

## Processing Optimisation Study reduces Etango CAPEX by US\$73 million

Bannerman Resources Limited (ASX:BMN; NSX:BMN) (“**Bannerman**” or the “**Company**”) is pleased to announce the successful completion of the Etango Processing Optimisation Study (“**Processing OS**”) by its independent technical consultants, AMEC Foster Wheeler. The Processing OS is the first completed stage of the Etango DFS Update and, together with extensive confirmatory test-work, maintains Etango’s position at the forefront of the global uranium development pipeline.

### HIGHLIGHTS

- US\$73m estimated Etango processing-related capital cost savings (+/-30%)
  - Largest capital reductions from a simplified crushing circuit and confirmation that Ion Exchange is a viable and superior alternative to Solvent Extraction.
  - Process plant design and flowsheet remains low risk by industry standards.
- Etango operating costs reduced, with DFS Update to target improvements of US\$3+/lb U<sub>3</sub>O<sub>8</sub>
  - Improved recovery and reduced reagent consumption are key drivers.
  - Key capital reductions captured without trading off against higher operating cost.
- Further upside potential to be tested
  - Membrane Study to test nano-filtration technology in processing circuit.
  - Use of existing leachate solution and internal expertise ensures modest additional cost.
- Adding value through continued technical enhancement of Etango uranium project (Figure 1)
  - Initial Etango DFS completed in 2012, optimised in 2015 (mining) and 2017 (processing).
  - DFS Update to be continued in 2018.

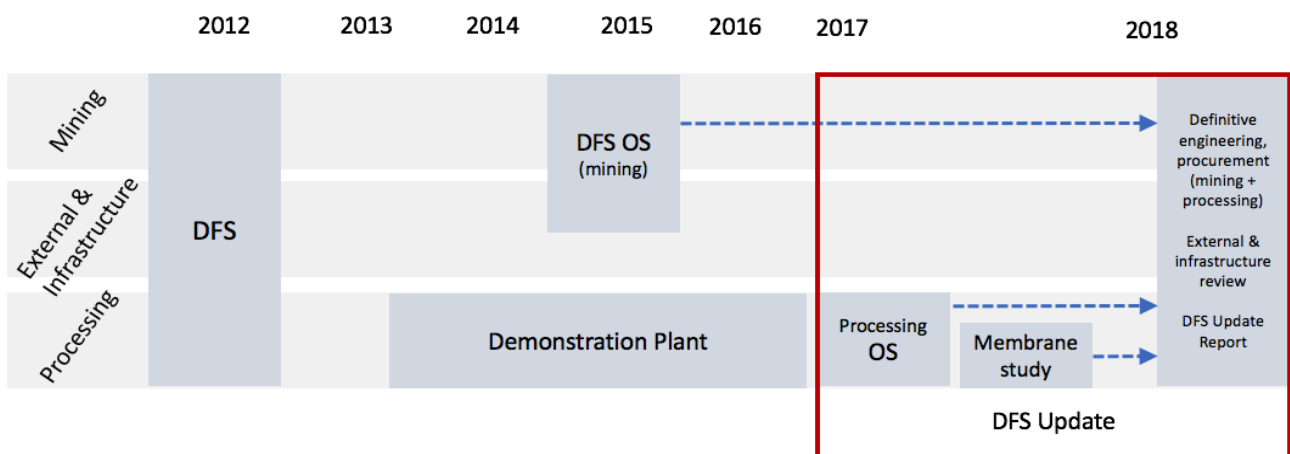


Figure 1 – Etango Processing Optimisation Study in context of technical enhancement of Etango uranium project.

## ETANGO PROCESSING OPTIMISATION STUDY SUCCESSFULLY COMPLETED

Bannerman's 95% owned Etango Project is one of the largest and most advanced uranium projects globally. Etango is located within the Erongo uranium province of Namibia, which also hosts the Rössing (Rio Tinto), Langer Heinrich (Paladin Energy) and Husab (China General Nuclear) uranium mines. Exploration at the Etango project commenced in 2006 followed by completion of a Scoping Study in 2007, Pre-Feasibility Study (PFS) in 2009, PFS Update in 2010, Definitive Feasibility Study (DFS) in 2012 and an Optimisation Study (mining) in 2015. In 2010, Environmental Approval of the proposed Etango mine was granted following completion of an Environmental and Social Impact Assessment. In 2017 a Mineral Deposit Retention Licence was granted over the project, with a 5 year tenure that may be extended.

The Etango Heap Leach Demonstration Plant was constructed in 2014, following which the Company ran a six-phase pilot program that concluded in January 2017.

Bannerman commenced the Etango Processing Optimisation Study (Processing OS) in the March 2017 quarter with the objective of incorporating the favourable results obtained in the Heap Leach Demonstration Plant Program and evaluating the application of recent processing technological advances since the 2012 DFS was completed. The results and recommendations from the Processing OS will be incorporated into the DFS Update, in conjunction with definitive level procurement aimed at capturing the deflation that has occurred in the resources sector since 2012.

A processing opportunity review workshop was held in January 2017 involving Bannerman and AMEC Foster Wheeler personnel. Discipline experts were engaged to critically review the project and identify potential options to improve the economics of the Etango Project and review/evaluate such options ahead of a DFS Update. After 133 improvement ideas were identified, high potential opportunities were prioritised in the key processing plant areas.

In November 2017 AMEC Foster Wheeler issued a detailed report following completion of the Processing OS. This report demonstrates the success of the study, the potential for nano-filtration to benefit the project (discussed below), and identified a number of areas where further potential capital and operating cost savings may be confirmed by the work to be undertaken during completion of the DFS Update.



Figure 2: The Etango Demonstration Plant generated pregnant leach solution for IX testwork

## ESTIMATED CAPITAL COST SAVINGS OF US\$73M (+/- 30%)

The Processing OS was undertaken with the primary objective of reducing the capital cost associated with the comminution circuit and processing plant design, without simply “trading off” reduced capital costs against increased operating costs. In addition to substantially reducing estimated pre-production capital by US\$73 million without an operating cost trade-off, the Processing OS identified further capital and operating cost reduction opportunities that can be evaluated during definitive level engineering and procurement to be completed under the DFS Update.

Identified capital savings were supported by revised budget quotations for new equipment and revised layouts and basic arrangements layouts. Civil, structural, electrical and instrument costs were benchmarked against current projects.

The most significant estimated capital cost savings resulted from the following:

- Simplifying the crushing, stockpiling and screening circuit;
- Confirmation that Ion Exchange is favourable to Solvent Exchange for both economic and operational reasons;
- Removing pinned bed clarifiers after the Heap Leach Demonstration Plant program confirmed the low suspended solids content of the PLS in the Etango solution; and
- The use of a single agglomeration unit.

The aggregate impact is an overall simplification of the Etango flowsheet that delivers an estimated US\$73 million savings, with a level of accuracy of +/- 30%.

### **Simplified comminution circuit**

Since the 2012 DFS, significant equipment development has taken place and larger and more reliable crushing units have become available. This enables single line crushing for the Project to be evaluated in the context of unit performance of recent installations at existing operations. Including these larger units in the flowsheet has also enabled the removal of a secondary screening stage, simplifying the flowsheet where the secondary crushed product can now be fed directly into the High Pressure Grinding Roll (HPGR) without the risk of feeding oversize material. This further reduces the number of conveyors, transfer points and circulating loads. To ensure adoption of single line crushing does not substantially increase production risks, the revised flowsheet includes an emergency fine crushed ore stockpile and rehandle system. The stockpile is designed to decouple the crushing circuit from the agglomeration and stacking circuit and minimize the effect of scheduled (or unscheduled) maintenance on production capacity.

### **Ion Exchange to replace Solvent Extraction**

The Etango DFS processing flowsheet was designed to extract uranium from solution utilising Solvent Extraction (SX) technology. The availability of large volumes of solution from the Etango Heap Leach Demonstration Plant provided an opportunity to challenge this design with the benefit of laboratory test-work and precise analytical data.

In-depth analysis was undertaken to assess the economic preference between extraction using Solvent Extraction (SX) and Ion Exchange (IX), taking into consideration the Etango pregnant leach solution (PLS) uranium tenor of approximately 300mg U<sub>3</sub>O<sub>8</sub>/L. As the SX and IX circuits employ different chemical systems for stripping the extractant and final product precipitation, the downstream product precipitation and product handling circuits were all incorporated into the analysis.

Analysis showed that there is no substantive variation in operating costs of the two options, however the capital cost of an IX circuit is considerably lower. The ammonium diuranate (ADU) precipitation in the SX route requires more expensive calcining equipment to produce the final U<sub>3</sub>O<sub>8</sub> product (at 700 to 800°C), whereas the uranyl peroxide (UP) precipitate produced in the IX route can be dried to UO<sub>4</sub> (at 120°C) in a

comparatively simple process. As ADU calcining requires significantly more fuel than the UP drying, there are further operational and safety benefits associated with adopting an IX extraction route.

IX testwork was completed at the Etango Demonstration Plant under the supervision of the AMEC Foster Wheeler subject expert. A typical two-staged approach was used for this work, firstly generating loading and elution isotherms to screen for the best resin products to take forward, followed by column tests on the selected resins. The net resin loading assumptions were achieved, with elution kinetics and the required volumes supporting the assumed design of the moving packed bed elution columns.

#### **Other capital savings**

A number of other capital savings opportunities were evaluated and, where necessary, tested internally, by AMEC Foster Wheeler or by equipment vendors. Several of these opportunities were confirmed and included in the Processing OS, whilst others were either eliminated or referred for further evaluation during definitive design and procurement. For example, larger agglomeration drum units are now more readily available and have proven themselves in commercial operation, particularly in Chile. A single unit reduces the number of associated items e.g. conveyors, feeders, weightometers and associated installation costs.

The Heap Leach Demonstration Plant testwork showed a relatively clean solution produced by the cribs with average suspended solids of approximately 75 ppm. The revised processing flowsheet has therefore removed the two pinned bed clarifiers, which are substituted by a settling pond. The use of sedimentation ponds is widely accepted and applied in the copper heap leaching industry with the use of clarifiers more frequent in agitated leach operations or for problematic heap leach solutions.

#### **Process flow sheet remains relatively low risk**

Etango distinguishes itself amongst large uranium projects globally as a low technical and operating risk project. Given the importance of security of supply to nuclear power planning, Etango's expected technical, geological, mineralogical and metallurgical reliability is a key attractive feature, particularly given the very large scale of the project. Maintaining Etango's relatively low operating risk profile was therefore a key parameter when undertaking the Processing OS.

All the changes incorporated into the Etango processing flowsheet have proven operating credibility. Although the operating risk profile of the project has increased slightly, the selected unit operation reliability and configuration remains straight forward and simple. In short, the flowsheet has been simplified and Etango's projected operating risk profile remains appreciably low by industry standards.

### **IMPROVEMENT IN OPERATING COST**

The Processing OS identifies significant potential operating cost savings and has led to the Company formulating a DFS Update improvement target of US\$3+/lb U<sub>3</sub>O<sub>8</sub>, compared with the operating costs published in the 2015 Optimisation Study. The most significant estimated operating cost savings resulted from the following:

- Testwork confirmed a 40% reduction in the binder required for the agglomeration process. Stacking tests and hydrodynamic column tests were performed at Mintek laboratories in South Africa with varying binder levels. The testwork concluded that a binder dosage of 150 grams per tonne of ore (as compared to the 250 g/t in the DFS) is sufficient for the target heap height and irrigation flow. This reduction in binder reduces the forecast operating cost by approximately US\$0.75/lb.
- The Heap Leach Demonstration Plant testwork over two years has consistently shown a final recovery of approximately 93% against the DFS projection for a scaled-up heap of 86.9%. The testwork results, which included 280 tonnes of ore, were used by AMEC Foster Wheeler to project a scaled-up

processing recovery of 87.8%. This improved recovery reduces the forecast operating cost by approximately US\$0.40/lb.

- The Heap Leach Demonstration Plant testwork also consistently showed acid consumption averaging 14.4kg/tonne compared to the DFS projection of 17.6 kg/tonne. The scaled-up acid consumption was reduced to a level of 16.8 kg/tonne. Further detailed engineering work will be done in the DFS Update to accurately reflect the operating savings achieved with this lower acid consumption and other opportunities to reduce acid costs such as membrane acid recovery.
- The operating savings obtained from the simplified comminution circuit will also be reflected in the DFS Update.

A range of further potential operating cost saving opportunities, such as reduced maintenance assumptions associated with capital reductions and the operating benefits of a simplified processing circuit, will be considered during the definitive level engineering and procurement to be conducted under the DFS Update.

Accordingly, further operating cost improvements are anticipated and the Company targets improvements of US\$3+/lb U<sub>3</sub>O<sub>8</sub> across the life of mine.

### MEMBRANE STUDY TO TEST FURTHER CAPITAL AND OPERATING COST REDUCTIONS

Membrane separation processes, in particular nano-filtration, have been used in the mining industry in a variety of applications, including recovering metals from solution, scavenging reagents for re-use, treating and recovering wastewater and environmental rehabilitation.

The Processing OS identified an opportunity to incorporate nano-filtration technology in the processing circuit. A desktop review of the Bannerman Heap Leach analytical data was undertaken, which evaluated the technical suitability of nano-filtration technology in the processing flowsheet as a first step to understanding the economic applicability of the technology. As a result, a variety of nano-filtration membranes will be tested using a membrane pilot test rig in November 2017.

The testwork will be undertaken at modest additional cost, as the program utilises uranium bearing solutions generated by the Etango Demonstration Plant and internal expertise. Accordingly, this use of existing resources and minor additional expenditure provides an excellent risk-reward return on investment.

The Membrane Study targets potential improvements to capital and operating costs deriving from membrane acid recovery (proven at the Kayelekera uranium mine<sup>1</sup>) and the potential for uranium recovery by nano-filtration. Identified benefits will then be incorporated into the DFS update.

The testwork will include the following:

Activity	Description	Target Completion Date
Concentrated eluate solution generation	Generation of concentrate eluate (CE) solution using a pilot elution column for Ion Exchange	end November 2017
Direct uranium extraction	Explore the application of a variety of nano-filtration membranes to extract uranium directly from heap leach solution	mid December 2017

<sup>1</sup> Peacock, M., et al (2016). Paladin Energy Ltd – Nano-Filtration Technology For Reagent Recovery. In: *ALTA 2016 Uranium-REE Sessions*. Perth. ALTA Metallurgical Services Publications

The above testwork will enable a full technical and economic evaluation of the application of membrane technology to the Etango Project, with results expected in the first quarter of 2018. Bannerman will provide further updates as the Membrane Study progresses.

### **DFS UPDATE TO BE CONTINUED IN 2018, ADDING VALUE THROUGH CONTINUED TECHNICAL ENHANCEMENT OF ETANGO**

The completed Processing Optimisation Study and initiated Membrane Study will provide valuable input into a DFS Update, to be continued in 2018. The DFS Update will include:

- Definitive standard engineering incorporating the enhancements from the mining Optimisation Study (2015), the Processing Optimisation Study (2017) and the Membrane Study (2018).
- Definitive level procurement to capture the full value of the mining sector deflation experienced since the 2012 DFS and to incorporate the competitive benefits from a broader range of technology and equipment vendors.
- Further possible improvements to mine design, mining approach and, if feasible, potential adoption of new mining technologies.
- Updated external/financial costs and potential infrastructure improvements.

The continued technical enhancement since the 2012 DFS repositions Etango and has confirmed the technical robustness of the project metrics. The Mining and Processing Optimisation studies and the extensive confirmatory testwork conducted at the Etango Demonstration Plant and external laboratories places Etango at the forefront of the global development pipeline of projects with targeted annual production at or above 2 Mlbs U<sub>3</sub>O<sub>8</sub> per annum.

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**About Bannerman** - Bannerman Resources Limited is an ASX and NSX listed exploration and development company with uranium interests in Namibia, a southern African country which is a premier uranium mining jurisdiction. Bannerman's principal asset is its 95%-owned Etango Project situated near Rio Tinto's Rössing uranium mine, Paladin's Langer Heinrich uranium mine and CGNPC's Husab uranium mine. A definitive feasibility study has confirmed the technical, environmental and financial (at consensus long term uranium prices) viability of a large open pit and heap leach operation at one of the world's largest undeveloped uranium deposits. From 2015-2017, Bannerman conducted a large scale heap leach demonstration program to provide further assurance to financing parties, generate process information for the detailed engineering design phase and build and enhance internal capability. More information is available on Bannerman's website at [www.bannermanresources.com](http://www.bannermanresources.com).

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