ARCADIS MINING
Solutions built on experience
Pinto Creek Diversion Channel, United States
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Cover: Lower Powers Gulch Spillway Channel Design and Construction, United States
SOLUTIONS BUILT ON EXPERIENCE

Keith Smith
Global Leader
Mining Solutions
Arcadis is the leading global natural and built asset design and consultancy firm, covering the whole asset lifecycle. For over a 125 years we have been working in partnership with clients around the world to deliver exceptional and sustainable outcomes.

Our reputation is built on a deep understanding of client needs, combined with our knowledge and experience worldwide. With 28,000 people working in more than 40 countries, we have built a global network that enables us to serve our local clients on a global basis.

Mining – one of Arcadis’ core sectors – presents vastly different requirements from other sectors. Many elements and areas require careful consideration during the entire life of a mining project to fulfill the needs of ‘pit to port’, from environmental to water, infrastructure, transportation, mineral and metallurgical throughout project implementation, operation and closure, as well as redevelopment opportunities. Further, the complexities of site location and socio-environmental issues are constant. Arcadis understands all those elements and areas. We have the capability and capacity to combine and consider them in delivering a successful project in line with the clients’ business and corporate social objectives.

We look forward to working with you.
Arcadis provides consultancy, design, engineering and management services in infrastructure, water, environment and buildings. Established in the Netherlands in 1888, Arcadis operates in over 40 countries with 28,000 staff worldwide.

Arcadis offers services tailored to all areas and disciplines from ‘pit to port’ for the entire mine and project lifecycle.

We provide services throughout the entire value chain – from strategic advice, planning, design and implementation, through to maintenance, operation, optimization and decommissioning. With our ‘pit to port’ concept, we provide services for all project phases: the license and permit, project studies (conceptual, pre-feasibility and feasibility), detailed design up to installation, start-up, and operation through to closure and/or decommissioning of a site. We offer our clients solutions that are robust in the long-term, viewed within the context of their business needs.

Our experience shows that the challenges faced by our clients are becoming enormous and increasingly complex. It is our ability to understand the specific needs of clients, in their local context, and our innovative application of services that are new to the industry combined with consolidated skills that deliver real results.

Arcadis has a substantial footprint worldwide. Our global network enables us to bring our knowledge and experience of projects worldwide and apply that expertise to specific local situations and needs.

While designing, managing the construction or operation, safety remains of paramount importance and environmental regulations continue to tighten their grip.

One of our key missions is to improve the quality of life worldwide by creating sustainable solutions. Health, safety and sustainability are central to everything we do: in our work with clients, in the way our company is organized and in our approach to social responsibility.

FACTS
Gross revenue by activity:

- Infrastructure 24%
- Water 15%
- Environment 33%
- Buildings 28%

Gross revenue €3 billion.
Exploitation of natural resources plays a vital role in the global economy. Important drivers are growing demands from emerging world markets and fluctuation in commodity prices. These drive demand for larger infrastructure and increased operational efficiency of existing and new infrastructure.
THE ARCADIS VIEW ON MINING

A CHANGING MARKET
The mining industry is cyclical and therefore faces a number of challenges. Efficiency, productivity, capital and operating costs and timing are always on the agenda; site location and environmental aspects (with increasingly demanding regulations) add complexity. Mining operations today are in remote locations, which brings major challenges such as connectivity across the facilities supporting mining operations; safety and health risks; and sustainability issues related to nature conservation and the living environment. A clear strategy in an uncertain market is the key to add value for our clients and to fit for the purpose.

FULFILLING THE POTENTIAL, MEETING THE DEMAND
The requirements for mining projects are different from any other sector. They need combined expertise in aspects such as; environmental knowledge for licenses and permits, geology and geotechnical, infrastructure, water resources, energy, mineral and metallurgical process, transportation and terminals (onshore and offshore). Our unique combination of deep sector knowledge, our global network and decades of experience set us apart from others, ensuring that we are best placed to respond to these challenges.

Whether our clients are exploring new mining opportunities, an operating mining entity, or dealing with mined land closure liability, we provide a flexible, sustainable and tailored approach. Drawing on Arcadis’ multi-disciplinary strengths, we work alongside project owners, operators, contractors and consultants across all geographies, integrating with their teams to deliver world-class projects.

FACTS
In a sustainable world:
Demand for energy natural resources, more diversified blend of fuels, especially renewables – requiring more steel than other energy sources and rare earth metals.

Demand for building materials; stronger, more flexible and lighter materials.

Demand for transport natural resources; greater use of materials such as composites and aluminium, plus steady demand for materials such as rare earth oxides.

Arcadis combines strategic advice with multi-disciplinary technical knowledge to develop mining operations that are environmentally responsible and adaptable to change, excelling market and client expectations. For more than 125 years Arcadis has been providing unique services tailored to the mining industry, for the entire project and mining lifecycle.
INTEGRATING ALL ELEMENTS AND AREAS FROM ‘PIT TO PORT’

The mining lifecycle covers a huge range of activities that start with licensing and permits, through to infrastructure, water chain and process capabilities, mining development and operation, and ultimately end with closure. Arcadis brings expertise from its specialist teams to provide a complete service, from ‘pit to port’. Mining services include geological database, resource and mining cost estimation, ore body modeling, mine planning, design and optimization. Beneficiation services cover a full range from crushing to refining. Methods of conveying materials and product include; conveyors, stackers and reclaimers, stockyard, ship loaders and unloaders, car dumping, dust control and slurry pipelines. Port services include; logistics, maritime works, control and power systems, and storage. Infrastructure services include; water supply, waste management, industrial buildings, roads and tunnels. Moreover, railway services include; specialized rail systems, signaling and communication, bridges and tunnels.

On top of the infrastructure complexity, mines have to treat the natural environment in a cost-effective way and comply with local legislation. They have to be safe places to work in, and healthy - not just for the workforce but for the local community too. Mining companies today expect to build responsible relationships with local communities and their shareholders. These companies also have to be resilient when global commodity prices fluctuate. These are some of the most relevant and unique challenges that mine owners and operators face. Such complexity requires a vast range of expertise; mineral and metallurgical knowledge, engineering, materials handling and safe operation, understanding of the environmental aspects, and community relations, following on from the legal and business advice. Arcadis brings expertise in each of these specialist areas as well as many years of experience in all phases of mining design, engineering and operations.
The Arcadis approach is to perform projects in phases, bringing consistency and predictability through the entire project lifecycle of mining development from pre-feasibility through to operations and decommissioning, whether it is a new site or optimization of an existing asset. We take a combination of aspects into consideration; the mineralogy, resources, socio-environment and the strategic fit with the client’s and market needs in terms of cost, quality and timing. For existing operations, Arcadis can assist clients to achieve the highest point of efficiency in their assets, bringing the required expertise for operational improvements.

Our attention to both the desired end results and the detail means that right from the start of the planning phase we identify, mitigate and even avoid issues that could affect the construction and safe running of a mining operation. With forward thinking and excellence integrated into every phase of the project from concept to closure, clients trust our multi-disciplinary experts to deliver efficiency, safety and sustainability for every mining project.

LOCAL, GLOBAL AND INDEPENDENT

Our local presence ensures that we maintain lasting relationships with our clients and to build in-depth understanding of local communities and environmental conditions, as well as local suppliers. Arcadis brings extensive knowledge and capabilities throughout all technical and managerial disciplines from projects and offices around the world, vitally important for efficient and safe construction and operation of a mine complex. This global network enables us to use our vast expertise to provide the best value added services and technologies adapted to the local needs of our clients.

By combining global expertise – engineering, procurement services, project and construction management, operational assistance and improvements, decommissioning and, finally, redevelopment opportunities – with local presence, the projects we deliver incorporate the highest levels of engineering and consultancy.
Clients need reliable planning, design, construction and operational expertise for mining operations that will maintain sustainable commercial value to their owners and operators. With experience in the development of mine complexes across the Americas, Asia, the Middle East and Australia, Arcadis has the proven ability to meet this need.
BUSINESS CONSULTING

In the natural resources business, whatever the commodity, there are similar challenges. Every decision taken today will have a long-term impact. Arcadis advises clients on all aspects of mining projects, from the initial financial, environmental and engineering studies through to enhancements and decommissioning. Our advice is neutral and independent, focused on achieving the client’s objectives in line with the requirements of corporate governance.

PROJECTS AND IMPLEMENTATION

Mine projects require a vast range of expertise; in processes, technologies, engineering, project management, construction management, procurement and contractor management through to start-up and commissioning further to a reliable CapEx and OpEx estimation. Arcadis brings together project teams from around the world with many years of experience and expertise in all phases of mining design, engineering and operations.

OPERATIONAL SUPPORT AND ASSET MANAGEMENT SERVICES

Arcadis provides support and improvements in all the areas encompassing ‘pit to port’ that are needed to realize or to improve productivity, at or even above the industry standard.

ENABLING INFRASTRUCTURE WORKS

Mining operations are usually in remote locations and require significant numbers of workers for their construction and operation, in addition to the requirements of infrastructure for the project implementation phase. Arcadis provides a comprehensive range of services as part of the designing and implementation management capability and capacity for the early infrastructure works. These typically require; complete lodging and amenities facilities for the construction and operation workers, infrastructure for receiving, transporting and storing equipment and utilities (power, water intake and treatment, sewage treatment, etc.).

ADDING VALUE TO THE WHOLE ASSET LIFECYCLE

Our unique combination of strategic advice and mining expertise means we can provide the most efficient integrated solutions and offer added value for asset management and renewal programs. Arcadis provides support and improvements in all the areas encompassing ‘pit to port’ that are needed to realize or to improve productivity, at or even above the industry standard.

CASE STUDY

SURFACE INFRASTRUCTURE MECHANICAL AND STRUCTURAL WORKS

Project: Ulan Coal Mine expansion, Australia
Date won / completed: 2007 / 2014
Client: Glencore Coal Assets Australia Pty Ltd

OUR CLIENT’S CHALLENGE

Ulan was expanding their underground mine to produce an additional 7mtpa and required additional surface materials handling infrastructure to transport coal from the underground portal to the CHPP and Train Load Out.

This expansion, the latest in a series of developments, gives the mine a potential output of 20 mtpa when combined with the existing Ulan No 3 underground mine and open cut operations.

OUR APPROACH

After completing the pre-feasibility and feasibility studies for the Ulan West Mine surface materials handling infrastructure, we were engaged to carry out the final detail engineering design and documentation of surface infrastructure mechanical and structural works. The infrastructure project included an overland conveyor chain in excess of 7 km, reclaim conveyor, 1.5km long overland downhill horizontal curved conveyor, product stockpile conveyors and stacker, reclaim tunnel and conveyor feeding the train load-out conveyor system.

The works were undertaken in two stages, which enabled:

• Development of the mine to proceed before the final infrastructure was installed
• Upgrading much of the existing infrastructure to accommodate the increased throughput.

OUTCOMES FOR THE CLIENT

• The re-use of existing plant and equipment and total design/construction time from concept idea to commissioning of Stage 1 of the project was nine months, giving the client significant capital cost savings over all other options considered for the project.
• This mine expansion provides significant future economic benefits to the local community and the State of New South Wales, with a projected mine life up to 2029.
OUR CLIENT’S CHALLENGE
Our client needed to remove contaminated soils and wastewater treatment plant sludge, and demolish selected structures at their North Facilities near Magna, Utah.

OUR APPROACH
We worked closely with our client and with the Utah Department of Environmental Quality and EPA oversight:
- Potential risk and hazards to human health and the environment were evaluated to support cleanup decision making, with full engagement with local stakeholders
- The contaminated soil management program included repository design and construction, soil excavation, sludge excavation and drying, material placement, and subsequent repository closure
- The $16 million demolition program included five major refinery buildings and a major smelting complex. Several thousand tons of materials were disposed of in offsite facility and Arcadis staff handled the manifesting of the hazardous waste.

OUTCOMES FOR THE CLIENT
- Innovative technical approaches and efficient project coordination resulted in client savings of over $165 million.
- Public involvement meetings, resolution of ownership issues, and public contact representation have contributed to the success of this project.

CASE STUDY
CLEANING UP: MINE-SITE REMOVAL ACTION, DEMOLITION AND RECLAMATION
Project: Soils and Wastewater Treatment Plant Ponds, United States
Date won / completed: 1995 / 2000
Client: Confidential

CASE STUDY
ENVIRONMENTAL IMPACT ASSESSMENT OF A PROTECTED MARINE AREA FOR NEW PORT
Project: Cruz Grande Port Project EIA, Coquimbo Region, Chile
Date won / completed: 2013 / 2015
Client: Compañía Minera del Pacífico S.A. – CAP Minería

OUR CLIENT’S CHALLENGE
The client required environmental approval for its iron ore loading port project (pellet feed) at a 13.5 million tons per year rate, which will provide services to new mining projects. The project is in Coquimbo Region, north of Chile, where important iron deposits and mines are located – and also in the area of indirect influence there dolphins (Tursiops truncates), penguins (Spheniscus humboldti) and cetaceans (minke, blue and humpback whales and sperm whales) and natural reserve for marine habitats.

OUR APPROACH
Arcadis prepared the Environmental Impact Study and supported its assessment by Governmental Environmental agencies, up until the obtainment of the environmental permit to build and operate the new port. The project is its located approximately 17 marine miles away from sensitive area (marine reserve), so it was necessary to prove that habitat and species would not suffer impacts and also to take the necessary precautions to ensure proper coexistence between the port and its surroundings.

OUTCOMES FOR THE CLIENT
Arcadis achieved environmental approval for the client, demonstrating that the coexistence of both the project and the marine reserve was possible, assessing potential impacts and generating adequate environmental measures and follow up plan.
OURS CLIENT’S CHALLENGE
CODELCO Chile needed a Mine Closure Plan for Division Salvador, including engineering and permits. This copper mine site includes both underground and open pit operations, and process lines of oxides and sulphides, waste leach dumps, waste ore dumps and tailings.

OUR APPROACH
The Arcadis approach considered a comprehensive methodology for mine closure, based on risk assessments (qualitative and quantitative), complementary studies and engineering, to support the legal permits and authorizations, as a one-stop-shop service. This work included the following main tasks:

• Strategy for closure, considering environmental, health and safety issues, under the regulatory framework and internal company guidelines
• Complementary studies, such as hydrogeology, geochemistry and acid rock drainage, delineation of impacts for superficial soil off-site (influence area), surface and subsurface soil investigation (process areas), human health risk assessment, and facility survey for cost estimation
• Engineering for closure works considering design and cost estimation
• Mine Closure Plan permit.

OUTCOMES FOR THE CLIENT
The closure planning and cost estimation delivered were adequately supported under a traceable methodology, based on sound technical information developed during the study.
Client: Anglo American Minério de Ferro do Brazil S.A.

OUR CLIENT’S CHALLENGE
The client, Anglo American (one of the largest mining companies in the world), wanted to expand their iron mining operations in Minas Gerais. They needed assistance with implementing a 529km pipeline connecting the beneficiation plant to the filtration plant in Rio de Janeiro – including the environmental aspects, to obtain the Environmental Viability Permit (Preliminary License in Brazil). The site is of archaeological importance, so they also required assistance with archaeological studies.

OUR APPROACH
Arcadis Logos developed implementation planning for the whole project up to completion, taking into account the interfaces with the other projects. Throughout the project implementation phase we were responsible for physical and financial control (managing around 250 contractor companies) and logistics planning for the whole pipeline.

The environmental services provided by Arcadis Logos included:
• Management of the implementation and operation phases of the Minas-Rio pipeline, considering the enterprise’s lifecycle in a very proactive way to assist the client in dealing with strategic issues
• Environmental Impact Assessment - Itapanhoacanga Project (Iron Mining), including social, archaeological and speleological components
• Archaeological research for Sapo Mine project, with a particular emphasis on improvement of the local cultural heritage
• Air quality and Noise Monitoring in the surroundings of Sapo Mine and along the pipeline during the operation phase.

OUTCOMES FOR THE CLIENT
The Arcadis Logos team’s contribution to the success of the project included:
• Cutting down on project CapEx, execution timeframe, labor accident risks, and environmental footprint
• Obtaining the Operation Permit ahead of schedule
• Enhancing relationships with the local community, especially improvement of the local cultural heritage.

CASE STUDY
ENVIRONMENTAL AND INFRASTRUCTURE SERVICES FOR A 529KM PIPELINE LINKING MINAS GERAIS TO RIO DE JANEIRO

Project: Minas to Rio project, Brazil
Date won / completed:
Environmental impact assessment and Itapanhoacanga Project: ongoing since June 2013
Archaeological research for Sapo Mine project: ongoing since June 2014
Air quality and noise monitoring in the surroundings of Sapo Mine and along the pipeline: commenced July 2015
CASE STUDY
CONNECTING A NEW MINE TO THE PORT, IMPROVING LOGISTICS AND REDUCING ENVIRONMENTAL IMPACT IN THE AMAZON REGION

Project: Vale North Logistic Complex (CLN), Carajás Railroad, Southeast Pará Railway Branch, Ponta da Madeira Port Terminal, Brazil
Date won / completed: 2008 / 2015
Client: Vale S/A

OUR CLIENT’S CHALLENGE
The client needed to connect their new iron ore mine in Southeastern Pará to the port terminal of Ponta da Madeira (TPPM) in the state of Maranhão and improve the North Logistic Complex (CLN) capacity with new railway lines connecting to the existing 900km Carajás railway (EFC). There were major environmental issues along this 40 year-old railway, it needed a Corrective Operation Permit and contamination had been detected. The most significant challenges were that the new 100km railway had to cross a preserved area in the Amazon forest and proximity to the urban area of Parauapebas city, which has a very high growth rate.

OUR APPROACH
• Railway branch: For the preserved area we proposed to build an over 2.5km long bridge, instead of a very large landfill, reducing the amount of deforestation needed and allowing some connectivity for the biodiversity. We proposed an Urban Insertion Program along the route of the railway in the stretch of urban sprawl, which includes a Green Space for both sides of the railway.
• EFC site remediation management: Arcadis sought to use the most advanced technologies to provide the customer operational and management gains, increasing the efficiency of remediation systems from 54 percent to almost 98 percent, thereby reducing the time invested in the remediation area. There was also a reduction in exposure of employees to operational risk.
• EFC Environmental Education Program: These included thematic workshops, educational lectures and campaigns to bring environmental issues to the attention of the local community.

OUTCOMES FOR OUR CLIENT
• Railway branch: The project was approved by the federal environmental agency and the permits were granted, with minimal impact on Amazon preserved areas.
• EFC site remediation management: The transparency and the speed of information sent by Arcadis has provided very reliable data; together with project management this has assisted the client in decision-making and strategic planning.
• EFC Corrective Operation Permit and doubling: as one of the stretches to be doubled is located inside a forested Amazon protected area (National Forest), the natural resources to be lost was quantified and assigned a monetary value. This financial resource was then applied in the National Forest.
OUR CLIENT’S CHALLENGE

Hunter Ports is proposing to develop a new state-of-the-art coal loading terminal on the former BHP Steel site, Mayfield, in Newcastle. Their proposal includes creating a new rail corridor through industrial land close to the Hunter River removing 90 per cent of coal trains from residential areas (to resolve congestion problems for the local community) and permitting the closure of the Mayfield rail corridor. The client needed designs and artist illustrations to inform and obtain the support of the local community and to satisfy state regulatory planning requirements. The requirement was urgent; a competitor had been working on the project without success for three years.

OUR APPROACH

- Arcadis was commissioned to develop high-level concept designs for new rail alignments coming into the site via Steel River, site grading and layout of the site stockpiles, buildings and amenities.

We also provided concept designs for road improvements in the local area to improve traffic flow for the project, including six intersections, an expansion of a four kilometre section of roadway from two to four lanes, upgrades to two existing bridges and the construction of two new bridges.

- To assist with stakeholder engagement, we coordinated the development of visual informative material: determining what format was suitable to present on the web, at community forums and in print media; and collaborating with artists, urban designers, project managers, and communications consultants.

OUTCOMES FOR THE CLIENT

- The illustrations were used in media communications Australia-wide to help stakeholders understand what impacts and benefits the development will bring both locally and nationally.

- Arcadis developed the outcomes required by Hunter Ports within a few short months to a high level of quality and detail, exceeding the expectations of our client. This has resulted in further opportunity for us to provide design services on the project.
OUR APPROACH
Arcadis research for Sapo Mine project, with a particular emphasis on improvement of the local cultural heritage
- Arcadis conducted an extensive field investigation program to further assess the hydrogeology of a buried arroyo, where most of the flux of arsenic occurs.
- We found that groundwater flow occurs within a narrow incised channel with a maximum depth of approximately 25 feet.
- Following a treatability study at the University of Waterloo laboratory, we designed permeable reactive barriers with zero-valent iron, which would achieve minimum residence times for full treatment as well as the expected 20-year lifetime of the remedy.
- We conducted field demonstrations of the treatment technology to obtain regulatory approval for the concepts as early as possible.
- We installed the permeable reactive barriers in combination with other construction activities to reduce total installation costs, using an innovative slide-rail system to resolve significant logistical restrictions.

OUTCOMES FOR THE CLIENT
- The permeable reactive barriers field demonstration design was presented and accepted by the Texas Commission on Environmental Quality and the USEPA.
- Arcadis’ Construction and Environmental Services Group has successfully completed the construction of two 140-foot-long permeable reactive barriers and is monitoring their performance.
- Our solution has enabled the client to remedy significant groundwater contamination.

CASE STUDY
HELPING REDUCE GROUNDWATER CONTAMINATION
Project: Former Smelter Site, El Paso, United States
Date won / completed: Confidential
Client: Confidential client

OUR CLIENT’S CHALLENGE
A lead and copper smelter in El Paso, Texas has resulted in impacts to groundwater across most of the site footprint, primarily in arsenic. High concentrations of arsenic and most of the groundwater flow were focused along former (now buried) arroyos. The goal of the project was to reduce concentrations of arsenic, cadmium, selenium, and other smelter-related metals in groundwater to below action levels.
OUR CLIENT’S CHALLENGE
An existing drainage channel around a 120-acre leach pad at the Carlota Copper Company mine needed to be re-routed. The spillway structure had to be designed to convey a 100-year storm event of 3,000 cubic feet per second down a 20 percent natural grade, discharging back into the natural trace of Powers Gulch. The project goal was to provide design, cost estimation, permit approval and construction support for the lined spillway developed as a series of drop structures to sustain the 100-year storm event.

OUR APPROACH
Arcadis designed and supported the construction of a nearly quarter mile long, 280 foot-high spillway to safely pass the mine leach pad and comply with permit requirements. The team:

• Provided effective data evaluation, field investigation, hydrologic and hydraulic modelling and interpretation, spillway design and construction support including quality assurance to obtain US Department of Agriculture (Forest Service) approval.

• Designed the spillway to maximize the use of the bedrock with a multiple drop structure design (280 feet of drop in 1,200 feet of channel) for energy dissipation and to control flow velocities.

OUTCOMES FOR THE CLIENT
The configuration was modelled in HEC-RAS, which showed that the required design flow would safely pass. The configuration included two 20-foot high 2:1 gabion drop structures, two 15-foot high rock-bolted vertical drop structures cut in bedrock and eight 15-foot high rock bolted 1:1 drop structures. The design also included the use of gabions, boulders, rip rap, geotextile and Pyramat for the erosion protection system.

CASE STUDY
SPILLWAY FOR CARLOTA COPPER COMPANY MINE, MIAMI, ARIZONA
Project: Lower Powers Gulch Spillway Channel Design and Construction, United States
Date won / completed: 2008 / 2009
Client: Quadra Mining Ltd., Carlota Copper Company
We have people and offices around the world. Our global network enables us to bring our knowledge and experience of projects worldwide and apply that expertise to specific local needs and situations. We are based in:

Australia  Bahrain  Belgium  Brazil  Brunei  Canada  Chile  China  Czech Republic  Dubai  France  Germany  Hong Kong  India  Indonesia  Italy  Jordan  Kazakhstan  Korea  Macau  Malaysia  Mexico  Mozambique  Netherlands  Oman  Peru  Philippines  Poland  Qatar  Romania  Russia  Saudi Arabia  Serbia  Singapore  Slovakia  Spain  Switzerland  Taiwan  Thailand  Turkey  United Arab Emirates  United Kingdom  United States  Vietnam
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