Frequently Asked Questions
Wanapitei River: Allen & Struthers

Thank you to the French River Delta Association, who submitted these questions to Xeneca.

A. Construction Phase

1. **Will road from Highway 637 be improved to all season?**

A final decision on access roads has not yet been made. Xeneca has identified several options to date, many of which originate from Highway 637. Xeneca is currently conducting studies to determine final routing and the road improvements and/or construction that will be required.

2. **What kind of bridge is being constructed over the Bear Chute?**

The original proposal had access roads on the east side of the Wanapitei River. However, Xeneca is now looking at access options coming from the west side. Should access be from the west, Xeneca would consider moving the powerhouse to the west side of the river, subject to environmental concerns and technical review. In this case, a bridge would not be required at the location noted on earlier road maps

3. **New road construction and transmission line construction will cover a minimum of 117 hectares (286.65 acres). What is the estimate carbon storage loss for cutting down trees?**

Canada hosts most of North America's boreal forest. Canada's vast boreal forest stores an estimated 208 billion tons of carbon (71 billion tons in forests and 137 billion tons in peatlands)—the equivalent of 26 years worth of global carbon emissions from burning fossil fuels. Some of the surface carbon may be lost in the physical footprint of the project but the loss of carbon storage is small and more than offset by the generation of emission-free electricity. Please note the answer to the following question.

4. **What is the estimated GHG emission for heavy equipment and trucks during construction?**

Xeneca will do its best to keep its carbon footprint as low as possible.
In *Methods to Assess the Impacts on the Natural Environment of Generation Options* (SENES Consultants Ltd., Sept. 2005, prepared for the Ontario Power Authority; http://archive.powerauthority.on.ca/Storage/15/1108_Part_4.4_SENES_Final_Report_to_OPA.pdf), CO_2 emissions from a rock filled dam during dam construction are stated to be 0.00063/MWh.
We recognize that during construction there will be a carbon footprint but over the 80 plus year lifespan of the project, the net benefit in term of reduced reliance on fossil fuels far exceeds the short term concern. AS noted above, The Allen & Struthers project will save 13.6 million kg of coal from being burned each year; this is enough electricity to power over 1,000 households.

5. **Will construction employees be housed on site? If so, what waste water handling facilities are planned?**

Construction employees will be housed in nearby communities.

6. **If workers are housed on site, what will happen to buildings upon completion?**

Please see A)Q5.

7. **What are fuel storage plans during and after construction?**

The requirements for fuel storage are still being determined. Where fuel storage is required, it will be stored in accordance with all provincial and federal health, safety and environmental regulations.

8. **What are the estimated nitrate concentrations and loading that will be released into the aquatic ecosystem from the use of explosives?**

Department of Fisheries and Oceans (DFO) guidelines will be followed. These guidelines stipulate that ammonium nitrate-fuel oil mixtures cannot be used in or near water due to the production of toxic by-products, e.g. ammonia (see http://www.dfo-po.gc.ca/Library/232046.pdf.) A paper by B. Forsyth *et al* on the use of explosives and water quality is attached (Appendix A.)

9. **What are the Spill Response and Emergency Response Plans for the period of construction?**

A Spill Response Plan must be created before construction; however, it has not yet been finalized.

10. **How will the Municipality be compensated for costs associated with any emergency? What is the compensation formula?**

Although Xeneca will take every precaution to prevent emergency situations, if municipal support is needed for a contingency response, Xeneca would take responsibility for related costs to the municipality. No compensation formula has been discussed with the municipality at this time, however, Xeneca will have a fully independent, qualified engineering firm prepare a safety plan around all of our power facilities and community input would be welcomed.

11. **Will debris from blasting be removed? If not removed, will it be crushed on site?**

Where viable in accordance with acid leachate testing, blast rock will be used in project construction. Material can also be used on non construction related projects such as the creation of fish habitat, recreational trails, canoe landing/launching, etc.

12. **How will the earthen dam on the west side of the River be accessed?**

The final layout of the access road has not yet been finalized, but this will be included in the planning. Please see the answer to A)Q1.

B. Connection Lines

Xeneca's connection lines for Allen & Struthers will be 44kV lines supported by utility poles.

1. **Is there a Class EA in process for the connection line?**

All EA work on connection lines & roads is included in the Waterpower Class EA.

2. **Presently the connection line plan ends before any known connection site – where are you connecting? An economic connection test (ECT) is the first hurdle to be passed before a FIT contract is awarded. Since there is no apparent connection point, we would like to review the connection test document.**

The Allen & Struthers project has passed ECT and has been awarded a FIT contract by the Ontario government. The connection point will be at Martindale TS Feeder 9M5, east of the site near the Town of Alban. The earlier map showed only the section of the line to be built by Xeneca. The section of line to be constructed by Hydro One Networks was not indicated. An updated map for both portions of the line is attached.

FIT contracts require a defined connection point where transmission capacity is available (based on a Transmission Availability Test (TAT).) The ECT is applied to those situations where the proposal fails the TAT and an upgrade to the transmission system is required to accommodate the new generation facility. In this case, transmission capacity was available without upgrade.

3. When would the ECT submission be available for review?

The Allen & Struthers project has passed ECT and has been awarded a FIT contract by the Ontario government. Please see B)Q2.

C. Headpond

A headpond is the water storage pond where the water level is controlled by the control structure (dam or weir.)

1. What is the Bathymetry and headpond depth? (mean, maximum and by season?)

The headpond will be 3.5m to 4.5m at the dam location, gradually diminishing in depth upstream of the site. Planned operational fluctuations of the headpond are available in the Operation Plan, which has been submitted to the MNR.

2. What is the total headpond area?

Including areas that are naturally inundated, the total headpond area will be 151 hectares. This is approximately 40 hectares more than current 110 hectares of land area occupied by the river at its current average flow level.

3. What is the storage capacity?

Assuming a 1 metre maximum drawdown of water, the maximum storage capacity of the headpond is 2.14 million m^3.

4. What is the shoreline slope?

The shoreline slope will not change from its natural slope, which, under natural conditions, is at a grade less than 15%.

5. What is the expected temperature and oxygen seasonal profile?

Xeneca is in discussions with MNR as to what pre- and post-operational studies are required. These parameters will be discussed. Given that long term storage (over 48 hours) is not contemplated and that most storage will occur in evening hours when solar warming is not a factor, water temperature increases are not expected to be significant

6. **What fish species are present?**

Present species include: Lake Sturgeon, Rock Bass, Brown Bullhead, White Sucker, Northern Pike, Johnny Darter, Pumpkinseed, Common Shiner, Smallmouth Bass, Silver Redhorse, Shorthead Redhorse, Mimic Shiner, Yellow Perch, Logperch S5, Bluntnose Minnow, Longnose Dace, Walleye Creek Chub and Central Mudminnow.

7. **What is their abundance?**

No abundance statistics are available from field surveys. However, with the exception of the Lake Sturgeon, all fish species present are common and widespread in Ontario. The presence of 19 species is indicative of a diverse fish community. This variety of species composition demonstrates that a complete range of trophic levels and ecological niches are currently being are filled, allowing the existing fish community to function as a self-sustaining ecosystem.

8. **Have you identified: spawning locations, incubation locations, nursing locations, migration routes, and overwintering and feeding areas?**

Visual field observations included documentation of habitats associated with specific life stages (i.e. spawning, nursery), substrate composition, aquatic vegetation and incidental fish usage of the area. Fish surveys included walleye spawning surveys and summer fish community sampling. General habitat mapping and photographic documentation were also conducted.

Moose wintering and aquatic feeding areas were identified by the consultant. Breeding bird surveys were also undertaken.

9. **What are expected consequences to spawning, incubation, nursing, migration, overwintering and feeding of increased depth, higher temperatures and water level fluctuations?**

Xeneca's field biology consultant has yet to complete their effects/mitigation report but this answer will be forthcoming.

10. **What are expected consequences for beavers, elk, waterfowl, bears, and moose with winter draw downs and changing ice conditions?**

Xeneca's field biology consultant has yet to complete their effects/mitigation report but this answer will be forthcoming. Xeneca has been and will continue working with the Sudbury Elk Restoration Committee and local conservation groups as well as MNR.

11. **Are reptiles and amphibians going to be exposed during winter draw down?**

Xeneca's field biology consultant has yet to complete their effects/mitigation report but this answer on amphibians will be forthcoming. A "winter drawdown" occurs on projects with large reservoirs where sufficient water can be stored during rains of the fall season and then used over the dry winter season. This type of operation would cause water levels to rise several meters in the fall season and then drop several meters during the winter season. Seasonal water storage and winter drawdown are not proposed for this project. There will be a daily water level change of 1 metre due to increased production during the daytime hours. The total amount of water used every day will be the natural run of river volume for that day.

12. **What wetlands and their classification will be flooded?**

Xeneca's field biology consultant has yet to complete their effects/mitigation report but this answer will be forthcoming. The total amount of flooding associated with the project is very small, and involves an increase of the current water surface area from 110 hectares to 151 hectares. Much of this increase is in the immediate river bank area and much of it is within the existing channel. However, where wetland areas are affected, the impacts will be assessed.

D. Downstream

1. **Are you committed to a stream bed morphology study pre and post operation?**

Xeneca is in discussions with MNR regarding the number of post-project study programs required. If river morphology studies are required, Xeneca will comply.

2. **Are you committed to a sediment sampling study to identify potentially toxic heavy metals entrapped in the river bed sediment?**

Xeneca is in discussions with MNR as to what pre- and post-operational studies are required. This parameter will be discussed.

3. **Have you done a complete vegetation census?**

Vegetation mapping was completed using a combination of aerial photograph interpretation and site-specific field investigations. All communities were described to the ecosite level, using the Ecological Land Classification (ELC) Field Manual. During these site investigations, Xeneca's field biology consultant conducted vegetation mapping of all features within the study area, and compiled a detailed plant list within each vegetation community.

4. **Are you going to inventory migrating bird nesting sites?**

Xeneca is in discussions with MNR as to what pre- and post-operational studies are required. This parameter will be discussed.

5. **Are you going to inventory wild rice beds?**

The consultant has not found any wild rice stands in the study area.

6. **What are the expected consequences to spawning and nursery sites?**

The consultant has yet to complete their effects/mitigation report but this answer will be forthcoming.

7. **Have Eastern Massasauga rattlesnake habitat sites been identified?**

Xeneca's field biology consultant strategically placed cover boards within study area to detect the species, but none were observed. However, the wetlands throughout the study area are considered to represent good habitat for this species.

8. **Will the operation of the dam meet Department of Fisheries and Oceans policy objective of Net Gain of Habitat or at least No Net Loss of Productive Capacity?**

Xeneca will be in future discussions with DFO and MNR as to what mitigations will be required to achieve the policy objective. A Letter of Advice or Authorization under the Fisheries Act will be required for the project.

E. Dam Operation (if approved)

1. What will rate of flow be?

Natural annual flow variation is 5 - 167m^3/sec. The plant will operate between 5 - 57 m^3/sec. Any flows above this range will be spilled over the weir.

2. What will be up ramping rate of flow?

This is not yet determined and will be determined as part of the EA process.

3. What will duration of up ramping flow be?

This is not yet determined and will be determined as part of the EA process.

4. What will be duration of the down ramping?

This is not yet determined and will be determined as part of the EA process.

5. Who controls dam operation and call for demand – Xeneca or IESO?

Xeneca will control dam operation. Under certain circumstances, IESO may shut down operation of the plant.

6. Is operation controlled on or off site?

As is common in the hydropower industry, operations will be controlled locally by protection and control equipment and monitored remotely. On-site manual control will also be possible.

F. Public Safety

1. Where will canoe portage be situated?

Discussions about a portage route are part of the Class EA. We encourage stakeholder input and welcome ideas.

2. Will water quality be checked on a regular basis?

Yes, during construction and post-construction periods

3. If water quality deteriorates and health issues arise in the park, who is liable for costs – Xeneca, Ontario Parks, or the Ontario Power Authority?

There are four existing hydroelectric generating stations upstream of the proposed project. Water quality in the park could possibly be affected by incidents (such as a spill) from any of these facilities or another external source. Under the circumstances described, if would need to be determined which owner's facility, if any (including Xeneca), might be at fault and, if so, would be liable for costs.

G. Economic

1. If project proceeds and damage to local business and property owners occurs, what is your economic mitigation plan?

If a business or property owner believes there is risk of loss due to the construction/operation of the Allen and Struthers GS, we would like to consult with them in order to either mitigate the impact or, if there is genuine loss, make arrangements for compensation. Through the project, it may also be possible to achieve benefits and Xeneca encourages local business and property owners to open discussions with us at the earliest possible juncture.

H. Aboriginal Affairs

1. **If the project proceeds, will the Aboriginal and Métis members of the French River Delta Association be given first priority for jobs and compensation?**

It is Xeneca's policy to hire locally, where possible and that includes preference for First Nation companies and skilled individuals who can provide qualified services at competitive rates. Construction will require skilled professionals, trades people and laborers as well as equipment and materials such as concrete, aggregate, steel, lumber and fuel. Xeneca will work with Communities to determine the best means of attracting qualified local goods and services.

Appendix A: Explosives and Water Quality

EXPLOSIVES AND WATER QUALITY

by
Bill Forsyth[1], Alan Cameron[2] and Scott Miller[3]

Abstract: Water quality regulations currently in place in Canada and the USA include criteria for allowable nitrate concentrations in mine effluent. These regulations extend not only to operating mines but also to mines at the permitting stage. In some cases, mines in the permitting process must demonstrate that their proposed practices will not result in levels above the regulatory limitations.

The primary source of the nitrates are the explosives used in the mining operation. The majority of the explosives used in the mining industry contain significant amounts of ammonium nitrate, often with some calcium nitrate or sodium nitrate.

Mining companies have opted for a number of different approaches to deal with this problem, ranging from using significantly more expensive explosive products to rigorous explosive management practices. Their approach is very dependent upon specific site conditions, infrastructure, mining rate, water treatment options and explosive costs.

Key Words: explosives, water quality, ANFO, mining, environment

Introduction

Water quality impacts due to the introduction of nitrates into the system can be a significant problem for a mining operation. The major source for the nitrates are explosives used in the mining process. A majority of modern commercial explosives contain ammonium nitrate (also sodium nitrate and calcium nitrate) as an oxidizing agent. Loading practices and blasting efficiency, as well as the presence of water, control the amount of these nitrates that enter the water system.

Nitrates can be introduced into the water in the mine or at a waste rock disposal site. They come from spillage during explosive transportation or charging, leaching of the explosive in wet blastholes or undetonated explosive in the broken rock after the blast. Techniques and/or procedures will be presented that can lead to the minimization of nitrates in water discharged from a mine.

Regulatory agencies in Canada and the United States are placing a significant emphasis on compliance with effluent nitrate concentrations. Typical limitations are established at 10 mg/l as N, based on the maximum contaminant level for potable use (U.S. EPA , 1986). In some instances lower levels are set when local water, non-degradation rules are applied (Kindt, 1994). Effluent requirements may also be based on government specified toxicity test criterion.

[1] Bill Forsyth, Associate, Golder Associates Ltd., Vancouver, B.C.
[2] Alan Cameron, Senior Blasting Consultant, Golder Associates Ltd., Sudbury, Ontario
[3] Scott Miller, Senior Project Manager, Golder Associates Inc., Denver, Colorado

Background

The impact of mining operations upon local water quality has been well documented. Collier (1964) studied the effects of coal mining on the Beaver Creek Basin, Kentucky during the period 1955-1959. Hackbarth (1979) studied the effects of surface coal mining on streams and springs in the Rocky Mountains from 1972 to 1978. The British Columbia Ministry of Environment studied the effects of explosives use on water quality around the Fording Coal mine during 1979-1980.

Explosives

Modern commercial explosives generally contain a fuel and an oxidizer (some explosives have sensitizers and other additives). Oxidizing agents are typically ammonium nitrate (NH_4NO_3), calcium nitrate ($CaNO_3$)and sodium nitrate ($NaNO_3$). Commonly used explosives can be divided into three groups, ANFO (Ammonium Nitrate and Fuel Oil), watergels/slurries and emulsions. All contain significant amounts of nitrogen, but have a different resistance to water and therefore varying degrees of capacity to introduce their nitrogen into the water system. The relative leaching rates when exposed to a large volume of water is shown in Figure 1. Even very water resistant emulsions can eventually have their nitrates leached out.

ANFO

The basic ANFO mixture (94% Ammonium nitrate, 6% fuel oil) contains 33% (by weight) of nitrogen. This nitrogen is in two very water soluble forms, ammonium (NH_4^+) and nitrate (NO_3^-) ions. ANFO has no water resistance (see Figure 1) therefore its nitrogen is readily soluble if exposed to water. In addition, Ammonium Nitrate is hygroscopic (i.e. absorbs any available water) and will pick up moisture from the air if left exposed. If ANFO absorbs too much water it may become de-sensitized, fail to detonate and result in explosive in the broken rock.

Watergels/Slurries

A typical watergel/slurry mixture contains 20% to 30% (by weight) of nitrogen. This nitrogen is in two very water soluble forms, ammonium (NH_4^+) and nitrate (NO_3^-) ions. The water resistance of a watergel/slurry mixture is good once the cross-linker has activated a gum. This gelled gum forms a relatively impermeable barrier between the oxidizing agents and any external water. The long term stability of the gelling agent is finite and the nitrogen can eventually be exposed to external water.

Emulsions

A typical emulsion mixture also contains 20% to 30% (by weight) of nitrogen. This nitrogen is in two very water soluble forms, ammonium (NH_4^+) and nitrate (NO_3^-) ions. The relative proportion of ion concentration is dependent upon the ratio of ammonium/calcium and sodium nitrate used in the formulation. The water in oil emulsion is very water resistant. The thin film of oil surrounding the salt solution minimizes contact with external water sources.

Nitrogen Cycle

The relationships between the various forms of nitrogen and changes that can occur in nature are shown in Figure 2. Explosives use can introduce nitrogen into the environment as NH_4^+ and NO_3^- (from NH_4NO_3, $CaNO_3$ and $NaNO_3$) and as N_2, NH_3, N_2O, NO and NO_2 gases formed during detonation (Pommel, 1983).

Nitrate and ammonia are generally the compounds of greatest concern for water quality degradation due to the potential human health and aquatic life impacts.

The following criteria have been established for nitrate and ammonia concentrations:

Drinking water criteria - maximum level for nitrate of 10 mg/l is based on the potential for methemoglobinemia development in infants. This condition develops when nitrate combines with hemoglobin to form methmoglobin, which does not absorb oxygen. Death can result from lack of oxygen. There are no drinking water or human health based ammonia criteria. State or Provincial criteria are frequently established as narrative or numeric standards based on antidegradation.

Aquatic life criteria - nitrate can effect aquatic life in three ways: direct toxicity (similar to impact on humans), reduction in dissolved oxygen, and cutrophication. There are no aquatic life criteria established for nitrate. The acute toxicity of ammonia is primarily due to the un-ionized free ammonia molecule (NH_3). Ammonia toxicity is related to temperature and pH of the water. Numeric or narrative ammonia standards are calculated using stream specific pH and temperature.

Explosives Use in Mining

Explosives use can be divided into two types, small quantity/high frequency and large quantity/low frequency. Examples of the first use would be drifting, raising and shaft sinking. Examples of the second type would be stope or bench blasting. The potential for introduction of nitrogen into the water system is dependent upon the following:

1. The specific explosives used
2. The water conditions
3. The handling and management of the explosives
4. The efficiency of the blasting operations

The specific explosive chosen will control the absolute amount of available nitrogen, the potential rate of release and the ease of release in the water system. This ranges from ANFO with a high nitrogen content and very low water resistance to film wrapped emulsions with a lower nitrogen content and a much higher water resistance.

The water conditions will determine the water volume and flow rate the explosive is exposed to in the blasthole. The amount of water available to transport the nitrogen in the mine water system will also influence the relative concentration of nitrogen.

The handling of the explosive product has the most significant influence on the quantity of nitrogen entering the water system. In the case of ANFO, losses occur as spillage during filling of explosives loading equipment, actual loading of blastholes and disposal of excess product. Wiber (1991) reports that these losses could amount to between 5% and 15% of total ANFO used. Golder Associates (1993, unpublished) found that, for a particular mine, nearly one tonne of ANFO was entering the water system per month (5.2% of total use). The losses are not limited to the use of ANFO. Pommen (1983) reports that 6% of the total nitrogen used at Fording Coal's operations was entering the surface and ground water. The primary explosive at this site was a slurry.

The efficiency of the blasting operation will control the amount of nitrogen available from undetonated explosives. Blastholes may fail to detonate due to proximity effects such as dislodgment or desensitization. Poor design or execution are the most common causes of "misfires". Advanced blast monitoring routinely shows that 10% to 20% of blastholes misfire in a given blast. Inaccurate drilling can also result in severe proximity effects. The ultimate result is undetonated explosives in the muckpile and available for dissolution into the water system.

Explosives Management

A substantial reduction in nitrate concentration can be achieved through proper management of the source material. Education of operating personnel on the problem of nitrates in the water is the first step. Appropriate handling and loading procedures represent the most cost effective means of reducing nitrate concentrations.

Education

It is important that all employees are made aware of the potential magnitude and severity of the nitrate problem. Case studies have shown significant reductions in total dissolved nitrate levels after implementing employee education programs. Wiber (1991) shows a greater than 30% decrease in total ammonia as N in mine discharge water at Hemlo Gold Mines, Golden Giant Mine during the summer of 1991 (Figure 3). An education program was given as the primary reason for the decrease.

Handling and Loading Practices

ANFO is the most commonly used explosive in the world and the most common source of nitrates in mine water. The following practices are especially important:

- Identification of blastholes containing water and proper procedures for loading a wet blasthole. Any water in a blasthole must be removed prior to loading with ANFO.
- Adequate unloaded collar lengths must be established to reduce both "blowback" when loading pneumatically and blasthole proximity effects.
- Proper "standoff" distance and loading vessel pressure to reduce "blowback" during pneumatically loading ANFO.
- Partially used bags of ANFO must be resealed and returned to the explosive magazine.
- Loading equipment must be cleaned in an area where the water can be properly handled.

Emulsion and slurry/watergel explosives have significantly higher water resistance but must be handled with the same care and attention to realize the potential benefits. The following practices are important:

- Spills of the product must be handled correctly. Improper cleanup could result in explosives in the mine water and/or the broken rock. This rock could end up on a waste pile where the nitrates will eventually be leached from the explosive.
- Proper loading techniques must be followed when loading a bulk product into a wet blasthole. The product should be extruded into itself and not into water. Water entrapped in the explosive during loading can reduce the efficiency of the detonation and increase the amount of available nitrates.

Indications from operating mines are mixed, Wiber (1991) reported that the level of nitrates in the mine effluent at Falconbridge's Thayer-Lindsey Project was reduced when ANFO use was discontinued (at a cost of $50/ft of advance) whereas Pommen (1983) reports continued high levels of nitrates in the mine water at Fording Coal with the use of a slurry product.

Treatment Options

Nitrate removal technologies are outlined in a paper by Kindt (1994) and can be divided into three categories. These categories are ion exchange, electrochemical ion exchange and biological denitrification (or combinations of the three). Some of these technologies have been traditionally applied in municipal waste water treatment.

For a generic project outlined in Kindt (1995) the following operating costs were given for a range of treatment options per 1000 gallons of treated water, estimated capital costs are given in brackets:

Ion Exchange	$1.28 ($400K)
Electrochemical ion exchange	$0.57 ($590K)
Submerged rotating biological contactor	$0.95 ($460K)
High rate fixed film biological filters w/intermittent backwash	$0.95 ($770K)
High rate fixed film biological filters w/continuous backwash	$0.95 ($345K)
Low rate fixed film biological reactor	$0.80 ($395K)
Ion exchange and electrochemical ion exchange	$0.52 ($485K)
Ion exchange and biological denitrification	$1.10 ($675K)

Note: all costs in US dollars. Additionally, costs assume treatment of 100 gpm at a nitrate concentration of 25 to 100 mg/l with a treatment objective of 10 or less mg/l of nitrate.

Ion exchange removal of nitrate is a proven and established commercial process. Ion exchange resins are placed either in a fixed bed or suspended in a reactor as a slurry. The untreated mine water is then contacted with resins to affect treatment. A fixed bed configuration is the most common configuration and is similar in design to a filtration system. The advantages of ion exchange is the excellent performance reliability, especially with fluctuating flow and nitrate levels. Disadvantages include relatively high capital and operating costs and disposal of backwashed brines. Additionally, clarification and filtering of the mine water may be required if the total suspended solids concentrations are above 10 mg/l.

Electrochemical ion exchange of nitrate is an emerging technology which has not been utilized in large scale operations. The principal advantage of the process is that the nitrate is completely destroyed through conversion to nitrogen gas eliminating the requirement for secondary disposal of brines or sludges. However, high operating costs due to power consumption is a significant disadvantage. As with ion exchange, clarification and filtration of the mine water may be required prior to electrochemical destruction.

Biological denitification is a technology which utilizes anaerobic bacteria and an organic food source for biochemical reduction of nitrate to nitrogen gas. The process completely destroys nitrate through conversion to nitrogen gas eliminating the requirement for secondary disposal. The process is well established and forms an integral component of many municipal wastewater treatment plants. The process involves living organisms or bacteria, which are sensitive to fluctuations in mine water chemistry. The mine water chemistry may require pre-treatment to create an environment suitable for biological treatment.

Nitrate and nitrogen compound treatment technologies are generally feasible and potentially economically viable. However, emphasis by the mining industry should be placed on pollution prevention alternatives and treatment used only if absolutely necessary.

Summary

The need to address the potential for nitrate contamination of surface and ground water around mine sites is becoming increasingly important. The largest source of nitrates at an operating mine are explosives. Given that explosives are an integral part of the mining cycle, the most logical approach to reducing nitrate levels is proper management of their use. The approach outlined below is based upon increasing economic costs:

1. Develop and implement explosive management practices.
2. Evaluate and improve the current level of blasting efficiency.
3. Change to a more water resistant explosive product.
4. Assess treatment options.

Significant reductions in the nitrate level of mine discharge water can usually be achieved through care and attention to detail in the mining operation with little added cost to the mining operation. This may require some alteration to the bonus system used at many underground mines to reflect the importance of good house keeping and appropriate use of explosives.

References

Collier, C.R., 1964. Influences of strip mining on the hydrologic environment of parts of the Beaver Creek Basin, Kentucky, 1955-1959, United States Geologic Survey, Professional Paper, 427-b, 85p.

Hackbrath, D.A., 1979. The effects of surface mining of coal on water quality near Grande Cache, Alberta, Canadian Journal of Earth Science, Vol. 16.

Kindt, G.S., Stevenson, J.A., Hunt, W., Miller, S. and Mudder, T., 1994. Review of Mine Water Nitrate Removal Technologies, Presented at Northwest Mining Association, Spokane.

Pommen, L.W., 1983. The effect on water quality of explosives use in surface mining, British Columbia MOE Technical Report 4.

Wiber, M., Connel, R., Michelutti, B., Bell, B., Joyce, D.K. and Luinstra, W., 1991. Environmental Aspects of Explosives Use, Northwest Mining Association Short Course, Spokane.

U.S. Environmental Protection Agency, 1986. Quality Criteria for Water 1986, Office of Water Regulations and Standards, Washington, D.C., EPA 440/5-86-001.

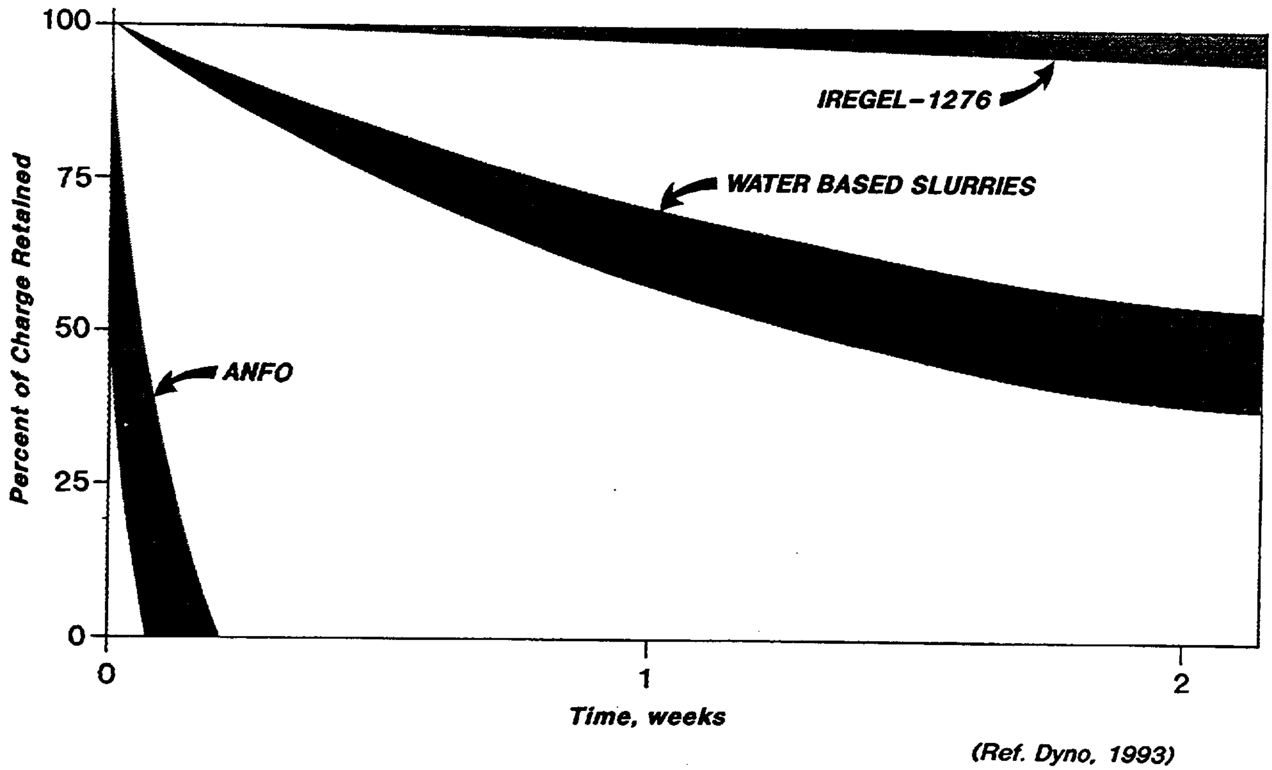
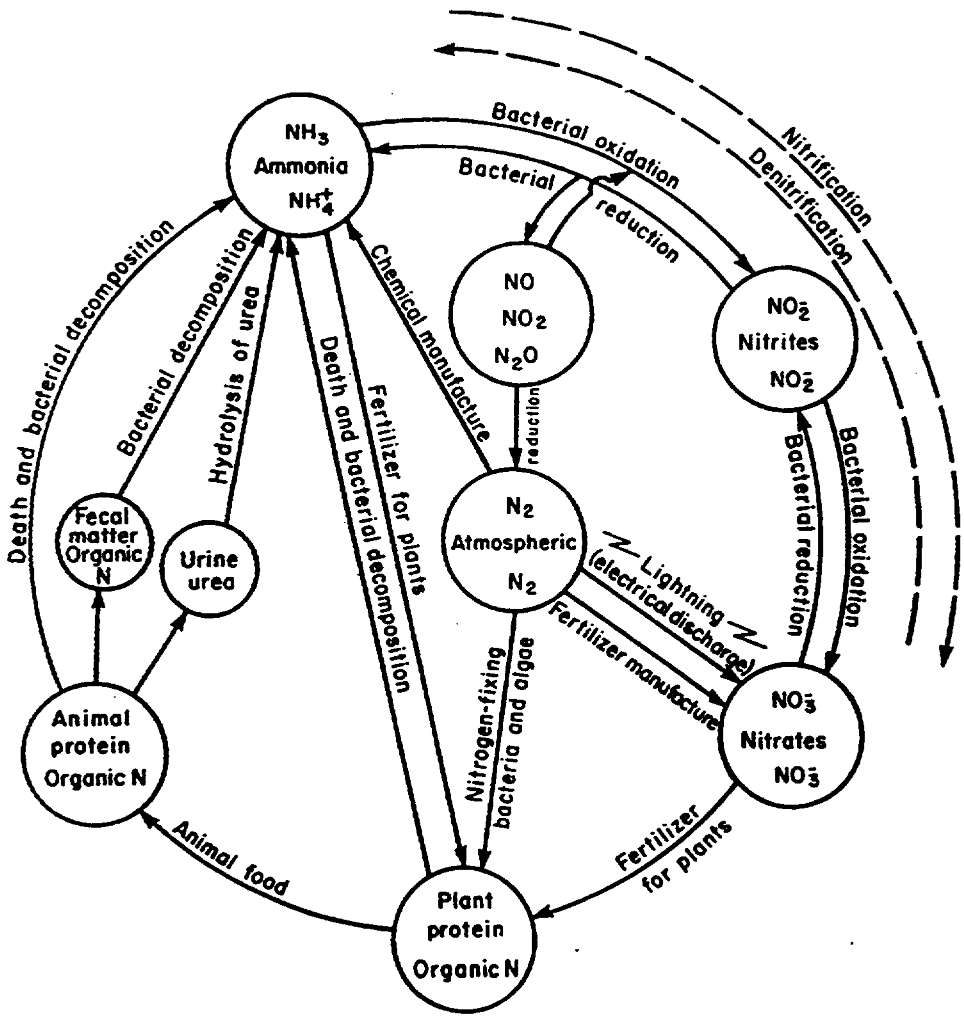
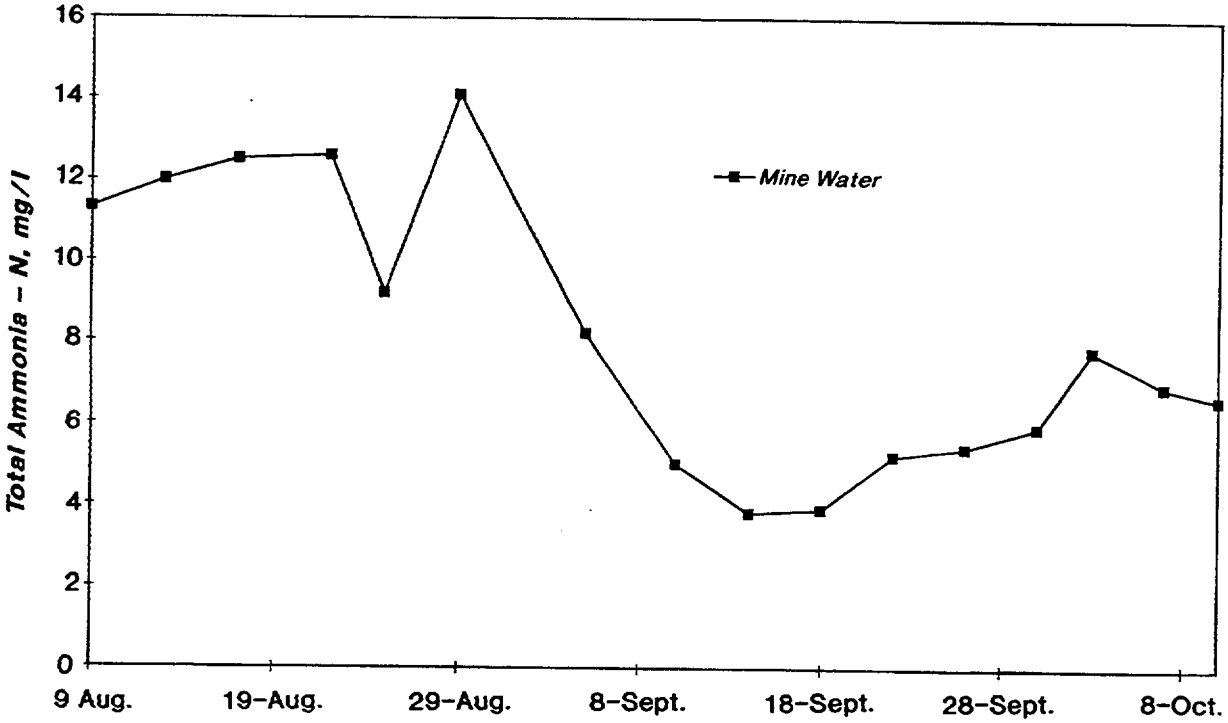


Figure 1 - LEACHING TEST RESULTS: PERCENT OF UNDISTURBED CHARGE vs TIME



(Ref. Pommem, 1983)

Figure 2 - THE NITROGEN CYCLE



(adapted from Wiber, 1991)

Figure 3 - MINE WATER MONITORING FOR TOTAL AMMONIA AS N
Summer 1991, Hemlo Gold Mines Inc., Golden Giant Mine.