TAILINGS DISPOSAL HISTORY, PRACTICES AND EFFECTS AT CYPRUS NORTHSHORE MINING[1]

by

P. L. Pastika[2]

Abstract. Cyprus Northshore Mining currently owns and operates the Peter Mitchell Mine near Babbitt and the E.W. Davis Concentrating and Pelletizing Facilities and MP7 Tailings Basin at Silver Bay, Minnesota. The property, formerly owned by Reserve Mining Company, illustrates several cause-and-effect relationships of Governmental and Corporate policies and actions on mine and plant operations and subsequent tailings disposal practices. Reserve was the focus of a landmark environmental legal battle over the disposal of tailings from its operations into Lake Superior. As a result Reserve was forced to convert to an on-land system of tailings disposal and built and operated the MP7 Tailings Basin. Reserve's bankruptcy created serious problems at the MP7 Basin. Operating conditions imposed by the Courts and State Agencies created potential long-term stability problems with the basin dams and raised reclamation costs from the premature closure to prohibitive levels. In reopening the property, permit operating conditions were modified, and Cyprus agreed to operate the basin in a manner to reduce future environmental liabilities and closure costs. Current basin operations are focused on treating and discharging water from the basin to reduce the volume of water stored behind the dams and on utilizing the fine and coarse tailings from plant operations to form large covered beaches upstream of the dams to improve long-term basin stability.

1. Paper presented at the 1992 National Meeting of the American Society for Surface Mining and Reclamation, Duluth, Minnesota, June 14-18.

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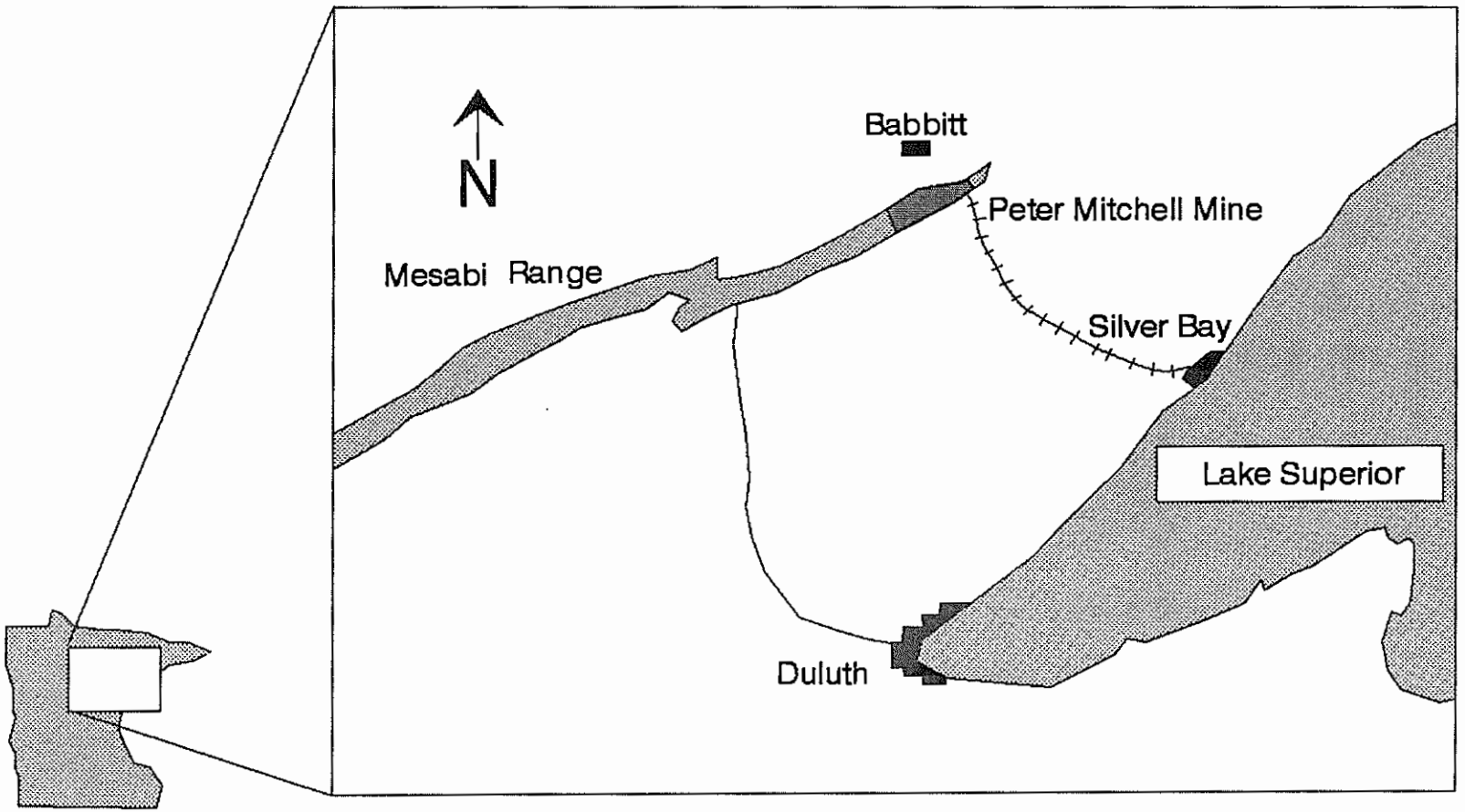
Introduction

The Peter Mitchell Mine in Babbitt and the E. W. Davis Works in Silver Bay, Minnesota are currently owned and operated by Cyprus Northshore Mining, a subsidiary of Cyprus Minerals Company. Crude taconite at 25% magnetic iron is mined from the pit at Babbitt, shipped by rail to the plant at Silver Bay, concentrated to 65% total iron, and pelletized for shipment by boat to steel mills in the lower Great Lakes region.

The history of the property is a classic case of the actions,

Proceedings America Society of Mining and Reclamation, 1992 pp 397-418
DOI: 10.21000/JASMR92010397

CYPRUS NORTHSHORE LOCATION



reactions and interactions between economic, governmental and environmental forces over the last century. Discovered in the late 19th century, the ore body has been mined at various times by three different companies and gone through numerous cycles as times and conditions have changed.

This paper will explain briefly the early history of the property and the forces that led to the decision to place tailings in Lake Superior and will focus on the tailings disposal practices resulting from the court case, some of the problems created, and current steps being taken to eliminate or minimize these problems.

Early History

The following brief description of the early history of the property, summarized from "Pioneering with Taconite" by E. W. Davis, 1964, lays the groundwork for some of the taconite mining practices followed even to date and illustrates, in the work of the Mines Experiment Station of the University of Minnesota, the initial Government involvement and support of mining and development in general.

The commercial history of the property began in the last part of the 19th century. The ore body, lying at the eastern end of the Biwabik Iron Formation, was discovered in 1865 by Christian Wieland and Peter Mitchell. Prompted by samples brought back from the area, a group of Michigan investors formed the Mesaba Iron Company to obtain mineral claims in the area.

The ore, however, proved to be low grade, averaging only 25% magnetic iron, and it was recognized that some method would have to be developed to upgrade the ore to make it usable in making steel. In 1913 this task was undertaken by the University of Minnesota through its Mines Experiment Station. With this government support to develop the process, a group of investors led by D. C. Jackling, formed the Mesabi Iron Company to develop and mine the deposit.

By 1922 the Mines Experiment Station had developed a process to upgrade the ore to 60+% iron, and the world's first commercial taconite mine and plant was built and in operation at the new town of Argo, just south of present-day Babbitt. The plant operated for two years producing a sintered product for sale on the open market.

The Mesabi Iron Company, however, was doomed from the start. The ore was hard, costs to upgrade it to an acceptable level were high, and the initial product produced was of marginal quality. Of more importance, however, many new high grade iron mines of the western Mesabi were just coming into full production and these mines were owned and operated by the steel mills. All the new mines created an oversupply of iron ore and, in the face of low demand caused by poor economic conditions, the price paid for iron ore by the steel mills collapsed. Taconite at anything less than a massive scale became uneconomic. Furthermore, the Mesabi Iron Company had no connection to the steel companies and sold only on the open market. In a weak market controlled by the buyers, the open market ceased to exist. In 1924, unable to generate sales to expand operations to a profitable level, Mesabi ceased operations and closed the mine and mill. The first cycle had ended but a lesson had been learned that would not be forgotten. Taconite

mines had to be very large to be economic.

Two events, the second World War, and a major tax law change in Minnesota, brought the property back to life. In 1939, the newly formed Reserve Mining Company obtained the rights to the property. Starting where the Mesabi Iron Company ended, Reserve, along with several other companies and the Mines Experiment Station, began development of a new generation of taconite plants.

World War II with its high demand for steel accelerated the depletion of the natural ores of the Mesabi Range. What only a generation earlier had appeared to be inexhaustible supplies of iron ore were recognized as very finite. The steel companies began to look elsewhere for future supplies, and taconite was the only major domestic choice.

The second factor to accelerate the mining of taconite was a change in Minnesota tax laws. Iron ores in Minnesota were subject to an ad valorem tax, a tax based on the tonnage of known reserves of ore a company controlled. Taconite mines required hundreds of millions of tons of proven reserves to justify the costs of the initial investment. The ad valorem tax as applied to natural ores would have made taconite uneconomic. In view of this, after a sometimes difficult struggle championed by E. W. Davis of the Mines Experiment Station, Minnesota passed a new law in 1941 removing the ad valorem tax from taconite and replacing it with a tax on actual production.

World War II created the demand. The new Minnesota tax law created the economic climate. Continuing work on the process at the Mines Experiment Station and at the steel companies solved the technical problems that plagued the Mesabi Iron Company. Reserve Mining Company would be built. The second cycle had begun.

Reserve Mining Company

Even in the very preliminary stages of planning it became obvious that the viability of Reserve depended on several key factors, size, water availability and large areas for tailings disposal. Size was primary. With the memory of the failure of the Mesabi Iron Company still fresh it was decided, from the start, to construct a plant that would ultimately be able to produce 10 million tons of taconite pellets per year (Davis, 1964). Such a plant would produce more in a week than Mesabi did in its entire two-year life.

The huge amounts of water needed for such a massive scale of operations forced the critical decision of plant location. The site of the Mine sits directly astride the continental divide. Water from the east part of the property flows north through Canada to Hudson Bay. Water from the western part of the property flows south to Lake Superior and eventually the Atlantic Ocean. A plant capable of producing 10 million tons of pellets per year required up to 500,000 gallons per minute of water. Even with a large tailings basin to reclaim and recycle much of the requirement, it was felt that sufficient water was not available at the mine. (Davis, 1964)

Less than 50 miles distant to the south lay Lake Superior with abundant water. Placing the plant on the lake meant higher transportation costs to haul three tons of ore to the Lake versus one ton of pellets, but with a private railroad this was the cheapest option.

This solved the water problem (Davis, 1964).

The placement of the plant on Lake Superior, however, created another major problem, tailings disposal. The land along Lake Superior was very rugged, and insufficient area was available near the proposed plant site for the large tailings basin required. Again the government, through the Mines Experimentation Station, helped with the solution. The Mines Experiment Station along with the St. Anthony Falls Hydraulic Laboratory of the University of Minnesota conducted a series of tests to determine the effects of placing the mill tailings into the Lake (Davis, 1964). The following quote, taken directly from "Pioneering With Taconite" by E. W. Davis, summarizes the results of the tests. "It was our conclusion that the fine tailings from all the magnetic taconite on the Mesabi could be put into the deep water of Lake Superior and would have no harmful effect on its usefulness or beauty."

With this support Reserve applied for the necessary permits to build a plant at Silver Bay, just north of Beaver Bay, on the shore of Lake Superior and to appropriate water from the Lake for use in the plant and to discharge the tailings from the operation back into the Lake.

In December of 1947, based on the data and supporting testimony from the Mines Experimentation staff, the agencies granted the required permits. The plant would be built at Silver Bay, and the tailings would be placed in Lake Superior. The die was cast for the next stage in the cycle.

Construction was completed, and Reserve's plant at Silver Bay began operation in 1955. Ten years later, after an expansion to double the initial capacity, production surpassed the 10-million-per-ton level envisioned in the original plan. Reserve's owners, now Armco and Republic Steel, had secured the base for their future supply of iron ore.

Tailings Disposal into Lake Superior

With permits to place tailings into Lake Superior, tailings disposal for Reserve was simple. Two launders extended out of the lower end of the plant and carried the tailings along with several hundred thousand gallons per minute of mill water directly into the Lake. Because of their heavy nature, most of the tailings settled out of suspension immediately after leaving the launder, forming a large delta extending out into the Lake. The process mill water and the very smallest tailings particles, generally less than 25 microns, flowed over the edge of the delta and down into the Lake as a heavy density current. Fresh water for the plant was pumped from the lake through an intake located away from the tailings delta. The system appeared to be working as predicted by the Mines Experiment Station.

The Reserve Court Case

During the late 1960's, however, problems with placing the tailings into the lake began to appear. In general, a growing environmental awareness resulted in increased scrutiny of industrial operations and discharges. This in turn led to the passage of new, more stringent laws and regulations to set water quality standards for state and interstate waters. More specifically, evidence began to accumulate that indicated that not all the fine tailings from Reserve's discharge

were being carried to the bottom of the lake by the heavy density current. Minerals specific to Reserve's tailings were being found in lake bottom sediments as far away as Duluth and Wisconsin (Draft MP7 EIS, 1978). Apparently micron-size particles of tailings were staying in suspension and being transported by currents throughout the western basin of Lake Superior.

In 1969 the United States Department of Interior published a report stating that all the fine tailings discharged by Reserve were not being transported to the bottom of the lake adjacent to Silver Bay as required by the 1947 permits. Federal and State proceedings were started to force Reserve to remedy the problem. Reserve appealed the governmental actions claiming that the new state standards did not apply. The Minnesota Pollution Control Agency countersued in February, 1970, alleging Reserve was polluting Lake Superior and sought an order halting disposal of the tailings in the Lake (Draft MP7 EIS, 1978). The opening volleys in a landmark environmental battle had been fired. The court case cycled back and forth until 1974 when the U.S. District Court ruled that Reserve's discharges into the air and water contained "asbestiform fibers" and substantially endangered public health (Draft MP7 EIS, 1978). This was by no means the end of the legal battles but marked a turning point and raised the standards any future tailings disposal system would have to meet. The focus of the battle changed from whether or not the tailings should be put in Lake Superior to where or even if an on-land tailings basin should be built, and how it should be operated in view of the "fiber" threat.

After several more legal circles, all parties finally agreed that Reserve would construct a tailings basin inland from the lake at Mile Post 7 along the company railroad. All the tailings from the projected remaining 40-year life of the property would be placed in this basin and the company would cease placing tailings into Lake Superior.

Because of the threat to public health from the "asbestiform fibers" in the tailings as defined by the Federal Court, several stringent conditions were applied to the permits issued for the construction and operation of the MP7 Tailings Basin. The major conditions from the MDNR and MPCA permits were:

1. To limit airborne emissions, all tailings except those used for dam or dike construction had to be placed and kept UNDER WATER.

2. There could be no discharge of water from the basin or the plant. The plant had to operate as a totally closed system. Limited make-up water could be added to the system to replace evaporation, etc., but all plant water, runoff, seepage, etc. had to be collected and pumped to the basin.

3. The basin dams had to be constructed to strict standards with impervious cores and sealed abutments and cutoff trenches to limit seepage. Each dam also had to have separate seepage recovery facilities to catch any seepage or runoff and return it to the basin.

4. To eliminate the possibility of accidental discharge of water during a major storm,

the dams had to be built without any emergency overflow structures. This meant the dams had to be built and maintained with sufficient freeboard to store the maximum probable storm possible for the area. For the basin site this was defined as 30 inches of rain over a 36-hour period.

5. The tailings dams had to be designed by and all construction activity had to be monitored by a qualified engineer not employed by Reserve. The state had the right to place inspectors of their own on the job at Reserve's expense.

6. Extensive air and water quality monitoring at Reserve's expense was required to assure compliance with permits and to document nondegradation of the surrounding environment.

Of all the conditions, the first two listed, to store all tailings under water and to collect and store all water from the process including runoff, forever, were to prove most crucial. These conditions forced the creation of a large free-water lake behind the dams with no provisions for any emergency discharge.

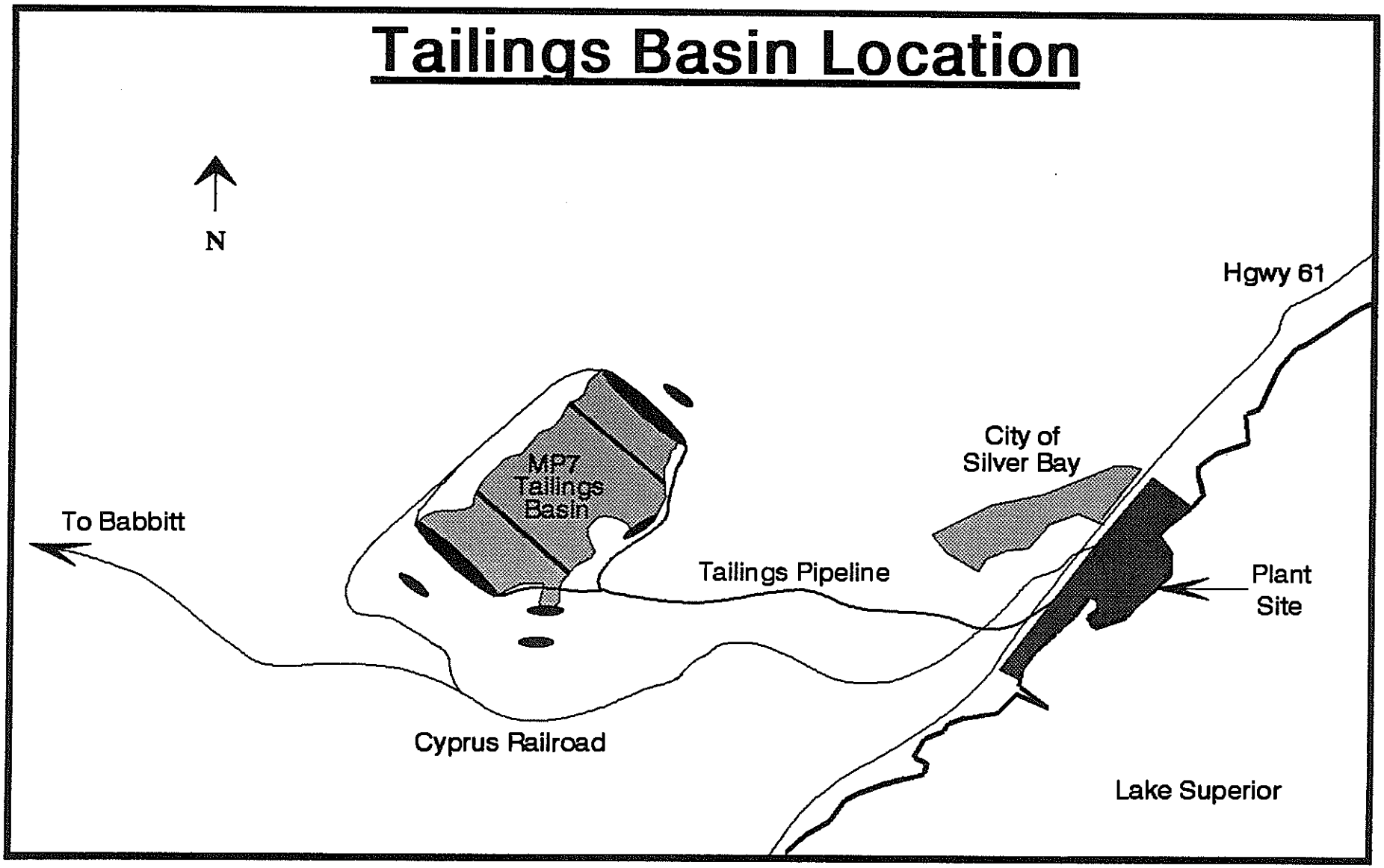
On-Land Tailings Disposal by Reserve

By mid-1980, plant modifications and preliminary construction of the basin required for on-land tailings disposal were completed, and Reserve began to place all the tailings from its operations in the MP7 basin. The overall cost of the conversion to an on-land tailings disposal system including new facilities in the plant to control airborne emissions and reduce silica in the pellets was in excess of 400 million dollars.

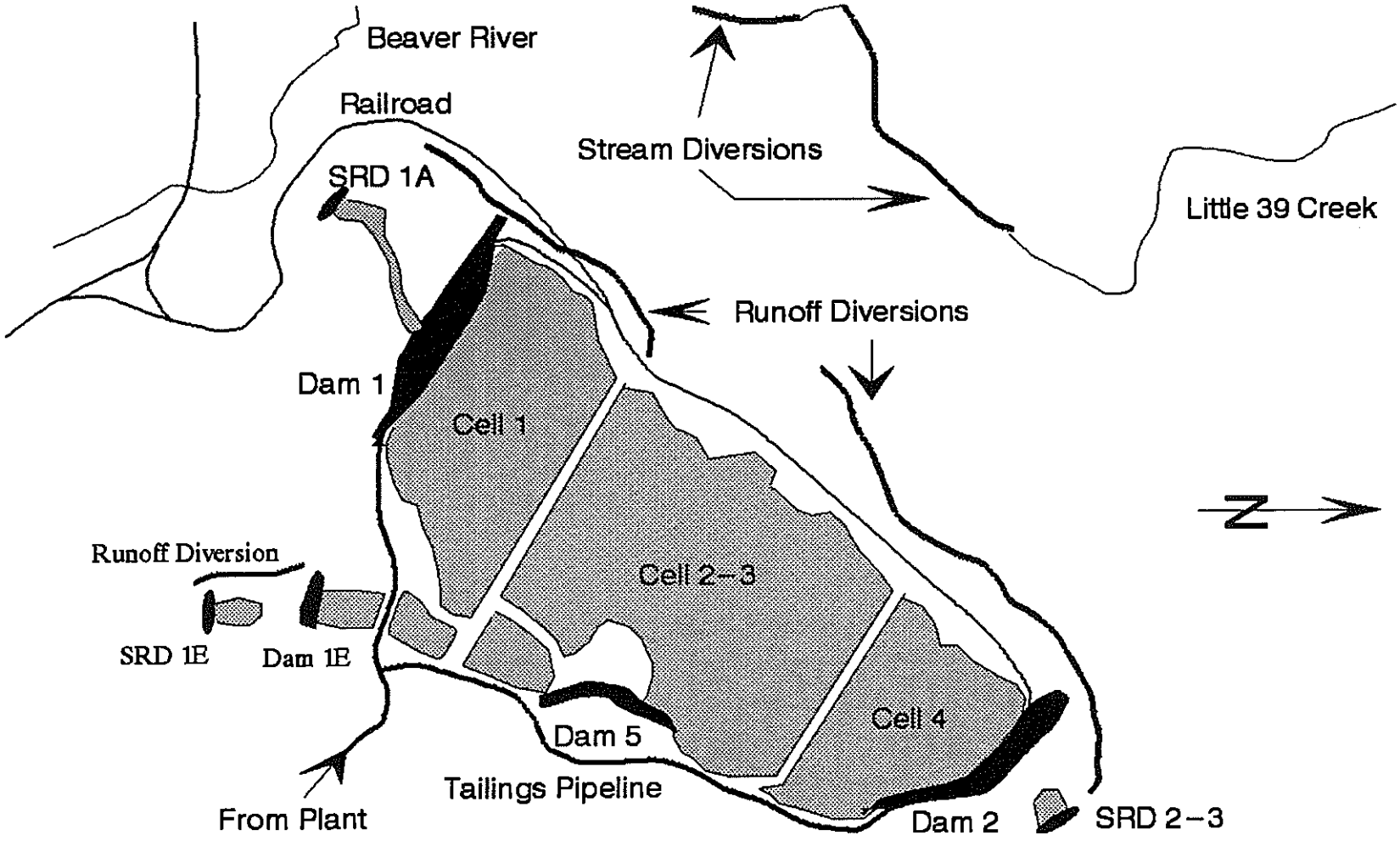
Initially the system worked extremely well. The MP7 basin proved to be a technically feasible, environmentally sound method of tailings disposal. Within a short period, however, a problem began to develop. The entire system including the plant, basin, and system water balance had been designed for a 10 million ton per year operation. In 1982, the pellet market collapsed and Reserve was forced to reduce operations to rates of less than 4 million tons per year. At these operating rates excessive water began to accumulate in the basin and insufficient tailings were available to continue to raise and support the dams to keep ahead of the accumulation of water. Furthermore, the long-term reclamation plans for the basin called for eliminating the free-water pool over the last years of operation to minimize the long-term safety problems associated with dam stability. The massive volume of free water accumulating over the tailings threatened the ultimate reclamation of the basin.

By 1983 it became obvious that some method would have to be found to control the water level in the basin at low production rates. An Engineering study by Klohn Leonoff indicated that, at the low plant operating rates predicted for the foreseeable future, substantial amounts of water would have to be eliminated from the system to bring the water balance back into equilibrium. After studying available options and making all plant modifications possible to limit water going to the basin, inflow still exceeded capacity by 2000 gpm. The only practical solution remaining was to discharge water directly (Klohn, 1983).

Tailings Basin Location

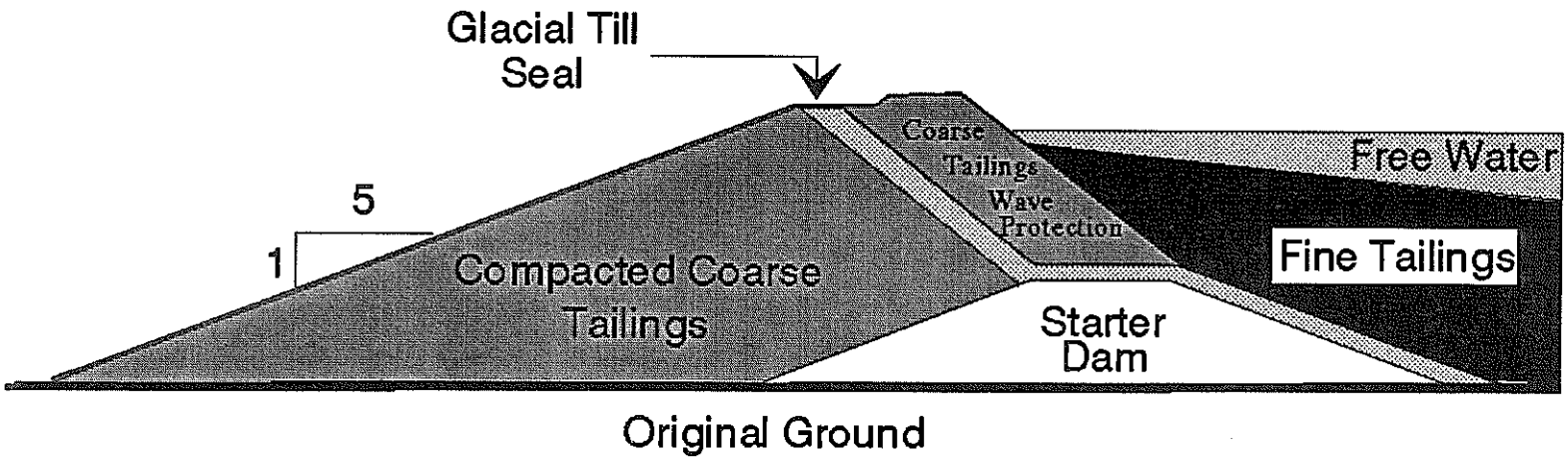


Tailings Basin General Arrangement



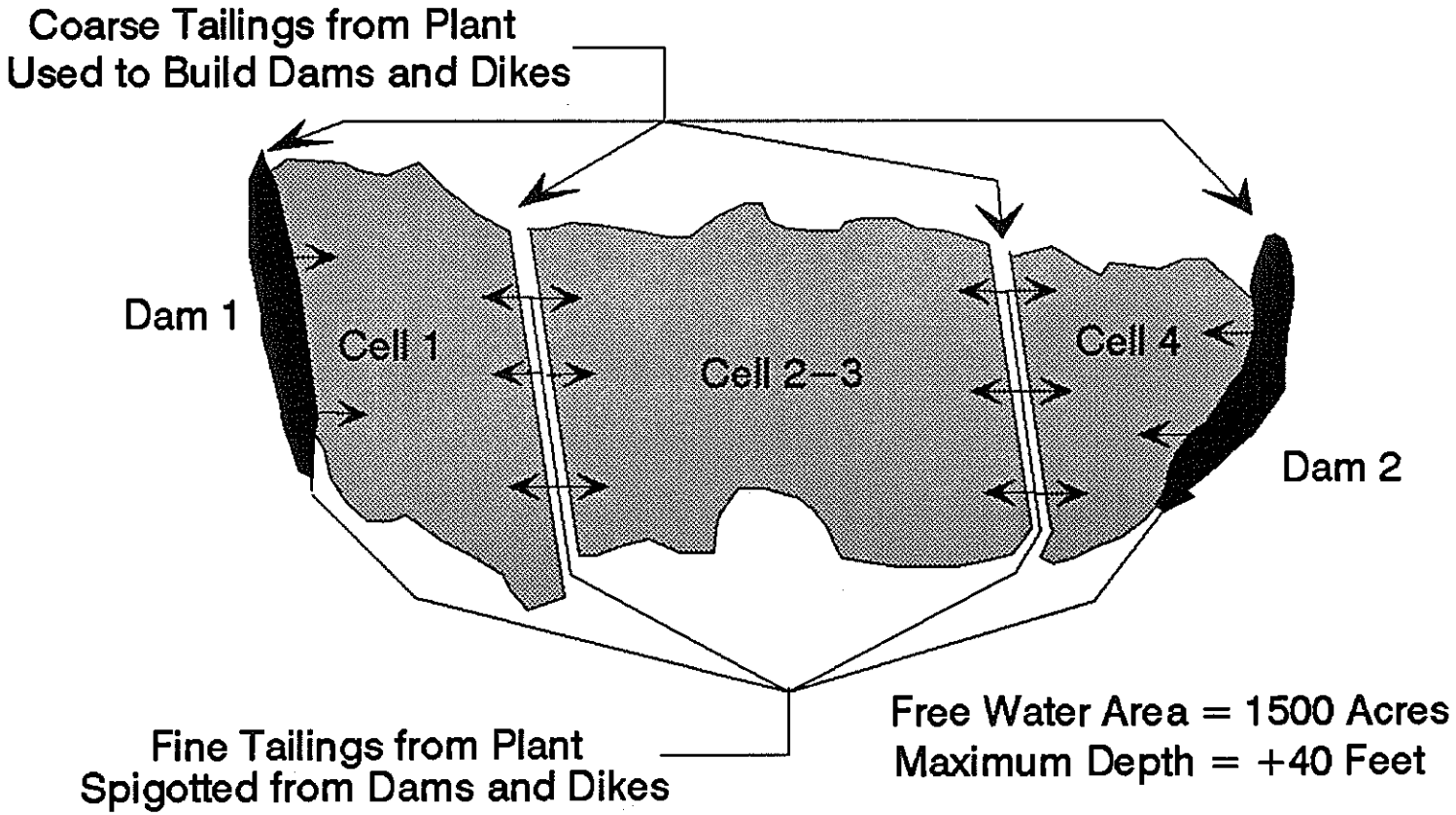
Cross Section: Dam 1

Looking West



Original Ground

1986 MP7 Basin Operations



To regain control over the basin water balance, Reserve requested permission from the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency for permission to discharge water from the basin. After consideration and study, the State Agencies modified the basin permits to allow Reserve to discharge the required water using "best available technology" to filter the effluent so that it would contain less than 1 million "fibers" per liter.

With this Reserve built a sand and charcoal filtration plant at the basin capable of treating and discharging 2500 gpm. The plant was completed and placed in service in mid-1985. After an initial break-in and learning period, the plant proved capable of removing approximately 99% of influent fibers at the designed flow rate. The basin water level could be controlled independently without regard to plant production levels. This proved critical with events to follow.

In the summer of 1986, the continuing struggle of the steel industry forced LTV, one of Reserve's two owners, into bankruptcy. Through the bankruptcy LTV rejected all its responsibilities at Reserve including its share of the 400 million dollar debt incurred when Reserve upgraded its process and converted to the on-land tailings disposal system. Faced with assuming the entire debt load alone, Armco Steel, the other owner, placed Reserve in bankruptcy. Reserve Mining Company was shut down. The second cycle had ended.

The Bankruptcy

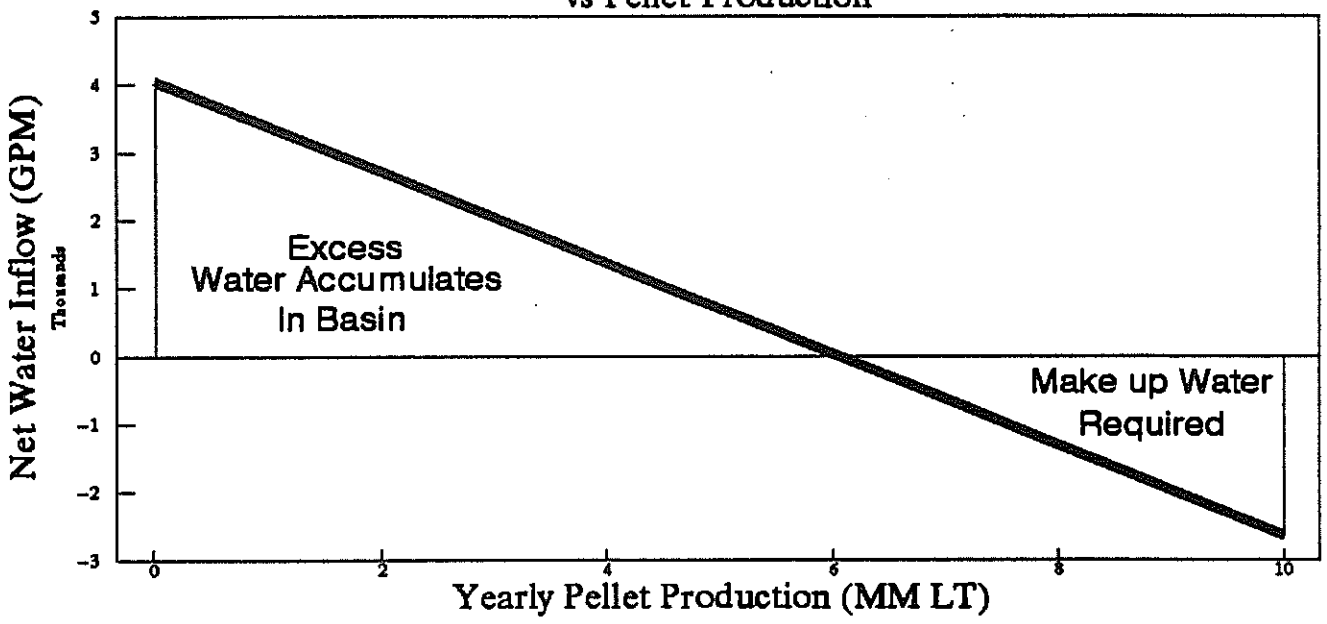
The closure of Reserve created immediate and serious problems at MP7. The tailings basin, designed to solve the potential environmental problem with "fibers", became a very real and pressing environmental liability itself. The large free-water pool directly against the dams threatened the long-term stability and safety of the structures. The very real possibility existed that future problems caused by erosion or other means could cause a failure in one of the dams with catastrophic results. If the basin were to be permanently closed, the free water would have to be removed or at least reduced significantly in volume. In addition, natural borrow material from pits near the basin would have to be taken to cover the fine tailings areas as they became exposed as the pond level was reduced. This would have created another area to be reclaimed at the end of the closure.

Two more immediate and very real problems were who was to maintain and pay for short-term upkeep of the basin while a long-term solution could be found and how would a long-term solution be financed. Studies by Dames & Moore indicated that any final closure of the basin acceptable by the state would cost between 45 and 90 million dollars including perpetual maintenance costs (Dames & Moore, December 1987).

LTV was protected by bankruptcy. Maybe they could be forced to pay, maybe not. Reserve as a company had ceased to exist. Reserve's assets were being sold to finance the bankruptcy proceedings. Armco was still solvent but shaky, and any expenses of the magnitude for long-term closure could have made its survival questionable. The potential existed that the State of Minnesota would have to pay a significant portion of the cost of any solution.

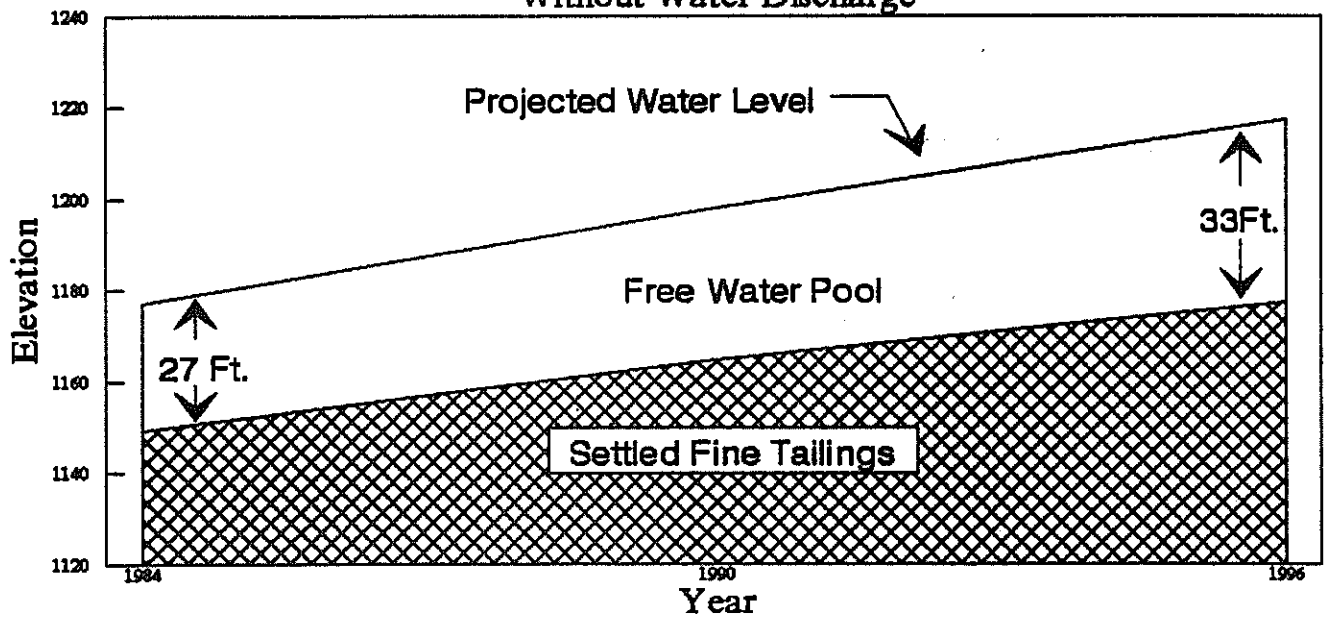
MP7 Water Balance

vs Pellet Production



MP7 Pond Elevations

Without Water Discharge



The short-term payments for basin upkeep were provided for by an agreement between the involved parties to share costs. For the long-term, the most attractive solution was to close the basin while operating. An operating plant would help remove the free water from the basin and provide the coarse tailings to cover the fine tailings areas exposed as the water was drawn down. With the reopening of the property even for a limited period the best option to limit long-term closure liabilities, the Bankruptcy Trustee began negotiations with several companies interested in the property.

Cyprus Northshore Mining

The third and current cycle began in 1989 with the purchase of Reserve's assets by Cyprus Northshore Mining, a division of Cyprus Minerals. Through an agreement between Cyprus, Armco, the State of Minnesota, and the Bankruptcy Trustee, Cyprus agreed to reopen and operate the property to facilitate ultimate closure of the tailings basin. Key points of an agreement from the stipulation agreement between the parties are;

1. Armco agreed to purchase 7.5 million tons of pellets from Cyprus over an interim period.

2. During the interim period Cyprus would operate the tailings basin in accordance with a plan produced by Klohn Leonoff and approved by all parties. The "Consensus Closure Plan" scheduled basin operations to minimize basin closure and reclamation costs at the end of the interim period.

3. During the interim period of basin closure, final closure liability would be covered by a refundable bond set aside by LTV and a guarantee by Armco to cover any remaining closure costs.

4. During the interim period Cyprus could walk away from the operations with liability limited to only the areas it operated at the mine and plant but no liabilities at the basin.

5. During or at the end of the interim period, Cyprus could decide to continue operations, discontinue the basin closure plan, and accept reclamation liabilities at the basin. At this time the liability of the other parties would cease.

Current Tailings Disposal Operations

The current tailings disposal practices at Cyprus are similar to those used by Reserve except for one critical area. All the tailings being produced do not have to be placed under water and as a result the free-water pool required at the basin can be reduced to a manageable and reclaimable level.

The MP7 Tailings Basin occupies a broad valley approximately seven miles inland from the plant. A natural ridge forms the eastern boundary of the basin. High ground provides containment to the west. Major stream diversions on the northwest side of the basin limit runoff into the basin to help control the water balance. Seepage recovery dams downstream of each dam collect any seepage or runoff from the dams to be pumped back into the basin. The basin is currently two and one-half miles long, one mile wide and covers 1500 acres.

All tailings dams were designed by Klohn Leonoff Engineering to strict specifications and are similar to large earthen dams for hydroelectric projects. Each dam is zoned for strength and drainage including filter zones of appropriately sized tailings. Each dam also contains an impervious core of local glacial till to provide a seal. The coarse tailings and till placed into the dams are inspected for size distribution and water content, placed in shallow lifts, and compacted to specific densities. All construction on the dams is observed by inspectors working for Klohn Leonoff.

To ensure nondegradation, water and air quality in and around the basin and plant are monitored by Cyprus personnel through a series of automated sampling stations or by regular hand samples. Piezometers, settlement plates, strain gauges, and tilt gauges in the dams, monitor dam safety. Wells located downstream from the basin monitor seepage quantity and quality.

Makeup water required by the concentrator is collected from the clear water pool at the basin and pumped back to the plant through a buried 24-inch line. This limits water requirements from Lake Superior to small amounts of clear water needed for seal water systems, etc.

To reduce the basin water volume, the Water Treatment Plant at the basin is being operated at maximum capacity and water is being treated and discharged at a rate designed to draw the basin level down 4 feet over the interim period.

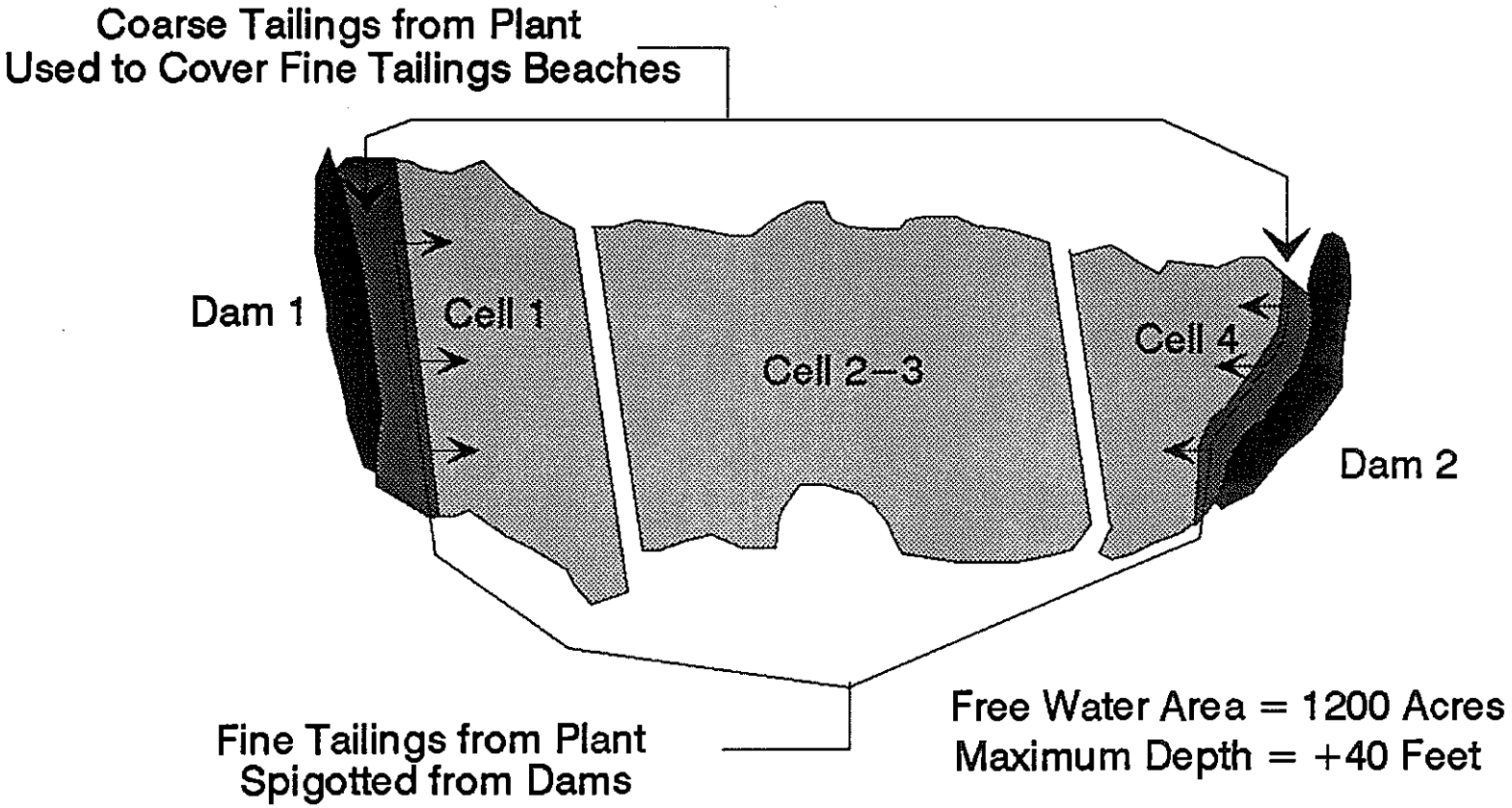
The fine tailings from the plant are collected in four 400-foot diameter clarifiers on the old delta and pumped to the basin through one of two 24-inch diameter pipelines. The fine tailings are spigotted from the major dams at each end of the basin to create large beaches extending 300 to 400 feet upstream from the face of each structure. This is standard practice at most tailings operations and moves the free water away from the face of the dams and buttresses the upstream portions of each dam.

The coarse tailings from the plant are rail-hauled to the basin in trains consisting of 30 to 35 side-dump cars with 80-ton capacity each. At the basin the cars are dumped at each dam and moved into place by loader/truck combinations or dozers to place a 3- to 4-foot thick capping layer over the fine tailings beaches. This prevents wind erosion of the fine tailings and provides a reclaimable surface.

Reclamation activities follow closely behind operations. As coarse tailings areas become inactive they are treated with dust suppressants if required and vegetated. The following section from the Cyprus Operational Plan for the MP7 Disposal System describes reclamation methods for basin areas.

When tailings areas become available for planting, the surface is watered thoroughly to soak the surface immediately prior to seeding. The surface is then scarified. The area to be seeded is fertilized with a 10-10-10 dry commercial fertilizer at a rate of 500 pounds per acre. After the fertilizer is applied, the area is dragged with a roller-harrow or equivalent equipment to incorporate the fertilizer into the tailings. Seed with a premixed blend of 13% birsfoot trefoil, 24% vernal alfalfa, 2% redtop, 19% inter-

1992 MP7 Basin Operations



mediate wheatgrass, 11% reed canary grass, 11% orchardgrass, and 21% Kentucky 31 fescue is applied at 30 pounds per acre. After seeding a roller harrow is used to compact the surface with the rollers moving parallel to the contours. Vegetation established early in the growing season requires additional 10-10-10 fertilizer at 500 pounds per acre broadcast as a top dressing during the first year. All plantings are fertilized in a similar manner the second season.

The vegetation program is under the control of the Cyprus Technical Services Department. Technical Services checks for nutrient requirements, effectiveness of growth and estimates of ground cover, and modifies vegetation plans, and schedules remedial actions or additional seedings as required.

The end result of the current basin operations will be to fill in the northern and southern portions of the basin to shrink the free-water area and volume by approximately 50% by the end of the interim operating period. At such a time, should Cyprus decide not to continue operations, the final reclamation of the basin will be completed, and the entire area will be revegetated and returned to a natural, productive, and stable condition.

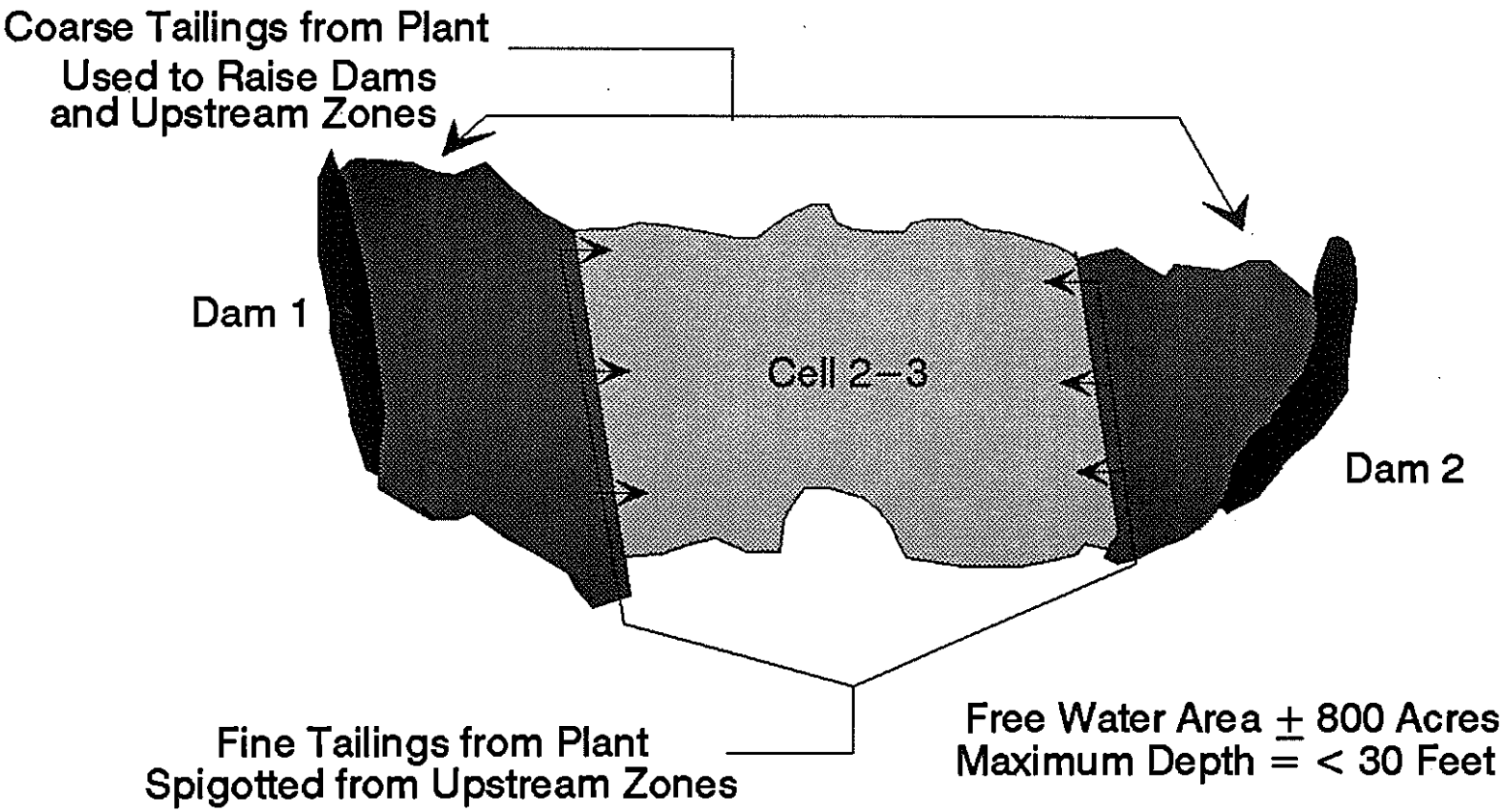
If at any time Cyprus decides to continue operations past the interim period, basin operation will still continue in a similar manner. The fine tailings will still be spigotted from the dams and covered with coarse tailings to provide a broad, stable zone upstream of each dam. As equilibrium is reached between the width of the upstream zones and plant operating rates, the dams and upstream zones will be raised as required for the life of the property. At the same time the volume of the free-water pool will be kept at a minimum to reduce future final reclamation costs.

In addition to the safe storage of tailings, one bonus from the MP7 operations has been the creation of a unique mixed woodland and wetland environment that provides a diversified habitat for wildlife (Dames & Moore, November 1987). The basin is home to deer, moose, bear, fox, mink, otter, beaver, coyotes, and at least two threatened or endangered species, Grey Wolves and Bald Eagles. With the abundant water and wetlands, the basin has become a major nesting site for several species of waterfowl including several families of loons and geese. Strategically located along Lake Superior, the basin has also become a stopping point for all types of migratory birds. Several species of fish including native brook trout inhabit the basin diversions and pond itself. Deer in particular have benefitted from the ongoing reclamation activities, and it is not unusual to see 10 to 20 deer in a trip around the pond.

Conclusions

Tailings disposal practices have gone through several cycles at the E. W. Davis Plant in Silver Bay. The trend over the years, as for all activities of man, has been to place increasing emphasis on protection of the environment. This is only right and proper. The result at MP7 has been to create an environmentally sound state-of-the-art tailings disposal system. As a bonus the tailings basin provides a diversified wetlands environment in an area where such habitats are rare. The basin is home to various forms of wildlife and is testimony to the fact that with proper care, Industry

Ultimate MP7 Basin Operations



and Nature can coexist.

However, the path to the current condition has not been entirely smooth. Economic factors have imposed several "boom and bust" cycles on the property. Governmental regulatory policies and actions have been inconsistent, and the Government's role has changed generally from advocate to adversary. Of most importance, however, both Corporate and Government decisions and actions have at times been shortsighted with respect to future economic factors and effects. In particular, in requiring Reserve to place all the tailings at MP7 under water, potentially serious long-term problems were created. If one purpose of history is to teach, then one lesson this case should provide is that economic factors and future economic conditions must be considered in governmental regulatory actions--even in environmental matters.

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