and the availability of crystallized halite for constructing the embankments.

Case B: At an operating gold mine in Nicaragua under water-surplus conditions, the MAA guided the selection of the preferred alternative for expanding tailings storage capacity. Options included different technologies, raising the existing dam, constructing a new dam, or using multiple in-pit facilities. Slurry deposition in a new in-pit facility emerged as the preferred solution due to the short time required for permitting, constructing and commissioning the facility, the reduced risk of tailings release due to the absence of dams, the low CAPEX and OPEX costs, the flexibility for future expansions, and the opportunity for integration with closure planning.

Case C: At a gold-silver mine in southern Argentina, the MAA was used to determine the preferred alternative for tailings storage expansion. Alternatives included raising the existing TSF, constructing a new dam, implementing a central thickened deposition (CTD) strategy at the existing TSF, and in-pit deposition. Upstream raising of the existing TSF was picked as the preferred option, with CTD and in-pit deposition identified as opportunities for integration with future Life of Mine (LOM) expansions and closure planning.

The MAA enabled the identification of preferred solutions by balancing cost-benefit considerations with overall project risks and uncertainties, while providing the operational flexibility required to increase tailings storage capacity, in line with future LOM expansion and closure planning.

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MARÍA DEL PILAR RICO

María del Pilar has over four years' experience and has participated in several mining projects, particularly those involving non-conventional tailings deposition methods such as filtered tailings dry stacking and co-disposal/co-mingling alternatives. Her experience includes early-stage mining projects development, operational support, and the development of deposition strategies for tailings storage facilities, tailings alternatives assessments, GISTM compliance, independent reviews and due diligence, among others.

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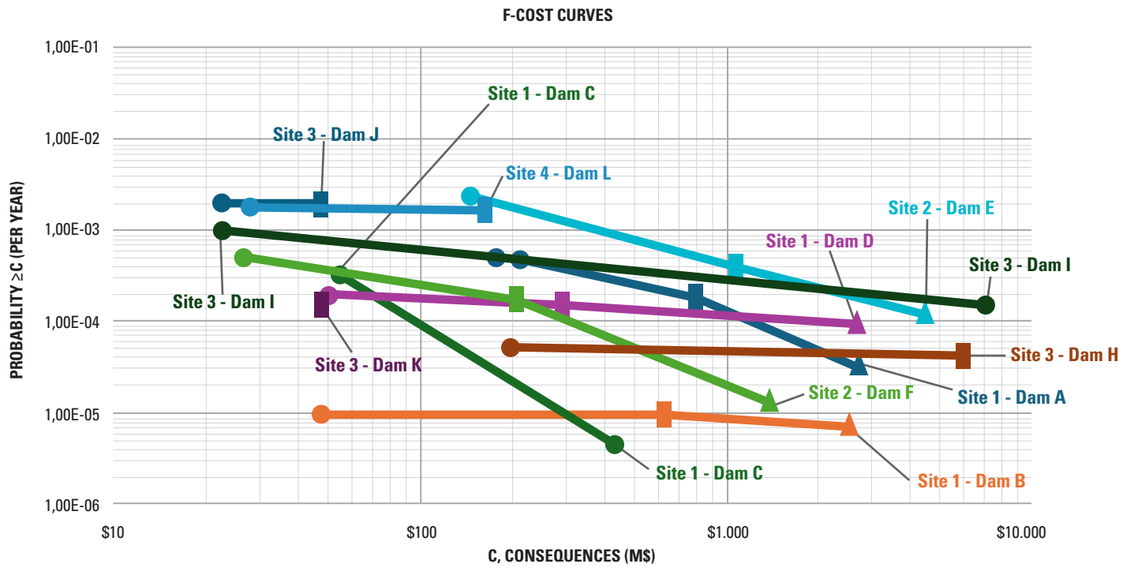
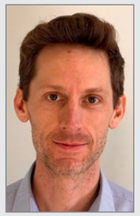
Current construction of the spent brine evaporation pond using crystallized halite.

Using F-N and F-Cost curves for tailings dam risk quantification and prioritization

Figure 1: F-Cost curves for the 12 TSFs in the assessed portfolio (site and dam identifiers anonymized).



CESAR OBONI



Cesar is a senior quantitative risk analyst with over 15 years of experience in probabilistic and reliability-based assessments for mining and infrastructure. He has evaluated consequences and risks for more than 40 tailings storage facilities worldwide and co-authored over 45 technical papers. His work focuses on integrating probability, consequence, and cost–benefit logic to support ALARP and risk-informed decision making. He co-authored Tailings Dam Management for the Twenty-First Century.

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Sustainable tailings management often depends on directing finite capital to where it most reduces overall portfolio risk: not only life-safety, but also environmental, social, and reputational impacts, in line with the spirit of the Global Industry Standard on Tailings Management. SRK recently completed a semi-quantitative tailings storage facility (TSF) risk assessment for a client with operations across North and South America. Tailings dam risks were initially evaluated using the client's corporate, TSF-specific risk matrices and F-N curves, which plot the annual probability of failure (F) against the potential loss of life (N) to guide risk tolerability.

While F-N curves are a valuable benchmarking tool for fatality risks, they do not on their own support prioritization and capital allocation across the TSF portfolio. Their focus is narrow: capturing only fatality-risk through Potential Loss of Life (PLL) estimates and excluding environmental, legal, and reputational impacts. Their exposure assumptions also distort comparison: PLL accounts for population exposure, so calculated fatality risk falls when fewer people are present, whereas environmental impacts are fully exposed (effectively 100%) and can therefore be underrepresented when non-safety consequences dominate. F-N curves also overemphasize rare extremes: a catastrophic dam breach can appear more critical than a dam experiencing frequent, localized failures that release tailings to the environment. Yet the latter may represent a higher overall risk in expected annual terms, with greater implications for long-term sustainability.

To overcome these limitations, SRK broadened the framework along three lines. The assessment extended beyond life-safety to the consequence types listed above. Annual probabilities of failure (without exposure adjustment) were used for all consequence types, while PLL remained the basis for life-safety. A financial proxy then expressed every consequence in monetary terms, allowing consistent comparison across sites and categories; integrating the F-Cost curve yields the total risk as expected annual financial loss.

In practice, this dual framework provides a defensible life-safety benchmark together with a financially grounded measure for portfolio prioritization, weighing catastrophic-but-rare failures against recurring mid-level risks that quietly accumulate higher expected annual losses, and aligning risk management with broader sustainability objectives.

Figures 1 and 2 illustrate the outcome for the assessed portfolio of 12 TSFs across four sites. The F-Cost curves plot the annual exceedance probability against total expected loss (M$) on a common monetary scale; the resulting treemap then makes immediately visible that two TSFs together account for roughly two-thirds of portfolio risk, sharpening where capital allocation has the greatest impact.

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Ryan is a senior geotechnical engineer at SRK in Vancouver with over 13 years of experience in civil and geotechnical engineering. He specializes in tailings and mine waste management, risk assessment, and dam safety reviews. Ryan has contributed to projects across Canada, Australia, Chile, Brazil, Mexico, and the USA. He holds a BEng (Hons) in civil engineering from the University of Western Australia and an MEng in geotechnical engineering from the University of British Columbia.

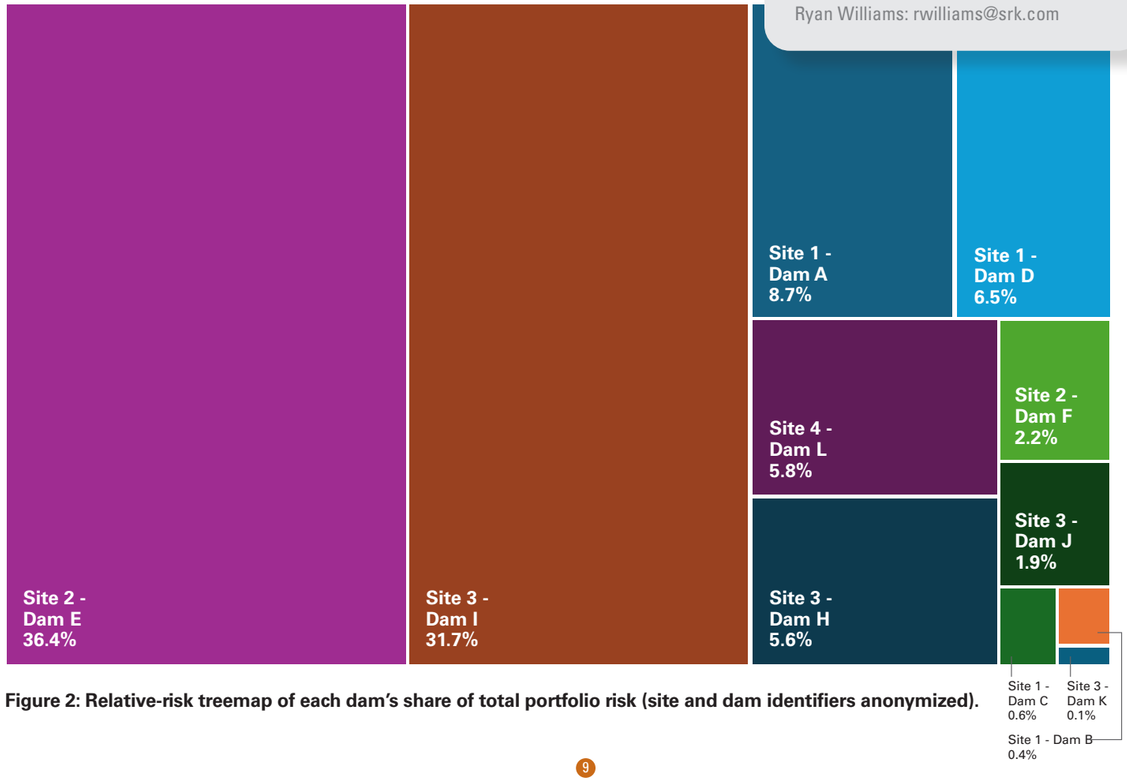

Figure 2: Relative-risk treemap of each dam's share of total portfolio risk (site and dam identifiers anonymized).

Human rights: de-risk and drive investment

ALICE EVANS

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Understanding and managing actual and potential human rights risks is an increasingly important component of project development and operation. SRK has developed a Human Rights Assessment (HRA) tool (process shown in the figure below) to support multidisciplinary collaboration and support identification of who may be at risk, and how, where, and when impacts may occur. Drawing on practical examples, the article highlights how the HRA tool has supported informed project or operational decision making.

Prioritising Risks and Informing Resource Allocation: The HRA conducted for GoviEx Uranium's Muntanga Project in Zambia identified risks that needed to be elevated in priority, with additional risk controls being incorporated into the feasibility study design.

Alignment with International Standards: An HRA approach was applied to assess human rights risks at Norsk Hydro's legacy tailings facilities in Germany, helping to ensure compliance with Requirement 1.1 of the Global Industry Standard on Tailings Management.

Improve Business Confidence: Investors increasingly consider environmental and social performance when making decisions, with growing emphasis on evidence that human rights are being addressed in projects. Organizations that prioritize human rights and address reputational risk may be better positioned to meet the expectations of customers, investors, and prospective employees.

Linking Environment, Health and Safety, and Human Rights Functions: The outputs of the HRA can be integrated into existing management systems and business functions. For example, with support from SRK, one project incorporated human rights considerations into internal air quality and noise technical standards.

With increasing legislation, voluntary performance standards, and disclosure requirements linked to rising expectations from investors and society, understanding human rights impacts at all stages of a mine's life cycle is increasingly critical. Recognising how mining activities may affect human rights—and embedding mitigation measures into business practices and decision-making—is the hallmark of a responsible company. The HRA approach provides a structured framework to support these efforts.

The results can be embedded into existing risk management systems and used to demonstrate outcomes to interested stakeholders. As access to capital tightens and investor scrutiny increases, companies that integrate human rights with environmental, health and safety, and corporate social responsibility functions may be better positioned to strengthen their social licence to operate.

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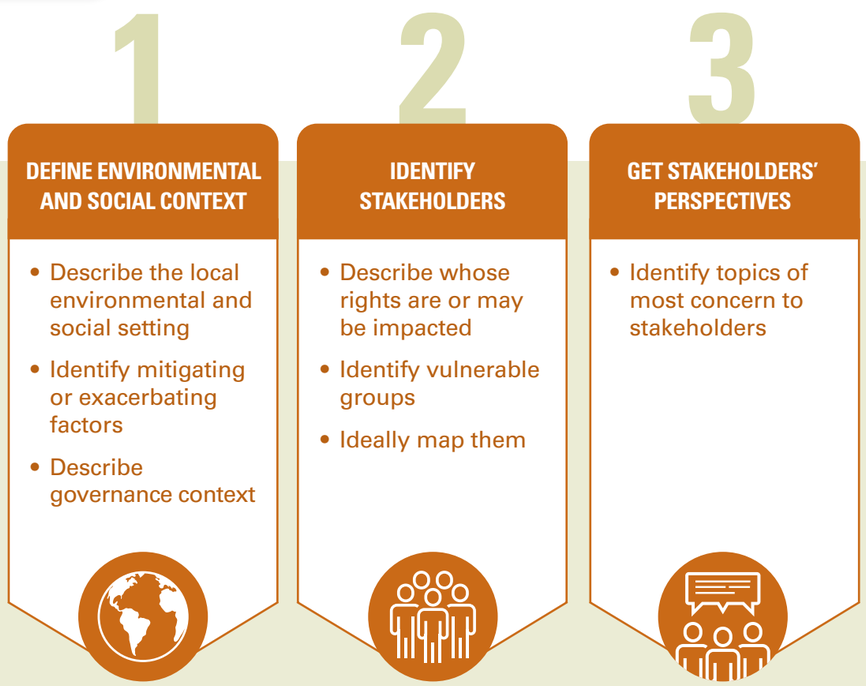
The stages of SRK's Human Rights Risk Assessment Tool.



Responsible mining in Central Asia: case studies in alignment

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Central Asia is a region rich in minerals, with countries such as Kazakhstan, Kyrgyzstan, Uzbekistan, and Tajikistan boasting significant reserves of gold, copper, uranium, and critical minerals. As global demand for these resources grow, the region faces both opportunities and challenges in ensuring mining activities align with responsible mining principles. In response, governments and operators are embedding sustainability into their mining practices and adopting global leading international frameworks, including the International Council on Mining and Metals' Mining Principles, the Global Industry Standard on Tailings Management, the Responsible Gold Mining Principles (RGMPs), and the International Cyanide Management Code (ICMC).

Across Central Asia, lenders' requirements and evolving regulations are proving to be powerful catalysts for change, driving the regional mining industry towards greater responsibility. Access to development finance and international bank facilities are now closely tied to demonstrable ESG performance. Financial institutions and export credit agencies increasingly require companies to implement structured roadmaps, to undergo independent audits, and to provide verifiable progress reports. This trend is reshaping corporate strategies, embedding sustainability into core business models, and accelerating the adoption of best practices in governance, safety, and community engagement.

A notable example comes from Uzbekistan's Navoi Mining and Metallurgical Company (NMMC)—one of the world's largest gold producers—which illustrates a shift from commitment to demonstrable progress. As part of its transformation program and financing requirements with international lenders, NMMC initiated steps to align with the RGMPs and ICMC. SRK supported this process by developing time-bound implementation roadmaps and conducting an independent audit to assess the company's readiness and progress toward compliance. The review evaluated management systems, governance arrangements, site-level practices, and corrective actions required to align operations with international standards.

This structured roadmap approach—linking lender covenants, public reporting and third-party review—has emerged as a credible template for other regional operators, reassuring stakeholders of the industry's commitment to sustainability.

A second example relates to cyanide stewardship, with JSC "AK" Altynalmas' Pustynnoye mining and metallurgical complex achieving ICMC certification in August 2024. This followed an independent audit against International Cyanide Management Institute's Mining Operations Verification Protocol. This certification sends a strong regional signal that mining operations can meet the Code's stringent criteria, and underscores the Pustynnoye complex's commitment to responsible mining practices and environmental stewardship.

These examples show that Central Asia's mining sector is seeking alignment with internationally recognised responsible mining standards, offering a positive outlook for a more sustainable future. Their progress reflects a broader regional shift toward frameworks that prioritise environmental stewardship, social responsibility and transparent governance.

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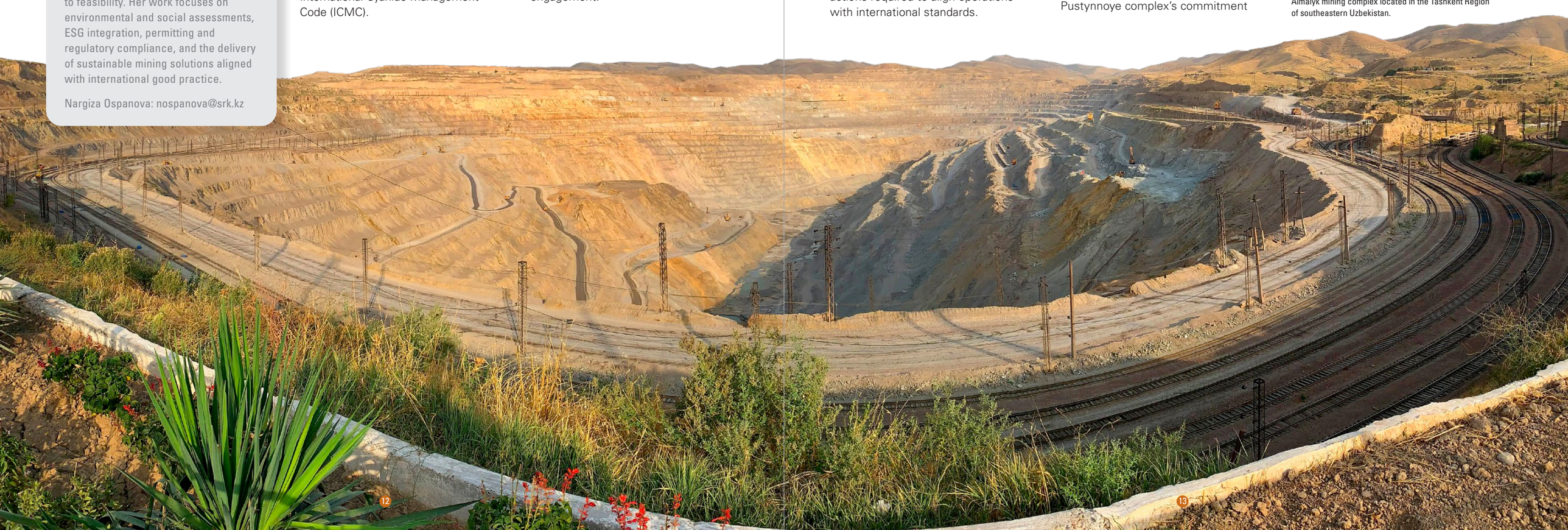
Almalyk mining complex located in the Tashkent Region of southeastern Uzbekistan.



Mining challenges in a changing climate

CARLA GUZMÁN

Carla is a civil engineer with a major in hydraulic, sanitary and environmental engineering. She has over 12 years of experience as a hydraulic civil engineer in the mining industry and has contributed to numerous multidisciplinary projects involving water resources engineering, water management planning, climate change assessment, hydraulic and hydrological modelling, R analytics, and water balance modelling.

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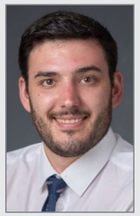

Joss holds an MSc in hydrology. He has over four years of experience in the mining and environmental sectors and has contributed to multidisciplinary projects involving climate change assessments, hydrological and water balance modelling (ACRU, PCSWMM), GIS and R analytics, urban runoff studies, and wetland assessment using remote sensing.

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Climate variability and long-term climate change are critical drivers of hydrological risk. Establishing a robust, representative historical climate baseline is therefore a necessary first step. A clear baseline defines a site's natural variability, seasonal cycles, and the frequency and magnitude of extreme events. It provides the foundation for calibrating and validating models used for water balances, diversion systems, and tailings design and management.

At sites where increased water is projected, potential risks include the need for enhanced treatment, flood prevention, and revisions to diversion and storage infrastructure. This is particularly relevant for tailings facilities that may receive higher peak volumes. Conversely, where reduced water availability or more frequent droughts are anticipated, these conditions may require sites to source alternative supplies, increase storage recycling capacity, and optimize water use, while managing impacts on processing, washing, and transport. Water scarcity can also heighten community tensions and environmental pressures that disrupt operations.

By combining multiple data sources—including on-site gauges, regional networks, quality-controlled reanalysis and satellite products—and applying bias correction to climate models, SRK delivers a comprehensive, defensible climate baseline. A key focus is

Figure 1: Polar plot of daily temperature ranges.

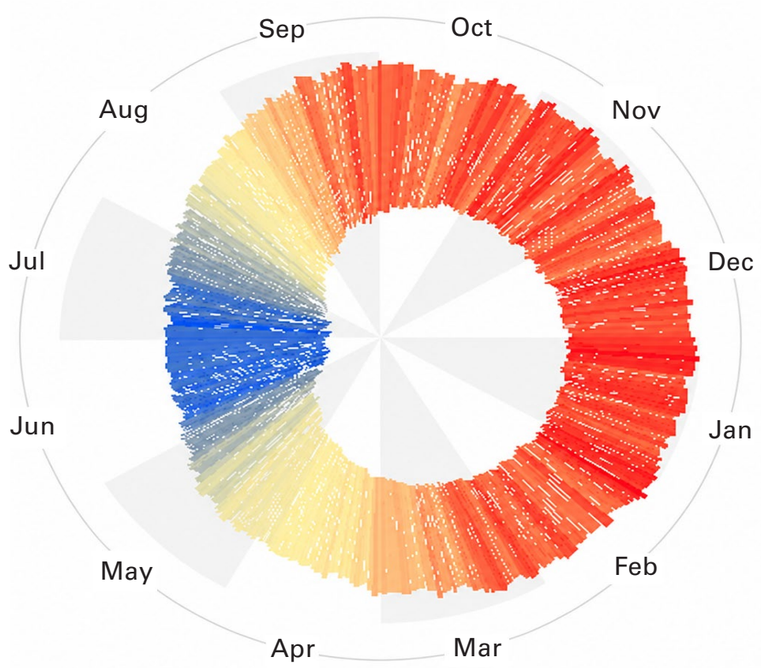
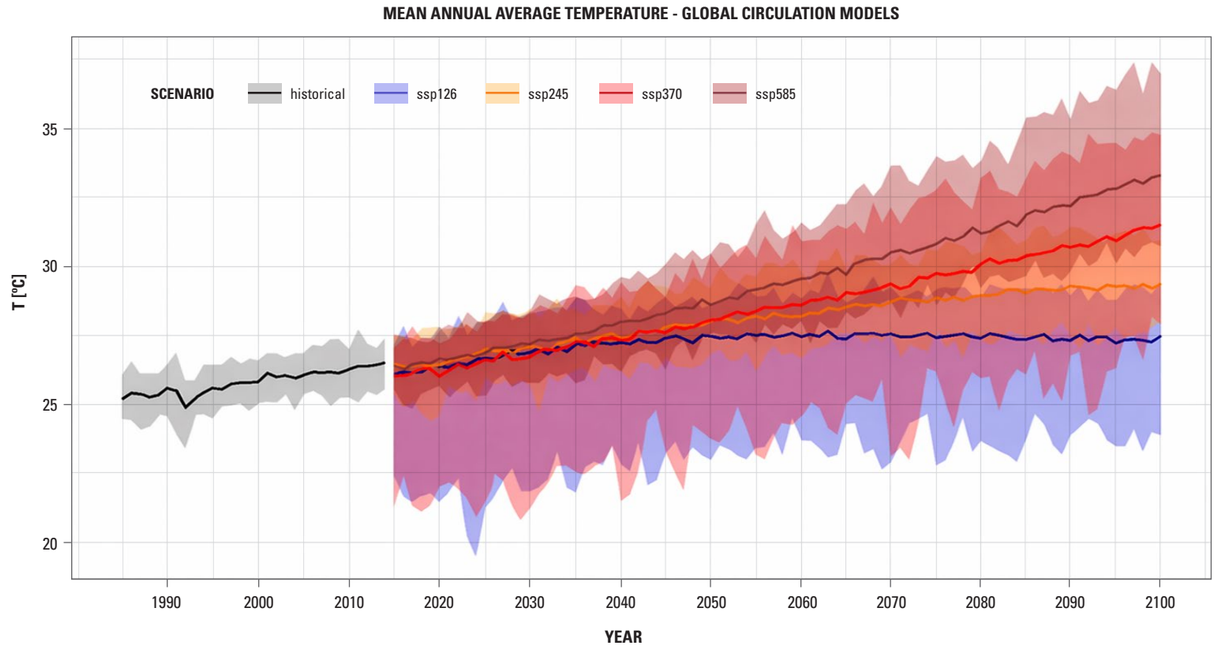


Figure 2: Mean annual average temperature based on climate change scenarios in a particular site.



presenting the data in a clear, concise and easily interpretable manner. An example is presented in Figure 1, which indicates the average daily temperature range throughout the year. A well-documented baseline is also a requirement of Global Industry Standard on Tailings Management and of many lenders.

Once a robust climate baseline has been established, climate change projections can be used to assess whether water availability at the site is likely to increase or decrease. Using the latest Global Circulation Models and data science tools, (an example is presented in Figure 2) SRK develops site-specific climate projections for mining projects, quantifying changes in precipitation patterns, temperature extremes, droughts and wet periods, heat waves, and other relevant meteorological variables. Understanding the potential future variations in climate is vital for risk assessment and for the resilient, safe design, operation, and closure of mining projects.

In an uncertain future, one certainty remains: the climate will continue to influence water availability at mines and their ability to use this vital resource. To minimize risks and strengthen resilience, it's essential to adapt proactively rather than reactively—considering environmental, social, and economic factors. SRK's climate change specialists work closely with multidisciplinary teams to provide defensible climate scenarios and a clear understanding of associated risks. This collaboration ensures that clients receive comprehensive guidance to identify, assess and minimize risks, ultimately leading to safer and more resilient mining operations in the future.

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Adapting mining operations to climate change: risk analysis framework

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Andreina is a civil engineer with over five years of professional experience. She has worked on urban sanitation projects and, since joining SRK, has diversified her responsibilities across various mining projects. Andreina has contributed to the design of mine-waste storage facilities for conventional tailings and spent brine. Her experience has also led her to take part in audits and mine closure plan design. She has additionally participated in environmental management projects that incorporate climate change considerations into their analyses.

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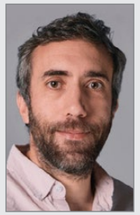

Dr Juan Mussat is a senior civil engineer with over 10 years of experience in structural and geotechnical seismic engineering, structural dynamics, and natural hazards risk analysis. He holds a PhD and has expertise in vibration monitoring, numerical analysis, and system identification. He has also contributed to assessing the resilience of critical infrastructure, including evaluating a nuclear power plant's resistance to tornado hazards and analysing risks associated with climate change scenarios.

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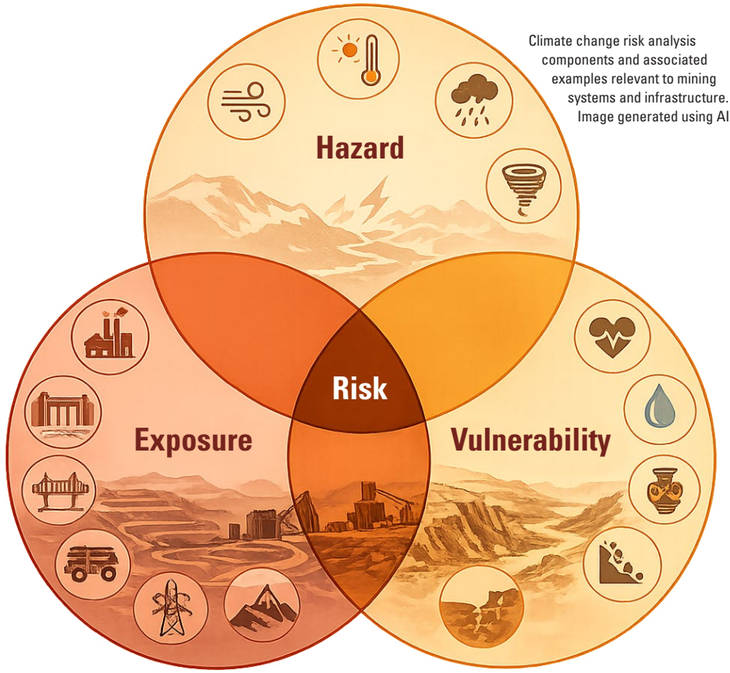
Climate change poses challenges to the mining industry. It can impact the conditions at mining sites, both during operations and post-closure, and affect host communities and the environment, increasing the complexity of stakeholder interactions. This makes proactive climate change risk studies essential to strengthen resilience and adaptive capacity. While climate change can give rise to both physical and transition risks, this article focuses on assessing and managing physical risks.

A physical climate change risk analysis for a mining site typically involves three steps: (1) a site-specific climate change study to characterize chronic and acute physical hazards; (2) assessment of physical climate change risks and opportunities; and (3) prioritization of action plans to develop and implement adaptation measures to improve climate change resilience.

Climate change characterization includes analyzing the site's meteorological conditions and how they evolve over representative time intervals (e.g., 30-year periods) extending to the end of the 21st century. Based on climate change projections, as described in the article, "Mining challenges in a changing climate", environmental and social studies, design reports, management plans, and technical documentation, characterize the site's exposure and vulnerability to physical hazards related to climate change. Project components are then classified according to spheres of influence, ranging from full-control to no-control: mining activities and infrastructure, uncontrolled infrastructure and supplies, external supply chains, and the communities of interest and the natural environment.



Climate change risk analysis components and associated examples relevant to mining systems and infrastructure. Image generated using AI.

At SRK, a multidisciplinary team analyses hazard scenarios to identify consequences and probabilities, followed by the risk categorization. Individual risks are grouped to plan adaptation strategies. For physical hazards linked to climate change, consequence categories may include impacts on the mine's reputation, the need to review infrastructure design, and the potential for increased operational interruptions or delays.

The accompanying Figure 1 summarizes a risk register by sphere of influence and consequence category, illustrating how risks and opportunities are distributed in a case study.

Adaptation strategies require active stakeholder involvement to integrate diverse perspectives into design reviews, operational procedures, and updates to control and monitoring plans. They should prioritize a holistic, site-wide approach rather than focusing solely on individual facilities, considering a range of potential climate scenarios.

It is also important to recognize that key risks may lie beyond a mine's direct control, with catchment-wide water resource management often emerging as a critical priority. The inherent uncertainty of climate projections highlights the need for sustained stakeholder engagement, multidisciplinary input, periodic plan reviews, and complementary studies to support the long-term resilience of the design.

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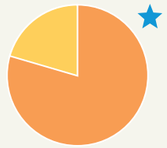
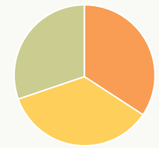
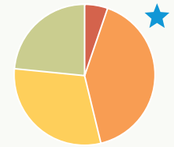
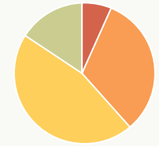
Figure 1: Example of risk categories and opportunities distribution based on spheres of influence and consequence category.

Consequences / Spheres of influence	COI and Natural Environment	External Supply Chain	Non-controlled inputs	Mine infrastructure and operations
Reputation				
Infrastructure design review required				
Potential disruptions or delays in operations				

RISK CATEGORY Low Medium High Very High

Opportunity

Implementing GHG accounting in practice

DHIREN NAIDOO

Dhiren has 18 years of experience working in decarbonisation and air quality. He holds ISO 14064-3 (GHG verification) certification and has delivered projects across Africa, the Middle East, Europe, North America, and Australia in sectors including mining, energy, waste management industry, and oil and gas. Dhiren specialises in GHG accounting, verification, mitigation, and net-zero planning, as well as air-dispersion modelling, emissions licensing, and air-quality impact and management assessments.

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Since 2011, SRK has provided greenhouse gas (GHG) accounting services to the mining industry, supporting clients in their decarbonisation efforts. To foster sustainability within the company and its service offerings, it began conducting its own GHG accounting to better understand the practical application of GHG accounting principles.

SRK started reporting Scope 1 and 2 emissions in 2022, covering fuel use, generators, air conditioning, refrigeration, and office electricity. This established an emission baseline and highlighted data and reduction opportunities. In 2024, Scope 3 accounting was trialled across nine relevant categories; since 2025, it has formed part of the annual GHG inventory.

In establishing SRK's carbon footprint, challenges familiar to many mining companies were encountered, including issues with data quality, boundary definition, and consistency across diverse operations. In response, the company developed GHG accounting tools to automate data input, apply standardised emission factors, and support alignment with the GHG Protocol and ISO 14064.

Through developing its internal GHG inventory, SRK gained practical experience in emission accounting, factor development, and reporting frameworks. This hands-on experience provided additional insight into the application of these approaches in practice. Development of these internal tools now enables SRK to establish comprehensive inventories for mining projects, processing facilities, logistics, and supply chains, encompassing all emission scopes.

The next step in this journey is SRK's decarbonisation framework, with emission-reduction targets to guide operations—including transitioning to low-emission vehicles, adopting renewable energy, and embedding sustainability throughout its offices and projects. This will further enhance understanding of the practical considerations associated with implementing emissions-reduction measures and decarbonisation strategies internally, while providing insight into the industry's own challenges.

Looking ahead, SRK aims to align its corporate and client-focused decarbonisation strategies with international best practices. By integrating sustainability across its activities, the company continues to develop data-driven approaches that reduce emissions, improve efficiency, and advance low-carbon mining alternative solutions.

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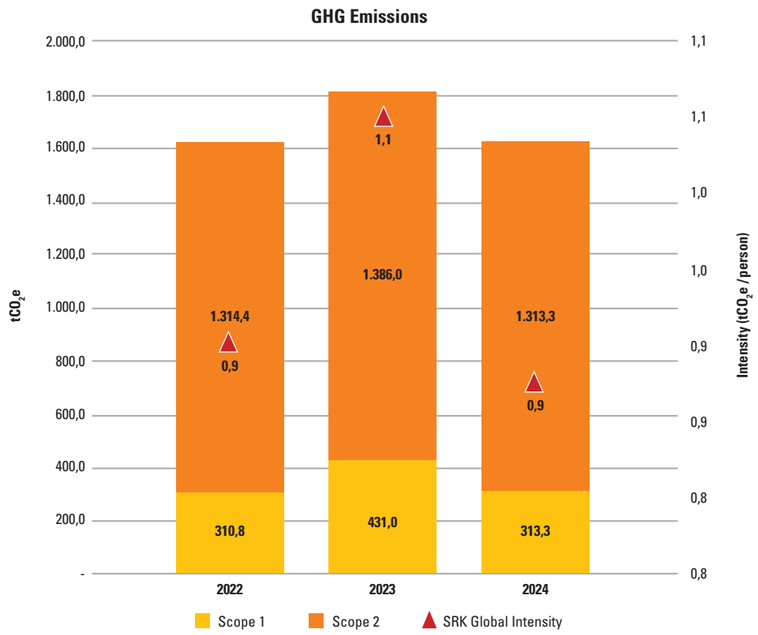

Co-disposal as a tool for sustainable mine water management

Managing poor-quality water from mine wastes is one of the biggest challenges facing mining companies globally. Management tools can be classified along a spectrum. At one extreme, strategies attempt to shut down leaching processes, often leading to the incorrect assumption that the site can be completely abandoned. Examples of these strategies include subaqueous disposal using impoundments and the placement of liners. At the other extreme, there can be reliance on water treatment, which requires conveyance and storage of contaminated water and management of treatment residuals.

Between these extremes are tools that reduce source leaching but ensure a continued site presence to allow for long-term monitoring and maintenance. An example of such a tool is co-disposal (blending) of waste rock classified as potentially acid generating (PAG) and non-PAG so that the resulting mixture behaves as non-PAG. When properly executed by scheduling placement to achieve intermingling, acidification of the PAG components can be prevented in perpetuity, thereby eliminating the high concentrations of metals associated with acid rock drainage. There is no reason these conditions cannot be sustained indefinitely.

Weathering processes will continue at low rates, but leaching may occur at levels low enough that either drainage treatment to achieve acceptable concentrations for discharge is never required, or semi-passive water treatment technologies can be used. These management measures may require a limited ongoing site presence but, importantly, conveyance and storage of highly contaminated acidic water can be avoided.

SRK has been working with several clients to implement co-disposal of PAG and non-PAG waste rock, with a focus on the mining approaches required to achieve effective intermixing.

The scale at which mixing needs to occur is based on theory[1] and has been demonstrated to prevent acidification at small scales, which is the ultimate objective[2].

(1) https://doi.org/10.1144/geochem2021-066

(2) https://bc-mlard.ca/files/presentations/2023-19-DAY-DONKERVOORT-waste-rock-geochemical-management-practices-teck.pdf

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STEPHEN DAY

Stephen is a corporate consultant based in the Vancouver office, specializing in mine-waste geochemical characterization, development of waste-management concepts, and water-chemistry prediction. He has spent more than 25 years advancing waste-rock co-disposal concepts, from field-scale demonstrations of the theoretical basis to collaboration with mining companies in designing and implementing full-scale systems.

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Strategic blending of PAG and non-PAG waste rock to prevent acid rock drainage and reduce treatment needs.

Water stewardship in the mining industry

LINDSAY SHAND

Lindsay is a partner and a registered principal environmental geologist and hydrologist, as well as an AWS-credentialed specialist, based in SRK's Cape Town office. She has over 25 years of experience in water stewardship, environmental water management, including baseline monitoring, environmental site assessment and remediation of sub-surface contamination. Lindsay has managed a wide range of projects across South Africa, Mozambique, Zambia, Eswatini, Namibia, Nigeria and Ghana, with particular expertise in water stewardship and long-term surface and groundwater-monitoring programs related to groundwater abstraction and its associated impacts.

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According to the EY Top 10 Business Risks and Opportunities for Mining and Metals report of 2025, water stewardship is receiving increasing scrutiny from investors. Many mining companies have set targets and commit to advancing water stewardship, including disclosure to stakeholders.

Mining companies, investors and governments now recognise water as a key constraint to the sector's growth—whether due to water scarcity, its excess, or social opposition. As a result, there is growing momentum for mines to adopt a water stewardship approach that builds business resilience while protecting people and environment.

The International Council on Mining and Metals (ICMM) launched its Water Stewardship Maturity Framework in November 2023 to guide mining and metals companies towards more responsible water use and management. The Framework provides a standardized approach, recognizing that water connects a mining operation to its surrounding landscape and communities. It aligns with leading external guidance and reporting initiatives and help organizations manage water as a shared and vital resource.

The Framework also supports integration of water considerations into broader corporate priorities such as climate resilience, cultural heritage protection, nature-positive development, social inclusion, and operational performance. It helps companies address the growing challenges of a changing climate, increasing pressure on shared water resources, and the need to ensure equitable access to water, sanitation, and hygiene for all. Applying water stewardship principles at mine sites has demonstrated benefits beyond traditional water management.

A water stewardship integrated tracking tool has been developed by SRK to assist mining and industrial clients to electronically capture their water stewardship progression in relation to either the ICMM Water Stewardship Maturity Framework or the Alliance for Water Stewardship (AWS) International Standard.

The tool provides opportunities to generate linked documents that support the operations water stewardship initiatives, providing both an interactive site-specific tool and an audit ready system. The tool incorporates the Water Stewardship Plan, which provides the roadmap for current and future water stewardship initiatives and the tracking thereof.

Water stewardship is becoming an essential part of corporate strategy—reducing costs, improving water security, and unlocking opportunities through collaboration. Using global best-practice tools such as the ICMM Water Stewardship Maturity Framework and the AWS International Standard helps mining companies mitigate water-related risks and contribute to a more water-secure future.

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Water stewardship: Mining's blue responsibility. Image generated using AI.

Benchmarking water efficiency in mining: a path to sustainable practices

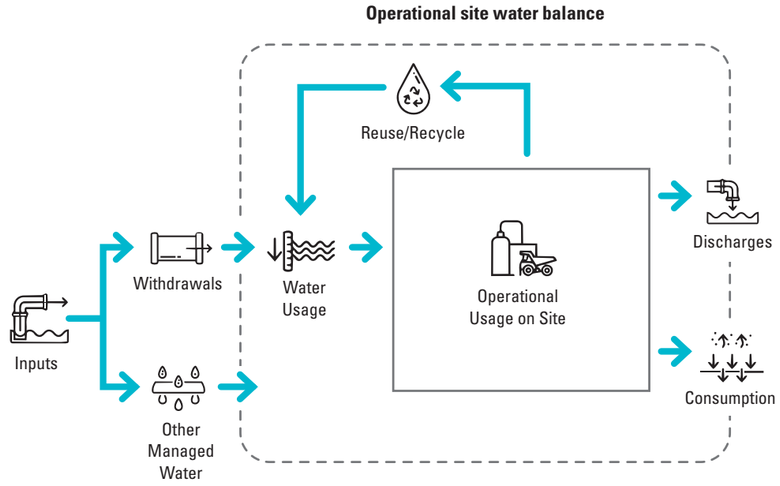
To help mines assess and improve their water management practices, SRK has developed a comprehensive database and benchmarking tool. This tool evaluates key water management metrics across the industry, leveraging widely recognized International Council on Mining and Metals (ICMM) and Global Reporting Initiative (GRI) water accounting standards. Each metric is broken down by water quality (high or low) and source (surface water, groundwater, seawater, or third-party water). This granular approach allows mines to compare their performance with others and identify specific areas for improvement.

A meaningful benchmark considers the unique characteristics of each operation. For example, an open-pit copper mine in a dry climate will have different needs than an underground gold mine in a tropical region. The SRK tool allows users to apply filters—such as mine type, location, climate, and processing methods—to ensure a like-for-like comparison.

Let us consider an anonymous open-pit copper mine in Chile that withdraws 1.62 m^3/tonne ore processed. When benchmarked against all mines, it ranks in the 38th percentile for water withdrawals, indicating it withdraws less water than 62% of mines. This may seem efficient. However, when compared only to other open-pit copper mines in dry climates, it ranks in the 64th percentile, suggesting there is room for improvement.

The insights gained from benchmarking can form the basis of the improvement process, and tools like marginal abatement cost curves and multiple accounts analyses can be used to prioritize high impact low-cost opportunities for improvement.

Like any tool, benchmarking has its limitations. The SRK database relies on self-reported data, which can introduce inaccuracies. While 90% of the companies for which data were collected adhere to ICMM and GRI standards, there is no universal method to verify the data. Additionally, the tool compares operations to industry norms rather than theoretical maximum efficiencies, and regional reporting standards can vary. Despite these challenges, benchmarking provides invaluable insights. By identifying areas of improvement, operations can reduce both their environmental impact and the risks associated with water scarcity.



Water scarcity remains a critical risk to the global mining industry, but our pathway to improved water efficiency is attainable. Benchmarking offers a practical starting point for mines to assess their performance and prioritize actions. By leveraging data and learning from peers, mining operations can take meaningful steps toward sustainable water management—ensuring both their operational resilience and their environmental stewardship for decades to come.

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NOAH LEVIN

Noah has over eight years of experience developing and optimizing environmental emissions reduction strategies for mining and metallurgy projects. He holds a degree in chemical engineering from Queen's University. His work focuses on assessing long-term environmental impacts and designing mitigation approaches. At SRK, his expertise includes water quality characterization, water and load balance modelling, efficiency studies, ICMM water accounting, source investigations, and tool development, applying statistical and data science methods in Python to analyze and predict water performance.

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Hydrogeological conceptual models for sustainable water management

DIEGO SÁNCHEZ

Diego is a principal hydrogeologist at SRK Argentina. He has 15 years of experience in hydrogeology and water management for mining projects across Latin America. Diego specializes in developing conceptual and numerical groundwater models to support environmental approvals, water balance assessments, and hydrochemical evaluations. He provides technical support to engineers of record and project teams, integrating hydrogeological insight into sustainable water management strategies.

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In mining, water sustainability challenges are increasingly complex. The interaction between surface and groundwater systems, coupled with climate variability and the need to ensure both water availability and quality, requires a robust understanding of hydrogeological processes. Within this context, water stewardship is grounded in a simple principle: we cannot manage sustainably what we do not understand. The conceptual model provides the framework to turn scattered data into integrated knowledge—and knowledge into responsible decisions.

A conceptual model is a structured representation of how groundwater systems function. It integrates geological, structural, geochemical, hydrological, geophysical, and climatic information to describe flow mechanisms and connectivity. This synthesis process—outlined in modelling guidelines such as Chile's Guía para el Uso de Modelos de Aguas Subterráneas (SEA, 2012), the UK Environment Agency (2002), and the USGS Guidelines for Evaluating Ground-Water Flow Models (Reilly & Harbaugh, 2004)—defines the hydrogeological setting, recharge and discharge zones, and surface–groundwater interactions. It establishes the foundation on which numerical models, monitoring programs, and management decisions are built.

More than a preliminary stage, the conceptual model is a technical instrument for hypothesis testing and uncertainty reduction. As emphasized by Ardito et al. in Requirements for Defensible Ground Water Modeling (2004), the robustness of the conceptual model determines the defensibility of all subsequent analyses.

At SRK Argentina, this approach supports the characterization of aquifers, the assessment of connectivity between surface and groundwater systems, and the evaluation of water management strategies across the mining life cycle—from exploration and design through operation and closure.

In one recent mining project for a confidential client, the conceptual model was updated after new hydrogeological, hydrochemical, and monitoring data became available. This process helped refine the understanding of recharge and discharge mechanisms, identify potential hydraulic connections between mine facilities and surrounding receptors, and improve the design of the monitoring network. The updated conceptual model also provided a clearer technical basis for evaluating management measures and communicating key uncertainties to project teams, authorities, and stakeholders.

This type of application shows the conceptual model is not only a descriptive exercise, but a practical decision-support tool. By testing assumptions against field evidence, it helps identify data gaps, prioritize additional investigations, and focus management actions where they can have the greatest value.

Building a robust conceptual model is an investment in sustainability. It enables watershed-bed management, as promoted by the International Council on Mining and Metals Water Stewardship Position Statement (2017). By identifying natural system limits, prioritizing preventive actions, and ensuring transparent communication, the conceptual model underpins sound water management.

Ultimately, it provides traceability, transparency, and credibility—the core attributes of responsible and forward-looking water management in modern mining.

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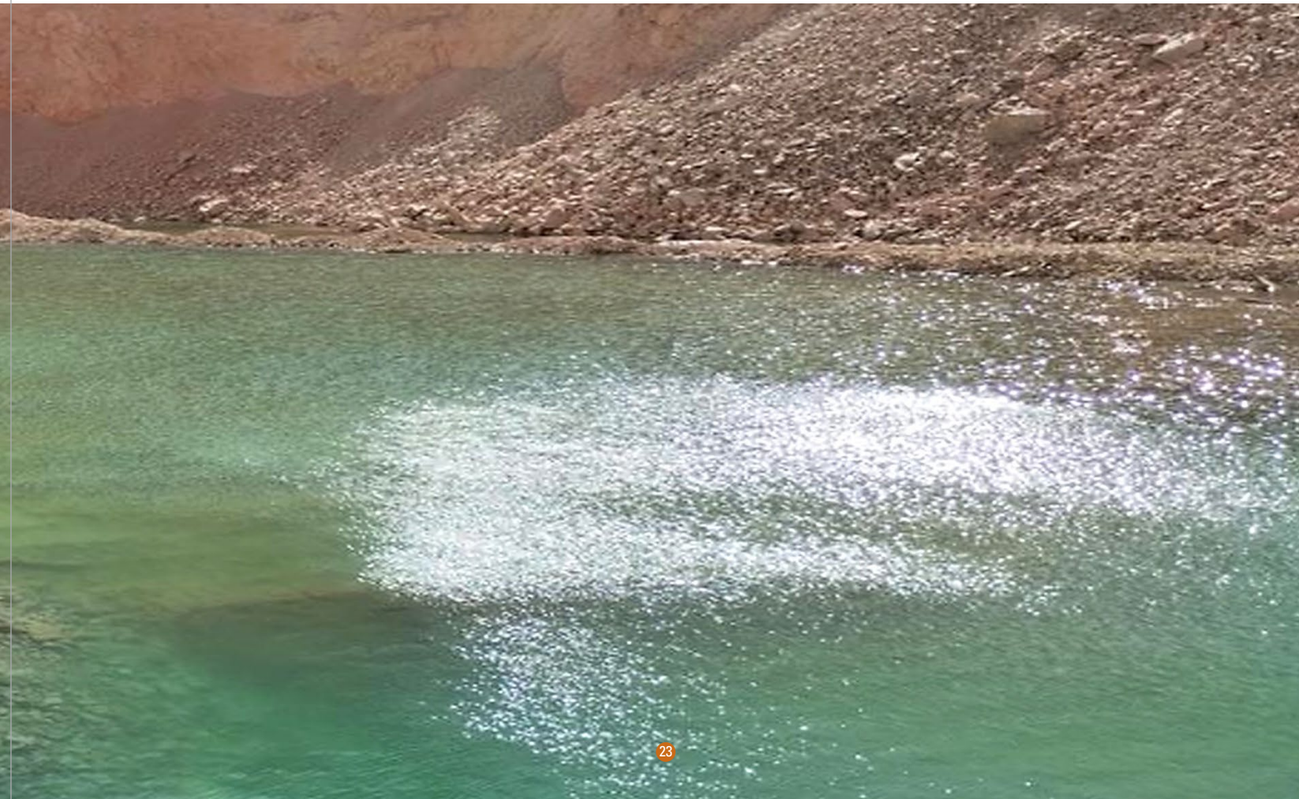
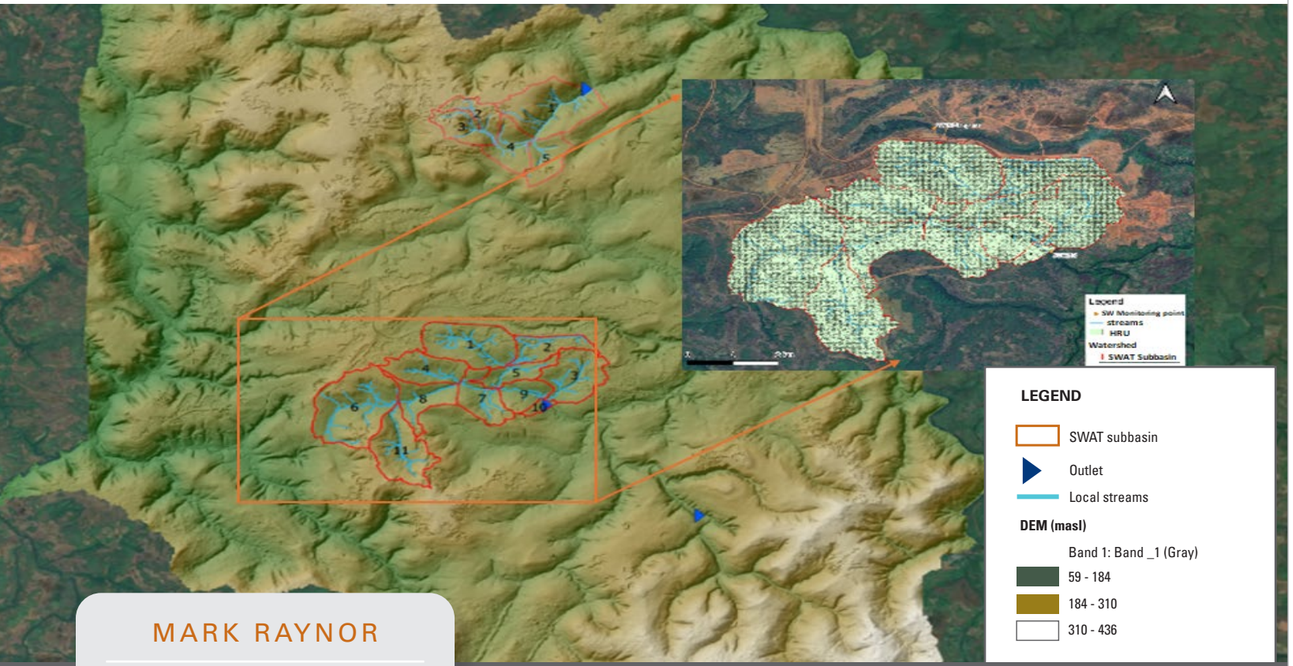
Hydrogeological conceptual models support integrated water management and informed decision-making in mining.



Integrating surface and groundwater modelling for catchment hydrologic assessments



Delineated Subbasins and Hydrologic Response Units (HRUs) from SWAT+ model.

MARK RAYNOR

Mark is a principal hydrogeologist with 18 years' international experience in the mining and water resource sectors. His areas of specialisation include mine dewatering and pore pressure control, water balance modelling, groundwater recharge, field hydrogeology, and water resources assessment. He has carried out numerous dewatering evaluations and reviews at operational open pit and underground mines. He has extensive slope depressurisation experience and was a contributing author to CSIRO's "Guidelines for Evaluating Water in Pit Slope Stability".

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Effective water stewardship demands a holistic approach to managing water resources, particularly at the catchment scale. Catchments are complex systems where surface water and groundwater interact dynamically, influencing water availability, quality, and ecosystem health. Assessing these interactions is critical for sustainable water management, especially in regions affected by mining, agriculture, and urban development. However, traditional approaches often focus on surface water or groundwater in isolation, resulting in incomplete assessments and less effective management strategies.

Integrated surface water–groundwater modelling bridges this gap by providing a comprehensive framework to simulate how the two systems interact. This approach improves understanding of how changes in one domain such as altered land use or topography affecting surface runoff— can influence the other, including groundwater recharge or discharge. For instance, mining activities can significantly modify topography, land cover, and drainage networks, leading to shifts in streamflow, evapotranspiration, and groundwater dynamics. Without an integrated model, these impacts may be underestimated or overlooked, leading to inadequate design decisions.

At a bauxite mine in Guinea, SRK successfully applied the SWAT+ hydrological model to better understand surface water-groundwater interactions and establish baseline conditions across the catchment. Using land use, soil, topography, and climate data as input, the model simulated streamflow, groundwater recharge, and evapotranspiration under both current and post-mining scenarios. SWAT+ revealed how mining activities, such as excavation and pond formation, altered hydrological processes, reducing streamflow while increasing aquifer recharge in some areas. These findings guided the development of targeted mitigation measures, including rehabilitating mined areas, installing sediment control structures, and implementing progressive site rehabilitation to minimize adverse impacts on water resources, quality and ecosystems.

SWAT+ has proven valuable for simulating and understanding baseline conditions and for predicting hydrological impacts of mining activities. By integrating surface water and groundwater processes, the model supports more accurate predictions of water availability and quality, helping ensure sustainable water management practices and regulatory compliance. These insights benefit not only mining operations but also the surrounding communities, industries, and ecosystems.

The importance of integrated modelling extends beyond mining to applications in agriculture, urban planning, and climate change adaptation. As water resources face growing pressures from human activities and environmental change, tools like SWAT+ provide a robust foundation for informed decision-making. By adopting integrated surface water–groundwater modelling, stakeholders can ensure that water stewardship efforts remain effective, equitable, and sustainable across entire catchment.

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Saeed is a senior hydrologist with expertise in climate data analysis, surface water hydrology, and water balance modelling. He specialises in using advanced hydrological tools such as SWAT+ to assess water resource dynamics in mining and environmental projects. Saeed's work focuses on integrating hydrological, GIS, and remote sensing tools to support surface water and flood modelling for sustainable water management and regulatory compliance.

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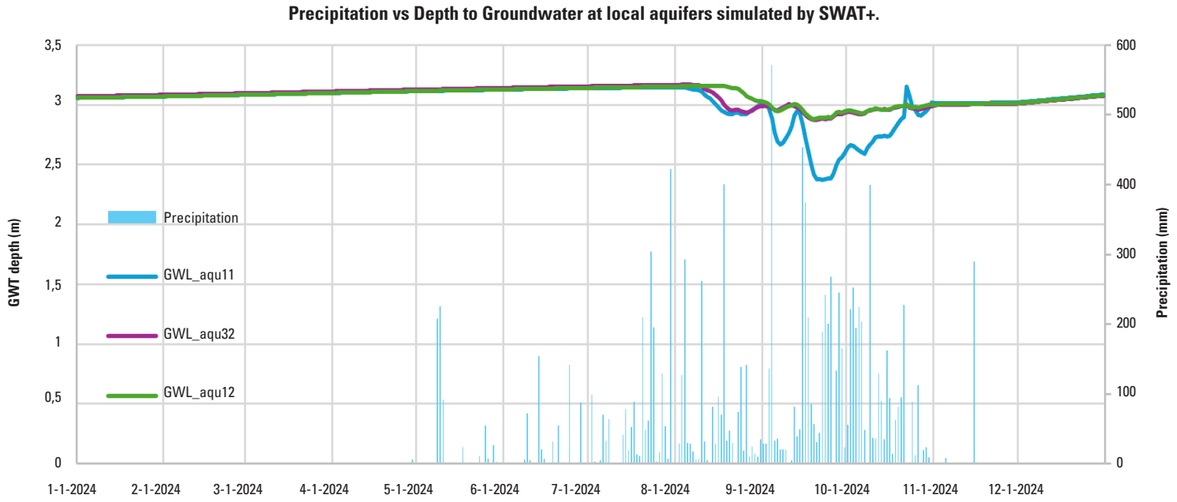

Habitat modelling: how a rare lizard shaped a wind farm's design

CHRISTOPHER DALGLIESH

Chris is a partner and principal environmental scientist with over 39 years of experience across Southern Africa, West Africa, South America, the Middle East, and Asia. He has worked extensively in natural resources, mining, oil and gas, waste, energy, renewables, infrastructure, and industrial sectors. Chris has directed and managed environmental and social impact assessments (ESIAs) to international standards, and regularly leads due diligence studies and E&S reviews for financial institutions.

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The charismatic Sungazer lizard *(Smaug giganteus)* is quietly influencing the future of renewable energy in South Africa's Free State Province. Endemic to specific grassland types in the region and listed as Vulnerable by the International Union for Conservation of Nature, this elusive reptile is also targeted by the illegal pet trade, making its protection both urgent and complex.

During the environmental impact assessment for the 56,000-hectare Renoster Wind Farms Development, SRK and Red Cap Energy encountered a key challenge: how to safeguard a species that is notoriously difficult to detect without compromising project feasibility. Traditional field surveys are impractical for this species over such an extensive area, yet relying solely on micro-siting would not meet the requirements of South African conservation law, which mandates avoidance not just of known locations but also of potential habitat for cryptic species of conservation concern.

To address this, SRK collaborated with environmental data scientists to develop a high-resolution habitat-suitability model using multi-year satellite imagery, terrain analysis, and machine-learning algorithms—including Artificial Neural Networks, Random Forest, and MaxEnt. The model analysed over 8,000 verified habitat records and 5,000 pseudo-absence points, mapping 19,725 hectares of potentially suitable habitat, of which 5,379 hectares were identified as high-likelihood zones.

This data-driven insight guided a full redesign of the wind-farm layout, with infrastructure strategically relocated to avoid core habitat areas. The final project footprint affects less than 0.5% of modelled suitable habitat and actively protects corridors connecting habitat patches—well within thresholds of acceptable ecological change.

As the first of several wind farms planned in the region, the Renoster project sets a benchmark for integrating biodiversity science into infrastructure planning. It demonstrates how data-driven methods can reconcile renewable-energy development with species protection, securing a viable future for the Sungazer in a changing landscape.

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The Sungazer lizard, also known as 'ouvolk' in Afrikaans – which translates to 'old folk'. Photo credited by: Dr Shivan Parusnath, lead field specialist.

Quantifying and controlling environmental noise through advanced acoustic modelling

Working in collaboration with colleagues from the United Kingdom and Kazakhstan offices, the South African team was appointed to undertake a noise impact assessment (NIA) for a proposed hot briquetted iron facility in Central Asia. The client faced two pressing challenges: understanding the ambient noise impact of the facility on surrounding communities and determining whether the proposed noise abatement technologies would be effective in practice.

SRK's involvement provided clarity and confidence at a critical stage of project development. By engaging closely with the client's team, the work included a development of a comprehensive acoustic inventory of potential noise sources associated with the facility. This inventory included both unmitigated and mitigated sound power levels, allowing the client to clearly see the difference that abatement measures could make. Importantly, the efficiency of each proposed noise control technology was assessed to ensure that design decisions were based on realistic performance expectations rather than theoretical assumptions.

To translate technical data into actionable insight, SRK conducted advanced environmental acoustic modelling using SoundPLAN (v5.1). The modelling accounted for site-specific factors such as building geometry, topography, and equipment-specific sound power levels, as well as the complex phenomena of sound reflection and diffraction. This enabled the simulation of operational scenarios and prediction of the spatial extent of noise impacts with precision.

GIS mapping software was then used to generate clear graphical representations of sound pressure levels across the surrounding area. These maps provided an intuitive understanding of how noise would propagate from the facility, and how mitigation measures would reduce impacts. The assessment was designed to comply with national laws and international standards, including the World Bank Group's Environmental, Health, and Safety Guidelines and International Finance Corporation Performance Standards.

By directly addressing the client's concerns, the NIA gave the project team confidence the facility design could meet environmental standards while maintaining operational efficiency. In doing so, the client was able to move forward with a technically robust and commercially viable project design from a noise management perspective.

This case study demonstrates how advanced acoustic modelling can support project development by informing design decisions and contributing to broader assessment and engineering studies as projects advance.

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HASHEEL TULARAM

Dr Hasheel Tularam is an environmental noise specialist with over 12 years of cumulative experience in the environmental consulting industry. Having been actively involved in a range of ambient-noise monitoring campaigns for more than a decade, complemented by his expertise in Geographic Information Systems (GIS), he undertakes acoustic-modelling assessments that range from screening-level studies to detailed source-and-terrain-based models using predictive platforms such as CadnaA and SoundPLAN. He provides advice on proactive risk-mitigation measures across diverse operational settings.

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Acoustic noise modelling of a mining site and surrounding landscape. Image generated using AI.

Modelling Glare and Flicker: data-driven tools for sustainable renewable energy projects

Light reflecting (glare) off PV panels.

KELLY ARMSTRONG

Kelly is an environmental scientist with experience in visual and environmental and social impact assessments (ESIAs). She has completed numerous visual impact assessments (including glare and flicker modelling) for infrastructure, renewable energy and mining projects. She also manages ESIA projects in the renewable energy, residential, aquaculture, marine, industrial, and mining sectors, for both the private and public sectors. Kelly holds a BSocSc (Hons) in environmental and geographical studies from the University of Cape Town, South Africa.

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Solar and wind energy facility projects can pose risks to nearby residents, motorists or pilots. Developers are therefore increasingly required to consider visual impacts. Glare from photovoltaic (PV) panels and shadow flicker (or simply flicker) from wind turbines, can affect comfort, safety and overall community acceptance of renewable energy infrastructure.

Glare modelling evaluates the intensity, frequency and duration of light reflection from PV plants, identifying which receptors are likely to be exposed to visual discomfort or safety risks, including temporary after-image or flash blindness. In parallel, flicker modelling simulates the moving and erratic shadows produced by rotating turbine blades, allowing developers to determine when, where and how often flicker may occur throughout the year.

Recognising the importance of understanding and managing these impacts, SRK has integrated glare and flicker modelling into visual impact assessments that feed directly into broader environmental and social impact assessment processes for renewable energy projects. Specialised modelling tools are used to quantify glare and/or flicker, providing developers with concrete data to inform design choices, particularly the layout of PV plants and the micro-siting of turbines. Outputs from the modelling include detailed maps and exposure statistics that show not only the spatial reach of potential effects, but also their timing, duration and recurrence across different seasons.

Results are then analysed against international good practice guidelines, such as those adopted by the International Finance Corporation, ensuring projects comply with recognised standards. This facilitates evidence-based decisions on PV panel and turbine orientation and layout, physical screening measures, and operational adjustments to minimise impacts. Embedding modelling early in project design fosters an iterative, adaptive design process that supports the delivery of renewable energy while safeguarding the wellbeing of affected communities.

SRK's niche modelling expertise enables our ESG consultants to quantify impacts that were once difficult to measure, and to evaluate the effectiveness of mitigation measures, translating sustainability principles into practical, defensible solutions for real-world projects.

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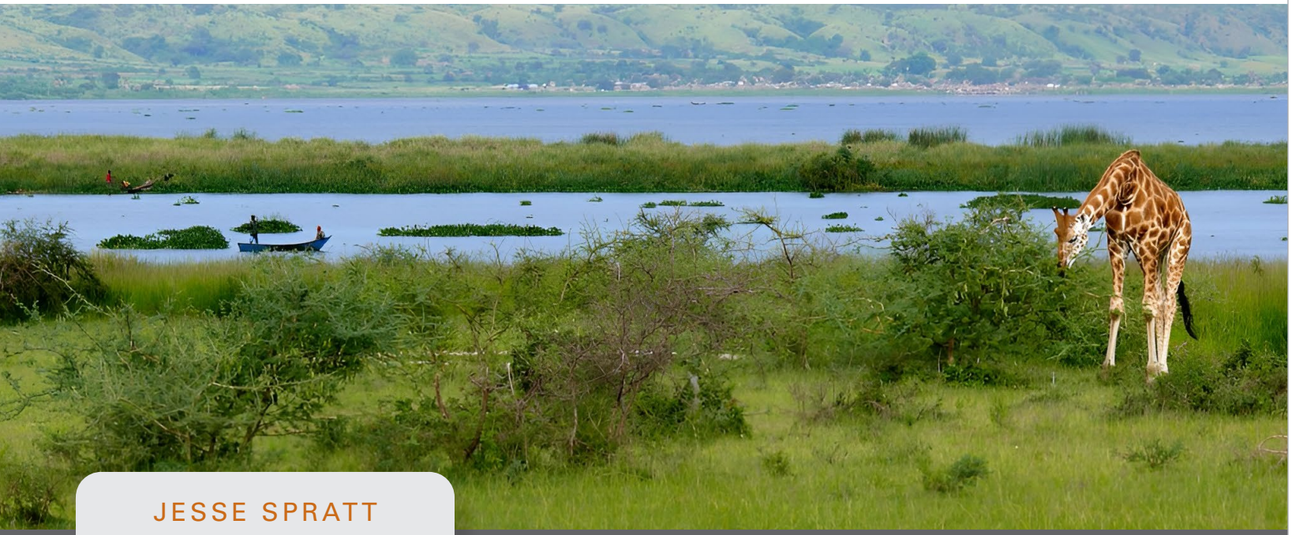
Shadow of turbine cast over the landscape.

Demystifying cumulative impact assessment



Some of the valued environmental and social components of Lake Albert.

JESSE SPRATT

Jesse is a senior environmental consultant with the ESG team in SRK South Africa. He has experience in the field of environmental and sustainability management with a keen focus on sustainability consulting. He holds a MSc in geography from the University of the Witwatersrand, Johannesburg. He has regional experience with projects ranging across Africa. Fields of expertise include mining related projects and permitting, sustainability and environmental management and strategy, water and waste management, and renewable energy.

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Globally, many environmental impact assessment (EIA) regulatory frameworks require practitioners to identify and assess cumulative impacts. However, EIAs often fail to adequately evaluate these effects, usually because of a lack of clarity regarding the approach. As it is now considered critical to understand the additive, synergistic and interactive consequences of a project, cumulative impact assessment (referred to here as CIA) has evolved over the past three decades from a loosely defined, risk-based concept into a more structured practice.

Several guidance documents have been prepared by international lenders and multilateral agencies to support developers in assessing their cumulative impacts. The 2013 Good Practice Handbook on Cumulative Impact Assessment and Management prepared by the International Finance Corporation (IFC) is widely used and defines the six-step process, which are integrated into the case study.

The ESG team based in Johannesburg, has applied the IFC's CIA methodology on several projects in Africa. In 2023, SRK served as technical advisor to a regional environmental and social impact assessment for the Kabalega Industrial Park (KIP) project near Lake Albert in Uganda. Developed by the Uganda National Oil Company, the multi-component KIP includes an international airport, an oil refinery complex, industrial and commercial zones, and associated oil pipelines from three major oil fields, each with a separate EIA.

The CIA considered a range of potential cumulative impacts, including influx-induced pressure on social services and livelihoods, exploitation of forest resources, habitat fragmentation, and overexploitation of Lake Albert. Initially, valued environmental and social components (VECs) were identified, then spatial and temporal boundaries and environmental drivers defined.

These three initial steps set the scene for the assessment of cumulative impacts using a scenario-based spatial and temporal analysis approach.

The two analytical steps involved the assessment and significance of identified cumulative impacts. Under scenario A, potential cumulative impacts associated with the KIP were evaluated. Scenario B added other developments within a defined 20 km area of influence while scenario C also considered planned regional projects. These scenarios were mapped using GIS overlays to identify significant cumulative impact areas. The base layer featured key infrastructure, VECs and KIP. By identifying the accumulation of impacts on VECs, it was possible to map the likely extent of the cumulative effect for each scenario. The significance of each scenario was assessed using a 6x6 evaluation matrix, indicating severity on the one axis and extent on the other axis.

The sixth step involved the development of tailored strategies that informed KIP's wider governance systems and strengthened project-specific management plans. It demonstrated how cumulative impacts assessments can support more integrated project outcomes.

As the CIA practice continues to evolve, there is now a growing range of examples and tools available. By combining diverse data sources, engaging experts in a collaborative way, and applying a strategic analytical approach, it is possible to deliver in-depth and insightful analyses of projects' cumulative effects.

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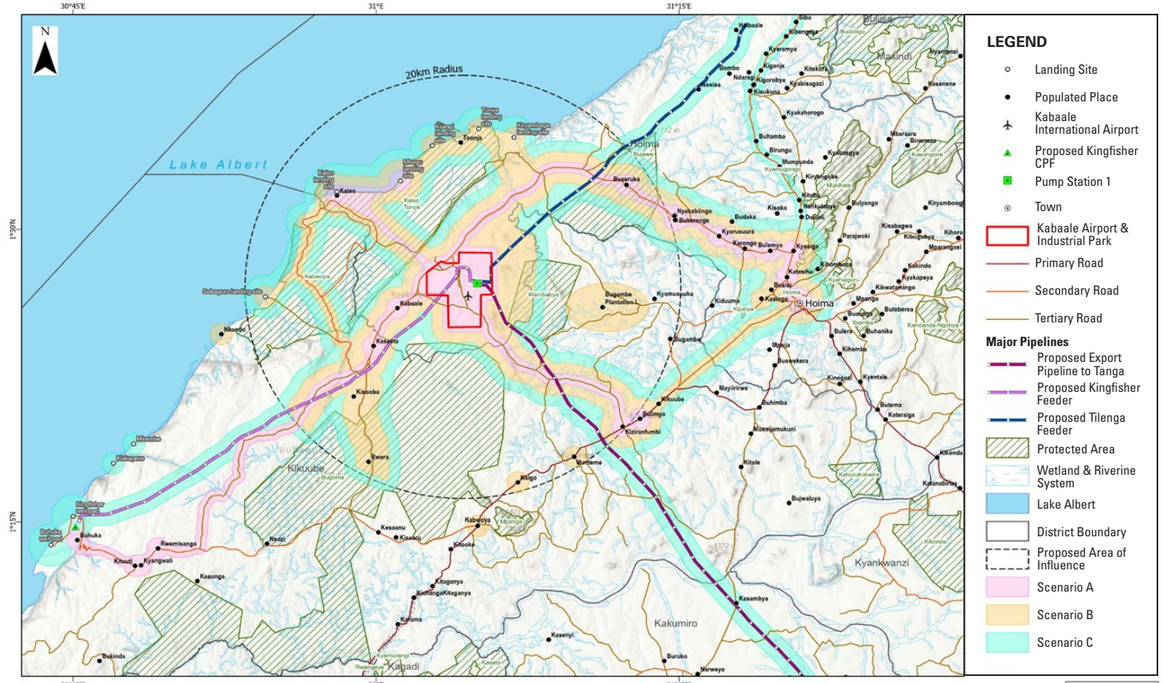
Cumulative impact scenarios map



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KABAALE INDUSTRIAL PARK RESIA
AREAS OF POTENTIAL CUMULATIVE IMPACT

Data Source: Esri Basemap	
Scale: 1:400,000	
Projection:	Datum: WGS84
Central Meridian/Zone:	
Date: 10/02/2023	Compiled by: LOUA
Project No: 588337	Fig No:
Revision:	Date:

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