"ISL pattern reserve requirements for today's spot price,"

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"ISL Pattern Reserve Requirements for Today's Spot Price,"

or

"How Many In-Place Pounds are Needed for a Mining Pattern to be Profitable in Today's Market."

Recent uranium spot market values place additional burdens on the geologist and project manager to identify mineralized ore that will yield a profitable return on investment to the mining venture and its investors. The author reviews the various cost components that comprise the total work effort required to produce uranium via ISL methods to arrive at a suitable ore grade that will guarantee profitably. Amortization of costs based on recent expenditures for typical ISL operations are used in conjunction with wellfield development, operating, and restoration costs to determine the ore value required to show a positive return on investment.

INTRODUCTION

Recent uranium spot market values place additional burdens on the geologist and project manager to identify mineralized ore that will yield a profitable return on investment to the mining venture and its investors. Today's uranium spot market environment is requiring *in-situ* leach (ISL) producers to constantly evaluate ore quality to insure that profitably, or positive cashflow, will be achieved. A brief review of the total work effort required from ISL producers to generate a pound of uranium is worth summarizing.

Twelve discreet cost and work components comprise the efforts to produce a pound of uranium. They are in order of expenditures: project finance, land, environmental, exploration drilling, plant capital, definitive drilling, development drilling, plant operations, wellfield operations, restoration, reclamation and closure, and royalty. These cost classifications can be further refined into those expenses that will be amortized over the entire production of the project, and those investments specific to individual mine units. Five of these cost categories, (finance, land, environmental, plant capital, and exploration) are amortized over all future production from the project and subsequently will be referred as 'Pre-Development' costs. The remaining cost elements (definitive drilling, development drilling, wellfield operations, plant operations, restoration, reclamation and closure, and royalty) are 'Development' costs, and are dependent on the ore configuration. Consequently they are the focus of this study.

Pre-Development

An abbreviated review of each component that makes up pre-developmental costs is essential to understand the accounting fundamentals. Finance charges typically include all future capitalized interest and the amount of the loan origination fee that can range between five and ten percent of the total amount borrowed. The cost of money can be substantial. Land expenses comprise lease acquisition and holding costs, while environmental expenditures include all expenses for permitting and licensing. Exploration costs are those charges that were initially made to adequately satisfy management that sufficient mineral potential was present for continued development. Depending on the extent that a property was initially tested for mineralization, additional exploration charges could be required if new areas, and deeper sands need to be explored. Finally the construction cost and site reclamation of the main processing plant will be amortized over all future production. The combined value of all the aforementioned costs can be quite a burden in a depressed spot market. Therefore an attractive ore body can insure that developmental costs are minimized to insure a profit margin for the investor.

Development

Definitive drilling is the first phase undertaken in the installation of a wellfield. This type of close spaced resource development is conducted in known mineralized areas to determine the extent and configuration of the ore. The amount of definitive drilling required should be sufficient to determine the statistical boundaries of the ore. It is with this preliminary geologic information that a wellfield design of injection and production wells is generated. Over-drilling in this development phase to satisfy accuracy and assurance of reserves should be reserved only to specific areas of geologic difficulty as these costs must, in the future, be offset in savings from developmental costs.

Developmental drilling costs consist of casing and cementing injection/production wells with their ancillary equipment and piping . Shallow, deep and production monitor well costs are included in this stage of resource development. Wellfield and plant operating costs are dependent on the grade of the ore, depth, thickness of the ore interval, reagent usage, pattern spacing, hydrology, electrical costs, pore volume size, pore volumes circulated to achieve recovery, and drilling penetration rates to name a few variable factors. Restoration and reclamation expenditures can be based on industry experience, namely the number of pore volumes of water withdrawal and recirculation to achieve a water quality consistent with baseline quality. While it is important to recover as much of the resource base as is economically possible, it often times is necessary to “step over” areas of weaker mineralization because of low market price conditions.

Any project being considered for development and requiring financing should be able to withstand the scrutiny of a bank loan committee. The loan committee most likely would want assurance that the loan, plus interest, had a strong probability of being repaid. To conduct an economic evaluation of this magnitude would require a very detailed inspection of leachability, location, political environment, and mine scheduling from pre-development through closure. Taking into account a detailed schedule of expenditures for each of the preceding twelve categories would provide assurance of the profitability if there was sufficient quantity and grade of ore present. It is with the understanding of the need that sufficient grade and quantity of ore must be present to ensure a project’s profitably with today lower spot prices that this study was undertaken.

Assumptions

A mining company, ABC Inc., is evaluating whether to acquire a property with estimated mineralization of 40,000,000 lbs. U_3O_8. To acquire this property, that incidentally has a royalty payment of 7%, an up front cash payment of $10,000,000 US is requested for transferring the lease and exploration drill hole data and logs. Furthermore it has been estimated that $2,000,000 US will be required to fully permit the initial phase of the project. Financing is required for plant construction ($20,000,000), initial wellfield ($2,500,000) and permitting costs, plus an additional $6,000,000 in working capital if the property is acquired and developed. The interest rate is 0.75% compounded monthly (9% annualized), and it is contemplated that repayments will begin one year after production commences and that it will be totally repaid after 5 years of operations. The loan
origination fee of 6% is also financed and applied towards the total loan. Table 1. itemizes these costs, fees, and interest charges.

1. Property Acquisition	$10,000,000
2. Permitting	$2,000,000
3. Plant Construction	$20,000,000
4. First Wellfield	$2,500,000
5. Working Capital	$6,000,000
Total	$40,500,000
6. Origination Fee @6%	$2,430,000
Loan Amount	$42,930,000
Repayment Amount	$1,066,191
Total Interest	$21,041,479
No. of Payments	60

Table 1. Principal and Interest

These six pre-development costs, plus the future site reclamation expense, comprise the amortize expense for all future production from the project. Table 2. summarizes the amortized cost components based on 28,000,000 pounds recoverable..

Category	Amount	Cost/lb.
Land	$10,000,000.00	$0.36
Environmental	$2,000,000.00	$0.07
Plant Construction	$20,000,000.00	$0.71
Site Reclamation	$4,000,000.00	$0.14
Debt Service, first 7 years	$21,041,479.00	$0.75
Loan Origination Fee	$2,430,000.00	$0.08
Total	$59,471,479.00	$2.12

Table 2. Amortized Costs

Process Description

An *ISL* feasibility study was conducted to develop the various variable and fixed cost components that are required functions within the mathematical model. Fifty employees were deemed necessary in achieving success. Wellfields were considered that were capable of delivering a range of flowrates between 63.5 liters/sec. and 300 liters/sec. Labor rates range from $8.65/hr to $11.54/hr. while salaries vary from $20,000 to $150,000. Electrical costs were reasonably estimated at $.07/Khr. Ancillary expense includes such items as: medical benefits, telephone, postage, office supplies, copy equipment, data processing, licenses, property taxes, office equipment maintenance, travel & entertainment, and equipment rental. The extraction plant consists of an alkaline ion exchange loading and elution circuit. A peroxide precipitation process is included with the resulting yellowcake slurry dewatered and dried utilizing a filter press and a state-of-the-art low temperature vacuum dryer. A waste disposal well and multiple doubled lined waste storage ponds were also considered a necessary component to the overall flexible and efficient design.

Well Development Costs

Individual injection, production, and monitor well detailed cost schedules were employed to generate the variable and fixed components necessary to drill and case a series of wells that comprise a wellfield. Variable costs were those items associated with depth: drilling time, casing, cement, electrical cable, etc. Fixed costs included those items that were needed regardless to depth: pumps, meters, electrical starters, etc. In addition, a fixed monthly charge for labor and ancillary costs was also developed as these costs reoccur and are not dependent on the number of wells completed each month. Five employees were budgeted to carry out these activities. Drilling activities were performed by independent contractors.

Plant and Wellfield Operating Costs

Fixed monthly labor and ancillary charges were calculated based on a staffing of 45 employees. Plant costs are essentially all fixed costs with the exception of chemicals needed for precipitation, and costs for yellowcake drying and shipping. The exceptions are a function of the quantity of uranium processed each month. Labor and ancillary expenses are reoccurring costs that vary little with the quantity of uranium dried.

Wellfield electrical and oxygen expense varies with the volume of lixiviant circulated. Additionally the cost of maintaining an operating wellfield is dependent on the number of wells in operation. Replacement of pumps, motors, repairs to meters, and electrical starters comprise the other variable cost. Once again a fixed labor and ancillary component occurs that has been calculated for a typical wellfield operation.

Restoration

Upon the completion of mining, the wellfield solutions must be restored to pre-mining quality in most circumstances. Historically an average of eight (8) pore volumes of groundwater sweep and water purification has been required to meet this objective. Once again monthly fixed costs associated with wages and ancillary expenses are incurred. The volume of fluids circulated and treated each period, and the number of operating wells comprise the only variable cost factors. Electricity, wellfield replacement hardware, and pretreatment chemicals are included in these variable costs. Groundwater is withdrawn, disposed of, and/or treated for reinjection to accomplish restoration. Plugging each well after final regulatory restoration approval constitutes the final work effort of the uranium producer. A fixed charge for a contractor's plugging fee, and a variable expense dependent on the volume of cement required to plug each cased well has been taken into account in this portion of model. All these assumptions are detailed in Table 3. It is on these values that the computer model is based.

1. Drilling costs are $120/hr with penetration rates of 50 feet/hr.
2. Property acquisition - $10,000,000 US.
3. Environmental Permitting is anticipated to be $2,000,000 US.
4. Exploration costs to drill up additional resources are:

- $14.02/m - includes labor, drilling, logging, and plugging
- Drill patterns are staked out on 30.48 meter by 30.48 meter grids

5. Exploration and Definitive costs are one half of Development Costs
6. The ore is at a depth of 122 meters, with a tonnage factor of 1.797 mton/m^3
7. Average ore thickness is 3.048 m, Porosity is 30%.
8. Plant Capital Costs for infrastructure and IX Plant are $20,000,000 US.
9. Resource Development costs to drill and complete wells are:

	Fixed	Variable
• Injection well	$6,241	$29.55/m
• Production well	$11,783	$51.74/m
• Monitor well	$5,843	$25.45/m
• Monthly fixed wages and ancillary expense	$45,226	

10. Ratio of Injection **:** Production **:** Monitor well - 1.1 **:** 1.0 **:** 0.21

11. Plant Operating Cost are:

Precipitation chemicals =	$0.55/Kg ($0.25/lb.)
Drying and delivery =	$1.05/Kg ($0.48/lb.)
• Monthly Plant fixed wages and ancillary costs =	$129,000

12. Wellfield Operating Cost are:

Electricity =	$.071/m3
Variable costs =	$.051/m3
Monthly wages, ancillary and fixed costs =	$102,764
Average well flowrate =	3.175 l/sec (50 gallons/minute) - 6.23 days/PV

14. Restoration and Reclamation Costs are:

Well plugging fixed expense	$1270/well	
-		
Well plugging variable expense -	$1.65/m	Pattern Restoration Flow -1.27 l/sec
Pore Volumes treated -	8	# Patterns being restored - 25
Monthly wages and ancillary expense -	71,058	# Months to Restore - 4.1
Electrical -	$.275/m3	
Variable expense -	$.061/m3	

Table 3. Model Assumptions

MODEL

Definitive Costs

50% of Development Costs (B + C + D) --A

Development Pattern Costs

Depth{#inj well x (cost/m)+#prod well x (cost/m)+#monitor well x (cost/m)} --B
{#inj well x cost/well + #prod well x cost/well + monitor well x cost/well} --C
Monthly wages and ancillary cost / patterns drilled each month --D

Plant and Wellfield Operating Costs

Pore Vols. x PV factor x length x width x thk x porosity x wellfield Cost/m^3 --E
(Wellfield and Plant wages and ancillary)/monthly production --F
Chemical Cost/lb U3O8 --G

Restoration Costs

Pore volume x PV Factor x porosity x # restoration PV x variable cost/m^3 --H
Monthly wages and ancillary cost/ # of patterns restored x months to restore --I
# of pattern wells x plugging fixed cost --J
# of pattern wells x variable plugging x depth --K

Pounds Recovered

(A+B+C+D+E+H+I+J+K) / (Spot Price - G - F - Amortized Cost - Royalty) --L

Equation L is the algorithm for calculating the required pounds to be recovered from a mining pattern for a given market price. Conversion to Grade Thickness product is illustrated in equation M.

GT(m) = L x 100 / (length x width x tonnage factor) / 2204 / %Recovery --M

RESULTS

Fully Amortized Cost Case

Figures 1 and 2 depict the required Grade-Thickness (GT) product and average wellfield lixiviant concentration for the conditions set in Table 3 over a broad range of spot market prices for annual production rates of 2 and 1 million pounds respectively. The assumptions contained within Table 3 allow for a wide range in latitude for processing wellfield solution. The labor and staffing adopted in the assumptions can easily operate a commercial ISL project up to flowrates of 317.5 liters/sec. (5,000 gpm). Well spacing of 30.48m. by 30.48m. (100ft. by 100ft.), and 30.48m by 15.24m (100ft. by 50ft.) are depicted to illustrate that closer well spacing necessitates higher GT values for the mining project to remain economical. For uranium spot prices of $9.50/lb. And an annual production of 2 million pounds, an average GT(m) value of 0.645 (2.115 GT(ft.), 23,718 lbs. U_3O_8) is needed for the wider well spacing. For the closer well spacing a GT(m) value of 1.083 (3.552 GT(ft.), 20,242 lbs. U_3O_8) is required to maintain economic viability.

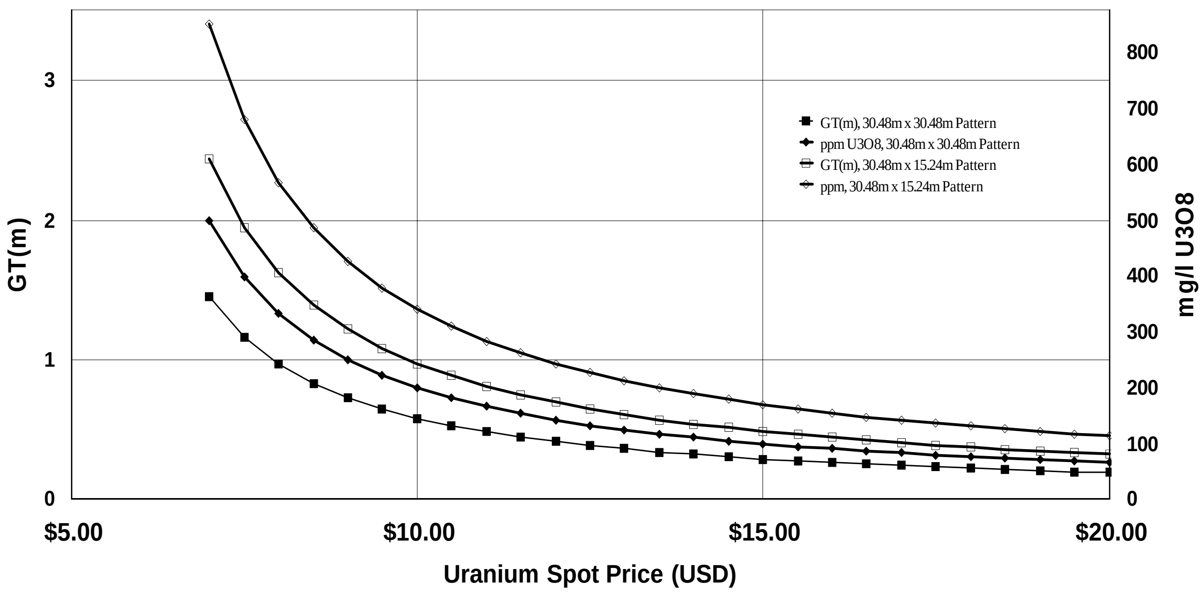

Figure 1 - GT(m) and Wellfield Lixiviant Concentrations for Fully Amortized Costs 2,000,000 lbs./year

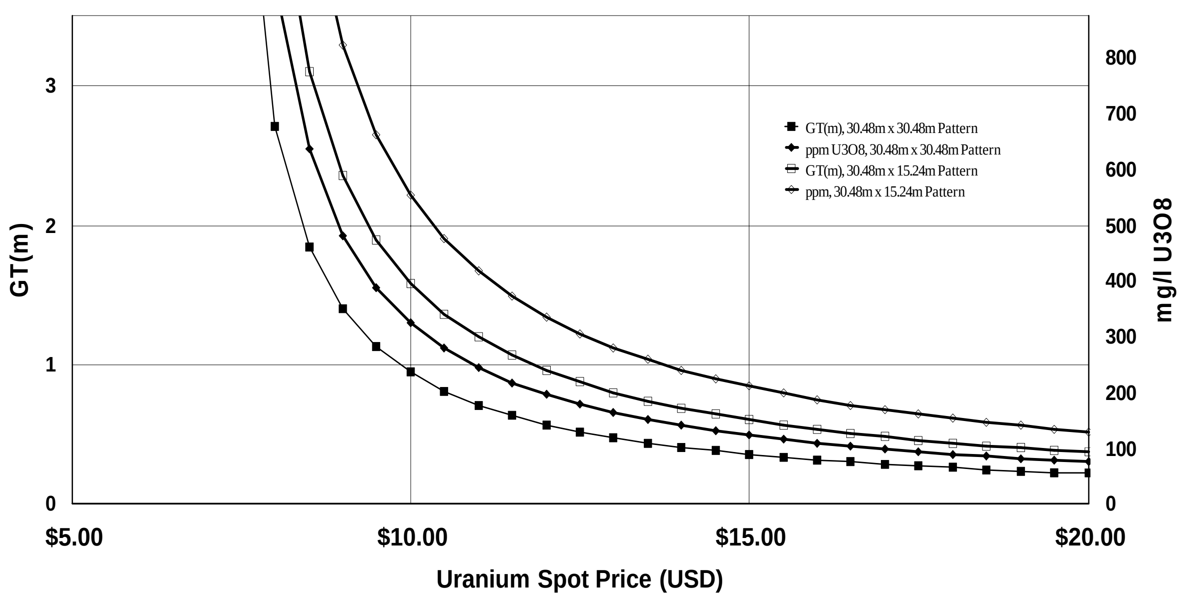

Figure 2 - GT(m) and Wellfield Lixiviant Concentrations for Fully Amortized Costs 1,000,000 lbs./year

Values for each of the model's components for a spot price of $9.50 are tabulated in Table 4. Both well spacing cases for a production rate of 2,000,000 lbs. per annum are illustrated.

	30.48 meter by 30.48 meter	30.48 meter by 15.24 meter
A	$17,655.00	$17,250.00
B	$10,930.00	$10,930.00
C	$19,875.00	$19,875.00
D	$4,505.00	$3,696.00
E	$4,146.00	$2,073.00
F	$1.39	$1.39
G	$0.73	$0.73
H	$4,567.00	$2,283.00
I	$11,652.00	$5,834.00
J	$2,921.00	$2,921.00
K	$463.00	$463.00
L	0.645	1.083

Table 4 - Model Equation Values

In the late seventies when uranium spot prices exceeded $40/lb. USD there was a legitimate argument concerning operating at higher plant flowrates and lower lixiviant concentrations. For today's economic conditions, the reverse is true. High solution concentrations and lower plant flowrates are required to minimize the overall wellfield development costs. Because there will be much fewer mineralized areas within a mine plan that meet the stringent GT(m) requirement for today's spot price, there will be corresponding fewer number of well patterns required to achieve production. The correlation between spot price, project flowrate, and lixiviant concentration are born out in the output of the model. For instance at $9.50/lb. USD and 2,000,000 pound annual production an average flowrate of 130 liters/sec. (2,044 gpm) and lixiviant concentration of 221 mg/l is mandated. Conversely at $18/lb USD spot price an average flowrate of 375 liters/sec (5,903 gpm) and plant feed of 77 mg/l is required to sustain an economic production.

Sans Amortization Costs

There certainly are situations where a company may elect to operate in the red. Sunk funds expended for the amortization of the project may be written off, if allowed, thereby lowering the bar for profitability. Figure 3 illustrates the pattern ore requirements for justifying all present and future expenditures, and totally writing down all amortization expenditures.

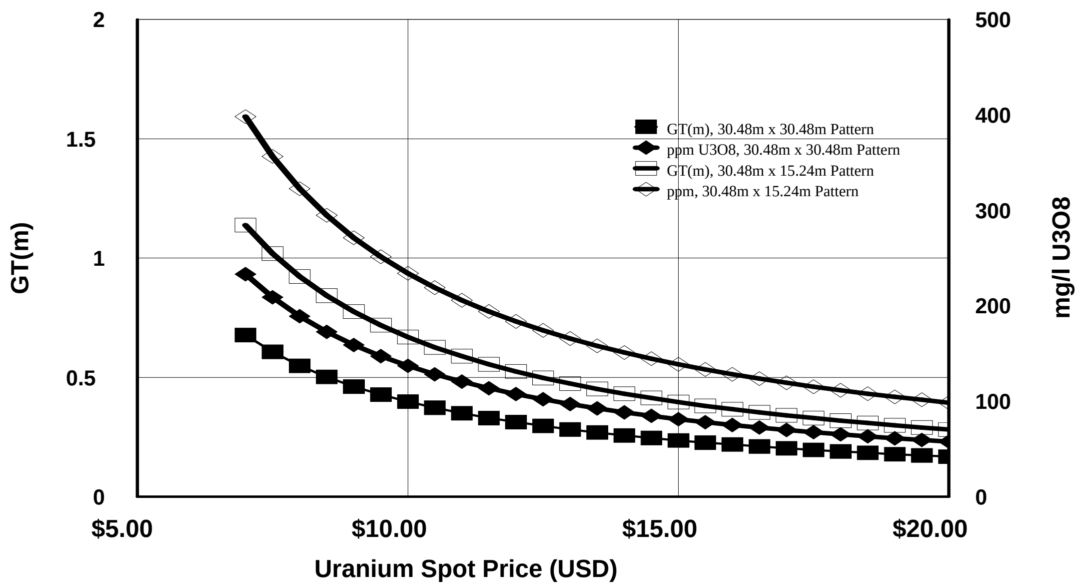

Figure 3 - GT(m) Required for all Costs Sans Amortization
2,000,000 lbs/year

Figure 3 depicts for $9.50/lb. U_3O_8 an average solution concentration of 145 mg/l and plant operating flowrate of 198 liters/sec (3,121 gpm) for well patterns containing an average GT(m) of 0.422 (1.385 GT(ft), 15,533 lbs U_3O_8). I suspect that presently there are very few ISL projects operating at these sustained conditions.

Cashflow Case

The cashflow case examines the scenario where all sunk funds (amortization) and future expense (restoration and reclamation) are ignored. Wellfield development expenditures, plant and wellfield operating costs, and royalty are the only cost components that figure into the cost of production. Figure 4 illustrates this case.

At this operating mode our $9.50/lb. USD standard case lowers the GT requirement to an achievable 0.304 GT(m) (.998 GT(ft), 11,192 lbs. U_3O_8). The lixiviant plant throughput must average 275 liters/sec (4,332 gpm) to achieve the 2 million pounds initially specified. A lower annual production of 1 million pounds would increase the GT(m) ore grade sought to 0.425 (1.396 GT(ft), 15,653 lbs. U_3O_8) in order to absorb all the fixed costs associated with wellfield development and operating. An average lixiviant grade of 146 mg/l operating at 98 liters/sec (1,550 gpm) would sustain production for 1 million pounds.

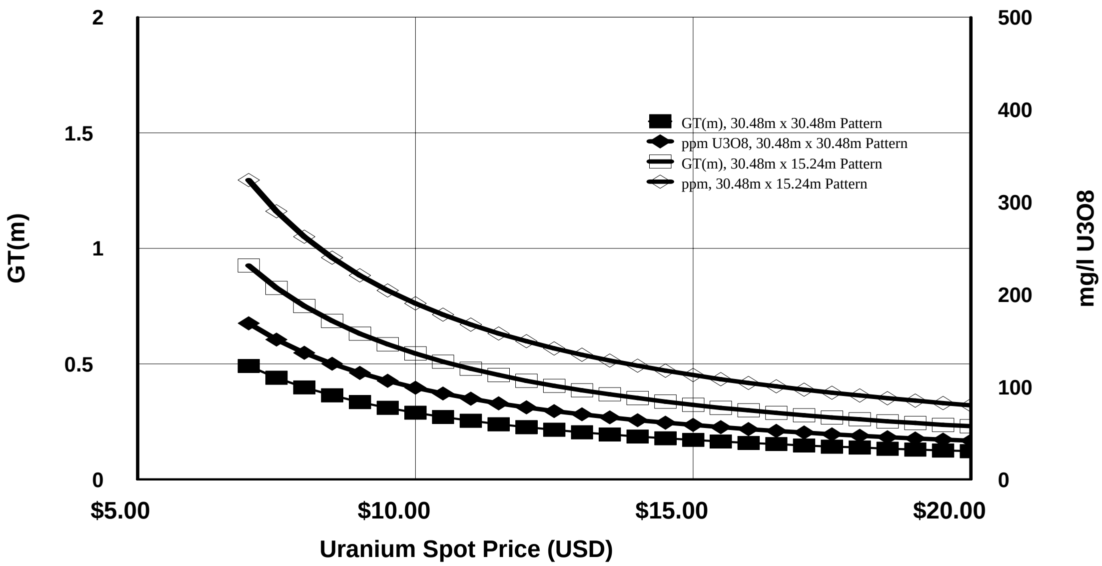

Figure 4 – GT(m) and Lixiviant Concentrations to Sustain Cashflow

Incremental Cost Case

The final case to be examined is one where all the amortized costs, wellfield development costs, and restoration and reclamation costs are ignored as cost components. Only royalty, and plant and wellfield costs are considered to be relevant in the production process. However for incremental production to have merit, an annualized production rate must be achieved from the balance of the existing wellfield. Simply stated the production to sustain annual production must be satisfied within the majority of well patterns.

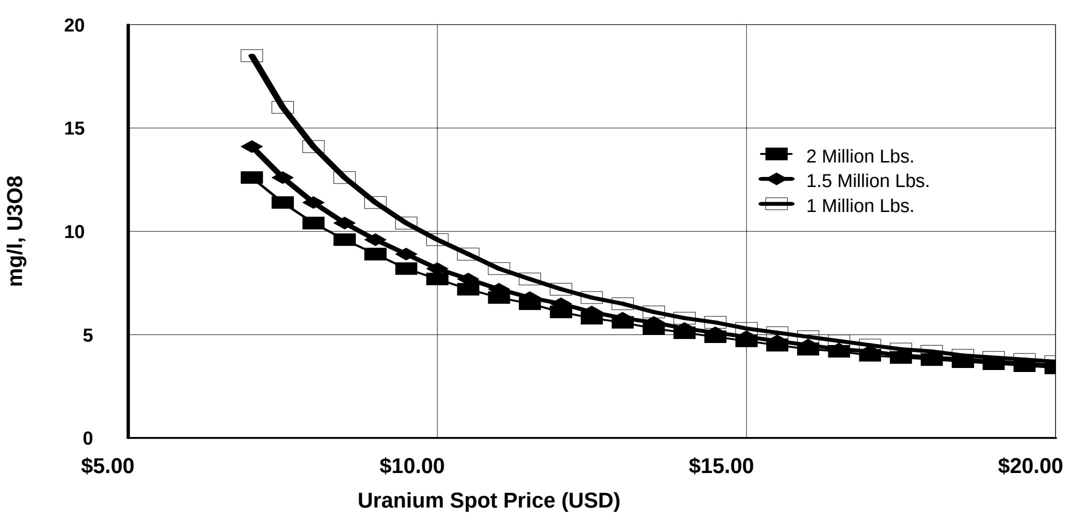

Figure 5 - Incremental Cost Lixiviant Concentrations for Varying Production Rates

Incremental patterns operated to augment the annualized production should conform to that illustrated in Figure 5 for a range of production rates. Another instance when incremental costs are valid is after the mining pattern achieves the recovery sought. Then, and only then, have all the costs for development, amortization, and restoration and reclamation been fully earned.

CONCLUSIONS

You should have learned that management can no longer ignore the physical and economical constraints which makes an ISL mining project successful. It is important for upper management and mine management to understand the relationships among all the variables that affect unit production costs. Pattern well spacing has an enormous impact on economics as we have seen. Project financing can also add a significant burden to the amortized costs.

This model allows sensitivity testing for just about all the variable factors that today's manager will encounter. Ore depth, well flowrate, pattern dimensions, ore thickness, recovery factor, pore volumes to achieve recovery, pore volume factors, porosity, tonnage factor, electrical costs, labor, chemical costs, restoration parameters, etc. can independently, or collectively, be varied to determine the ore grade required to maintain profitability. This model is an indispensable tool for any ISL producer as it provides a medium to understand the inter-relational factors governing ISL mining.

It is unlikely that there exists an ISL producer who can profitably produce fully amortized uranium at today's depressed spot market prices. The figures presented in this study clearly illustrate the average solution grade that must be produced from a wellfield pattern to be profitable for today's market price. At current uranium spot prices of $9.50 USD, averaging uranium solution grades of 222 mg/l is extremely rare to fully amortized costs for two million pounds annual production case. But this is the value that a commercial ISL operation must sustain to be profitable for the assumptions presented.

More likely, today's miners are hopeful for higher prices in the near future to offset the deficits currently being accrued. This is based on suspected below grade lixiviant concentrations most projects historically have produced. Many obviously are operating in a cashflow mode, or may have escalating contracts negotiated when prices were higher. Matching sales contracts are also beneficial to the producer in achieving higher prices thereby allowing lower grade ore to be mined.

Today's spot prices mandate that the mine manager and geologist develop a tool to establish an ore criteria to insure that profitability exists in any of the various forms; fully amortized, without amortized costs, or cashflow. This model herein when updated with current operating data will insure they are expending their efforts and spending their capital wisely.

In today's uranium market place, ISL technology demands high quality ore to be competitive with current spot market prices. Although more economical then conventional mining, the economic pressures exerted upon the small ISL community are mounting. Financial write downs of capital may keep the creditors at bay. Operating in a cashflow environmental may further their cause of sustainability. However in the final chapter mines with great ore and management will persevere when depressed prices are prolonged.