Study and Report on the Effects of the Expanded Development of the Barton Sand and Gravel Pit

NEW SCANDIA TOWNSHIP, MINNESOTA

Prepared for

WASHINGTON COUNTY PLANNING DEPARTMENT

October 9, 1987

BARR ENGINEERING CO.
Minneapolis, Minnesota

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EFFECTS OF THE EXPANDED DEVELOPMENT
OF BARTON SAND AND GRAVEL PIT
NEW SCANDIA TOWNSHIP, MINNESOTA

I. INTRODUCTION

A. Authority and Purpose of Study

This study was authorized by the Washington County Planning Department. The study will assist the Advisory Committee in reviewing an Environmental Assessment Worksheet submitted by Barton Sand and Gravel Co. The Committee wishes to further evaluate the impact of a proposed expansion of the Barton Pit on local water resources in the area. Specific questions to be answered include:

1. What is the immediate and long-term impact of development of the water use by the pit operation on area wells?

2. What is the immediate and long-term impact of development of a 50-acre surface water pond on the surficial aquifer and specifically German Lake?

3. What is the immediate and long-term potential contamination, if any, to the surficial aquifer due to (a) the pit gravel washing operation and (b) the air pollution control device associated with the on-site asphalt plant?

B. Study Location

The location of the Barton Pit is shown in Figure 1. The pit is 1/4 mile east of County Highway 15 (Manning Avenue) and 1-1/2 miles north of State Highway 97. This is in the east central portion of Section 7, T32N, R21W in New Scandia Township. The pit and surrounding lakes including Forest Lake, German Lake, and Bone Lake are within the boundaries of the Forest Lake Water Management Organization.

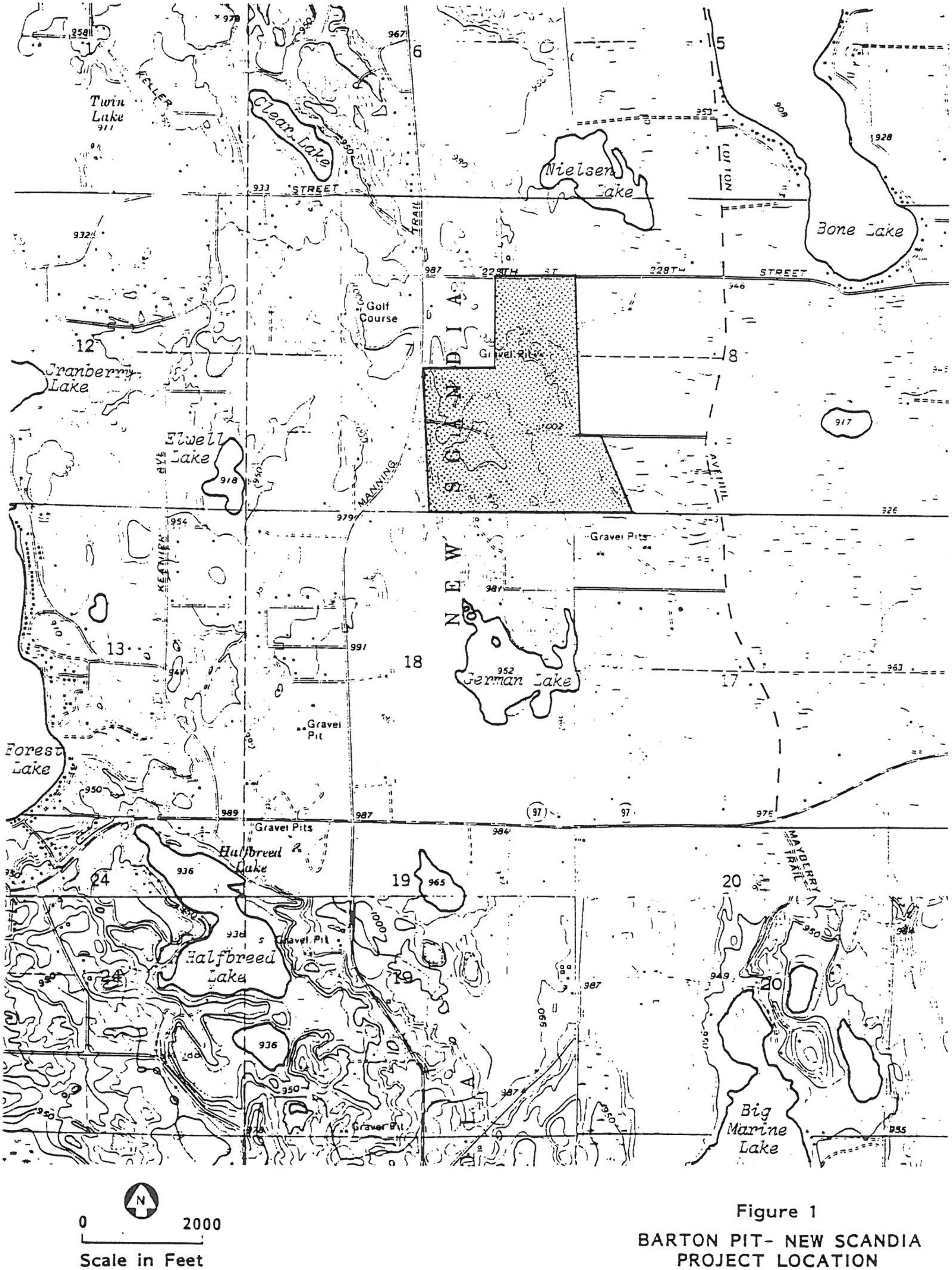

Figure 1
BARTON PIT- NEW SCANDIA
PROJECT LOCATION

C. Description of Barton Mining Operation

History of Site

According to information supplied by Barton Sand and Gravel Co., the site has been mined since at least 1962. Prior owners of the company are reported to be as follows:

1962-1972	J.W. Craig
1972-1974	Dependable Asphalt
1974-1979	B-TU Mix
1980-August 1985	H & S Asphalt
August 1985-Present	Commercial Asphalt Co./ Barton Sand and Gravel Co.

According to the Barton Co., in the years 1972-1978, an asphalt plant was operated intermittently on the site by Dependable and B-TU Mix. This plant is reported to have used an air scrubber with a self-contained water tank. Fines from the tank were withdrawn and re-introduced into the asphalt mix.

In May 1980, the H & S Asphalt Co. completed a well on the site and began operations with the present asphalt plant. The plant was used intermittently from 1980 to 1985. Commercial Asphalt, one of the Barton companies, has been operating the plant approximately 7 months per year since August, 1985.

Present Operation

The present Barton mining operation consists of the removal of sand and gravel from immediately below the surface of the property to a depth of approximately 70 feet. The material is processed on site by screening and crushing of oversized material to produce various aggregate products including Class 5 aggregate for road construction and various bituminous aggregate materials for further processing in the making of bituminous asphalt. It is also possible that materials might be used in the making of concrete, although this is not a present use of the site.

An asphalt plant is located on the property. According to the Barton Company, this is a continuous process (drum mix) plant with an average production of approximately 2000 tons per day. A schematic drawing of a drum mix plant (from Gunkel and Bowles, 1985) is shown in Figure 2. The aggregate is placed in a rotary drier where it is dried and heated. The drum has flights or vanes which cause the aggregate to fall through the heated air. The drum is reported to be 32 feet long and 7.5 feet in diameter. Hot asphalt cement is added to the mix which is delivered in trucks for road construction. Temperature of the mix at the drum outlet is between 250 and 300 degrees Fahrenheit. The plant is estimated to use 100 tons of asphalt and 1900 tons of aggregate per day. In 1986, 175,000 tons of bituminous mix was sold.

The plant is fueled by waste oil or #4 fuel oil at a rate of 2000 to 3000 gallons per day. To meet air quality standards, the plant uses a wet scrubber to remove particulates from the exhaust. Water from an on-site well is sprayed in a fine mist into the exhaust stream. Water use is estimated to be 200 gallons per minute. The water removes the fine particles of rock dust and small amounts of bituminous materials and combustion by-products. This water is discharged to a small pond, approximately 60 feet by 100 feet in size. This pond occasionally overflows to a larger pond located on the northern 40-acre parcel where it infiltrates and evaporates.

The small pond is reported to have originally been lined with clayey materials found on the site. Particulate material accumulates in the smaller pond and is removed approximately twice per year by backhoe to a depth of approximately 6 feet. The material is dried and added to the asphalt mix.

The plant operates under an air quality permit from the Minnesota Pollution Control Agency and a groundwater appropriations permit from the Department of Natural Resources.

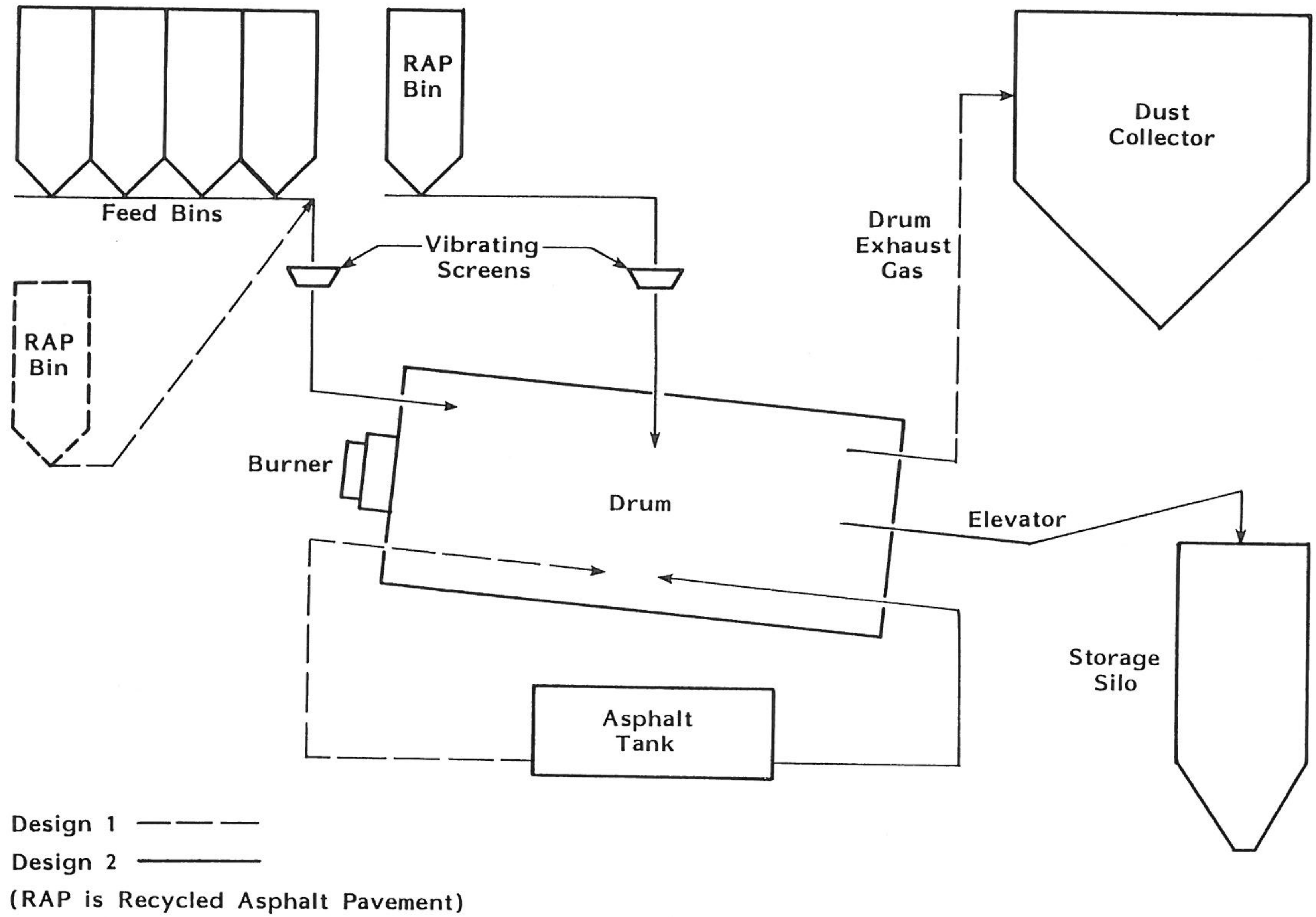

Figure 2

Schematic Diagram of Drum Mix Asphalt Plan
(From Gunkel and O'Boyle, 1985)

Proposed Future Activities

The Environmental Assessment Worksheet (EAW) contains the following statement regarding future activities on the site:

> "Barton Sand & Gravel Co. owns approximately 217 acres in New Scandia Township. Approximately 45 acres is currently actively mined. Over the next 25 to 35 years, an additional 75 acres is proposed to be mined. Approximately 400,000 tons per year of aggregate would be removed from the pit. Existing elevations of the unmined area is 1,000 to 1,010. A 50-acre pond would result from the mining with a bottom elevation of 870 to 890. Therefore, approximately a 120 to 140-foot elevation change could be anticipated as a result of the mining. The following numbered items outline in more detail the project:
>
> 1. Aggregate material shall be mined and sold from this pit as the market conditions of this area may demand.
>
> 2. Estimated time required to complete removal, storage, or excavation; number of acres involved; estimate of amount of material to be removed:
>
>   Time Period First Phase 0-10 Years:
>   Second Phase 10-25 Years
>   Third Phase 25-35 Years
>
>   Number of Acres: approximately 120 acres
>
>   Material to be Removed: this number will depend heavily on the market demand. Current estimate: 400,000 tons per year."

In addition to this statement, the EAW indicates in Section 3, Page 2 that a gravel washing operation is proposed. The Barton Company was asked to supply additional information on the proposed gravel washing operation and replied that although the washing operation is not presently needed, it might be added in the future if concrete products are to be produced at or near the site.

The proposed washing operation would include a wet washing operation to remove silt and clay-sized particles. The water for the washing operation would be supplied by the on-site well initially. A pond would be developed to store and settle the wash plant effluent. Water would be recycled from the pond to the wash plant; the well would be used only for make-up water. Withdrawal rates from the well would be limited to 200 gallons per minute.

D. History of Citizen Concern and Well Testing

The plant is located in New Scandia Township in north-central Washington County. Nearby land use is agricultural and rural residential. Local residents have observed that mining and asphalt operations at the pit have increased since installation of the present plant in 1980 and especially since the acquisition of the plant by Commercial Asphalt in 1985. Increasing population density in the township has also given the plant more neighbors. Metropolitan Council figures indicate that the population density of New Scandia Township has doubled since 1970.

With publication of the notice of the EAW preparation, the residents have become more active. One family (Nelson) had their well water privately analyzed on June 26, 1987. Reports of finding of polynuclear aromatic hydrocarbon (PAH) compounds caused the Solid and Hazardous Waste Division of the Minnesota Pollution Control Agency to sample the Nelson well in late July but analyses of this sample produced no indication of PAH's.

Citizens asked the Minnesota Pollution Control Agency (MPCA) to investigate the water quality of the plant effluent. Staff of the Water Quality Division of the Minnesota Pollution Control Agency sampled the effluent from the air quality scrubber and found PAH's in excess of drinking water standards. These laboratory reports are contained in Appendix A.

To Sue Turner
Pls send copy of this to Dave Sellergren and put original w/ our copy - [illegible]
12/1/87

Barr
Engineering Company

7803 Glenroy Road
Minneapolis, MN 55435
612/830-0555

November 27, 1987

Mr. Robert Lockyear, Director
Washington County Planning Department
14900 61st Street North
Stillwater, MN 55082

Dear Mr. Lockyear:

This letter is written to formally correct two items in our October 9, 1987 report on the Barton Pit expansion in New Scandia, Minnesota.

The items are:

1. The original report had duplicate pages 8 and 9. Copies of page 8 were given to you and handed out at the meeting. An additional copy of page 8 is included with this letter.

2. Page 20 ~~refers to a concentration as being~~ "more than 300 times the MPCA ~~standard~~ for drinking water .0028 ug/L." This statement should be "more than 30 times the Minnesota Department of Health Recommended Allowable Limit (RAL) for drinking water of .028 ug/L."

These changes would not alter our conclusions or recommendations as set forth in the report. I hope that by formally providing this information we will have eliminated possible future misunderstandings.

Sincerely,

Nels P. Nelson

NPN/jmr
c: Jim Strudell
Janet Dalgleish
Gaylen Ghylin
Sue Tuomi
Dr. H.O. Pfannkuch
RLLET/327,0

On July 27, another family (Sandok) had their well sampled and tested for PAH's. Again PAH's were found by the private lab and the MPCA sampled the well on August 19. Again the MPCA found no detectable PAH's. On August 19 a third family (Fena) had their well privately analyzed and the MPCA analyzed a sample taken at the same time from this well. Again, the private lab found PAH's while the MPCA did not.

A fourth family (Warning) had their well sampled on August 18 by a different private lab and no detectable PAH's were reported.

To help resolve the discrepancy, the Department of Health also analyzed extracts of the private samples of the Sandok and the Nelson wells and in one case found some PAH compounds but at lower levels than the private analyses had shown. A duplicate analysis did not reveal these compounds.

Laboratory reports and correspondence regarding these samples are included in Appendix B.

II. GEOLOGY OF STUDY AREA

A. Regional Geology

The presence of hummocky topography and numerous lakes and wetlands in the area of interest indicate that it is located in an area of glacial moraine deposition. These unconsolidated glacial materials overlie layers of sedimentary bedrock that have an uneven erosional surface.

The site is situated in an area where deposits of both the St. Croix and Pine City end moraines occur (Hobbs and Goebel 1982). The St. Croix moraine was deposited in the area during an advance of the Superior Ice Lobe approximately 20,000 years ago. The moraine deposited by the Grantsburg Sublobe of the Des Moines Ice Lobe was created approximately 14,000 years ago (Wright, 1972).

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A geologic cross section was constructed using well logs provided by drillers to the Minnesota Geological Survey. Copies of these well logs are included in Appendix C. Figure 3 shows a location of cross section, which is illustrated in Figure 4. The cross section shows that a bedrock valley is incised immediately to the west of Manning Road between Forest and German Lakes, exposing older underlying bedrock units. Information contained in the well logs was not specific enough to identify glacial units according to their phase of deposition.

B. Bedrock Stratigraphy

As seen in Figure 4, driller's logs reveal the presence of two bedrock units underlying the site. The lowermost unit is the Cambrian Jordan Sandstone, which is seen only in the bedrock valley to the west where the overlying units have been eroded away. The other bedrock unit is the Prairie du Chien Group, which is comprised of the lower Oneota Dolomite and the overlying New Richmond Sandstone. The bedrock lies at depths ranging from approximately 80 to 200 feet below the ground surface.

C. Stratigraphy of Glacial Drift

The bedrock underneath the site is overlain by a sequence of glacial materials. Immediately above the bedrock is what appears to be a till layer, comprised of sand and clay with the upper contact at approximately Elevation 860 feet MSL. This is overlain by a layer of sand and gravel with an uneven upper surface. The sand and gravel layer is overlain by a sand and clay layer that occurs westward from near German Lake. Towards the west central portion of the cross section the upper sand and clay layer is overlain by more sand and gravel with a local occurrence of clay in the uppermost horizon.

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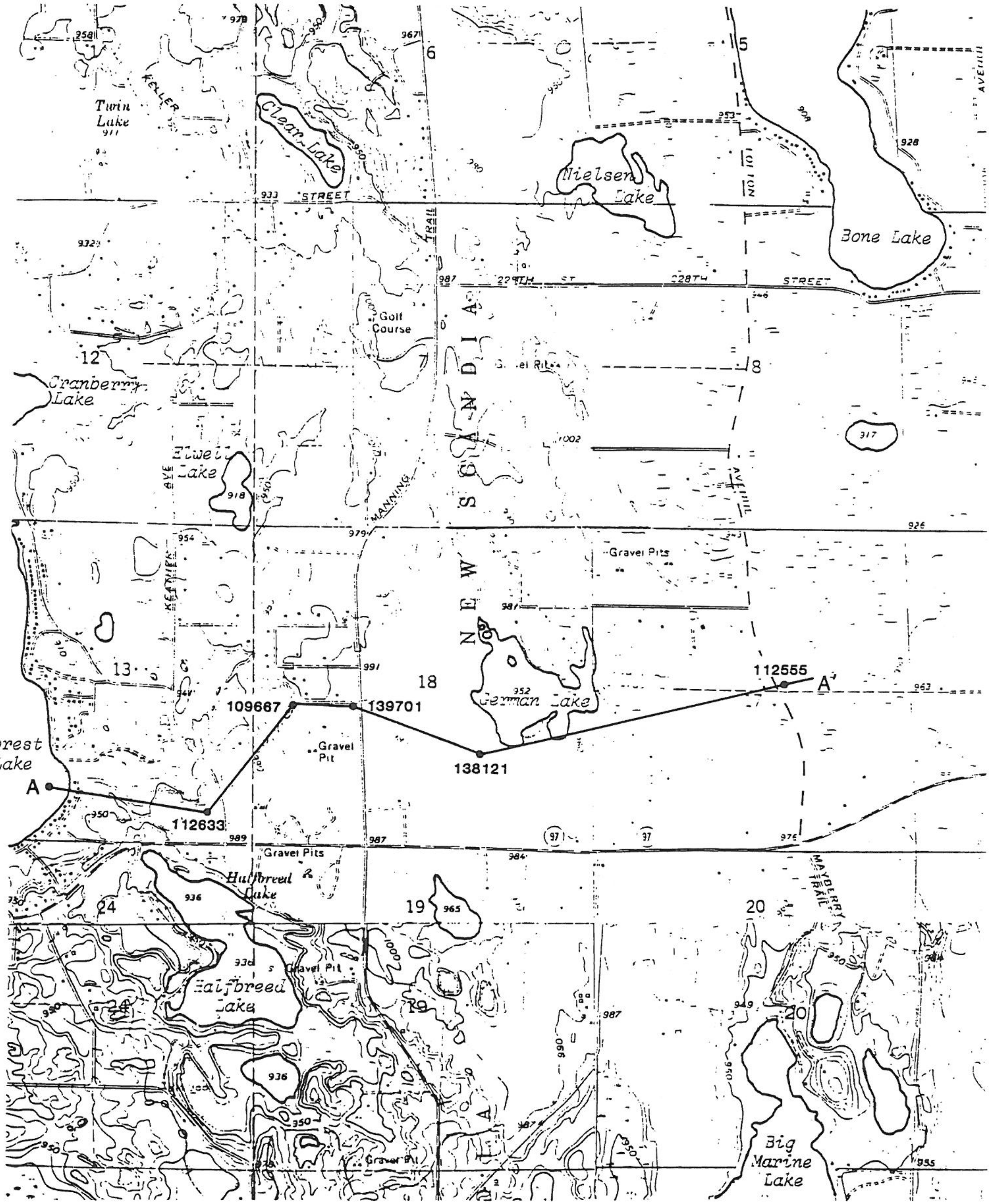

N
0 2000
Scale in Feet

112633 Well Location With Minnesota Geologic Survey Well Number

A – A′ Cross Section Location

Figure 3

LOCATION OF GEOLOGIC CROSS-SECTION

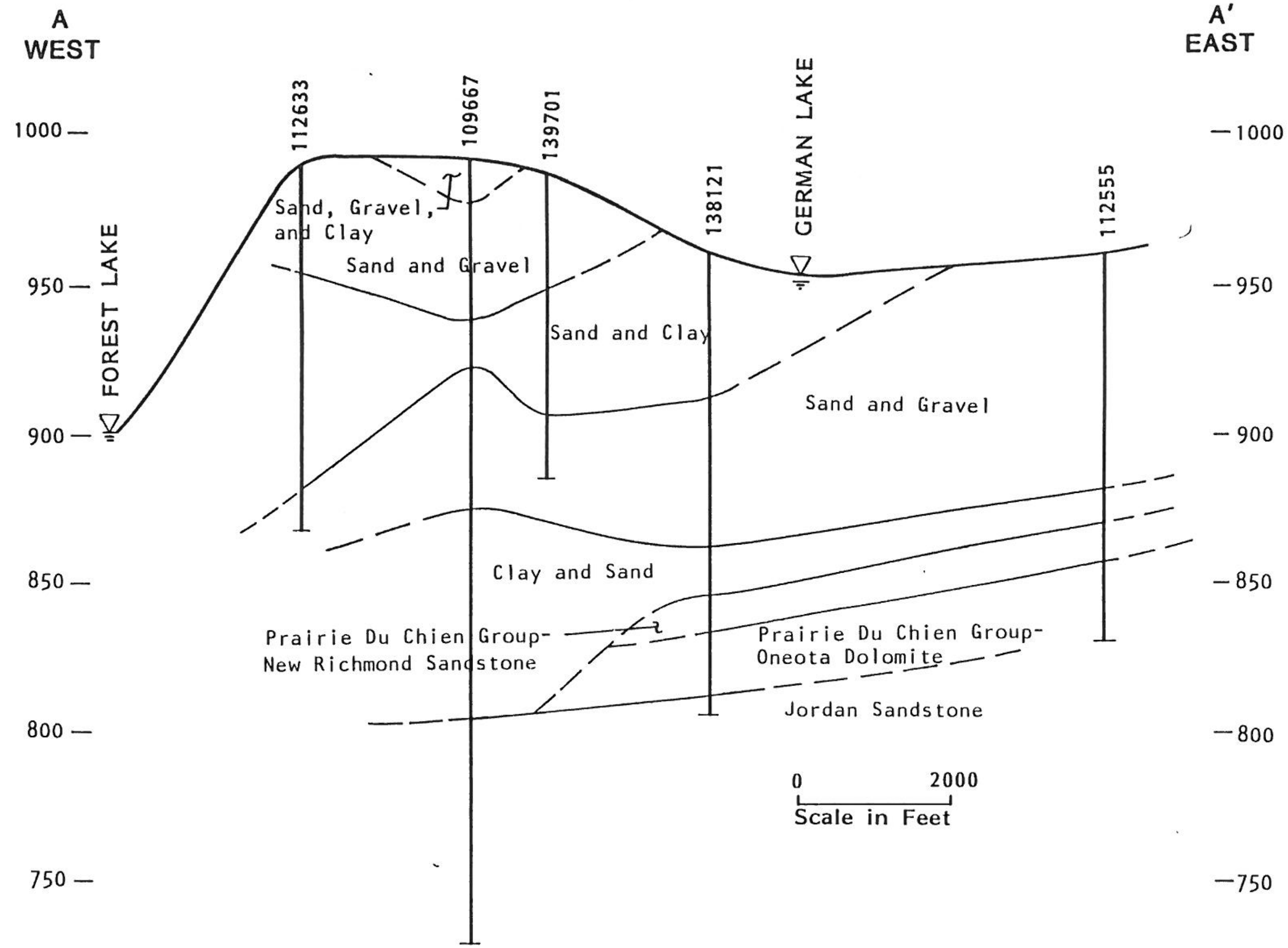

Figure 4

GEOLOGIC CROSS-SECTION A-A'

III. HYDROGEOLOGY OF STUDY AREA

A. Hydrogeologic Properties of Geologic Materials

A key parameter in modelling groundwater flow is the permeability or hydraulic conductivity of the aquifer material. In the case of the present study area, no direct measurement of hydraulic conductivity was available. To make an indirect estimate of hydraulic conductivity, Hazen's approximation was used (Lambe, 1969, p. 290). This method relies upon grain size analyses and is considered to be a reasonable procedure for estimating the hydraulic conductivity of sandy materials.

In response to requests for assistance, the Barton Company took two samples of material from the working face of the pit and had them analyzed for grain size. The results of these tests are included in Appendix D. Using these results, Hazen's approximation yields an estimated hydraulic conductivity ranging from 1×10^{-2} cm/sec to 4×10^{-2} cm/sec. This is considered reasonable for granular soils such as those found on the site. In developing the model, the latter value was found to provide results most closely approximating field conditions. The model was based on the assumption that the glacial drift is a homogeneous and isotropic unconfined aquifer.

B. Groundwater Flow Patterns

The project site is located approximately equidistant from three major lakes which have a significant effect upon the groundwater flow regime. To the west, Forest Lake has an outlet to the north via the Sunrise River which flows through Comfort Lake. To the northeast, Bone Lake drains to the northeast and ultimately to Comfort Lake. To the south, Big Marine Lake has an outlet to the south to Turtle Lake. Additionally, the more distant effects of the St. Croix River and the Green Lake-Chisago Lake chain of lakes help to determine the regional groundwater table.

Within the immediate study area, numerous small depressions exist. Many of these appear to be poorly drained and are believed to be expressions of the groundwater table. These include German Lake, Elwell Lake, Clear Lake, and Nielson Lake.

Previous regional studies have addressed the groundwater flow patterns in the area in a general fashion. Water-table contour maps prepared by the USGS (USGS, 1972) attempted to define the water table elevation from the level of nearby lakes and streams. The maps show showed the area to be near a local groundwater recharge area with flow passing both to the west to Forest Lake and to the north-northwest.

A more detailed study was done in 1980 by Barr Engineering Co. as part of the Flood Insurance Study for Big Marine Lake (Barr, 1980). Unpublished maps prepared for this study indicate that flow in the surficial aquifer is locally to the north-northwest. However, within one mile of the site flow diverges to the south and west. The same Barr study showed flow in the subcropping bedrock to be eastward towards the St. Croix River.

C. <u>Description of Modeling Technique</u>

The technique used for modeling groundwater flow is described as the analytical element model. This method was published by Strack and Haitjema (1981) but a full description will be given by Strack in a text on groundwater flow that is scheduled to be published by Prentice-Hall sometime in 1988. The analytic element method consists of superposition of analytic functions, each representing a specific feature of the aquifer system. For the present model, functions are used to model the wells and to add a uniform infiltration rate due to rainfall infiltration because the primary lakes are modelled by line sink functions or line doublet functions.

The model is not intended to be a perfect description of actual flow on the site. The technique used for this study is to make conservative assumptions in every respect where accurate data are missing. When this has been done, the changes contemplated by the applicant are superimposed upon the conservative model and the resulting impacts are evaluated. By this method, it can be surmised that the model represents the extreme limit of potential effects.

A major conservative assumption lies in the description of the aquifer thickness and characteristics. It appears likely that the surficial aquifer is hydraulically separated from the subcropping bedrock by the clay layer, as illustrated in Figure 4. The top of the clay layer is situated approximately at Elevation 860 ft. MSL. The assumption that the surficial aquifer is isolated from the bedrock aquifers greatly limits the transmissivity of the aquifer and increases the effects of any hydrologic disturbance of the aquifer. Groundwater contours predicted by the model are shown in Figure 5.

The groundwater flow model was able to reproduce in general fashion the water table configuration as observed from lakes and wells. The flow pattern is believed to be reasonable but has not been calibrated against local field conditions. Flow is generally to the north from the site, which is a recharge area. Flow occurs in three directions toward the major discharge points for the surficial aquifer.

D. <u>Flow Velocities</u>

Using the conservative assumptions in the model, flow velocities are estimated to be relatively high. The assumption contained in this model is that the flow is confined to a single upper aquifer of relatively high permeability. If the aquifer were continuous with the Jordan aquifer, average flow velocities would be much lower. Using an estimated porosity of 30%, flow velocities in the study area are estimated to be 500 feet per year. This estimate is subject to wide variation due to uncertainties in the estimate of hydraulic conductivity and aquifer thickness and should be used with care.

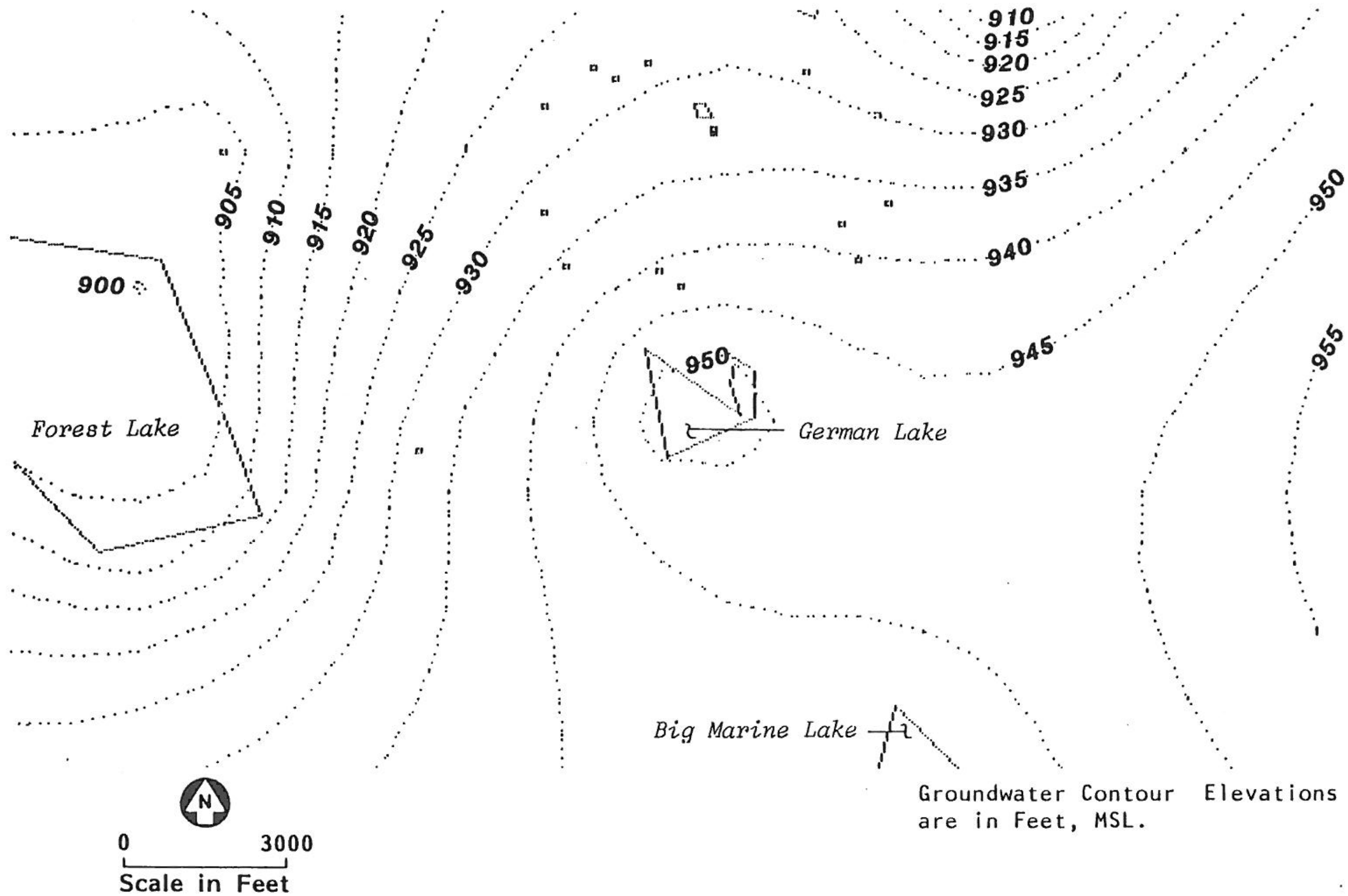

Figure 5

HYPOTHETICAL GROUNDWATER
MAP OF PRESENT CONDITIONS

IV. IMPACT OF PIT EXPANSION ON GROUNDWATER FLOW

A. Impact on Wells and Surficial Aquifer

Immediate Impact

The immediate impact of the pit expansion will be negligible until mining occurs below the groundwater table, estimated to be Elevation 925. At that time, the withdrawal of gravel from below the water table surface will produce a void in the soil which will be filled by groundwater. The net result will be to draw groundwater from other areas to fill the void. In any year, the withdrawal of gravel from below the water table will probably be a fraction of the total mining operation.

The withdrawal of 100,000 tons per year using a 7-month construction season and 10-hour work day would average 140 gallons per minute of solids withdrawn. A more conservative assumption may be made by assuming that a single dragline is working at a capacity of 2,000 yards per 10-hour day, when material with a wet weight of 120 pounds per cubic foot at 10 percent moisture content. This results in a calculated peak withdrawal rate of 233 gallons per minute. Both of these estimates represent extreme values for proposed withdrawal which will be mitigated by periods of disuse of the pit at night and during winter months.

Using the 233 gpm withdrawal rate, with average lake levels and infiltration of 4.75 inches per year, the groundwater model indicates a drawdown of 0.2 feet at German Lake and 0.6 feet at the nearest residential well due to excavation of the pit. Actual drawdowns would probably be less since excavation is not expected to occur constantly at such a high rate.

Long-Term Impacts

Over the duration of the pit expansion, a 50-acre lake will be created with a maximum depth of 45 feet. If we conservatively neglect the water already present in the soil voids, the average withdrawal rate over a period of 30 years is equivalent to a pump removing 1.7 gallons per minute. Even if the entire pond area were excavated in one year, the pumping rate would be equivalent to 51.63 gallons per minute. It may be seen that the long-term pumping rate will be far less than the peak rate analyzed above and that long-term effects of the pit expansion will be negligible.

V. IMPACT OF POND DEVELOPMENT ON GROUNDWATER FLOW

The development of a lake at the mining site could have two possible effects in addition to the impacts described above. One possible impact might be expected during extreme dry conditions when water will evaporate from the lake surface and be replaced by water from the surficial aquifer. This might tend to reduce levels in nearby lakes and wells. On the other hand, during periods of above-average precipitation the lake may tend to act as a recharge area for the local groundwater and increase water table levels.

The calculated maximum withdrawal rate during dry weather may be estimated by using the combination of wind speed and relative humidity as calculated in the 1980 study of the hydrology of Big Marine Lake (Barr, 1980). In that study, using weather data from Stillwater and Forest Lake, the maximum calculated lake evaporation for 79 years of record was 12.3 inches per month in 1936. Over a 50-acre lake, this would correspond to a withdrawal of 6.8 gallons per minute. To better simulate drought conditions, levels of Forest Lake and Big Marine Lake were set at Elevation 899.5 and 930.0, respectively. Assuming this steady state condition prevailed, the model predicts that maximum drawdown would be 1.3 feet at the nearest residential well and 0.5 feet at German Lake.

An alternative problem could be recharge of water from the pond due to wet weather. The anticipated watershed area of the lake will be 70 acres. Again, using the Big Marine Lake simulation, the effect of pit development was estimated for several of the wettest years. The worst case found was in simulation of the year 1965 when calculated yield to groundwater increased by 55 percent. This is equivalent to a recharge rate of 42 gallons per minute at the pond. Levels of Big Marine Lake and Forest Lake were set at Elevation 942.5 and Elevation 901.8, respectively. If this condition prevailed as a steady state, the model shows a hypothetical water table surface increase of 0.04 feet at German Lake and 0.05 feet at the nearest residential well.

VI. POTENTIAL CONTAMINATION FROM MINING EXPANSION

Contamination from Gravel Washing Operation

Gravel washing is not now carried out at the New Scandia Pit. The Barton Company stated that it has no current plans to install a wash plant but may install one if concrete production were begun at the pit. Concrete production would occur only if a nearby business opportunity occurred. Aggregate for use in concrete can have little or no material finer than a standard No. 200 sieve.

The gravel washing operation will produce an effluent containing very fine sand and silt-sized particles. Few if any clay size particles would be expected since washing of clayey materials is not considered a feasible process due to the cohesiveness of the clay materials. The wash plant effluent would be discharged to a settling pond. Water from the pond would be recycled to the wash plant. The settling pond would be emptied as required to retain enough volume to produce usable intake water for the wash plant. The bottom of the settling pond would be sealed with impervious material.

Two potential routes for contamination of groundwater from a gravel washing operation would be either contamination of the water through leaching of materials from the sand and silt into solution in the water or transport of the fine materials themselves into the groundwater system.

Leaching of materials from the soil particles in the wash plant into the groundwater does not appear to be a reasonable possibility. All materials in the washing process, including water, coarse soil particles, and fine soil particles, are already present in the groundwater system itself. As water flows through the soil in a natural condition, there will be decades or centuries available for solid material to dissolve into the groundwater. The fact that the water has been brought into contact with additional soil in the washing process does not appear to be a serious threat. This conclusion is based on the assumption that no chemical agents will be introduced to aid the washing process or accelerate the settling process.

The second scenario for groundwater contamination by wash plant would involve the passage of fine particles through the soil itself. In order for this to occur, the material to be transported would have to be dispersive and fine enough to pass through the natural soil. A dispersive soil is one which will break into individual particles. In Minnesota, clay soils are generally not dispersive and act as a continuous plastic mass rather than as individual particles. Particles of silt size are more dispersive.

For particles silt size or larger, the ability of a soil to screen particle movement has been analyzed for use in the design of dams. Terzaghi's filter criteria (Lambe, 1969) were applied to the soils on-site. This method indicated that a soil with an average particle size of approximately .05 mm would be effectively trapped even under the strong gradients present in earthfill dams. This would correspond to a silty soil. Under the far milder gradients and much lower velocities of the natural groundwater system, it appears unlikely that silt particles could travel through the soil.

In addition to this analysis, it may be reasoned that if natural soil particles could travel through the soil, in the course of geologic time natural groundwater flow would already have transported them to groundwater discharge zones such as Forest Lake or the St. Croix River.

In summary, movement of clay deposits or silt particles due to washing operations does not appear to be a likely problem.

VII. POTENTIAL CONTAMINATION FROM PAH's IN ASPHALT PROCESSING

A. Findings to Date

The major point of concern in reviewing the operation of the plant is the results of MPCA testing of the scrubber effluent and north pond. These analyses showed significant quantities of carcinogenic PAH's in the effluent from the scrubber and in the water in the north pond. The sum of total carcinogenic PAH's in the sample from the north pond was approximately .93 ug/L (micrograms per liter) or more than ~~300~~ 30 times the MPCA's standard for drinking water of ~~.0028~~ .028 ug/L. The ~~MPCA~~ Health standard for total non-carcinogenic PAH compounds in drinking water is .280 ug/L.

.028

B. Sources of PAH's in Asphalt Process

Two possible sources of the PAH's are the asphalt itself and the burner fuel. According to the Barton Co., the asphalt used in the operation is 85 to 100 or 120 to 150 penetration grade asphalt. Bituminous mix in 1987 has averaged 4.9% asphalt by weight so the plant uses 100 tons of asphalt per day of operation. Asphalt has been tested at other locations and found to contain from 3 to 100 ug/g of polynuclear aromatic hydrocarbons (IARC, 1985). It has been hypothesized that the steam produced in the drying operation causes the drum to act as a distillation column, stripping the light-end hydrocarbons from the liquid asphalt. (Gunkel and Bowles, 1985). The wet scrubber is an effective means of removing PAH's from asphalt plant air emissions (Lehmden et al, 1965) but the resulting scrubber water effluent will contain these PAH compounds.

Assuming that the asphalt used by Barton is represented by the previously cited values this would result in the processing of between 270 and 9080 grams per day of PAH's in the asphalt plant from the asphalt. Given the 200 gallon per minute water flow estimate, the PAH's in the asphalt alone, if totally transferred to the water, could produce a concentration of between .6 to 20 milligrams per liter. Since the PAH's found in the scrubber effluent are approximately 1,000 times weaker than this, it is evident that the remaining PAH's are either being retained in the asphalt or passed through the scrubber.

A second possible source of PAH's in the asphalt process is the fuel for the burner which heats and dries the aggregate product that is mixed with the asphalt. According to the Barton Co., the New Scandia plant is fueled with waste oil or No. 4 fuel oil at a rate of 1 to 1.5 gallons per ton of mix produced. In a normal day, therefore, 2,000 to 3,000 gallons of waste oil or No. 4 fuel oil are burned. Waste oil can contain large amounts of PAH's. A standard reference in this area (Verschuern, 1983) lists the following (non-inclusive) values for used motor oil after 10,000 kilometers (6,200 miles):

Pyrene	300 - 700 mg/kg
Chrysene	55 - 141 mg/kg
Benzo(a)pyrene	110 - 242 mg/kg
Benzo(ghi)perylene	46 - 83 mg/kg
Fluoranthene	129 - 270 mg/kg
Total Listed PAH's	640 - 1,436 mg/kg
Total Carcinogenic PAH's	211 - 466 mg/kg

The input of carcinogenic PAH's into the burning process could therefore be from 1300 to 3000 grams per day or roughly the same magnitude as the asphalt input. The fuel is, of course, subject to temperatures in excess of 1000 degrees which would tend to destroy these PAH'S through combustion. In summary, it appears that while significant amounts of PAH's are passing through the plant, far less than one fiftieth of one per cent is being discharged through the scrubber effluent. Another very small fraction of the total may be emitted through the stack but the majority appear likely to be retained in the asphalt or destroyed by burning. Nonetheless, the small amount of PAH's retained by the scrubber water are in excess of drinking water standards.

C. <u>Disposal of PAH's</u>

Since the scrubber effluent contains carcinogenic substances, the disposal of the effluent is of concern to the community. The scrubber effluent passes first to a small pond, approximately 60 feet by 100 feet in size. Most particulate matter settles out in this pond. The pond, according to Barton Co., is emptied of solids once or twice per year and the residual solids are re-introduced into the asphalt mix. The dry weight of material in the pond when full would be approximately 1,000 to 2,000 tons.

The pond occasionally overflows to the "north pond" where it infiltrates and evaporates. This pond was reportedly used by H&S Asphalt for disposal of fine materials from pit operations. The scrubber has an estimated annual water use of 1.4 million cubic feet per year or 10.5 million gallons per year. The two ponds could have an average evaporative capacity of approximately 2 gallons per minute. According to the Barton Company none of the water is recycled, so it is evident that almost the entire pumpage is re-introduced to the groundwater.

It might be thought that the particulate matter in the effluent would have a significant portion of the PAH's adsorbed on it. Most particulates are removed in the first pond by sedimentation and re-introduced into the asphalt process for disposal. Disposal of the particulate matter would be equivalent to disposal of the PAH's. Unfortunately, particulate matter is recycled only from the first pond and PAH concentrations are not significantly lower in the second pond than in the first. It appears that either in the scrubber or in the primary pond a solution equilibrium may be achieved between adsorbed and dissolved PAH's. This means that the majority of PAH's from the scrubber leave the site via the groundwater system.

The groundwater model indicates that the majority of the water infiltrated into the pond will be recaptured by the well when it is operating. Testing of the Barton Pit well would verify some of the assumptions and tentative conclusions listed above.

D. Groundwater Transport of Contaminants

It appears likely that immediately adjacent to the Barton ponds a region of groundwater exists which contains carcinogenic PAH's. It is well known that PAH's adsorb readily onto fine particles in the soil and it would appear that significant attenuation of concentrations would be expected. However, given the estimated flow velocities and length of time which the present plant has operated, water from the site could have travelled thousands of feet.

The groundwater model developed in this study is intended to be a hypothetical "worst case" description of the groundwater flow for analysis of drawdown effects. Using this model for determination of groundwater flow patterns and velocities was not felt to be a responsible procedure.

E. Evidence of PAH Contamination of Nearby Wells

The 1987 well testing program described in the introduction was reviewed to determine if any significant conclusions could be reached from these data regarding the likelihood of residential well contamination.

The major problem with the data is that all analyses were conducted with High Performance Liquid Chromatography. This method is very susceptible to false positive readings due to interference from other organic molecules of similar molecular weight or structure. The alternative to this method would be the use of gas chromatography with detection by mass spectrography with enhanced low-level resolution. Unfortunately, this method is not available to the MPCA through the Department of Health and few, if any, laboratories in the Twin Cities area have the equipment to perform it. Costs for this method are at least four hundred dollars per sample.

The Serco Analyses of the Fena, Sandok and Nelson wells were performed using HPLC with a single ultraviolet absorbtion detector. A text on PAH analysis (Futoma et al, 1981) stated:

"The main advantage of UV (ultraviolet) detectors is that they are simple and easy to operate. In practice, their usefulness for PAH detection of HPLC elutants is generally confined to a subordinate role. UV detectors are often used in series with fluorescence detectors as a means of providing a general response before the fluorescence detector provides a more selective response."

Without a fluorescence detector, therefore, false positive readings are very likely. The positive readings obtained from the Nelson, Sandok and Fena wells should be viewed with extreme caution. Where substances are detected at levels very close to the detection limit, or where a duplicate analysis does not detect the substance, the analysis may be considered to have very little reliability.

The Warning well sample was also analyzed by HPLC but the laboratory used both ultraviolet and fluorescence detectors. Greater confidence can therefore be placed in the results of this analysis. Since the greatest danger with HPLC is from false positive readings, the finding of no PAH's can be considered reasonably certain.

The Department of Health analyses were also performed by HPLC with two UV and two fluorescence detectors. Two wavelengths were used for each type of detector to increase the certainty of identification of individual PAH's. The generally negative results can therefore be viewed as reasonably certain. The Department of Health analysis of the Serco extracts of the Sandok and Nelson samples showed some indications of PAH's in one analysis. Values were at or near the detection limit in one case. A duplicate analysis indicated no detectable PAH's. Such ambiguous results again indicate the likelihood of false positive readings. This judgment is reinforced by the fact that previous analyses of these wells by the Department of Health had produced negative results.

In summary, the data examined show no solid evidence that PAH's have been found in private wells.

VIII. RECOMMENDED MEASURES

1. Sample Barton Well. The Barton well is the most likely location for determination of PAH concentrations passing into the groundwater at the site. It is already installed and can be easily sampled. The high pumping rate and proximity to the infiltration ponds mean that if PAH's are found anywhere in the groundwater, they should be found here first. Because of the importance of this location, sampling using GC/MS methods and strict quality control procedures would be advised.

2. Install Monitoring Wells Monitoring wells will help determine groundwater flow directions and can be sampled for organic compounds. The water level readings will also help determine whether local well failures or lake level changes could conceivably be related to operations in the Barton Pit. At least three wells will be needed to determine groundwater flow. These wells must be installed with caution to ensure that neither the soil nor well materials are contaminated during installation. The exact location and construction of the wells should be determined by the Barton Company and the MPCA.

3. Eliminate Infiltration of Scrubber Effluent The Barton Company should be required to present a plan for elimination of infiltration of scrubber effluent on their site. The simplest method would be to use a baghouse for particulate control. This would eliminate the entire water cycle in the plant.

   A wet scrubber presents the continuing problem of leakage but also has the benefit that the well on site will be used intermittently to provide make-up water and will therefore remove contaminated groundwater. If a wet scrubber will continue to be used, the plan should include requirements for an adequate holding area capable of removing particulates to the degree necessary to recycle the water. It should also address the need for sealing the effluent holding area and for protecting and verifying the integrity of the seal, especially during sediment removal operations. The plan should include adequate record keeping to establish the water balance of the plant and include the

LIST OF REFERENCES

1. Asphalt Institute, A Brief Introduction to Asphalt, Seventh Ed., College Park, Md, 1974.

2. Barr Engineering Co., "Hydrologic Analysis of Big Marine Lake and Big Carnelian Lake", 1980.

3. Futoma, D. J., Smith, S. R., Smith, T. E., and Tanaka, J., Polycyclic Aromatic Hydrocarbons in Water Systems, CRC Press, Boca Raton, 1981.

4. Gunkel, Kathryn and Bowles, A., "Drum Mix Asphalt Plants -- Maryland's Experience", Presentation at Annual Meeting of Air Pollution Control Association, Detroit, June, 1985

5. Hobbs, H.C., and J.E. Goebel, 1982, Geologic Map of Minnesota Quaternary Geology, 1:500,000, Minnesota Geological Survey State Map Series S-1.

6. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans; Polynuclear Aromatic Compounds, Part IV, Bitumens, Coal-Tars and Derived Products, Shale-Oils and Soots, International Agency for Research on Cancer, Lyon, 1985.

7. Lambe, T. W. and Whitman, Robert V., Soil Mechanics, John Wiley & Sons, New York, 1969.

8. Larson, D. Unpublished Water Table Maps in Files of United States Geological Survey, St. Paul, 1972.

9. Lehmden, D. J., et al, "Polynuclear Hydrocarbon Emissions from Selected Industrial Processes" ,Journal of the Air Pollution Control Federation 15(7), July, 1965.

10. Meyer, Adolph, Elements of Hydrology, Second Ed. John Wiley & Sons, New York, 1944.

11. Strack, O.D.L. and H.M. Haitjema, "Modeling double aquifer flow using a comprehensive potential and distributed singularities, 1. Solution for homogeneous permeability. Water Resources Research 17(5), pp.1535-1549, 1981.

12. Verschuern, K., Handbook of Environmental Data on Organic Chemicals, Second Ed., Von Nostrand, Reinhold, New York, 1983.

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