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ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

PROCEEDINGS

Technical Seminar for the Expert Advisory Group to Aquatic Fauna Committee, AOSERP

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Alberta ENVIRONMENT

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INTRODUCTORY REMARKS

DR. MARTIN BIK

Upon receiving the request from Ron Wallace to contribute to this seminar, the Oil Sands Environmental Study Group realized that one of the better ways to create an atmosphere in which the industrial and environmental research worker could engage in constructive dialogue would be the provision of as much technical information as time would permit. We have learned from previous disagreements, that the main obstacle to mutual appreciation and understanding resides in an insufficient appreciation of the technical aspects of oil sands resource extraction technology and development on the environmental side, and a lack of comprehension of desirable environmental protection objectives on the industrial side. You may place this seminar in the larger context of our belief that through provision of adequate technical information, industry can assist environmental researchers in the identification of the environmental problems attending oil sands development that require resolution.

DR. RON WALLACE

I would like to give you a very brief background for our being here today and the purposes of the Aquatic Fauna Committee.

The Aquatic Fauna Committee is trying to take a long-range view of the development of the oil sands and the impact that it will have upon the aquatic resources of the oil sands area. Before this program begins, we're trying to ask precise, cogent, farseeing questions that we feel will be important to the legislators and the policy implementors in respect to the development of this area. These questions are also being asked in an attempt to pinpoint areas which will need to receive attention from biologists, ecologists, and other scientists associated with this program over the next five to ten years. Finally, this exchange could be a vehicle toward catalyzing this long-range view of the problems.

The Committee has brought together a group of biological scientists from all across Canada to give us their views on our direction and the questions we should be asking over the next three to five years. We hope to bring this group of people together again during the life of the project to let them have a look at some of the data that we're actually generating. We feel that this type of approach is in many respects unique (as is AOSERP itself) in that if we can call on as many experts or people who have had direct involvement in programs similar or identical to the oil sands development, in the long run we shall be much further ahead.

INDUSTRY PRESENTATIONS

P. Cotsworth

An Overview of Oil Sands Mining

W. L. Cary

Practical Problems of Oil Sands Mining and Tailings Disposal

L. Nichols

A Review of Mining and Depressurizing Activities

M. Raisbeck

The Aquatic Environmental Implications of Home Oil's Mining and Upgrading Scheme

B. McCartney

Insitu Extraction

R. Schutte

The Extraction Process and its Chemical Byproducts, as Used by Syncrude

M. Bik

Answers to your Questions; Industry's Information Needs as Perceived by Syncrude

PETER COTSWORTH:

The speakers who follow me will cover some of the detailed problems on tailings disposal, mine dewatering, extraction effluents and insitu extraction, so in essence, what I would like to discuss is, what an oil sands mining project looks like, how it is developed, and how it operates from the overview position.

First of all, the real question: Do we really need oil sands plants? The answer to most of you around this table has to be "Yes or No". As an Albertan, the policy of the Energy Resources Conservation Board is to maintain reserves in this Province to serve Alberta's needs. However, in the very foreseeable future, the energy in the oil sands will be needed. I now refer to some numbers generated by the National Energy Board and the Canadian Petroleum Association as late as October 1974. I have no reason to believe this situation has dramatically changed in the interim. It is estimated that by 1980 the Canadian demand would be approximately 2.35 million barrels per day and the Canadian probable production would be about 1.7 million barrels per day, including 155,000 barrels of synthetic crude. In other words, as early as 1980, Canada will lack 650,000 barrels per day. As early as 1985, the demand will have climbed to 2.8 million barrels per day and probable production will be only 1.35 million barrels a day, including 400,000 barrels of synthetic crude.

Within ten years, if we are to maintain our existing growth in consumption along with the corresponding standard of living and industrial production levels, Canada will be desperately short of produced oil. It will be necessary to import almost 1.5 million barrels a day, more than half the national consumption at that time. If exploration in the frontier areas fails to achieve the desired results in the next few years, it is apparent that self-sufficiency in the 1980s is an unattainable goal without considerable production from the oil sands. The unpalatable alternative facing Canadians is to rely on ever increasing imports of oil and to accept the unfavorable balance of payments that must surely follow. True, there have been some turndowns in consumption and there have been some recently recorded discoveries by Panarctic in the Arctic regions, but no matter how you look at it, this is the "glue" into which Canada is plunging headlong. By rough calculation, towards 1985, on the basis of an offshore price of $15 per barrel, the balance of payments deficit that results from heavy importation of oil will approach $8 billion per year. Furthermore, all the charts and graphs which allow for new energy sources (such as nuclear energy) are beginning to predict that once self-sufficiency in Canada is lost, it cannot be regained before the year 2000. This is an awesome burden to impose on the present and future citizens of Canada, one which I think politicians don't spell out clearly to the average Canadian, as few politicians are concerned with what happens in the year 2000.

This dilemma has very onerous aspects, one being the lead time (approximately eight years) to put a plant in production. If we squander the next eight years by inaction, all the action in the world will not save the situation. At this stage enormous quantities of goods or money will be flowing out of the country. How are we going to raise the money in mid-1985 to build these plants? I'm afraid we aren't, and the result will be that Canada, by virtue of a new-found debt burden, will be relegated quickly to a second class standard of living from which it will not have the immediate ability to recover. Why aren't we building these plants now? The answer is simple. The burden of taxes, royalties, inflation, high interest rates, and the demand by Government for ever increasing recoveries and improved environmental circumstances are such that each component has made these projects unattractive to investment capital.

For the reasons I have given before, I can state, with little or no qualification, that as a Canadian, I feel it is in my best interest to see adequate development of the oil sands to demonstrate our ability to be self-sufficient. I recognize that time is not on our side, and I think that it is important that the participants in AOSERP understand these pressures of time and product costs and respond accordingly.

An oil sands complex basically breaks down into three components: mining, primary extraction, and upgrading. The standard 125,000 barrel per day plant is the break point from some of the economic advantages of escalation of scale. For this standard plant, it is necessary to mine approximately 160 million tons of material a year on an average waste ratio of 0.7. To clarify, if we have 70 ft. of combined overburden and reject and 100 ft. of oil sands above a 6% bitumen cutoff, we have a waste ratio of 0.7. The yearly mine production is made up of approximately 96.5 million tons of tar with an average bitumen content of 11.5%. Within the oil sand zone, 43 million tons of overburden and 20.1 million tons of low grade or reject material are found. The magnitude of this mining compares with the largest mines in the world. The daily volumes to be moved are such that they would cover a Canadian football field to a depth of about 120 ft. This must be sustained in a climate that is more severe than the posted average for Siberia. Unfortunately, deposits of oil sand are heterogeneous both in the vertical and the horizontal direction, so what we end up with is a series of deposits in any particular lease which are mineable under certain circumstances.

One must realize that the variation in bitumen content in the ore ranges from 6% to 18% by weight. The ERCB, as a guideline, feels it is desirable to reach a 6% by weight bitumen content in the ore and out to a waste ratio of 1.5:1. This usually represents the bulk of the deposit in any mineable area. Unfortunately, the interests of the Department of the Environment and the ERCB are slightly at cross purposes here for as the grade of ore sand goes down, the proportionate quantity of tailings goes up and the requirement for water to process a barrel of bitumen goes disproportionately up. For example, under average conditions with 11.5% bitumen in the feed of 12,236 tons per hour, we need 0.66 tons of water per ton of oil sand; for limiting conditions with 9% bitumen in the feed of 16,000 tons per hour we need 0.88 tons of water per ton of oil sand. Therefore, the trick in mining is to attempt to blend high grade and low grade ore to level out the plant requirements. Unfortunately, it would not be uncommon to go for many years with a satisfactory mine plan and then find in the fifteenth year that all the machines happen to be in a position of low grade ore. This would have disastrous results. Mine planning becomes a very careful examination of the ability to supply ore in the needed quantities throughout the life of the project. Within relatively short periods, the necessary averaging must be achieved. For this reason, no mine planner would ever have a single prime excavating machine in the Athabasca oil sands.

After examination of other potential systems such as bucket dredging, shovels and trucks, and scrapers, despite the fact that the unit prices for these types of operation are somewhat comparable, the mine planner concludes that he has two choices: bucket wheels with conveyors (the system practiced by G.C.O.S.) or large draglines with reclaimers and conveyors. Neither choice is perfect, but for a specific mine, one choice is better than the other. Draglines usually enjoy a modest economic advantage, but since all the prime excavating equipment operates on the top of the same high wall, an interdependence of efficiency develops. Further, all the ore that a dragline excavates and places on top of the highwall has to be reclaimed; that is, moved again before feeding the plant.

Because of the geometric limitations of draglines, the usual principal restraint is depth of ore. If the ore is deep, in the order of 300 ft. from the surface, draglines without elaborate rehandling systems cannot excavate this ore in a single pass and their main advantage is lost. If one were to ignore ore that has been exposed at this depth after going through all the problems of removal of overburden, reject, mine dewatering, etc. it would have to be viewed as a wasteful practice and I question if the ERCB would permit it. Draglines, because of the way they operate, have much greater vulnerability to slope failure than other systems.

On the other hand, bucket wheel excavators, because they normally work in benches down in the pit, can go to much greater depths, are not as seriously encumbered by the operations of adjacent equipment and can produce excavated material of reasonable lump size. This protects the transportation system and can accomplish blending if enough units are used. However, bucket wheel excavators have a much lower availability (they suffer frequent shutdowns for maintenance) than draglines and may result in a greater swing of feed to the plant if a key unit in rich ore goes down. Further, bucket wheel excavators require excellent mine dewatering because the units are actually placed down in the pit. They also require a separate transportation system to handle reject material. As a generality, bucket wheel excavators are in their first generation of development in oil sands application and are not considered as rugged as the dragline.

Currently, only two transportation systems are available to handle the masses of material in an oil sands operation: railroads and conveyor systems. As a generality, conveyor systems have an advantage due to the relatively short hauls that one finds in an oil sands mining operation and conveyor systems they are technically improving at a rapid rate. Rail systems are subject to the problems of ore grade. If one works in the pit, rail systems require expensive support systems and are highly labor intensive, but they are well proven in the Canadian climate. The trend, however, is for developers to move to conveyor systems.

No matter how one mines initially, each mine requires an overburden disposal area. Before overburden is placed in such an area, an inventory of the quality of the material must be made. Useful materials such as clays for impervious seals in dikes, gravels for concrete work and sands for filters are inventoried before disposition of the overburden material is made. I feel this will play an integral part in the ultimate reclamation of the area.

I cannot leave the topic of mining without referring to Mine Dewatering. In order to successfully work a conventional mine system, any mine must be dewatered to artificially create a suitable working habitat and improve slope stability characteristics. The normal method is surface drainage and pumping. Tests show that in order to open a pit approximately 3200 ft. square, we would require 24 wells, each pumping 20 gallons per minute, and 9 wells, each pumping approximately 500 gallons per minute. Chloride contents of the water produced does not exceed 500 ppm in any instances on the tests conducted to date. Before developing a mine plan we feel we would have to do more research in this area since it is highly site specific.

In the matter of Primary Extraction, to date all developers have opted for the K.A. Clark hot water process with minor innovations. The Clark system is a relatively simple system (refer Figure 21). In high grade ore it works well but it gets into trouble when the fines content increases. Again we have the pressure from the ERCB, in the interest of conservation, to utilize more low grade ore. This translates into relatively more fines per barrel, more water, more tailings ponds problems, etc.

In this system, tar sand is mixed with hot water, caustic and steam in a conditioning drum to produce a pulp. Following the conditioning drum, clay lumps and rocks are removed by screening. The pulp receives further hot water as it passes to a primary separation unit. The primary separation unit separates the feed into various components by virtue of density differential. The froth rises to the top where it is skimmed off and the sand settles to the bottom where it is pumped to tailings. A middlings portion with a 10% bitumen to mineral ratio develops and represents about 25% weight of the total. The middlings is transferred to a scavenger unit where, by agitation and the injection of air, it produces a low grade highly mineralized bitumen froth. This froth is combined with the froth from the primary separation unit for treatment in a froth treatment unit. The froth, containing substantial quantities of water and mineral, is diluted with naphtha allowing the bitumen to form a hydrocarbon blend lighter than water. Two stages of centrifuging removes the majority of minerals and water. Diluent naphtha is continuously recovered by distillation in a diluent recovery unit. The water is driven off with the naphtha separated in a reflux accumulator drum. The diluent is recycled to froth treatment.

Because the extracted bitumen is not a saleable product in this form, upgrading is necessary for transportation and to insure sale. Many methods can be used for upgrading, but all essentially accomplish the same thing. They either add hydrogen, remove carbon, or both, to improve the quality of the product. As a result, it produces naphtha or a lighter material, light gas oil, heavy gas oil, and residue which can be coke or heavy oil. Currently, G.C.O.S. practices delayed coking upgrading. This is a commercially proven process in which the extracted bitumen is heated and flashed in a fractionating tower and the bottoms are charged to coke drums. Drums are decoked with hydraulic equipment and the coke is consumed in the power house.

Syncrude and the AOP group have declared their intention to use a fluid coking process as licenced by Exxon Research and Engineering. The upgrading of the raw feed is based on thermal cracking. Heat is supplied by means of circulating hot coke. The reaction products are scrubbed to remove coke fines and are separated in a fractionator to produce various cuts. One of the reaction products is coke, over and above that consumed in the process. Stack gasses from the coker burner contain sufficient CO to fire a CO boiler which recovers heat usually in the form of steam and eliminates the CO emission to atmosphere.

In all of these processes the sulphur content from the raw bitumen starts to concentrate in either the coke or residues. The energy in these heavy materials must be conserved so either the coke or heavy residue is burned for power generation. This poses a grave sulphur emission problem. If you explore the data in the Application 7554, you will see that the sulphur content in heavy gas oil, when used as fuel, is 0.7% weight. When coke is used as fuel in a high pressure boiler the sulphur content is 8.9%. This is why many people choose not to burn coke as it introduces enormous SO_2 removal problems.

The products of the fluid coker must be treated in the hydrotreating section for further removal of sulphur and nitrogen, and to saturate olefinic material. Hydrogen is produced by steam reformation of plant fuel gas. Gas streams from vapor recovery and hydrotreating units contain hydrogen sulfide, and are fed to an amine treating unit and the recovered H_2S then goes to a conventional Claus sulphur recovery unit. A sour water stripper cleans the sour water produced by the fluid coker, overhead drum, hydrotreater separator and vapor recovery units before this steam is released to the effluent treating system. This unit reduces the H_2S and ammonia content in the effluent water to about 1 ppm. The effluent is subject to treatment by an API separator where oil is removed permitting the water to be reused. The stripped gas is combined with the H_2S rich stream from the amine treater and fed to the sulphur recovery plant. This in essence is a typical upgrading system which produces a product of approximately 30° API gravity, low in sulphur and of transportable and saleable quality.

The design in our Application has a sulphur emission of 0.5 long tons per thousand barrels of bitumen feed, and liquid wastes are handled as follows:

Hydrocarbons processed from a slop tank.

Off spec. hydrocarbons, spillages, drips and drains are recovered by a separator in the oily water system.

The oily water system will handle sour water stripper bottoms, drips and drains from the process units and drainage from the storage areas.

The effluent from this system is treated in a biox unit after passing through a separator and air flotation unit. The water is then reused in the primary extraction process.

The storm water is initially handled by the oily water sewer and thereafter diverted to the cooling water spray pond.

Sanitary waste is treated in a package unit equipped with a tertiary filter. The effluent is diverted to the waste water pond.

Certain liquid wastes, such as water derived from ion exchange washes, boiler blowdown and upsets in the oily water system are not suitable for reuse. These will be routed to a waste water pond designed to accommodate the waste water for the life of the plant.

Solid wastes outside of tailings can be derived from treating gaseous and liquid wastes. These waste materials are gypsum from stack gas treating and cold lime clarifier sludge and are transferred to the gypsum pond.

All other solid wastes are used as land fill.

In general, aqueous process waste discharges are contained within a closed loop system incorporating artificially created impoundment ponds. Selection and preparation of these ponds will ensure containment of toxic elements and other water pollutants.

One important problem that oil sands operations must face is seepage from tailings ponds. It is important to realize that with a mine 300 ft. deep and a tailings pond nearly 250 ft. high, any seepage will preferentially migrate to the mine dewatering system and consequently, will circulate back into the water loop supporting the complex. It is difficult for me to envisage how much of this water could get off lease. One problem we face when we dewater a mine is, "What is the best procedure if the chloride content jumps to 15,000 ppm or greater?". Do we retain these waters on lease or do you try to release them on a controlled basis when the river levels are high enough to absorb specific quantities without damage? I think the latter is the best solution.

In conclusion, the designers of an oil sands complex sincerely attempt to satisfy the environmental needs set by the various authorities and certainly try to keep all possible situations under control. However, I am not prepared to pretend that we know all the answers. I would prefer to see controlled releases, particularly of liquid waste, to avoid accumulation of garbage where possible. I would hope AOSERP can derive some scientific data which establishes clearly when releases can be made and what safe levels really are.

TABLE 1

Typical Liquid Effluents for 125,000 bbl/day Plant

STREAM NAME	MATERIAL	CHARACTERISTICS	VOLUMES
			T.P.S.H. Net
Tailings (Pond size Min. 2400 acres)	Slurry	Bitumen 84 T.P.S.H. Mineral 9708 T.P.S.H. Water 9639 (minus 6137 recycle)	Bitumen 84 Mineral 9708 Water 3502
Froth Treatment Tailings 600 acre waste water pond	Slurry	Bitumen, Mineral, Water, Naphtha Bitumen 7.5 4.8% S Naphtha 57 API 2%	Bitumen 35 Mineral 141 Water 861 Naphtha 21
Oversize from Conditioning Drum	Solid		Bitumen 21 Mineral 519 Water 77
Mine Drainage	Water	TDS 2500 CL. 500 ppm	450
Boiler blowdown Boiler Plant Ash Sanitary Waste & Iron Exchange to 600 acre waste water pond	Liquid		70
To sour water stripper	Liquid		

(a) fluid coker overhead drum
(b) hydrotreater separator
(c) inlet scrubber to sulphur plant

The above liquid stream goes from the sour water stripper to API Separator along with the following:

Drips and drains
Storm water

Then the resulting liquid goes through air flotation for final oil and particulate removal, then through the Biox and back to primary extraction.

To gypsum pond 140 acres	Slurry	Effluent from cold lime clarifier sludge and Chiyoda	55

WASTE WATER SYSTEM (EXCLUDING PRIMARY EXTRACTION)

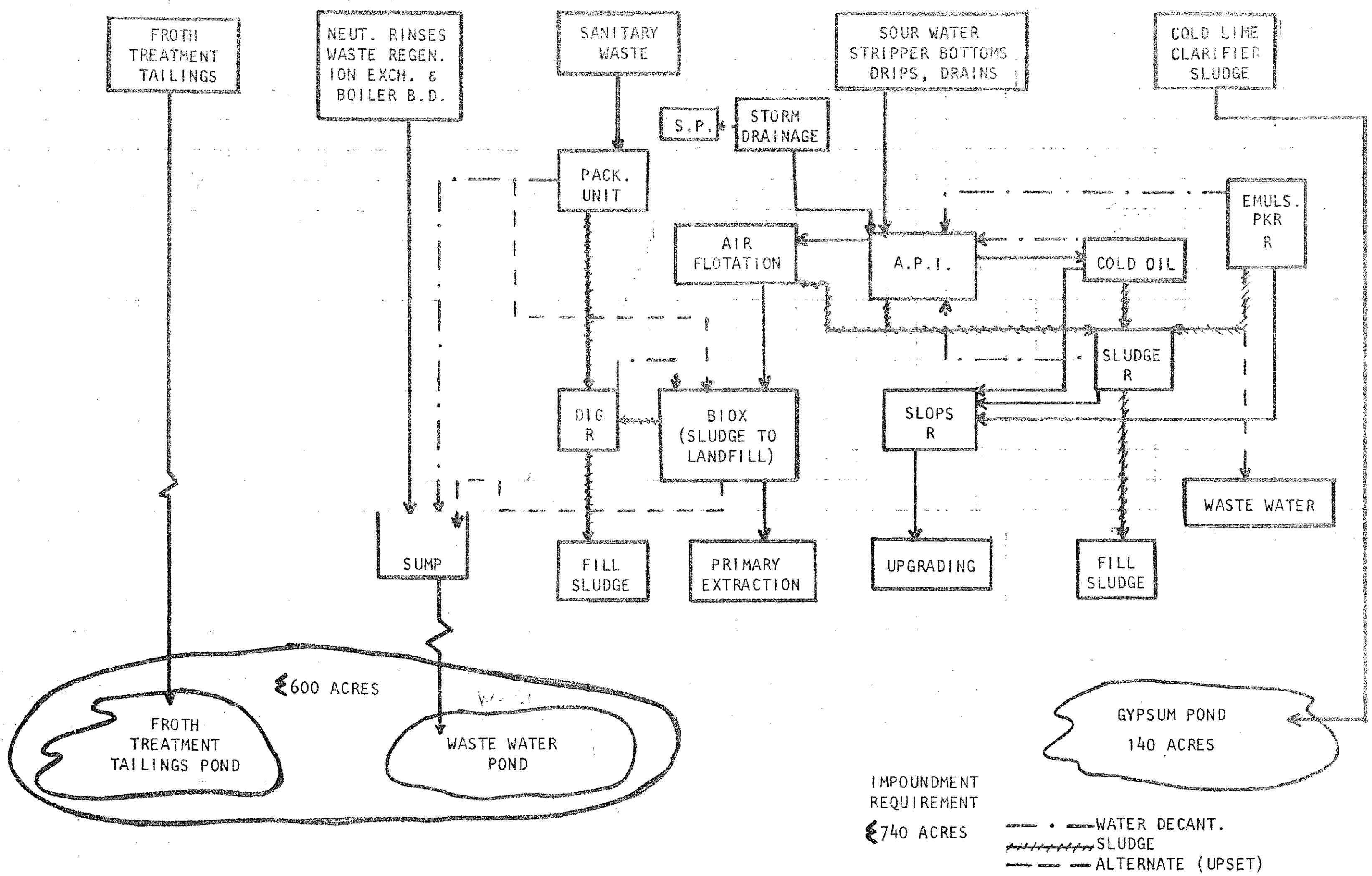


FIGURE 1

W.L. CARY:

I'm going to talk about our liquid effluent disposal and its impact on the environment from published material which we have given to the Department of the Environment, and the ERCB.

The G.C.O.S. area contains the Athabasca River, a tailings pond, a freshwater pond, a river and water pond, a wastewater pond, the extraction plant, and our processing area. Water is taken from the Athabasca River into a freshwater pond (or river-water pond) with the objective of depositing any silt into the river. We have a fairly large pumping capacity, and any overflow is pumped back. From the freshwater pond, water is pumped to various units in much the same as any other refinery. We divide the water into; river water, which is just as it is; fire water, which goes into the fire water lines and is essentially a stagnant system (until you have a fire); the boiler feed water, which is highly treated water; a drinking water system; and utility water, or service water. They are all treated slightly differently, so they can be used in different places.

Most of the water goes into the process area. It is divided into four different streams, and used in all the various aspects of a refinery. Water that does not touch any oil is sent directly back to the freshwater pond. Water which is relatively free of oil is bypassed directly to the wastewater pond. The rest is taken through a water-treating setup, a series of API separators removing the oil and grease, and sent to retention ponds allowing for surface oxidation in the pond. The water stays in the pond for about ten days and then outfalls to the river.

Volumes are about 20 million gallons a day from the river (Canadian gallons). A portion of the water is evaporated as steam from the cooling spray. Some returns out the outfall, and approximately 8 million gallons are recycled to keep the pond full. The largest amount of the remainder, anywhere from 3 to 5 thousand gallons a minute, is used in the extraction plant. Water essentially is make-up water because most of the water in the extraction plant is taken from the tailings pond, and clear water is pumped back. The actual usage is the material which goes to the pond, and is left as part of the sludge, the problem Dr. Hynes referred to, and the portion left in the dike itself. Essentially, the only other water effluent that we have is the dike seepage. It is not really seepage; that is a misnomer. There are actually filter drains, a system where water is taken to a ditch and then out to the river.

Let's discuss what we are sending out in the outfall. The volume is approximately 8 million gallons per day, and that is an extremely variable figure. We realize this is a little high and we are making efforts to bring it down. These materials are analyzed on a daily basis, and the results are averaged for the month and sent to the Department of the Environment. Last year's figures are in our annual report which is available from the DOE. Our suspended solids are as follows:

1. Oil and grease (yearly average) = 10.9 milligrams/litre (ppm)
2. Threshold odor (yearly average) = 250
3. COD (yearly average) = 121
4. Phenols = 10.3 lbs/day
5. Ammonia (as nitrogen) = 1.6
6. pH = 8.3
7. BOD = 25.2
8. TOC = 180

The month of December is an example of what can happen in oil sands operations. An operator left a caustic valve open going into one of the final treatments before the syncrude was sent down the line. Only a certain amount of caustic is to be added and the valve was left open for too long, in fact for several days before we noticed. High pH's resulted, close to 9.5, which were above our requirements. We had to make adjustments in the wastewater pond. One of our saving graces was our large pond, and we were able to divert to it. After correcting the fault, we still had the liquid which was causing the problem in the pond, but we were able to bypass within the pond, so that our outfall was lower than it would have been otherwise. Part of the bypassing procedure brought the total suspended solids up to 200 ppm.

The other effluent is from the filter drains. The soils mechanic consultant, R.M. Hardy, has recommended (and we have carried out) the use of filters within our dike in order to lower the phreatic water line in the dike itself. If filters were not present there would be a tendency for slumping. So, in order to increase the stability of the dike, we have placed filter drains around the dike. The filter drain essentially is a thick layer of coke ten ft. deep and fifty ft. wide. Placed in this are perforated pipes taking the water down to the toe of the dike. This causes the lowering of the phreatic water line creating a stable dike. This should not be regarded as seepage out of the pond (we have some data to back this up). Leakage may occur at high points but in the bottom layer our sludge settles out creating a sealant for the dike. Clay is often used as a sealant in dikes, and the majority of our sludge is clay, so essentially we have construction water. As the dike is built with sand, we pour the tailings into a small diked-off area at the top, the sand settles out and the water with the fines goes over the top into the pond. The water that must leave goes down through the filter drains.

In the early days before there was a trout test, we tested the toxicity of this material. We allowed it to go into the river because it appeared to be almost the same quality as our effluent. We started using the trout test and our standards were raised. Also, the quality of this material seemed to change. Now the water leaving the filter drains into the river. We know it is toxic with a high organic content and we are trying to do something about it; however, it is a very difficult problem for two reasons. One, we have to try and make it compatible with the water balance (if we do collect it), and two, it is a very difficult collection problem with 75 different outlets two to three miles around the dike. Gallonage applied to the filter drainage runs around 500,000 to 700,000 per day.

Discussion:

MASUDA: Why isn't that filter drainage put back through the process plant (wastewater pond)?

CARY: Our treatment essentially consists of removal of oil and grease and there is some oxidation in the surface of our ponds. We just don't believe that it would be sufficient to handle that.

MUNDIE: What is the minimum river discharge in gallons per day?

CARY: Mean river flow is 22,800 cubic ft. a second. Minimum recorded (February 1964) - 3,410 cubic ft. a second. Maximum recorded in 1960 spring runoff - 150,600.

MUNDIE: Will it be the practice to give data, not only as the mean value, but also as the extreme value? I note the figures you give us tend to be mean values over a month or a year ... it would be of interest to know the minimum and maximum values of effluents.

CARY: I don't have those at my fingertips.

MUNDIE: Is it the intention to provide data which include the extremes as well as the means?

CARY: No. We provide data to the ERCB and the DOE according to what they ask for. They don't ask for that.

ROSENBERG: Do you have an estimate of the amount of recharge going on in the bottom of that tailings pond? You know approximately how much goes out the walls?

CARY: No, we don't.

ROSENBERG: You are assuming that the bottom has been made impermeable with the sludge and the clay, but do you have actual measurements?

CARY: I don't know even how we would get them or what they would mean if we would get them?

ROSENBERG: Do you have contingency plans in the event of dike collapse for dike materials running into the river, and if you had to do it over again, would you put the dike by the river?

CARY: No, we wouldn't put it by the river, in fact we wouldn't be allowed to. We have a commitment to the ERCB to fill up that pond and make it into a plateau as soon as possible. Collapse - no, I can't say that we have a contingency plan. We have a very good consultant, we have an area where there is no earthquake ever recorded. We just don't believe it will ever happen. If you were up on that dike, you wouldn't believe it would ever happen either. It is a massive one.

HATFIELD: Have the toxic components of the construction water been isolated to any extent?

CARY: I have a draft report that was written by Steve Hrudey of EPS. He has tried to isolate the actual compound. We've looked at it from the point of view of COD, TOC and phenols. Phenols are low, but COD is high. PH is good, running around 7.5 to 8.4. Oil and grease varies, probably due to the differences and changes in the flow as we construct the dike. It comes out at different points. The sampling of this at 75 different points and the fact that you are constructing at different points all the time presents problems. It runs up to 116 milligrams/litre. Suspended solids have a variability from 6 to 374 ppm. I think most of the time it is running clear. Phenols, are low - running around .02 to .24 where the water licence calls for .3. COD runs twice as high as the water licence - about 300 to 410, and the organic and inorganic carbot are both high. We haven't any licence figures for those.

L. NICHOLS:

Introduction:

I would like to present a general review of mining and depressurizing activities, a brief discussion of our Beaver Creek diversion scheme, and then a discussion of the tailings area touching on some of the hydrological aspects of that area.

Figure 2 shows the Syncrude operations in the Ft. McMurray area. Project 1 is centered on Lease #17, adjacent to Mildred Lake, midway between Ft. MacKay and Ft. McMurray. Syncrude's operations are restricted to Lease #17 and #22, with the exception of some construction to the southeast centered along the Ruth Lake Valley and the Poplar Creek system.

Figure 3 shows the Athabasca River and the various river basins that have been studied by Syncrude or which are affected by the overall mining scheme. These are: the Poplar Creek basin, a little over 41 sq. miles; the Beaver Creek basin, 106 sq. miles; the Ruth Lake basin, 9 sq. miles; the mining area itself, 11 sq. miles; the plant site, 4 sq. miles; Creek #4, which as of a month ago, was part of the Beaver Creek system; 17 sq. miles; Creek 3, 10 sq. miles; Creek 2, 11 sq. miles; Bridge Creek, 13 sq. miles, and the tailings pond, approximately 12 sq. miles.

Beaver Creek Diversion Scheme:

Figure 4 illustrates the detailed layout of the 25 year mine area, plant site and tailings pond area. The Beaver Creek diversion scheme was required because Beaver Creek flows are quite large, and its location interferes with the mining operation, the plant site, and the tailings pond. One of the key structures of the diversion scheme is the Beaver Creek Dam, an earth-filled structure approximately 10,000 ft. long. It was constructed to standard earth-filled dam requirements to cut off both the Beaver Creek Valley, as well as the adjacent Ruth Lake Valley. The crest of the earth-filled structure is approximately 1,025 in elevation. In contrast, the surface of the mining area is approximately 1000 ft. in elevation.

Essentially, the flow of water in Beaver Creek has been cut off. Flows through the reach of Beaver Creek below the Dam are now restricted to local runoff. A reservoir, elevation 1025 ft and shown by the dashed line in Figure 4, has been cleared to accept the backwater as it rises behind the Dam. A diversion ditch, or canal, was cut through the ridge between Beaver Creek and Ruth Lake Valleys to divert the flow into the Ruth Lake Valley. A second diversion canal is proposed for the south end of Ruth Lake in order to lead the water through to Poplar Creek. The second phase of the diversion scheme is the construction of an earth-filled embankment and a spillway structure into Poplar Creek Valley. This part of the scheme is still under construction and will be ready, late 1975 or early 1976, to accept the full Beaver Creek flow from Ruth Lake Valley.

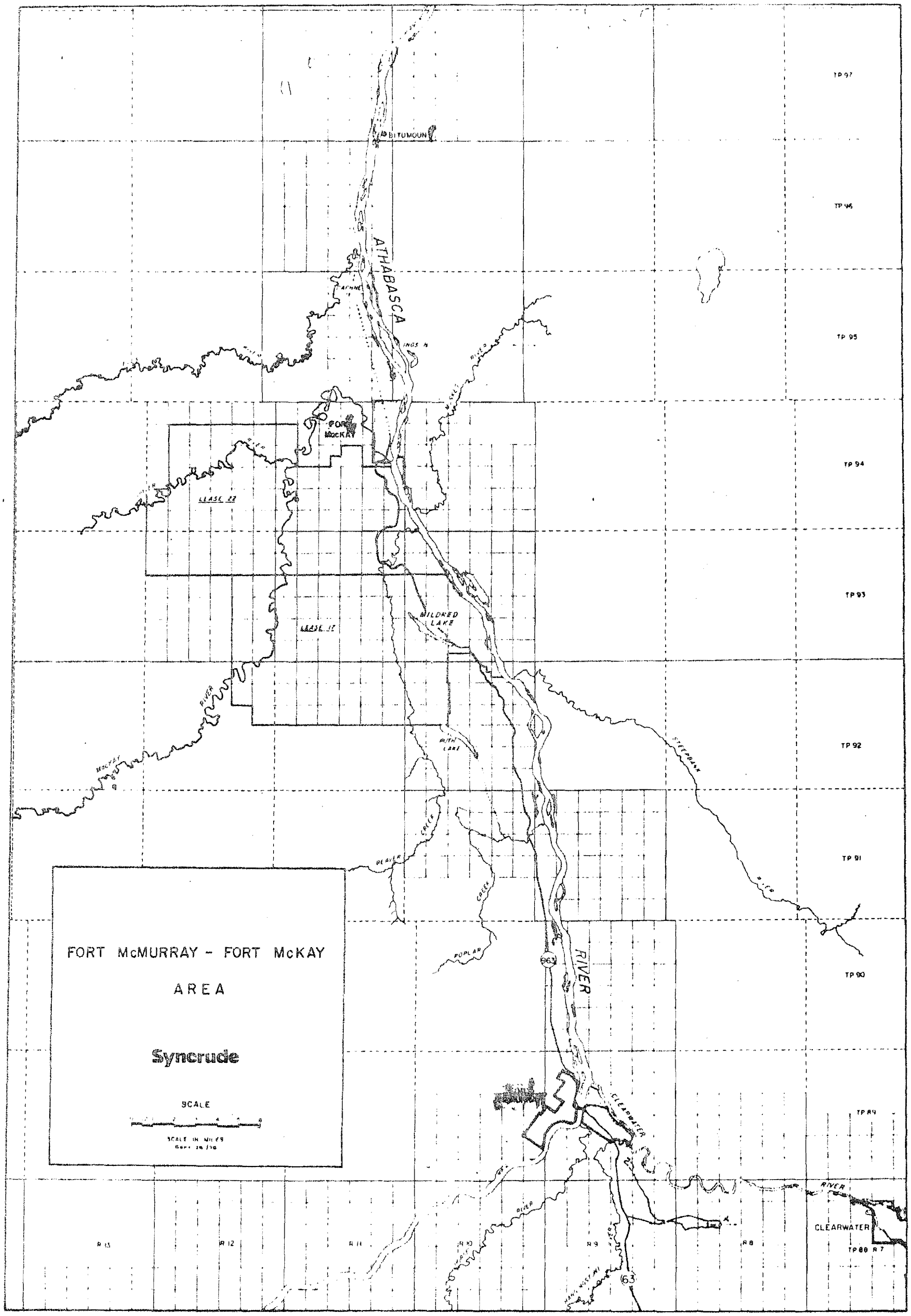
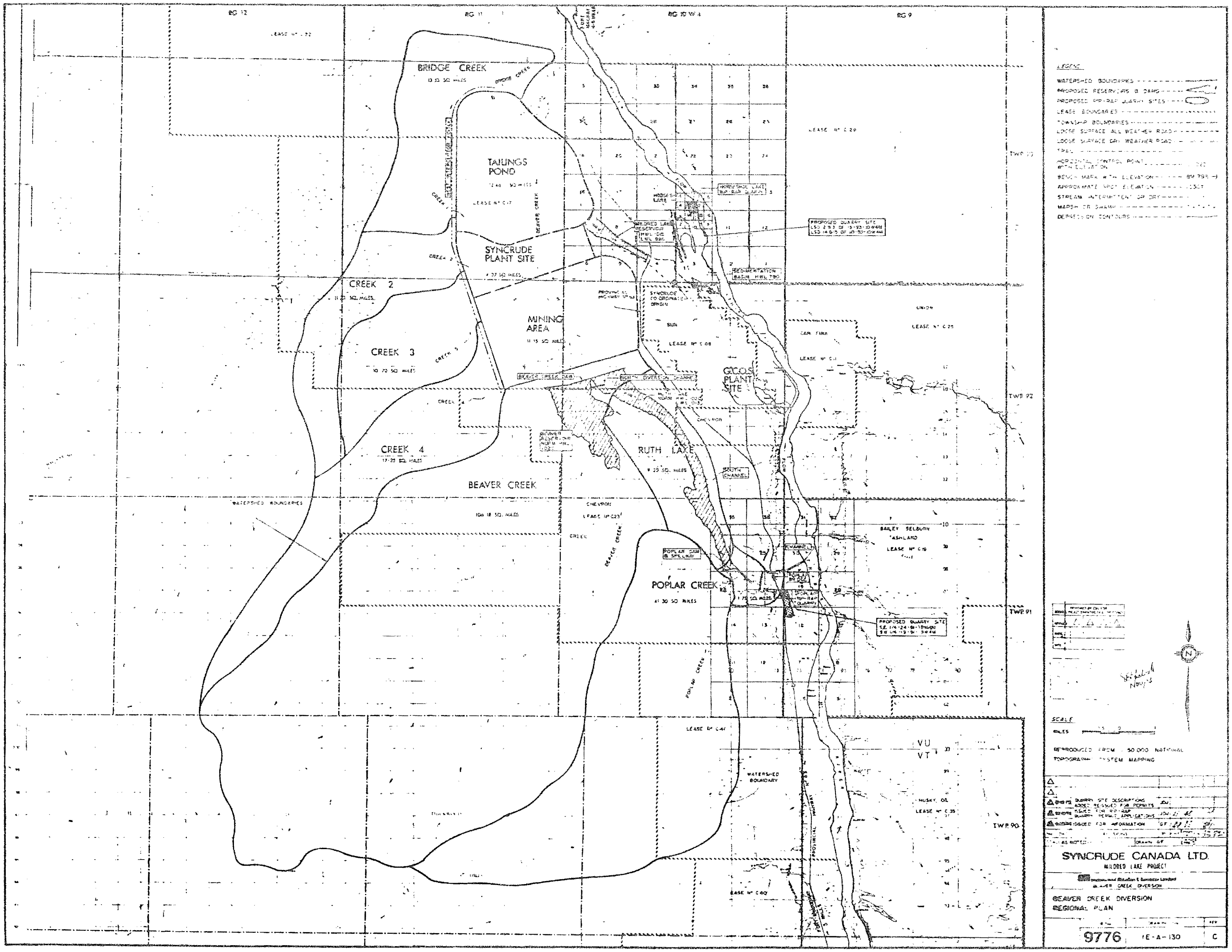

FORT McMURRAY - FORT McKAY
AREA
Syncrude
SCALE
ATHABASCA
RIVER
BITUMOUNT
FORT McKAY
MILDRED LAKE
CLEARWATER
TP 97
TP 96
TP 95
TP 94
TP 93
TP 92
TP 91
TP 90
TP 89
TP 88 R 7
R 13
R 12
R 11
R 10
R 9
R 8
63

FIGURE 2


BRIDGE CREEK
TAILINGS POND
SYNCRUDE PLANT SITE
CREEK 2
MINING AREA
CREEK 3
CREEK 4
BEAVER CREEK
RUTH LAKE
G.C.O.S. PLANT SITE
POPLAR CREEK
TWP 93
TWP 92
TWP 91
TWP 90
RG 12
RG 11
RG 10 W 4
RG 9
LEGEND
WATERSHED BOUNDARIES
SCALE
SYNCRUDE CANADA LTD.
MILDRED LAKE PROJECT
BEAVER CREEK DIVERSION
REGIONAL PLAN
9776
E-A-130
C

- 18 -

 DRAWING IN FEET

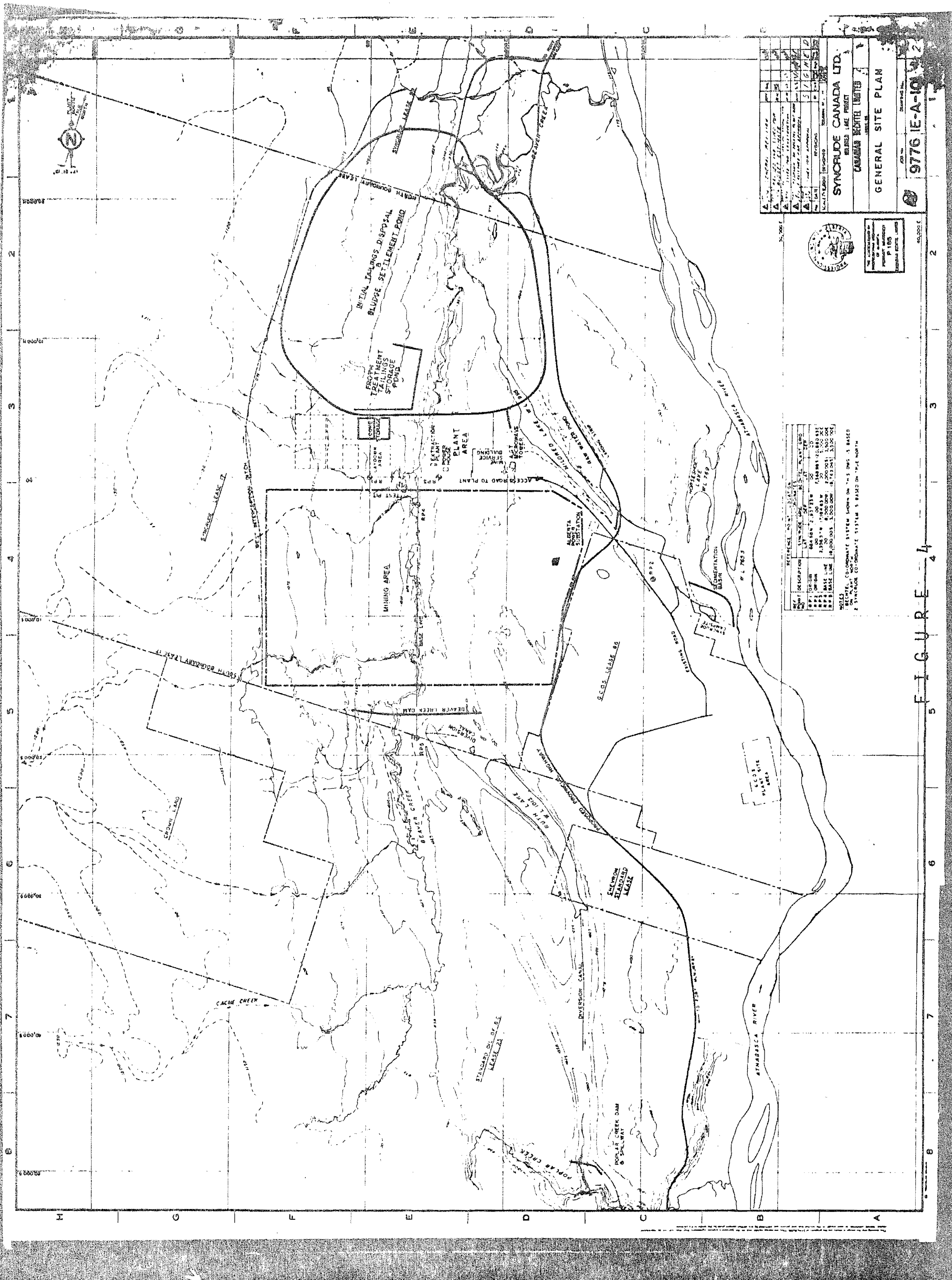


FIGURE 4

The final portion of the diversion scheme has been to construct an interception ditch on the west side of the 25 year mining area in order to divert flows of Creeks #2, #3 and #4 (Figure 3). These flows will be carried to Bridge Creek, which is a small tributary of the Beaver Creek system, and will discharge into the Athabasca River through the lower reaches of Beaver Creek (Figure 4). In addition, although they are not shown on Figure 4, intermediate drainage systems across the mine site will carry runoff into the tailings pond. These are the major components of the Beaver Creek diversion scheme, which will be completed in the spring of 1976.

Mine Area Depressurizing Program:

The purpose of the depressurizing scheme is to improve the safety of the mine highwall by decreasing fluid pressures in the basal aquifer sands below the tar sand. The initial excavation in the mine involves an opening cut 170 ft. below the present surface at the base of the oil sand plant feed as shown on Figure 5. This schematic drawing illustrates the position of one of four similar draglines and one of four bucket wheel reclaimers. Draglines operate in two modes: the first cuts the surface overburden and deposits it in the Beaver Creek Valley, the second cuts the feed and deposits material in a windrow to the east of the excavation for reclaim by the bucket wheel excavators. This type of mining requires maintenance of safe operating slopes by ensuring the pore pressures be at a minimum level in the aquifers which underlie our pit.

As a result of these depressurizing requirements, we have undertaken a number of test programs to identify the characteristics of the aquifer's geometry, geology, hydraulic properties as well as water qualities. In the spring of 1974, a full scale depressurizing program (which is also being operated as a test program), was initiated in order to optimize the various components going into the scheme.

Figure 6 illustrates two cross sections in the mine area. One section trends north to south and the other east to west. Both sections show the stratigraphy of the mine site and particularly the relationship of the water sands (aquifers) to the other geological units.

Figure 7 illustrates the depressurizing well layout as part of the pre-mining operation to lower the piezometric heads in the aquifers. The initial scheme shows a series of five well lines that will be completed in 1976. These extend across a width of 2500 ft. and the total length of the mine. In addition, a set of cutoff wells will be located on the north and south mine boundaries. These wells are 400 ft. apart on the five lines. Their spacings have been dictated not only by the geometry and characteristics of the basal aquifers, but also by the mine layout of equipment, conveyors, draglines, and our initial back-filling operation of the Beaver Creek Valley.

The wells in the north half of the mine area started operating at the end of June of this year. In September, 1975, the remainder of

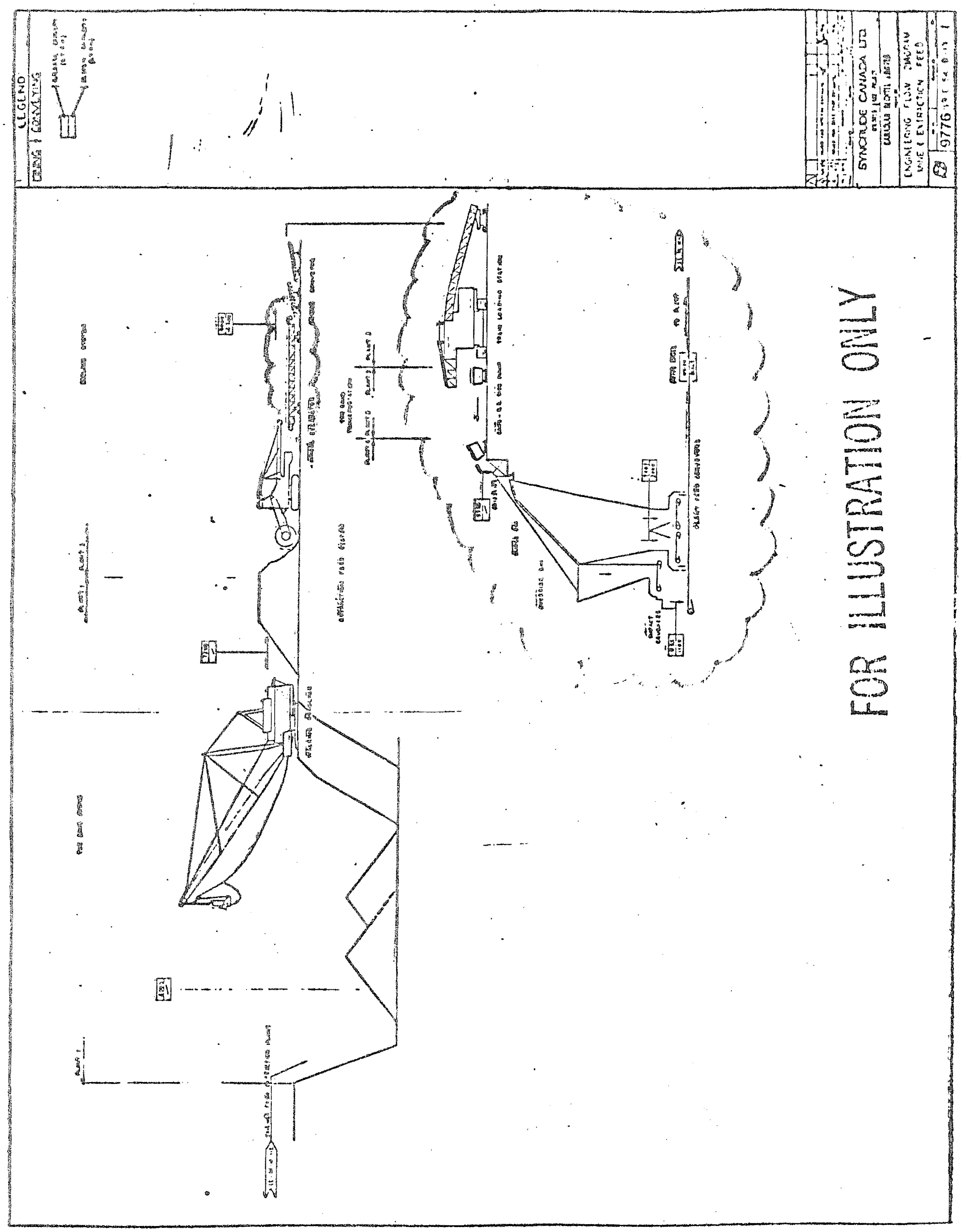
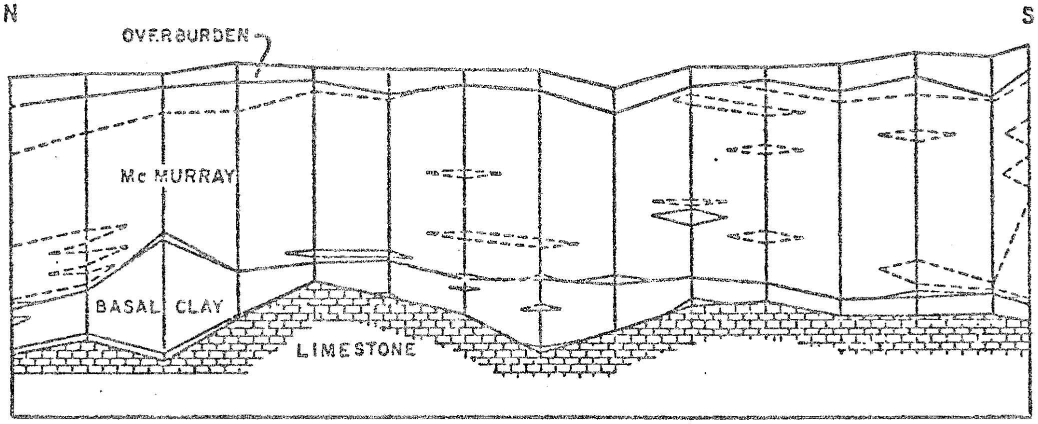
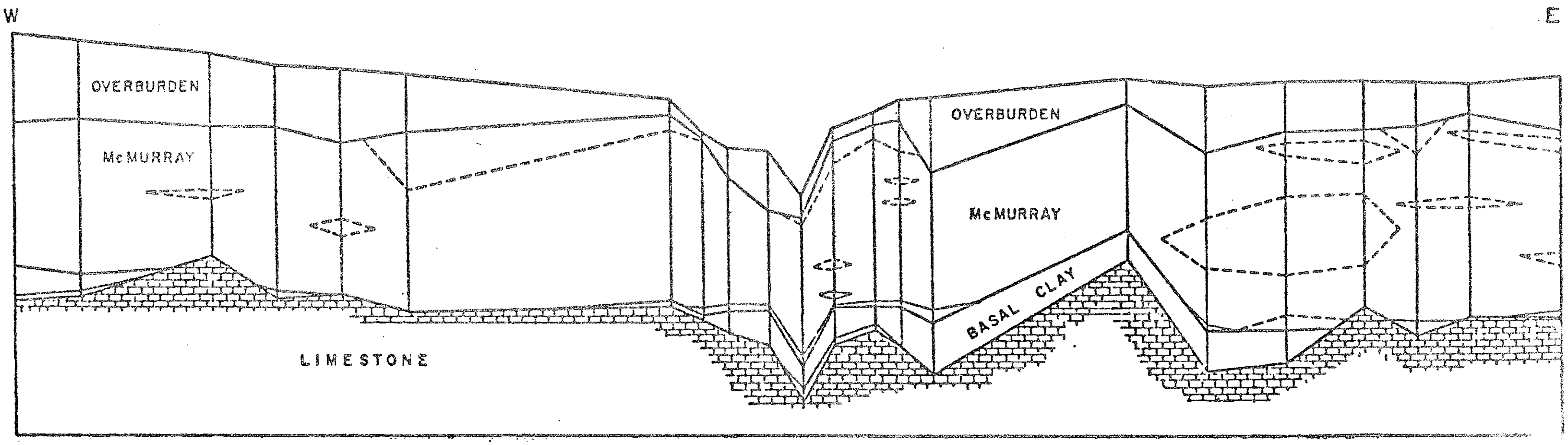

LEGEND
SYNCRUDE CANADA LTD.
ENGINEERING FLOW DIAGRAM
MINE & EXTRACTION FEED
9776
FOR ILLUSTRATION ONLY

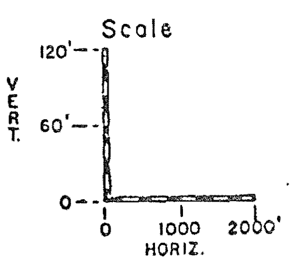
FIGURE 5

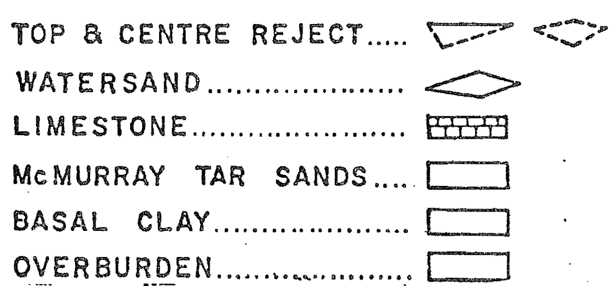


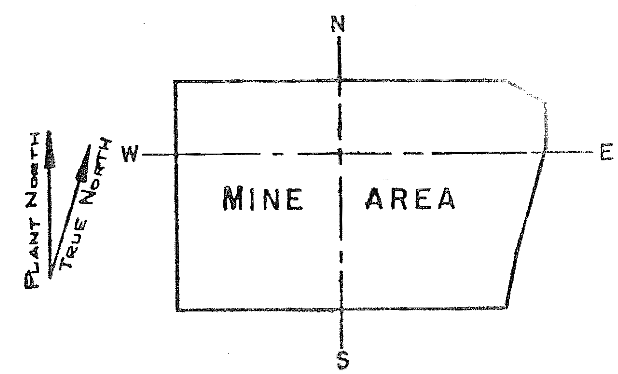
TYPICAL N-S SECTION THROUGH CENTRE OF 25 YR. MINE AREA



W-E SECTION THROUGH CENTRE OF 25 YR. MINE AREA







PLAN OF DEPRESSURIZING WELLS

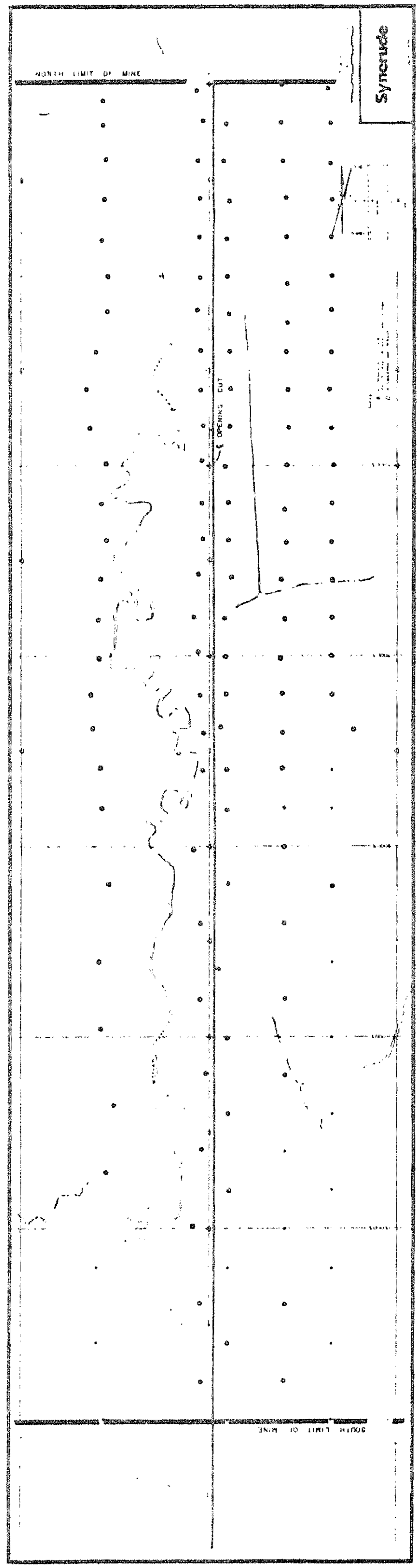


FIGURE 7

the wells went into operation, bringing the total number of wells to 95. The wells continue operation until early December, whereupon there will be a pause through the winter for two reasons: a) to minimize higher operating costs due to cold weather and b) to ascertain recovery conditions of the piezometric head as a result of the pumping activity.

Figures 8a and 8b are the drawdown curves of four wells selected at random showing the results of pumping activities in terms of piezometric head changes for the first 60 days of pumping. Generally, there has been a significant flattening of the drawdown ranging from 100 ft., to about 30 ft. The curves are a reflection of the complexities and variations of the aquifer. They also indicate that, for this particular density of wells, there has been a degree of recovery from the basal aquifers exterior to the area in which we have been pumping. This is the reason for the flattening of the drawdown curve.

Figure 9 shows the 25 year mine area and two sets of groundwater level contours for the basal sand aquifer. One set of contours depicts initial conditions prior to pumping and the second set depicts conditions after 89 days of pumping. The 1000 ft. pressure head is the equilibrium situation or original piezometric measure level in the basal aquifer. After 89 days of pumping drawdowns to the 950 and 900 levels have occurred.

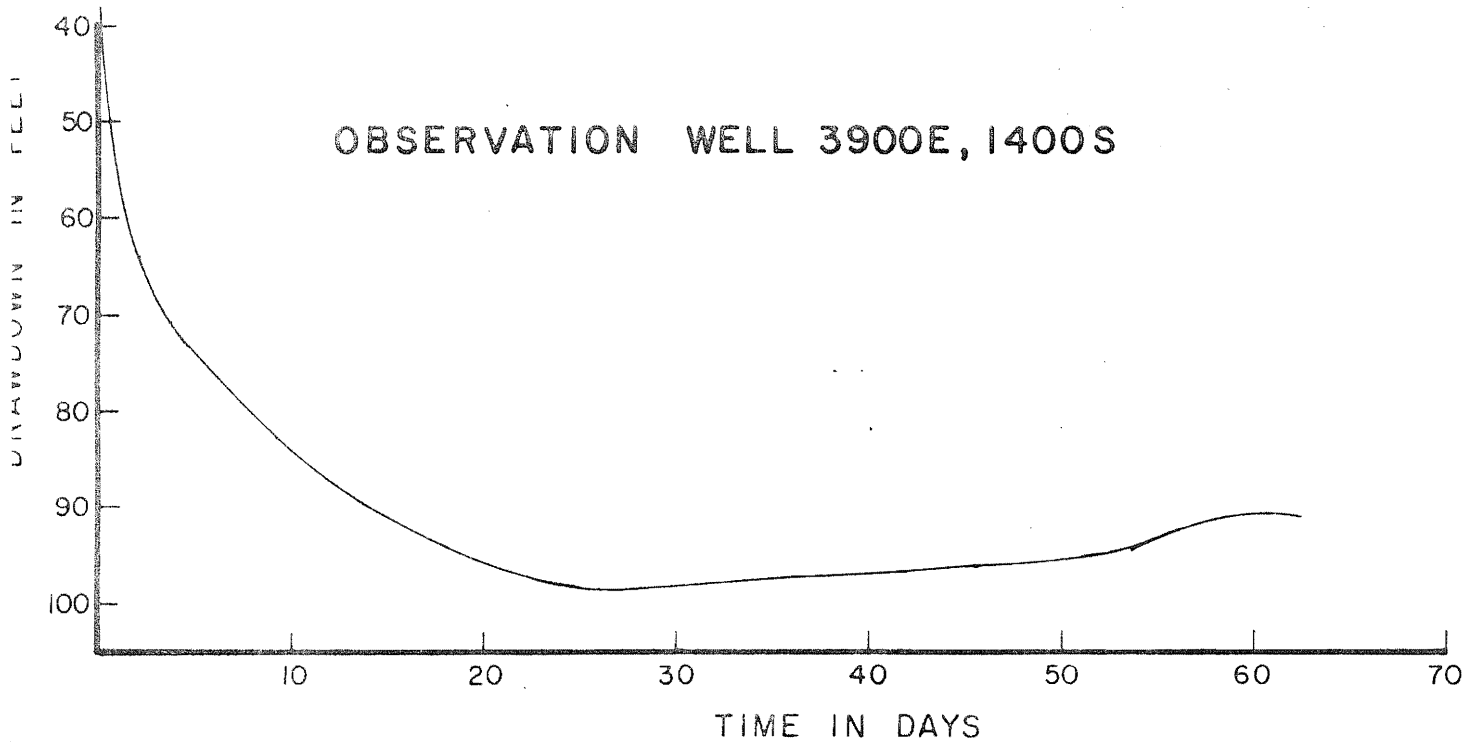
Pumping rates in excess of one cubic ft. per second of discharge water from the basal aquifers have been attained. The water has a chloride content in the range of 4000 to 4500 ppm. In comparison to sea water it is best described as a brackish water. There is considerable variation of water quality from area to area and well to well, ranging in concentration of what would appear to be close to sea water to nearly fresh water. These data give some indication of the complexity of the aquifers, their genesis, and in turn the complexity of making reasonable predictions.

An observation program, which encompasses the entire mine site, has commenced. We have established a number of observation points, both for taking water quality samples, as well as monitoring piezometric levels. These observation wells are shown as black dots on Figure 9. All the wells will be sampled for both water quality and gas analysis data. An attempt has been made to demonstrate the complexity of the aquifers with respect to water quality, and particularly projections of water quality.

Predictions of water quantity are complex. One parameter used in this tabulation is the amount of gas in the aquifers, therefore, we are essentially dealing with a two phase, not a single phase, system. Our predictions for water quantities tend to be greater than those actually achieved, due to the presence of dissolved gasses. Gas is dissolved in the water and as the pressures are decreased, the gas comes out of solution and keeps the piezometric levels higher than predictions in a single phase system.

Figure 10 is a contour map of the top of the Devonian limestone showing a depression in the Devonian limestone extending through the central part of our mine site. Coinciding with this depression are the

DRAWING IN FEET



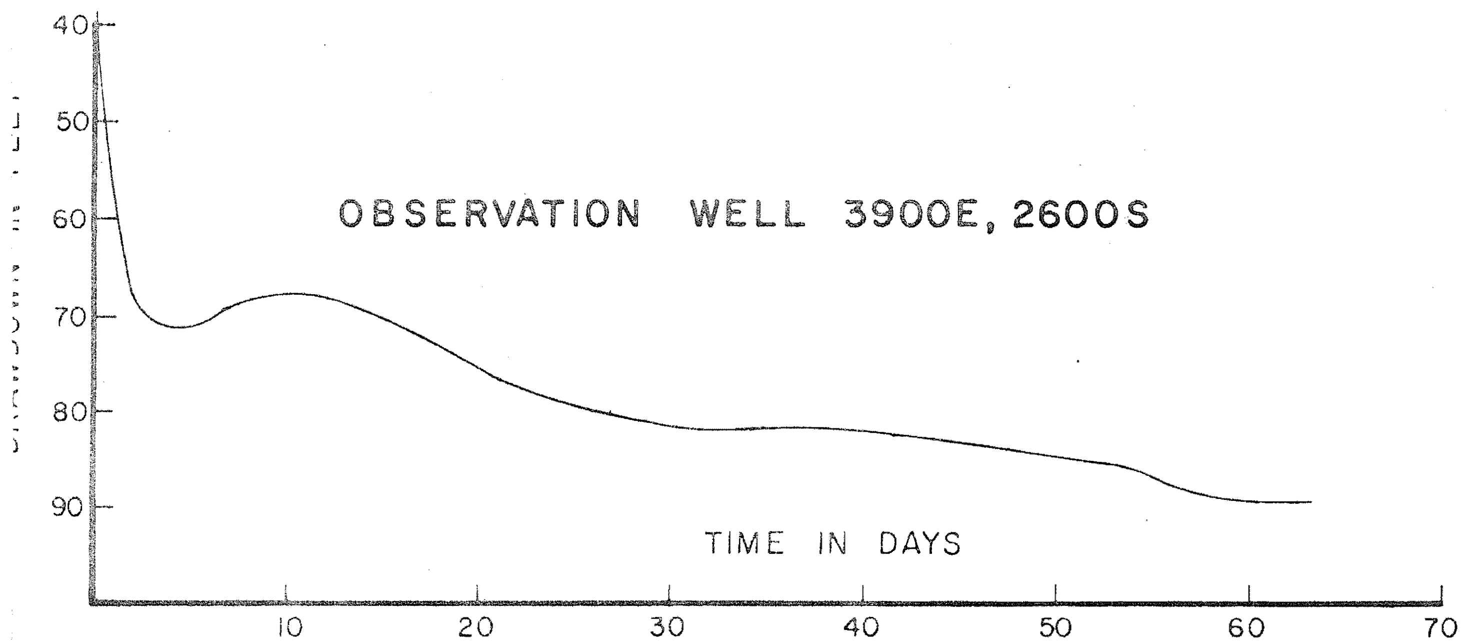
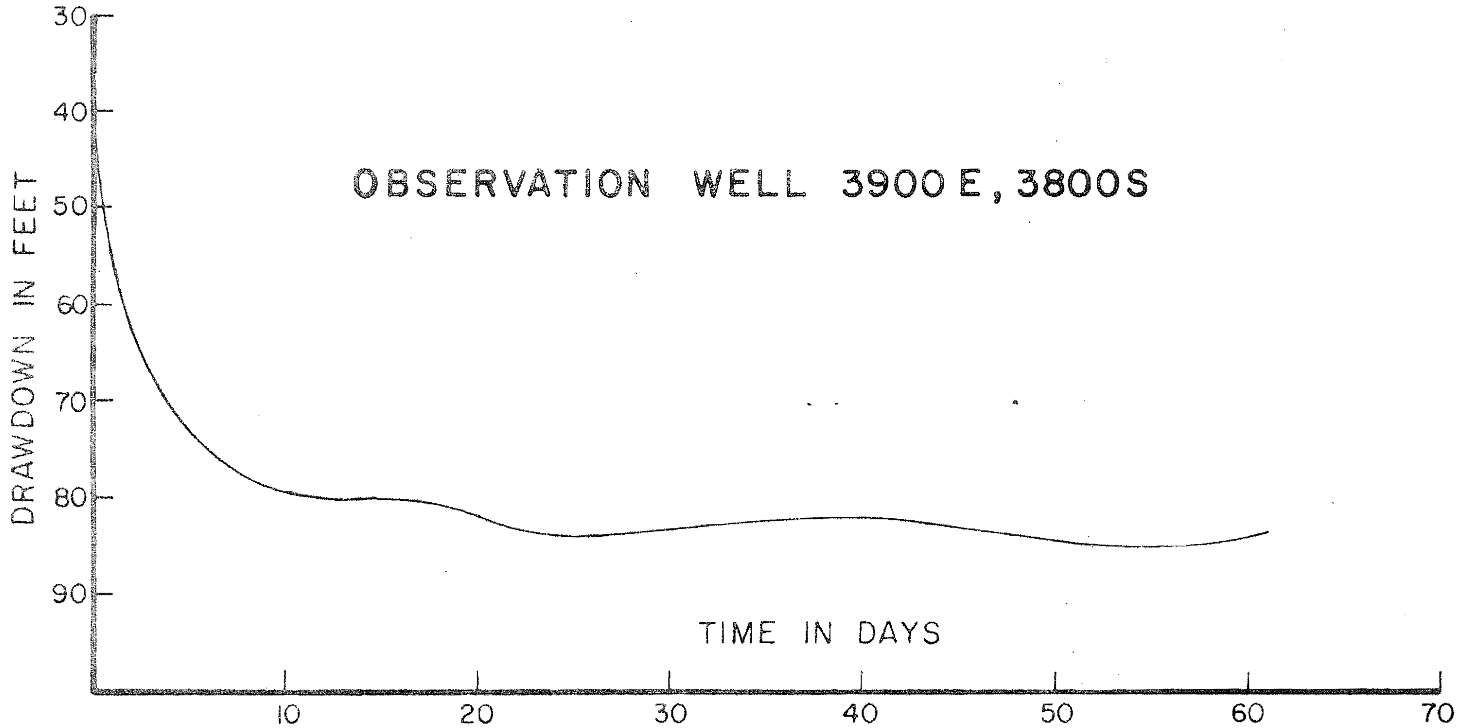


FIGURE 8a


OBSERVATION WELL 3900 E, 3800 S
DRAWDOWN IN FEET
30
40
50
60
70
80
90
TIME IN DAYS
10
20
30
40
50
60
70

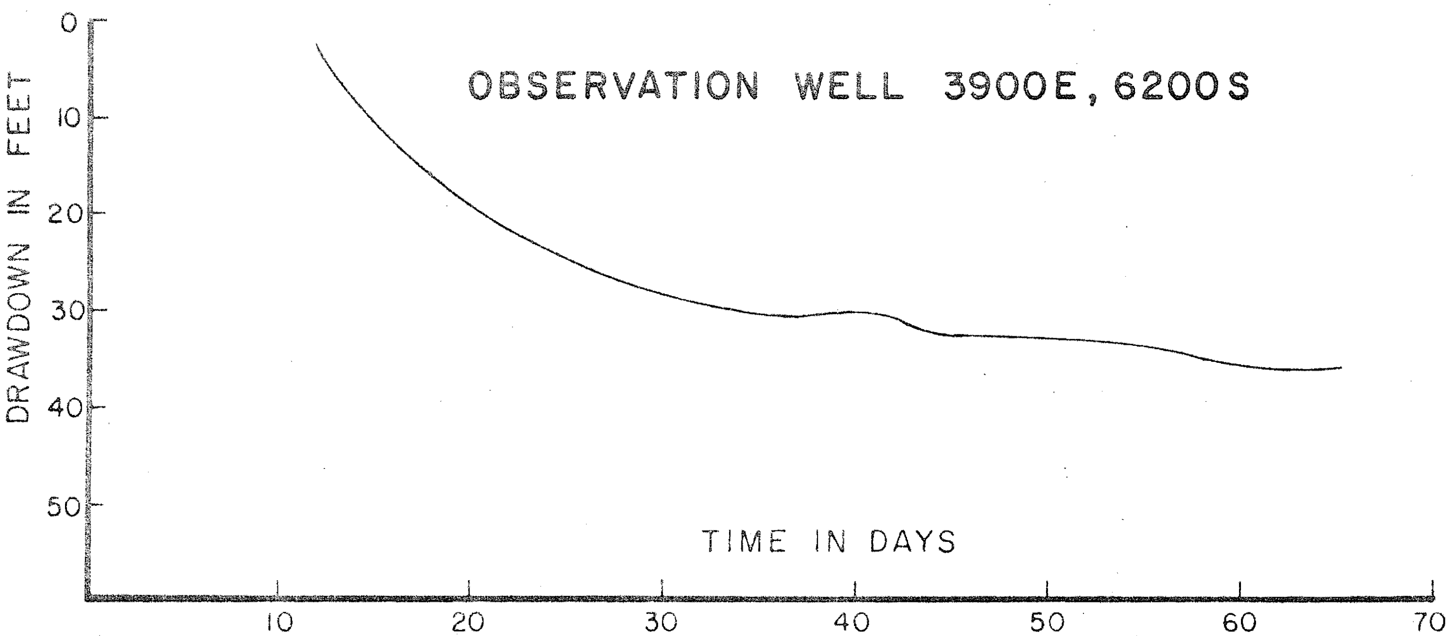
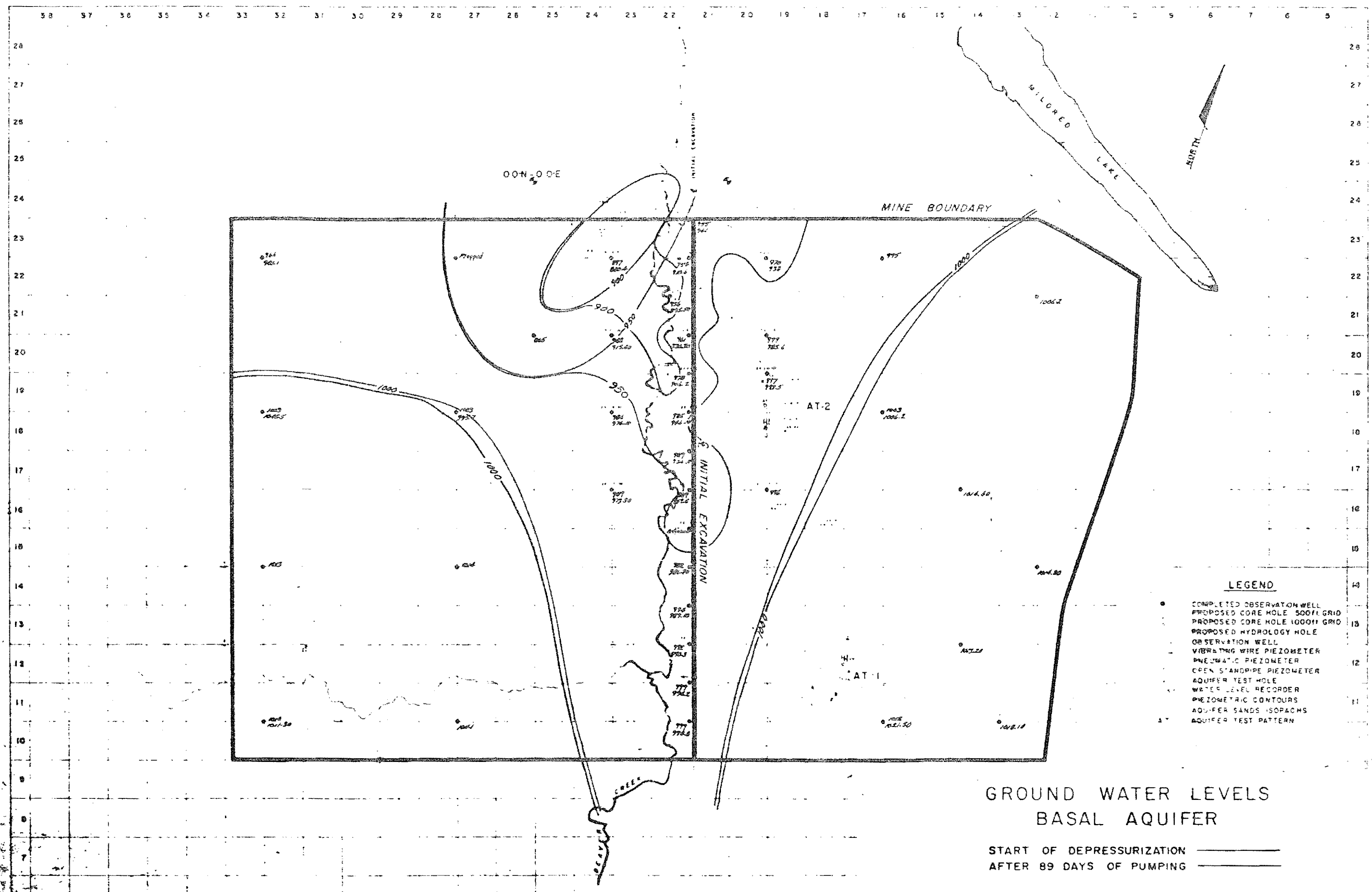

OBSERVATION WELL 3900 E, 6200 S
DRAWDOWN IN FEET
0
10
20
30
40
50
TIME IN DAYS
10
20
30
40
50
60
70

FIGURE 8b



MINE BOUNDARY
MILDRED LAKE
NORTH
INITIAL EXCAVATION
AT-2
AT-1
1000
950
900
LEGEND
COMPLETED OBSERVATION WELL
PROPOSED CORE HOLE 500ft GRID
PROPOSED CORE HOLE 1000ft GRID
PROPOSED HYDROLOGY HOLE
OBSERVATION WELL
VIBRATING WIRE PIEZOMETER
PNEUMATIC PIEZOMETER
OPEN STANDPIPE PIEZOMETER
AQUIFER TEST HOLE
WATER LEVEL RECORDER
PIEZOMETRIC CONTOURS
AQUIFER SANDS ISOPACHS
AQUIFER TEST PATTERN
GROUND WATER LEVELS
BASAL AQUIFER
START OF DEPRESSURIZATION
AFTER 89 DAYS OF PUMPING

FIGURE 9

basal sands and clays which underlie the oil sand feed. This face provides the main control for the interpretation and the estimations of the extent of the basal sands. Three basal aquifer sands have been identified on a genetic basis. Unit "A" (Figure 11) is the lowest aquifer sand and closely coincides with the depression in the surface of the underlying limestone. Unit "B" (Figure 12) consists of aquifer sands that are inter-bedded with the basal shales while Unit "C" (Figure 13) shows the upper aquifer sand which grades into tar sands. The essential difference between the oil sand and the aquifer sand is that water is replaced by bitumen. The upper aquifer sand unit is the most extensive unit, covering much of the mine area as well as the plant site.

Surface Groundwater Regime:

Surface groundwater regimes include groundwater flow systems in the Pleistocene material above the McMurray Formation. All data indicates that the groundwater regimes in the overburden materials are separate from the groundwater regimes in the basal aquifers as well as any low grade sands containing water in the McMurray formation. In the strict hydrological sense, the basal aquifer is a confined system. The over-burden is a semi-confined system because the bottom of the overburden is a no-flow boundary.

Generally, with regular mining methods, no problems arise handling overburden materials up to 40 ft. However, for surface muskeg areas, excavation and backfilling are required in order to have a proper working mine surface that will carry the mine equipment, conveyors, draglines, etc. In areas where the overburden exceeds 40 or 50 ft, dewatering for the purposes of slope stability is required.

In areas where thick Pleistocene materials exist, dewatering will be necessary. In Figure 14 the area or zone of thick sediments is outlined by the isopachs coinciding with Beaver Creek. Essentially, the sediments have a canoe shape and range in thickness to 80 ft. A pumping program in this area is underway in order to identify a proper dewatering design for this particular area. It is our intention to bring pressure levels from the level of Beaver Creek to the bench levels that will exist in this area. In other words, drawdowns of 50 to 60 ft. are being sought. Water quality analyses will be completed. It is anticipated that this water quality will be better than the basal aquifer water. It is our intention to discharge this surface water into the tailings pond area. If this is not feasible, because of the construction schedule for the tailings pond starter dike, disposal to a natural water system will be followed.

Disposal of Well Water:

All depressurizing wells are discharging into Beaver Creek. Systematic monitoring of both water quality from the wells and water quality in Beaver Creek, at a point downstream from where all the wells discharge, has been underway since pumping began.

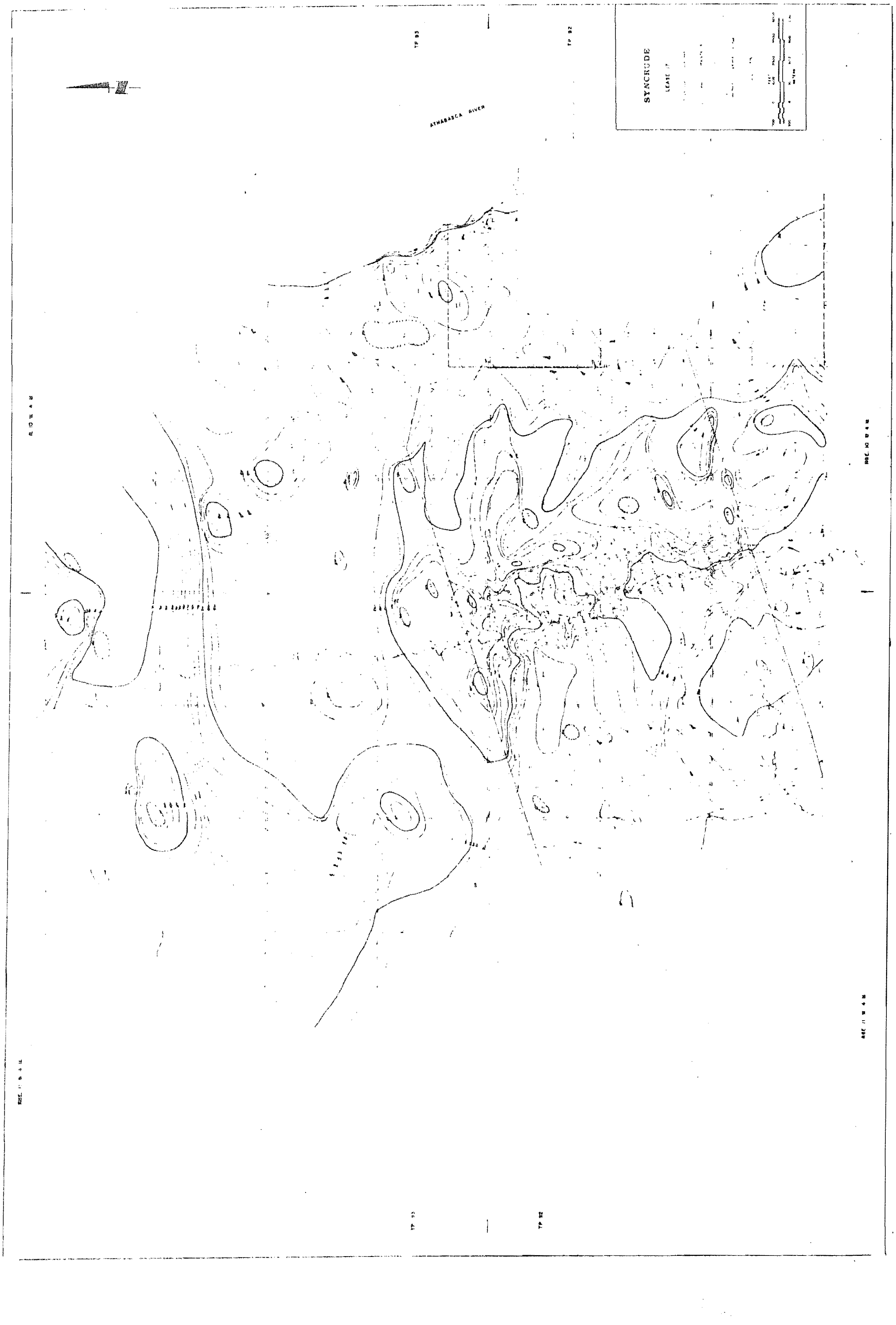


FIGURE 10

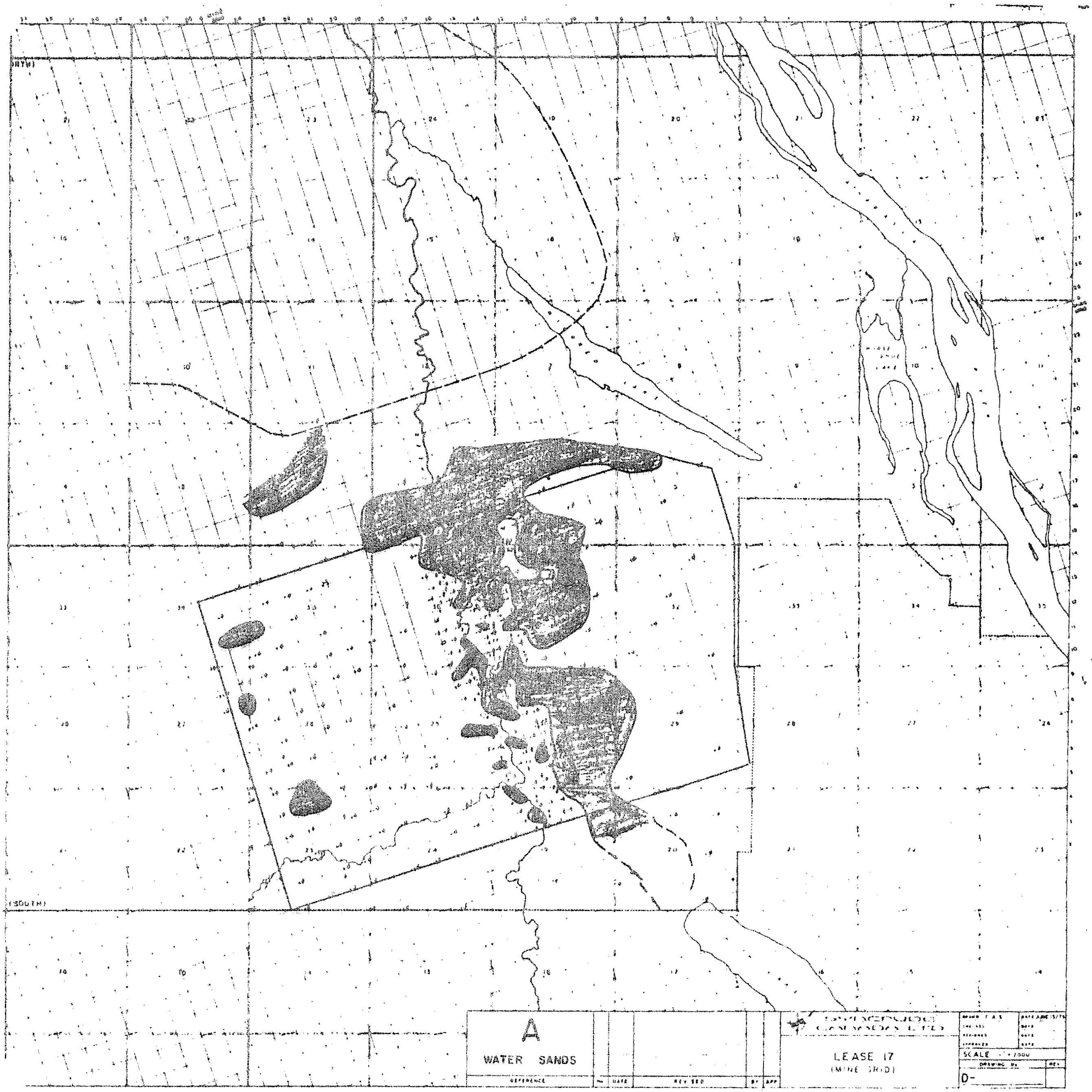

(NORTH)
(SOUTH)
A
WATER SANDS
REFERENCE
DATE
REVISED
BY
APP
LEASE 17
(MINE GRID)
SCALE
DRAWING No.
REV
D-

FIGURE 11

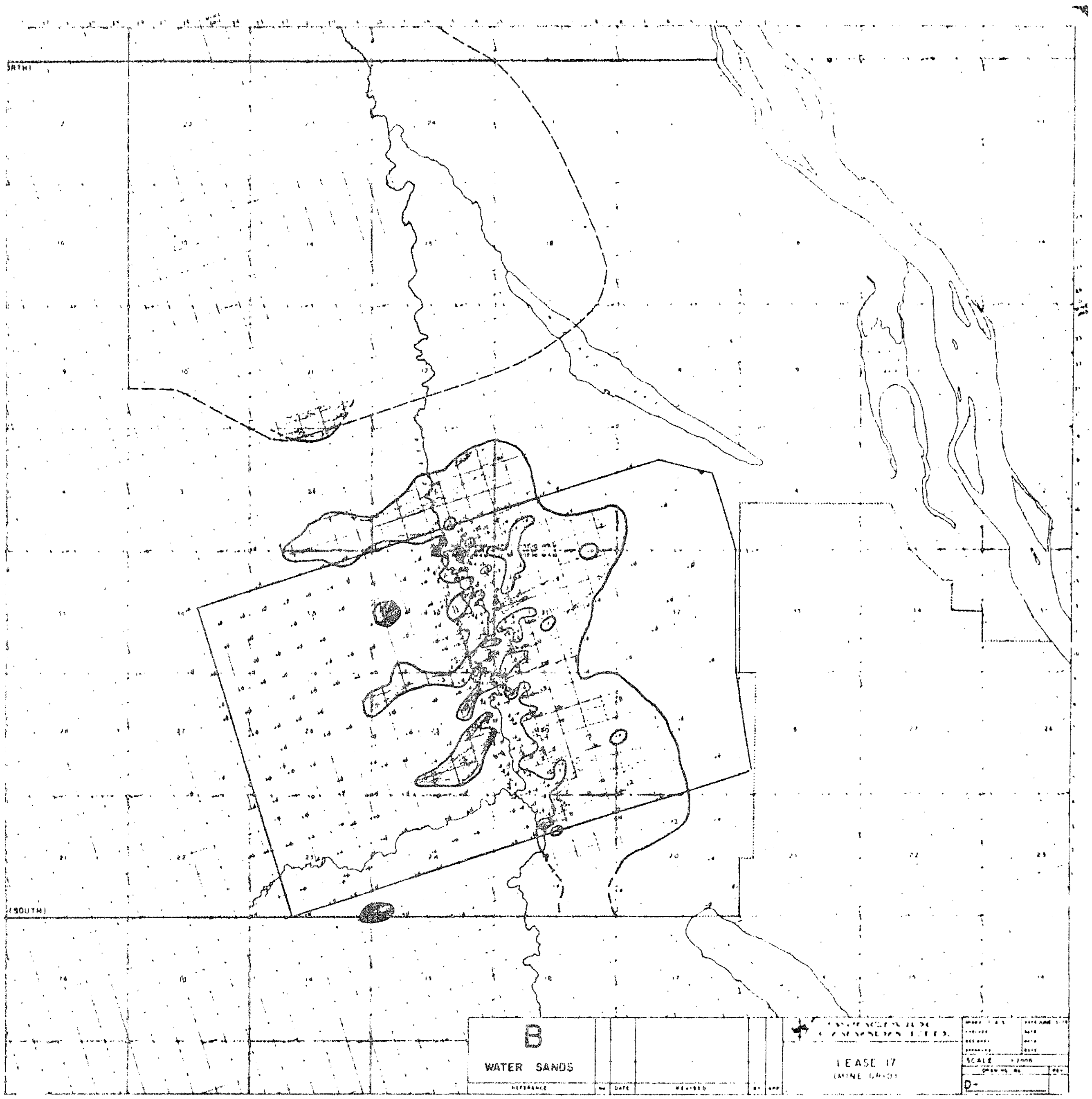


FIGURE 12

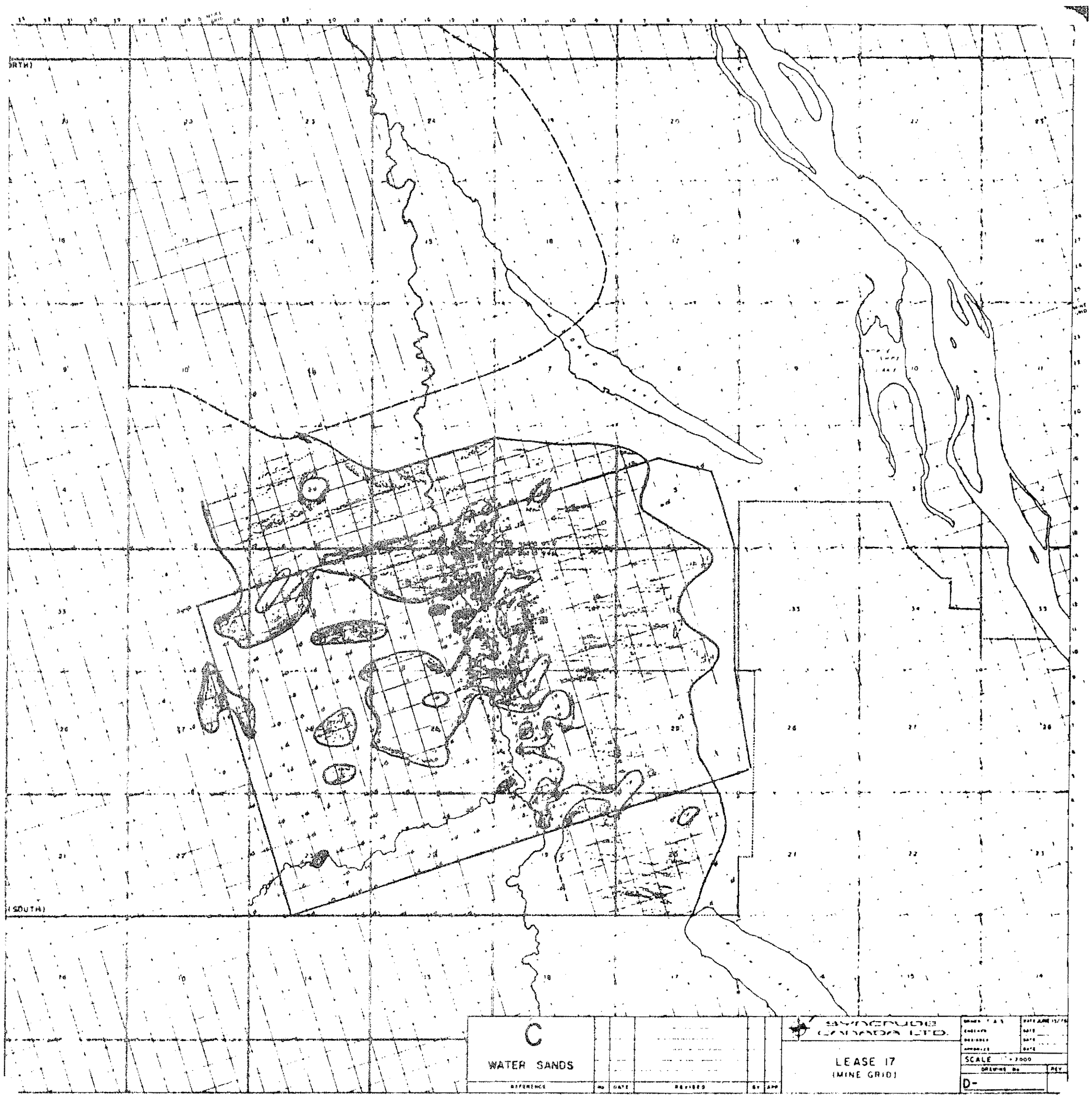
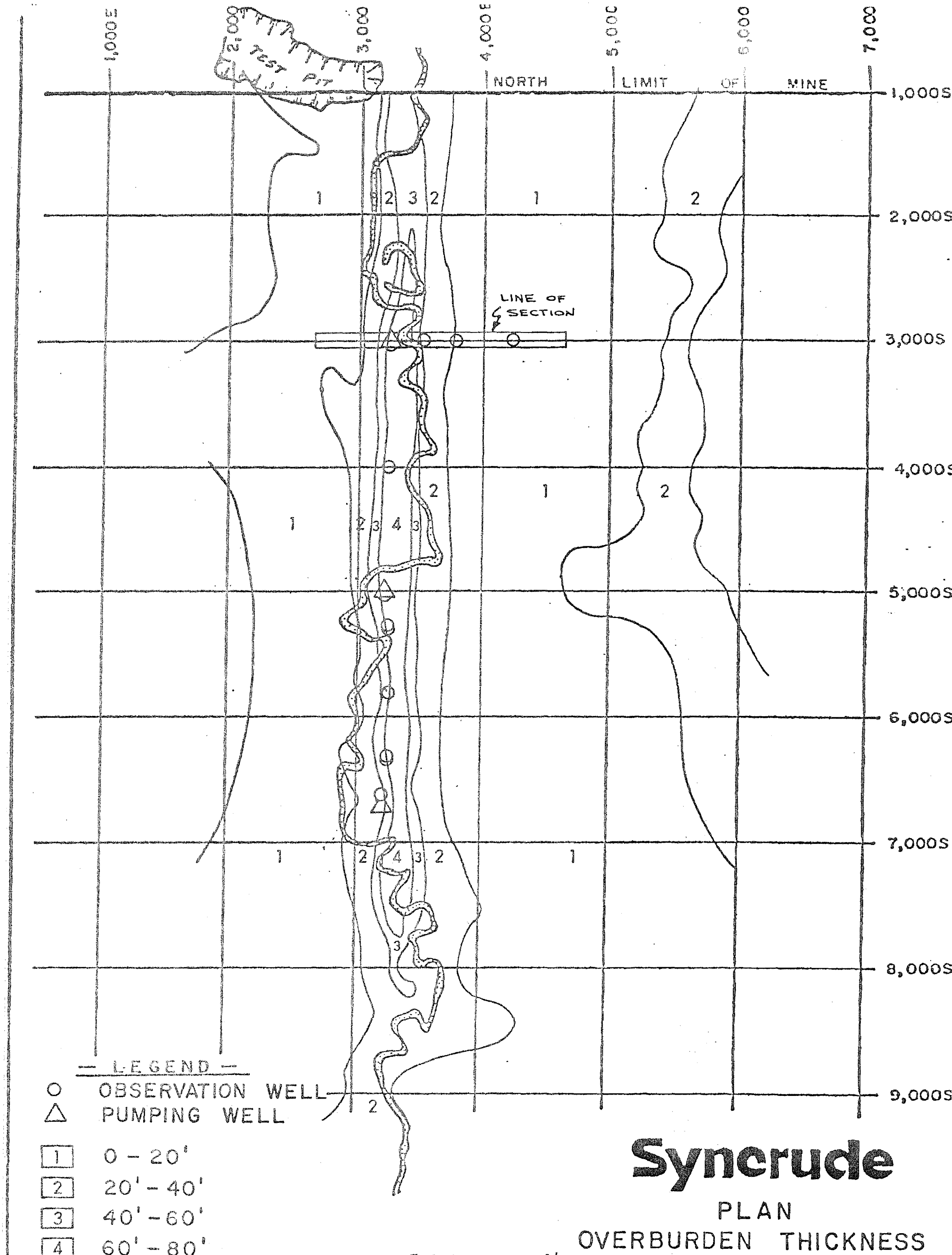


FIGURE 13



Syncrude

PLAN
OVERBURDEN THICKNESS

FIGURE 14

Figure 15 gives three important disposal parameters. The first bar chart is the Beaver Creek Hydrograph showing averages of Creek flow ranging from 30 to 40 cubic ft. per second. This range compares to the total well flow of 1 cubic ft. per second. The second bar chart shows weekly average chloride ion content of Beaver Creek below the last point of discharge of our wells (the Ft. McKay road crossing). Levels vary from 20 ppm. chloride to a little over 100 ppm. chloride. The maximum limit, as established by both Syncrude and the Government, is 500 ppm. chloride. The last bar chart simply shows the total well production on a weekly average, expressed as gallons per minute.

Some interest was expressed during the previous discussion of the effects on the Athabasca River. Figure 16 shows an average hydrograph for the Athabasca River together with a curve which illustrates the average chloride concentration of 17 ppm. Two additional chloride concentration curves, with differing rates of mine water discharge at 6000 ppm. chlorides, shows the maximum anticipated chloride level to be 34 ppm.

In contrast to these levels, natural chloride levels in Poplar Creek have reached 700 ppm. while those in the Clearwater River attain 37 ppm. These natural background chloride conditions offer an interesting comparison with those values shown in Figure 16.

Tailings Pond Area:

Figure 3 shows the proposed tailings pond and sludge settlement area. The initial tailings impoundment will commence in the northern portion of the tailings area within Beaver Creek Valley. Impoundment will be accomplished by construction of an earth-fill starter dike. The starter dike will be constructed to normal compacted earth-fill dam requirements to ensure adequate safety against slope failure, and to preclude the possibility of abnormal seepage rates. By 1979, a fairly large segment of dike will be constructed along the northern perimeter of the tailings area. At the present time, design and exploratory work are still in progress.

One study, soon to commence, will identify water quality of the surface groundwater regime by installing a number of observation wells both inside and outside the tailings area. They will provide information on water quality and levels and the nature of the sand and gravel deposits (aquifers) within the Pleistocene portion of the stratigraphic profile.

A detailed study of the portion of the tailings dike which crosses Mildred Lake is underway. The south end of Mildred Lake (Figure 3) will function as a storage area for temporary residence of plant process water. This portion of the starter dike will be constructed to reduce seepage from the tailings area to Mildred Lake.

A regional Pleistocene geology study is underway on Leases 17 and 22 with emphasis on the mine and tailings areas. It is felt that detailed knowledge of the Pleistocene stratigraphy is essential in order

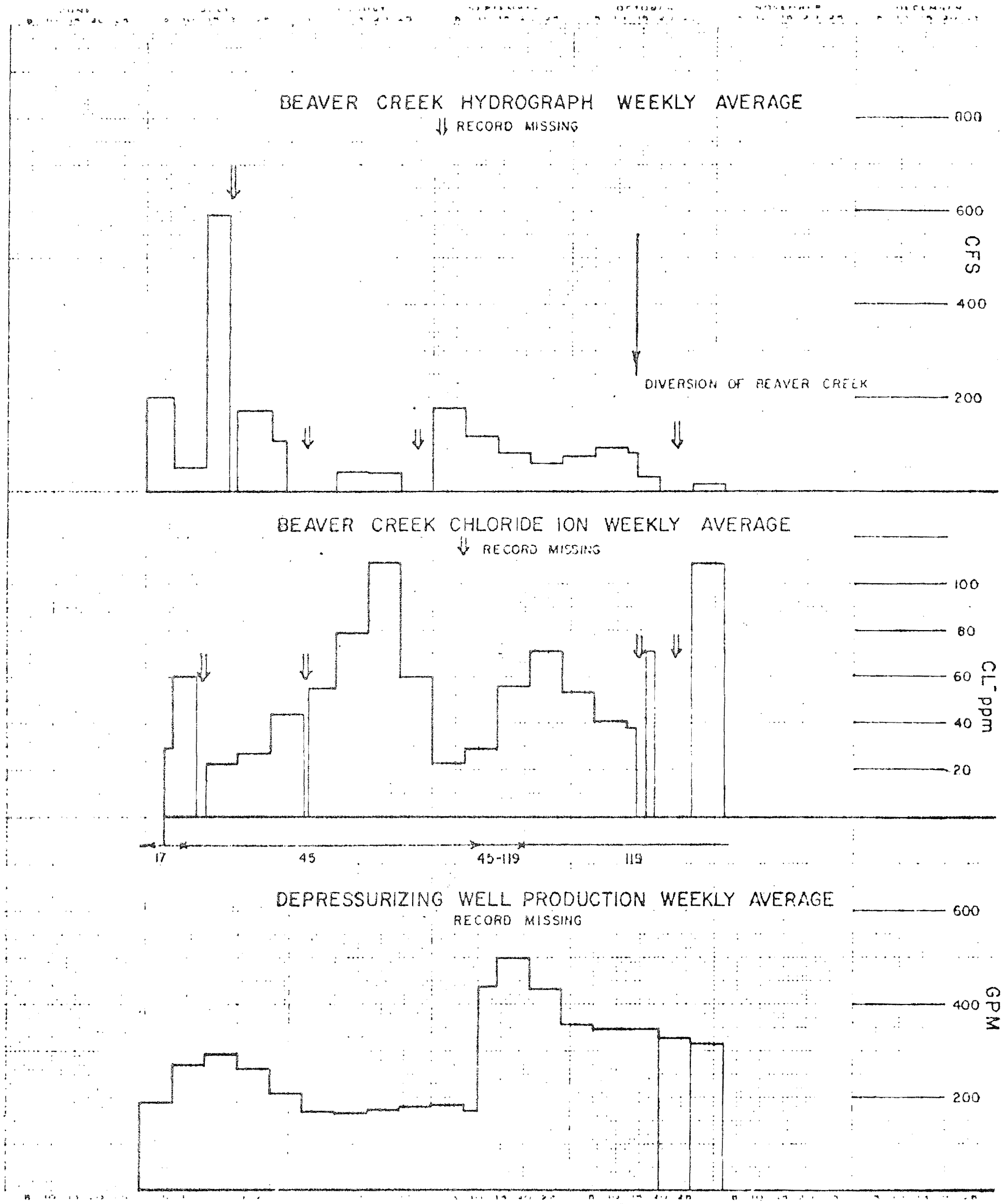
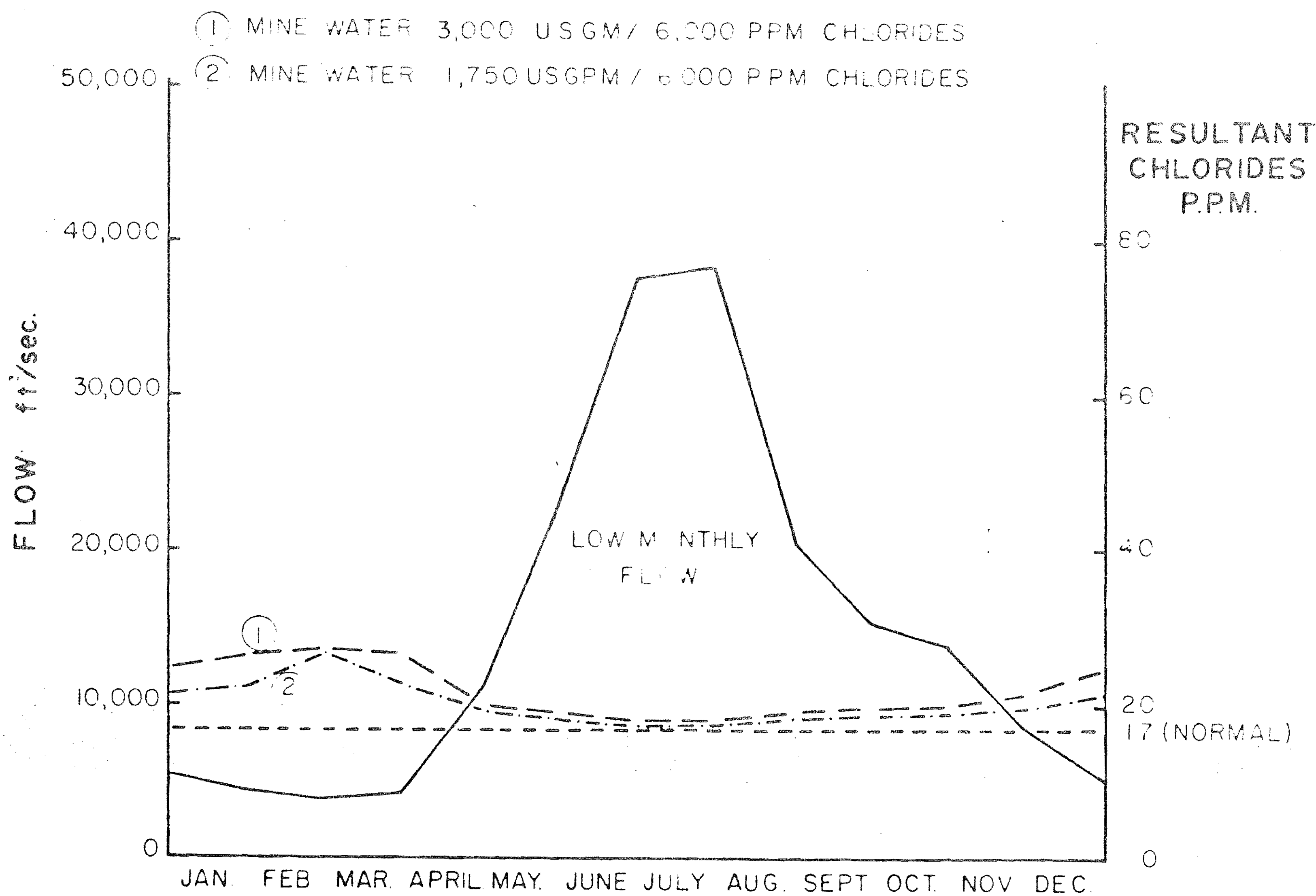

BEAVER CREEK HYDROGRAPH WEEKLY AVERAGE
RECORD MISSING
DIVERSION OF BEAVER CREEK
600
400
200
CFS
BEAVER CREEK CHLORIDE ION WEEKLY AVERAGE
RECORD MISSING
100
80
60
40
20
CL⁻ ppm
17
45
45-119
119
DEPRESSURIZING WELL PRODUCTION WEEKLY AVERAGE
RECORD MISSING
600
400
200
GPM

FIGURE 15

Figure 16



**MINE WATER EFFLUENT VS.
ATHABASCA RIVER SALINITY**

to understand its effect on storing water in the tailings pond.

Several years after mining commences, it is planned to dispose of the tailings within the mine. It is intended that the mine be used primarily for the storage of the sand fraction of the tails. Conceptually, this mode of storage will require the construction of earth-fill cells where the sand tails will be placed. However, detailed engineering design work has not yet been completed on this concept (see Figure 17).

Mr. Chairman, that concludes the remarks I would like to make at this time.

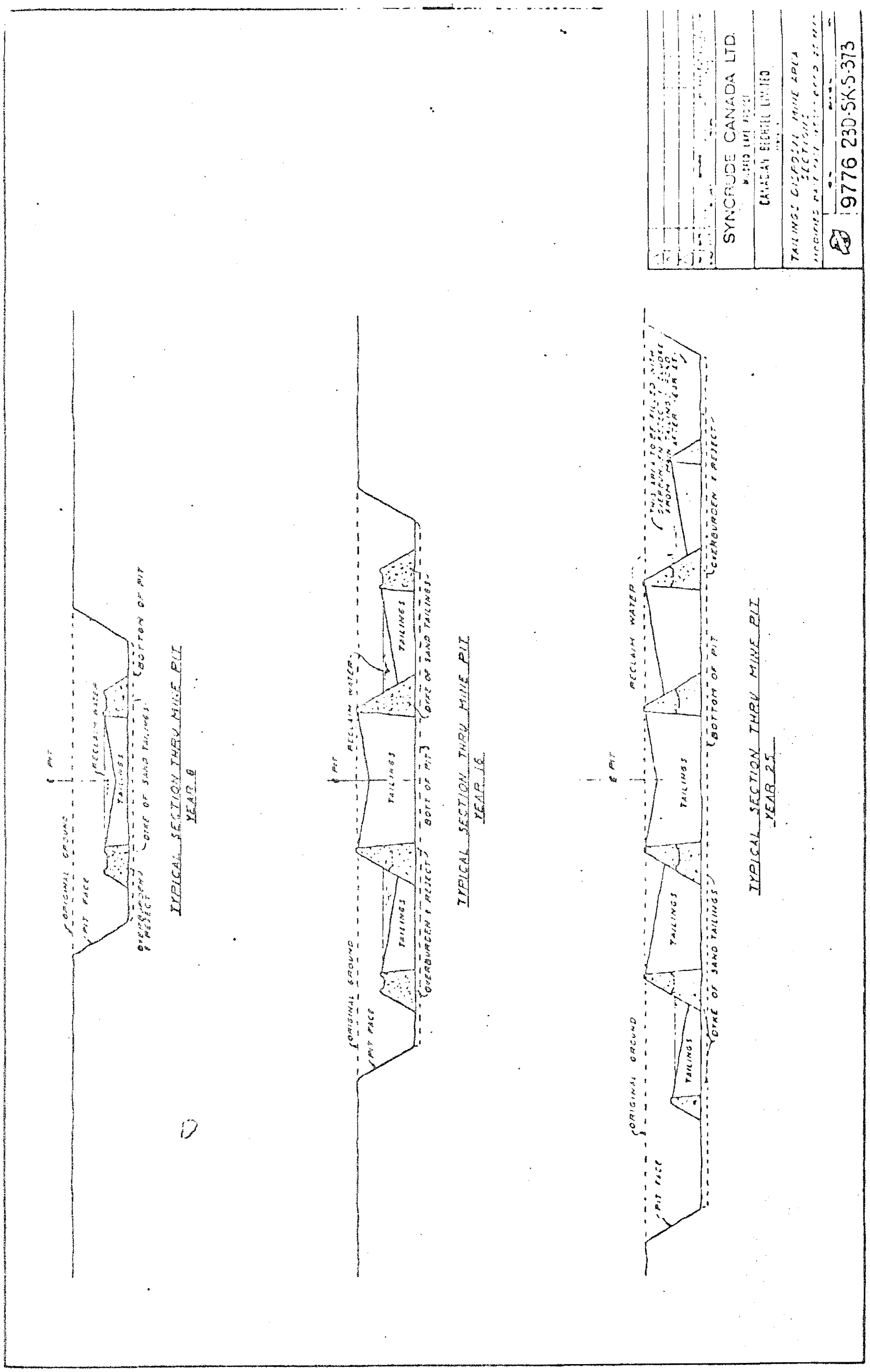

SYNCRUDE CANADA LTD.
CANADIAN BECHTEL LIMITED
9776 230-SKS-373
TYPICAL SECTION THRU MINE PIT
YEAR 8
TYPICAL SECTION THRU MINE PIT
YEAR 16
TYPICAL SECTION THRU MINE PIT
YEAR 25
ORIGINAL GROUND
PIT FACE
TAILINGS
RECLAIM WATER
BOTTOM OF PIT
DYKE OF SAND TAILINGS
OVERBURDEN & REJECT

FIGURE 17

M. RAISBECK:

1. Introduction:

Figure 18 shows that oil sands Lease 30 is located south of Shell's Lease 13 and north-east of Syncrude's Lease 17. Home Oil Company Ltd. and Alminex Ltd. obtained the Lease in 1959. Subsequent drilling programs and evaluations led to an application to the ERCB in early 1974 for permission to build a 103,000 barrel per day facility[1]; in May 1975, ERCB issued its approval of the application[2].

This paper briefly describes the hydrology and aquatic fauna baseline conditions on Lease 30 while touching upon a few of the aquatic development implications which are under consideration.

2. Hydrology:

In considering the hydrology of the area, one must be cognizant of both the surface and groundwater regimes. Regarding surface water, Lease 30 lies within the drainage of the Muskeg River and its tributaries, except the tip of the panhandle of the Lease which abuts against the Athabasca River. The drainage basin of the Muskeg River has an area of approximately 540 square miles. Elevations range from 775 ft. at the Athabasca River, to 1900 ft. at the drainage divide in the Muskeg Mountain area to the east.

The open water system on the Lease comprises, the Muskeg River, Hartley Creek, an unnamed upper tributary of the Muskeg River in the eastern portion of the Lease, and several small lakes in the northwest corner of the Lease. Integral to the open water system are the pervasive wetlands, e.g. muskeg. Generally, these wetlands serve as a reservoir in conjunction with the open water system. In some instances, however, the wetlands serve as watertracks which conduct seepage flow across the Lease independent of open water bodies. Figure 19 indicates that there are three major concentrations of watertracks present, one in the south-east portion, one in the south central portion, and a small group in the west central portion.

Hydrological investigations which have been conducted on the Lease include:

(i) Watershed delineation

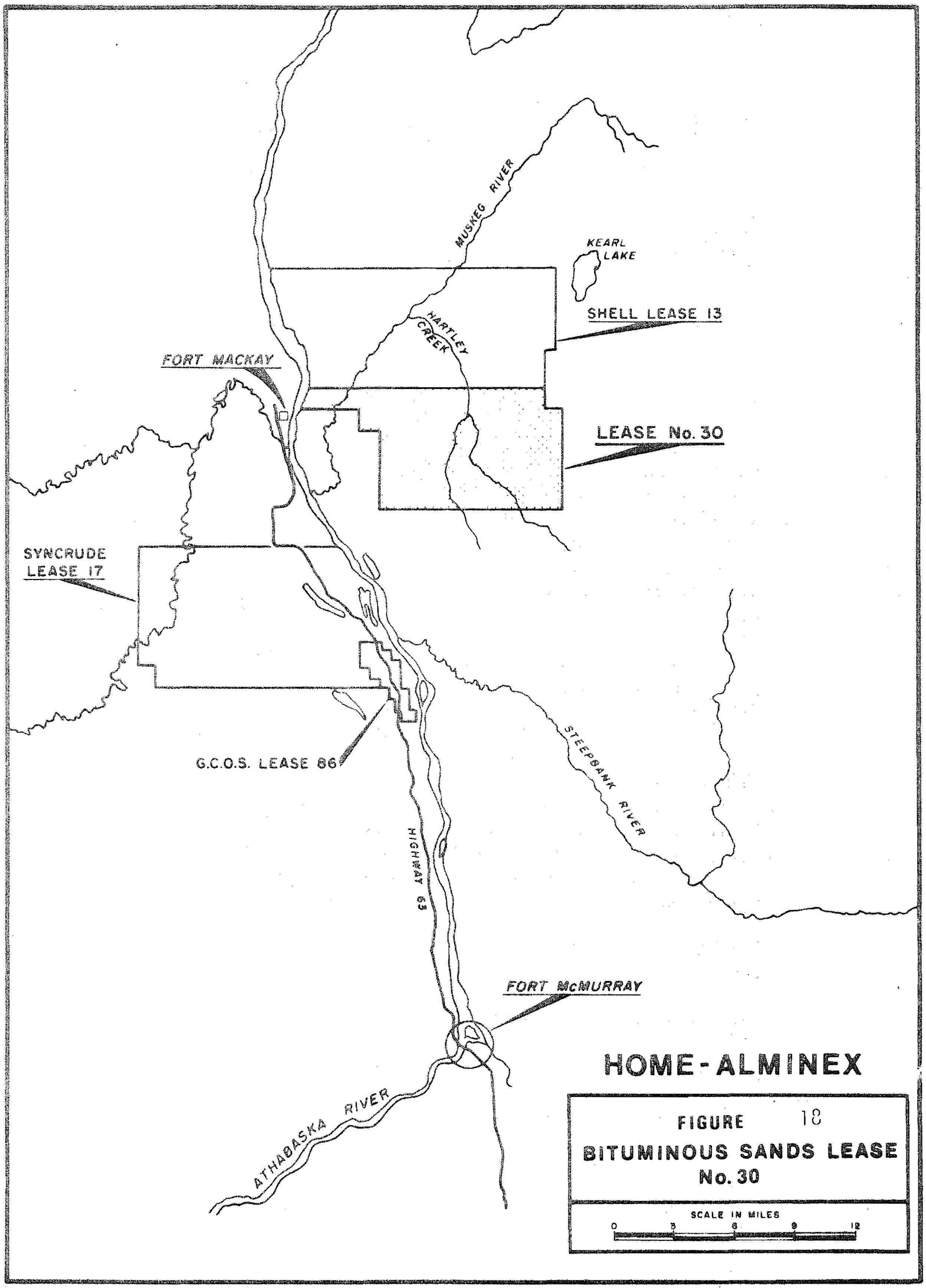
(ii) Existing flow determinations

(iii) Flood flow predictions

(iv) Lake depths

(v) Water chemistry

With respect to the latter, several samples have been taken from the open water system to provide baseline water quality data for


KEARL LAKE
MUSKEG RIVER
SHELL LEASE 13
HARTLEY CREEK
FORT MACKAY
LEASE No. 30
SYNCRUDE LEASE 17
G.C.O.S. LEASE 86
STEEPBANK RIVER
HIGHWAY 63
FORT McMURRAY
ATHABASKA RIVER
HOME-ALMINEX
FIGURE 18
BITUMINOUS SANDS LEASE No. 30
SCALE IN MILES
0
3
6
9
12

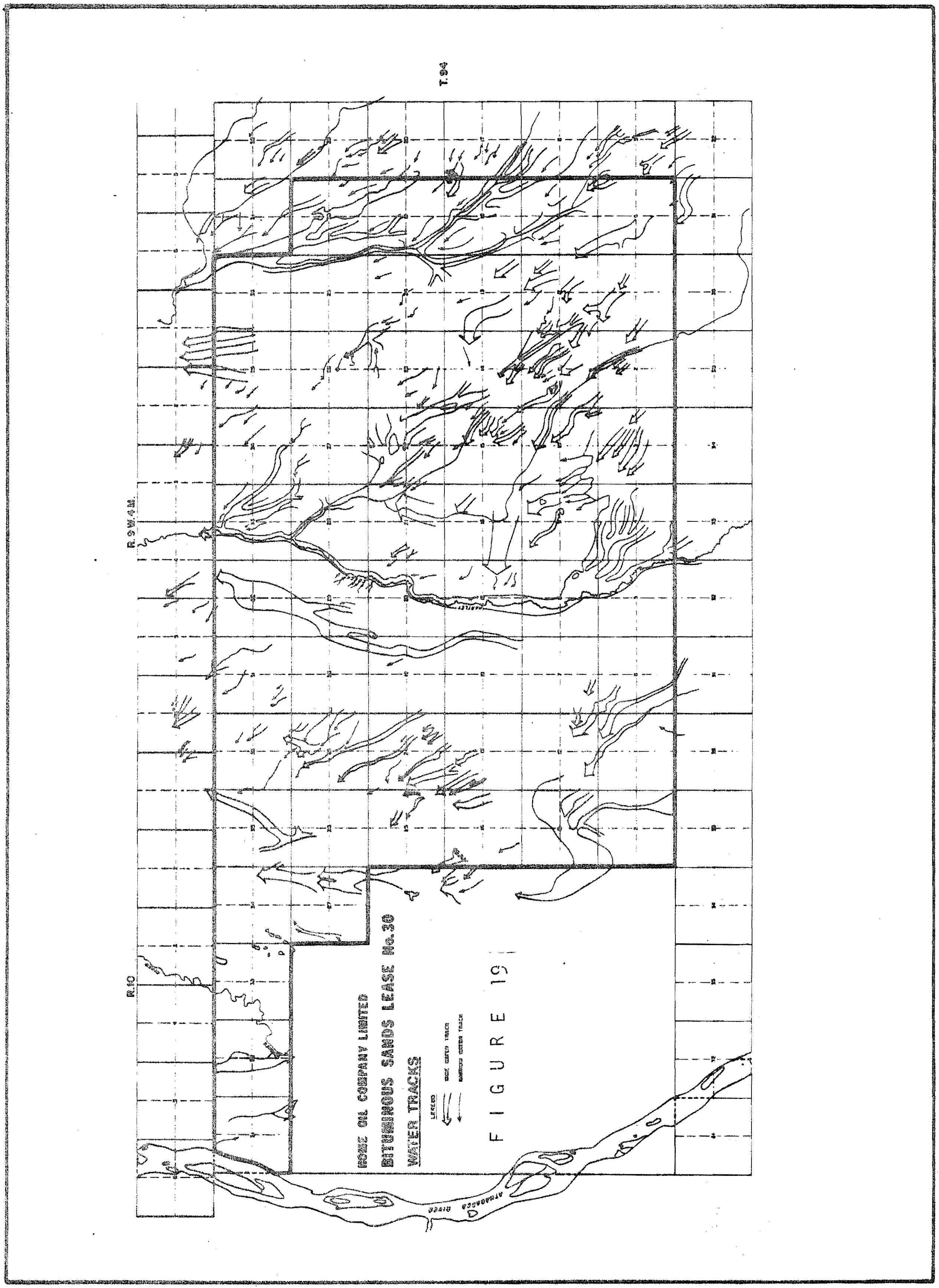

T.94
R.9 W.4 M.
R.10
HOME OIL COMPANY LIMITED
BITUMINOUS SANDS LEASE No. 30
WATER TRACKS
LEGEND
ATHABASCA RIVER

FIGURE 19

future reference. A typical analysis is presented in Table 2. Comparisons with Alberta Surface Water Quality Criteria indicate that some values already exceed the standard, notably phenolics. Table 3 shows the water properties of the Muskeg River leaving the Lease. In this case, the baseline value for pheolics is satisfactory, but the values for iron and mercury are excessive. The occurrence of groundwater is shown schematically in Figure 20. Groundwater occurs:

(i) In the muskeg and permeable beds associated with the glacial tills.

(ii) In the lean or barren sands occurring within the ore-body.

(iii) In the basal water sands.

(iv) In the Devonian limestones.

Data collection has focused on aquifer definition of the overburden and basal aquifers. Aquifer characteristics which have been collected include: transmissibility, storage coefficient, continuity, artesian conditions and water chemistry.

A typical analysis of formation water from the basal sand is presented in Table 4 and is seen to be generally brackish.

The main development implications with respect to Hydrology include:

(I) Diversion of the Hartley Creek

Several miles of the west branch of Hartley Creek are inside the boundary of the mining area. This will necessitate intercepting Hartley Creek upstream of the mining area and diverting it. When the boundaries of the mining areas are confirmed, a series of test holes will be drilled along the proposed route. This will confirm soil conditions for channel design and locate any bedrock obstructions which may cause re-routing. Any rock located could also be used for bank protection.

(II) Drainage of Overburden

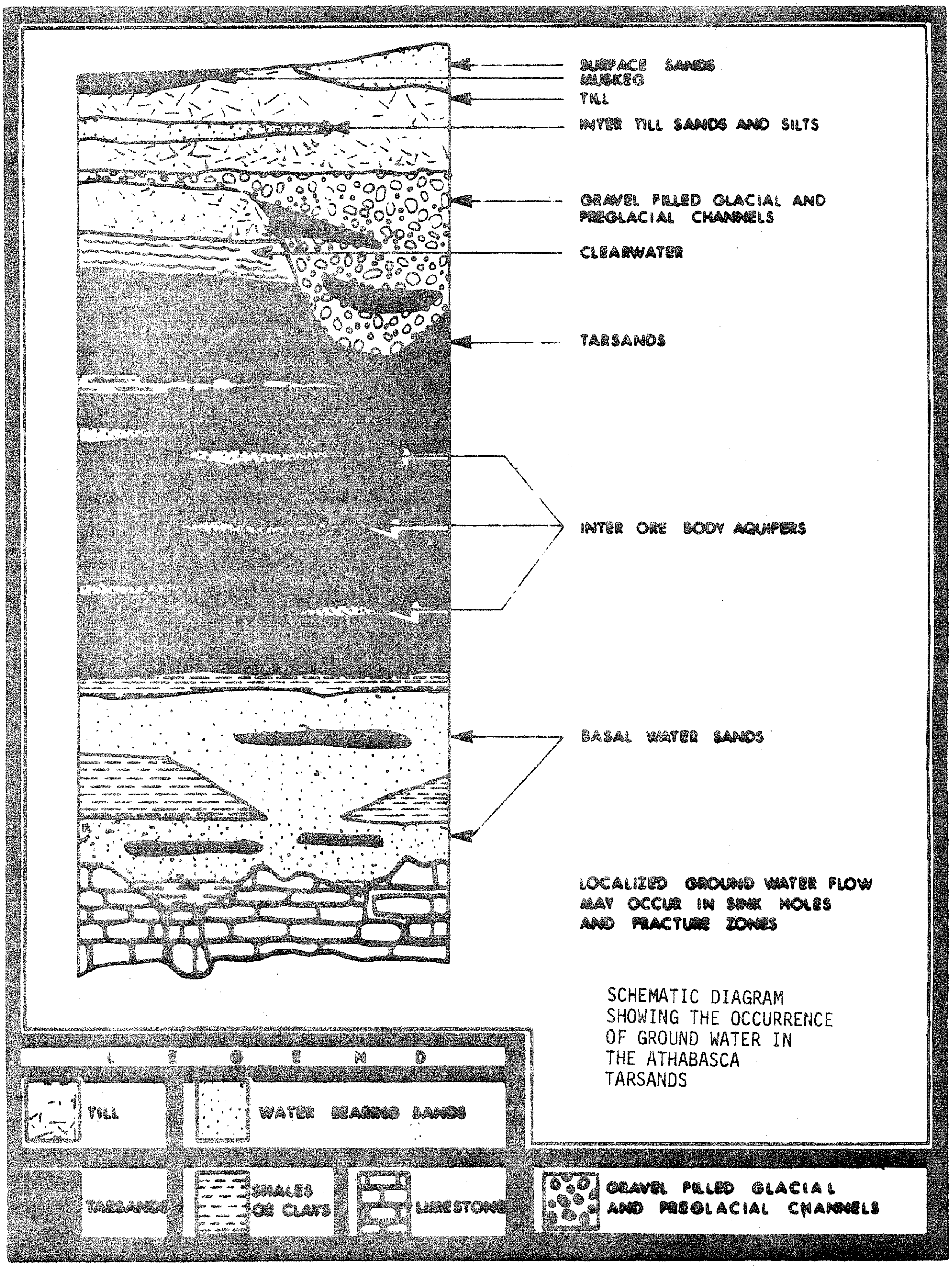
The ground surface has to be drained and cleared of muskeg in order to:

(i) Allow vehicular movement across the Lease.

(ii) Facilitate the construction of the Process Plant.

(iii) Prevent seepage over the mine face.

Dewatering will create cones of depression during the construction and operation phases of the project. It is estimated, however, that the effect of dewatering will be in the order of only hundreds of



SCHEMATIC DIAGRAM
SHOWING THE OCCURRENCE
OF GROUND WATER IN
THE ATHABASCA
TARSANDS

F I G U R E 20

TABLE 2. Water properties of Hartley Creek leaving Lease

Physical Analysis		Elemental Analysis (ppm)	
Dissolved solids, ppm	354	Arsenic	n
pH	7.7	Barium	n
Suspended Solids, mg/l	1.0	Cadmium	n
Temperature, ^{o}C	7.5	Calcium	25
Threshold Odor Number	2	Chromium	0.003
		Cobalt	n
Chemical Analysis (ppm)		Copper	0.01
Ammonia Nitrogen	0.96	Cyanide	0.01
Bicarbonate		Iron	0.01
Biochemical Oxygen Demand	1	Lead	n
Chemical Oxygen Demand	66	Magnesium	10
Chloride		Manganese	n
Dissolved Oxygen		Mercury	n
Nitrate	0.28	Nickel	n
Oils and Greases	2	Potassium	10
Organic Carbon		Selenium	0.5
Phenolics	0.02*	Silver	n
Phosphate	0.005	Sodium	4
Sulphate		Zinc	n
Sulphide	0.01		

Sampled September, 1974
* - Exceeds Alberta Surface Water Quality Criteria
n - Not detected

TABLE 3. Surface water properties Muskeg River leaving Lease (Panhandle area)

Physical Analysis		Elemental Analysis (ppm)	
Dissolved solids	229	Arsenic	<0.010
pH	7.9	Barium	
Suspended Solids	5	Cadmium	<0.005
Temperature ^{o}F	33	Calcium	
Threshold Odor Number	0	Chromium	<0.01
Turbidity	4	Cobalt	<0.01
		Copper	<0.005
Chemical Analysis (ppm)		Cyanide	
Ammonia Nitrogen	< 0.02	Iron	0.88*
Bicarbonate	145	Lead	<0.025
Biochemical Oxygen Demand	< 1	Magnesium	
Chemical Oxygen Demand	52	Manganese	0.05
Chloride	1	Mercury	0.0004*
Dissolved Oxygen	11.8	Nickel	<0.0100
Nitrate	< 0.02	Potassium	2
Oils and Greases	1	Selenium	<0.0050
Organic Carbon	31	Silver	
Phenolics	< 0.002	Sodium	12
Phosphate	< 0.05	Zinc	<0.005
Sulphate	< 1.0		
Sulphide	< 0.05		

Sampled October, 1973

* - Exceeds Alberta Surface Water Quality Criteria

TABLE 4. Water analysis of formation water in basal sands, central area of Lease 30

Determination		ppm
pH	7.48	
Total dissolved solids		6960
Ignition loss		580
Sodium & Potassium (Calc. as Na)		2588
Calcium Ca		59
Magnesium Mg		57
Carbonate CO_3		Nil
Bicarbonate HCO_3		1695
Alkalinity Total as $CaCO_3$		1391
Iron Fe		0.33
Fluoride F		1.00
Nitrate (NO_3)		less than 0.5
Sulphate SO_4		36
Chloride Cl		3250
Total hardness as $CaCO_3$		382

Sampled March, 1975

yards from the dewatering wells or ditches and should not severely disrupt the main elements of the surface water system.

(III) Depressurization of the Basal Water Sands

The basal water sands have to be depressurized to prevent heaving problems in the pit floor and instability in the pit walls. As I mentioned above, the formation water from the basal sands is generally brackish, which gives rise to corrosion and disposal problems. Possible alternatives for disposal include:

(i) Groundwater injection - only feasible if there are suitable formations available.

(ii) Disposal in surface streams - compare volumes to be discharged with contributions from natural salt springs.

(iii) Disposal in impoundment ponds - may not be practical if water from the pond is recycled to the process.

(iv) The use of treatment processes.

(IV) Seepage from Tailings Ponds

Two previous papers discussed this implication and it is sufficient to say, if contaminants enter the groundwater system, they may migrate to surface streams and rivers, thereby affecting water quality.

3. Aquatic Fauna:

Available information on fish consists of reports by Griffiths[3], Lombard North Group Limited[4], Renewable Resources Consulting Services Limited[5], and Canada Land Inventory Fisheries Capability Maps.

These studies were undertaken in various sections of the Muskeg River and Hartley Creek, at various times of the year, using a number of methods of capturing fish. Both the Muskeg River and Hartley Creek on the Lease are low gradient streams. Grayling are locally present in pool areas whereas the lengthy sections of stream, between grayling pockets, support low numbers of white and long-nose suckers.

A study of Benthic Macroinvertebrates has also been carried out by Beak Consultants Limited[6]. A total of 12 samples were collected, six from one site on the Muskeg River and six from one site on Hartley Creek. Muskeg River samples were collected with a power dredge while a Sucker Sampler was used on Hartley. Samples were only identified to the level of the major taxonomic group. Selected samples were identified to the genus or species level. Results of the study suggest that both streams are generally in a healthy undisturbed state.

Issues of particular concern include:

(I) Excessive Sedimentation

Excessive sedimentation could be especially serious since increased sediment load restricts light penetration. This reduces the development of aquatic vegetation, invertebrates, fish eggs and fry. Extreme concentrations of sediment may even kill adult fish.

(II) Introduction of Pollutants:

Although the possibility exists for small accidental spills of pollutants, large scale and long term pollution by toxic chemicals will be avoided by appropriate environmental protection plans. For example, continued monitoring of water quality should allow the preservation of conditions within the limits necessary.

(III) Physical Alteration of Stream Channels

Possible future diversion of Hartley Creek will require considerable care to prevent disruption of downstream spawning and rearing areas. Although we are cognizant of the fact the classical canalization of streams eliminates littoral areas and rooted plants as well as creating great uniformity along the watercourse, the techniques we should use at the present time are not clear.

Culverts and bridges built with regard to the ability of fish to navigate the increased water velocities can present an effective obstacle to fish movement upstream. Fortunately, this problem can be easily overcome through appropriate design of such structures.

(IV) Increased Exploitation of Fish Resources

A difficult problem is created by the tremendous potential increase in pressure on recreational fisheries as a result of human population increases. Stringent restrictions may have to be applied by the appropriate authorities to prevent undue exploitation of this resource. It may be necessary to discourage over-harvesting through mechanisms such as condition-of-employment agreements with employees.

4. Conclusions:

From this brief report of the Home-Alminex Aquatic Studies, it is likely that one of the most significant long-term effects of this oil sands development will be upon the hydrology of the area, which includes both the surface and groundwater regimes.

With respect to aquatic fauna, at one point in time, a value judgement has to be made on the fisheries resources of the Muskeg River and Hartley Creek. For example, should the fish in Hartley Creek be protected and if so, what mitigating procedures should be employed. Do we have enough information to replicate a stream suitable for grayling? If not, how much research is needed.

Finally, in light of the lack of firm guidelines for oil sands development, Home is presently monitoring environmental research conducted by other bodies and the company will tailor its future programs accordingly.

References:

1. Home Oil Company Limited and Alminex Limited, "Application to Energy Resources Conservation Board" (April, 1974).

2. Energy Resources Conservation Board, "In the Matter of an Application of Home Oil Company Limited and Alminex Limited under part 8 of the Oil and Gas Conservation Act", ERCB Report 75-4 (May, 1975).

3. Griffiths, H.E., "Preliminary Fisheries Survey of the Fort McMurray Tar Sands Area", unpublished report to Albert Fish and Wildlife Diversion (1973).

4. Lombard North Group Limited, "Supplementary Ecological Baseline Measurements of Tar Sands Lease C-13", unpublished report prepared for Shell Canada Limited (1973).

5. Renewable Resources Consulting Services Limited, "Fisheries Investigation of the Muskeg River and Hartley Creek, 1974", unpublished report prepared for Shell Canada Limited and Home Oil Company Limited (1974).

6. Beak Consultants Limited, "Macroinvertebrate Survey of the Muskeg River and Hartley Creek", unpublished report prepared for Home Oil Company Limited (1973).

B. McCARTNEY:

We have all heard statements to the effect that Alberta's oil sands deposits are Canada's largest petroleum resource. The major challenge facing us is the economical conversion of this resource into usable energy in an environmentally acceptable way. The state of current technology limits the potential of the oil sands, particularly those that require insitu methods, but technology is not the only barrier to oil sands development. The prime barrier today is economic uncertainty characterized by changing conditions with respect to future capital and operating costs, cost inflation, energy prices, royalty, taxes, and availability of manpower and materials. Commercial feasibility studies indicate that the initial investment required for large-scale oil sands schemes, producing 100 MBPD of upgraded oil, are in the $2 billion plus range and the cost of insitu and mining schemes will be similar. In order for commercial development to proceed, a prospective developer must have confidence in his technology and an opportunity for economic application of hard won technology.

Technology and economics cannot be separated. What appears to be a technological barrier can disappear according to one's perception of economics. The object of any prospective developer is an economically viable, environmentally acceptable project. Environmental protection is an obligation and a cost of oil sand development. Projects will be proposed, assessed, built and operated in accordance with contemporary environmental values. To the extent that these values are clearly defined, environment programs are anticipatory and inseparable from technological and economic concerns. However, as these values change our programs must be reactive.

In order to assess the environmental implications we should first examine the technological barriers to insitu oil sand development. First and foremost is the nature of the resource. The development of any oil sands recovery process demands an understanding of the nature of oil sands and their physical and chemical behaviour.

The oil sands have four key controlling characteristics with respect to insitu recovery.

- The heavy oil or bitumen is too viscous to flow naturally - it lacks any mobility
- The oil saturated sands are essentially impermeable - there is no fluid communication in the reservoir
- Oil sands reservoirs have little or no internal natural drive energy - recovery requires the application of external energy
- The oil sands reservoir is not homogenous - it is a highly variable, unconsolidated heterogenous resource.

An effective insitu recovery scheme must change one or more of these characteristics. Most proposed insitu recovery methods involve increasing oil mobility by heating or adding solvents or emulsification agents. The problem is penetration and intimately contacting this essentially impervious mass in a cost effective way.

A look at a viscosity/temperature chart for heavy oils shows why thermal methods are attractive. A relatively small increase in temperature results in a large decrease in viscosity. Recognizing the effectiveness of heating the oil, the question then is one of getting the heat into the reservoir. This can be accomplished in a number of ways including injection of a hot fluid, such as steam, or by insitu combustion, which involves injecting air and burning part of the bitumen to generate heat. It can be accomplished by insitu explosions (nuclear or conventional) or application of electrical energy or a form of electromagnetic or acoustic radiation directly to the reservoir. The most commonly practiced methods today are steam stimulation, steam displacement, and insitu combustion. There have been a number of field pilot tests of these methods in the oil sands over the past 15 years.

A recovery mechanism based on a solvent can act in two ways. Dissolving the oil in solvent or the solvent in oil for transportation to a producing well results in a very large decrease in viscosity, but the process is diffusion controlled thus very slow. The low initial oil mobility in the native reservoir severely limits the possible contact areas between the solvent and the oil. The high cost of solvents requires large inventory investments and normally requires solvent recovery equipment on site. Solvents can also cause deposition of asphaltenes which plug the reservoir.

Another possible extraction method is to emulsify the oil in a stream of water or fluid in order to move it to the producing well. The flowing fluid would have the same viscosity as the carrier. Two alternates are available: the direct addition of a surfactant or the addition of a surfactant-forming agent such as caustic. The main advantages of this method is the relatively low capital cost for injection equipment and the low fuel requirements. As with all other viscosity-reducing procedures, contact with the oil is a major problem. Most surfactants are expensive and are sensitive to temperature, salinity and other factors. Surfactant forming agents, such as caustic, are less expensive, but can react with clays and cause reservoir plugging. Surface separation of the oil from the emulsion also causes problems.

The idea of adding some secret ingredient "X" and converting or transforming the oil sands into a conventional light oil reservoir system has had tremendous appeal to many researchers, and over the years many suggested secret ingredient "X-s" have been announced. Most have disappeared into history. One must be skeptical of these schemes since they suffer the same basic problem as thermal or solvent methods, - a need to contact the oil to be effective.

Mobility and contacting problems can be alleviated by moving the reservoir to the surface. Two modes of mining have been suggested for application in deep oil sands shaft mining and solution or hydraulic mining. The former involves conventional mining procedures, the latter involves a water jet in a large diameter well-bore to break up the oil sand and carry it to the surface. Shaft mining requires expensive material and equipment with high operating costs; solution or hydraulic mining requires numerous expensive large-diameter wells, a high cost water handling system and very large volumes of water. In both cases, the tar still must be separated from the sand when it is brought to the surface.

Recognizing the nature of the oil sands which I highlighted initially, I believe you can visualize a large number of limitations to the successful application of each of these potential insitu recovery methods. Any process that depends on contacting the oil with some other fluid is limited by problems associated with establishing and maintaining injectivity of the fluid, slow rate of diffusion controlled processes, and fluid and energy losses in the reservoir. In addition, the reservoir is a complex system that responds differently in different places.

There is no doubt in my mind that all the recovery processes discussed will result in some oil production, but how much, for how long, at what rate, under what conditions and at what cost are critical unknowns. Laboratory research, including mathematical and physical model simulations and engineering studies, contribute significantly to the theoretical development of a given insitu recovery process; however, the major technological advances have developed from applying the processes in the field. Real operating problems are then identified and addressed, and key operating results, such as well productivity, well life, oil recovery and operating costs, are defined. This is a long term and costly process, and only prospective processes, primarily thermal methods applied in the better quality oil sands reservoirs, have been the subject of industry testing over the past 15 years. Competing processes cannot be compared without field testing, - and there is no satisfactory way of extending or accelerating one's knowledge without a real-time site specific test. If you want to know how a well will perform in the sixth year, you have to operate it for the first five years. The successful development of any given process in the future will likely require close to 20 years of effort at a cost approaching $100 million per recovery method.

The technological confidence required to proceed to commercial operation requires demonstration and predictability of the recovery process. Critical to success or failure of any recovery technique is the nature of the reservoir in which it is applied.

It is obviously the activity on the surface rather than in the reservoir that has the potential for detrimental impact on the environment. In large scale commercial projects, we may need many thousands of wells with surface impact potentially serious. Surface disruption in an insitu project would be less traumatic than in mining projects, but it may be spread over a larger area. Wells must be accessible year round for servicing, and connected by pipeline systems for recovery medium distribution and collection of oil and well effluents.

In Imperial Oil's pilot operations at Cold Lake, we are minimizing surface disruption by developing a system using clusters of wells drilled from a single location. In our first pilots, the surface area was completely cleared to allow access to the wells. In subsequent pilots that still utilized vertical wells, green areas were left between the well locations so that approximately 35% of the land was disturbed. By using well clusters we have reduced the disrupted area including access roads to less than 10%, which is approaching a conventional oil field operation.

Each large insitu project using steam injection would require a great deal of water (in the order of 500 MBPD). In some locations this amount of water is available from surface water without causing adverse effects; in other locations water will not be available. One key environmental consideration of a steam-based insitu oil recovery process is the feasibility of reusing the produced water for steam generation. We have undertaken experimental and engineering studies on making steam. In this regard, we are also studying the use of saline water directly in boilers. Water treatment itself produces effluent liquids and sludges that must be disposed of so we must be sure that the cure is more acceptable than the illness.

Much more research is required to determine what can be done to reuse water and at what cost. The water produced with insitu oil production is different from the effluent from surface extraction in that it has a very low suspended solids content. We visualize a completely closed water system in which the produced water is separated from the oil; the bulk of it undergoes treatment to remove trace oil, calcium hardness and dissolved silica; then it is used in steam generation. The remaining water, which is mainly waste effluent from the treating process and blowdown from the boilers, is returned to the formation and replaces the oil that was produced.

In summary, the environmental implications of insitu recovery processes are similar to any large energy project. Insitu processes are not a way of avoiding adverse environmental effects. However, we do not see environmental technology and economics forming an inseparable mixture and development will proceed only if and when contemporary values in all these areas are satisfied.

R. SCHUTTE:

I would like to discuss, with the aid of diagrams, what the extraction process is all about. To begin with, the tumbler unit is feed oil sands, sodium hydroxide, steam and water (Figure 21). The reject from the tumbling process, about 2% of the oil sand, goes on to tailings ponds, the mined out site, or some other disposal area. The slurry with floodwater is then fed into an extraction unit from where the middlings go to secondary recovery. The secondary recovery goes through a cleaning stage and that water is immediately recycled. There is no chemical input in froth upgrading. The secondary recovery water joins the primary tailings so that we have a tailings stream that contains roughly 50 weight per cent solids and 50 per cent water. Soluble bitumen content in the tailings is roughly 300 ppm. Soap is also made from bitumen organic acids found on the fine solids, and this compounds our sludge problem further downstream.

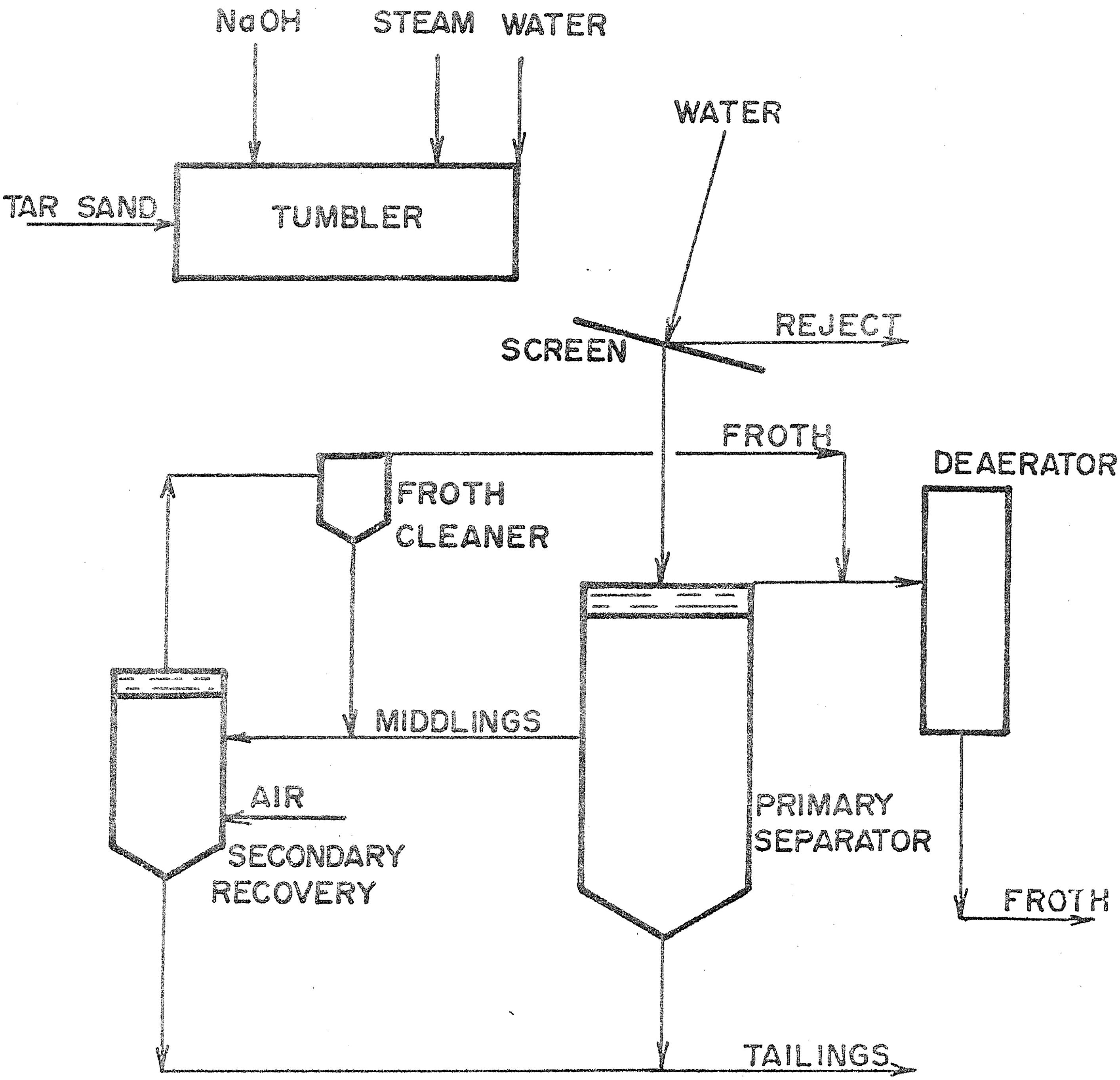
The froth moves on to a froth treatment plant (Figure 22). The scroll centrifuges take the froth, after some dilution with naphtha, and produces a scroll cake, essentially the solids from the froth. The diluted bitumen still contains water and fines and goes through disc centrifuges that are essentially cream separators which spin at about 3,000 rpm and weigh about 3,000 pounds. The water and the fines dilute the cake and are pumped to a tailings pond. There is oil in this stream which is very difficult to recover.

In a discussion of tailings water, tailings stream water quality, and projections of what water will be, you should understand that Syncrude doesn't have a plant, and we don't really know what it is going to be. We are interested in making water quality projections, but first we have to know the quantities of water. One question this morning was, "Can't you measure how much you have?" Unfortunately it is impossible to do a material balance under the tailings pond.

Water from extraction is roughly 67 million cubic meters per year (Figure 23 and 24), and the recycle is about half of that. There is some blowdown from all the other operations that enters the pond as well. Of the tailings pond volume, the free water volume is about 3,800 million cubic feet. At a recyle rate of 1,200, the average residence time in that pond is 3.2 years. This is essential to bring the fines down. With this enormous volume of water there is naturally going to be an enormous dilution of any chemicals you may have with the exception of the sodium hydroxide used in the process because it is used in enormous quantities as well.

The way our mine is laid out, we start mining near Beaver Creek Valley where chloride content is very low (80 ppm. on oil sand). About five years later, there will be 280 ppm. chloride in the oil sands. In the first five years, all the tailings will go to the tailings pond and there will be little recycling. By the end of the plant life, we will have 600 ppm. chloride in the water which will cause corrosion and a number of other problems. However, the plant will develop new methods

EXTRACTION



F I G U R E 21

FROTH TREATMENT

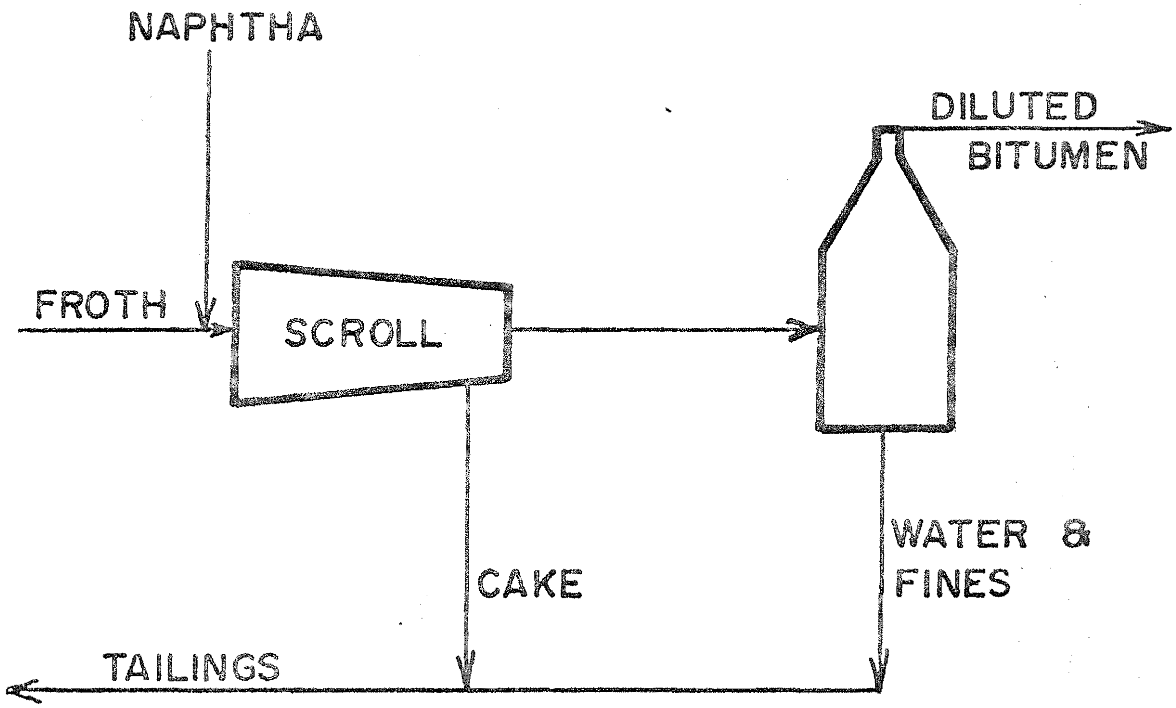
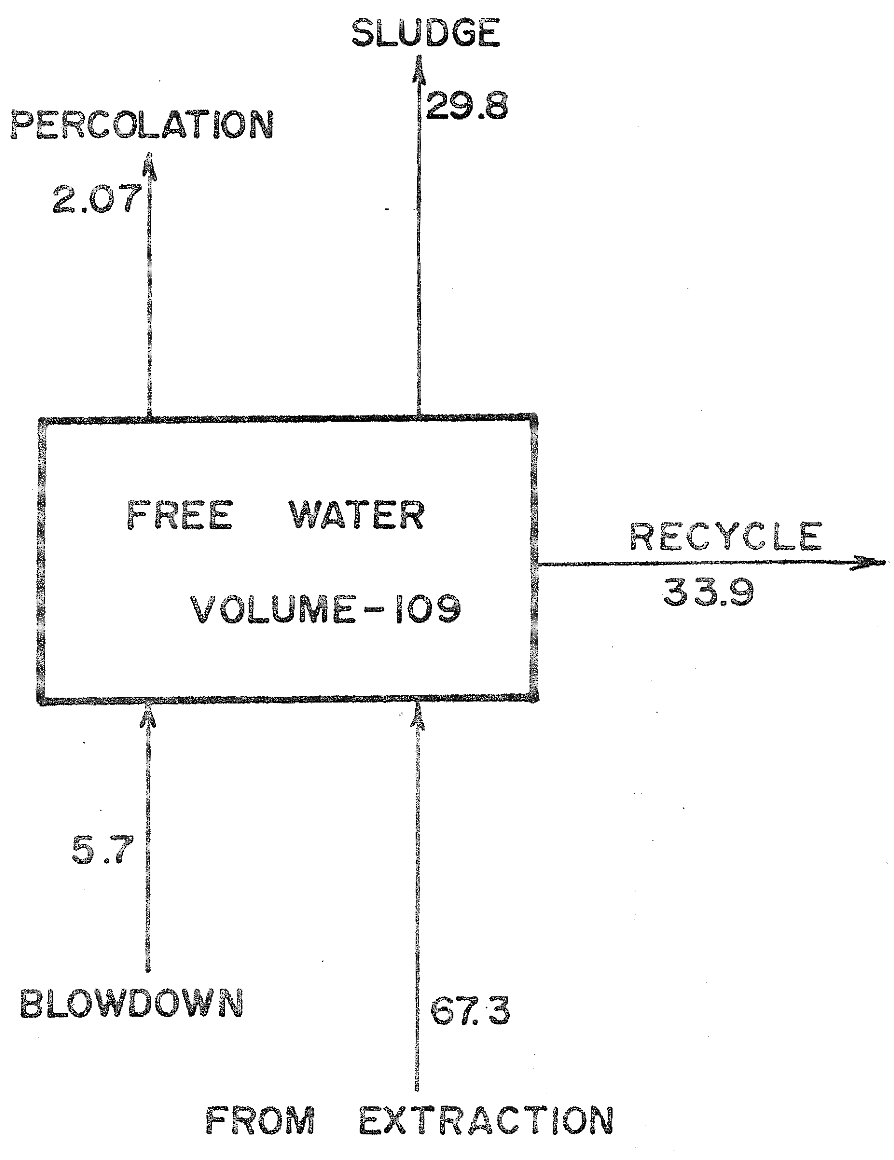


FIGURE 22

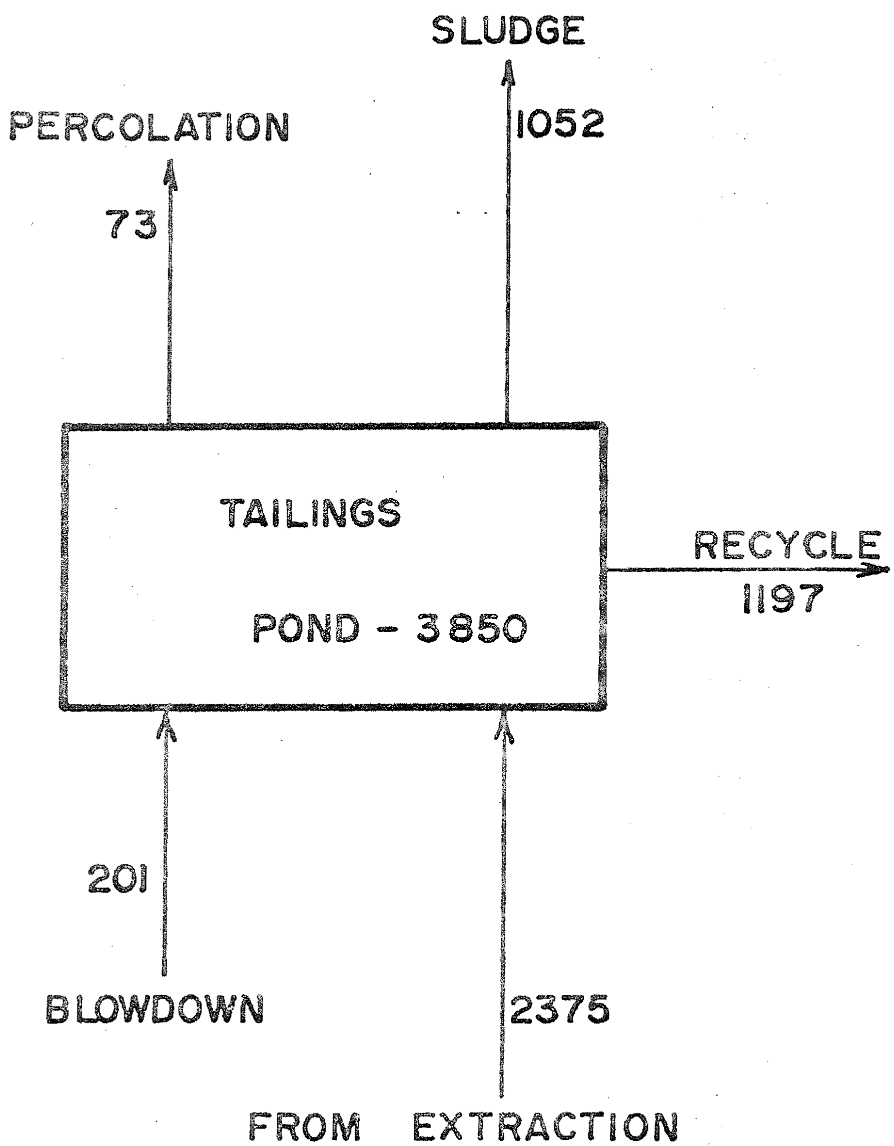
TAILINGS POND-WATER BALANCE



ALL FLOWS IN MILLIONS M^3/YEAR.

FIGURE 23

TAILINGS POND-WATER BALANCE



ALL FLOWS IN 10^6 FT.^{3}/YR.

FIGURE 24

of coping with these problems as development proceeds. If we learn how to use less water, we'll need less recycle water. The chloride may then build up to any level that we may have, but it won't hurt the plant. We are trying to develop a complete mathematical model of the tailings pond in order to give some indication where research should be.

I'd like to show you some of the input that this mathematical model needs. If you want to project what water quality will be in the future, first you need to know how fast you are going to be mining, and when you can put materials back into the mine which is the mine development reclamation plan. Once these are defined, we can construct the model. This is done to get an overall plant water management system, so operating people have some guidance to go by. Most of these things are, of course, ongoing inputs into that program.

Currently, we do have a simplified computer model. A sample of some output from our model is shown on Figure 25. I would like to draw your attention to the projected higher bicarbonate level. Since sodium hydroxide is used, CO_2 will dissolve from the atmosphere. The advantage of the high bicarbonate, is that at a pH of about 8.8 we will have just enough carbonate to precipitate calcium and magnesium, and these will not build up to any significant extent. Phenol is ill-defined because it depends on whether biological action is anticipated in the pond. If there is biological oxidation of 75% of phenol, we'll end up at .5. With no biological oxidation, we'll end up at 3. Naphtha and bitumen don't build up over the years. The biological action in the pond is something that we can't project. The projection is, at the moment, that it will be low, because of lack of nutrients, such as phosphate and nitrogen.

A point I would like to make at this stage, is that I have a feeling that people who are interested in fish life, etc., like to see clean water. From the extraction process point of view, I like to see clean water as well, because there are numerous things that can go wrong without clean water. We are interested in an ionic balance in our water. As a rule of thumb, the highest charged positive ions are the most detrimental. Sodium is okay; calcium, if you don't have too much; ferric, forget it - it can't run. When we deal with negative ions, it is the opposite. Hydroxide and chloride are not too bad, but still the worst of all the negative ions. Sulfate is easier to work with than chloride especially if you have phosphate. In fact, you can use phosphate to improve your process. We are interested in the ionic balance that we can anticipate in year five and year six, in order to know what to do when the time comes.

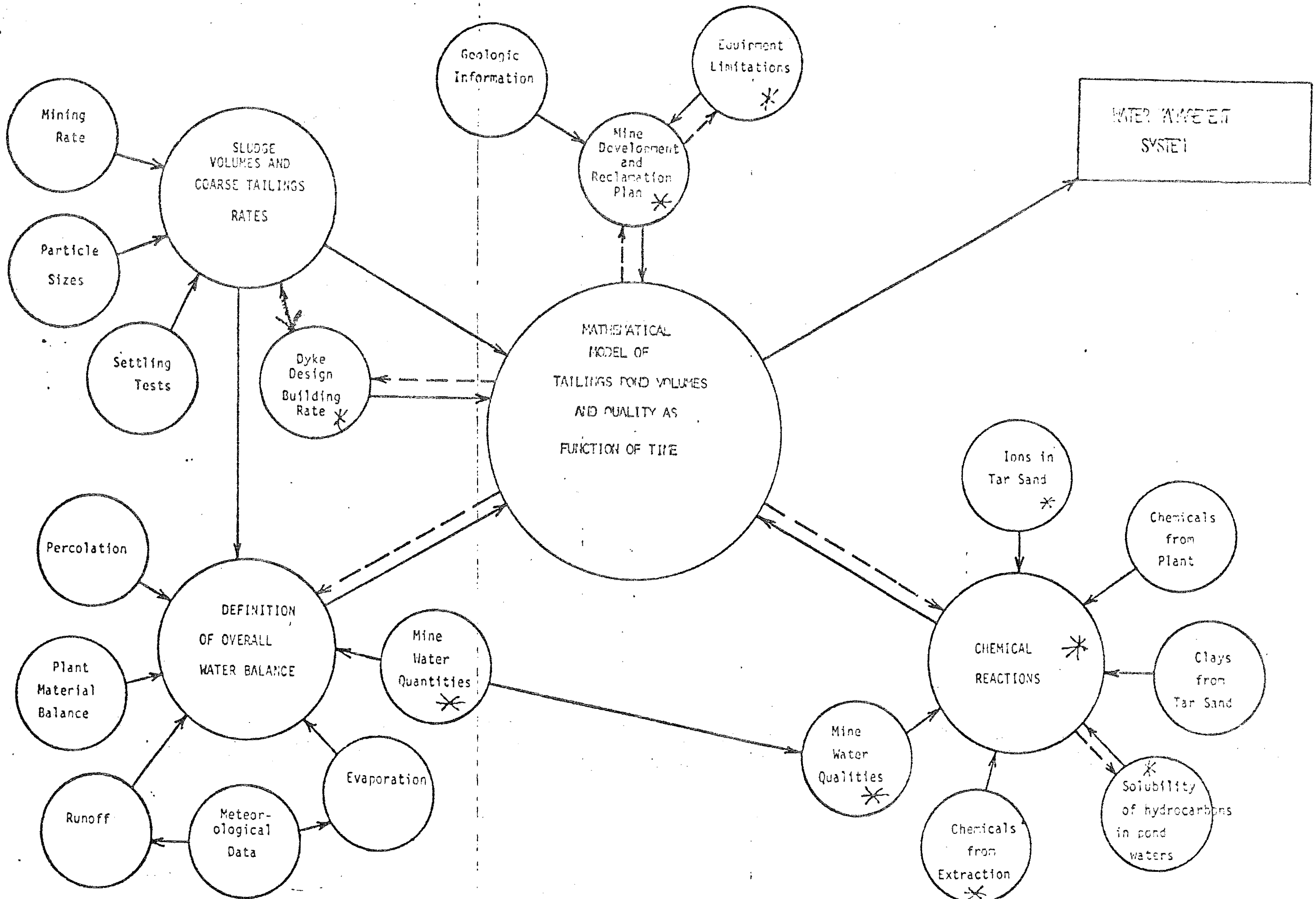

Mining Rate
Particle Sizes
Settling Tests
SLUDGE VOLUMES AND COARSE TAILINGS RATES
Dyke Design Building Rate
Geologic Information
Equipment Limitations
Mine Development and Reclamation Plan
WATER MANAGEMENT SYSTEM
MATHEMATICAL MODEL OF TAILINGS POND VOLUMES AND QUALITY AS FUNCTION OF TIME
Ions in Tar Sand
Chemicals from Plant
Clays from Tar Sand
CHEMICAL REACTIONS
Solubility of hydrocarbons in pond waters
Chemicals from Extraction
Mine Water Qualities
Percolation
DEFINITION OF OVERALL WATER BALANCE
Mine Water Quantities
Plant Material Balance
Runoff
Meteorological Data
Evaporation

FIGURE 25

Table 5. Calculated Chemical Contents of Pond Water per Year 13

	mg/dm^3
Na	700
K	20
Ca	30
Mg	15
Cl	650
SO_4	20
HCO_3	1400
CO_3	70
PO_4	0.5
SiO_2	10
Boron	3
Iron	2
Mn	1
Pb	0.02
Zn	0.02
Phenol	3.0 - 0.5
NH_3	0.5 - 0.3
Naphtha	105
Bitumen	438
pH	8.8

NOTE: A large number of simplifying assumptions were made to arrive at these numbers. Refinement is an ongoing program of the Research Department

Table 6. Process Chemicals

Material	Source	10^6 lb/yr.	10^6 kg/y.	ppm on Tailings Water
NaOH	Bitumen extraction	46.400	22.41	333
NaOH	Hydrotreating catalyst regeneration	2.813	1.28	19.0
K_2CO_3	Loss from CO_2 scrubbers	0.072	0.033	0.49
DEA	Loss from CO_2 scrubbers	0.007	0.0032	0.05
Phenol	Extracted from bitumen	0.111	0.050	0.74
	Diluent recovery overhead condensate	0.041	0.019	0.28
Ammonia	Sour water streams	0.024	0.011	0.16

Table 7. Water Conditioning Chemicals that enter Tailings Pond

Material		10^6 lb/yr	10^6 kg/y	ppm on Tailings Water
$Al_2(SO_4)_3$	Raw water clarifier	0.891	0.404	6.00
$Ca(OH)_2$	Lime softening	2.201	0.998	14.83
Inhibitor	Inhibit cooling tower corrosion	0.108	0.049	0.73
H_2SO_4	pH control of cooling tower	0.846	0.384	5.71
H_2SO_4	Demineralizer regeneration	1.562	0.709	10.53
NaOH	Demineralizer regeneration	0.789	0.358	5.32
Na_2SO_3	Boiler feed conditioning	0.053	0.024	0.36
PO_4	Sewage	0.088	0.040	0.60
EDTA	Boiler feed conditioning	0.001	0.00045	0.007
Anti-foam	Boiler feed conditioning	0.002	0.00091	0.014
Organic sludge conditioner	Boiler feed conditioning	0.001	0.00045	0.007
Polysulfide	Cyanide control	0.508	0.230	3.42

CHLORIDE CONTENT OF POND WATER

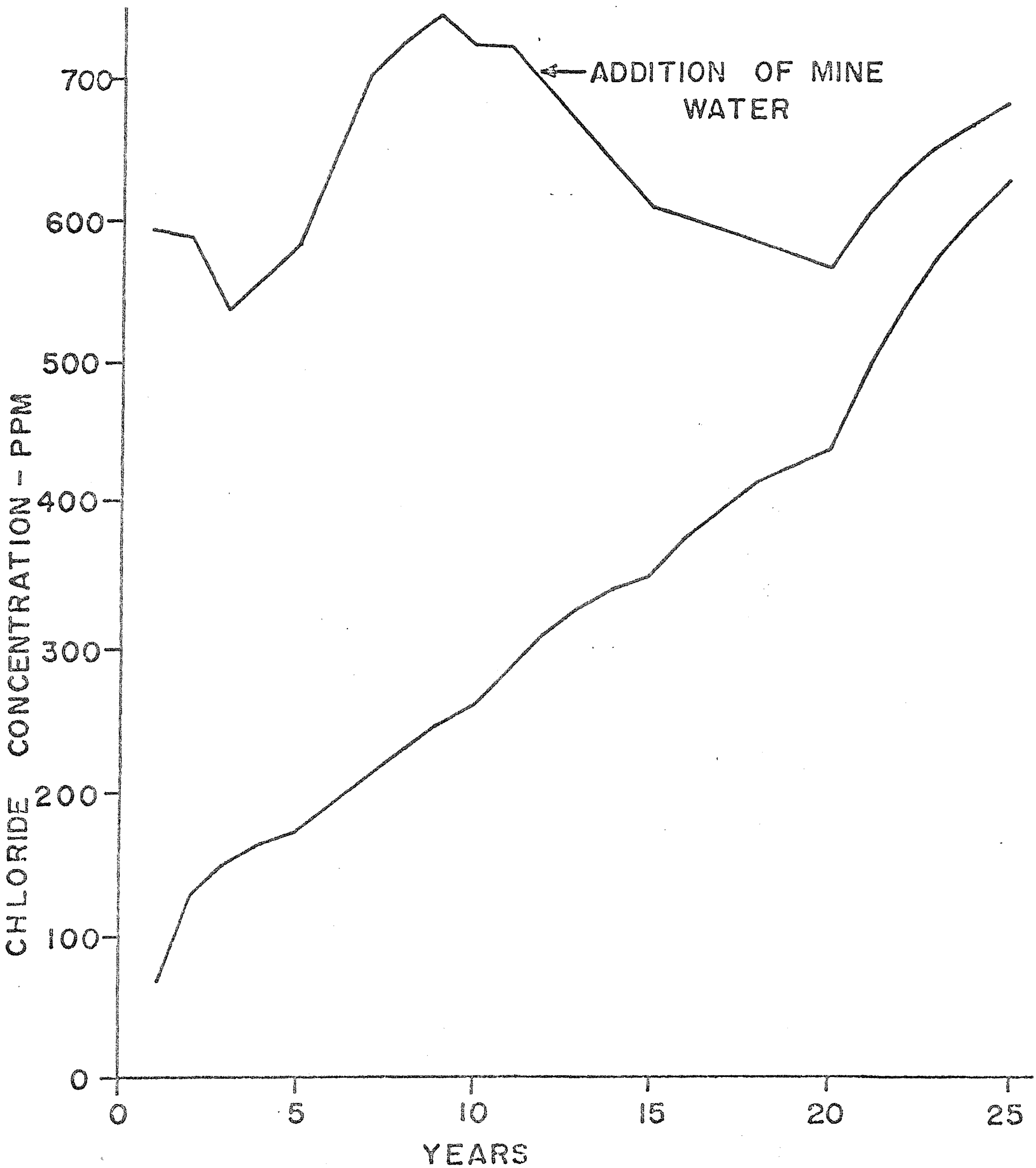


FIGURE 26

M. BIK:

Mr. Chairman, after all the engineering and process dissertations, perhaps somebody should address the environmental aspects of tar sands development, as viewed by an environmentalist working within the industry.

There are a number of points to be made, two of which are very positive. Bearing in mind your prayer for brevity, I will limit myself to two comments in the hyperbole category. First, oil sands mining is tantamount to cleaning up nature's biggest oil spill, and second, mine dewatering, if involving saline water, can be tantamount to putting that water back into the ocean, as long as regulatory permission can be obtained.

There are certain environmental risks associated with oil sands resource extraction developments. The source of these risks resides, in part in the lack of knowledge of the physical environment in which the development is taking place. For example, environmentally acceptable means of disposal for mine water may require considerable investments, if current views regarding the effects of increasing the chloride content of the Athabasca River, by a low number of ppm., are maintained. In the absence of hard information, there is a risk of needless expenditure if subsequent research work were to show that higher chloride levels can be accommodated without attendant adverse effects on biota. Conversely, there would be a risk of failure of environmental protection measures if current views were sustained by biological research, and regulatory limits on mine water disposal left flexible until research work has been completed.

Other risks are associated with the developments themselves. For example, there is a certainty that the release of water vapour from a tailings pond, up-grading complex and mining face will increase the incidence of fog, and ice-fog, in the vicinity of a resource extraction project. The risk lies in the unknown measure of the increase and the attendant extent to which it might affect the operation of the facility. (For the sake of brevity, the micro- and mesoclimatic effects, if any, were not considered.)

Decisions respecting both categories of risk - those associated with environmental hazards to the industrial operations and those associated with industrial hazards to the environment - frequently have to be taken in the absence of adequate information. Syncrude has high expectations of the Oil Sands Environmental Research Program. We expect this Program to provide us with the environmentally limiting design parameters which allow our engineers to create extraction facilities that are environmentally acceptable, as determined by objective scientific analysis of the environment. Too frequently, we see ourselves faced with constraints and limits which are imposed because of a lack of knowledge and understanding of the effects of going beyond them, and not because of certainties respecting adverse effects that will ensue if arbitrarily imposed limits are exceeded. And - equally important and needed - we expect the Oil Sands Environmental Research Program to generate the information regarding environmental hazards to industrial operations, required to improve planning and design. For example, better hydrogeological information permits us to improve the prediction of environmental effects of mine development, and improves the reliability of cost projections for mine development and dewatering.

The resolution of differences of opinion between the oil sands industry, the regulators and the environmental scientists will take time, patience and hard work. Jointly, with the scientists, we have to establish the scientific basis from which a rational consensus between reasonable men can be evolved regarding the critical values of environmental parameters beyond which effluents and emissions from resource extraction have demonstrable adverse environmental effects. In this endeavor, Syncrude is prepared to share its environmental baseline information with the research oriented scientists and other research workers, provided that the common courtesies with respect to ownership of information and review of its use are extended.

Jointly, with other oil sands leaseholders, Syncrude will participate, as a Canadian corporate citizen, in the process of establishment of fair, reasonable and equitable environmental regulation of oil sands resource extraction. The dialogue with the statutory regulatory authorities will, of course, be maintained primarily by the Oil Sands Environmental Study Group, which represents our industry in environmental matters. Syncrude's expectations of the dialogue are the establishment of that optimal combination of social, technical, economic and environmental constraints on oil sands development which best serves the provincial and national need.

The dialogue, of course, can only ensue, when the Oil Sands Environmental Study Program has made considerable progress towards completion of its task. We expect AOSERP to participate as an independent, objective scientific entity in the dialogue with the regulatory agencies, next to industry and other sectors of society. Syncrude can contribute the following answers to the six groups of questions:

The letter of permission issued to Syncrude under the Clean Water Act (Alberta) for the construction of the Mildred Lake Plant, prohibits the disposal of process effluents in the surrounding watershed. Except for intermittent mine water disposal, which is regulated by separate letters of permission, there is no disposal of effluents into the adjoining aquatic environments. Our current estimate of mine water disposal needs is for a maximum volume of circa 2.5 CFS with a maximum chloride content of 4400 ppm. for the coming year. This estimate is considerably lower in volume and chloride content than that used previously. Our current view is that the mine water problem, which received considerable attention from various quarters in the past, is smaller than originally estimated. We have now obtained some operating experience with mine dewatering and are reasonably confident that the dire predictions by certain consultants, which were based more particularly on experience in areas located to the east of the Athabasca River, do not apply to the current Syncrude mining site.

The letter of permission issued pursuant to the Clean Air Act for the construction of the Syncrude project, requires our sulphur recovery units to attain an operating efficiency of 95% for recovery of sulphur from the raw gas delivered to the units. This permit, also imposes a limit of 287 long tons per day on the emission of sulphur dioxide to the atmosphere. Should operational experience be better than the 95% operating efficiency, and should the actual performance of the units more closely approximate the theoretical efficiency limit of 98% sulphur recovery, then the main stack sulphur emissions would be lower than the quoted maximum volume.

The emission rates of vanadium and nickel can not be determined with certainty for the Mildred Lake plant. Actual operating experience has yet to be obtained. We did attempt to arrive at an approximation of these emission rates on the basis of refinery experience in eastern Canada with Venezuelan crudes that have a high vanadium content. On that basis, we estimate that if the total particulate concentration in our stack gas attains 105 ppm., or 294 kg/hr, and sand particulates attain 74 ppm. (kg/hr) and coke particulates 27 ppm. (87 kg/hr), the associated vanadium emission concentration will be 0.082 ppm. (230 grams/hr) and the nickel concentration 0.027 ppm. (75 grams/hr).

Our thinking on land reclamation potential is influenced by society's reclamation objectives. At the present time there does not appear to be a clear consensus on the optimal type of sequential land use for mined-out and reclaimed areas. Our objective, however, is to restore the landscape of the mined-out area to a level of biological productivity that is comparable to that occurring naturally prior to mining. With due regard for the low level of biological productivity of the site prior to mining, this reclamation objective is considered attainable. The original terrain, soil and vegetation conditions can not be restored, and the landscape will be of the man-made variety.

It is Syncrude's intention to rely on natural processes for the maintenance and diversification of the vegetation cover, once reclamation and revegetation work has been completed.

The surface and soil hydrology of the reclaimed and revegetated tailings cells that will be placed in the mined-out area will be different from that which occurred naturally prior to development. In a physiological sense, there will be a drier soil environment, more akin to the edaphic conditions occurring in association with dune sands.

Basing ourselves on the techniques developed by G.C.O.S. and the demonstrated feasibility of their revegetation procedures, it is Syncrude's view that a relatively rapid establishment of a grass cover, possibly with a mixture of shrubs, is attainable on the predominantly gentle slopes that will characterize the landscape of the reclaimed tailings cells. The composition of a forest cover, advocated by some, as well as the wisdom of attempts to establish one by artificial means, is a matter of speculation, at the present time. There might be merit in allowing natural colonization to proceed on a well-prepared growth medium. There is a sufficient number of natural seed sources in the surrounding terrain. Should such a natural process take place indeed, it then stands to reason that various forms of wildlife, naturally associated with the aspen cover that is expected to develop, might migrate into the reclaimed area. In Syncrude's view, one should rely, wherever possible, on the operation of natural processes, and aim reclamation activities at the removal of factors which inhibit their operation. Reclamation should avoid the introduction of yet more disturbance.

Syncrude's environmental strategy consists of a positive and determined attempt to fit in with the natural systems and naturally operating processes, wherever possible.

We recognize the existence of four interfaces between an oil sands development project and the natural environment: air, surface water, groundwater and land. The environmental effects of a project are determined by the measure of success achieved in the separation of the natural systems from the industrial development.

The man-made and man-controlled industrial processes which, if allowed to operate on nature's side of some agreed to physical location of these interfaces, and, if affecting the natural ecosystems adversely, are and should be the prime candidates for environmentally protective measures. Where are these interfaces located physically, in the case of the Mildred Lake Plant?

The land interface is delimited by that area where the actual surface disturbance is, or will be occurring: the mine, the upgrading plant, the tailings pond, the Beaver Creek diversion scheme and the construction of all the associated necessary facilities. Part of the activities across this interface involve the complete and permanent destruction of the existing natural environment; another part, the temporary, although long term disturbance of the land surface, after use, is available for other uses or can be allowed to return to the pre-existing wilderness state. The land interface involves the greatest disturbance, yet offers the least opportunity for environmentally protective measures. This is the environmental price that we must pay if we want to have the benefit of the resources. Environmental protection here has restoration, wherever possible, as its objective.

With the exception of temporary disposal of mine water, there are no flows from the project side of the surface water interface. The intake of a volume of water, not exceeding circa 1% of the content of the Athabasca River during its low flow condition is the only stream crossing this interface from nature's side. Diversion of Beaver Creek and the construction of run-off interceptor ditches should be seen as measures aimed at separating nature from the project along predetermined lines. These measures are definite disturbances of the margins of the surrounding ecosystems, implemented to reduce or eliminate environmental hazards to the project, and project hazards to the environment.

The interface with the subsurface aquatic environment is demarcated by the extent of the drawdown that will occur in association with the mine dewatering, and the rearrangements of flows that might occur as a result; moreover, there is considerable speculation as to what the effect of tailings disposal and more particularly the water associated with those tailings, might be. In our current estimate, there might be some initial seepage through relatively thin occurrences of Pleistocene overlying the impermeable oil sands. The self-puddling effect of seepage loaded with fines, however, is expected to reduce the seepage rates to values approximating zero in circa two years.

The near-surface groundwater flow through the overburden and more particularly the Pleistocene deposits, insofar as occurring on the plant site itself, has been segregated from external events by the construction, now almost completed, of the drainage interception ditches. Any flow of surface run-off from disturbed land is directed to reception systems on the plant site itself. Any flow derived from surface run-off from undisturbed areas outside the plant perimeter is intercepted by ditches and guided towards natural water systems.

The interface with the atmospheric environment is crossed by water vapour emissions from the surface of the tailings pond and possibly from the mine as well as from various points in the actual extraction and upgrading complex. Our central stack will emit, next to SO_2, an estimated 4 cubic ft. per second of NO, under normal operating conditions, next to CO_2, N_2, O_2 and water vapour.

This review leads to the conclusion that with respect to the emission of contaminants directly or indirectly to the aquatic environment, the only two areas of concern might be the unknown effects of SO_2 in the aquatic environment and the unknown, although estimated to be minor, amount of seepage that may reach the aquatic environment from a small sector of the tailings pond dike, where it crosses Beaver Creek. In that area, however, the core of the tailings pond dike will consist of a starter dike constructed of fill of lower permeability than expected to be experienced with tailings sand prior to the onset of the self-puddling effect. The grave concern expressed by some with respect to the impact on the surrounding aquatic environment of the Syncrude Mildred Lake Plant is largely unfounded.

With respect to accidental occurrences, such as the failure of the tailings pond dike, one must place confidence in the expertise of the geotechnical and the engineering professions. Whenever hydro-electric dam schemes become a subject of public controversy, the debate centers on the environmental effects of interrupted water flows, and of the clearing upstream from the dam in combination with fluctuating water levels, and adverse effects on fish migration and life cycles. Failure of such a dam never appears to become a subject for public debate. It seems to me, if the same measure of expertise and the same safety factors are applied to the design of the tailings pond dike of the Mildred Lake Plant as used for hydro-electric dam construction, that the probability of a disastrous event might be considered to be low. Although we agree with the aquatic environmentalist that the seriousness of such an event could be very high, depending on the location and volumes involved, I suggest to you that a multiplication of a low probability with a high seriousness, would lead to the conclusion that the threat and the deserved measure of concern and debate is, and ought to be, low. Provided adequate safety factors are incorporated in the design, we should accept the risk and leave it at that.

Syncrude's current level of expenditure on environmental subject matters is in the order of one million dollars per year. This number refers to expenditure on investigation of the environment itself. Within the research department, ten positions are now entirely dedicated to environmental subject matters. Our environmental field laboratory at Ft. McMurray employs six technicians. The environmental component of the Mildred Lake Plant operations laboratory will employ nine technicians and a supervisor. Concurrent with the expansion of the Operations Department in preparation for the completion of construction of the Mildred Lake Plant, a conservation group is now being assembled. The conservation group will contain the type of environmental protection group that is commonly associated with a refinery operation. Next to that, there will be a reclamation group, whose sole concern is reclamation and revegetation of mined-out areas, as well as revegetation of the very substantial amount of tailings pond dike that will be constructed for the Mildred Lake Plant. Both the Director of Research and Environmental Affairs, and the Director of Conservation report directly to a corporate Vice-President.

For a number of years Syncrude has monitored the sediment content of Beaver Creek and Poplar Creek, both of which are tributaries of the Athabasca River. We do not have information however, on the movement of sediment from land into existing water courses. With the exception of some occurrences that were clearly associated with disturbance due to construction, we assume that the variable sediment load in both tributaries is the result of the operation of natural processes. During 1975, a sedimentation pond was constructed on Beaver Creek to trap sediment that otherwise would have entered the Athabasca River as a result of construction activities.

We have no information available at the present time on the impact of changes in the groundwater table insofar as it might affect tributary streams. Starting this winter, we will be developing the network of observation wells, that, by permit condition, we are expected to put into place, to monitor flow as well as quality of groundwater around the tailings pond prior to, during, and after construction.

I would now like to address myself briefly to Syncrude's expectations of the Oil Sands Environmental Research Program, and more particularly to the program of the Aquatic Fauna Technical Committee.

We expect you to provide us with the environmental limits to industrial development. Perhaps I could illustrate this with an example, and I would like to take the somewhat controversial surface disposal of mine water to make my point. Since September of 1972, Syncrude has taken samples of Poplar Creek near the culvert passing under Highway 63. During three consecutive winters we observed a substantial surge in dissolved solids content in this creek. Summer levels are in the order of 250 to 300 ppm. Levels at the end of the winter may go as high as 2200 ppm. In March 1973 we measured approximately 1800, in March 1974 approximately 900, in March 1975 approximately 2200 ppm. The attendant maximum chloride levels were: in March 1973, approximately 750 ppm; in March 1974, 250 ppm; in March 1975, approximately 1150 ppm.

In 1974, Syncrude initiated a program of baseline inventory studies of the aquatic environment on Ruth Lake and Poplar Creek with some associated work on the upper reaches of Beaver Creek. The purpose here was to create a case history, recording the quality of the aquatic environment prior to, as well as after, the diversion of Beaver Creek. On the basis of 1974 work, the consultant which executes this study for Syncrude reported that the benthos population found in this stream attains densities similar to those reported for other streams in the province.

It appears reasonable to assume that the sources of the chloride in the Poplar Creek are similar to those that give us the elevated salinity levels in the mine water pumped from the mining area of the Mildred Lake Plant. The high salinity levels associated with low flow conditions in Poplar Creek, apparently occurring every winter, do not prevent the thriving of the benthos population during the other seasons. My question to you, is whether it is a fair statement to say that there is an indication here, in nature, that perhaps substantial volumes of saline water could be disposed of via natural water systems without damage or even disturbance to biological processes and biota, provided the discharge is made at times when biological productivity is not adversely affected. This is a very broad question, and much work needs to be done to define the environmentally acceptable levels precisely.

We would be disappointed if the Oil Sands Environmental Research Program would limit itself to simply describing the natural conditions. We expect it to go well beyond that. For example, limiting myself to industrial effluents for the moment, would it be possible to establish four ranges of effects for industrial effluents, were those to be placed in the natural streams and lakes? The ranges I am thinking of are:

1. No effect,

2. Disturbance; effects do not last beyond the period of disturbance,

3. Damage; the effects persist beyond the period in which effluents are placed in natural water bodies,

4. Destruction; effluents, placed in natural water bodies, initiate a chain of events which leads to a permanent change either in the quality of the aquatic ecosystems or in the biota which occupy those ecosystems; this change is irreversible.

Another area of concern, that I should like to bring to your attention, is the need we see for objective determination of the current fish content of the various water bodies in the general area of the oil sands development. In the past, because of a lack of appropriate information, we were forced to proceed with the development of our plans in a climate where all attention was focused on the effects that the Mildred Lake Project would have on one particular stream. Thus far, nobody is in a position to place that effect in the context of the potential productivity currently available in the aquatic environments of the oil sands. As such, neither you, nor we, nor the regulatory agencies, are able to make a quantitative judgement of the actual effect of the diversion of Beaver Creek on the biological productivity of the watersheds associated with the Athabasca River in this area. In the absence of hard information, the environmentalist of course, is inclined to lean conservatively and oppose such a diversion. He seems less concerned about the economic consequences on a provincial or national scale that result from that view. The resolution of such disagreements, on the basis of considered judgements and in the absence of hard information, leaves all participants in the discussion with rather dissatisfied feelings. It is disappointing indeed, to note that since the dialogue between the environmentalist, government and industry, ensued in earnest in, say, 1968, so little apparent progress has been made with the resolution of issues by consensus. The discussion, often heated and controversial, appears to be moving over the same ground. We hope that the Oil Sands Environmental Research Program will prove to be a turning point. Solid, long-term planning, adherence to that plan, recognition and acceptance of the role of the scientist as part of a team that also comprises industry and government, a willingness to cooperate and collaborate rather than confront, and the determination to work towards the establishment of a rational consensus between reasonable men, are essential prerequisites for success.

APPENDIX A

Qualitative Indications of Biological Productivity - Poplar Creek

Poplar Creek is a small, brownwater stream tributary to the Athabasca River. It contains a benthic fauna also found in other clean streams, and some resident fish populations which apparently reproduce in the stream. 1974 baseline study results are:

1. Temperature ranged from 0° C to 20° D during the study, and oxygen concentrations ranged between 8.0 and 11 ppm. Snow depths were great in March (60 - 70 cm) when ice thickness was small (8 - 30 cm).

   Much of the stream bottom contains oil sand, a result of erosion by and deposition in the stream.

   Total dissolved solids and chloride levels are highest in winter and chloride levels are similar to those of Beaver Creek which receives a saline effluent. The pH levels are about 8.0.

2. A total of 69 taxa were identified in benthic samples from Poplar Creek. Numbers were lowest in May (less than 20/2 $ft.^2$), similar in March and June (150/2 $ft.^2$), and rose to about 250/2 $ft.^2$ in August - September at the stations with rubble substrates. Above the spillway, low populations of about 30/2 $ft.^2$ were found. Such levels are similar to those reported for other streams in the province. Below the spillway, mayflies, stoneflies and/or caddis flies dominate except during May, when *Empididae* dominated the low populations. Above the spillway, *Chironomidae* were most important, numerically. Diversities were similar at all stations, being about 2.75 in March, somewhat lower in June - July, and rising to about 3.0 in August - September.

3. The surveyed segment of Poplar Creek can be divided into a 4.25 km lower section having a lower gradient (0.3%), a mean width of 5.9 m, a mean depth of circa 0.7 m, a low proportion of riffles (12%), and a sand/silt substrate, and a 1.42 km upper section with a higher gradient (0.5%), a mean width of 5.4 m, a lower mean depth of circa 0.6 m, a higher proportion of riffles (38%), and a gravel-sand/silt substrate.

   Fish collections indicate a resident, reproducing population of some grayling in the upper section, and probably of white suckers throughout. Some pike occur in the lower section.

	Dissolved solids	Suspended solids	Dissolved oxygen	C.O.D.	B.O.D.	Conductivity	Chloride	Sodium	Oil & Grease	Phenol
Sep 30/72	531	3.2	--	--	9	--	126.0	110	0.4	--
Nov 29/72	--	--	--	34.4	--	--	85.0	--	--	0.003
Mar 6/73	1778	2.4	--	52.0	3	--	747.0	554	2.4	0.008
May 25/73	254	11.0	7.5	72.0	16	--	--	--	0.4	0.003
Jul 4/73	268	20.4	6.4	37.9	7	--	10.5	--	2.8	0.002
Sep 21/73	384	2.3	--	77.7	70	--	56.0	57	0.5	0.004
Nov 21/73	352	4.8	--	90.2	17	--	51.0	--	<0.2	<0.002
Jan 19/74	828	9.8	10.5	33.0	12	1320	232.0	181	0.2	<0.002
Mar /74	899	--	--	53.1	4	1270	257.0	--	3.9	0.003
Jun 19/74	--	--	13.0	172.2	4	--	32.0	--	0.4	<0.002
Jul 24/74	293	20.0	8.5	75.7	2	370	41.0	5.9	2.9	<0.002
Sep 17/74	319	32.0	9.8	145.6	4	421	73.0	55.0	1.0	0.005
Oct 28/74	245	14.0	10.0	70.0	33	305	11.0	11.0	4.4	0.013
Dec 9/74	517	6.7	9.4	167.5	5	556	210.0	96.0	2.8	0.014
Jan 20/75	1013	20.7	11.0	82.5	4	1443	425	335.0	2.4	0.018
Mar 3/75	2229	12.7	11.0	109.1	<4	2399	1150.0	540.0	2.7	0.030

.............The above samples were taken upstream from Highway 63 Culvert.............................

	Dissolved solids	Suspended solids	Dissolved oxygen	C.O.D.	B.O.D.	Conductivity	Chloride	Sodium	Oil & Grease	Phenol
Apr 14/75	310	26.0	11.0	94.5	2	326	66.0	46.0	7.5	0.014
May 26/75	174	123.0	10.5	53.6	10	166	8.7	21.0	3.3	0.007
Jul 7/75	274	12.0	7.5	50.9	2	301	23.7	36.0	0.8	0.009

.............The above three samples were taken c.500 yards upstream from Highway 60 Culvert............

TABLE 8. Lower Poplar Creek--Relevant Water Quality Data.

SUMMARY

DR. WALLACE:

Gordon Hodgson is going to present a summary of the issues and problems that we have discussed today.

G. HODGSON:

I am not going to read from a prepared script, but rather discuss some of the issues that have been raised. Just a historical note, ... I remember walking down the main street of Ft. McMurray when there was only one street, 32 years ago, when K. Clark was stopped by the local postmaster, who was also the local druggist, and the question then, was "When, now when, are we going to get a plant here?" This was 32 years ago. It's interesting to see the process that was in hand at that time, being displayed here today. One of the major changes that has taken place over that period of time is that now we can talk, not about $200 million worth of investment, but about $2 billion worth of investment per plant. That is a real slap in the eye to the technologists who have been working in those 32 years.

I was sitting here today trying to make a series of notes of what was not being said. For a moment, and you will forgive me for saying this, I thought I was getting a numerical snow job from some of my engineering friends. We seemed to be missing the objective of the meeting. We were discussing things that didn't pertain to the Aquatic Fauna Committee, as I understood it to be. Unfortunately, during this meeting we have tended to let ourselves fall into the classical conflicts between environmentalists and industry rather than keep to our common interests. Surely, we all have a common objective or common problem, of meeting the energy supplies, while maintaining environmental preservation.

One issue that I didn't see addressed was, the leakage of trace metals into the environment. Dr. Bik dealt with this issue but perhaps he missed discussing "What is the effect of trace metals on the environment?", although he did say that we must have a real situation, and test it there. This is true; trace elements can go up the stack or leak out of the plant, but they are not necessarily hazardous for having done so. It is necessary to have a real life testing situation. The atmospheric fallout of sulphur dioxide and SO_3, was dealt with rather rapidly. There is some information on acid rain, but this is something I am sure the Aquatic Fauna Committee is aware of and plans to deal with. There was no discussion of the impact of these developments on the Peace-Athabasca Delta. Perhaps there were implied statements but it wasn't brought out with any great degree of clarity.

The discussion on land and stream reclamation allowed us to touch upon micro-meteorology and the effect of changes in the micro-meteorological conditions on aquatic life. A discussion of reclamation also leads us into the problem of defining the social values that are involved with development yet no one has defined the objectives of the Aquatic Fauna Committee. Is it here to protect the environment? Is it here to protect the water quality as defined by a hydrology engineer? Is it here to protect the social system? Is it here to protect the native community, part of the social system? You can define the objectives in terms of bacteria, invertebrates and the fisheries resources, but that will ultimately involve the native communities, and their dependence, in some instances, on the aquatic resources, such as commercial fishing.

Another issue discussed today is the particularly deadening realization that there is very little that we can do about developing innovation in the production systems that we are speaking about. This is determined by the overall economics of the entire issue, the scale and the financing demands that are integral in the whole operation. One would want to say a tailings pond of 12 square miles can't be tolerated. We could, therefore, move toward changing the system in order to avoid that degree of alienation of that land, but as was pointed out earlier, the scope for that kind of innovation is very limited at this time. In order to finance a project of that magnitude right now, your engineering plans must be firm, and time is not available to build a holding system and prove it to the extent that the owners of the money will be convinced that it is a sound approach.

So, you have a number of ideas that you would like to apply to this process. You would like to eliminate some water, and you would like to have a hard shell around the whole process so there's no leakage, and you must have it remain as a simple system, that is the basic design criterion. We can go to the extent of saying, "What can we do with 12 square miles of dirty water?". We can contour it, make it a natural shape, design picnic grounds all around it, build a marina on the side of it, stock it with fish, or can we? How far are we from the stage where it is not an eyesore, but an attraction? These are some of the things that I am sure that this Committee would be interested in following up on.

Of course, the ultimate objective is to reach a situation where we develop rational operating standards, which was discussed today. Operating standards are the only hard reference points that the engineering community can work on. Well, how do we really define these standards? I think that it is up to the AOSERP group to see that the standards are developed, redeveloped and redefined in a realistic way. I am not suggesting that the present ones are unrealistic, but we should develop a system that is much more sensitive to the demands that are laid upon it.

GENERAL DISCUSSION

CARY: I have a few points to raise on the sludge problem. GCOS and its parent company, Sun Oil Limited, have left no known avenues unexplored to find a solution since the magnitude of the problem was discovered during field testing in a period of 1966. Approximately $1.5 million and 50 man years have been spent by our own people and our consultants working with us. We have also been very generous in shipping out samples to those interested in trying to solve it. The amount of time and money spent by the 60 odd interested manufacturers, institutions, inventors, entrepreneurs, etc. is impossible to estimate. When a given possible solution arises, we address ourselves to three separate but independent questions:

(a) Does the idea work, that is, is it feasible and will it solve the real problem?

(b) What does it cost; the total must be within the total resources of the project.

(c) How can it be implemented in our particular situation?

Three strategies or solutions of the problem are possible. The input of water to the hot water extraction process might be reduced so that the fines and water will be stored and locked up in the sand. The present hot water process will not perform efficiently under these conditions, and therefore some later modifications are required. Our efforts have been concentrated on removal of the water from the sludge to obtain a low concentration of solid material. A third strategy is return of the sludge to the environment. This alternative is not desirable, but it may be necessary after appropriate treatment, as a final solution.

HYNES: My concern, as a stream biologist, is that sludge is remaining in a potentially available form, and this is dangerous. I appreciate the problem, but fine silt is known to do an immense amount of damage to the aquatic environment, and this is one of the threats that hangs over the running water environment. It sits there almost indefinitely, if you don't have a good mechanism for getting the sludge down.

CARY: I agree one hundred per cent, but as of this time, we have no solution.

PAHL: Has any projection been made with respect to the long-term maintenance required on the finished dike, and what are the prospects 50 years, 100 years down the road with respect to that essential working system? Will it ever dry up? Will it ever become load-bearing, given present knowledge about the dike?

CARY: As far as revegetating the outside of the dike is concerned, we are still in the learning process. We need to create a self-sustaining ecology on those dikes. At the moment, we have cut grass and a few trees, and this is obviously not self-sustaining. We have had problems, for example with mice proliferating there. What the final lease will look like, is difficult to predict. It will probably result in, if we don't solve the sludge problem, one large tailings pond or several large tailings pond if we go away from the river. We are committed to filling in the present tailings pond alongside the river.

PAHL: Will they require maintenance, in your terms of operation, or will they be self-sustaining? This would imply that there is no maintenance required.

CARY: No maintenance required ... that is right.

HATFIELD: In my readings about the oil sand development, there is frequent reference to the 10% use of the Athabasca River at its minimum monthly flow, and I presume that is whenever the maximum number of plants are in operation. Then this figure is qualified by introducing the maximum recycling of the water. What relationship is there between the total amounts of water used and the ability to recycle the water? If your technology doesn't improve your recycling amounts, how much would this add to your total water use?

SCHUTTE: In the first three years our plant will use about 1% of the lowest recorded river flow, and if there were 10 operating plants, the figure would be 10%. Theoretically, all plants won't operate at the same time, and I would say that even 10 operating plants would never use more than 5% of minimum flow. Bill Cary mentioned that if the amount of water used in the hot water process could be reduced, so that all the water going into the tailings is just the water that stays in the process stages, we would all be in better shape. The sludge pond would be drastically reduced. Unfortunately, it can't be done at the present time.

HATFIELD: You are assuming that with technology you would be able to recycle at least half?

SCHUTTE: Oh yes.

HYNES: May I direct my question to Dr. Bik, because he told us that they had information on the biota of a few streams involved in their area that have, at times, a very high chloride content. I say this against the background of work that has been done in my laboratory recently, where we have been trying to study the effects of salt on the stream biota in southern Ontario, and we find the cut-off point of no disturbance, is about 1000 ppm, 1000 mg/m chloride. I was very intrigued by your high figures in relation to your statement that you had a normal biota. I wonder if that information can be made available to us?

BIK: The exchange of environmental information between Syncrude and AOSERP was the subject of some discussion yesterday. I believe that we have made sufficient progress to assume that information will be made available very soon. A very substantial amount of biological information on the Athabasca River, Beaver Creek and Poplar Creek is yet to be published by Syncrude. Do you require the information for a program separate from AOSERP?

HYNES: I am asking for it because it seems to me, obviously this is an odd biota, ... it is not a normal biota, because normal biota respond to much lower levels than this. What I am saying here is that if we do have such a biota that has evolved or been selected in this area, that is enormously important if we're running a risk of increasing salt concentrations. It seems to me that this is a very important development. Now if that biota is there, one thing I would say right now to Syncrude is -- for God's sake, don't destroy it, because it may be only there, and we may need it.

BIK: Well, I think there are a couple of more things in the Athabasca area that have similar characteristics. I would like to make another point clear. It has been Syncrude's policy for some time now to publish it's biological information. We feel that which we consider to be truly baseline information should be put in the public domain. However, our main priority at the moment is building a plant, and other things will just have to fall in line when we have a bit of space.

ROSENBERG: The Beaver Creek study said that the population of benthic invertebrates in Beaver Creek were well below normal for the rest of the province. I was very interested to hear that the creeks you mentioned had the same levels of population as the rest of the province.

BIK: This was a quotation taken from a consultant's report that held that Poplar Creek, which lies to the south of our Lease, is really no different in this respect from the concentrations you find in other streams in Alberta.

SPRAGUE: As far as I am concerned, the number one question mark in my mind is the sulphur dioxide emissions from the stack. I understand these are two or three thousand tons a day from the Syncrude plant.

BIK: No, that is a misleading statement by an environmental organization that creates fear among the public which is not warranted. It wants to stop Syncrude. These are the permitted volumes which we are not to exceed. We will emit 287 tons per day of sulphur dioxide and that is on the assumption of 95% recovery efficiency of the Claus units of which we have two. The theoretical efficiency of those units is in excess of 98%. Our operating experience probably will be somewhere between 95% and 98%.

SPRAGUE: I am not familiar with these units. Are they designed to remove sulphur dioxide?

SCHUTTE: No, they are designed to remove hydrogen sulfide from gasses. H_2S is scrubbed and sent to the Claus unit where 1/3 of the hydrogen sulfide is oxydized to form SO_2. The SO_2 reacts with the remaining H_2S to form elemental sulphur. That unit has a 95% efficiency minimum. The gas that is left over is called tail gas. The tail gas is incinerated and goes through the stack. We have to count that in our total sulphur emissions.

SPRAGUE: How does this compare to what would be going out if you had no controls?

BIK: The design recovery volume for 125,000 barrels a day is 825 tons of sulphur, and multiply this by two gives the volume in tons of sulphur dioxide. Approximately 3/5 of the permit volume of sulphur dioxide comes from our CO boilers which are fueled by the coking units. That circuit has no sulphur recovery on it. So, part of our sulphur originates in the combustion of coke in the cokers. That places, under the maximum situation, 92 tons of sulphur per day into the atmosphere. The amount of sulphur that we can attribute to the tail gas is, I believe, 52 tons per day.

SCHUTTE: The big sulphur plants in the province, which clean up gas, regularly run just over 99% sulphur recovery with H_2S. That is proven technology for that type of feed stock. The problem with the bitumen is that it contains nitrogen leading to the production of ammonium sulfide, and the ammonia content in the feed to the Claus plant is quite high. We don't know whether we can control the thing to the extent that we can reach 98% or 99%. The Energy Resources Conservation Board agreed to our 95% removal. We feel that very thorough research could achieve controlling the process with the ammonia.

WALLACE: One of the figures that was relayed to us, four cubic ft. per second of nitrogen oxide emission from the Syncrude type plant, is a small figure in seconds, but is equivalent to 345,600 cubic ft. per day. Is this sort of level anticipated for the long term, or do we see improvements in technology dealing with nitrogen oxide emissions?

BIK: I think once our ammonia recovery proved to be economically viable, that figure would decrease.

MUNDIE: What is going to happen when there are several plants emitting SO_2?

BIK: Our current sulphur emission limits were set on the basis of the assumption of five concurrently operating plants. These were also set in the absence of hard scientific information as to what proper operating standards should be. That, hopefully, is one of the guidelines we will get from AOSERP Research.

SCHUTTE: There is technology to reduce sulphur emissions, but you pay a price. Shell, in its application, decided to clean up the gasses by burning the gas. They paid the price of 1½% less liquid oil recovery. They were willing to live with it, but the costs of environmental protection means society gets less oil. If you want to reduce this last 200 tons of sulphur, you are really paying so many barrels of oil a day.

KLAVERKAMP: Dr. Bik, do you have data that you can give us at this time of what might be the metal concentration in liquid effluents?

BIK: Well, we have a certain amount of environmental baseline information including the heavy metal work that can be made available. The general approach by Syncrude to this whole question of sharing information will be that environmental baseline information can be shared under certain conditions, environmental control information can not.

ROSENBERG: Smaller running water systems are probably less able to hold or physically handle impact such as addition of sediment that is not normally present. Do you know what the change in discharge will be when the waters from Beaver Creek are diverted in Poplar? Will it be a factor of ten times or three times? Do you have any estimate on that?

NICHOLS: The Beaver Creek hydrograph is approximately three times that for Poplar Creek.

ROSENBERG: What type of terrain does the diversion run through? Is it glacial overburden, till, fines, boulders or what?

NICHOLS: Very briefly, the sediments along the diversion from the dam down the spillway structure are generally glacial sediments or primarily till, some of which has been washed by pro-glacial activity. At the south end of Ruth Lake the upper layer of sediment is recent organic material and silts. Below the spillway are fluvial sands generally fine grained, cross-bedded and locally containing some silt. From Highway 963 to the Athabasca River are flood plain sediments consisting primarily of sands and silts.

ROSENBERG: It is a highly erodable terrain then, isn't it? So we will have to have close monitoring of the resultant levels in that last 8,000 ft.?

NICHOLS: Yes, the last reach of stream from the spillway through to the Athabasca River lies within erodable sediments. Monitoring is being taken into consideration subsequent to the actual diversion. We are also working at designing structures which will prevent or minimize erosion. There is a new bridge being built across Poplar Creek and associated with that construction there is a drop structure being constructed in the creek channel which is designed to control erosion around the bridge piers.

ROSENBERG: How does the level of Devonian limestone in the groundwater below the tailings pond compare to that in the mining area itself? Is it lower, higher?

NICHOLS: Drill stem tests conducted within the Devonian limestone in our mine site indicate that this unit is an aquiclude, not an aquifer. There is essentially no fluid pressure level to measure.

ROSENBERG: Of the tailings pond work that you've done on the mining area I've wondered why, with an area of potential impact as great as the tailings, you wouldn't do work with regard to the hydrology of the tailings pond first.

NICHOLS: Simply, following our schedule, mining substantially precedes any plant operation of discharging to the tailings area. We certainly won't start pumping into the tailings pond before June 1977. Currently, we are doing some work now on the tailings area, to get a better understanding of the glacial geology, the Pleistocene geology and also it's hydrology. We are planning to put in a significant number of observation points, both for the purposes of monitoring water quality as well as quantities in that area.