ASX Announcement
ASX: BOE

3 April 2019

Boss completes Phase 1 of Honeymoon Re-start Strategy and identifies further improvements for expansion

HIGHLIGHTS

- Phase 1 testwork and trade-off studies examining processing options deliver data required for Honeymoon Definitive Feasibility Study (DFS) flowsheet development
- Study confirms NIMCIX ion exchange equipment as the preferred system for Honeymoon
- Cost estimates for NIMCIX equipment in-line with the Pre-feasibility results
- Alternate elution process identified to further increase the uranium tenor in the feed liquor, reducing reagent consumption and operating costs
- Final DFS flowsheet for Honeymoon re-start and expanded production confirmed
- Honeymoon DFS underway and on track for completion in Q3 CY2019.

Boss Resources Limited (ASX: BOE) is pleased to announce it has completed the proposed trade-off studies, the final step in the first phase of a three-phase Re-Start Strategy for its 100%-owned Honeymoon Uranium Project in South Australia. The studies confirm NIMCIX as the preferred ion exchange technology and defined the final process flowsheet for Honeymoon's expansion.

DRA Global in Perth, Western Australia, completed the studies based on the results of earlier ANSTO Minerals (ANSTO) optimisation testwork programs. The three studies included:

- Equipment selection and costing for various ion exchange (IX) technologies;
- Confirmation of the configuration and costs associated with a nano-filtration stage originally proposed to treat the IX eluate; and
- A cost estimate of the ANSTO-patented alternate elution process to allow production of a higher-grade uranium eluate directly from IX, using an intermediate conversion stage.

Results from the studies helped Boss further define the optimal process and will be included in the Definitive Feasibility Study (DFS) examining the Honeymoon Re-start, which is due for completion Q3 2019.

Boss Resources Managing Director Duncan Craib said, *"Phase 1 of Honeymoon's re-start strategy is complete on time and within budget and will help us in further optimising our process. A number of improvements have already been identified for the project, key amongst these is the incorporation of ion exchange technology and its utilisation of the field leach trialled resin, a major breakthrough for the commercial expansion of Honeymoon. We have now moved onto the next phase which will see us complete the Definitive Feasibility Study for Honeymoon's Re-Start, expected to complete in 2H CY19."*

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HONEYMOON RE-START STRATEGY

With Phase 1 of the Honeymoon Re-start Strategy complete, Boss has commenced Phase 2, which is expected to be completed in Q3 2019, with Phase 3 following shortly after.

Phase 1: Generation of final input data required for a Honeymoon DFS. This included a drilling program to deliver a measured and indicated resource, an optimisation program to deliver further cost savings and/or process improvements, and a preliminary execution plan, updated cost estimate and schedule for re-start of the existing solvent extraction (SX) plant.

Phase 2: Completion of a DFS and permitting updates. The DFS engineering works; process, engineering design and cost estimation, will use the results from the Phase 1 studies along with the outputs of the wellfield design, derived from the updated mineral resource, to deliver an independent feasibility study report.

Phase 3: The third phase covers the detailed execution planning, operational readiness inclusive of the SX plant recommissioning plan, in conjunction with the ion exchange plant detailed design.

On completion of the three-phase strategy, Boss will be in a position to proceed to mine, assuming a specified global uranium price has been achieved to satisfy the targeted IRR and NPV return to shareholders. In-situ recovery (ISR) mining is a cost effective and environmentally acceptable method accounting for 50% of world uranium mined. The Honeymoon Uranium Project combines ISR with IX production to support operations in the lowest cost quartile of world-wide producers. Boss' proposed production strategy to deliver 3.2Mlb U_3O_8 equivalent per year from Honeymoon is based on the following stages:

Stage 1: Restart of the existing operation; which will involve the use of existing wellfields, and restarting the existing SX plant with minor modifications to rectify identified operational issues. Construction of the IX plant will commence;

Stage 2: Ramp up of plant capacity to 2Mlb/annum U_3O_8 equivalent using the combined SX / IX system;

Stage 3: Ramp up plant capacity from 2Mlb/annum to ~3.2Mlb/annum U_3O_8 equivalent (after validating the IX technology) through the addition of further IX columns.

Ion Exchange Trade-off Study

The most significant capital outlay identified in the Pre-Feasibility Study (PFS) are the ion exchange columns. Accordingly, Boss' trade-off study considered a range of potential ion exchange technologies including the NIMCIX columns previously identified in PFS. The study also considered fixed bed reactors, Koenigstein columns and Kemix pump cells with CCIX elution. Two continuous / simulated moving bed systems were also reviewed but were dropped early on in the study due to perceived issues with treating the high flowrates and / or lack of sufficient technical information provided to assess viability of the process.

In the case of the NIMCIX and fixed bed reactors two variations were reviewed; a single elution stage versus two elution stages (one for each adsorption column) for NIMCIX and a 5 module versus 7 module fixed bed reactor set-up (effectively testing an optimal and conservative superficial velocity in the individual units).

The single stage elution NIMCIX was eliminated after receiving the equipment capex, as the cost savings with using only one elution column was not considered significant enough to justify the additional complexity of resin management. The capital cost for the remaining options are shown in Table 1.

Capital Costs (AUD, $M)	**NIMCIX 1**	**Fixed Bed** 5 Modules	**Fixed Bed** 7 Modules	**Kemix/CCIX**
Directs	17.78	11.61	14.84	26.53
Indirects	10.16	12.98	11.85	14.51
TOTAL	**27.95**	**24.59**	**26.69**	**41.04**

Table 1: *Capital Cost Estimates for Ion Exchange Options*

NIMCIX and Fixed Bed capex numbers were similar (and in line with our PFS cost estimates), with the Kemix option being considerably more expensive. The two preferred options (NIMCIX and 7 Module Fixed Bed) were carried forward for the estimation of the operating costs with the comparative costs shown in Table 2.

Operating Cost (AUD, $M/y)	**NIMCIX 1**	**Fixed Bed** 7 Modules	**Comments**
Labour	N/A	N/A	Assume same labour across options
Power	0.41	2.23	
Maintenance Materials	0.89	0.74	
Reagents & Consumables	0.97	1.09	
Miscellaneous	N/A	N/A	Assume same miscellaneous costs such as lab costs across options
TOTAL	**2.27**	**4.06**	

Table 2: *Operating Cost Estimates for Ion Exchange Options*

The study concluded the NIMCIX columns are not appreciably more expensive than the Fixed Bed options; operating cost savings are significant and will realise better project economics than the Fixed Bed option.

The NIMCIX option is also better suited to the Gould Dam expansion concept where resin will be loaded remotely and transported to a central elution and refining facility to be stripped of uranium before being returned to the satellite adsorption plant. Whilst the Fixed Bed system could be adapted, it is not specifically designed for resin to be removed from the columns.

A review of the commercial applications of the NIMCIX technology was also undertaken. The technology is used at Swakop Uranium (15Mlbs U_3O_8 equivalent/ annum design production rate) and at Vaal Reefs South, which has been operating for over 30 years. In addition, four other South African uranium plants (Blyvooruitzicht, Hartebeesfontein, Chemwes and Merriespruit) successfully used NIMCIX in the 1980s and a NIMCIX plant was built for the Homestake uranium mine in the USA around this time. The technology therefore has a substantial history in the industry, providing confidence in its suitability to the Honeymoon process.

The NIMCIX column with the two-stage elution will be used in the DFS as the go-forward option.

Nano-filtration Trade-off Study

ANSTO investigated nano-filtration (NF) of the IX eluate as a means of increasing the tenor of uranium prior to precipitation, and to recover NaCl for IX elution. DRA Global used the results from this work to define a suitable flowsheet for the process and develop capital and operating costs for process.

It was identified as part of the ANSTO work that the eluate needs to be partially neutralised prior to NF which means an ultrafiltration step is also required to ensure no precipitates enter the NF circuit. Two options were considered for this: 100% neutralisation with caustic; and partial neutralisation with the SX strip liquor and then used caustic to make up the difference.

The proposed circuit is shown below in Figure 1:

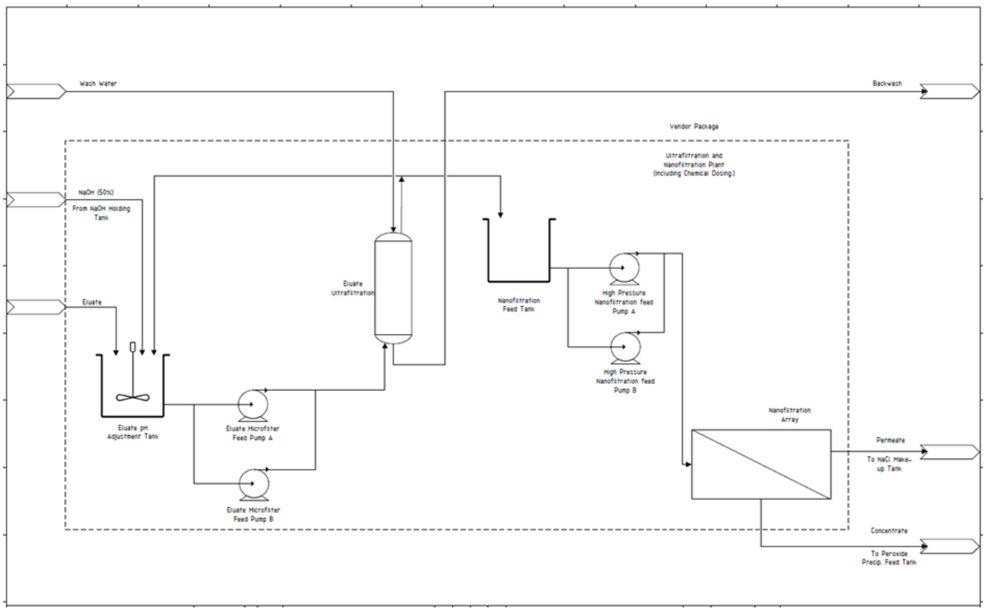

Figure 1: Neutralisation, Ultrafiltration & Nano-Filtration Flow Diagram

The proposed circuit's cost estimates are shown in Table 3 and Table 4.

Item	Eluate AUD, $M	Eluate & SX Strip AUD, $M
Neutralisation & Ultrafiltration	0.35	0.37
Nanofiltration	0.40	0.43
Membrane elements	0.32	0.33
Standby pumps	0.05	0.05
Sub-total: Equipment	**1.12**	**1.18**
Transport	0.10	0.10
Installation	0.75	0.75
Commissioning	0.05	0.05
TOTAL	**2.02**	**2.08**

Table 3: *Capital Cost Estimates for Nanofiltration Circuit*

AUD/y, $M/y	Eluate AUD/y $M/y	Eluate & SX Strip AUD/y $M/y	**Comments**
Labour	0.50	0.50	No increase in labour required
Power	0.50	0.53	
Maintenance Materials	0.10	0.10	
Reagents	2.90	2.30	
Consumables	0.10	0.10	
Miscellaneous	0.20	0.20	
TOTAL	**4.30**	**3.73**	

Table 4: *Operating Cost Estimates for Nanofiltration Options*

The work concluded that:

- 80 per cent recovery of the sodium chloride (elution reagent) is feasible
- The U_3O_8 concentration in the eluate can be increased from ~2.8g/l to ~13.3g/l in the NF concentrate which is similar to the SX strip liquor and is suitable for precipitation
- The current residence time in the Honeymoon precipitation circuit is 5 hours. Testwork has shown that at the tenors seen in this testwork uranium precipitation occurs within 2 hours and as such the current circuit has enough capacity to treat both the SX strip and NF concentrate liquors.

Although technically successful, the NF option may not be preferred for the project due to its higher operating cost. Boss therefore decided to investigate the alternate elution process developed by ANSTO in more detail and maintain the NF option as an option B.

Alternate Elution Process

As an alternative to the base case standard elution and NF flowsheet, ANSTO developed a two-stage elution process which was tested and shown to produce comparable eluates to that expected from the IX / NF concept. The first stage of the alternative process converts the uranium on the resin. This step strips ~5% of uranium from the resin (which can be returned to PLS), but allows for a much more efficient elution to occur with the standard eluate.

The approach taken was to design the first stage of elution as a batch process instead of incurring the cost of another pair of NIMCIX columns (1 per module). As such, some pumps and screens would need to be upgraded to cater for an increased instantaneous flow rate compared to the base case option.

A simplified flow diagram of the process is shown in Figure 2 with the incremental capital and operating costs (compared to the NF option) shown in Table 5 and Table 6.

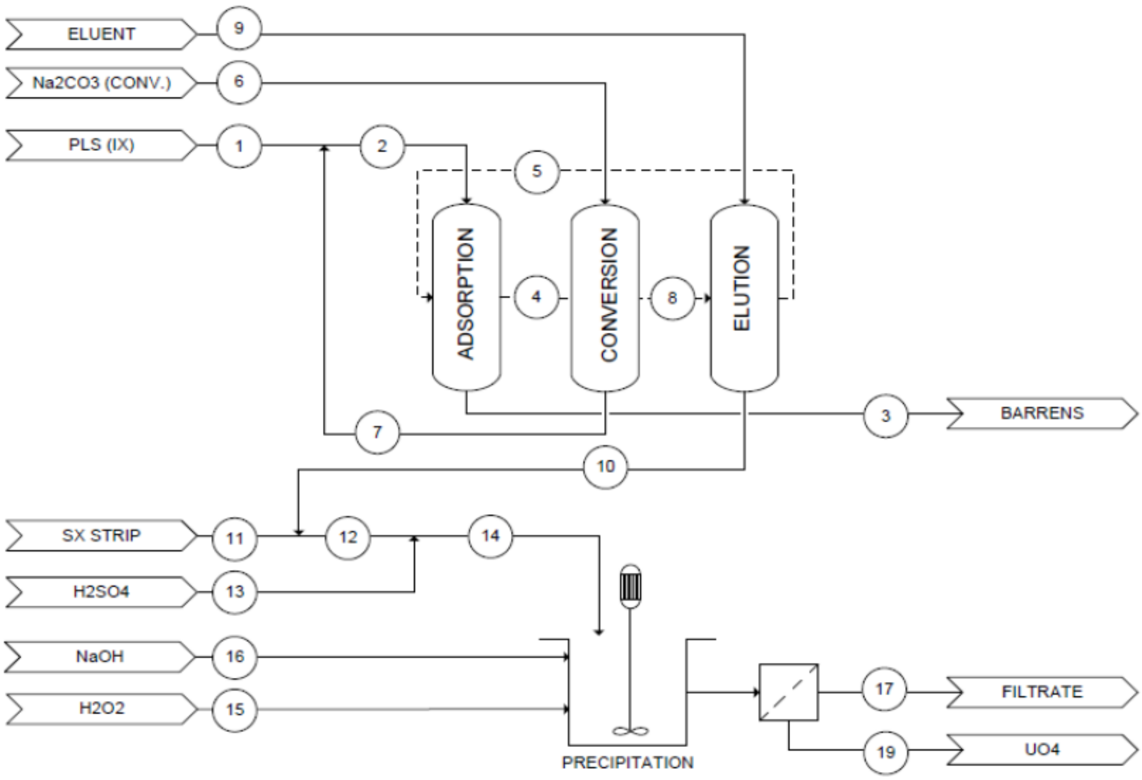

***Figure 2:** Two-Stage Elution Flow Diagram*

	Nanofiltration AUD, $M	Two-stage Elution AUD, $M
Directs **Indirects**	Included in Vendor Estimate	0.53 0.16
TOTAL	**2.08**	**0.69**

Table 5: *Incremental Capital Cost Estimates for NF vs. Two-stage Elution*

AUD/y, $M/y	**Nanofiltration** AUD, $M/y	**Two-stage Elution** AUD, $M/y	**Comments**
Labour	0.50	-	Extra operators required for NF
Power	0.53	1.05	2 Stage Elution – increased power for conversion stage heating
Maintenance Materials	0.10	0.02	4% of Mechanical Cost
Reagents & Consumables	2.40	0.27	Significant cost of NaOH for NF compared to Na2CO3 for 2 stage elution Only variance in NaCl included
Miscellaneous	0.20	0.20	Laboratory Allowance
TOTAL	**3.73**	**1.54**	

Table 6*: Incremental Operating Cost Estimates for NF vs. Two-stage Elution*

The study concluded both the NF and alternate elution processes are viable, although NF may be capable of creating a marginally higher tenor liquor to feed into precipitation.

Operationally, both options contribute to increased complexity in the operation of the plant. The NF option will introduce a continuous, but multicomponent process (estimation of 80 membranes) which will require additional resources to maintain. The two-stage elution process introduces the logistics complexity of a batch stage (conversion) between the semi-continuous adsorption and elution stages.

Both of the options are successful in reducing elution reagents and increasing the tenor of U_3O_8 in solution for precipitation, however the two-stage elution process is the preferred option for the following reasons:

- Lower capital costs
- Lower operating costs
- Comparable technical risk

and will be carried forward to the DFS as the go-forward option.

Next Steps

As announced previously, the work to date highlighted areas for further attention, and recommended the following testwork:

- Conduct lock-cycle tests of the two-stage elution process using a fixed bed lead/lag/elute apparatus or moving bed arrangement;

- Trial a continuous uranium precipitation process to validate the batch results seen here for the combined liquors. Recycling should be tested as this would likely produce particles of larger size and more favourable morphology, which would improve the solid/liquid separation and drying characteristics.
- Regarding solvent extraction, the work showed that the current phase modifier (TBP) is the preferred reagent. Further work is required to fully understand and optimise the scrubbing circuit, in particular:
  - Impact of chloride on the scrubbing of iron and zinc;
  - Use of uranium to scrub iron (III) and zinc at several acidities.

The trade-off studies and Phase 1 testwork have successfully delivered the required inputs for the flowsheet development in the DFS. The DFS basis is now being finalised and tenders will be sent out shortly to companies to allow engineering work on the study to begin.

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