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PHOENIX RISING: THE APPLICATION OF ISR FOR HIGH GRADE URANIUM MINING IN THE ATHABASCA BASIN

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ABSTRACT

Denison is pioneering the use of the In-Situ Recovery (ISR) mining method in the Athabasca Basin region of northern Saskatchewan (Canada), at the company's Phoenix Uranium Deposit located on the Wheeler River property. Given the unique geology and high grades of the Phoenix deposit (Reserves of 59.7 M lbs. U_3O_8 grading 19.1% U_3O_8), Denison is using a unique application of existing and proven technologies from both the mining and oil & gas industries to engineer field conditions for an innovative application of the ISR mining approach – pairing the world's most utilized and lowest cost method of uranium mining with one of the world's highest-grade undeveloped uranium deposits.

Proven freeze technology is planned to be used to surround the high-grade Phoenix deposit, within which an ISR wellfield of over 300 wells are planned to be installed. Permeability enhancement techniques from the pump and injection wells can be used to augment the natural hydrogeological flow paths facilitating a higher degree of contact of lixiviant with uranium ore. Injection pressure and pumping rates are the primary tools to be used to direct the lixiviant through the wellfield pattern, simulating, to some degree, the natural "sweep" of traditional ISR operations. Wells are expected to be outfitted for both pumping and injection, allowing reversal of flows to facilitate a higher recovery of the deposit.

The successful application of ISR in any geological environment largely hinges on three fundamental requirements: 1) permeability (of the deposit), 2) leachability (of the mineralization), and 3) containment (of the mining solution). Denison has systematically advanced several staged technical programs at Wheeler River, to reduce the project risk associated with these requirements.

In-ground permeability tests conducted via a series of commercial scale wells (CSWs) have evaluated the physical flows and connections through the groundwater systems within the orebody, demonstrating the positive application of ISR and the amenability of the Phoenix deposit. Subsequent hydrogeologic modelling incorporating the results of the in-ground permeability tests produced the "proof of concept" for the application of the ISR mining method at Phoenix, with respect to potential operational extraction and injection rates.

The high-grade nature of the Phoenix deposit at the Wheeler River Project is expected to produce a high-grade Uranium Bearing Solution (UBS) from the wellfield which facilitates the use of direct precipitation for on-surface processing. Specialized core leaching tests have been undertaken to simulate expected field conditions and the characteristics of recovered UBS. Test results to date have far exceeded the UBS grade estimated in Denison's Prefeasibility Study of 10 g elemental uranium per litre of UBS, and long-duration testing has demonstrated overall estimated recovery of uranium in excess of 97% and an average recovered solution uranium head grade of 18.3 grams per litre – demonstrating excellent recovery of uranium from intact high-grade core without the use of permeability enhancement.

In October 2021, Denison completed an ISR field test program which included an ion tracer test utilizing a five-spot pattern of CSWs. The program was successful in demonstrating production flowrates assumed in the Pre-Feasibility Study, confirming hydraulic control of injected solutions during the ion tracer test, establishing breakthrough times between injection and recover wells consistent with previous 'Proof of Concept' modelling, and also showcasing the ability to remediate the test pattern by completing a 'clean up phase' following the tracer test.

In September 2022, after several years of de-risking field investigations, Denison completed a Feasibility Field Test ("FFT") which was designed to assess the effectiveness and efficiency of the leaching process in the ore zone. The first component of the test included the controlled injection of an acidic mining solution into the ore zone within a portion of the CSW test pattern installed in 2021 and the recovery of the solution back to the surface ('Leaching Phase'). The FFT recovered approximately 14,400 lbs U_3O_8 over 10 days of active leaching following completion of initial acidification of the leaching area.

A Neutralization Phase, designed to reverse the residual effects of any remaining acidic solution from the Leaching Phase, was undertaken in October 2022. Overall, the results of the Neutralization Phase achieved the key pH restoration parameter outlined in the applicable regulatory approvals for the FFT, and verified the efficiency and effectiveness of the process for returning the leaching area to environmentally acceptable pH conditions.

Test and design work, to further evaluation and optimize the application of ISR at Phoenix are ongoing in support of a future Feasibility Study.

Keywords: in-situ recovery, core leach tests, permeability enhancement, Athabasca Basin, freeze technology, high-grade uranium