Located over 750 kilometres northeast of Saskatoon, Orano’s McClean Lake site is comprised of several uranium mines and one of the most technologically advanced uranium mills in the world—the only mill designed to process high-grade uranium ore without dilution.

Orano has operated several open-pit uranium mines at the McClean Lake site, and is evaluating future mines at and near the site.
The McClean Lake Mill

The McClean Lake mill is the only facility in the world capable of processing high-grade uranium ore without dilution. It can process uranium ore grades over 100 times the world’s average grade.

The mill has an annual production capacity of 24 million pounds of uranium concentrate, and it can receive and process uranium ore from conventional mining and high grade ore slurry obtained through advanced remote mining techniques. The mill currently processes the high-grade ore slurry it receives from the Cigar Lake mine, the world’s second-largest and highest-grade uranium mine.

The McClean Lake site operates on a week-in/week-out rotation schedule for workers, over 50% of whom reside in northern Saskatchewan communities.

Mill Schematic
Mill Layout

1. Grinding
2. Ore Slurry Receiving
3. Leaching
4. Counter-Current Decantation
5. Clarification
6. Solvent Extraction
7. Yellowcake Precipitation
8. Calcining & Packaging
9. Water Treatment
10. Oxygen Plant
11. Ferric Sulphate Plant
12. Tailings Neutralization
13. Acid Plant
14. Ammonium Sulphate Crystallization Plant
15. Tailings Management Facility
How Uranium Extraction Works

1. Grinding
2. Ore Slurry Receiving
3. Leaching
4. Counter-Current Decantation
5. Clarification
Grinding breaks down the ore into small particles that are mixed with water to generate an ore slurry. The ore is fed by a front-end loader to a large grate, called a grizzly. Ore that is too large to fit through the grizzly is crushed with a hydraulic rock breaker. Once through, the ore goes into two mills where water is added: an autogenous grinding mill, followed by a ball mill. The ore slurry is discharged to air agitated storage tanks called pachucas.

The ore received at McClean Lake from the Cigar Lake mine arrives already ground up as a slurry.

Ore slurry arrives in specially designed containers on heavy transport trucks from the Cigar Lake mine located about 80km south of McClean Lake. The slurry, containing an average grade of 18% uranium, is unloaded using a specifically designed vacuum and container wash system. The slurry and wash water are put through a thickener. The thickened slurry is then pumped into storage tanks called pachucas.

Leaching involves extracting uranium from the ore by dissolving it into a sulphuric acid solution. Ferric sulphate and hydrogen peroxide are used to oxidize the uranium into a soluble form. This is a non-selective process, meaning that other naturally occurring elements such as iron, arsenic and molybdenum are also dissolved.

Counter-Current Decantation (CCD) washes the uranium solution from the waste solids in the leached residue. The CCD wash solution flows in one direction and the leached residue flows in the opposite direction. The slurry is fed through a series of thickeners where the solids are separated from the liquids. The waste solids, containing a very small amount of soluble uranium, are sent to the Tailings Neutralization circuit.

Clarification removes suspended solids from the uranium solution after CCD, using a clarifier and sand filters. This is necessary because the Solvent Extraction (SX) circuit downstream cannot accommodate any solids.
How Uranium Extraction Works

6. Solvent Extraction

7. Yellowcake Precipitation

8. Calcining & Packaging

9. Water Treatment

10. Oxygen Plant
Solvent Extraction (SX) creates a purified and more concentrated uranium solution. By passing the uranium solution through a series of mixer and settler cells, the uranium is selectively extracted from the solution with an organic solvent. This stripping process increases the uranium’s concentration by five to ten times. The remaining solution, stripped of its uranium, and containing waste metals is sent to the Talings Neutralization circuit.

Precipitation converts the uranium from a solution to 60% solid after going through a centrifuge wash. The molybdenum present as an impurity in the solution is extracted by passing the solution through a series of carbon columns before precipitating the dissolved uranium. Ammonia is then used to adjust the pH to bring the uranium out of the solution, producing ammonium diuranate solids. This form of uranium concentrate is yellow, giving it the term “yellowcake.”

Calcining dries the yellowcake at high temperature to a black powder called uranium oxide concentrate, or more commonly, calcined yellowcake. The yellowcake from the Precipitation circuit is fed to a centrifuge which removes almost all of the moisture. The remaining product is then completely dried in a furnace with multiple hearths, known as the calciner. This occurs at a very high temperature of about 800°C. The dry calcined yellowcake is then placed in storage bins. The final product contains about 85% uranium with less than 0.5% moisture. Although it is now powder black in colour, it is still referred to as yellowcake. Packaging transfers the calcined yellowcake powder from the bin into steel drums. The loaded drums are trucked off site in truck-trailers and sea containers for domestic and overseas shipments. Each drum contains about 400 kilograms of yellowcake.

There are two water treatment plants at McClean Lake. The JEB Water Treatment Plant treats all domestic waste water, mill process waste solution and site runoff from the mill terraces. The Sue Water Treatment Plant treats all water associated with mine dewatering at the Sue site, domestic waste water and Sue site runoff water. Both water treatment plants remove dissolved metals and suspended solids so the water can be discharged into the Sink/Vulture Treated Effluent Management System, meeting federal and provincial water quality requirements.

The Oxygen Plant concentrates oxygen from ambient air using Pressure Swing Vapor Absorption (PSVA) technology. The air is passed through a molecular sieve to produce a gas with a concentration of more than 90% oxygen. The oxygen is compressed into large storage receivers within the Oxygen Plant. Oxygen is used on-site to make ferric sulphate.
How Uranium Extraction Works

Ferric Sulphate Plant

Tailings Neutralization

Acid Plant

Ammonium Sulphate Crystallization Plant

Tailings Management Facility
The **Ferric Sulphate Plant** uses magnetite ore, water, sulphuric acid and oxygen gas to produce a ferric sulphate solution. It is made in a batch process using stirred pressurized reactor vessels. Ferric sulphate is manufactured on site and used in the water treatment, tailings neutralization and leaching processes.

The **Tailings Neutralization (Tails Neut)** circuit processes all mill waste streams to create a solid waste (tailings) and a liquid waste, which undergoes further processing in the JEB Water Treatment Plant before being discharged to the environment as effluent. The water treatment sludges, slurry from CCD and raffinate solution from SX are collected and treated together in the Tails Neut circuit. Waste metals in the raffinate are precipitated using ferric sulphate at a carefully controlled pH. Acid residue from the slurry and raffinate are neutralized using lime. To control radium, we use barium chloride and ferric sulphate. After treatment, the solids are separated from the liquids in the tailings thickener. The solids are then pumped to the Tailings Management Facility (TMF) for permanent disposal.

The **Acid Plant** converts sulphur to sulphuric acid. Elemental sulphur is burned to create sulphur dioxide gas and steam. A catalyst is used to convert sulphur dioxide gas into sulphur trioxide gas, which is then absorbed into water to create 93 to 98% sulphuric acid. This essential process reagent is stored in two large tanks. Steam generated during this process is used throughout the plant for heat and milling purposes.

The **Ammonium Sulphate Crystallization Plant (CX)** treats excess process fluids from mill circuits that contact ammonia (SX, Yellowcake Precipitation and Calciner). The CX plant uses an evaporator crystallizer circuit to produce a granular ammonium sulphate fertilizer by-product.

**Tailings** are made up of left over products from the ore, waste solutions and chemicals used during the milling process. All mining and mineral processing facilities produce tailings. At McClean Lake, the tailings composition is designed for long-term stability and the tailings quality is continuously monitored. The Tailings Management Facility (TMF) design allows for the management of tailings and prevents adverse environmental effects. The tailings are placed in the TMF as a thickened slurry, which settles and consolidates over time. These tailings are not free flowing and are fully contained in the facility. The TMF is designed to ensure that the groundwater flows around the tailings. The TMF is a state-of-the-art facility designed with final, safe decommissioning in mind. It is part of Orano’s commitment to the protection of the environment.
The Tailings Management Facility (TMF) allows proper waste management, which minimizes potential adverse environmental effects.

Tailings are waste products resulting from milling uranium ore. This waste is made up of leach residue solids, waste solutions and chemical precipitates that are carefully engineered for long-term disposal. The TMF serves as the repository for all resulting tailings. This facility allows proper waste management, which minimizes potential adverse environmental effects.

Orano recently received approval to expand the McClean Lake TMF to maximize the capacity of this former JEB pit, now used as a waste management facility.
SABRE Mining Method

Orano is developing the Surface Access Borehole Resource Extraction (SABRE) mining method, which uses a high-pressure water jet placed at the bottom of the drill hole to extract ore from the surface.

Orano has conducted a series of tests with this new cutting-edge mining method and is evaluating its potential for future mining operations.

SABRE would allow Orano to access deposits from the surface using a small footprint, hence limiting potential environmental impact.

Training

Through the support of a wide variety of innovative training programs, Orano builds opportunities for both present and prospective employees.

Our operational training requirements include classroom and on-the-job training, one-on-one training with a mill trainer, equipment training with vendors, peer-training with senior operators and self-study courses.

Orano has partnered with Northern Career Quest, a joint federal, provincial and local northern initiative, to offer the Mill Operator Training Program. Since the start of the program in 2012, over 90 residents of northern Saskatchewan had the opportunity to learn new skills and experience life at McClean Lake. Nearly 85% of the trainees now work at the McClean Lake mill, while others are applying the skills they learned to other industries.
Orano’s Commitments

Environment, Health & Safety

We are committed to developing and maintaining a healthy and safe work environment by following world-class best practices that safeguard people and the environment.

Protecting workers, the environment and neighbouring communities are fundamental principles guiding Orano’s activities. We are committed to developing and maintaining a healthy and safe work environment by following world-class best practices that safeguard people and the environment. McClean Lake strives to maintain low rates of lost-time accidents through a wide range of safety-related programs, training and by fostering safety culture.

- McClean Lake maintains its certification in ISO 14001 standard for environmental management and OHSAS 18001 standard for occupational health and safety management.
- Extensive monitoring programs include regular sampling of air, water, land, plants and animals on site and downstream.
- Worker radiation doses are continually monitored and remain well below the regulatory limit, demonstrating the effectiveness of the radiation protection program and of the mill design to process high ore grades.
Orano strives to create employment opportunities for workers from northern Saskatchewan. The week-in/week-out rotation schedule enables employees and their families to remain in their home communities, which in turn benefit from an increased economic base and valuable trade and professional skills.

Charter flights collect workers from several communities and cities, making it convenient for them to travel to and from McClean Lake. Residence facilities ensure employees are comfortable; living quarters are equipped with games rooms, a fitness centre, a racquetball/squash court, musical instruments, a library and a computer lab, and all workers are treated to fantastic food. Employees also enjoy outdoor activities at McClean Lake such as swimming, fishing, cross-country skiing and stargazing.
Orano transforms nuclear materials so that they can be used to support the development of society, first and foremost in the field of energy.

The group offers products and services with high added value throughout the entire nuclear fuel cycle, from raw materials to waste treatment. Its activities, from mining to dismantling, as well as in conversion, enrichment, recycling, logistics and engineering, contribute to the production of low carbon electricity.

Orano and its 16,000 employees bring to bear their expertise and their mastery of cutting-edge technology, as well as their permanent search for innovation and unwavering dedication to safety, to serve their customers worldwide.

Orano, giving nuclear energy its full value.

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