US EPA RECORDS CENTER REGION 5
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List of Summarized Reports

Description of Former Reilly Site and Operations

1. Student project (U of Minnesota) on the Creosote Problem in St. Louis Park by James F. Bailey (July 1, 1978).

2. Memorandum of Waste Disposal Republic Creosote Company and Reilly Tar and Chemical Company by Dale Wikre, Kyle Bishop, G.R. Koonce (April 22, 1970).

3. Reilly memorandum form C.F. Lesher to P.E. White discussing Reilly's operating conditions (May 14, 1968).

4. "Report on Investigation of Disposal of wastes at the Republic Creosote Company, St. Louis Park, Minnesota" by L.L. Kemps (May, 1938).

5. "Report on Waste Disposal at Republic Creosote Company and Reilly Tar and Chemical Company, St. Louis Park" by G.R. Koonce, E.A. Pryzina (April, 1970).

6. Memorandum from J. Fred McCarthy--driller contracted by St. Louis Park (December 13, 1934).

Hydrogeologic Studies

7. "Preliminary Evaluation of Ground Water Contamination by Coal Tar Derivatives, St. Louis Park, Minnesota" by Marc F. Hult, Michael E. Schoenberg (October, 1979).

8. "Contamination of Ground Water by Coal Tar Deriatives, St. Louis Park Area, Minnesota--Conceptual Basis, Methodology and Preliminary Resutls of Physical Laboratory Models" by H.O. Pfannkuch (1979).

9. "Soil and Ground Water Investigation--Coal Tar Distillation and Wood Preserving Site, St. Louis Park, Minnesota" by Allan Gebhard (June, 1977).

10. "Hydrogeologic Study of the Republic Creosote Site" by Gerald M. Sunde (July, 1974).

Environmental Contamination Studies

11. Memorandum from Rolland Grabbe, Organics Section Chief, U.S.G.S. Denver Laboratory (September 4, 1980).

12. "Report of Soil Sampling--City of St. Louis Park" by Hubert H. Huls (June 5, 1979).

13. "Report of Well Water Survey--St. Louis Park, Minnesota" by Lawrence H. Breimhurst (August 3, 1978).

14. "Soil Contamination by Creosote Wastes--A Quantitative Physical/Chemical Analysis of the Northern Portion of the Former Republic Creosote Site" by National Biocentric, Inc. (November 1, 1976).

15. "Report on Investigation of Phenol Problem in Private and Municipal Wells in St. Louis Park, Minnesota, Hennepin County" by Minnesota Department of Health (September 1974).

16. "An Assemblage of Analytical Data Regarding the Reilly Tar and Chemical Property, St. Louis Park, Minnesota" by St. Louis Park Health Department (August 1, 1972).

17. Letter from Sewer Board to H. McPhee, City of St. Louis Park Re: Discharge of Contaminated Pond Water to Sewer by Russell Susag (July 27, 1972).

18. Letter to H. McPhee, City of St. Louis Park, Re: Phenol Contamination of Wells in St. Louis Park by R. Burd (November 5, 1970).

19. Memorandum from R.E. Frazier, MDH, Re: St. Louis Park well water analyses (April 20, 1970).

20. "Preliminary Soils Investigation for Republic Creosote Company" by J.S. Braun (October 13, 1969).

21. "Ground Water Investigation Program at St. Louis Park, Minnesota Progress Report 1" by Eugene A. Hickock (September 26, 1969).

Potential Pollutant Sources Other Than Reilly

22. U.S.G.S. Memorandum to M. Hult from E. Godsy: Bacterial Sampling at St. Louis Park, Minnesota (September 16, 1980).

23. Letter to E. Ross from M. Hult Re: Multi-aquifer Wells (April 23, 1980).

24. Letter to MPCA Concerning Pentachlorophenol Contamination of the Androc property well in St. Louis Park, Minnesota by David Giese (April 19, 1979).

25. "Report on Investigation of Individual Water Supplies, St. Louis Park, Minnesota" by F.J. Kilpatrick, Paul B. Johnson (March 11, 1960).

Risk Assessment

26. "Epidemiologic Investigation of Third National Cancer Survey Data for St. Louis Park, Edina, Richfield and the Minneapolis-St. Paul Standard Metropolitan Statistical Area with a Historical Review of St. Louis Park's Water Supply" by Kari H. Dusich (September, 1979).

27. "Health Implication of Polynuclear Aromatic Hydrocarbons in St. Louis Park Drinking Water" by MDH (November, 1978).

28. "Assessment of Possible Human Health Effects Resulting from the Contamination of the Former Republic Creosote Site" by MDH (October, 1977).

Remedial Measures and St. Louis Park Restoration Projects

29. "Proposal for Consultant Services--Drinking Water Treatment and Remedy Evaluation" by Eugene A. Hickock (April 11, 1980).

30. "Feasibility Study of Providing a Section of St. Louis Park with Minneapolis Water" by Naeem Qureshi (April 7, 1980).

31. "Summary Report on the City of St. Louis Park Activated Carbon Pilot Plant Study--July and October 1979" by Daryle A. Thingvold (January 11, 1980).

32. "Proposal for Analysis and Plan--Remedy of Ground Water Contamination St. Louis Park" by Eugene A. Hickock (January 1980).

33. Requests for Proposals of Study: Evaluate, and Prepare a Cost Analysis and Plan for the Remedy of Ground Water Contamination Resulting from Discharge of Industrial Chemicals at the Site of a Former Creosoting Plant by Edwin H. Ross (November 20, 1979).

34. "Louisiana Avenue Extension Report" by MDH, Soil Exploration of St. Paul, Braun Engineering, Serco (1978).

35. Letter to Richard Koppy, City of St. Louis Park, Re: Excavation of Contaminated Soil from Oak Park Village Area by Archie Carter (January 10, 1978).

36. "Soil Investigation--Proposed Storm Sewer and Holding Ponds Near Highway 7 and Louisiana Avenue, St. Louis Park, Minnesota" by Donovan K. Stormoe (April 16, 1974).

37. Letter to G. Koonce, MPCA, in reference to storm water study performed by Orr-Schelen-Mayeron by John Badahich (November 15, 1973).

38. "Storm Water Study, Public Improvement No. 72-43 (Republic Creosote Area)" by Wayne R. Long (August 6, 1973).

39. "Surface and Subsurface Ground Reclamation--Republic Creosote Site" by Wayne R. Long (April 23, 1973).

Miscellaneous

40. "St. Louis Park Water Supply System" by Kari H. Dusich (1979).

41. "Water Resources Data for Minnesota, Water Year 1976" by U.S.G.S. (July 1977).

42. Transcript of Public Hearing for the Application of the City of St. Louis Park for an NPDES Permit to Discharge from a Wastewater Treatment System on the Former Republic Creosote Site to Minnesota Creek conducted by MPCA (February 27, 1975).

Description of Former Reilly Site and Operations

Title

Student project (U. of Minnesota) on the creosote problem in St. Louis Park

Author

James Bailey
Student, University of Minnesota

Date

July 1, 1978

Purpose

To describe the operations at the Republic creosote refinery and treatment plant from start to finished product. Also, to present background information on the wood preserving industry.

Context

Four avenues existed for creosote contamination:

1. Major spillage due to tank failure, accidental overflow, etc.;

2. Everyday spills, leaky pipes, drippings from treated wood products, etc.;

3. Seepage from waste water disposal ponds and sludge disposal sites;

4. Rainwater runoff through the creosotes yard.

The only waste water from the wood treatment process was stream condensate and boiler blowdown which were discharged into a settling basin. The overflow from the basin passed through the same line to the ditch, as the waste water from the refinery.

The refinery received coal tar from which the lighter fractions (naphthalene, benzene, etc.) had already been removed.

The creosote oil was produced by the distillation process. The 2% "wet cut" was removed from the oil and discharged through a pipe line into a skimming tank along with the condensor cooling water (volumetric flow rate = 40 gallons per minute [gpm]). The 2% "wet cut" amounted to 10,000 gal/month.

The skimming tank underflow passed through two straw filters before discharging into the ditch which passed under Highway 7.

Summary

The Republic Creosote Plant did not store petroleum products on their property in a safe manner. The effluent from the refinery and treatment processes were not adequately filtered before discharge. Runoff water was allowed to cross the plant property, possibly picking up creosote residues, instead of being diverted away from company property.

Report presents a flow diagram of plant.

Title

Memorandum of Waste Disposal, Republic Creosote and Reilly Tar and Chemical Company

Authors

Dale Wikre, Kyle Bishop, G.R. Koonce

Agency

MPCA

Date

April 22, 1970

Time Period

Sampling inspections conducted April 14 and 18, 1970

Purpose

Bioassays and phenol analyses were conducted at several points in the transport of wastes from the Reilly site to assess the environmental hazard of the Reilly waste disposal practices.

Data

Upsteam of the culvert leaving the Reilly property - 4/18

	Phenol	Fathead Minnows
No dilution	-	immediate fatality
25% dilution	227 mg/l	immediate fatality
5% dilution	55 mg/l	fatality w/in 24 hours

Pond South of Highway 7

No dilution	14-19 mg/l	fatality w/in 24 hours
75% dilution	10.5-17 mg/l	fatality w/in 24 hours

4/14 data was analyses for biological oxygen demand (BOD), dissolved oxygen (DO), suspended solids (SS), and turbidity.

Conclusions

1. Reilly is operating in violation of Minnesota water quality regulations for discharge of phenols and without a permit.

2. The 96 hour TL_m50 for fathead minnows is between 8-19 mg/l of phenols. [TL_m50 = concentration at which 50% of the test oganisms survive within the specified time limits.]

3. The authors were unable to conclude that runoff water is leaching phenols from the Reilly property to the ground water.

COPY

REILLY TAR & CHEMICAL CORPORATION

Mr. P. E. White - St. Louis Park

Indianapolis

C. F. Losher

May 14, 1968

ST. LOUIS PARK - WATER POLLUTION

During my visit last week, we reviewed in general the refinery operating conditions that might contribute to water pollution at St. Louis Park, and the following are notes on this for our files.

Reference to the files will indicate that the plant does have a crude settling basin installed some years ago. This was originally equipped with baffles so as to settle out and permit pumping off of sediment and heavier oils. The effluent then flows by gravity underground through the plant to an open trench along the property line and from there under Walker Street out of the plant. At the time of our observation last week, the level of solids in the settling pond was quite high, the condition of the baffling system in the pond is questionable, and the visual appearance and quantity of oil going out of the plant was terrible.

One of the problems in operation of the settling basin could be the solids from the boiler blowdown. They increase the quantity and consistency of settlings in the basin, making them difficult to dispose of and changing their characteristics, as well as settling out along the entire effluent system when they aren't controlled within the settling basin. Consideration might be given to additional or supplementary facilities to handle those separately or bypass them.

With reference to the refinery, the water cut is presently dropped by gravity from the pans into your ground tank #5. General practice is to pump material from the ground tank about twice per week, moving the oil into storage, following the visual appearance of the oil by a stream sample off the pump, and when water is reached the header is switched and the water is discharged into the trench at the refinery. The trench flows through the refinery into the sump adjacent to the above mentioned settling basin and the sump pump pumps the material up into the far end of the settling basin. Present changes in the refinery include the installation of above ground receiving tanks. One of these will be used for the water cut. The water cut tank will have side outlets to permit draining water into a line to the settling pond. These changes are expected to be completed this year.

Contaminated water also originates at the tar cistern. Water accumulates on the surface of the tar and is handled quite irregularly, possibly at 30 to 60 day intervals. The water is either pumped off the surface of the tar in the cistern onto the yard or it is overflowed from the cistern onto the yard. Theoretically, the yard in this area runs off southwest towards the effluent outlet under Walker Street.

COPY

REILLY TAR & CHEMICAL CORPORATION

We urgently need an overall review of our water handling and a total plan towards which we can proceed in steps.

Very truly yours,

C. F. Lesher

CFL/bc

cc: Mr. H. L. Finch - St. Louis Park
Mr. M. Mitchell - Reilly Lab.
Mr. R. J. Hennessy - Reilly Lab.

REILLY LABORATORIES
Indianapolis, Ind.
CLEARED

104351

Title

Report on Investigation of Disposal of Wastes at the Republic Creosote Company, St. Louis Park, Minnesota

Author

L.L. Kemps, Assistant Public Health Engineer

Agency

MDH

Date

May 1938

Purpose

Summarize and investigate Reilly's disposal methods
Major products--creosote and road oil
Secondary products--benzol, tar acids and coke
18,000 gpd production capacity (tar) 6,000 gallons of water discharged weekly to swamp.

5/16/38	Drainage ditch to swamp	200 gpm	(estimated flow rate)
5/18/38	Drainage ditch to swamp	150 gpm	(estimated flow rate)

Tar accumulation on sides and bottom of ditch

Sample data

Phenols--data had been presented in attachment to report which was lost over the years.

Conclusions

A number of wells have been abandoned because of tarry taste (at least 8 wells effected according to this survey). No sources other than Reilly and Republic Creosote of materials causing tarry taste identified in this survey.

Recommendations

Current disposal methods should be discontinued. The water should be treated and wastes disposed of elsewhere.

Location

U.S. EPA, Region V files

Title

Report on Waste Disposal at Republic Creosote Company and Reilly Tar Chemical Company, St. Louis Park

Authors

G.R. Koonce, E.A. Pryzina

Agency

MPCA

Date

April 1970

Purpose

This report incorporates the April 22, 1970, Wikre, et.al., report and summarizes the investigative and analytic information conducted in previous inspections regarding Reilly's disposal methodologies.

Data

	Phenols (mg/l)		
	4/16/70	8/1/68	6/13/68
effluent at source	-	380	160
effluent leaving property	1100	140	130
pond at W. Lake & Louisiana	18.3	-	-
at first pond	-	1.9	-
at second pond	-	0.8	-
Highway 7	-	15	-
Minnehaha Creek upstream	.01	-	-
Minnehaha Creek downstream	.01	-	-

(See attached maps for sampling locations)

Conclusions

1. Effluent acutely toxic to fathead minnows.

2. Effluent discharged is in violation of Minnesota standards for phenol, BOD suspended solids and turbidity.

3. Company does not have operating permit for a waste disposal system.

4. Phenolic contamination of soils is "undesirable" and may cause contamination of municipal water supply.

5. Actual surface runoff pollution problem and potential ground water pollution problem.

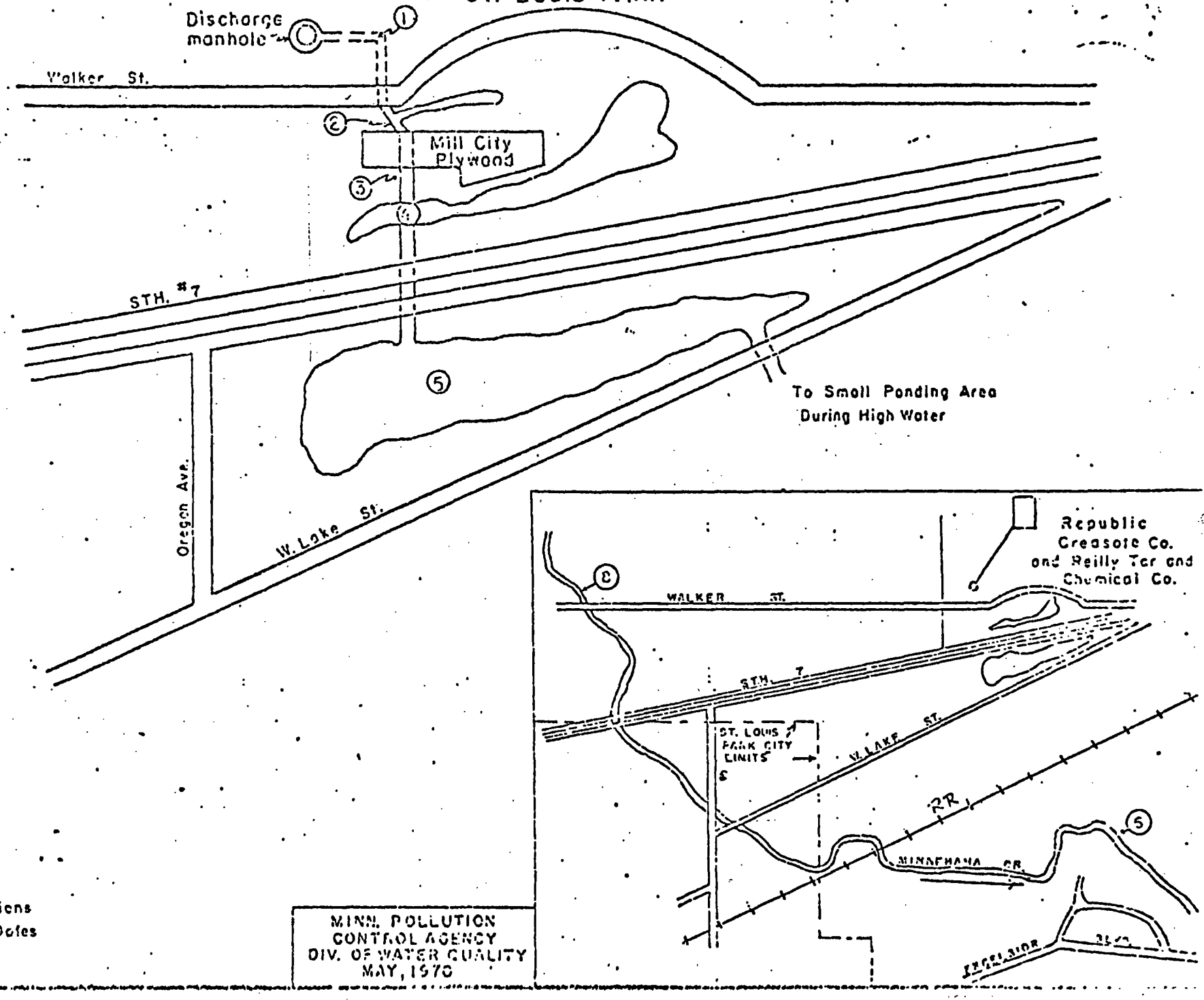
Recommendations

1. Adequate treatment of wastes prior to discharge.
2. Adequate safeguards on storage tanks.
3. Control and divert runoff.
4. Consider excavation of contamination site.

Location

U.S. EPA, Region V files

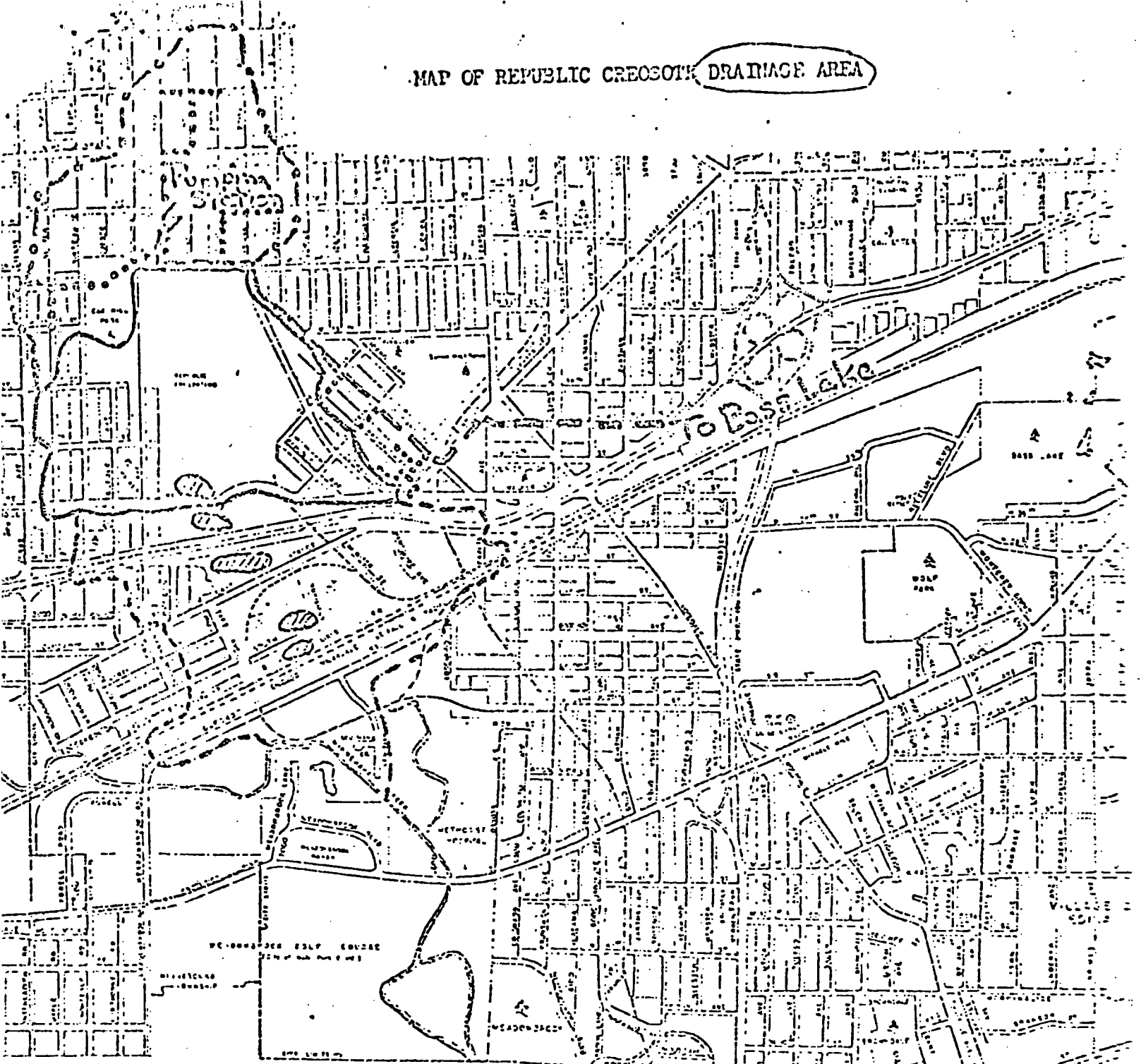
SKETCH MAP OF REPUBLIC CREOSOTE CO. AND REILLY TAR AND CHEMICAL CO. ST. LOUIS PARK



LEGEND
1-Sampling Stations
4-14-70, 4-18-70. Dates

MINN. POLLUTION CONTROL AGENCY
DIV. OF WATER QUALITY
MAY, 1970

MAP OF REPUBLIC CREOSOTE DRAINAGE AREA



LEGEND

Area at present DRAINING INTO Creosote area

Area DRAINING INTO PROPOSED STORM SEWER (Part of Proj. 66-17) OUTLET INTO Ma'ha'ha Creek

Area WITHHELD FROM Cresote area by PONDING AND PUMPING

Present PONDING

Proposed storm sewer & under const. by Lamotti & Sons

INFORMATION FROM STORM SEWER PROJECT 66-17 by DUANE LORSU[illegible] ENGR. DEPT. St. LOUIS PA[illegible]

C- 5	Quebec Avenue	J-11	Woodland Drive	N-10	
O-20	Quebec Drive	F-10	Wood Lane	R-16	
	Quentin Avenue	I-18	Wyoming Avenue	K- 5	
O-16					
C- 5	Raleigh Avenue	I-18	Kenwood Avenue	I-16	
J-12	Randall Avenue	K-21	Xylon Avenue	K- 9	
O-13	Republic Avenue	L-13			
[illegible]	[illegible]	J-1[illegible]	Yeager Avenue	I-1[illegible]	

Title

Memo from J. Fred McCarthy--Driller contracted by SLP for repair of municipal well

Author

J. Fred McCarthy, McCarthy Well Company

Agency

for SLP

Date

December 13, 1934

Time Period

contracted February 1933

Purpose

McCarthy was employed by the city to case a well above the Jordan aquifer in an effort to repair the well for use. (We think they were talking about old SLP #1. Unfortunately the actual well was never specified in memo. Old SLP #1 was closed in 1933 because of tarry taste and to prevent infiltration of tar materials into the well.)

Location

SLP Public Works files
U.S. EPA, Region V files

Comment

The memo described the packing techniques and materials ulitized.

In the first paragraph, McCarthy mentions two wells on Reilly site used by Reilly to drain creosote into the deeper aquifers.

Hydrogeologic Studies

Title

Preliminary Evaluation of Ground Water Contamination by Coal Tar Derivatives St. Louis Park Area, Minnesota

Authors

Marc F. Hult, Michael E. Schoenberg

Agency

U.S.G.S. in cooperation with MDH

Date

October 1979

Time Period

Fiscal year 1979 (Report is part of an ongoing study.)

Purpose

The total project will attempt a detailed understanding of the ground water flow and the transport of organic materials in the SLP area. This report presents a preliminary assessment of the problem and makes available the collected data. (This report is not interpreted in detail.)

Conclusions

Operation of the Reilly plant between 1917-1972 resulted in a long and complex history of ground water contamination. Coal tar derivatives have entered the ground water system through three major paths. Drift contamination resulted from: 1) infiltration of spills and drippings; 2) recharge from ponds south of the site which recieved process runoff and contaminated process water.

Prairie du Chien-Jordan contamination has resulted in part from: 3) W-23 coal tar contamination. Multi-aquifer wells have significantly contributed to contamination of the Prairie du Chien-Jordan.

Location

M. Hult's file, U.S.G.S.
U.S. EPA, Region V files

Comment

Much data was collected in this first year of study. This is an important report as there is a very thorough explanation of the geologic system.

Title

Contamination of Ground Water by Coal Tar Derivatives, St. Louis Park Area, Minnesota--Conceptual Basis, Methodology, and Preliminary Results of Physical Laboratory Models

Author

H.O. Pfannkuch
Professor, Department of Geology & Geophysics
University of Minnesota

Agency

for U.S.G.S.

Date

1979

Time Period

1979 to present

Purpose

This report is background or supplemental to column studies being conducted by Pfannkuch. The purpose of these column studies is to: 1) outline the physical parameters of dispersion and sorption; 2) describe the laboratory measurements and methodologies; and 3) generally relate the laboratory situation to the field. The results of these column studies will be used to: 1) refine the modeling being done by Hult; 2) guide field data collection; and 3) provide values for the digital computer transport model.

Pfannkuch is using three types of columns: 1) Ottawa sand (control); 2) Drift; and 3) St. Peter sandstone. Sodium chloride was used as a tracer. Phenol was used as a standard and naphthalene as an experimental transport compound.

This project is a subcontract of the MDH-U.S.G.S. cooperative arrangement.

Conclusions

The main purpose of the reported experiments was to validate the test methodologies for future laboratory column sorption studies. The results showed a typical bell-shaped response to the input function, slightly skewed to the right which is expected when adsorption occurs. The breakthrough curves were characteristic of adsorption.

Location

M. Hult's file, U.S.G.S.

Comment

No numerical values of dispersion or sorption coeffecients were published within this report. Hopefully, such parameters will be developed form future experiments.

Title

Soil and Ground Water Investigation--Coal Tar Distillation and Wood Preserving Site, St. Louis Park, Minnesota

Author

Allan Gebhard, P.E., Barr Engineering

Agency

for MPCA
($108,000 from the Legislature in 1975)

Date

June 1977

Time Period

Phase I--Spring 1975 - May 1976
Phase II--May 1976 - June 1977

Purpose

1. Measure the extent of coal tar wastes in the soil;

2. Measure the effects of these wastes on surficial and bedrock ground water quality;

3. Define the interactions between the surficial ground water systems and the underlying bedrock aquifer;

4. Predict future impacts of the waste deposits on ground water quality; and

5. Recommend corrective actions and further studies necessary to solve any identified problems.

Data

Two phases for data collection totalling 17 soil borings and ground water samples. Phase I data were used to draw concentration isopleths of phenol and benzene extractables. Phase II data are attached.

Conclusions

See attachments

Recommendations

See attachments

Location

U.S. EPA, Region V files

Comment

Sample data were analyzed for phenols and benzene extractables, neither of which are very specific. The benzene extractable data is not included because we do not have the historical links that are available with phenol analyses. Gebhard also concluded that it was not possible for the Prairie du Chien-Jordan municipal wells to be contaminated with coal tar derivatives. However, Gebhard did not mention the significance of multi-aquifer wells in this report. In the Barr report, the only transport mechanisms considered were horizontal and vertical seepage, not multi-aquifer well contributions.

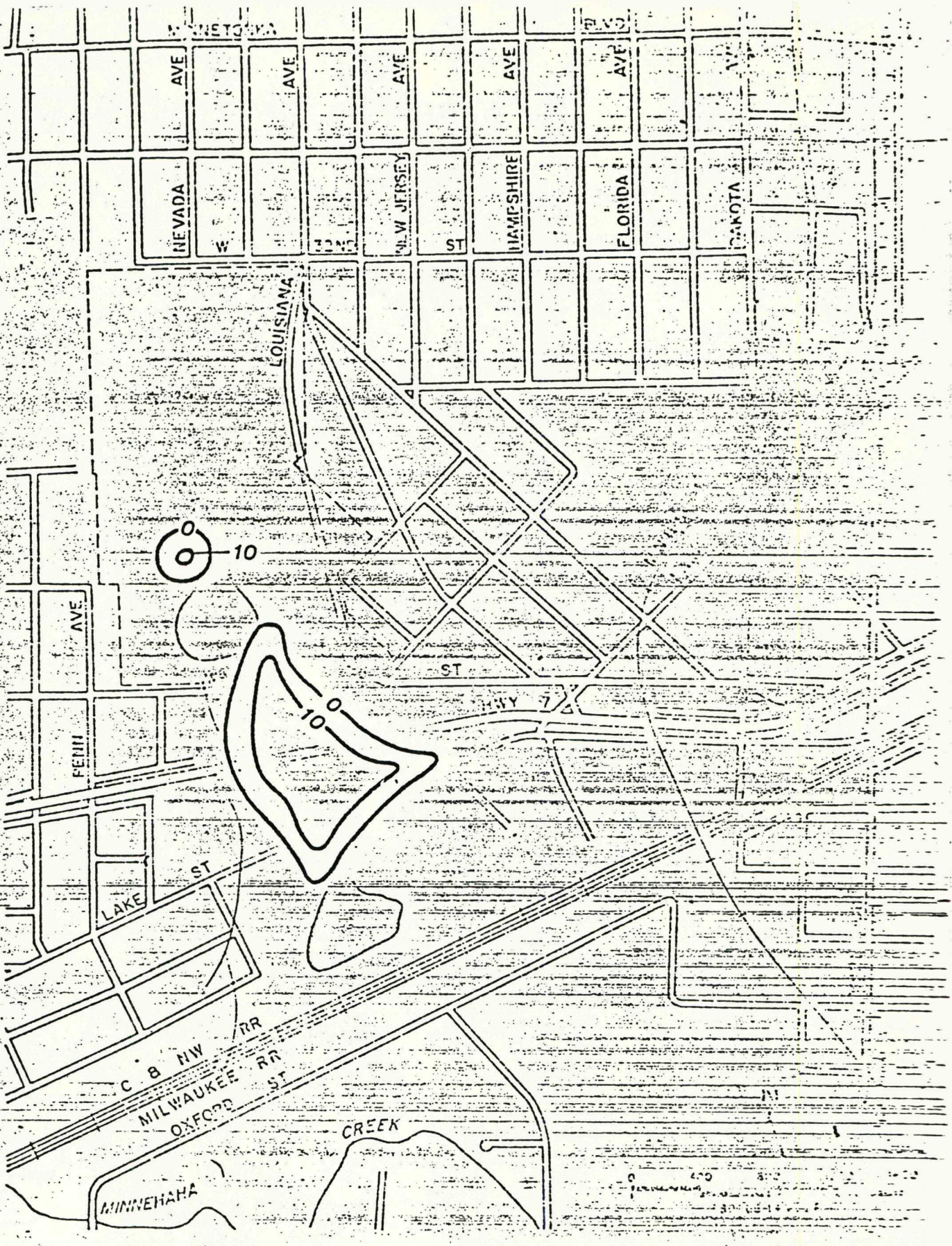


FIGURE 29

REMOVAL DEPTH CONTOURS
Soil With Phenolic Concentrations
Greater Than 10 mg/kg

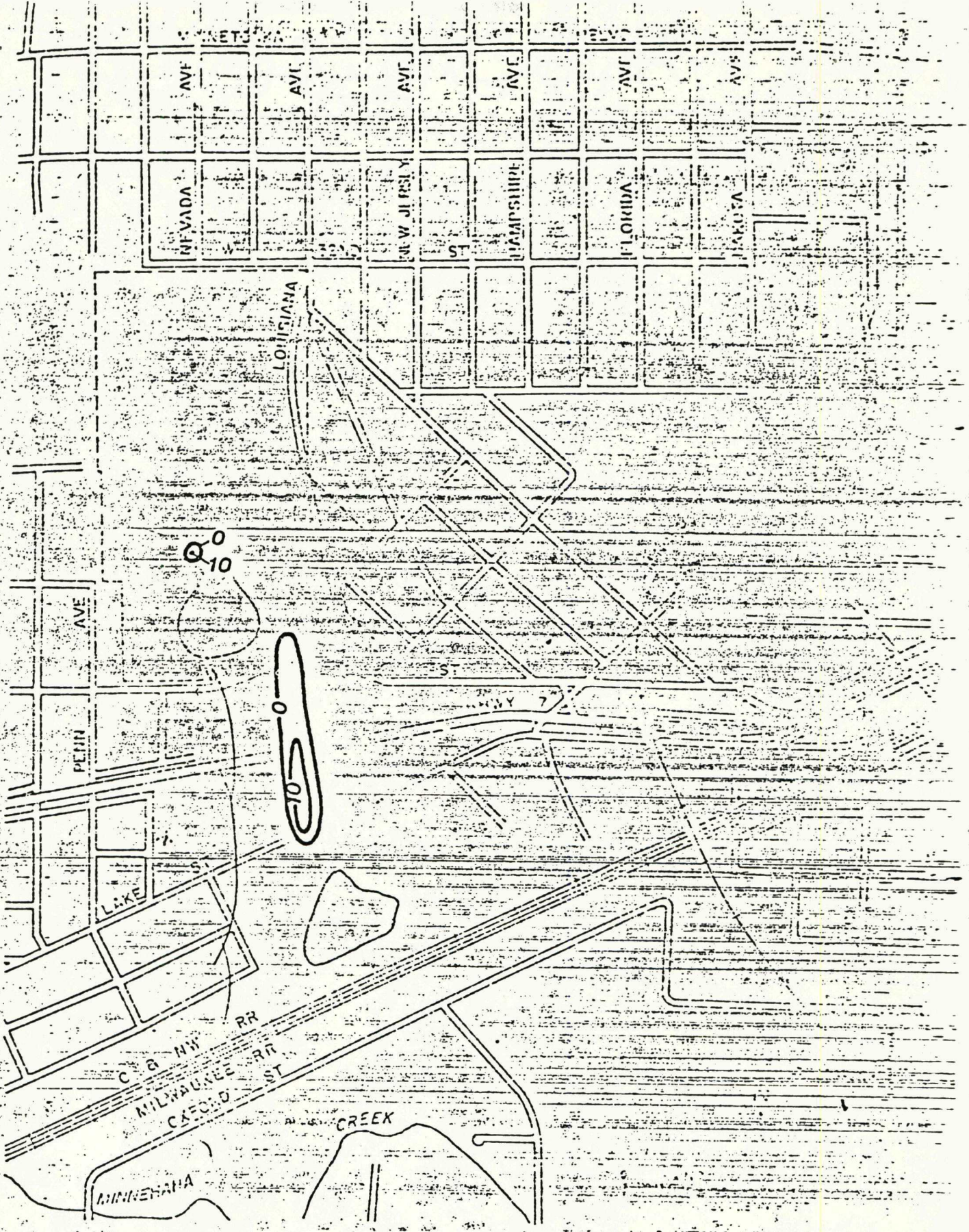


FIGURE 30

REMOVAL DEPTH CONTOURS
Soil With Phenolic Concentrations
Greater Than 100 mg/kg

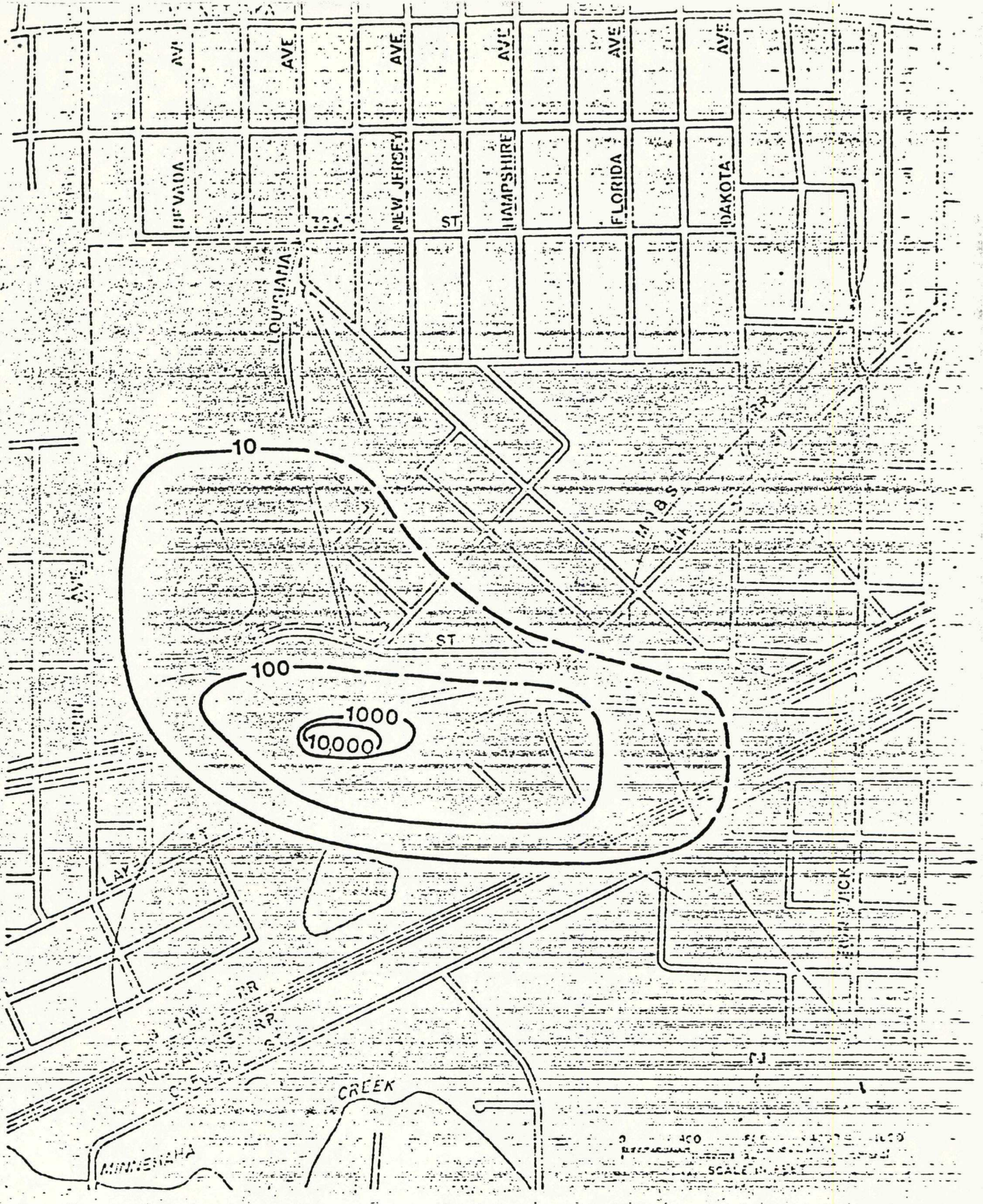


FIGURE 16

PHENOLIC CONCENTRATION CONTOURS--
GLACIAL DRIFT (μg/l)--FIRST INTERPRETATION

groundwater

middle aquifer:
Prairie Du Chien
Jordan
Aquifer.
BARR
ATTACH 5

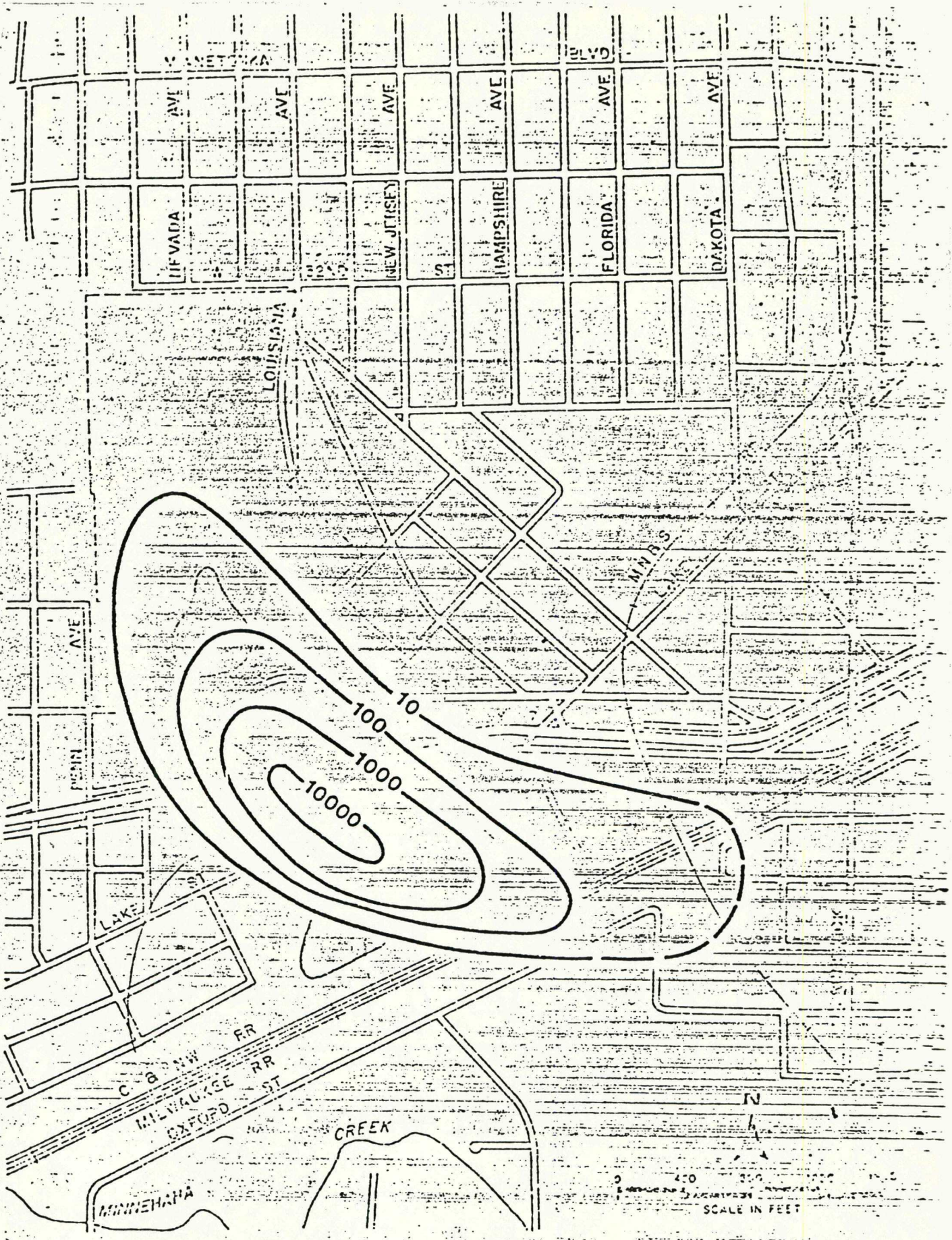


FIGURE 17

PHENOLIC CONCENTRATION CONTOURS--
GLACIAL DRIFT (μg/l)--SECOND INTERPRETATION

groundwater

SECTION VII

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Based on the analyses carried out in this study, the following conclusions are made:

1. Analytically detectable quantities of coal-tar derivatives were present in approximately 90 percent of the soil samples collected and analyzed during this study. Coal-tar derivatives are present in much greater concentrations throughout the soil column on the southern portion of the coal-tar distillation and wood-preserving site and south of the site than on the northern one-half of the site. For example, benzene extractable concentrations greater than 1,000 mg/kg are present at a depth of 50 feet south of the site, whereas they are typically present at concentrations between 100 mg/kg and 200 mg/kg below the surface soils on the northern portion of the site. Chrysene, benz(a)pyrene, benz(c)phenanthrene and a number of other unidentified polynuclear aromatic hydrocarbons are present in the visible coal-tar wastes found near the surface throughout the study area and at depth south of the site. No attempt was made in this study to define the public health risks associated with these materials in the soil.

2. Ground water in the glacial drift south and southeast of the site is moving laterally through the outwash material and vertically into the Platteville limestone. Vertical flow to the Platteville in the area southeast of the site is equal to or greater than lateral flow through the outwash. Ground water movement through the Platteville is lateral, most likely toward the buried bedrock valley southeast of the site.

3. Ground water in the glacial drift south and southeast of the coal-tar distillation and wood-preserving site is contaminated with coal-tar derivatives. From its point of deposit by surface flows, the movement of the waste has been lateral with ground water flow and vertical due to its higher specific gravity and due to the vertical ground water movement. The wastes contain measurable phenolics and polynuclear aromatic hydrocarbons such as pyrine. Polynuclear aromatic hydrocarbon concentrations of 3,400 mg/1 and phenolic concentrations of 50 mg/1 have been detected at a depth of 50' below the ground surface in the area between Lake Street and Highway 7. These wastes have traveled at least 1,000' to the southeast and to the glacial drift/bedrock contact where polynuclear aromatic hydrocarbon concentrations of 1.7 mg/1 and phenolic concentrations of .3 mg/1 have been measured. Thus, it can be concluded that phenolics and polynuclear aromatic hydrocarbons are contained in ground water reaching the Platteville limestone over at least a portion of the area southeast of the site. No attempt has been made in this study to define the public health risks associated with these materials in the ground water.

4. Phenolic concentration contours in the glacial drift south and southeast of the site are likely moving southeastward at rates between 30 and 150 feet per year. Ground water quality in the glacial drift aquifer is not at a steady-state condition and the concentration of coal-tar derivatives will continue to increase away from the area of concentrated coal-tar waste. Reasonable estimates of flow through the Platteville limestone indicate that water in the Platteville takes on the order of 20 to 50 years to reach the buried bedrock valley from the area southeast of the site although flow times could be much less. The quality of water moving through the Platteville is also not at a steady-state condition and the concentrations of coal-tar derivatives will likely continue to increase.

5. The buried bedrock valley southeast of the site is a recharge area to the St. Peter sandstone. Ground water reaching the buried valley either through the glacial drift or the Platteville can enter the St. Peter sandstone. From the buried valley, movement will likely be eastward out of the study area. The potential effect of this movement was not determined.

6. A number of wells in the area are uncased through two or more bedrock aquifers and thus provide potential pathways for ground water to move between the upper more contaminated aquifers such as the glacial drift and Platteville and the lower aquifers.

7. Data collected for this study supports earlier data that indicate very low, but detectable concentrations of phenolic compounds in bedrock wells beneath the site and at a municipal well field located north of the site. The very low concentrations of phenolics in the St. Peter sandstone measured south and southeast of the site can be attributed to leakage through the Glenwood or to leakage through uncased wells. The trace phenolic concentrations measured in the Mt. Simon-Hinckley wells on the site and at the City's well field are attributed to movement of coal-tar derivatives from a Mt. Simon-Hinckley well on the site to the municipal well field. The available information, however, is not sufficient to explain the reason for the measured phenolic concentrations in the municipal St. Peter and Prairie du Chien-Jordan wells at the municipal field north of the site or at other municipal well fields in the area. In the case of the St. Peter wells, the gradients are sufficient to transmit seepage from uncased wells to the municipal well field; however, the time since construction of the uncased wells is too short for these wells to be the source of phenolics in the municipal wells. In the case of the Prairie du Chien-Jordan wells, the computed gradients indicate that ground

water cannot be transmitted from the site to the municipal well field north of the site.

8. Since the quality of the water in the glacial drift and Platteville is not at a steady-state condition, the quality of water in the St. Peter aquifer, which is influenced by seepage from the glacial drift/Platteville, is also not at steady-state. Due to its greater distance from the area of waste concentration in the glacial drift, the quality of the water in the St. Peter will change more gradually than the quality of water in the drift or Platteville. Since the quality in the Prairie du Chien-Jordan cannot be explained by the available data, no comments can be made about future changes in the quality of water in this aquifer. The quality of the water in the City's Mt. Simon-Hinckley wells is likely controlled by recharge through uncased Mt. Simon-Hinckley wells. Since future ground water quality around these uncased wells should not change significantly, it can be concluded that quality of the Mt. Simon-Hinckley aquifer has, for practical purposes, reached a steady-state condition. Thus, very little change in the quality of this aquifer is anticipated due to the wastes discharged from the former coal-tar distillation and wood-preserving facility.

9. The coal-tar derivatives in the glacial drift ground water system represent a potential threat to the underlying ground water aquifers due to the uncased wells, due to flow to the buried bedrock valley, due to seepage through the Glenwood and due to the fact that existing industrial wells that acted as barriers to waste movement down-gradient of the contaminated ground water are being abandoned, thereby increasing the potential for the spread of the identified wastes.

10. The control of ground water movement in the glacial drift to prevent the spread of the coal-tar derivatives is technically feasible using a system of pump-out wells in the glacial drift to control ground water gradients. The system investigated in this study assumed one well placed in the area of severest contamination in the wetland area north of Lake Street and south of Highway 7 and two wells located to the east and southeast. The western gradient control well will remove the severest contamination that is likely the source of most coal-tar derivatives detected in this study. The eastern two wells will remove material that has escaped from this source and is traveling either through the drift or Platteville. Peak phenolic concentrations in the discharge from the well system are predicted to be on the order of 1 to 3 milligrams per liter and peak polynuclear aromatic hydrocarbon concentrations are predicted to be on the order of 100 milligrams per liter. Concentrations of phenolics from the system are predicted to be less than .1 milligrams per liter after about 15 to 20 years of pumping while on the order of 50 to 100 years will likely be necessary to reduce phenolic concentrations below .01 milligrams per liter. The effect of desorption from soil particles could not be quantified, but will likely increase the pumping needed to reach these concentrations.

11. The sanitary sewer and the existing surface water treatment and disposal system were evaluated as disposal routes for the effluent from the gradient control wells. The most logical route for the effluent during times that high phenolic concentrations are produced will be the sanitary sewer. Sanitary sewer disposal is estimated to cost on the order of $10,000 to $15,000 per year. A service availability charge of approximately $100,000, however, could be assessed by the Metropolitan Waste Control Commission if the discharge is judged to be

permanent. The second disposal route is the existing treatment facility that is in place to treat storm water runoff from the site prior to discharge to Minnehaha Creek. In concept, the existing treatment system could provide the required treatment. Bench scale and pilot scale studies will be needed to determine if modifications to the existing facility will be necessary to treat the effluent. Combinations of these two disposal routes are possible, such as disposal of effluent from the western gradient control well to the sanitary sewer system and disposal of effluent from the eastern wells to the existing surface water treatment facility.

12. The volumes of soil that must be excavated to remove various concentrations of phenolics and benzene extractable material in the soils were evaluated. On the order of 700,000 cubic yards of soil must be excavated to remove all soil with phenolic concentrations greater than 1 mg/kg. On the order of 400,000 cubic yards of soil must be excavated to remove soils with benzene extractable concentrations greater than 1,000 mg/kg. Excavation of contaminated soil is not an alternative to gradient control. Excavation of the most contaminated soils will, however, reduce the time required to control gradients in the area. The amount of time reduction, however, is not quantifiable.

RECOMMENDATIONS

Based on the analyses carried out for this study and on the preceding conclusions, the following recommendations are made:

well abandonment

1. All bedrock wells constructed so as to provide pathways for ground water to move between the drift/Platteville and St. Peter and between the St. Peter or Prairie du Chien-Jordan and Mt. Simon-Hinckley aquifers should be grouted and abandoned. Highest priority should be given

to locating and abandoning wells in the area bounded by Texas Avenue on the west, Minnetonka Boulevard on the north, Highway 100 on the east and Minnehaha Creek and Excelsior Boulevard on the south. Wells in this area should be located and abandoned immediately. The investigations summarized in this report indicate that these wells present potential pathways for the movement of coal-tar derivatives to the lower aquifers and, in fact, represent the only reasonable means by which ground water in the Prairie du Chien-Jordan and in the Mt. Simon-Hinckley formation could be contaminated with waste from the site of the former coal-tar distillation and wood-preserving facility.

2. Since the abandonment of uncased wells near the site will likely result in the movement of recharge from the buried valley to the St. Louis Park municipal well field to the north, St. Louis Park wells 1, 2 and 3 should also be abandoned.

3. The potential impact of the identified high concentrations of coal-tar derivatives in the glacial drift ground water are significant enough that mitigative measures are recommended to halt the movement of these wastes.

4. The control of ground water gradients in the glacial drift ground water system is technically feasible and the system presented in this report or a similar system should be implemented. It is recommended that design of the gradient control wells begin immediately. The first step in the design will be to place the additional wells and borings needed to define the exact location of gradient control wells. The next step will be to place one or more test wells to verify the aquifer characteristics needed to complete the design. The third step will be to complete the design and construct the wells.

5. Water pumped from the gradient control wells should be discharged to the sanitary sewer, at least initially. After the more highly contaminated ground water has been removed from the glacial drift or after treatability of the waste has been better defined, it may be possible to discharge the effluent from the wells to Minnehaha Creek after appropriate treatment.

6. Bench scale and pilot scale studies should be conducted to define the treatability of the ground water using either the existing surface water treatment facility or a new treatment concept.

7. The effectiveness of the gradient control system should be monitored both in terms of the ability of the wells to capture coal-tar derivatives through the glacial drift and Platteville limestone and, if the effluent is discharged to Minnehaha Creek, the ability of the treatment facility to meet effluent limitations prior to discharge.

8. Two additional wells should be placed in the St. Peter formation beneath the area of elevated coal-tar derivative at the drift/Platteville contact to monitor the quality of water in the St. Peter. If the average concentration of the phenolics, as measured by the MBTH Method, exceeds a concentration on the order of 20 micrograms per liter, significant change will have occurred and gradient control or some other appropriate mitigative measure should be required to control movement of the wastes in the St. Peter.

9. Further information is needed regarding the effect of the trace phenolic concentrations measured in the municipal wells in St. Louis Park. It is recommended that studies be carried out to define the potential public health effect of these trace phenolics.

10. A better definition of hydrogeology is needed in the buried bedrock valley located near Highway 100 and Excelsior Boulevard. Specifically, soil borings and piezometers should be placed in the valley to define its extent and to estimate gradients and likely vertical flow rates. In addition, monitoring wells should be placed near the western edge of the valley to define the quality of water discharged to the valley from the site area through the glacial drift, Platteville and St. Peter units. A monitoring well should also be placed in the St. Peter north of the valley to monitor the quality of the water in the aquifer between the valley and the City well field to the north.

Title

Hydrogeologic Study of the Republic Creosote Site

Author

Gerald M. Sunde, Consulting Engineer

Agency

for SLP

Date

July 1974

Time Period

April - July 1974

Purpose

The purpose of this study, was to hydrogeologically analyze the Republic Creosote site and adjacent areas with particular attention toward phenol flow mechanics in the surficial and bedrock aquifers in St. Louis Park.

Sample Data

The Sunde report recognized the St. Louis Park analytic summary of 1972-73 phenol data, but used the MDH phenol analyses conducted in 1973-74. (U.S. EPA has the 1973-74 MDH phenol data sheets and this data is included in U.S. EPA summary of data report.)

Conclusions

Sunde concluded that phenol movement through the aquifer systems was caused by something other than vertical seepage. The most likely cause being multi-aquifer wells--St. Peter to Prairie du Chien-Jordan. Sunde suggested that W-23 and W-38 may have also caused phenol contamination to the Hinckley aquifer. Sunde also discussed the possibility of multi-source versus Republic Creosote as the cause for phenol contamination of the SLP ground water. No specific responsible parties were listed. Sunde also discussed the analytic accuracy of the data presented.

Recommendations

1. Plug and seal Hinckley wells W-23 and W-38. (estimated cost- $6,000)

2. Plug and seal Prairie du Chien-Jordan wells.
(estimated cost $16,800, excluding W-38)
- NON-RESPONSIVE [redacted]
- W-38

3. Abandon SLP Wells Nos. 1, 2, 3 (29th and Idaho)

4. Seal SLP Wells Nos. 1, 2, 3 (cost $5500)

5. Convert industrial wells to nonpotable use wells in the St. Peter (act as barrier wells)
- Minnesota Rubber Company
- Flame Industries
- O&S Machines
- Robinson Rubber Company

6. St. Peter well on site--find and seal

7. Suggest excavation, pump out wells and land farming of pollutant source soils.

8. Further sampling--chemical and physical

9. Development of the site to prevent any further plume movement.

Location

SLP Public Works files

Comment

#9 - No elaboration on this point in the report and of questionable validity.

Environmental Contamination Studies

Title

Memorandum of September 4, 1980 from Rolland Grabbe, Organics Section Chief, U.S.G.S. Denver Laboratory, to Marc Hult

Purpose

Base-neutral analysis of sample No. 70778, U.S.G.S. Well No. P14

Summary

Base-neutral analysis by U.S.G.S. Denver laboratory showed preliminary results of much higher concentrations of low molecular weight (light) compounds than expected. It is possible that concentrations are actually several orders of magnitude higher than PAH concentrations reported by MDH. No analysis for chlorinated organics. Most compounds were substituted benzenes.

Location

M. Hult file, U.S.G.S.

Title

Report of Soil Sampling City of St. Louis Park

Author

Hubert H. Huls, Chemical Engineer, Serco

Agency

for SLP

Date

June 5, 1979

Time Period

October - November 1978

Purpose

This report summarizes soil boring data taken for a proposal to construct a bowling alley on the former Reilly site.

Sample Data

Phenol analyses on soil samples were conducted according to Standard Methods--amino antipyrene colorimetry.

Site 1 - Louisiana Ave., Oakleaf Drive & Second Street, N.E.
Site 2 - Oak Park Plaza on Reilly site.
Site 3 & 4 - Reilly site along Louisiana Avenue.

10/10/78

dry wt. mg/kg	Phenol	site #1	site #2
	boring depth		
	4.5' - 2'	0.2	dup. 0.2, 0.3
duplicate	14.5' - 17'	0.2, 0.3	dup. 0.2, 0.3
	24.5' - 27'	0.2	0.3
	34.5' - 37'	0.2	0.3
	44.5' - 47'	0.2	0.4
dup.	54.5' - 57'	0.2, 0.4	-
	64.5' - 66'		0. 3
	74.5' - 75'	0.2	

		site #3	site #4
	4.5' - 7'	0.3	0.3
	14.5' - 17'	0.3	0.4
dup.	24.5' - 27'	0.3, 0.3	0.4
	34.5' - 37'	0.3	0.4
	44.5' - 47'	0.3	0.3
	54.5' - 55.5'	0.3	0.3
	64.5' - 66'	0.3	0.3

Hexane extractable analyses were also conducted. Analyses are not reported here because the results are nonspecific.

Location

SLP Public Works files

Title

Report of Well Water Survey St. Louis Park, Minnesota

Author

Lawrence H. Breimhurst, Serco Laboratories

Agency

for SLP

Date

August 3, 1978

Time Period

June - July 1978

Purpose

To determine if there were detectable levels of phenols in the St. Louis Park water supply.

Sample Data

14 municipal wells in SLP and 5 surrounding suburban wells
Serco & MDH split samples
(See attached)
All the samples were collected by Serco personnel on 6/27, 28, 29/78

Conclusions

1. Trace levels of phenols at a few wells.

2. Serco analyses--All well water samples were $\leq$ 2 ug/l (ppb).

3. MDH--slightly higher results.

4. There was no identifiable hydrogeologic pattern to the results.

5. Laboratory differences were not significant.

Recommendation

Routine quarterly phenol monitoring of all SLP wells

Location

SLP Public Works files

TABLE II

SURROUNDING COMMUNITY AND OUT STATE WELL DATA
ST. LOUIS PARK WELL WATER SURVEY
SERCO Laboratories JUNE - JULY, 1978

CITY	WELL #		DEPTH	CAPACITY	YEAR CONSTRUCTED
Robbinsdale	2	[redacted]	624 ft	880 gpm	1944
Plymouth	2	NON-RESPONSIVE	394 ft	2100 gpm	1970
Minnetonka	11		498 ft	1300 gpm	1972
Hopkins	4		548 ft	2300 gpm	1954
Edina	6		505 ft	1100 gpm	1954
Waite Park	3		100 ft	600 gpm	1974*
Brainerd	7		150 ft	2500 gpm	-
Rochester	20		907 ft	1000 gpm	1964

*Began use May 1978

50035122

TABLE III

RESULTS OF LABORATORY ANALYSIS FOR PHENOLS
ST. LOUIS PARK WELL WATER STUDY
SERCO LABORATORIES JUNE - JULY, 1978

CITY	WELL #	PHENOL, mg/l SERCO	PHENOL, mg/l MN. DEPT. OF HEALTH	DATE COLLECTED
St. Louis Park	3	<0.002	<0.002	June 28, 1978
St. Louis Park	4	<0.002	0.0039	June 28, 1978
St. Louis Park	5	0.002	0.0065	June 29, 1978
St. Louis Park	6	<0.002	<0.002	June 28, 1978
			0.0059*	
St. Louis Park	7	<0.002	0.0078	June 29, 1978
St. Louis Park	8	<0.002	0.014	June 29, 1978
St. Louis Park	9	<0.002	0.0073	June 29, 1978
			0.0032*	
St. Louis Park	10	<0.002	0.0044	June 28, 1978
St. Louis Park	11	<0.002	<0.002	June 28, 1978
			<0.002*	
St. Louis Park	12	<0.002	0.0024	June 28, 1978
St. Louis Park	13	0.002	<0.002	June 29, 1978
St. Louis Park	14	<0.002	<0.002	June 29, 1978
St. Louis Park	15	<0.002	0.005	June 28, 1978
St. Louis Park	16	<0.002	<0.002	June 29, 1978
Robbinsdale	2	<0.002	<0.002	June 27, 1978
Plymouth	2	<0.002	0.0024	June 27, 1978
Minnetonka	11	<0.002	<0.002	June 27, 1978
Hopkins	4	0.004	0.0029	June 27, 1978
			0.0018*	
Edina	6	0.004	0.0077	June 27, 1978
Waite Park	3	0.01	<0.002	June 29, 1978
Brainerd	7	<0.002	<0.002	June 29, 1978
Rochester	20	0.005	<0.002	July 5, 1978
			<0.002*	

*Duplicate analysis - Separate bottle

50095123

Title

Soil Contamination by Creosote Wastes--A Quantitative Physical/Chemical Analysis of the Northern Portion of the Former Republic Creosote Site

Author

National Biocentric, Inc.

Agency

for SLP

Date

November 1, 1976

Time Period

July - October 1976

Purpose

In April 1976, SLP submitted an environmental assessment to the Minnesota Environmental Quality Council (MEQC) covering its proposed development of the former Reilly site. The southern portion of the site was removed from the proposal because of questionable soil quality. Shallow auger borings were taken from the field for visual and olfactory contamination. MEQC ruled that development of the northern portion was permitted if contaminants were removed. Therefore, a grid soil boring program was implemented and is summarized herein.

Sampling Data

A - shallow auger borings (visual contamination)
2-8ft. depth of contamination, limited aerial extent

C - 4 borings (8/76) for chemical analyses
1) deep contamination ("A" above)
2) shallow ("A" above)
3) land-farming area
4) no contamination

D - resistivity patterns (9-10/76)

See attachments

Conclusions

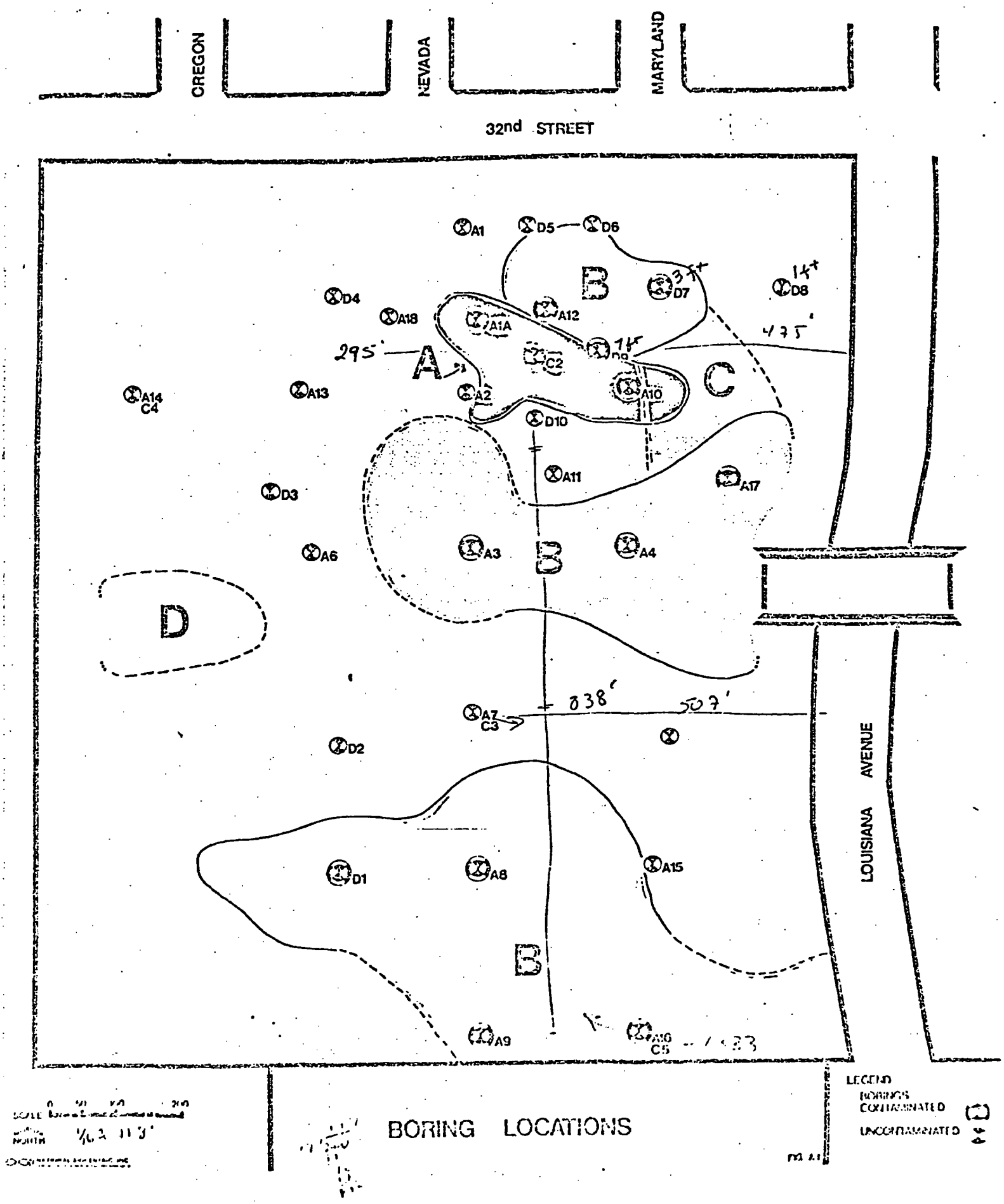
Zone A - Deepest contamination, chemical sample C-2
Visible contamination 1.5-15 feet, odors to 50 feet
2-8 feet depth of contamination at ends

Zone B - (3 areas) chemical sample C-5
Contamination 1-2 feet thick, 1-3 feet from the surface

TABLE 1

INFRARED CORRELATION TO POLYAROMATIC HYDROCARBONS

Sample Description	I.R. Scan #	Presence of PAH Indicated by I.R.	Approximate Concentration Range (Mg/Kg) Dry Weight	Odor in Soil	Visual Soil Contamination
C-2, Depth 4½ Feet	125	Large	2,600-2,000	Heavy	Yes
C-2, Depth 4½ Feet (GC Clean-up)	126	"PAH Fraction"	2,300		
C-2, Depth 31 Feet	127	Large	3,800-3,000	Slight	No
C-3, Depth 6 Feet	128	None	<50	None	No
C-3, Depth 16½ Feet	130	None	<50	None	No
C-4, Depth 3 Feet	132	Moderate	1,800-1,100	Slight	No
C-4, Depth 11 Feet	133	Small	430-310	Slight	No
C-5, Depth 2½ Feet	134	Trace	40-20	Slight	Yes
C-5, Depth 10½ Feet	135	Trace	50-25	None	No


OREGON
NEVADA
MARYLAND
32nd STREET
LOUISIANA AVENUE
A1
D5
D6
B
D7
D8
D4
A18
A1A
A12
475'
295'
A
C2
C
A14
C4
A13
A2
A10
D10
A11
A17
D3
A6
A3
B
A4
D
838'
507'
A7
C3
D2
D1
A8
A15
B
A9
A16
C5
LEGEND
BORINGS
CONTAMINATED
UNCONTAMINATED
BORING LOCATIONS

Title

Report on Investigation of Phenol Problem in Private and Municipal Wells in St. Louis Park, Minnesota, Hennepin County

Author/Agency

MDH

Date

September 1974

Purpose

Low levels of phenolic compounds were detected in raw water collected from several St. Louis Park municipal water supply wells. These test results, combined with the proximity of the Reilly Tar operation prompted a more detailed study of the ground water in the surrounding area.

The field investigation involved a well water testing program in which one sample per week was collected from each available municipal well and several private wells in the general area of the Reilly Tar property. The investigation extended over a 10 week period. Soil samples were also taken south of the Reilly Tar site on February 22, 1974.

Data

Water anlayses for all samples were conducted in the Analytical Services Laboratory of the MDH. The phenol determination was made using the MBTH (manual 3methyle-2-benzothiazolininone) method. Phenol data is presented on 15 municipal wells and 10 private wells for 10 sampling periods, and is attached to this summary. Average phenolic concentrations for the 25 wells over the sampling period is also attached.

Findings

1. Greater than or equal to 0.002 mg/l (ppm) were detected in both municipal and private wells in the St. Louis Park area.

2. Wells sharing the highest concentrations and most consistent phenolic presence are located closest to the former Republic Creosote site.

3. It is estimated that phenols can be found in well waters from the shallower drift wells down to approximately 900 feet.

4. The Flame Industries well showed continuous low level phenol concentrations; the Robinson Rubber Company well showed continuous high level phenol concentrations; most wells had recurring patterns with an occassional high value. The intermittant occurrence of phenols in wells may be related to the hydraulic influence of well pumping patterns.

5. Soil samples from bore hole #13 at a depth of 45 feet had a pronounced creosote odor and black viscous apppearance.

Recommendations

1. Conduct comprehensive geologcial and hydrological study to determine the effects of the former Republic Creosote operation on the aquifers in the area.

2. A study to determine the feasibility of rehabiliation of the aquifers should be undertaken.

3. An ongoing epidemiological study review should be made of the possible public health hazardous resulting from the pollution of the affected aquifer.

4. A monitoring system should be established to determine if the affected area is expanding.

5. Contingency plans to protect the present sources of ground water should be developed. Removal of contaminated materials may be needed to alleviate the chronic source of pollution. Remedial treatment of water before use may be needed.

Location

MDH files

TABLE 1

PHENOLS Mg/L

Date of Sampling	Well No. 1	Well No. 2	Well No. 3	Well No. 4	Well No. 5	Well No. 6	Well No. 7	Well No. 8	Well No. 9	Well No. 10
2/5/74	.007		<.002	<.002	<.002	<.002				<.0
1/30/74	<.002		<.002	<.002	<.002	<.002		<.002		<.0
1/22/74	.009		.004	<.002	<.002	<.002				<.0
1/16/74	<.002		<.002	<.002	<.002	<.002				<.0
1/8/74	.003		.006	<.002	<.002	.007		<.002		<.0
1/3/74	<.002		.005	<.002	.003	<.002		.002		<.0
12/27/73	.008		.002	<.002	<.002	<.002		.003		.01
12/18/73			<.002	<.002	<.002	<.002		<.002		.0
12/11/73			<.002	.007	.005	<.002		<.002		<.0
12/4/73	.013		.002	<.002	<.002	.002		.014		.0
9/25/73	<.002				<.002			.004		.01
9/18/73	.035		<.002	<.002	.070	.004	<.002	.044	.003	.0
Average	.0075		.0017	.0006	.0065	.001	.0000	.0074	.003	.0

Date of Sampling	Well No. 11	Well No. 12	Well No. 13	Well No. 14	Well No. 15	Union 76	City Hall	Flame Ind.	Robinson Rubber
2/5/74	.025	.007	<.002		<.002			.004	1.1
1/30/74	<.002	<.002	<.002		<.002			.004	1.1
1/22/74	<.002	<.002	.006	.002	<.002			.004	1.2
1/16/74	<.002	<.002	<.002	.003	<.002			.003	1.1
1/8/74	<.002	<.002	<.002	<.002	.003			.004	1.0
1/3/74	<.002	<.002	<.002	<.002	<.002			.004	1.2
12/27/73	.002	.004	<.002	<.002	<.002		<.002	.003	1.2
12/18/73	<.002	<.002	<.002	<.002	<.002	<.002		.004	1.0
12/11/73	.007	<.002	<.002	<.002	<.002			.002	1.1
12/4/73	<.002	<.002	.004	<.002	.007				
9/25/73		<.002	<.002						
9/18/73	.007	.022	.018	<.002	<.002				
Average	.0037	.00275	.0023	.00055	.0009	.000	.000	.00355	1.1

PHENOLS Mg/L

Date of Sampling	Minnesota Rubber	S & K Products	Food Producers	McCourtney Plastics	Q & S Co.	Burdick Grain
[illegible]/74	<.002	<.002	<.002	.003	.002	.017
[illegible]/74	<.002	<.002	.013	<.002		<.002
[illegible]/74	<.002	<.002	<.002	.003		<.002
[illegible]/74	<.002	<.002	.006	.003	<.002	.005
[illegible]/74	.003	<.002	<.002	.004	.004	
1/[illegible]/74	<.002	.007	<.002	.003	<.002	
12/27/73	.009	.003	<.002	.023		
12/18/73	.003	<.002	.002	.002		
12/11/73	<.002	<.002	<.002	.003		
12/4/73						
9/25/73						
9/18/73						
Average	.0022	.0011	.0023	.00488	.0015	.0055

Total Samples	197
Positive	81
<.002	116

Well No.	Depth	Casing Depth	Formation	Average Phenolic Conc. Mg/Lit (From table I)
1	290'	104'	St. Peter/ Shakopee	.0075
2	290'	104'	"	
3	286'	103'	"	.0017
4	503'	415'	Jordan	.0006
5	465'	305'	Shakopee/ Jordan	.0065
6	480'	430'	Jordan	.001
7	446'	247'	Shakopee/ Jordan	——
8	507'	314'	Shakopee/ Jordan	.0074
9	473'	289'	Shakopee/ Jordan	.003
10	500'	315'	Shakopee/ Jordan	.003
11	1,085'	880'	Hinkley	.0037
12	1,095'	900'	Hinkley	.00275
13	1,045'	891'	Hinkley	.0023
14	485'	389'	Jordan	.00055
15	503'	398'	Shakopee/ Jordan	.0009
16	500'	425'	Jordan	
#1	274'	213.5'	St. Peter	
nn. Rubber Co.	475'	288'	Shakopee/ Jordan	.0022
cCourtney Plastics	394'	246'	Shakopee	.00488
Sq K Prod.	312'	244'	St. Peter/ Shakopee	.0011
ame Ind.	335'	257'	Shakopee	.00355
obinson Rubber	182'	?	St. Peter	1.1
eed Produc.	--	--	---	.0023
ordick Grain	--	--	---	.0055

Title

An Assemblage of Anaytical Data Regarding the Reilly Tar and Chemical Property, St. Louis Park, Minnesota

Agency

SLP Health Department

Date

August 1, 1972

Time Period

1968 - 1972

Purpose

The City of St. Louis Park put this report together to inform Federal and State agencies of the data available at that time, so that a joint decision would be made concerning the need for additional investigative work.

Conclusions

Page 28: contamination is slight. "In fact, opinions expressed by staff of the NUS Corp, the MPCA and the MDH indicate that contamination, as a result of this particular situation will not occur in the future."

The sewer board will permit phenol/oil/grease-contaminated water to be discharged into sewer system during the redevelopment project.

Recommendations

Proceed with redevelopment project.

Data

Attached to this summary were data reports (Appendices) found elsewhere within this document.

Appendix A - MPCA Report on Waste Disposal at Reilly. 1970

B - Ground Water Investigative Program at St. Louis Park, Hickock and Associates. 1969

C - Memo, to MPCA, from MDH, Analytical Services. 1970

D - Report of NUS Corporation concerning phenol contamination of wells in SLP. 1970

E - Log of Borings, SLP, Reilly Site. 1971

F - Letter from Sewer Board regarding disposal of ponded water south of Highway 7. 1972

G - Preliminary Soil Investigation for Republic Creosote Co. 1969

H - Letter from Jane McKinnon regarding plantings. 1972

I - Correspondence regarding construction of utilties for creosote property. 1972

Location

M. Hult's file, U.S.G.S.

Comment

The conclusions alledgedly made by NUS, MPCA, and MDH that the environmental contamination is slight may have been influenced by two factors:

1. The extent of PAH contamination was not yet known.

2. There was a major emphasis on redeveloping the site at the time of this report. This appears to be the motivation behind the report since the recommendation made in the report is to proceed with redevelopment.

II. Analyses of Runoff Waters for Phenols

In order to attempt to assertain whether phenols were picked up by water traveling over the surface of the Creosote property, several runoff samples were taken to measure the amount of phenol in water running from bituminous streets onto the Republic Creosoting property, samples 1, 2, 4, 1a, 2a, and in runoff from the property, sample 3 (see Figures 1, 2, 3, and 4.) According to measurements in Figures 1, and 2, the average phenol content of runoff going onto the Creosote plant property was .03 and .018 mg/l, respectively. Runoff water from the Creosote property was .06 and .09 mg/l, tending to indicate that the amount of phenol runoff onto the plant is somewhat less than the phenol content of runoff water directly from the property. This would seem to indicate that phenolic substances are originating from the plant site.

****

Figure 1. Amount of phenol found in surface water (runoff) samples - 11/16/71, analyzed by Tri-City Laboratory (see Figure 4 for locations).

Location		Phenol (mg/l)
1a.	2nd St. N.W. & Republic (into plant)	.015
2a.	35th and Pennsylvania (into plant)	.045

1500003

Figure 2. Amount of phenol found in surface water (runoff) samples 10/9/70, analzyed by Tri-City Laboratory (see Figure 4 for locations).

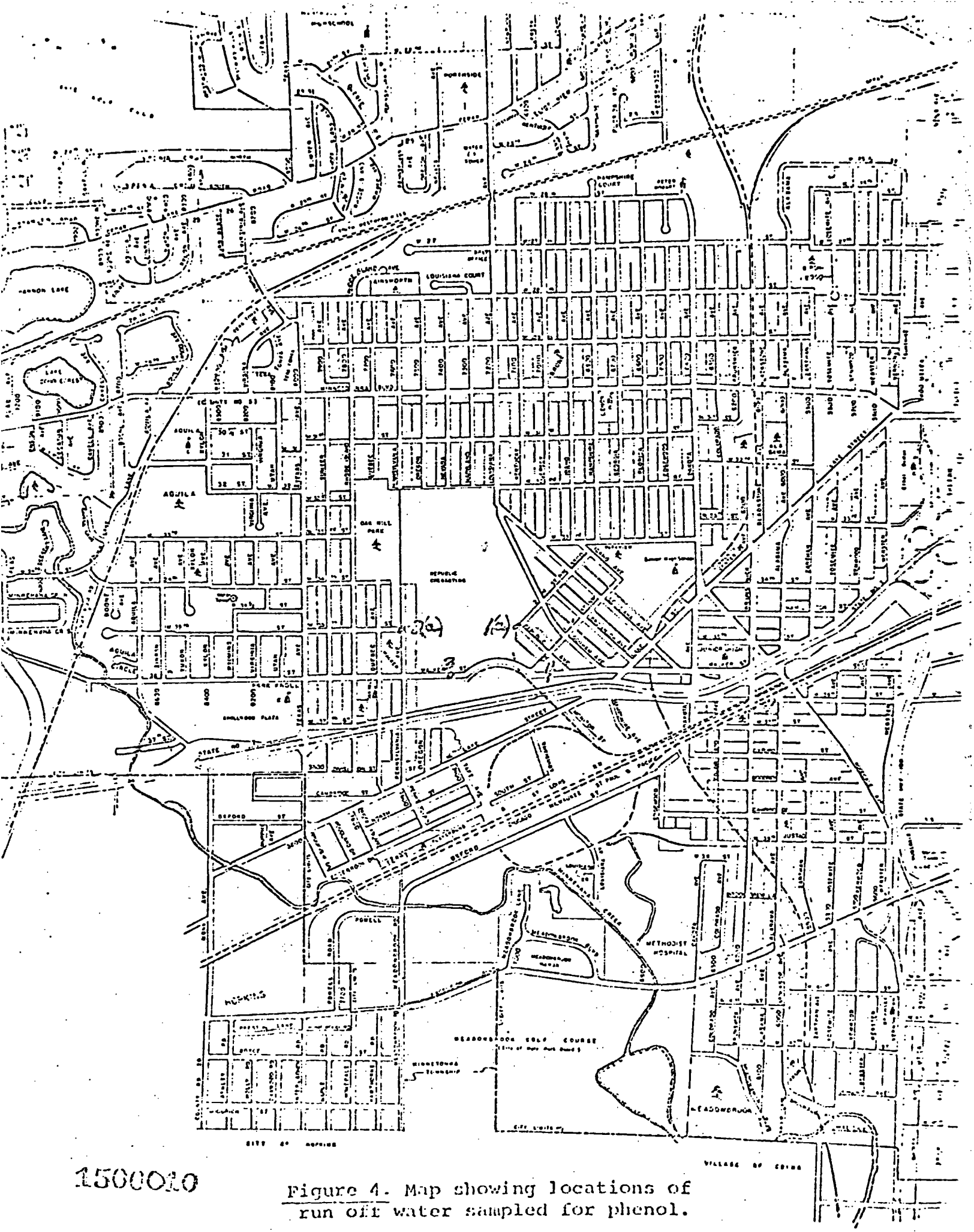
Location	Phenol (mg/l)
1. 2nd St. N.W. and Republic (into plant)	.008
4. 1st St. N.W. between Republic & Walker (into plant)	.008
3. Walker (plant runoff)	.066
2. 35th and Pennsylvania (into plant)	.020

****

Figure 3. Amount of phenol found in surface water (runoff) analyzed by Tri-City Laboratory.

Location	Phenol (mg/l)
Unknown (plant runoff)	.09

1500009



1500010

Figure 4. Map showing locations of run off water sampled for phenol.

Figure 5. Amount of phenol found in the effluent ditch of and other ponds surrounding the Creosote property. (see Figure 7 for locations.) Sampled by Minnesota Pollution Control Agency.

Sample Source	6/13/68	8/1/68
Effluent at source	160	.380
Effluent leaving property	130	140
At Highway 7	---	15
At first pond	---	1.9
At second pond		0.8

****

Figure 6. Amount of phenol found in the effluent ditch of and swamps around the Creosote property, 6/21/72 and 7/7/72, analyzed by Tri-City Laboratory.

Sample #	Description of Sample	6/21/72 (ppm)	7/7/72 (ppm)
1	Ditch north of Walker	0.65	7.5
2	Ditch south of Walker	0.80	11.5
3	Swamp So. of Highway 7	0.25	0.15

1500012

Figure 8. Complete analysis of the water found in the effluent ditch of the ponds around the Creosote property, and in Minnehaha Creek. Sampled by Minnesota Pollution Control Agency, April 16, 1970.*

Station	Description
1	Effluent leaving Republic Creosote's property
4	Pond at W. Lake St. and Louisiana Ave. receiving effluent
6	Minnehaha Creek upstream from Republic Cresote's operation
8	Minnehaha Creek downstream from Republic Cresote

Sample Number	1	4	6	8
Date Collected	4/16/70			
Time Collected	3:00 pm	11:00 pm	2:00 pm	2:30 pm
Temperature	24° C	12° C	12° C	11° C
Total Solids	500	410	490	730
Total Volatile Matter	300	110		230
Suspended Solids	82	33	34	160
Suspended Volatile Matter	56	26	17	54
Turbidity	96	29	13	31
Total Hardness as $CaCO_3$	100	130	260	270
Alkalinity as $CaCO_3$	530	130	170	170
pH Value	8.7	7.1	8.1	8.1
Dissolved Oxygen	0.4	4.6	16	16.6
5 day Biochemical Oxygen Demand	710	65	3.8	8.0
Ammonia Nitrogen	230	6.0	.20	.13
Phenol	1100	18.3	< .01	<.01

*Results are in milligrams per liter except as noted.

1500014

Figure 10. Water samples taken from City and private wells and analyzed for phenol content by the St. Louis Park Tri-City Laboratory. (measured in parts per billion)

Well	8/8/69	3/9/70	3/18/70	3/23/70	4/20/70	10/14/70
1	-1					
2	-1					
3	-1					0
4	-1		10	-1		
5	-1		10			
6	-1	18	-1	-1		
7	-1					
8	-1		10	10		
9	-1					
10	2					0
11						0
12			-1	-1		
13		21		-1		
14						10
Park Pet			20		23	0
Northland Alum.					16	
S & K Prod.			12			
Robinson Rubber		8	6		2	
Flame Ind.		15	-1		6	0

Phenol

Figure 9. Water samples taken from City and private wells and analyzed by various laboratories.

Well #	NUS (mg/l)	Hickok (ppm)	Burdick (ppm)	State H.D. (mg/l)
1	---	.014	---	
2	---	.008	---	
3	<.001	.012	.002	
4	<.001	.014	.008	<.005
5	---	.014	---	<.005
6	<.001	.023	.0025	---
7	---	.013	---	<.005
8	<.001	.012 (8a-012)		<.005
9	---	.013	---	<.005
10	<.001	.014	---	---
11	---	trace	0.000	---
12	---	.018	0.000	---
13	<.001	.018	0.000	<.005
14	<.001	.009	0.000	<.005
Flame Ind.	.001 (0.000)*			<.005
Northland			0.008	
Park Pet	<.001			---
Minn. Rubber			0.000	
Park Elevator			0.008	
S & K Products				<.005
McCourtney Plastic				<.005

*Phenol was not detected in this water by gas chromotography

1500015

Figure 13. Soil samples taken along West Lake Street during construction of Hopkins force main, November, 1970. (see Figure 12 for location)

Sample	Phenol ppm
Soil 1 (11/23/70)	330
Soil 2 (11/23/70)	260
*H_2O - 1 (11/29/70)	85
*Soil - 3 (11/29/70)	390
*Soil - 4 (11/29/70)	120

*All samples approximately 280 feet from spur tracks on west side - 8 feet deep.

1500020

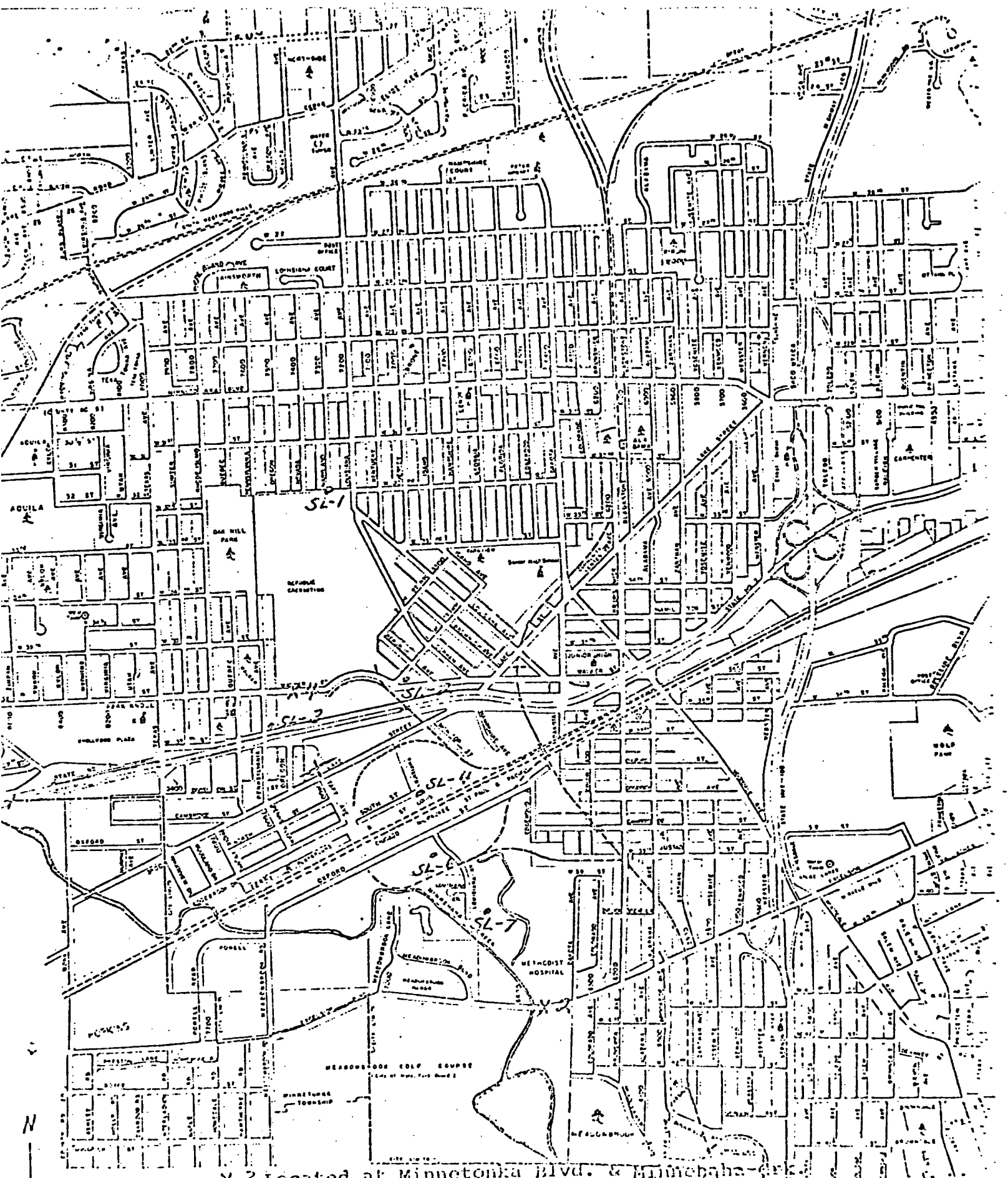


Figure 12 Log of soil borings and phenol content of soil at various depths.

Title

Letter from Sewer Board to H. McPhee, City of St. Louis Park, concerning discharge of contaminated pond water to sewer

Author

Russell Susag, Metropolitan Sewer Board

Date

July 21, 1972

Subject

Sewer Board granted permission to empty phenol-contaminated pond water into sewer. It was also contaminated with grease and oil.

Sample Data

Phenol: 11.5 mg/l
Grease & oil: 51 mg/l

Location

Appendix F of SLP report: An Assemblage of Analytical Data Regarding the Reilly property, 1972
M. Hult's file, U.S.G.S.

350 Metro Square Building, 7th & Robert Street, Saint Paul, Minnesota 55101 Area 612, 222-8423

July 21, 1972

Mr. Harvey J. McPhee
Director of Public Health
City of St. Louis Park
5005 Minnetonka Blvd.
St. Louis Park, Minnesota 55416

Re: City Request For Industrial Waste Disposal

Dear Mr. McPhee:

This is in reply to your request of July 18, 1972 for Sewer Board permission to discharge ponded water to the Metropolitan Disposal System.

To summarize, the City is planning redevelopment of the Reilly Chemical and Tar plant site. There exists near the plant site a pond with an estimated 2,500,000 gallons of water of a questionable nature. During utility installation for the redevelopment, it may become necessary to dewater the ponded area, and since the water cannot be discharged to Minnehaha Creek, quality determinations were made regarding compliance to the Sewer Board's Waste Control Rules and Regulations.

Samples were taken on July 6 and analyzed for phenol content by your laboratory, and samples were taken on July 12 and analyzed for grease and oil content by the Sewer Board laboratory. Results are as follows:

Sample location	phenol (mg/l)	grease and oil (mg/l)
Ditch north side of Walker St.	7.5	41
Ditch south side of Walker St.	11.5	41
Pond south side of Highway 7	0.15	51

The grease and oil concentration is within the Sewer Board's acceptable limit of 100 mg/l. Therefore, permission is granted to discharge the pond water to the sewer system. One condition is that the water be discharged at a relatively low rate (approx. 200 gpm) to minimize the possibility of a malodorous condition arising due to phenols. If nuisance conditions do arise, you will be notified to take corrective actions.

1500082

Title

Letter to H. McPhee (City of St. Louis Park) concerning phenol contamination of wells in SLP.

Author

R. Burd, NUS Corp.

Date

November 5, 1970

Subject

Well samples analyzed by Dr. Baker of the Carnegie-Mellon Institute, Pittsburgh

Conclusions

1. Phenolic compounds were detected in Republic Creosote effluent water, at approximately 13 mg/l.

2. Phenolics were not found in well water.

Sample Data

Phenol (approx. 13 mg/l) only found in effluent from site. Data is attached to this summary.

Location

Appenidix D; SLP report: An Assemblage of Analytical Data Regarding Reilly Property, 1972
M. Hult's file, U.S.G.S.

Table 1
St. Louis Park, Minnesota Water Analyses

Sample No.	Location	Washed Ice Concentration Ratio	Odor	Organic Analyses	Area, in.^{2} of Peak @ 0.3 rel. elution 1% sample
1	Effluent	as received	Cresolic	6.5 mg/l phenol or o-cresol ~13 mg/l based on phenol calibration factor for entire area	0
2	[redacted]	143:1	light sulfuric*	0 phenol	4.72
3		273:1	very light*	0 phenol	0.18
4		85.7:1	barely detectable*	0 phenol	3.36
5		120:1	very light*	0 phenol	0.10
6		214:1	very light*	0 phenol	0.05
7		125:1	very light*	0 phenol	0
8		103:1	very light*	0 phenol	0
9	Well @ Flame, Ind.	157:1	sulfuric; mineral springs*	0 phenol	3.29
10	Park Pet Hospital	107:1	barely detectable*	0 phenol	0

EXEMPTION 9-WELL

*light-colored yellow ppt. in samples as received, these ppt. were dense in concentrates.

1300023

LABORATORIES
15 [illegible] AVENUE
PITTSBURGH, PA. 15[illegible]
412-922-2[illegible]

Mr. Harvey McPhee
Public Health Sanitarian
City of St. Louis Park
5005 Minnetonka Blvd.
St. Louis Park, Minnesota 55416

Client No. 6157.04
Date Sampled 10/21/70
Date Received 10/22/70
Date Reported 10/23/70

Rice Sample No.	Client No.	Sample Source	Phenol mg/l
100701	1	Effluent Ditch	9.79
100702	2	[redacted]	<0.001
100703	3		<0.001
100704	4		<0.001
100705	5		<0.001
100706	6		<0.001
100707	7		<0.001
100708	8		<0.001
100709	9	Well @ Flame Industries	0.001
100710	10	Well @ Park Pet Hosp.	<0.001

EXEMPTION 9-WELL

Special Instructions

1500076

*Test results reported in ppm unless otherwise noted

Title

Memo: St. Louis Park Well Water Analyses Sent to MPCA

Author

R.E. Frazier

Agency

MDH

Date

April 20, 1970

Subject

Analyses and comments on well water sampled for phenolics.

Conclusions

In all cases, phenolic concentrations were less than 5 mg/l. They do not believe wells are contaminated, however, a serious hazard exists in that there is a substantial quantity of phenolics on the surface of the ground in the vicinity of the wells. This potential threat should be removed as soon as possible.

Sample Data

Phenolics, all less than 5 mg/l, in well water.

Location

Appendix C in SLP report: An Assemblage of Analytical Data Regarding the Reilly Property, 1972
M. Hult's file, U.S.G.S.

Title

Preliminary Soils Investigation for Republic Creosote Company

Author

J.S. Braun, Soil Engineering Services

Date

October 13, 1969

Purpose

To indicate the general foundation conditions over the tract relating to establishing property values and for use in a preliminary evaluation of foundation conditions for industrial buildings.

Conclusions

23 soil borings were taken. Special foundation procedures would be needed over approximately 50% of the area if city was to begin building.

Location

Appendix G, SLP report "An Assemblage of Analystical Data Regarding Reilly Property", 1972
M. Hult's file, U.S.G.S.

Title

Ground Water Investigation Program at St. Louis Park, Minnesota
Progress Report 1

Author

Eugene A. Hickock

Date

September 26, 1969

Purpose

To determine the extent of phenol contamination in the major aquifers in the vicinity of the Reilly site.

Data

Seven soil borings were taken from the drift aquifer along with the water analyses summarized in the attached Table 1. The results of leachate analyses from the soil borings have been lost through the repeated replications of this report.

Conclusions

1. Phenols are contained in Reilly's wastes.

2. Phenol contamination has penetrated down through the Jordan aquifer.

3. The city wells have phenol concentrations >.001 mg/l or 1 ppm [U.S. Public Health Service Drinking Water Standard].

4. Phenols have been detected at distances 1.5 miles from the site.

5. Shallow (drift) private wells in the vicinity of the Reilly site have been abandoned.

6. St. Peter, Jordan and Hinkley aquifers are the major productions aquifer for SLP.

7. General direction of ground water movement is to the east, although it may be locally controlled by pumping.

8. Biodegradation of phenols by microbes is not presently fully understood.

9. Present study should be considered as part of an ongoing investigation.

Recommendations

1. Untreated waste disposal from the site should be prohibited.
2. Further study.
3. Immediate study of the following:
    a. monitoring from selected wells for phenol concentrations
    b. water-level monitoring
    c. stream and storm sewer monitoring
4. More shallow soil borings for analysis to determine shallow flow system.
5. Installation of observation wells through the Jordan aquifer.
6. Conduct a pump test.
7. Program for removal of highly contaminated waters.
8. Excavation of contaminated soils.
9. Containment of contaminated ground water.

Location

U.S. EPA, Region V files

TABLE I

WATER ANALYSIS OF

ST. LOUIS PARK, MINNESOTA

September, 1969

Well No	Geologic Formation	Phenols in ppm
1	St. Peter	0.014
2	St. Peter	0.008
3	St. Peter	0.012
4	Jordan	0.014
5	Jordan	0.014
6	Jordan	0.023
7	Jordan	0.013
8	Jordan	0.018
8A	Jordan	0.012
9	Jordan	0.015
10	Jordan	0.014
11	Hinckley	Trace
12 (Before Iron treatment)	Hinckley	0.018
12 (After Iron treatment)	Hinckley	0.018
13 (Before Iron treatment)	Hinckley	0.018
13 (After Iron treatment)	Hinckley	0.018
14	Jordan	0.009
19	------	0.028
23	St. Peter	0.023
33	------	0.02
Mahe. Cr. Sample #1		0.02
Mahe. Cr. Sample #2		0.02
Drainage Ditch (7200 Walker St.)		Excess of 2.0 ppm

Analysis by E.A. Hickok & Associates

TABLE 2

WELL WATER ANALYSIS 1946-1968

PHENOL CONCENTRATIONS - PPM

ST. LOUIS PARK, MINNESOTA

Sample Date	WELL NUMBER 3	4	5	6	11	12	13	14	33
1/14/46		0.100							
9/30/46		0.115	0.02						
10/4/46									
10/16/47				0.007					
10/24/47			0.02						
4/19/48				0.015					
4/23/48				0.015					
4/ 3/48		.005							
6/23/48		0.010							
6/30/48		0.005							
6/5/48		0.070							
6/5/48		0.015							
6/13/48		0.070							
2/6/68									0.008
3/7/68	0.002	0.008		0.0025	0.000	0.000	0.000	0.000	

All wells to left of this line for which there are figures indicated drinking is the standard as for back in 1946

well #4 same to have gotten better since then

Potential Pollutant Sources Other Than Reilly

Title

Memo to M. Hult: "Bacterial Sampling at St. Louis Park, Minnesota"

Author

Edward Godsy

Agency

U.S.G.S., Western Region

Date

September 16, 1980

Subject:

It is well known that microbes can decompose organic matter in anaerobic environments, and that CO_2, CH_4, and H_2S are generally the end products.

In order to do a complete study of microbial activity at St. Louis Park several different types of analyses and experiments were performed. They were as follows:

1. Enumeration of the six major types of bacteria that would be expected in an anaerobic environment.

2. Direct microscopic enumeration of all bacteria in a water sample.

3. Survey of bacteria in water samples capable of aerobic degradation of phenol, naphthalene, and creosote.

4. The ability of the hydrocarbon phase from W-13 to support aerobic growth.

5. Qualitative analyses of dissolved gases on selected wells.

Conclusions

Samples taken in or near the hydrocarbon pools of the drift and Platteville aquifer contain methane bacteria, which is indicative of organic degradation. The presence of methane bacteria in the surface aquifer is probably due to the slow degradation of the peat deposite. The hydrocarbon pool in the drift also contains bacteria capable of naphthalene degradation.

It appears that in the drift aquifer active organic degradation is taking place between P-124 and W-117. The entire suite of bacteria necessary to complete the conversion of coal tar acids to CO_2 and CH_4 are present. The low numbers of bacteria are probably due to the low temperative of the water (= 11°C).

In the Platteville aquifer, there is not as much positive data, but the presence of methane bacteria in W-107 and W-18 would indicate that there is some organic degradation taking place.

Data

The report presents the enumeration of bacteria found in 13 wells at the SLP site. It also presents a qualitative analyses of dissolved gases for 13 well water samples.

Location

M. Hult's file, U.S.G.S.

Comments

Microbial action is expected to be minimal because of the low soil temperatures.

Title

Letter to Edwin Ross

Author

M. Hult

Agency

U.S.G.S.

Date

April 23, 1980

Purpose

List of multi-aquifer wells and steps which may be taken by U.S.G.S. to assess the contribution of the multi-aquifer wells to the contamination problem in SLP.

Gasoline contamination in a piezometer
Golden Auto Parts
Androc Chemical
Sewage contamination from septic tanks
Prestolite
Old sugar beet well on the Reilly site (W-23)

Location

M. Hult's files, U.S.G.S.
U.S. EPA, Region V files

Comments

The following two additional potential sources were not listed by M. Hult in the letter:

D&A Lubricants
SLP municipal fuel storage tanks

Title

Letter to MPCA regarding Pentachlorophenol Contamination of the Androc Property Well in St. Louis Park.

Author

David Giese

Agency

MDH, Division of Environmental Health

Date

April 19, 1979

Subject

A fire occurred at the Androc Chemical Company or or about December 31, 1974. In addition to other chemicals, 23,850 lbs. of pentachlorophenol was being stored at the Androc property on the day of the fire. The water used during the fire may have carried chemicals into the ground water.

On February 25, 1976, MPCA sampled the Androc well for pentachlorophenol and found concentrations ranging from 4.045 ppm at the time of first pumping to 14.1 ppb after 10 minutes of pumping.

Results of soil and water tests by National Biocentrics of 3 locations on the Androc property showed significant levels of pentachlorophenol and phenol as deep as five feet in the soil.

Remedial work to eliminate the contamination consisted of the shallow excavation of specific contaminated areas and removal of chemical tanks. The well was sealed and abandoned in 1979.

Location

D. Devlin's files, EPA-HQ

Title

Report on Investigation of Individual Water Supplies
St. Louis Park, Minnesota

Author

F.J. Kilpatrick, Assistant Director, Division of Environmental Sanitation
Paul B. Johnson, Public Health Engineer

Agency

MDH

Date

March 11, 1960

Time Period

January 11 - Februbary 4, 1960

Purpose

The purpose of this ground water sampling survey was to determine to what extent the quality of the water of individual, private wells in St. Louis Park has been affected by the individual sewage disposal system (septic tanks) and other sources of contamination used within the community. This study was conducted upon the request of SLP. Ninety-four private wells were sampled and analyzed for nitrate nitrogen and surfactant concentrations. Twelve more samples were analyzed for coliforms.

Sample Data

Ten of the samples contained $\geq$10 ppt nitrate nitrogen. Eleven of the samples contained measurable concentrations of surfactants. No sample contained coliform organisms.

Analytic results were attached to the report and are not included.

Conclusions

Only two of the contaminated wells (>10 ppt nitrate nitrogren) were from wells lcoated in the drift. The contamination is spread throughout the drift aquifer rather than being isolated underneath septic system properties. 60% of the drift, 35% of the Platteville and <10% of the wells in the St. Peter were affected. Because the samples were taken in large number and randomly throughout SLP, a projection was made generally to the SLP ground water quality.

1. Ground water was contaminated with sewage.

2. 30% of the private wells are contaminated (350-525).

3. 10.6% of the wells contain nitrate nitrogen >10 ppt and are unsafe for preparation of infant formulas (106-160)

4. >1/2 of wells of depths to 75ft. and 1/3 of wells of depths between 75-110 ft. are contaminated. Therefore, the drift and Platteville, possibly the upper St. Peter, only are contaminated.

5. The contamination may contain toxic materials.

6. The number of coliform samples was an inadequate basis for predictions and conclusions.

7. The contamination will continue and increase in concentration with continued private sewerage disposal systems use.

8. Ground water of SLP was unsafe.

Recommendations

1. Municipal water supply system should be extended to SLP as soon as possible.

2. Uncased wells terminated in the St. Peter should be abandoned immediately and filled. (Multi-aquifer well pollutant movement theory).

3. Water with surfactant or nitrate nitrogen concentrations in excess of 1 ppm should preferably not be used. Water with nitrate nitrogen concentrations ≥10 ppt should never be used for preparation of infant formula.

Location

M. Hult's file, U.S.G.S.

Risk Assessment

Title

Epidemiologic Investigation of Third National Cancer Survey Data for St. Louis Park, Edina, Richfield, and the Minnesota-St. Paul Standard Metro Statistical Area with a Historical Review of St. Louis Park's Water Supply.

Author

Kari Hanson Dusich (U. of Minnesota) and MDH

Date

September 1979

Purpose

To use Third National Cancer Survey data to evaluate the significant of any differences in cancer incidence in SLP compared with Edina, Richfield, and the Minneapolis-St. Paul Standard Metropolitan Statistical Area. The Third National Cancer Survey data represent the three year period 1969 to 1971.

Results

For males, no cancer rates in SLP were statistically significant. Among females, age-adjusted rates for all cancer sites combined, for breast cancer, and for cancers of the gastrointestinal tract were higher in SLP than in Edina, Richfield and the Minnesota-St. Paul area. The excess in gastrointestinal cancer rates for females was only slightly significant. All cancer sites combined and breast cancer, were highly statistically significant.

Cancer rates for Jewish populations given in the literature are contradictory, varying from less than to higher than those for non-Jewish whites. Because of the sizeable Jewish population in SLP, estimated to be 20% in 1971, the influence of this factor is of particular interest, but would not explain the 1.5 fold difference in rates even if 20% of the SLP breast cancer cases were Jewish and a two-fold relative risk existed.

Summary

At the present time, the elevated incidence of breast cancer cannot be attributed to the water contamination, although the limited information available does not rule out such an association.

Data

The report contains statistical data to support the claims made. No water sampling data is found within the report.

Appendix B - Selected Computer Printouts

C - General Information on Water Supply Systems

D - St. Louis Park Water Supply System

E - St. Louis Park Water Contamination Problem

F - Literature Review of PAH in Water

Location

D. Devlin's file, EPA-HQ

Title

Health Implications of Polynuclear Aromatic Hydrocarbons in St. Louis Park Drinking Water

Author/Agency

MDH, Health Risk Assessment Section

Date

November 1978

Purpose

This report was an assessment of the first phase of a study of the municipal wells in the area to determine the concentrations of specific polynuclear aromatic hydrocarbons in the St. Louis Park, Edina, and Robbinsdale wells.

Data

Well water samples were analyzed for PAH compounds by high performance liquid chromotography (HPLC) using a modification of a method developed by the U.S. EPA (picks up fluorescing PAHs). Positive results were obtained for 4 of the 7 compounds that were analyzed for, specifically pyrene, fluoranthene, anthracene, and naphthalene. Identification of these compounds was confirmed by gas chromatography/mass spectrometry. The PAH data is attached to this summary.

Conclusions

1. In order of decreasing contamination, SLP Wells Nos. 10 and 15, 7 and 9, and 14 were the most heavily contaminated. The use of the water in these wells may significantly increase the intake of PAH compounds which have been shown to possess carcinogenic properties in lab studies or to have chemical properties which enhance the carcinogenicity of certain compounds. Wells Nos. 10, 15, 7, 9 and 14 are all in the Prairie du Chien-Jordan aquifer.

2. The geographical distribution of the contaminated SLP wells suggest the source of contamination is the former Republic Creosote site. The study indicates that the contamination is moving northward, reflecting the complexity of the ground water flow patterns in the area. (Ground water generally flows to the east in the Prairie Du Chien-Jordan aquifer.)

3. The task of risk assessment for this case is a difficult one because there are no epidemiologic studies on exposure to PAH compounds via ingestion and because PAH compounds detected in the SLP water supply are co-carcinogens, the health effects of which would be partially dependent on interaction with other compounds in the drinking water mixture.

4. The risk assessment in this report involved a comparison of a drinking water exposure with all other ingested exposoure to pryrene, fluoranthene, anthracene, with the conclusion that potential risk exists, since the drinking water exposure adds to the other ingested exposures of PAH.

5. SLP Wells Nos. 10 and 15 exceed the drinking water standard for PAH compounds as set by the World Health Organization (WHO).

Recommendations

Periodically sample the SLP water supply for PAH compounds at a number of locations in the distribution system to determine the effect of dilution with water from uncontaminated wells, the magnitude of any seasonal variations in PAH concentrations, and the actual population dose distribution.

Location

D. Devlin's file, EPA-HQ

Comments

This report was based upon the very first HPLC-PAH analysis. At that time, MDH analyzed for only 7 PAHs. They presently analyze for 21 PAHs.

Also, the WHO standard was the only drinking water standard existing in 1978.

TABLE 1*

PAH in Drinking Water
(Nanograms/Liter)

	Well	Depth (feet)	Aquifer	A	P	FI	BaP	BghiPE	OPP	N
	SLP #3	236	PSP	< 1.9	< 47	<0.9	<1.1	< 4.4	< 1.1	<10
closed	SLP #4	500	SJ	< 1.9	< 47	4.5	<1.1	< 4.4	< 1.1	<10
	SLP #5	465	SJ	< 1.9	< 47	7.4	<1.0	< 4.1	< 1.2	<10
	SLP #6	480	SJ	< 1.9	< 47	<1.0	<1.0	< 4.8	< 1.5	<10
closed	SLP #7	446	SJ	11.4	104	7.4	<1.1	< 4.4	< 1.1	<10
	SLP #8	507	SJ	< 1.9	< 47	<0.8	<1.1	< 4.4	< 1.1	<10
closed	SLP #9	473	SJ	12.2	199	21.1	<1.1	< 4.4	< 1.1	<10
closed	SLP #10	500	SJ	100	800	450	<1.1	< 9.8	< 2.1	-
	SLP #10	500	SJ	54	486	152	1.3	4.4	< 1.2	80
	SLP #11	1000	H	< 1.9	< 47	< 0.9	<1.1	< 4.5	< 1.1	<10
	SLP #12	1095	H	< 1.9	< 47	< 0.9	<1.1	< 4.5	< 1.1	<10
	SLP #13	1040	H	< 1.9	< 47	1.0	<1.1	< 4.5	< 1.2	<10
	SLP #13	1040	H	< 1.9	< 47	< 0.9	<1.2	< 4.9	< 1.1	<10
	SLP #14	485	SJ	6.3	< 47	4.2	1.8	5.5	2.2	<10
	SLP #14	485	SJ	6.3	< 47	2.4	<1.2	5.4	< 1.1	<10
closed	SLP #15	503	SJ	190	750	390	<1.2	<10.7	< 2.4	-
	SLP #15	503	SJ	241	1221	292	1.5	6.8	2.0	160
	SLP #16	500	SJ	< 1.9	< 47	< 0.8	<1.1	< 4.4	< 1.1	<10
	Edina #2	460	SJ	< 1.9	< 47	3.1	<1.1	< 4.6	< 1.1	<10
	Edina #3	475	SJ	< 1.9	< 47	1.0	<1.1	< 4.6	< 1.1	<10
	Edina #4	495	SJ	< 1.9	< 47	0.9	<1.1	< 4.6	< 1.1	<10
	Edina #7	547	SJ	< 1.9	< 47	<0.8	<1.1	< 4.7	< 1.1	<10
	Edina #15	405	SJ	< 1.9	< 47	<0.8	<1.1	< 4.6	< 1.1	<10
	Edina #17	461	SJ	< 1.9	< 47	<0.8	<1.1	< 4.7	< 1.1	<10
	R #1	624	SJ	< 1.9	< 48	2.8	<1.2	< 4.9	< 1.1	<10
	R #2	624	SJ	< 1.9	< 47	2.1	<1.2	< 4.9	< 1.1	<10
	R #4	402	SJ	< 1.9	< 47	0.9	<1.2	< 4.9	< 1.1	<10
	WBL #3	289	SJ	< 1.9	< 48	<1.0	<1.0	< 5.1	< 1.6	<10
	F #13	332	SJ	< 1.9	< 48	1.5	<1.2	< 6.3	< 2.0	<10
	Edina P #1	-	-	< 1.8	< 45	2.1	<0.8	5.6	< 1.2	<10
	Edina P #2	-	-	< 1.8	< 45	1.2	<0.8	< 3.4	< 1.2	<10

Well	Depth (feet)	Aquifer	A	P	Fl	BaP	BghiPE	oPP	N
Edina P #3	-	-	< 1.8	<45	2.3	<0.8	3.9	< 1.2	< 10
Edina P #4	-	-	< 1.8	<45	< 0.8	<0.8	< 3.4	< 1.2	< 10
Glenwood Englewood	-	-	< 1.9	<47	< 0.9	<1.2	6.8	1.6	< 10
Minneapolis	-	-	< 7.0	<210	9.3	<3.6	<13.0	< 1.7	-
St. Paul	-	-	< 7.0	<210	4.7	<3.6	<13.0	< 1.7	-

* < = less than detection limit, A = anthracene, P = pyrene, Fl = fluoranthene, BaP = benzo[a]pyrene, BghiPe = benzo[ghi]perylene, oPP = o-phenylenepyrene, SLP = St. Louis Park, R = Robbinsdale, F = Fridley, WBL = White Bear Lake, PSP = Platteville-St. Peter, SJ = Shakopee-Jordan, H = Hinkley

Title

Assessment of Possible Human Health Effects Resulting from the Contamination of the Former Republic Creosote Site

Author/Agency

MDH, Health Risk Assessment Section

Date

October 1977

Purpose

The report examines and makes recommendations relative to those aspects of the St. Louis Park-Republic Creosote problem which relate to public health. The report is meant to serve as a starting point for an ongoing process of risk assessment. The report deals only with the contamination of drinking water supplies.

Conclusions

PAH accumulate in the fatty tissue of biological matter. This results in significant accumulation and biomagnification of PAH in the body tissues of a variety of organisms.

A literature survey indicated that a number of PAH compounds, creosote, and coal tar containing PAH are carcinogenic to one or more species of animals.

Environmental carcinogens usually occur in a complex mixture. The mixture of chemicals can multiply the risk of cancer that would be encountered from one carcinogen above. This may result from the summation of the effects of several carcinogens or from exposure to co-carcinogens and tumor-promoters. Phenol, for example, is not carcinogenic but has been shown to promote the tumorogenic activity by benzo(a)pryrene.

For the assessment they estimated both the maximum accepatable benzo(a) pyrene concentration in drinking water and the existing concentrations of benzo(a)pyrene in the water supplies of St. Louis Park and Edina. They then evaluated the significance of the difference between the two values and found that the estimated exposure was about 1,000 times higher than the maximum accepatable exposure which was estimated to be very low, 3.1×10^{-14} ug/l. These findings suggested to them the existance of a potentially serious public health problem.

Recommendations

1. Determine the possible source of coal tar taste in "old city well #1" which extends into the St. Lawrence shale and is cased to the top 60 feet of the Shakopee limestone. This "taste" might indicate that the Prairie du Chien-Jordan is seriously contaminated within the study area.

2. Examine the buried bedrock valley to the east of the site to determine the presence or absence of a high permeability "pipeline" at the valley which could provide a rapid travel path for contaminated ground water.

3. Conduct solubility studies to determine to what extent constituents of coal tar wastes are soluble in ground water under environmental conditions (necessary to predict movement of contaminants).

4. Determine which aquifer is the source of the high phenol concentrations in the Robinson Rubber Company well.

5. Design and implement a pumpout and barrier well system capable of removing and halting the spread of contaminated water in the drift and lower aquifers. Barr Phase II has recommended that the effluent from the barrier well system be discharged into the sewer. MDH stated that the wastes must receive extensive treatment before discharge to the sewer because the literature indicated that conventional sewage treatment would not be effective in removing PAH compounds.

Location

D. Devlin's file, EPA-HQ

Comments

Several assumptions were made, not all of which may be valid. It was assumed that the phenol/PAH ratio is the same in SLP as it is at the Reilly site. It was also assumed that the resulting estimated PAH values are associated with beno(a)pyrene in the same ratio as has been found in European ground water.

The evaluation addressed solely the carcinogenesis due to benzo(a)pyrene, and consequently did not address adverse health effects due to exposure of other PAH and phenolic compounds.

Remedial Measures and St. Louis Park Restoration Projects

Title

Proposal for Consultant Services--Drinking Water Treatment and Remedy Evaluation

Author

Eugene A. Hickock and Associates

Agency

for SLP

Date

April 11, 1980

Time Period

May 1, 1980 - November 30, 1980 (there was a delay in startup of two months, so expect feasibility report in January 1981)

Proposal

Hickock is to provide technical and economic information necessary for the design and implementation of a carbon treatment system for at least SLP Wells Nos. 10 and 15. This project is a subset of the remedial evaluation contract between Hickock and MDH.

Task 1 - Review earlier studies and identify alternative methods of treatment

Task 2 - Design and supervise treatment testing program (sampling program)

Task 3 - Develop treatment process operating characteristics

Task 4 - Develop treatment process costs for design, capital investiment, operating expense and maintenance expense

Task 5 - Preparation of an engineering feasibility report

Task 6 - Grant assistance

Task 7 - Interaction

Budget - $25,000

Location

D. Koppy's file, SLP

Title

Feasibility Study for Providing a Section of St. Louis Park with Minneapolis Water

Author

Naeem Qureshi, Engineer

Agency

City of Minneapolis, Department of Public Works

Date

April 7, 1980

Purpose

To present the feasibility of providing a section of SLP (E. of State Highway 100, S. of State Highway 7) with Minneapolis water. The area is called the Southwest High Service Area.

Conclusions

Cost: $71,800 for domestic and fire use at 60 psi pressure
total demand = 11,871 gpm
existing connection included from the 24" main on 38th Street and extended
(total design 12,000 gpm)

Recommend

Purchase compound water meter and piping
completed construction by 7-7-80 (projection)

Location

SLP Public Works file

Title

Summary Report on the City of St. Louis Park Activated Carbon Pilot Plant Study--July and October 1979

Author

Daryle A. Thingvold, PhD
SERCO Laboratories

Agency

for SLP

Date

January 11, 1980

Time Period

July and October 1979

Purpose

SLP conducted two small pilot studies to determine the feasibility of using powdered activated carbon (PAC) for removing PAHs.

July 1979 - Well No. 15 @ 1000 gpm and carbon slurry (PAC) at two different concentrations approximately 2 mg/l and 10 mg/l. PAC was removed via sand filtration.

October 1979 - similar smaller-scale study

Data

MDH and SERCO split samples to be analyzed for PAH concentrations by HPLC methods in July. SERCO analyzed October samples. Post filtration values were compared to non-PAC treated values. Results were grouped as: untreated (sampled at well head); post-sand filter, treated (carbon slurry @ 1-4 mg/l), post-sand filter, treated (carbon slurry @ 9-12 mg/l); post-sand filter, untreated.

There was a discrepancy between SERCO and MDH results. SERCO results were generally lower than MDH results.

PAC @ 1-4 mg/l reduced phenanthrene concentrations to 200-300 mg/l from 1500 mg/l
PAC @ 9-12 mg/l, PAH concentrations "appear to be significantly reduced"

(Data summary attached)

Conclusions

PAC removes PAHs from water.

Recommendations

A more detailed pilot study to determine most efficient PAC removal concentrations with minimum costs.

Location

SLP Public Works file

Comments

Water treatment by carbon adsorption can be implemented through two different mechanisms: powdered activated carbon (PAC) and carbon columns.

PAC may be added to the water stream prior to sand filtration. PAH removal is dependent upon the contact time with the PAC. Therefore, adequate mixing is necessary. The PAC is removed by the sand bed. The addition of the PAC decreases the useful life of the sand filter. When the sand is removed and replaced, the spent sand becomes a hazardous waste and must be disposed of accordingly. PAC is most commonly used by sanitary engineers in wastewater treatment plants. However, disposal of the sand is sometimes forgotten and may present a disposal problem.

Carbon columns may be portable installations added to the treatment system already in place. The spent carbon can be recycled. Many of the problems with PAC use are not applicable to carbon columns. However, the use of columns requires monitoring of adsorption parameters in addition to influent and effluent PAH concentrations.

ST. LOUIS PARK
PILOT CARBON TREATMENT STUDY
JULY 16-20, 1979
WELL NUMBER 15
MINNESOTA DEPARTMENT OF HEALTH's RESULTS
SERCO Laboratories January 9, 1980

Test Condition	Partial List of Parameters (ng/l)					
	Acenapthene	Anthracene	Phenanthrene/Pyrene*	Fluorene	Fluoranthene	Chrysene
Untreated Samples						
7/16 11:00 AM	3200	-	1700	-	510	<25
7/18 11:00 AM	2400	-	1800	-	440	<25
7/19 5:00 AM	2800	-	1900	-	380	<25
7/20 5:00 AM	<2.2	60	1400	-	190	-
Post Sand-Filter Untreated						
7/16 11:05 AM	<140	-	6.1	-	3.6	<25
7/16 11:00 PM	2500	-	1900	-	84	<25
7/16 5:00 PM	1600	-	440	-	91	<25
7/19 3:00 AM	4800	-	1100	-	32	<25
7/19 3:00 AM (Dupl.)	3900	-	1000	-	32	<25

* co-eluting compounds
< means "less than"

ST. LOUIS PARK
PILOT CARBON TREATMENT STUDY
JULY 16-20, 1979
WELL NUMBER 15
MINNESOTA DEPARTMENT OF HEALTH's RESULTS
SERCO Laboratories January 9, 1980

Test Condition	Partial List of Parameters (ng/l)					
	Acenapthene	Anthracene	Phenanthrene/Pyrene*	Fluorene	Fluoranthene	Chrysene
Post Sand-Filter Treated, 1-2 mg/l						
7/17 11:00 AM	910	-	430	-	89	<25
7/17 11:00 AM (Dupl.)	1200	-	360	-	81	<25
7/17 5:00 PM	1300	-	300	-	62	<25
7/17 11:00 PM	170	<8.0	180	-	39	<25
7/17 11:00 PM (Dupl.)	2700	-	190	-	30	<25
7/18 5:00 AM	1500	-	180	-	28	<25
7/18 11:00 AM	2600	-	210	-	41	<25
7/18 5:00 PM	190	<8.0	210	-	17	-
7/18 9:00 PM	190	<8.0	240	-	15	-

* co-eluting compounds
< means "less than"

TABLE 1

ST. LOUIS PARK
PILOT CARBON TREATMENT STUDY
JULY 16-20, 1979
WELL NUMBER 15
MINNESOTA DEPARTMENT OF HEALTH's RESULTS
SERCO Laboratories January 9, 1980

Test Condition	Partial List of Parameters (ng/l)					
	Acenapthene	Anthracene	Phenanthrene/Pyrene*	Fluorene	Fluoranthene	Chrysene
Post-Sand Filter Treated, 9-12 mg/l						
7/19 5:00 AM	110	<8.0	510	-	14	<25
7/19 11:00 AM	21	<8.0	10	-	7.0	-
7/19 5:00 PM	<2.2	<8.0	27	-	3.6	-
7/19 11:00 PM	<2.2	<8.0	<1.0	-	1.0	-
7/20 5:00 AM	<2.2	<8.0	<1.0	-	1.2	-
May-August 1978	-	190	750[1]	-	390	-
	-	241	1221[1]	-	292	-

* co-eluting compounds

[1] Pyrene only

< means "less than"

	July 19			July 20		May 29, 1979
)::00 PM	3:00 AM[A]	4:00 AM[B]	5:00 AM	4:00 AM[B]	5:00 AM	
	-	-	9	-	12	
).0	-	-	10.0	-	10.0	
.5	-	-	6.5	-	6.5	
	<81	<52	<49	<87	<58	390
	<12	<8.0	<7.5	<9.3	<8.9	170
	<0.2	***	<0.1	<0.7	<0.2	63
	<0.2	2.3	<0.1	4	<0.2	1
	<0.8	<0.9	<0.5	<0.9	<0.6	6.3
	<0.2	***	<0.1	<0.7	<0.2	63
	<0.4	<0.6	<0.3	4.0	<0.3	<0.57
	<81	<52	<49	<87	<58	390
	<0.4	1.1	0.4	2.0	<0.3	290
	<220	<140	135	<240	<160	<56
	<9.4	<6.0	<5.7	<10	<6.7	160
	<2.0	<2.1	<1.2	<1.5	<1.4	150

***co-eluting compounds--
total result is 27 ng/l

TABLE 3

ST. LOUIS PARK
PILOT CARBON TREATMENT STUDY
OCTOBER 2-4, 1979
WELL NUMBERS 15 AND 11
SERCO LABORATORIES' RESULTS

	Date							
	October 2		October 3		October 4			
	8:00 AM	2:00 PM	2:00 AM	2:00 PM	2:00 AM	12:00 PM	2:00 PM	2:30 PM
Acenaphthene, ng/l	<390**	<470**	<720**	<420**	<360**	<340**	<430**	<490**
Anthracene	<190	<220	<340	<200	<170	<160	<200	<230
Benzo(a)anthracene	<13*	<16*	<10*	<15*	<13*	<12	<15	<17
Benzo(a)pyrene	<4	<4	<6	<4	<4	<3	183	<5
Benzo(ghi)perylene	<13	<16	<10*	<18*	<12	<12	<15	<17
Chrysene	<13*	<16*	<10	<15	<13*	<12*	<15*	<17*
Dibenzo(ah)anthracene	<6	<8	<2	<7	<5	<3	<7	<3
Fluorene	<390**	<470**	<720	<420	<360**	<340**	<430**	<490**
Fluoranthene	<5	<6	<9	<5	<5	<5	203	<7
Naphthalene	<320	<380	<590	<340	<300	<280	<350	<400
Phenanthrene	<110	<140	<210	<120	<110	<100	<120	<140
Pyrene	<21	<24	<37	<21	<19	<18	<22	<26

** co-eluting compounds

* co-eluting compounds

< means "less than"

12/28/79

Title

Request for Proposal to Study, Evaluate and Prepare a Cost Analysis and Plan for the Remedy of Ground Water Contamination Resulting from Discharge of Industrial Chemicals at the Site of a Former Creosote Plant in St. Louis Park, Minnesota.

Author

MDH, Edwin H. Ross, Project Offier

Date

November 20, 1979

Time Period

April 1, 1980 - June 30, 1981

Budget

$120,000

Objectives

To provide the technical and economic information necessary to design and implement a remedial program to eliminate the chemical contamination of the ground water.

1. Evaluation of gradient well systems

2. Treatment of gradient well discharge

3. Excavation

4. Additional considerations-U.S.G.S. refinement

Location

U.S. EPA, Region V files

Title

Proposal for Analysis and Plan--Remedy of Ground Water Contamination, St. Louis Park

Author

E.A. Hickock, P.E.
Hickock and Associates

Agency

for MDH

Date

January 1980

Time Period

January 1980 - June 1981

Purpose

In response to MDH "request for proposals" dated November 20, 1979, Hickock and Associates, Inc. will work in team with Henningson, Durham and Richardson, and Geraghty and Miller.

1. Study and evaluation of the cost effectiveness of a gradient control well system; evaluation of methods for treatment and disposal of the water discharged from the gradient control wells and the contaminated soils.

2. Participation in refinement of the U.S.G.S. diffusion-dispersion model.

3. Definition and evaluation of a system to treat the water pumped from the gradient control wells.

4. Evaluation of the volume of contaminated material and procedures for possible excavation. Methods of treatment and disposal of the excavated material will be investigated.

5. Review and evaluation of all existing data.

6. Literature review in establishing accepatable levels of contaminants.

7. Estimation of the relative effectiveness of various combinations of barrier wells, treatment systems, and excavation programs with cost effectiveness evaluations.

8. Preparation of a detailed work plan with schedule.

9. Interaction

10. Final report due June 30, 1981.

Location

U.S. EPA, Region V files

ORATORY ANALYSIS
RK SOIL BORINGS
ARK, MINNESOTA
IES MARCH, 1978

ING #3

Benzene extractables mg/kg dry weight	Phenolics mg/kg dry weight
120	0.5
-	-
158	<0.2
-	-
281	0.4
14	<0.2
-	-
816	0.3
510	0.5
-	-
416	0.5

ING #4

Benzene extractables mg/kg dry weight	Phenolics mg/kg dry weight
24000	1.2
440	<0.2
590	<0.2
-	-
615	<0.2
-	-
350	0.7
-	-
530	0.9
-	-
404	0.7
1470	<0.2
470	-

500348-19

Final Results

RESULTS OF LABORATORY ANALYSIS
ST. LOUIS PARK SOIL BORINGS
ST. LOUIS PARK, MINNESOTA
SERCO LABORATORIES MARCH, 1978

BORING #1

Depth	Analyzed	Lab. No.	Total Solids Percent	Benzene extractables mg/kg dry weight	Phenolics mg/kg dry weight
5'- 6½'	X	1510	85.9	2300	0.67
12'-13½'	X	1511	84.6	6300	4.6
17'-18½'	-	-	-	-	-
24½'-26'	X	1512	84.9	230	0.73
35'-36½'	X	1513	88.8	600	1.1
40'-41½'	-	-	-	-	-
44½'-46'	X	1514	89.4	440	1.0
49½'-51'	-	-	-	-	-
55'-56½'	X	1515	88.4	370	0.35
60'-60.4'	-	-	-	-	-
65'-66½'	X	1516	89.1	96	0.53

BORING #2

Depth	Analyzed	Lab. No.	Total Solids Percent	Benzene extractables mg/kg dry weight	Phenolics mg/kg dry weight
5'- 6½'	X	1602	50.9	430	<0.2
10'-11½'	-	1603	-	-	-
15'-16½'	X	1604	84.8	240	<0.2
19½'-21'	-	1605	-	-	-
24½'-26'	X	1606	88.7	710	<0.2
39½'-40'	X	1607	83.2	610	<0.2
44½'-46	X	1608	89.5	22	<0.2
49½'-51'	-	1609	-	-	-
54½'-56'	X	1610	88.9	517	<0.2
59½'-61'	-	1611	-	-	-
64½'-66'	X	1612	88.6	480	<0.2

Title

Louisiana Avenue Extension Report

Agencies/Companies

MDH in cooperation with Soil Exploration of St. Paul, Braun Engineering and SERCO Labs

Time Period

Soil Exploration and MDH sampling occurred between March 10-23, 1978. Braun Engineering took 27 soil borings between 2-4-75 and 5-15-75.

Purpose

During March 1978, Soil Exploration of St. Paul took six borings along the proposed Louisiana Avenue Extension between Lake Street and Oxford Street. Separate boring logs were prepared by Soil Exploration and the MDH. Five borings were analyzed for four PAH compounds (fluoranthene, Benzo(a)pyrene, Benzo(g,h,i)perylene, o-phenylenepyrene). Phenolic concentrations were also measured for all six borings. The phenolic analyses were conducted by the SERCO labs.

Conclusions

Analyses of the six borings made by Soil Exploration/MDH showed that Borings Nos. 1, 3, and 4 were contaminated with PAH compounds, while Borings Nos. 5 and 6 (further east from the site) appeared to be free of PAH contamination. Phenolic contamination existed in boring Nos. 1, 3, and 4, but was not detected in Borings Nos. 5 and 6.

In virtually all 27 borings made by Braun Engineering in the Spring of 1975 a "chemical smell" was detected indicating some degree of contamination.

Data

Attached to this summary are the data from the MDH logs, Soil Exploration logs, PAH analyses, and Braun Engineering logs. Also included are maps to identify the location of the soil borings.

Location

D. Devlin's file, EPA-HQ

RESULTS OF LABORATORY ANALYSIS
ST. LOUIS PARK SOIL BORINGS
ST. LOUIS PARK, MINNESOTA
SERCO LABORATORIES MARCH, 1978

BORING #5

Depth	Analyzed	Lab. No.	Total Solids Percent	Benzene extractables mg/kg dry weight	Phenolics mg/kg dry weight
5'- 6½'	X	1728	13.8	34000	<0.2
10'-11½'	-	1729	-	-	-
14½'-16'	X	1730	37.5	8800	<0.2
20'-21½'	-	1731	-	-	-
25'-26½'	X	1732	37.2	10750	<0.2
30'-31½'	X	1733	40.7	10000	<0.2
50'-51½'	X	1734	90.2	95	<0.2
55'-56½'	X	1735	86.9	520	<0.2
60'-61½'	-	1736	-	-	-
65'-66½'	X	1737	91.8	130	<0.2
70'-71½'	-	1738	-	-	-

BORING #6

Depth	Analyzed	Lab. No.	Total Solids Percent	Benzene extractables mg/kg dry weight	Phenolics mg/kg dry weight
5'- 6½'	X	1801	29.7	7740	<0.2
10'-11½'	-	1802	-	-	-
15'-16½'	X	1803	44.9	4680	<0.2
20'-21½'	-	1804	-	-	-
25'-26½'	X	1805	29.6	11500	<0.2
30'-31½'	-	1806	-	-	-
35'-36½'	X	1807	72.1	1360	<0.2
40'-41½'	-	1808	-	-	-
45'-46½'	X	1809	86.6	59	0.2
50'-51½'	-	1810	-	-	-
55'-56½'	X	1811	89.4	168	0.2
60'-61½'	-	1812	-	-	-
65'-66½'	X	1813	91.8	260	<0.2
70'-71½'	-	1814	-	-	-

I) MDH logs:

Boring 1	- Strong mothball odor	10-35'
Boring 2	- Petroleum odor	10-15', 45-50'
Boring 3	- Strong odor	40-55'
Borings 4-6	- No odor nor visible detection	

The petroleum odor found at depth 40-50 feet appears to occur at or above a clay layer. Borings 1-3 appear to be contaminated by coal-tar derivatives.

II) Soil Exploration logs:

Boring 1 - Creosote odor - 0-10½', 17½'-18½', 24½'-26', 30'-31', 37'-62'
Visible creosote - 0-10½', 17½'-18½'
Boring 2 - Creosote odor - 12'-23', 46'
Boring 3 - Creosote odor - 15½'-22', 33'-36', 63'-71'(?)
Borings 4-6 - Clean

Borings 1-3 indicate creosote contamination, while borings 4-6 appear to be clean.

III) PAH analyses on selected logs:

	Fluoranthene	Benzo(a)pyrene	Benzo(g,h,i)perylene	O-phenylene pyrene
Boring 1				
12-13½'	190 mg/kg	19.1 mg/kg	-	7.24 mg/kg
Boring 3				
35-36½'	5.83 µg/kg	< 0.93 µg/kg	< 4.03 µg/kg	< 1.34 µg/kg
50-50½'	5.40 µg/kg	0.89 µg/kg	2.00 µg/kg	1.13 µg/kg
65-66½'	5.68 µg/kg	1.35 µg/kg	3.15 µg/kg	3.43 µg/kg
Boring 4				
14½-16'	475 µg/kg	36.4 µg/kg	-	17.3 µg/kg
55-56½'	31.2 µg/kg	< 0.31 µg/kg	-	< 0.44 µg/kg
Boring 5				
5-6½'	<35 µg/kg	< 1.3 µg/kg	< 5.4 µg/kg	< 1.8 µg/kg
14½-16'	< 8.7 µg/kg	< 1.2 µg/kg	10.9 µg/kg	< 3.6 µg/kg
25-26½'	2.96 µg/kg	< 0.66 µg/kg	2.8 µg/kg	< 0.91 µg/kg
30-31½'	2.79 µg/kg	< 0.62 µg/kg	2.6 µg/kg	< 0.86 µg/kg
50-51½'	2.31 µg/kg	< 0.34 µg/kg	1.4 µg/kg	< 0.46 µg/kg
55-56½'	2.21 µg/kg	< 0.33 µg/kg	1.4 µg/kg	0.92 µg/kg
65-66½'	2.96 µg/kg	< 0.33 µg/kg	1.39 µg/kg	< 0.45 µg/kg

0020752

Boring 6				
5-6½'	2.32 µg/kg	< 0.66 µg/kg	< 2.80 µg/kg	< 0.90 µg/kg
14½-16'	1.33 µg/kg	< 0.67 µg/kg	< 2.91 µg/kg	< 0.93 µg/kg
25-26½'	1.97 µg/kg	< 0.67 µg/kg	< 2.85 µg/kg	< 0.91 µg/kg
Peat	7.82 µg/kg	0.66 µg/kg	2.80 µg/kg	0.92 µg/kg

Borings 5 and 6 appear to be clean. In fact, these analyses were used in deciding whether or not construction on the railroad bridges should proceed. Boring 4 indicates significant levels of PAH compounds at a depth of 14½-16 feet.

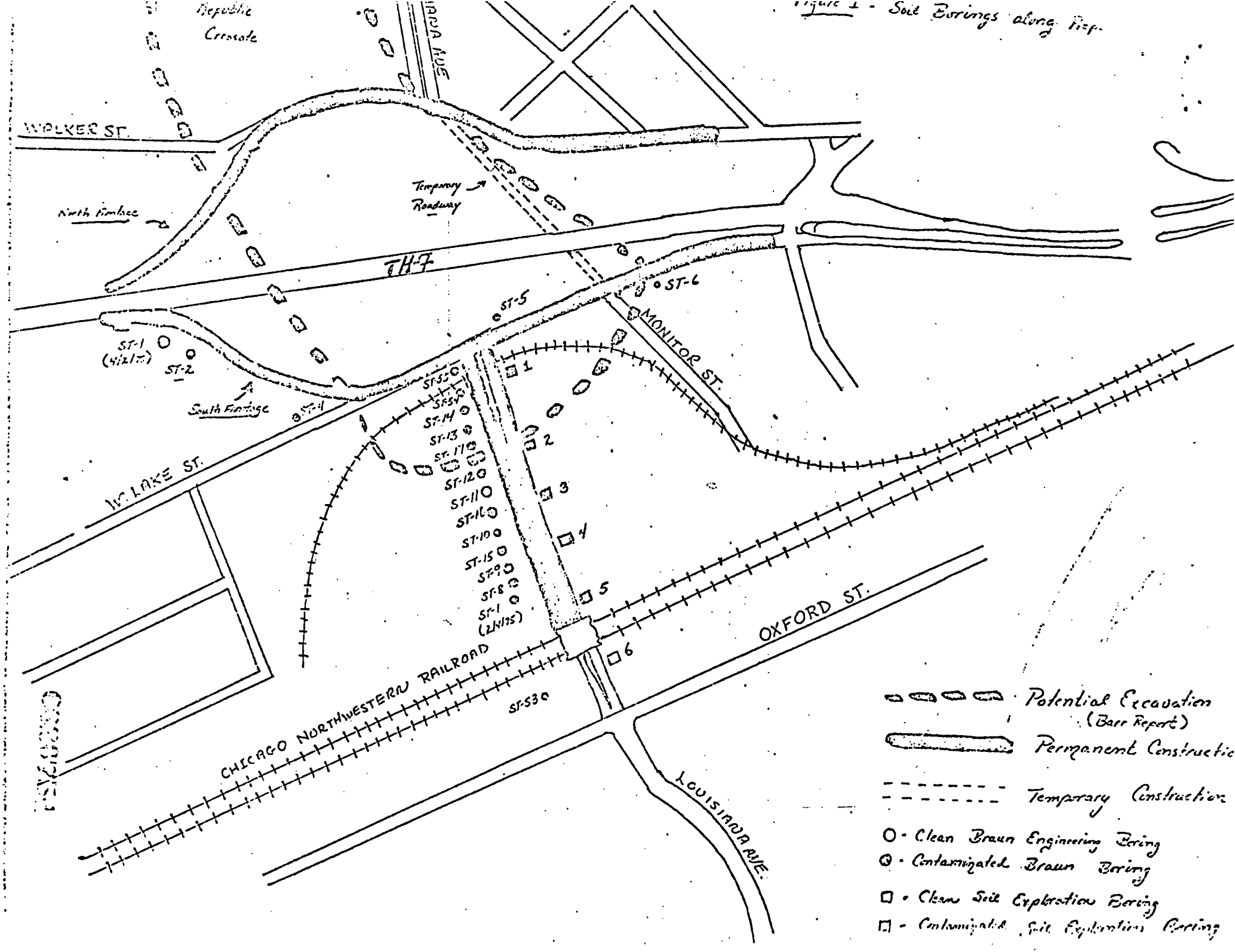
IV) Braun Engineering Testing for Louisiana Avenue Extension (2/4/75-5/15/75):

Braun Engineering made 27 soil borings during the Spring of 1975 along the proposed Louisiana Avenue extension between Lake Street and the railroad tracks and along the bypass routes. Virtually all the borings south of Lake Street indicate some contamination at various depths. The extent of contamination does not quite reach the railroad tracks. The depths at which contamination was found are listed below for the appropriate logs. Please refer to Figure 1 for the location of the logs.

Log Number	Location	Depth (feet)	Description
ST-1(2/4/75)	Louisiana extension	-	Clean
ST-1(4/2/75)	South frontage	-	Clean
ST-2	South frontage	13-15.5	Slight chemical smell
ST-4	South frontage	0-20.5	Strong chemical smell
ST-6	Lake & Monitor	0-20.5	Slight chemical smell
ST-8	Louisiana extension	23-26	Strong chemical odor, visible creosote
ST-9	"	13-16	Slight chemical smell
ST-10	"	11-15	Slight chemical smell
ST-11	"	-	Clean
ST-12	"	4.5-13	Strong chemical smell
		18-30.5	Slight chemical smell
ST-13	"	4.5-6	Strong chemical smell
		12.5-14.5	Slight chemical smell
ST-14	"	18-25.5	Slight chemical smell
ST-15	"	9-28.5	Slight chemical smell
ST-16	"	9-16	Strong chemical smell
		16-22	Slight chemical smell
ST-17	"	4-6	Strong chemical smell
		12-25.5	Slight chemical smell
ST-53	South of tracks	34-50	Slight chemical smell
		60-71	Slight chemical smell
ST-54	Louisiana & Lake	16-33	Strong chemical smell
ST-55		0-11	Strong chemical smell
		11-30.5	Slight chemical smell

6620753

Figure 1 - Soil Borings along Rep.



Title

Letter to Richard Koppy, City of St. Louis Park, Concerning Excavation of Contaminated Soil from Oak Park Village Area

Author

Archie Carter
Braun, Carter and Associates Consulting Engineers

Date

January 10, 1978

Subject

Creosote material was removed to a depth of at least 8 feet during excavation of the Oak Park Village area. Where creosote contamination was high, excavation was to approximately 12 feet. In all, a total of 44,130 $feet^3$ of contaminated material was removed.

Location

SLP files

Comments

The 44,130 $feet^3$ of contaminated soil was mounded to the southwest of Oak Park Village, according to Vern Tollesfrud, SLP Public Works engineer.

Title

Soil Investigation--Proposed Storm Sewer and Holding Ponds Near Highway 7 and Louisiana Avenue, St. Louis Park, Minnesota
Public Improvement 72-43 #20070

Author

Donovan K. Stormoe, P.E.
Soil Exploration Company
662 Crownwell Avenue
St. Paul, Minnesota

Agency

for SLP

Date

April 16, 1974

Time Period

February 1974

Purpose

The purpose of this report was to evaluate the ground water and soil conditions for compatability with proposed storm sewer and holding ponds system.

Site: west of Highway 7 and West Lake intersection
north boundary - Walker Street
south boundary - railroad tracks

Sample Data

17 soil borings from the drift and Platteville. The summaries accompanying each soil boring describe the geologic column through the boring. All borings have several surficial feet of peat. Many borings note approximately 10-15 feet of black or brown "muck" at lower depths. No further description.

Laboratory analyses for phenols, and oil and grease were done on water and soil samples from Borings Nos. 5, 13 (deep borings) (see attached).

Conclusions

OK to construct one of the holding ponds leaving organic deposits (weak) in place. The pond should be hypalon lined. The pond bottom should be sloped and a layer of pervious materials placed just below the liner. The pond liner should be ballasted.

Recommendations

OK to locate storm sewer north of/and under Highway 7. The peat and organic material in other areas extend to depths of 50 ft. in places. This organic material is compressible and not suitable for storm sewer construction.

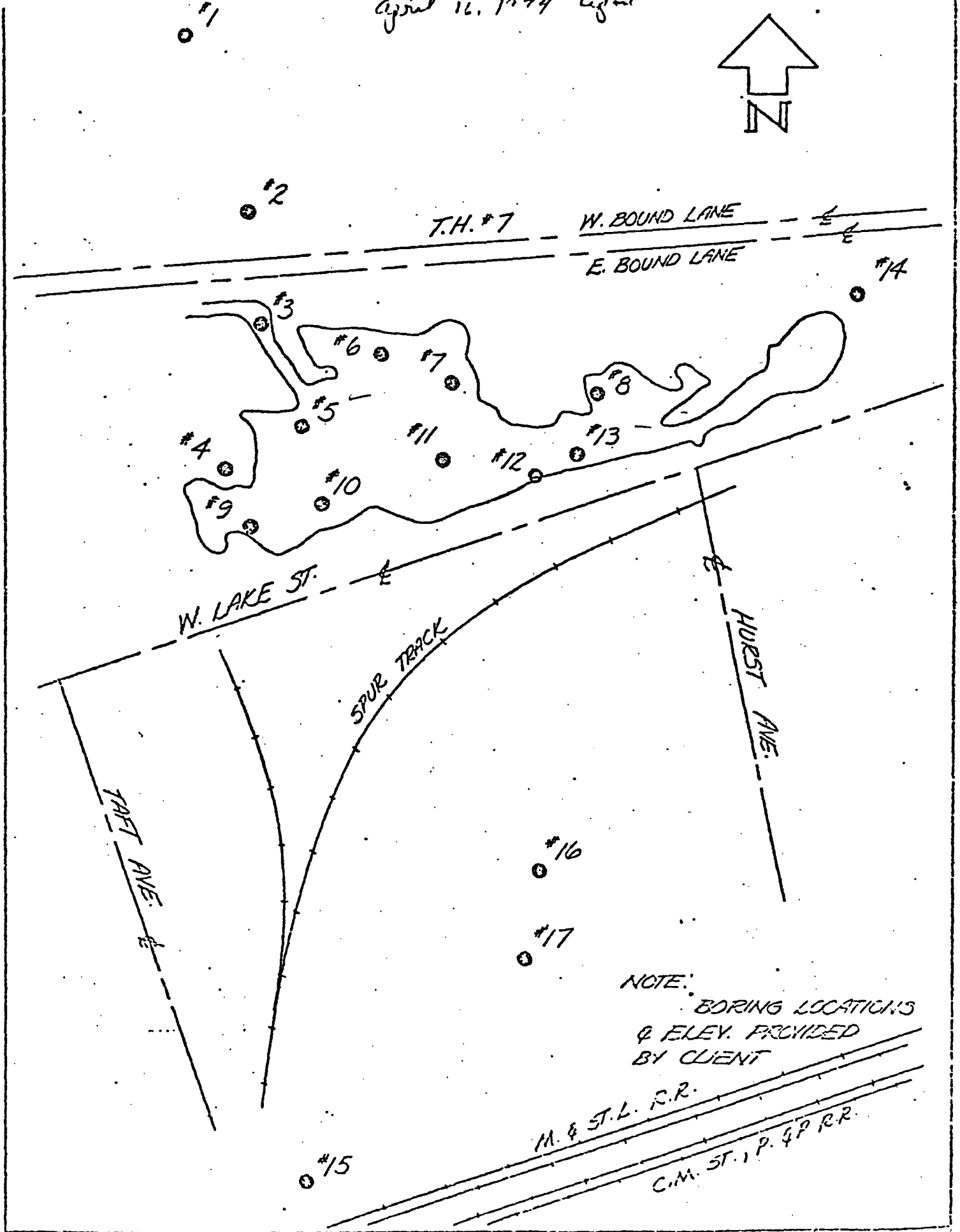
Recommend dewatering the site prior to pond construction.

Location

R. Koch's files, MDH

SOIL EXPLORATION COMPANY

April 16, 1974 Agent



SOIL TEST BORINGS	JOB NO. 20070	SCALE. NONE	DRAWN BY [illegible]	CHECKED BY [illegible]

April 16, 1991 Report

CHEMICAL TEST RESULTS

Job No 20070

BORING NUMBER	SAMPLE DESCRIPTION	SAMPLE DEPTH	SAMPLE ELEVATION	CHEMICAL CONCENTRATIONS (mg/l) PHENOLS	OIL, GREASE, & PARAFFIN
5	Water	25'	152.3	7.3	4685
5	Soil	20'-21'	156.3-157.3	N.D.*	150
5	Soil	40'-41'	136.3-137.3	N.D.*	160
5	Soil	60'-61'	116.3-117.3	N.D.*	160
13	Water	35'	142.8	25.5	3138
13	Soil	20'-21'	156.8-157.8	6.3	272
13	Soil	45'-46'	131.8-132.8	15.5	27,000
13	Soil	50'-51'	126.8-127.8	5.8	2216
5, 7, 9, 13 & 14	Soil	0'-9'	Above 168	91.4	115,000
16 & 17	Soil	0'-8'	Above 168	1.3	1265
16	Soil	20'-21'	154.8-155.8	N.D.*	372
(Bag)	100% Soil			N.D.*	21,795
(Bag)	50% Soil-50% Creosote			1.9	39,614
(Bag)	100% Creosote			16.3	119,034

*None detected. Test sensitive to concentration of more than 0.01 mg/l

.002

JOB NO. 20070 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO. 5

PROJECT PROPOSED STORM SEWER AND HOLDING POND - ST LOUIS PARK, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 177.3'	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS W	D	L.L. / P.L.	Cu
	PEAT, fine fibrous, black, frozen to ½' then wet, 0.3' layer of ice at the surface (Pt)	SWAMP DEPOSIT	2	*	1	SS				
			1½		2	SS				
			1/1½'		3	SS				
			1		4	SS				
9	MUCK, dark gray, soft (Pt)		1/1½'	*	5	SS				
12	BOGLIME, light gray, soft (OL)		1/1½'		6	SS				
14	SILTY CLAY, gray, soft (CL)	FINE ALLUVIUM			7	SS				
15½	SAND, medium grained, some gravel, gray, waterbearing, medium dense (SP)	COARSE ALLUVIUM	6		8	SS				
18	SAND, medium grained, a little gravel, brown, waterbearing, dense to medium dense to dense, a few lenses of gravel and silty sand (SP)		25		9	SS				
			13							
			13		10	SS				
36½			17		11	**				

Continued on Next Page

SOIL EXPLORATION COMPANY

JOB NO. 20070 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO. 5 cont.

PROJECT PROPOSED STORM SEWER AND HOLDING POND - ST LOUIS PARK, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL/PL	Qu
36½										
			20		12	SS				
			15		13	SS				
			28		14	SS				
			20		15	SS				
59	LEAN CLAY, a little gravel, gray, stiff (CL)		27		16	SS				
	*Note: water level is expected to rise to the surface based on observation while sampling and on appearance of sample **Drilling fluid wash sample ***No measurement recorded due to presence of drilling mud		28		—	—				
68½	End of Boring									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
2-20	9:00	16'	14½'		to	10'*
2-21	3:00	68½'	14½'		to	***
2-21	3:15	68½'	None		to	***
					to	

START 2-19-74 COMPLETE 2-21-74

METHOD 3¼ HSA 0' - 14½' @ 3:00

DM 16' - 68½'

CREW CHIEF Francis

SOIL EXPLORATION COMPANY

JOB NO. 20070 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO. 13

PROJECT PROPOSED STORM SEWER AND HOLDING POND - ST LOUIS PARK, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 177.8'	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS W	D	L.L. / P.L.	Qu
½	ICE									
	PEAT, fine fibrous, black and gray, wet (Pt)	SWAMP DEPOSIT	1/1½		1	SS				
			1/1½		2	SS				
			1/1½		3	SS				
			1/1½		4	SS				
			1		5	SS				
12	MUCK, gray, soft (Pt)		1/1½	*	6	SS				
			2		7	SS				
			3		8	SS				
			3		9	SS				
29										
	SAND, medium to coarse grained with gravel, gray, with gravel, waterbearing, dense to medium dense to very dense (SP-GP)	COARSE ALLUVIUM	19		10	SS				
			13		11	SS				
36	Continued on Next Page									

SE-3 (70-A)

SOIL EXPLORATION COMPANY

JOB NO. 20070 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO. 13 cont.

PROJECT PROPOSED STORM SEWER AND HOLDING POND - ST LOUIS PARK, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL/PL	Qu
36										
			12		12	SS				
			26		13	SS				
	*Note: water level is expected to rise to the surface based on observation while sampling and on appearance of samples **Drilling fluid wash sample ***No measurement recorded due to presence of drilling mud		29		14	SS				
			32		15	SS				
59	SILTY SAND, some gravel, gray, wet, very dense (SM)	TILL	33		16	SS				
63	SILTY SAND, a little gravel, reddish brown, dense, a few pieces of limestone at about 67' (SM)		26		17	SS				
67	Obstruction				18	**				

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
2-22	9:10	31'	29½'		to	14'*
2-22	1:15	67'	29½'		to	***
2-22	1:45	67'	None		to	***
					to	

START 2-21-74 COMPLETE 2-22-74

METHOD 3¼ HSA 0' - 29½' @ 1:15

DM 31' - 67'

Francis

Title

Letter to G. Koonce, Chief, Division of Water Quality, MPCA, in reference to storm water study performed by Orr, Schelen, Mayeron and Associates

Author

John Badalish, Orr, Schelen, Mayeron (OSM)

Date

November 15, 1973

Subject

Report says SLP bought the property to prevent further contamination of Minnehaha Creek. OSM developed a method providing for storm water conveyance, storage impoundment, land reclamation and treatment of "creosote area" to prevent degradation of creek. Detention ponds will be built on site. They discuss several alternatives for what to do with soil excavated to facilitate the detention ponds:

1. land farm utilizing aeration and fertilization.
2. off site disposal in landfill
3. controlled incineration

Conclusion

Land farming is the most practical means for disposing of these contaminated soils.

Location

M. Convery's file, MDH

Comments

The storm water project was part of the city's rehabilitation plan for the Reilly site.

Title

Storm Water Study, Public Improvement No. 72-43 (Republic Creosote Area)

Author

Wayne Long

Agency

Orr, Schelen, Mayeron and Associates

Date

August 6, 1973

Purpose

The report is presented in two phases. The first phase deals with the petrochemical pollution problem encountered on or near the site. Procedures for reclamation are discussed. The second phase is a feasibility report for storm sewer construction on the Republic Creosote Site.

The only pertinent information in this report is the recommendation for reclamation of the site. The recommendation was made by the American Petroleum Institute and several petroleum companies as well as Federal and State agencies. At the time of this report, phenol was considered to be the only contaminant.

Recommendations

The information obtained by the parties mentioned above indicates that the most feasible method of disposal for this type of waste problem is land farming of the contaminated soil.

Land farming is the technique of creating and maintaining the most advantageous aerobic action in the contaminated soil, allowing the natural organisms in the soil to degrade the phenolic pollutants. This is accomplished by thoroughly mixing the contaminated soil with farm fertiziler. Aeration will also be accomplished by this mixing thus creating a favorable aerobic condition for the degrading of the pollutant.

To verify the feasibility of the land farming procedure for this case, soil samples were sent to the U. of Minnesota for bioassay. The results were positive in that sufficient organisms exist in the soils at the site to assimilate the phenolic pollutants.

The report claims that by implementing land farming, contaminated soil can be cleaned up in one growing season.

Data

Exhibit II presents phenolic concentrations of samples taken on or adjacent to the Republic Creosote site. The tests were conducted by Tri-City Public Health Lab during the period of March/April 1973. Concentrations of phenol ranged from 6.5 ppm to 0.01 ppm.

Location

U.S. EPA, Region V files

Title

Surface and Subsurface Ground Reclamation--Republic Creosote Site

Author

Wayne R. Long, Engineer
Orr, Schelen, Mayeron and Associates

Agency

for SLP

Date

April 23, 1973

Purpose

To outline feasible methods for the public improvement of the Reilly site

Conclusions

Wastes are similar to refinery wastes and it is "highly unlikely" that the city water supply is in danger of being polluted by phenols. The most immediate hazard is surface runoff to Minnehaha Creek.

Recommendations

Land farm contaminated soils

Location

SLP Public Works files

Miscellaneous

Title

St. Louis Park Water Supply System

Author

Kari Hanson Dusich (U. of Minn) and MDH

Date

1979

Subject

Old City Well No. 1 was drilled in May 1932, and was closed in August 1934 due to the strong odor and bad taste of the water. (U.S.G.S reported that Old City Well No. 1 was abandoned in 1933)

In 1938, SLP made their final break from Minneapolis water services when they put Wells Nos. 2 and 3 into operation.

By the end of 1974 the City had:

1. 16 deep wells with a combined capacity of 26 million gallons per day.

2. 4 elevated towers with a combined capacity of 2.6 million gallons.

3. 4 ground storage reservoirs with a combined capacity of 5 million gallons.

4. Several iron removal plants.

It is not known how long PAH compounds have been in the SLP water supply as the instruments and techniques for their detection in water have become available only recently.

Data

Report presents information on SLP water supply stations and municipal wells. No sampling data is presented.

Location

Appendix D in the "Epidemiologic Investigation of TNCS Data for St. Louis Park, etc." September 1979
D. Devlin's file: U.S. EPA, HQ

Title

Water Resources Data for Minnesota, Water Year 1976
NTIS # U.S.G.S.-WDR-MN-76-1
U.S.G.S/WDR/HD-77/037

Agency

U.S.G.S., Water Resources Division

Date

July 1977

Time Period

October 1, 1975 - September 30, 1976

Purpose

The purpose of this study was to report water resources data for Minnesota for the water year 1976. Water quality of lakes, reservoirs, wells, springs, gaging stations and streams are reported.

Location

SLP Public Works files

Comments

This is an open data report. It contains no conclusions. This report has been the data base of other geologic summaries.

Title

Transcript of Public Hearing on the City of St. Louis Park's Application for a National Pollutant Discharge Elimination System Permit to Discharge from a Wastewater Treatment System on the Former Republic Creosote Site to Minnehaha Creek
Conducted by MPCA

Date

February 27, 1975

Location

SLP Public Works files

Comment

Three citizens opposing NPDES permit
Hearing Officer: J.A. Johannes
MNAG: William Donohue
Attorney for SLP: Wayne Popham
Attorney for Contractor, Lametti and Sons: Richard Dafney

Citizens:	Mattie Peterson	Minnesotans Against Pollution
	Steve Chapman	Minnesotans Against Pollution
	Larry King	Isaac Walton League

MINNESOTA POLLUTION CONTROL AGENCY
December 15, 1978

Briefing Memorandum Regarding
Reilly Tar and Chemical Company
in St. Louis Park

I. Background.

For over [redacted] a coal tar distillation and wood treating operation in St. Louis Park, Minnesota. [redacted] the [redacted] seeped into the soils and ground waters of the area. The geology of the site consists of approximately 70 to 90 feet of mixed sands, silts, peat and clay overlying a thick series of sandstones, limestones and shales. The bedrock aquifers are the principal source of municipal water for St. Louis Park and surrounding communities. Studies to date have identified the oily wastes themselves to a depth of approximately 60 feet. The upper-most bedrock aquifer contains greater than 1 milligram per liter (mg/l) phenols. [redacted] These wells are about 500 feet deep and up [redacted].

II. History of Action.

In 1970 the Minnesota Pollution Control Agency (MPCA) and the City of St. Louis Park filed suit against R[redacted] In 1973 the City dismissed its action as part of a purchase agreement. In 1978 the MPCA amended its original complaint to better define the ground water issues. Over the past three years the State

Legislature has appropriated over $400,000 to study the problem. The City has also invested sizable sums in various ground water and soil investigations. A sophisticated ground water modeling effort, scheduled for completion in late 1980, is being conducted by the U.S. Geological Survey (USGS). In the next couple months the State will be defining what additional studies must be completed in order to adequately define the problem and the solutions. Attempts will be made to identify sources of funding for the studies. The cost of corrective measures will likely be in the range of $10 million. Funding for these measures must also be found.

III. Appropriate Future Action.

It appears that adquate information on the health effects of PAH exists. Studies are now underway to better define the ground water hydrology of the area. A great deal of additional data is required on the extent of soil contamination, treatment or contaminated ground water. This information must be gathered through site specific studies. The EPA could provide assistance in identifying funding sources and making the required applications. This subject has been briefly discussed with John McGuire, Regional Administrator.

Report 4: Groundwater and Soil Contamination from Creosote and Coal Tar Derivatives in St. Louis Park, Minnesota.

This incident involves 80 acres of land located in the City of St. Louis Park, Minnesota which had been the site of a coal tar distillation process and wood creosoting operation for approximately 50 years.[1] In 1969 a groundwater investigation conducted for the City revealed low levels of phenols (trace - 23 ppb) in the municipal water supply.[2] Phenols are detectable by odor and taste at concentrations ranging from 10-100 ppb.[3] In addition, trace amounts approaching 1 ppb can impart an objectionable taste to water following marginal chlorination.[4] The investigation report indicated that the creosoting operation was the source of the contamination. The report also indicated that in 1932 one municipal and several private wells located near the site were abandoned due to a tarry taste.[5]

Subsequent analysis by the Minnesota Department of Health and the Carnegie-Mellon Institute failed to indicate any significant concentrations of phenols in the water. However, the health department did conclude that:

> ...it seems obvious that the disposal of a substantial quantity of phenolic material on the surface of the ground in a general area where there are wells producing water for human consumption is not desirable and constitutes a serious hazard.[6]

In October, 1970 the Minnesota Pollution Control Agency and the city brought suit against the generators seeking temporary and permanent abatement of further pollution of the air and water of the state.[7] The defendant generators counter claimed and discovery and investigation continued until September, 1971 when the generators closed down their operations. In June, 1973 the city purchased the property from the generators. The city proposed a plan to clean up the area which included land farming and obtaining a NPDES permit. However, due to lack of an adequate definition of the problem and sufficient technical data to determine the type and concentration of contaminants present in the ground, the Minnesota Pollution Control Agency withheld its approval of the city's plan pending an environmental assessment of the problem.[8]

In November, 1975 an engineering company was retained by the Minnesota Pollution Control Agency to evaluate the impact of the former generators on the soil and groundwater at the site.[9] Fourteen soil borings (a total of 196 samples) were taken within the site and analyzed for phenolic and benzene extractable materials. Eleven of these were analyzed by thin layer chromatography to determine the presence of polynuclear organic materials and five of these were subjected to gas chromatography to measure the concentration of six polynuclear organics.[10] In addition, nine groundwater monitoring wells were drilled in glacial soils and shallow bedrock within the site area. Samples were obtained from these wells and from five other municipal and industrial bedrock wells also located within the site.[11]

Analysis of the soil samples indicated phenolic concentrations ranging from <0.2 - 220 mg/kg depending upon depth and the particular area within the site.[12] In sufficient concentrations, phenols are toxic and they are suspected of being carcinogenic. Three polynuclear organics were also present: phenanthrene (<0.8 - 0.36 mg/g), chrysene (<3.2 - 171.5 mg/g) and pyrene (<0.2 - [illegible] mg/g).[13] There is evidence that these substances are neoplastigenic. Four well samples indicated phenolic substances ranging from 0.043 - 3.0 mg/l (43 - 3,000 ppb).[14] As previously mentioned phenolics are detectable by odor and taste at concentrations ranging from 10 - 100 ppb. and as low as 1 ppb. in chlorinated water.

There is uncertainty as to the exact manner in which the St. Louis Park site became contaminated. Apparently, over the 50 years in which the wastes were generated, there were numerous spillages, burial of spilled materials and solid wastes, pipeline breaks, waste discharges and contaminated run-off to sloughs, leakages from run-off catchment sumps and basins and dripping from freshly treated wood and poles.[15] At the present time there is a great deal of uncertainty as to what can be done to remedy this situation, a situation which potentially has long range and quite costly effects. Barr Engineering is continuing its study of the problem and is expected to recommend corrective actions and future studies needed to find solutions.[16]

REFERENCES

1. MPCA File, Division of Water Quality, Memorandum on Groundwater Contamination, St. Louis Park, Minnesota, Nov. 19, 1974.

2. MPCA File, Chronology of Creosote incident, St. Louis Park, Hennepin County, Oct. 29, 1974, p. 1.

3. Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971.

4. Ibid.

5. Chronology of Creosote incident, op. cit.

6. MPCA File, Memorandum from R.F. Frazier, Chief, Analytical Services Section, Minnesota Dept. of Health, to J.P. Badalich, Executive Director, MPCA, April 20, 1970.

7. MPCA File, Memorandum on Groundwater Contamination, op. cit.

8. Ibid.

9. Soil and Groundwater Investigation, Coal Tar Distillation and Wood Preserving Site, St. Louis Park, Minnesota, Phase I Report, Barr Engineering Co., May, 1976, p. 4.

10. Ibid., p. 5.

11. Ibid.

12. Ibid., Figures 1-8 and Appendix B.

13. Ibid., Table 1.

14. Ibid., Table 3.

15. Observations by MPCA and City staff, engineers and numerous employees, John Aho, Division of Water Quality.

16. Soil and Groundwater Investigation, op. cit.

PRIVILEGED

October 1, 1980

DRAFT

BRIEFING MEMO ON INDUSTRIAL PROCESS USED AT REILLY TAR & CHEMICAL CORPORATIONS AT ST. LOUIS PARK, MINNESOTA PLANT (1916-1973)

This memo will present the information available regarding the industrial processes carried out at the Reilly Tar and Chemical Corporation's St. Louis Park plant during its approximately 57 years of operation. Information regarding raw materials, refinery processes and products, creosoting plant (Republic Creosoting Company) processes and products, and waste-water treatment processes will be presented. From the information available to us, the known changes, disruptions and modifications to these processes will be traced through the history of the plant. In some cases, assumptions as to some of the minor processing steps will be made in an attempt to present a clear and complete picture of the plant operations.

For the purposes of clarity, this memo is divided into three main sections: 1) coal tar refinery operations, 2) creosoting plant operations, and 3) wastewater treatment plant operations. Each of these subjects will be presented with attention given to raw materials, processes, products, historical events, such as accidents, explosions, and process modifications, and state-of-the-art technology available to minimize pollution potential.

	Percent:
Light oil (up to 200°C):	
Crude ~~benzene and toluol~~	0.3
Coumarone, indene, etc.	0.6
Xylenes, cumenes and isomers	1.1
Middle (200°- 250°C) and heavy (250°-300°C:	
~~Naphthalene~~	10.9
Unidentified oils in range of naphthalene and methylnaphthalenes	1.7
a-Monomethylnaphthalene	1.0
b-Monomethylnaphthalene	1.5
Dimethylnaphthalenes	3.4
Acenaphthene	1.4
Unidentified oils in range of acenaphthene	1.0
Fluorene	1.6
Unidentified oils in range of fluorene	1.2
Anthracene oil (300°-350°C or end of distillation):	
~~Phenanthrene~~	4.0
~~Anthracene~~	1.1
Carbazol and kindred nonbasic nitrogen-containing bodies	2.3
Unidentified oils in range of anthracene	5.4
~~Phenol~~	0.7
~~Phenol homologues~~ (largely cresols and xylenols)	1.5
~~Tar bases~~ (mostly pyridine, picolines, lutidines, quinolines and acridine)	2.3
Yellow solids of pitch oils	0.6
~~Pitch greases~~	6.4
Resinous bodies	5.3
~~Pitch~~ (460° F. fusing-point)	44.7
TOTAL	100.00

(See Appendix A for chemical structure of the major compounds in this table.)

Coke oven tar is that portion of bituminous coal burned in a coke oven which volatizes (or vaporizes) upon heating at temperatures between 1000 and 1300°C and which is condensed as the gases are cooled. Coke oven tar is typically produced at the

forms may have been included to a small extent. The following paragraphs describe the sources of the various types of tars and the important characteristics of each.

Before discussing the various types of coal tar, I will present some of the typical characteristics and composition of coal tar. The following chart has been taken from "Asphalts and Allied Substances" by Herbert Abraham, Sixth Edition, Copyright 1961. As you will note many of the components are listed as "unidentified". As of 1966 only about 215 compounds from coal tar had been identified with researchers estimating that approximately 5000 compounds comprised coal tar.

The chart which follows was modified by adding typical temperature ranges at which the fractions are collected in the coal tar distillation process. The compounds presented as phenols, phenol homologues, tar bases, yellow solids of pitch oils, pitch greases, and resinous bodies can be found in varying amounts in more than one of the major fractions (light oil, middle oil, heavy oil, anthracene oil, and pitch).

STATE AND LOCAL EFFORTS TO PROTECT PUBLIC WATER SUPPLIES AND TO ABATE AND CONTROL POLLUTION OF THE GROUND WATER

10. As early as May, 1938, the Department of Health advised Reilly Tar that its waste water discharges contained unacceptable levels of pollutants and were imparting a tarry taste to water from nearby wells.

11. In October, 1970, St. Louis Park and the State, by its Pollution Control Agency, filed suit against Reilly Tar in the District Court of Minnesota, Fourth Judicial District, seeking abatement of air and surface water pollution from Reilly Tar's site. St. Louis Park voluntarily dismissed its suit in June, 1973, as a term of an agreement to purchase the Reilly Tar site.

12. In September, 1974, the Department of Health issued a report on wells in St. Louis Park which described elevated levels of phenols in the well water and called for a comprehensive geological and hydrological study of the area. During that month, Department of Health analyses of soil samples from the Reilly Tar site disclosed the presence of carcinogenic polynuclear aromatic hydrocarbons (hereinafter "PAH") compounds.

13. In March, 1975, the Pollution Control Agency issued a National Pollution Discharge Elimination System (hereinafter "NPDES") permit to St. Louis Park establishing treatment standards, monitoring requirements, and effluent limitations for discharges from a proposed St. Louis Park storm sewer system which would drain an area including the Reilly Tar site.

14. Between November, 1975, and July, 1977, Barr Engineering Company conducted a study of the site area and prepared reports for the State on contamination of the soil and ground water and future impacts on ground water quality. The final report recommended additional studies and corrective actions, including abandonment of multi-aquifer wells that were pathways for spread of contaminants. The State paid $108,000 for the Barr study.

15. In October, 1977, the Department of Health issued a preliminary assessment of possible health risks from contamination of municipal wells by carcinogenic PAH compounds, including recommendations for monitoring municipal wells in the St. Louis Park area for such compounds.

16. In April, 1978, the State sought to reactivate its state court action against Reilly Tar by seeking leave to amend its complaint to allege the recently discovered contamination of ground water by PAH compounds. St. Louis Park sought leave to intervene as a plaintiff. In September, 1978, these motions were granted. After interlocutory review was denied by the Minnesota Supreme Court, discovery was commenced by all parties and is continuing at this time.

17. In May, 1978, the Department of Health commenced High Performance Liquid Chromatography (HPLC) analyses of water from St. Louis Park and other municipal wells for PAH compounds.

Because of the level of PAH compounds found, St. Louis Park municipal wells 7, 9, 10 and 15 were closed in November, 1978. The potential hazard to the public health from the PAH contamination was reported in a Department of Health risk assessment report issued in November, 1978. Experimental treatment of water from the closed wells was undertaken by St. Louis Park in July and October, 1979. The wells have never been returned to service.

18. In July, 1978, the United States Geological Survey (hereinafter "USGS") commenced a cooperative project with the State to define ground water flow and transport of organic contaminants in the area of the site, including development of a digital computer ground water chemical transport model. The State has so far incurred expenses of $130,000 for the USGS study, including services provided in kind. Additional expenses will be incurred for USGS assistance.

19. In cooperation with the USGS, the State was able to locate, clean out, and seal or recomplete 24 multi-aquifer wells which were facilitating, or appeared likely to facilitate, the spread of contaminants to deeper aquifers. The cost incurred by the State for this well abandonment from July, 1979, to date has been $70,000.

20. In response to USGS reports of contaminated water moving down the well bore of W23, a deep well on the site formerly used in Reilly Tar's operations, St. Louis Park installed a packer in the well in July, 1979. This packer prevents further contamination

of the Prairie Du Chien-Jordan aquifer from this source.

21. In January, 1979, the State applied to the Administrator of EPA for designation of the aquifers underlying the Twin Cities Metropolitan Area as "principal source aquifers" pursuant to § 1424(c) of the Safe Drinking Water Act of 1974, 42 U.S.C.A. § 300h-3. This application was based upon the contamination of the aquifers by coal tar and coal tar derivatives from Reilly Tar.

22. In the October-November, 1979, additional PAH analyses led to the closing of St. Louis Park municipal well No. 4. This well was returned to service for three days in May, 1980, because of fire protection needs. It is currently closed.

23. In April, 1980, the State awarded a consortium of engineering firms headed by Eugene A. Hickok and Associates a $120,000 contract to research measures and unit cost estimates for abating the soil and ground water contamination emanating from the site. St. Louis Park has also entered into a contract with Hickok and Associates to examine treatment of well water and alternative municipal water sources. Work on this contract is in progress.

COUNT I

RESOURCE CONSERVATION AND RECOVERY ACT

24. The State incorporates herein by reference paragraphs 15-31 of the Complaint of Plaintiff United States of America.

(c) Well 4 was pumped on May 1 (311,000 gallons), May 3 (264,000 gallons), and May 5 (244,000 gallons) of 1980 in order to provide adequate pressure in the distirbution system of St. Louis Park for fire protection.

Wells 7, 9, 10, and 15 have never been in service. Well 15 has provided water to analyze the effectiveness of powdered activated carbon slurry treatment. Tests were conducted during July and October of 1979. All waters from Well 15 were discharged to wastes.

(d) Well 4 was placed into service because the City was facing a low-pressure condition in the distribution system in the southeast corner of St. Louis Park. This condition presented a particular problem in providing adequate fire protection. The well was operated on three (3) separate days.

3. (a) A brief study was conducted on treatment of contaminated water utilizing a small-scale, pilot treatment plant using powdered activated carbon (PAC) Tests were conducted during July (7/16/79 - 7/20/79) and October (10/2/79) of 1979.

(b) Powdered activated carbon (PAC) served as a media for absorption of PAH compounds. PAC was mixed with water to form a slurry, which was then pumped into the well head of well 15. The well was pumped at 1000 gpm. PAC levels of 1-2 mg/l, 4-5 mg/l and 9-12 mg/l were analyzed. PAC was removed on sand filters and the waters discharged to waste.

(c) The treatment studies conducted to date have indicated strong removal of PAH compounds, and have been very encouraging. Reductions of greater than an order of magnitude have been found, particularly for PAC concentrations of 9-12 mg/l. However, some of the results have been erratic and clearly a well-structured and intense study is required to determine the long-term effectiveness of the treatment system.

(d) The treatment studies have not had any impact on the water supply to date. The studies that were conducted were preliminary and further work is required before allowing treated water into the distribution system. The waters pumped from well 15 have been discharged to waste following treatment and sampling. Water from wells 7, 9, 10, 15, have never been used for supply and from well 4 for a brief period in early May.

(e) The City of St. Louis Park has retained a consultant (Hickok & Associates) to provide technical and economic information necessary to design and implement a carbon treatment system. Both powdered activated carbon and granular activated carbon will be investigated include interconnection with other municipal supplies (i.e. Minneapolis), deepening and reconstruction of existing wells, and dilution of contaminated water with uncontaminated water. This information will be completed by the end of 1980.

4. Contamination of the groundwater was first suspected in 1932 when the City of St. Louis Park constructed the first municipal well - a 16 inch, 540 deep well cased to 280 feet. (Shortly after well development, the water developed a pronounced taste and odor of creosote and the city had to abandon the well. This location is 3000 feet east of the Republic Creosote facility.

Contamination of all drift and bedrock aquifers has been identified. There are three primary sources of contamination:

(a) Spills and drippings on the site with infiltration of contaminants affecting groundwater on the site.

(b) Surface runoff and waste discharges draining into a swampy area immediately south of the Republic Creosote facility.

(c) Entrance of coal-tar directly into deep well on the Republic Creosote site and transport via uncased, multi-aquifer wells.

Sometime during the 1920's coal tar was introduced into the deep water supply well (909 feet deep) on the Republic site. This well penetrates through to the Mt. Simon-Hinckley aquifer and was originally open-hole through all the bedrock units. When the well was examined in 1979, the well was plugged at a depth of 595 feet with coal tar. To complicate matters, groundwater flowed from the St. Peter Sandstone through the well bore into the Prairie du Chien-Jordan system, at an estimated flowrate of 150 gpm. A packer was placed in this well to eliminate this flow.

The Drift-Platteville aquifer system is contaminated at least one mile to the east and southeast from Republic Creosote. Heaviest contamination appears to be in the swampy area between Lake and Walker Streets, immediately south of the facility. In this area, visible creosote-like oils are found to depths of fifty feet.

[redacted] The western distribution is unknown at this time. Although the regional flow direction of this aquifer system is to the southeast, local pumping centers appear to be primarily responsible for contaminant movement. As contaminated wells closer to the site are closed, contamination appears to move toward outlying, active wells. This appears to have been the case with well 4 which gradually became contaminated after municipal wells 7, 9, 10, 15 and some industrial wells were closed. Now that well 4 is closed, well 6 may become contaminated.

The extent and magnitude of contamination in the Franconia-Ironton-Galesville aquifer system and the Mt. Simon-Hinckley aquifer system are not well-defined at this time. Clearly, there is a source of contamination to these aquifer systems through the deep well on the site containing coal-tar and through multi-aquifer wells penetrating the Prairie du Chien-Jordan system. Municipal wells 11, 12, and 13, which draw from the Mt. Simon-Hinckley system, have no indications of contamination. There are few monitoring or private wells penetrating through these deeper aquifers, and so it is difficult to assess the extent of contamination.

(Table 2)

TABULATION SHEET

TOPIC St. Louis Park Municipal Wells.

	date of sample	lab number	total volume pumped in previous 24 hours	2-methylnaphthalene	acenaphthalene	biphenyl	anthracene	phenanthrene	pyrene	1,2,6,7-tetrahydropyrene	fluorene	fluoranthene	1,2-benzanthracene	chrysene	benzo (a) pyrene	9,10-benzphenanthrene	benzo (e) pyrene	perylene	benzo (g,h,i) perylene	benzo (k) fluoranthene	benzo (j) fluoranthene	triphenylenepyrene
			x 1000 gal.	nanograins/liter = parts per trillion																		
St. Louis Park #4	10-19-79	6563			230.	47.		66.	87.			5.8	<3.8	3.6	<5.4			<2.2				<2.6
St. Louis Park #6	10-19-79	6564			<24.	<5.5		<2.4	<14.			<3.7	<3.8	<3.6	<5.4			<2.2				<2.6
St. Louis Park #8	10-19-79	6565			<24.	<5.5		5.8	<14.			<3.7	<3.8	<3.6	<5.4			<2.2				<2.6
St. Louis Park #11	10-19-79	6566			<24.	<5.5		<2.4	<14.			<3.7	<3.8	<3.6	<5.4			<2.2				<2.6
St. Louis Park #12	10-19-79	6567			<24.	<5.5		<2.4	<14.			<3.7	<3.8	<3.6	<5.4			<2.2				<2.6
St. Louis Park #13	10-19-79	6568			<24.	<5.5		<2.4	<14.			<3.7	<3.8	<3.6	<5.4			<2.2				<2.6
St. Louis Park #4	11-8-79	7114			<120.	34.		36.	<17.			3.3	<4.0	<4.0	<6.0			<3.4				<2.8
St. Louis Park #15	11-8-79	7115			<600.	1300.		1000.	<84.			450.	40.	<20.	30.			<17.				<14.
St. Louis Park #4	11-16-79	7386			300.	19.		43.	<14.			1.9	<3.2	<3.8	7.4			<4.2				<3.0
St. Louis Park #4	11-16-79	7387			290.	18.		44.	<14.			2.0	<3.2	<3.8	12.			<4.2				<3.0
St. Louis Park #4	11-16-79	7388			290.	16.		40.	<14.			2.4	<3.2	<3.8	<6.4			<4.2				<3.0
St. Louis Park #4	11-16-79	7389			280.	17.		42.	<14.			3.1	<3.2	<3.8	<6.4			<4.2				<3.0
St. Louis Park #7	11-5-79	7796			<100.	<24.		<10.	←	→		<17.	<24.	<15.	<24.			<16.				<12.
St. Louis Park #9	11-5-79	7797			<100.	<24.		<10.	←	→		<17.	<24.	<15.	<24.			<16.				<12.
St. Louis Park #10	11-5-79	7798			<100.	930.		690.	←	→		810.	65.	<15.	44.			<16.				<12.
St. Louis Park #15	11-5-79	7799			<100.	1140.		1000	←	→		550	53.	<15.	38.			<16.				<12.
St. Louis Park #14	10-19-79	6569			39.	11.		12.	<14.			<3.7	<3.8	<3.6	<5.4			<2.2				<2.6
St. Louis Park #15	10-19-79	6570			<120.	[illegible]		1300	<70.			830.	39.	<18.	<27.			<11				<13.
St. Louis Park #16	10-19-79	6571			<24.	[illegible]		6.0	<14.			<3.7	<3.8	<3.6	<5.4			<2.2				<2.6
St. Louis Park #15	7-16-79	55087		<67.	3200	[illegible]		1700	←	→		510.	<52.	<25.	<2.2	<15.		<1.0				<1.0
St. Louis Park #15	7-18-79	55095		<67.	2400	←	→	1800.	←	→		440.	<52.	<25.	<2.2	<15.		<1.0				<1.0
St. Louis Park #15	7-19-79	55102		<67.	2800	←	→	1900.	←	→		380.	<52.	<25.	<2.2	<15.		<1.0				<1.0
St. Louis Park #15	7-20-79	55123			<2.2	[illegible]		60.	1100	←	→	190.			<2.2	<1.0		<1.0				<1.0

6620377

City of St. Louis Park, Minnesota

[redacted]

EXEMPTION 9-WELL

[redacted]

Response to Thomas C. Jorling
October 2, 1978, Request for Information
on Hazardous Waste Facilities

Threatens Public Health

Name: Reilly Tar and Chemical Co. and Republic Creosote

Location: St. Louis Park, Minnesota

Ownership: City of St. Louis Park

Operator: Same

Date Established: 1920s

Type of Business: Coal tar distillation, wood creosoting operation.

Status: Abandoned, land subsequently purchased by city

Financial: City will not provide funds for cleanup

Waste Handling: Spillages; burial; pipeline breaks; runoff to sloughs; leakage from freshly treated wood.

Type of Hazardous Waste Involved: Phenols and polynucleated aromatics

Size of Business: Groundwater contamination covers 2 sq. miles; 80 acres of soil are contaminated to a depth of 60 feet.

Condition of Facility: (See size of business)

Physical Factors: Glacial soils over shallow bedrock; nine monitoring wells and five municipal and industrial wells for sampling; 0-50 feet consists of mixed peat, clay, and gravel overlying sandstone, limestone and shales.

History and Dates of Incidents:

1932- Abandonment of one municipal and several private water supply wells due to tar taste
1969- Phenols reported in municipal water supply
1970- Minnesota Pollution Control Agency brings suit
1971- Generators close operations
1973- City purchases property.

Action Taken To Date: Minnesota Pollution Control Agency retained engineering consultant to evaluate impact of former generators. Study is continuing in order to recommend corrective action.

Cost:

Spent to date:	$100,000	Study by State
	$100,000	Study by City
	$250,000	Storm sewer diversion project, including lined lagoons
Future estimated costs:		
	$130,000	Additional studies for solution of problem.
	$70,000	To close down contaminated wells
	$130,000	Problem definition by U.S. Geological survey

Estimated cost for total cleanup:

10 to 100 million dollars (for 1 million cubic yds. of soil)

P/3/2
SW3127

National Governors' Association

Otis R. Bowen, M.D.
Governor of Indiana
Chairman

Stephen B. Farber
Executive Director

RECEIVED
APR - 8 1980
MINN. POLLUTION
CONTROL AGENCY

April 4, 1980

RECEIVED
APR - 8 1980
MINN. POLLUTION
CONTROL AGENCY

RECEIVED
APR 0 9 1980
MINN. POLLUTION
CONTROL AGENCY

Terry Hoffman
Minnesota Pollution Control Agency
1935 West County Road B-2
Roseville, Minnesota 55113

Dear Mr. Hoffman:

We are asking you to participate in a study conducted by the National Governors' Association. It will help determine how communities prevent the occurrence or mitigate the effects of natural and manmade disasters. This study will assist governors in making recommendations to the federal government about alternative forms of federal support for state and local hazard mitigation activities.

We believe that mitigation of natural and manmade hazards holds great opportunity for retarding the astronomical costs of disaster relief and recovery in this country. From a search of 1700 U.S. counties, we have noted particular mitigation efforts and achievements and chosen your site for study. We rely on participants at only 80 sites to help us ascertain and share the tools and techniques of disaster mitigation, especially the most helpful role for the new Federal Emergency Management Agency.

Luther Nelson of the Environmental and Energy Department has been helping us identify people who have played important roles in the Hennepin County Hazardous Waste mitigation effort. It was suggested that you could provide valuable information.

The information you provide is part of an ongoing National Governors' Association program to assist states in dealing responsively with natural and manmade disasters through Comprehensive Emergency Management which involves mitigation in addition to preparedness, response and recovery activities.

We know that you are busy and we are asking for quite detailed information; so we've minimized your burden through considerable advance research which we've computerized. Then, we have pulled out only a few parts for you to answer about those aspects of the mitigation effort with which you are most familiar.

9820796

We will be calling you soon by telephone to assure you have received this letter and discuss any questions you may have. We hope you will be able to respond within two weeks, or sooner, as described in the enclosed INTRODUCTION paper. Please feel free to call our research director Jim Morentz or his assistant Judith Kelly collect on weekdays between 10 and 12, Eastern Standard Time, when they will be here to consult with you. I will also be pleased to hear from you if those hours are not convenient. The number is (202) 624-5365.

Sincerely,

Hilary Whittaker

Hilary Whittaker, Director
Emergency Management Project

Enclosure

9820797

RRJ
6-4-80

6/5/80

JW
6/5/80

Ms. Hilary Whittaker, Director
Emergency Management Project
444 North Capitol Street
Washington, D. C. 20001

JUL 0 2 1980

Dear Ms. Whittaker:

Enclosed is a response to the questions contained in the waste disposal site history outline regarding Reilly Tar and Chemical Corporation, formerly of St. Louis Park. Along with the response are several attachments providing additional information on the site history, litigation, and extent of the contamination. Agency staff will be attending the Regional Meeting to be held in Minneapolis on Emergency Management and Mitigative Strategies. We share your belief that the mitigation of hazards due to improper disposal will reduce disaster relief and recovery costs. The Agency is currently expanding its ability to investigate and mitigate ground water pollution problems.

If there is any additional information you need regarding Reilly Tar and Chemical Corporation, please contact Richard Ferguson of my staff at (612) 296-7258.

Sincerely,

Terry Hoffman
Executive Director

TH:lmj

Enclosures

TH/RRF:lmj

bcc: RRF (green) with attachments
S. Shakman " "
M. Convery (MDH)" "
L. Richie " "

9820807

A. Description of the hazard: The operation of a coal-tar distillation and wood preservative plant in St. Louis Park from [redacted] resulted in soil and ground water contamination. [redacted] The aquifer underlies the area at a depth of 250 to 500 feet and is overlain by two bedrock confining beds and 70 to 100 feet of drift. The early contamination of this aquifer is believed to have resulted from the introduction of [redacted]

[redacted] In addition, at least 25 ungrouted or partially cased wells exist in the area of the site which may permit contaminated water from near-surface aquifers to flow downward into deeper bedrock aquifers. Injection rates of 20 to 150 gallons per minute were observed in five of nine wells open to the Prairie du Chien-Jordan aquifer.

[redacted] Chemical analysis of fluid pumped from monitoring wells suggests that low molecular weight compounds are moving preferentially through the drift-Platteville aquifer system.

B. Damaging effects of the hazard: The contamination of bedrock aquifers with coal-tar derivatives has had a significant impact on the City water supply of St. Louis Park. Five [redacted] In addition, the contamination of soil has made it necessary to restrict land usage. An agreement has been signed by the City and several state agencies that precludes the development of a large portion of the former Reilly Tar site and an adjacent area to the south. These restrictions have prevented permanent road construction that has been needed to alleviate serious traffic delays and rerouting. Recently, temporary road construction has been proposed that would alleviate some of the transportation problems in the area.

C. Frequency with which hazard creates a disaster: The contamination of ground water at St. Louis Park has continued to present new hazards. Earlier this year, a municipal well was found to be contaminated with PAH compounds. The well had previously been determined safe, based on a sampling effort that had identified 4 of the City's 15 wells as contaminated. This demonstrates the contamination is spreading and may, in the future, contaminate wells that are currently producing safe drinking water. The loss of the wells from the City's water supply has resulted in water supply shortages during the dry summer months.

D. Brief chronological history of past attempts to deal with this hazard: Enclosed is an attachment containing a chronological history of the ground water problem in St. Louis Park. There are several important developments that are not contained in the attachment; these are discussed under Item F of the Mitigation Site Background section.

E. Explanation of the relative success or failure of past attempts to deal with this hazard: There has been some success in locating and plugging multi-aquifer wells that have been acting as conduits for the movement of contaminants to lower bedrock aquifers. However, since some of the wells cannot be located, they will continue to be a source for the spread of the contaminants. In addition, the City of St. Louis Park has also had some success in removing the contaminants from one of the contaminated municipal wells.

F. Current efforts to mitigate disaster from this hazard: The Minnesota Department of Health (MDH) currently holds two contracts regarding the mitigation of the contamination problem. The contracts are with the U. S. Geological Survey (U.S.G.S.) and the team of Hickock and Associates, Geraghty and Miller, and Henningson, Durham and Richardson. [redacted] Prior to this effort, Barr Engineering Company was contracted by the state to assess the impacts of the former coal-tar distillation and wood preserving facility on the soil and ground water (see attachment).

The contract between the MDH and Hickock and Associates, et al., requires the consultant to analyze the contamination problem and design the mitigative action. The City of St. Louis Park also holds a contract with Hickock and Associates. Under the contract, the consultant's tasks include a study of the possible treatment methods for removal of PAH compound from the City's wells and the engineering design of the treatment system.

1. Changes you are trying to make in the hazard, the vulnerable human systems, or their interaction: The City of St. Louis Park has hired a consultant to study the treatability of the contaminants in the Prairie du Chien-Jordan aquifer. In addition, [redacted]

2. Achievements which would indicate to you that your mitigation efforts have been successful: The City of St. Louis Park has conducted a small scale test to investigate the use of granular activated carbon (GAC). The test showed that treatment utilizing an injection of a GAC slurry produced water of acceptable drinking quality. The well abandonment program has been successful in locating unused multi-aquifer wells and plugging them. This program has decreased the rate of spread of the contaminants to lower bedrock aquifers.

3. The major obstacles you have encountered in your attempts to mitigate disaster: 1) The complexity of the hydrogeology of the contaminated area makes it necessary to spend a great deal of time and effort in an investigative phase prior to direct mitigative action. 2) A better understanding is needed on the mechanisms of coal-tar movement and diffraction in the unsaturated and saturated porous media. 3) The high investigative costs and the high anticipated mitigative costs will have delayed the final resolution of the problem.

4. The resources (information, people, skills, technologies, dollars, etc.) for which you have greatest need to accomplish your mitigation goals: To better accomplish the mitigative goals, it would be useful to have a more thorough understanding of how coal-tar derivatives behave in various media under unsaturated and saturated conditions and under natural and induced ground water flow. The mitigative action taken will be limited by the available funding.

LITIGATION

A. Description of Liability for Clean-Up of St. Louis Park Disposal Site.

1. Plaintiff, State of Minnesota; Plaintiff-Intervenor, City of St. Louis Park; Defendant, Reilly Tar and Chemical Corporation.

2. Issue: Responsibility of Reilly Tar and Chemical Corporation for Monitoring and Remedying Extensive Ground Water Contamination which has Resulted from the Company's Discharge of Coal-Tar Waste and Spills of Coal-Tar and Coal-Tar Derivative Products.

3. Arguments to be Made on the Issue: In its Amended Complaint (copy attached) the State has Asserted the Following Eleven Counts.

   a. Failure to Obtain State Disposal Permit.

   b. Failure to Report and Abate Discharges Likely to Pollute Waters of the State.

   c. Failure to Comply with State Water Pollution Control Act.

   d. Failure to Obtain Permits for Storage of Liquids.

   e. Pollution of the Underground Waters of the State.

   f. Creation of a Statutory Public Nuisance.

   g. Violation of the State Environmental Rights Act.

   h. Creation of a Common Law Public Nuisance.

   i. Strict Liability for Consequences of an Unduly Dangerous Activity.

   j. Negligence.

   k. Violation of Riparian Rights of Other Users of Ground Water.

4. Level of Court: State District Court (Trial Court)

5. Ruling on the Case and Legal Basis: A District Court ruling of September 1, 1978 (copy attached), permitted amendment of the State's Complaint, permitted intervention of the City of St. Louis Park, and denied several grounds for dismissal urged by the Reilly Tar and Chemical Corporation.

6. Approximate Costs of Litigation for Both Parties: Substantial, but no precise figures currently available.

7. Description of Appeal: Reilly Tar and Chemical Corporation sought an interlocutory appeal to the Minnesota Supreme Court of the District Court Decision of September 1, 1978. The Minnesota Supreme Court refused to grant leave for such an appeal.

8. Purposes or results intended: Hold the company which generated the hazardous waste responsible for the adverse health and environmental consequences resulting from those wastes.

B. Provision For Enforcement Of The Judicial Decision: Litigation has not advanced to this stage.

C. Record Of Compliance With The Decision: Litigation has not advanced to this stage.

D. Organizations, Agencies, Companies, Or Influential People Aligned With the Plaintiff and Defendant in the Public Portrayal at the Litigation: The City of St. Louis Park is aligned with the State of Minnesota as Plaintiffs.

E. Effect of Liability for Clean-Up of St. Louis Park Disposal Site on Achieving the Purpose of Mitigation: Litigation has not advanced to this stage.

F. Achievements Which Would Indicate to You the Success (or failure) of Litigation in this Mitigation Effort: The litigation seeks to impose all monitoring and remedial costs on the company which generated hazardous waste. It is inappropriate at this time to speculate on other possible results of the litigation.

G. Particular Achievements Not Possible Without Liability For Clean-Up of St. Louis Park Disposal Site: It is inappropriate to speculate on this matter at this stage of the litigation.

H. Elements You Feel Are Essential To Have In Litigation In Order To Mitigate Hazards Like the Hazardous Waste Disposal Problem You Are Dealing With In Hennepin County: In addition to the necessary technical and legal staff, it is important to have a statutory and regulatory scheme which imposes liability on the generator of hazardous waste who subsequently abandons the site.

I. Anything Which You Would Have Done Differently, Or Changed, In The Litigation: It is inappropriate to comment at this stage in the litigation.

J. Recommendations About Litigation To Other Communities Faced With Conducting A Mitigation Effort: Seek to establish liability of waste generator as early as possible.

K. Major Problem(s) Faced and Way(s) They Were (or could have been) Resolved: It is inappropriate to comment on this matter at this stage of the litigation.

Enclosed is a copy of the State's Amended Complaint (April 1978), the State's Brief in Support of Permission to Amend the Complaint (June 1978), and the Supporting Affidavits of Sandra Gardebring and Dale Wikre, and Judge Kane's Order of September 1, 1978.

Coordination/Liaison

The Minnesota Pollution Control Agency is coordinating efforts to mitigate the ground water problems at St. Louis Park with the Minnesota Department of Health, Minnesota Department of Natural Resources, City of St. Louis Park, and the United States Geological Survey. Representatives from each governmental body meet every six weeks to direct the investigative and mitigative action. Thus far the coordination of the project by the committee has been successful. Several technical subcommittees have been established to meet special demands of the project that could not be met by a formal committee meeting of both supervisory and technical persons.

Elements essential to the coordination of successful mitigative action of ground water contamination problems of scope similar to that in St. Louis Park include: establishment of a committee with supervisory level persons representing each agency, technical staff participation at meetings, uninhibited discussions during meetings, efficient informational reviews and responses, timely and clear written communication, strong leadership, and focused objectives. The committee addressing the St. Louis Park matter has not encountered coordination problems and has continued to progress toward meeting the objectives of the committee.

NMENT

memorandum

DATE: June 10, 1981

REPLY TO ATTN OF: Chief, Central Laboratory, WRD, Denver, CO

SUBJECT: REPORTS AND STATISTICS - Water Quality: Results of the St. Louis Park water samples

TO: District Chief, WRD, Minneapolis MN
Attn: Marc Hult, WRD, St. Paul, MN

The custom analysis on six water samples from the St. Louis Park area have been completed.

The methods, procedures, and results for polynuclear aromatic hydrocarbons (PNA) by liquid chromatography are described in Chemist's Report I and by gas chromatography/mass spectrometry (GC/MS) in Chemist's Report II. Other organic compounds tentatively identified by GC/MS are reported in Chemist's Report II.

CHEMIST'S REPORT I

Six water samples (SLP #4, SLP #15, W-117, Flame Ind., W-13, and P-14) from Minnesota were each extracted with three - 40 mL portions of high performance liquid chromatographic (HPLC)-grade methylene chloride. The sample and the bottle were weighed before and after extraction. The methylene chloride extract was dried over sodium sulfate in a dark, explosion-proof refrigerator, for 2 hours or longer. (Previously, the sodium sulfate had been burned at 350°C for approximately 12 hours.) One-half milliliter HPLC-grade acetonitrile was added to the organic extract which was reduced to approximately 4 mL in a Kuderna-Danish (K-D) concentrator.

Special treatment was required with sample W-13. The interface between the methylene chloride and the aqueous layer on W-13 was not clearly discernable. A maximum amount of methylene chloride was removed from the separatory funnel without collecting any of the emulsified aqueous portion. Since some methylene chloride remained emulsified with the discarded aqueous layer, a portion of some constituents were lost. Therefore the reported values on W-13 are considered "minimum" values.

Sample P-14 was not concentrated after the K-D concentration step. The other samples were concentrated below 4 mL using an evaporative concentrator with dry, inert nitrogen flowing over the surface. After concentrating to 500 µL., 250 µL. were transferred to a micro-insert vial in the autoinjector and 100 µL. were injected into the high performance liquid chromatograph.

The instrument, column, and gradient conditions are as follows:

Instrument: Waters Associates - Model 440 (uv) detector at 254 nm. and 313 nm.

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GSA FPMR (41 CFR) 101-11.6
5010-112

Accessories: "Wisp" 710B auto-injector and the Model 720 System Controller with Data Module.

Column: Reversed phase, Beckman "Ultrasphere" - ODS - (C_{18}) - 5 micron - 25 cm. x 4.6 mm. I.D.

Conditions: 40-100% CH_3CN/H_2O - 55 min. run - 1.0 mL/min. flow rate; Chartspeed: 1.0 cm./min.

Fourteen polynuclear aromatic hydrocarbon (PNA) stock standards were prepared individually from pure standard material in methylene chloride. Three working solutions (0.2-11.0 ng/μL concentration) were prepared in acetonitrile by diluting appropriate amounts of the stock solutions. The working solutions were injected preceding and following the six sample analysis run.

The fourteen PNA's prepared were:

1) Naphthalene
2) Acenaphthylene
3) Fluorene
4) Acenaphthene
5) Phenanthrene
6) Anthracene
7) Fluoranthene
8) Pyrene
9) Chrysene
10) 1,2-Benzanthracene
11) Benzo(a)pyrene
12) 1,2:5,6-Dibenzanthracene
13) Indeno (1,2,3-c,d) pyrene
14) Benzo [g,h,i] perylene

Each PNA has a characteristic absorbance peak response ratio between 254 nm. and 313 nm. This ratio, in addition to the retention times, was used to identify the PNA. The results on the six water samples showing their corresponding PNA concentrations were tabulated using integrated area counts or peak-height measurements. The results are shown on the attached table.

The reported concentrations for some PNA's are higher from the analyses performed by HPLC than those performed by GC/MS. The values reported from the HPLC analyses are probably high due to two or more compounds being present under one peak.

W. R. White

W. R. White
Chemist

PNA Concentrations of Minnesota (St. Louis Park) samples
(µg/L)

Sample	Naphthalene	Acenaphthylene	Fluorene	Acenaphthene	Phenanthrene	Anthracene	Fluoranthene
W-13	*220,000	**<5,250	*110,000	*D-I (interference)	*630,000	66,000	*420,000
P-14	*270	<2.0	*6.3	*20	*1.8	0.10	<0.30
Flame Ind.	**<0.019	<0.02	**<0.002	**<0.036	*0.01	<0.001	0.04
W-117	**<0.018	<0.02	<0.002	*4.9	<0.001	<0.001	<0.007
SLP #15	0.07	**<0.02	*0.73	**<0.035	*0.11	0.07	0.07
SLP #4 (GC/MS did not analyze this sample)	<0.018	<0.02	<0.002	<0.036	<0.001	<0.001	<0.007

* Detected by GC/MS and by LC
** Detected by GC/MS, not by LC
< Less than minimum detectable limit. Dilution factors are included where applicable.

PNA Concentrations of Minnesota (St. Louis Park) samples (con.)
(μg/L)

Sample	Pyrene	Chrysene	1,2 Benzanthracene	Benzo(a) pyrene	1,2:5,6 Di-benzanthracene	Indeno-(1,2,3-c,d) pyrene	Benzo [g,h,i,] Perylene
W-13	*500,000	**<360	*300,000	*160,000	16,000	27,000	*92,000
P-14	0.85	<0.14	<0.12	<0.18	<0.27	<0.09	<0.29
Flame Ind.	<0.006	<0.001	<0.003	<0.005	<0.012	<0.002	<0.007
W-117	<0.006	<0.001	<0.003	<0.004	<0.012	<0.002	<0.007
SLP #15	<0.006	<0.001	<0.003	<0.005	<0.012	<0.002	<0.007
SLP #4	<0.006	<0.001	<0.003	<0.005	<0.012	<0.002	<0.007

* Detected by GC/MS and by LC
** Detected by GC/MS, not by LC
< Less than minimum detectable limit. Dilution factors are included where applicable.

CHEMIST'S REPORT II

Six samples were received from the Minnesota District for acid/base-neutral extractables and volatiles analyses (one sample, SLP #4, for acid/base-neutral extractables was received broken). The samples for acid/base-neutral extractables were adjusted to pH 11 and extracted with three 50 mL portions of methylene chloride (extracts for each sample were composited). The samples were then adjusted to pH 2, saturated with 50 mL di-ethyl ether, and extracted as above with three 50 mL portions of methylene chloride. (NOTE: Sample W-13 contained a visible organic layer which was emulsified and co-extracted with the water phase. Due to the dark coloration of this sample, the interface between the extraction solvent and the water phase was difficult to determine. Consequently, the extracts containing the base-neutral components were conservatively withdrawn leaving an ambiguous emulsion. The emulsion was withdrawn into a separate flask to avoid contamination during the acid component extractions. This emulsion was not composited with the base-neutral extracts, but is believed to contain a great deal of the base-neutral components. Therefore, estimated concentration figures listed should be presumed to be minimum values.)

The composited extracts were reduced using a Kuderna-Danish concentrator and further reduced to approximately 0.5 mL using a nitrogen evaporator. Sample nos. P-14 and W-13 were known to be heavily contaminated and were diluted 1:10 and 1:2000 respectively for base-neutral analyses and 1:10 and 1:20 respectively for acid analyses. The extracts were submitted for gas chromatography/ mass spectrometric analysis.

10 µg of the internal standard, d_{10}-biphenyl, were added to each extract (or 0.5 mL aliquot of the diluted extract). Approximately 1 µL of the extract was injected onto a 25m x 0.25mm i.d. SE-54 coated fused silica capillary column using the Grob (splitless) injection technique. The gas chromatograph was temperature programmed as follows: Initial temperature 50°C hold for 5 min., program to 300°C at 6°C/min., hold 300°C for 15 min. The mass spectrometer was scanned from 35 to 450 amu at 1 sec/scan. Peaks of interest were determined using the Biemann-Biller search routine. Spectra were tentatively identified using a computer assisted search of the National Bureau of Standards (NBS) mass spectral library. Those spectra meeting specified "Purity" and "Fit" criteria are given tentative identification in the accompanying tables. "Purity"and "Fit" are indicators of how closely the unknown spectrum resembles the library spectrum with the best possible value for each beins "1000". Concentrations were estimated by comparing the base peak of the internal standard (m/e 164) with the base peak of the identified spectrum, assuming a relative response factor of 1.0. The concentration estimates may be considered to be accurate to the nearest order of magnitude. The detection limit for this method is on the order of 1 µg/L for all compounds except for diluted samples P-14

and W-13, for which the detection limits for the base-neutral analyses would be 10 μg/L and 2000 μg/L respectively and for the acid analyses would be 10 μg/L and 20 μg/L respectively.

Samples for volatiles analyses were analyzed per "Determination of Selected Volatile Organic Priority Pollutants in Water by Computerized Gas Chromatography-Quadrapole Mass Spectrometry" by W. Pereira and B. Hughes as published in the Journal of the American Water Works Association, April, 1980. The samples were analyzed quantitatively for the following compounds and qualitatively for all others reported: (— on the volatiles tables indicates no quantitation was done.)

Methylene Chloride
Cyclohexane
Benzene
Trichloroethene
Toluene
Ethylbenzene

The detection limit for volatile compounds is on the order of 1 μg/L for all samples analyzed.

Michael Brooks

Michael Brooks
Chemist

There is no cost for these analyses in accordance with the agreement made by our previous laboratory chief. Rolly Grabbe had recommended that we request samples from you to test our new PNA method on waters containing detectable quantities of PNA's and to test our GC/MS method, used for oil shale retort waters, on the coal tar waste waters.

If you have questions, please call Rolly Grabbe at FTS 234-4992.

Howard E. Taylor
Chief, Denver Central Laboratory

rw

Attachments

cc: H. Feltz, WRD, Reston, VA
Analytical Services Coordinator, Reston, VA
Chief, Atlanta Central Laboratory
Regional Hydrologist, NE, Reston, VA
Regional Hydrologist, CR, Denver, CO

Table 1.

SLP #15

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
629	2,3 dihydro-1H-indene	922	992	1
841	4-methyl-2,3-dihydro-1H-indene	920	950	<1
1203	biphenyl	885	898	<1
1259	dimethylnaphthalene	913	926	<1
1300	acenaphthylene	931	954	1
1349	acenaphthene	978	989	1
1390	dibenzofuran	943	980	1
1477	fluorene	915	955	1
1715	phenanthrene	664	858	<1
Acid:				
541	phenol	922	962	4
Volatiles:				
59	methylene chloride	975	993	9
154	pentane	939	958	--
220	benzene	457	985	1
220	trichloroethene	490	996	2

Table 2

Flame Ind.

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
639	2,3-dihydro-1H-indene	824	954	<1
901	naphthalene	976	996	1
917	1-(2-butoxy ethoxy)ethanol	855	984	15
1350	acenaphthene	910	924	<1
1479	fluorene	881	915	<1
1716	phenanthrene	709	818	<1
Acid:				
534	phenol	940	982	1
Volatiles:				
58	methylene chloride	800	976	5
169	1,1,1-trichloroethane	498	743	—
219	benzene	669	986	1
219	trichloroethene	---	---	<1
304	tetrachloroethene	396	794	<1

Table 3

W-117

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
224	tetrachloroethene	974	998	25
360	xylene	942	992	2
423	(1-methylethyl)benzene	919	970	<1
532	ethylmethylbenzene	915	985	1
640	2,3-dihydro-1H-indene	910	994	30
722	dihydrobenzofuran	815	896	<1
734	methyl-2,3-dihydro-1H-indene	867	994	3
756	7-methylbenzofuran	906	978	2
763	3-phenyl-2-propenal	915	994	1
772	2-methylbenzofuran	871	967	1
845	methyl-2,3-dihydro-1H-indene	813	955	2
854	1,2,3,4 tetrahydro-1,4-methano-naphthalen-9-one	868	933	1
902	naphthalene	920	973	<1
910	dimethyl-2,3-dihydro-1H-indene	851	895	<1
927	dimethyl-2,3-dihydro-1H-indene	869	925	<1
1018	2,3-dihydro-benzo/B/thiophene	917	996	2
1059	2,3 dihydro-1H-indene-1-one	847	992	<1
1068	methylbenzo/B/thiophene	919	984	1
1102	methylbenzo/B/thiophene	888	966	<1
1157	diethylphenol	807	916	1
1164	dimethyl(methylethyl)benzene	785	953	<1
1184	2-(2 methyl-2-propenyl)phenol	804	929	<1
1254	pentamethylbenzene	840	928	<1
1350	acenaphthene	942	992	2
1688	3-methyl-2(1H)-quinolinone	813	906	<1
1755	4-methyl-2(1H)-quinolinone	803	876	<1
Acid:				
529	phenol	926	981	1

Table 3 (con.)

W-117

Volatiles:

69	methylene chloride	821	981	9
87	dichloroethene (3 isomers)	784	990	—
124	dichloroethene	971	997	—
134	dichloroethene	978	997	—
154	pentane	787	907	—
169	cyclohexane	854	961	2
219	benzene	---	---	10
220	trichloroethene	922	995	500
305	tetrachloroethene	976	995	280
316	toluene	882	956	<1
363	ethylbenzene	834	969	<1

Table 4

P-14

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
259	cyclohexanone	867	890	<10
291	ethylbenzene	944	998	500
305	xylene	922	987	400
319	dimethylthiophene	893	961	<10
351	xylene	922	983	250
415	(1-methylethyl)benzene	941	997	30
438	methyl cyclohexanol	848	972	<10
459	2-propenylbenzene	907	947	<10
491	ethylmethylbenzene	899	997	100
505	trimethylbenzene	920	996	50
525	aniline	929	998	10
527	ethylmethylbenzene	849	925	30
539	benzonitrile	835	996	30
555	ethylmethylbenzene	905	975	300
562	benzo furan	863	958	400
612	trimethylbenzene	893	994	50
639	2,3-dihydro-1H-indene	910	994	300
659	1H-indene	914	981	700
680	2-methylphenol	931	997	150
723	3-methylphenol	894	983	300
744	trimethyl-2-cyclopenten-1-one	794	967	<10
756	methylbenzofuran	902	978	50
766	3-phenyl-2-propenal	926	994	100
775	dimethylphenol	873	997	300
828	1-methyl-2,3-dihydro-1H-indene	795	823	20
830	ethylphenol	686	950	100
836	ethylphenol	933	995	100
846	3-methylindene	904	959	50
854	dimethylphenol	891	993	350
858	1,2,3,4-tetrahydro-1,4-methano-naphthalen-9-one	845	864	50
866	dimethylphenol	830	935	500
894	ethylphenol	848	947	250
911	naththalene	852	923	850
915	dimethylphenol	831	937	150
937	1,6-dimethyl-2,3-dihydro-1H-indene	720	773	<10

Table 4 (con.)

P-14

Base-Neutral:

948	trimethylphenol	881	988	200
963	dimethylbenzo furan	825	921	<10
983	ethylmethylphenol	853	989	150
988	trimethylphenol	866	982	200
1001	ethylmethylphenol	890	998	350
1007	ethylmethylphenol	844	985	250
1039	ethylmethylphenol	835	997	350
1047	trimethylphenol	893	996	150
1054	trimethylphenol	878	994	200
1063	diethylphenol	720	919	<1
1071	2,3-dihydro-1H-indene-1-one	929	997	50
1087	2-methylnaphthalene	868	997	500
1112	2-methylnaphthalene	873	978	400
1155	dimethylbenzaldehyde	797	993	200
1209	biphenyl	914	989	100
1214	p-(2 methylallyl)phenol	811	948	20
1220	pentamethyl benzene	806	956	50
1229	2-ethylnaphthalene	808	972	30
1244	dimethylnaphthalene	803	948	20
1265	dimethylnaphthalene	637	951	30
1270	dimethylnaphthalene	813	864	20
1292	dimethylnaphthalene	835	967	10
1313	dimethylnaphthalene	870	979	10
1321	hexamethylbenzene	780	921	20
1356	acenaphthene	934	990	20
1368	triethylbenzene	696	944	10
1388	2-naphthalenol	795	984	50
1395	1,1'-biphenyl-2-ol	774	936	30
1397	dibenzofuran	808	876	100
1399	1-naphthalenol	868	980	100
1429	fluorene	896	974	40
1456	2-methylnaphthalenol	865	967	10
1477	1-methylnaphthalenol	618	910	10
1503	4-methylnaphthalenol	665	911	<10
1657	phenanthrene	933	970	100
1721	9-H-carbazole	885	989	30
1759	dibenzo/B,E/1,4/dioxin	804	891	<10

Table 4 (con.)

P-14

Acid:

536	phenol	958	976	10
675	methylphenol	927	993	40
719	methylphenol	892	979	150
766	dimethylphenol	870	991	<10
824	2-ethylphenol	951	995	20
843	dimethylphenol	898	992	100
884	dimethylphenol	887	987	150
916	dimethylphenol	913	995	100
925	3-chlorophenol	921	998	30
991	ethylmethylphenol	740	951	10
1025	ethylmethylphenol	866	987	40
1050	benzene acetic acid	900	968	30
1089	3-methylbenzoic acid	872	985	20
1095	4-methylbenzoic acid	699	776	<10
1246	dimethylbenzoic acid	608	917	<10
1411	methylpropylphenol	705	883	10
1604	2-naphthalencarboxylic acid	841	970	<10
1621	1-naphthalencarboxylic acid	845	927	30

Volatiles:

58	methylenechloride	885	992	8
169	cyclohexane	691	908	<1
182	thiophene	840	985	--
195	cyclohexene	928	975	--
219	benzene	948	972	110
220	trichloroethene	---	---	1
242	cycloheptene	891	907	--
259	methylcyclohexane	777	981	--
268	tetrahydro-2-methyl thiophene	754	983	--
278	3-methyl thiophene	868	975	--
305	tetrachloroethene Perchloroethylene	573	957	<1
315	toluene	928	994	56
332	ethylthiophene	833	980	--
362	ethylbenzene	865	949	160
367	dimethylthiophene	603	870	--
373	dimethylthiophene	874	960	--

Table 5

W-13

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
314	ethylbenzene	954	996	2,000
328	xylene = dimethylbenze	937	995	6,000
370	xylene	938	983	2,000
502	ethylmethylbenzene	907	994	2,000
514	trimethylbenzene	931	991	2,000
536	ethylmethylbenzene	886	907	2,000
562	trimethylbenzene	921	991	4,000
567	benzofuran	852	919	4,000
576	hydrocarbon			*
616	trimethylbenzene	938	993	2,000
624	2-propenylbenzene	893	920	<2,000
640	2,3-dihydro-1H-indene	915	988	20,000
656	1-H-indene	947	987	20,000
681	methylphenol	924	982	<2,000
685	isopropylmethyl benzene	912	977	<2,000
720	methylphenol	767	978	2,000
754	7-methylbenzofuran	930	970	<2,000
760	hydrocarbon			*
763	3-phenylpropenal	946	993	2,000
786	tetramethylbenzene	937	967	<2,000
825	4-methyl-2,3-dihydro-1H-indene	897	996	2,000
845	5-methyl-2,3-dihydro-1H-indene	699	948	4,000
847	dimethylphenol	881	950	2,000
853	methylindene	897	955	2,000
885	dimethylphenol	875	986	2,000
907	naphthalene	896	993	230,000
930	hydrocarbon	---	---	*
933	5,6-dimethyl-1H-benzeneimidazole	842	911	<2,000
952	hydrocarbon	---	---	*
954	4,7-dimethylbenzofuran	856	949	<2,000
964	hydrocarbon	---	---	*
992	ethylmethylphenol	775	940	<2,000
1008	1,3-dimethyl-2,3-dihydro-1H-indene	869	938	<2,000
1031	4,7-dimethyl-2,3-dihydro-1H-indene	625	846	<2,000
1046	hydrocarbon	---	---	*

Table 5 (con.)

W-13

Base-Neutral:

1067	5-methyl-benzo/B/thiophene	943	984	2,000
1080	2-methylnaphthalene	914	997	120,000
1085	hydrocarbon	---	---	*
1091	6-methyl-benzo/B/thiophene	897	944	2,000
1105	1-methylnaphthalene	898	977	4,000
1204	biphenyl	927	988	20,000
1224	2-ethylnaphthalene	856	972	10,000
1230	hydrocarbon	---	---	*
1239	dimethylnaphthalene	924	994	20,000
1250	3,6-dimethylbenzo/B/thiophene	720	900	<2,000
1261	dimethylnaphthalene	915	995	10,000
1265	dimethylnaphthalene	924	994	10,000
1287	dimethylnaphthalene	918	993	6,000
1300	acenaphthylene	912	982	4,000
1308	dimethylnaphthalene	878	966	4,000
1316	hydrocarbon	---	---	*
1352	acenaphthene	931	988	8,000
1366	hydrocarbon	---	---	*
1395	dibenzofuran	913	990	60,000
1410	trimethylnaphthalene	819	944	4,000
1483	fluorene	884	964	40,000
1494	hydrocarbon	---	---	*
1503	1-(2-propenyl)naphthalene	849	932	2,000
1526	methyldibenzofuran	837	963	8,000
1543	methyldibenzofuran	902	978	10,000
1554	hydrocarbon	---	---	*
1596	dehydrophenanthrane	912	974	6,000
1611	dihydrophenanthrene	815	973	2,000
1615	hydrocarbon	---	---	*
1620	methylfluorene	890	982	6,000
1622	hydrocarbon	---	---	*
1629	methylfluorene	684	916	4,000
1642	methylfluorene	697	959	2,000
1668	hydrocarbon	---	---	*
1678	hydrocarbon	---	---	*
1685	dibenzothiophene	780	966	10,000
1722	phenanthrene	939	984	110,000
1731	hydrocarbon	---	---	*
1733	anthracene	899	957	2,000
1741	hydrocarbon	---	---	*

35-122

Table 5 (con.)

W-13

Base-Neutral:

1781	9-H-carbazole	813	973	10,000
1804	1-phenylnaphthalene	754	905	2,000
1820	methyldibenzothiophene	734	940	2,000
1840	hydrocarbon	---	---	*
1845	methylphenanthrene	908	974	8,000
1852	methylphenanthrene	895	980	8,000
1877	methylphenanthrene	722	879	6,000
1926	2-phenylnaphthalene	869	967	4,000
1946	hydrocarbon	---	---	*
1962	dimethylphenanthrene	766	926	<2,000
1972	dimethylphenanthrene	715	946	<2,000
1991	dimethylphenanthrene	771	959	2,000
2025	fluoranthene	956	994	4,000
2046	hydrocarbon	---	---	*
2077	pyrene	944	985	2,000
2168	methylpyrene	844	964	4,000
2185	methylpyrene	890	943	2,000
2190	methylpyrene	605	857	2,000
2212	methylpyrene	808	955	<2,000
2220	methylpyrene	797	933	<2,000
2235	hydrocarbon	---	---	*
2279	1,1':2',1" terphenyl	713	860	<2,000
2321	benzo/B/naphtho/2,1-D/thiophene	858	938	<2,000
2332	benzo/C/phenanthrene	783	851	<2,000
2383	benz/A/anthracene	917	981	4,000
2393	chrysene	856	952	4,000
2644	benzo/K/fluoranthene	848	883	<2,000
2701	perylene	879	891	<2,000
3017	benzo/g,h,i/perylene	752	813	<2,000

*"hydrocarbon" refer to a series of alkanes which cannot be distinguished by mass spectrometry - Total estimated concentration 70,000 µg/L.

29-2/225

Table 5 (con.)

W-13

Acid:

539	phenol	958	991	50
679	methylphenol	911	992	60
720	methylphenol	895	981	300
846	dimethylphenol	602	992	20
884	dimethylphenol	895	984	100
921	dimethylphenol	651	852	<20
1028	ethylmethylphenol	756	915	<20
1030	benzeneacetic acid	876	960	20
1036	methylbenzoic acid	694	923	40
1096	methylbenzoic acid	762	911	100
1604	2-naphthalene carboxylic acid	771	987	20

17

Volatile:

58	methylene chloride	758	976	5
154	pentane	945	960	--
170	cyclohexane	917	972	8
182	thiophene	831	938	--
215	methylcyclopentene	820	859	--
218	benzene	921	950	240
242	cyclo heptene	838	885	--
259	methylcyclohexane	892	994	--
268	tetrahydro-2-methyl-thiophene	794	879	--
278	methylthiophene	837	962	--
312	toluene = methylbenzene	866	980	270
332	dimethylcyclohexane	754	923	--
359	trimethylcyclohexane	532	963	--
361	ethylbenzene	788	912	370
365	dimethylthiophene	708	823	--
367	methylheptane	897	979	--
372	dimethylthiophene	694	954	--
394	dimethylheptane	925	992	--

18

Table 6

SLP #4

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Volatiles:				
58	methylene chloride	890	995	12
153	pentane	911	949	—
219	benzene	742	987	1
220	trichloroethene	---	---	<1
304	tetrachloroethene	265	818	<1
325	trimethylbenzene	837	965	—
395	trimethylbenzene	883	993	—
397	trimethylbenzene	820	994	—

Acid/Base-neutral (sample received broken).

Introduction

This report presents a summary of all pertinent technical information concerning the Reilly Tar and Chemical case in St. Louis Park, Minnesota. It is divided into the following four sections:

1. Summaries of all reports, interoffice memos, and letters pertaining to the technical aspects of the case including data presented therein;
2. List of possible witnesses;
3. Presentation of all ground water data pertaining to this case;
4. Information concerning ongoing work and work planned for the future.

The report summaries in Section 1 are generally arranged according to the following topics: a description of Reilly's operational and site conditions hydrogeologic reports, environmental contamination studies, potential pollutant sources other than Reilly, assessment of risk, and remedial measures. Many of the reports contain information on more than one topic. Those reports are placed according to their major topic.

The following agency/municipality files were searched to provide for a complete and comprehensive summary:

1. Minnesota Department of Health (MDH)
2. Minnesota Pollution Control Agency (MPCA)
3. City of St. Louis Park (SLP)
4. U.S. Geological Survey (U.S.G.S.)
5. U.S. Environmental Protection Agency - Chicago, IL
6. U.S. Environmental Protection Agency - Washington, D.C.

This summary report will be updated as new information becomes available.

ecology and environment, inc.
International Specialists in the Environmental Sciences

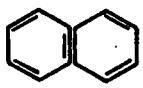
Technical Brief

Number 11 3 October 1980

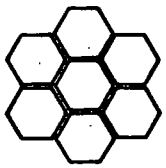
ANALYSIS OF POLYNUCLEAR AROMATIC HYDROCARBONS

The Analytical Services Center of Ecology and Environment, Inc., performs analyses to determine the presence and extent of polynuclear aromatic hydrocarbons in air, water, soil, sediment, and particulate matter.

Polynuclear aromatic hydrocarbons—also called polycyclic aromatic hydrocarbons, PNAs, or PAHs—comprise a large class of organic compounds containing carbon and hydrogen combined in two or more condensed (joined) rings. The lowest member of this class is naphthalene (moth balls):



One of the highest members is coronene:



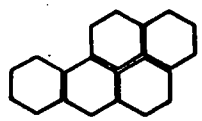
In nature, these ring structures are found in a number of products including coffee, clove stems, eucalyptus oil, and in smoke from open burning such as forest fires.

These compounds also occur in such diverse sources as fossil fuel combustion products, motor vehicle exhaust, fumes from coke ovens, refuse incineration, and cigarette smoke. Recently about 1,000 different PAHs were identified in cigarette smoke.

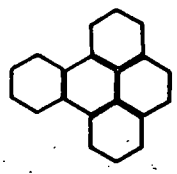
Since PAHS occur so often and because many are known carcinogens or cocarcinogens, there is now justifiable concern regarding their measurement and control. The PAH dibenz [a,h]-anthracene was, in fact, the first chemical substance of known structure to be identified as a carcinogen almost 50 years ago. The relative carcinogenic potency of PAHs as a class is second only to alfatoxins, yet the variation of PAH molecular structure can profoundly influence carcinogenic activity which ranges from inactive (e.g., anthracene), through borderline (e.g., benz[a] anthracene), to highly carcinogenic (e.g. BP, 7, 12 dimethyl benz [a]anthracene). The study of PAHs is further complicated by the fact that significant differences in biological activity are seen in structurally related compounds.

A good example of this difference is provided by comparing the structures of benzo [a] pyrene (B[a]P) and benzo [e] pyrene (B[e]P).

Benzo [a] pyrene
B[a]P



Benzo [e] pyrene
B[e]P



Although both are widely distributed throughout the environment, only B[a]P is of marked environmental concern, owing to its much greater carcinogenicity. Analytically, these two compounds are very difficult to separate and identify.

Concern for the deposition of PAHs in

the environment is further increased by recent discoveries that PAHs in the atmosphere are concentrated on the surface of particulate matter. Additionally, it has been determined that most of the mass of PAH is associated with aerosol in the respirable size range.

Consequently, new technologies, especially those involving combustion, must be looked at closely in regard to possible PAH generation.

Identification and determination of PAH components in complex organic mixtures found in industrial emissions or environmental samples is a challenging task owing to the complexity of the components present even in relatively simple samples. Early methods of PAH analysis concentrated on the measurement of only one PAH, benzo [a] pyrene, as an indicator of PAH contamination. Recent advances in chromatography have allowed investigators to gain further insight into the nature and extent of PAH contamination. The advent of computerized Gas Chromatography/Mass Spectrometry (GC/MS) has been instrumental in the identification of many new PAHs in the environment.

E & E's Analytical Service Center utilizes its GC/MS system to identify and quantify PAHs in environmental samples. Its Hewlett Packard 5993 GC/MS can accept capiliary columns, greatly enhancing its ability to separate complex PAH mixtures. E & E's ASC can perform PAH analysis on air, water, soil, sediment, and in particulate matter collected from mobile and stationary sources.

Figures 1, 2, and 3 are read-outs from E & E's GC/MS system, showing the processes whereby several PAHs were identified in an air and a sediment sample. Figure 1 gives the results of the analysis of the standard used to compare against sample results. Figure 2 shows the analysis of an air sample collected on highvol filters at a hazardous dump site in Pennsylvania. Figure 3 is the analysis of a sediment sample collected in the Buffalo River at the point where it enters Lake Erie.

Naphthalene, fluorene, anthracene pyrene, and fluoranthene were found in the air sample. These same compounds plus chaysene and benzo(K)-fluoranthene were detected in the Buffalo River sediment.

ANALYSIS OF POLYNUCLEAR AROMATIC HYDROCARBONS
(Cont.)

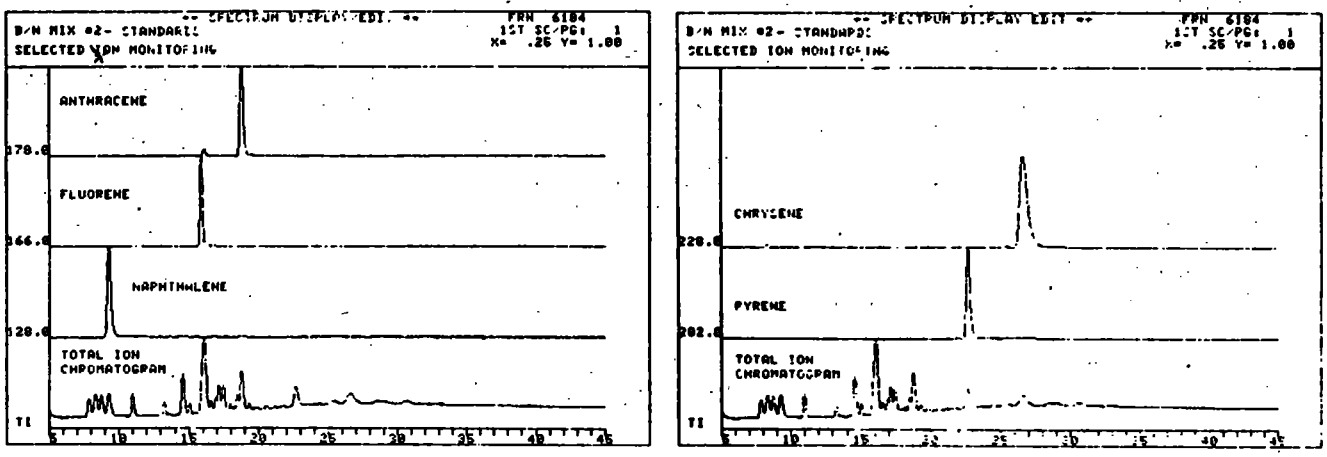


Figure 1 GC/MS STANDARDS

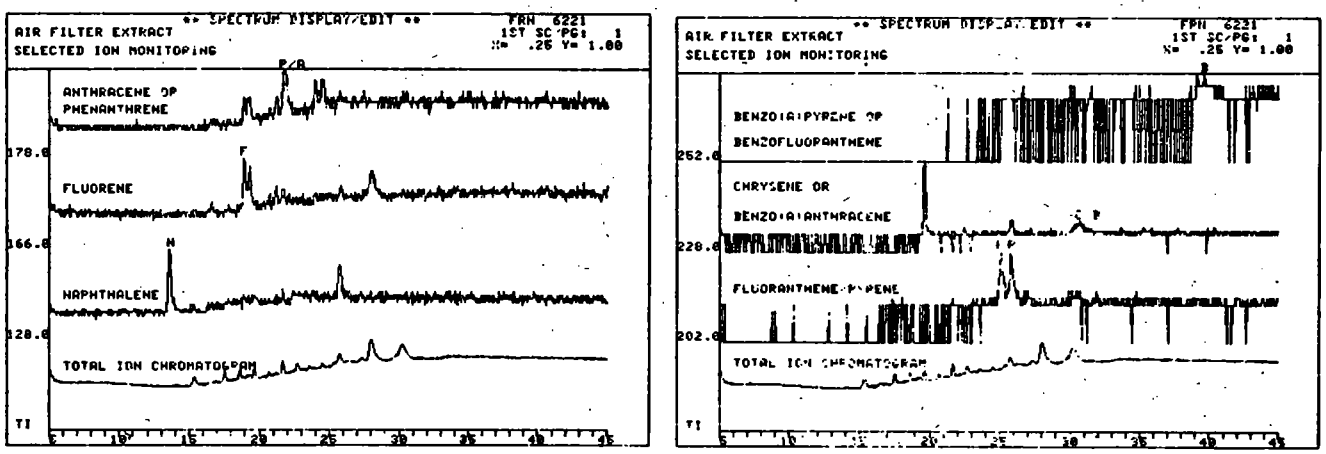


Figure 2 GC/MS ANALYSIS OF AN AIR SAMPLE

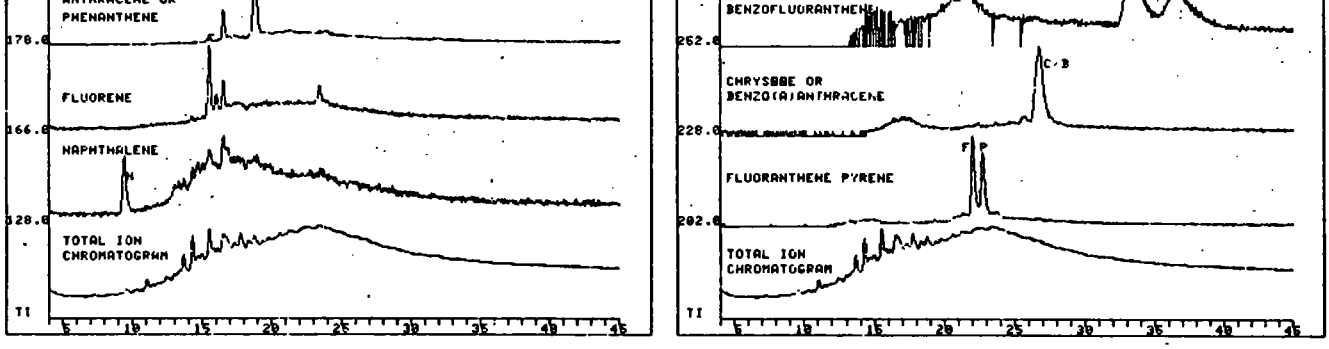


Figure 3 GC/MS ANALYSIS OF A SEDIMENT SAMPLE

R. Malcom

TRANSPORT OF COAL-TAR DERIVATIVES IN THE PRAIRIE DU CHIEN-JORDAN AQUIFER, ST. LOUIS PARK, MINNESOTA

A Project Proposal

by the

Minnesota District
U.S. Geological Survey

February 1981

INTRODUCTION

Operation of a coal-tar distillation and wood-preserving plant during 1918-72 in St. Louis Park, a suburb of Minneapolis, resulted in contamination of ground water. The severity of the contamination, and the efforts of local, State, and Federal agencies to define and resolve the technical, management, and legal issues involved, have made the matter highly visible. The Minnesota Pollution Control Agency and Region V of the EPA agree that coal-tar derivatives in ground water in St. Louis Park is the most significant single example of ground-water contamination identified to date within their jurisdictions.

In July 1978, the U.S. Geological Survey, in cooperation with the Minnesota Department of Health (MDH), began a 2-year project to develop a detailed understanding of the transport of coal-tar derivatives through the ground-water system in the St. Louis Park area. Information on multiaquifer wells in the area was provided to the MDH in February 1979. Hult and Schoenberg (1980) summarize data obtained during the first year of the study and present preliminary conceptual models of the mechanisms and pathways of contaminant transport. Hult (1981a) interprets these and additional data in greater detail and presents the results of preliminary analytical and computer modeling of transport in the Prairie du Chien-Jordan aquifer. Hult (1981b) evaluates the effect of multiaquifer wells on the spread of contaminants between aquifers.

As stated in the project proposal for the first 2-year project (December 1978, p. 2):

> "The problem is complex... The first two-year study (MN 79-061) will provide valuable insight into the problem and will aid decisions on probable continuation of the project for at least two more years. Development and application of a calibrated ground-water transport model to evaluate the possible effects of remedial actions proposed by State and local agencies will require extension of this project."

The new 2-year project now being proposed is in agreement with the timing and purpose of the project foreseen in 1978 and cited in the previous paragraph. The major effort will be to help resolve the contamination problem. Research by the Geological Survey of the St. Louis Park problem will have significant transfer value to similar problems elsewhere.

> "Because of intense local concern, considerable Federal interest, complexity of the problem, and difficulty of effective remedial action, it is anticipated that continued funding will be available. The approach to the problem must therefore balance the immediate needs of the cooperators with the longer-term requirements of a more definitive study." (1978 project proposal, p. 4).

THE PROBLEM

The problem of most immediate concern to the city and to State and Federal regulatory agencies is the presence of toxic organic compounds in water withdrawn from some municipal wells. When the first municipal well was drilled in 1932, the Prairie du Chien-Jordan aquifer contained water having a coal-tar taste at least 3,500 feet from the plant site. During 1978-80, use of five more St. Louis Park municipal wells completed in this aquifer was discontinued because the wells yielded water containing trace amounts of coal-tar compounds, including benzo(a)pyrene, a carcinogen.

Contaminants in the Prairie du Chien-Jordan aquifer have moved at least 2 miles northeast and southeast of the plant site. The direction and rate of contaminant movement changes with time because the bedrock ground-water flow system continually adjusts to hydraulic stresses caused by ground-water withdrawals and flow through wells that connect more than one aquifer. Contaminants can move rapidly through the Prairie du Chien-Jordan because the upper part of the aquifer is a carbonate rock having fracture and solution-channel permeability and low effective porosity. Consequently, the concentration and composition of contaminants in water pumped from individual industrial and municipal wells completed in the aquifer fluctuates with time.

The Prairie du Chien-Jordan aquifer is the region's major ground-water resource. About 75 percent of ground-water withdrawals in the St. Louis Park and Minneapolis-St. Paul metropolitan areas are from this aquifer. The aquifer is relatively well protected from near-surface sources of contamination. In the St. Louis Park area, it is 250 to 500 feet below land surface and is overlain by drift, two bedrock confining beds (Glenwood and basal St. Peter), and two bedrock aquifers (Platteville and St. Peter). Nonetheless, it is now contaminated. The project now being proposed will focus on the Prairie du Chien-Jordan aquifer because of its local and regional importance and the significance of the contamination to municipal water supplies.

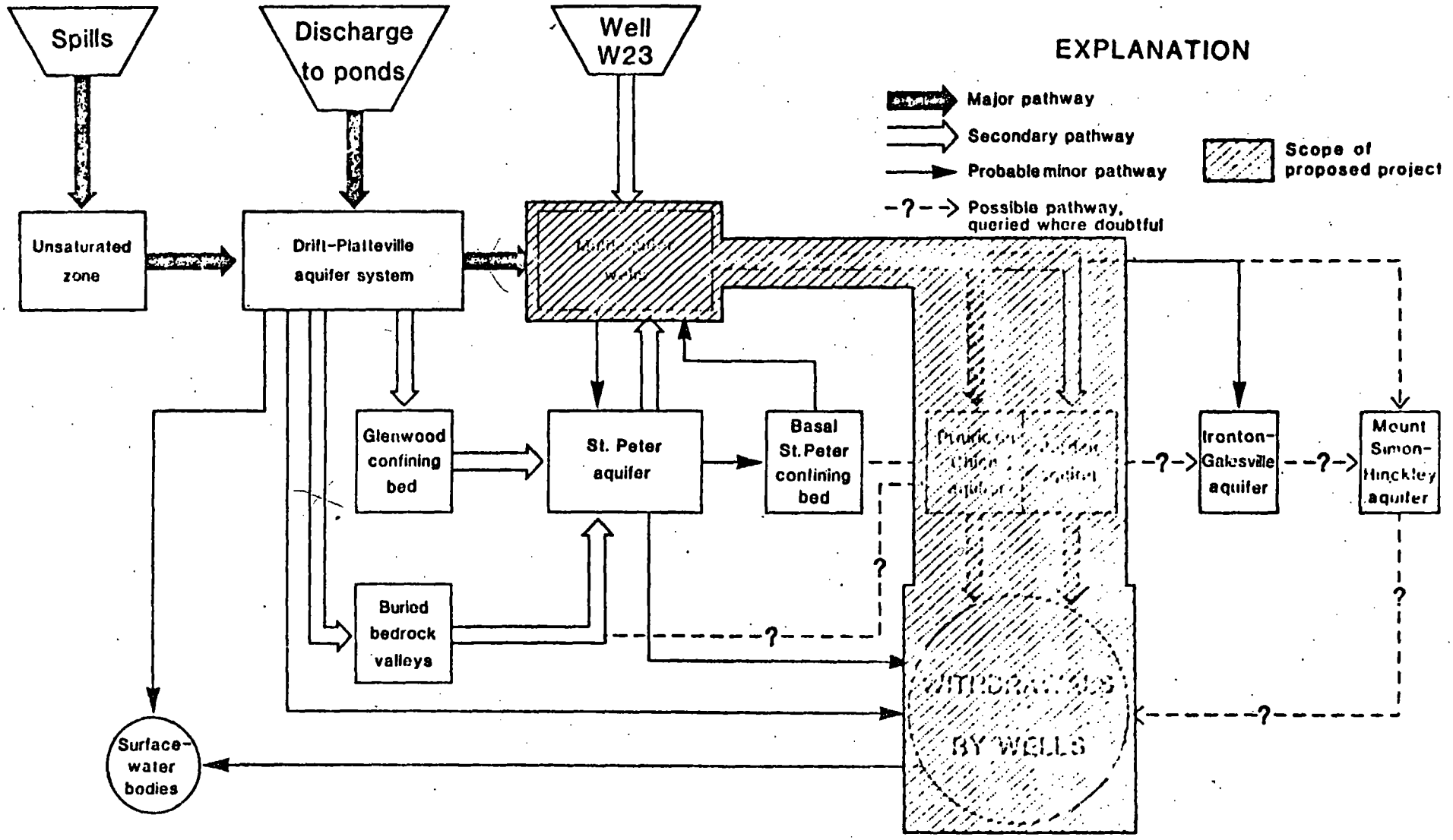


Figure 1.—Flow chart showing conceptual model of introduction and transport of coal-tar derivatives through the ground-water system, St. Louis Park area, Minnesota and scope of proposed project (modified from Hult, 1981a)

The greatest mass of contaminants is in the drift and uppermost bedrock aquifer (Platteville) near the site. Figure 1 shows the conceptual model of the introduction and transport of contaminants through the ground-water system. Coal-tar derivatives reached the water table by percolation through the unsaturated zone and through ponds that received surface runoff and process water from the plant (fig. 1). Parts of the drift contain an undissolved liquid mixture of many individual coal-tar compounds. In June 1980, a sample of this liquid from a monitoring well completed in the drift 50 feet below the water table contained 97,000 mg/L total organic carbon. The hydrocarbon fluid has moved vertically downward essentially perpendicular to the direction of ground-water flow because it is more dense than water. It is moving more slowly than the ground water because it is more viscous. Ground water entering the area of the plant site through the drift is contaminated by partial solution of the hydrocarbon fluids and by release of compounds sorbed on the drift materials. The contaminated water moves laterally to the east and southeast and downward into the Platteville aquifer. Water in the drift 4,000 feet from the site contains less than 10 mg/L dissolved organic carbon, but has a distinct "chemical" odor and contains a large proportion of coal-tar compounds of high solubility in water relative to compounds of low solubility. It seems that some organic compounds moving through the drift are being degraded by anerobic bacteria to other organic compounds and to methane. The USGS research group, with the assistance of the District, is continuing to investigate the rates of degradation, the compounds being degraded, and the nature of intermediate degradation products.

Contaminants entered the uppermost bedrock aquifer, the Platteville, directly from the drift and have moved at least 7,000 feet from the site. The contaminants reached deeper bedrock aquifers, primarily the Prairie du Chien-Jordan, through wells that hydraulically connect the aquifers (fig. 1). Coal-tar compounds have moved to a depth of at least 650 feet in the bore of a multiaquifer well 4,000 feet from the site. Locally, the contaminants have reached the St. Peter aquifer through the Glenwood confining bed and (or) through bedrock valleys where the confining bed has been removed by erosion (fig. 1). In addition, coal-tar has entered bedrock aquifers, possibly from a spill, directly through a well on the site that was drilled in 1917 to a depth of 909 feet (well W23; fig. 1).

OBJECTIVES

The goal of this and the previous study is to obtain a detailed understanding of the transport of coal-tar derivatives through the Prairie du Chien-Jordan aquifer in the St. Louis Park area. This understanding will be used to test management strategies suggested by the cooperators or their consultants and will have considerable transfer value to similar problems elsewhere.

The specific objectives are to:

1. Improve understanding of the distribution and movement of selected coal-tar derivatives in the Prairie du Chien-Jordan aquifer.
2. Provide for consultation between the USGS, EPA, MDH, MPCA, the city of St. Louis Park, and the private consultants to MDH.

3. Provide for continued geophysical logging and evaluation of multiaquifer wells as they are located in the field.
4. Obtain additional information on the physical and chemical characteristics of the source volume of contaminants in the drift and in well W23.
5. Preserve continuity in the collection of time-series, water-level, and pumpage data from all aquifers.
6. Provide continuing support for related, but separately funded, research by the Geological Survey, such as the study of biodegradation of coal-tar derivatives.

SCOPE

A major emphasis in the proposed project is development of a method for evaluating the effectiveness of measures proposed to minimize both the concentration of coal-tar derivatives in municipal wells and the continued spread of contaminants in the Prairie du Chien-Jordan aquifer. Hult (1981a) has shown that manipulation of withdrawals from industrial and municipal wells, in conjunction with a continued effort to locate, evaluate, and seal multiaquifer wells that permit contaminated water to flow into the aquifer, may be effective in minimizing the concentration of contaminants reaching municipal wells. Preliminary solute-transport computer models have proven to be useful tools in evaluating the problem. The proposed project focuses on refining these tools to better reflect hydrogeologic conditions and on using them to evaluate the hydrologic effects of future management.

Multiaquifer wells are the major pathways identified, to date, of contaminant transport to the Prairie du Chien-Jordan aquifer (Hult, 1981a; 1981b). Continuing evaluation of multiaquifer wells, in conjunction with the well-abandonment program of MDH, is within the scope of the proposed project. Reconstruction of multiaquifer wells as monitoring wells would be highly desirable but would require additional funding.

Evaluation of other pathways of contaminant transport to the aquifer, such as those shown in figure 1, will depend mostly on previously collected data. Coal tar entered the Prairie du Chien-Jordan aquifer through a deep well on the site (well W23; "Hinckley well on the site"). The coal tar in and around the well may be a continuing source of contaminants to the aquifer (Hult, 1978; 1981a; 1981b; Hult and Schoenberg, 1980). Tar and water samples from the well will be collected and analyzed for the proposed project. Additional steps needed to evaluate this source have been suggested to the MDH and would require additional funding. Contaminants may also be entering the Prairie du Chien-Jordan from the overlying St. Peter aquifer (fig. 1). The mass of contaminants entering the aquifer through this path seems to be small compared with entering through multiaquifer wells (Hult 1981a). Additional monitoring wells would be needed to further test this hypothesis and would require additional funding.

Management strategies aimed at minimizing the impact of the contaminants are summarized in table 1. Each of the three user alternatives have been implemented or are being evaluated by the city of St. Louis Park. The quality of water withdrawn from municipal wells is being monitored by the city and the MDH. Pilot studies by the city and their consultants have shown that organic contaminants can be partly removed by treatment with activated carbon. The city has increased withdrawals from deeper wells in the Mount Simon-Hinckley aquifer and is evaluating the cost and desirability of deepening wells, drilling new deeper wells, and (or) obtaining water from Minneapolis.

Table 1.--Summary of management strategies to minimize the impact of ground-water contaminants (modified from Hult, 1981a)

1. USER ALTERNATIVES

   a. Monitor the quality of water at the well head. If quality is unacceptable,

   b. Treat, or

   c. Develop alternative supplies.

2. AQUIFER MANAGEMENT

   a. Prevent or reduce movement of contaminants into the aquifers. For example, locate and seal multiaquifer wells that permit contaminated water to flow into the Prairie du Chien-Jordan aquifer.

   b. Control the movement of contaminants within the aquifers, so that the concentration of contaminants at each withdrawal well does not exceed acceptable limits. In the Prairie du Chien-Jordan, this might be accomplished by manipulating pumpage from municipal and industrial wells and by pumping wells installed for controlling hydraulic gradients.

3. SOURCE MANAGEMENT

   a. Intercept contamination leaving the source with withdrawal wells, treat (if necessary), and reinject or discharge.

   b. Immobilize the contaminants in the source either with hydraulic or physical barriers or by chemically reducing contaminant solubility.

   c. Convert contaminant compounds in the source to other compounds that are less toxic by encouraging insitu degradation by anerobic bacteria or by providing oxygen for degradation by aerobic bacteria.

   d. Remove (partly) the source by excavation and pumpout wells.

The proposed project will focus on using a solute-transport model to evaluate the hydrologic effects of the aquifer-management strategies for the Prairie du Chien-Jordan indicated in table 1. The MDH began a program of well abandonment in February 1979, based on information provided by the USGS. This program has been effective in reducing the amount of contaminants entering the Prairie du Chien-Jordan aquifer. Manipulating pumpage from wells may be effective in reducing the contaminant concentration at any given well and in preventing further spread of contaminants. Figure 2 shows changes in the concentration of some coal-tar compounds in water from St. Louis Park municipal well 4 and pumpage from municipal well 6. Well 4 was pumped only for obtaining samples. Both wells are completed in the Prairie du Chien-Jordan aquifer; no other nearby wells were known to have been pumping during the period indicated. The data from wells 4 and 6 support the tentative conclusion that manipulating pumpage may be effective in reducing contaminant concentrations at individual withdrawal wells. However, additional time-series data on contaminant concentration, pumpage, and water levels are needed to test whether the correlation between pumpage and chemical concentration is coincidental or whether there is a causal relationship.

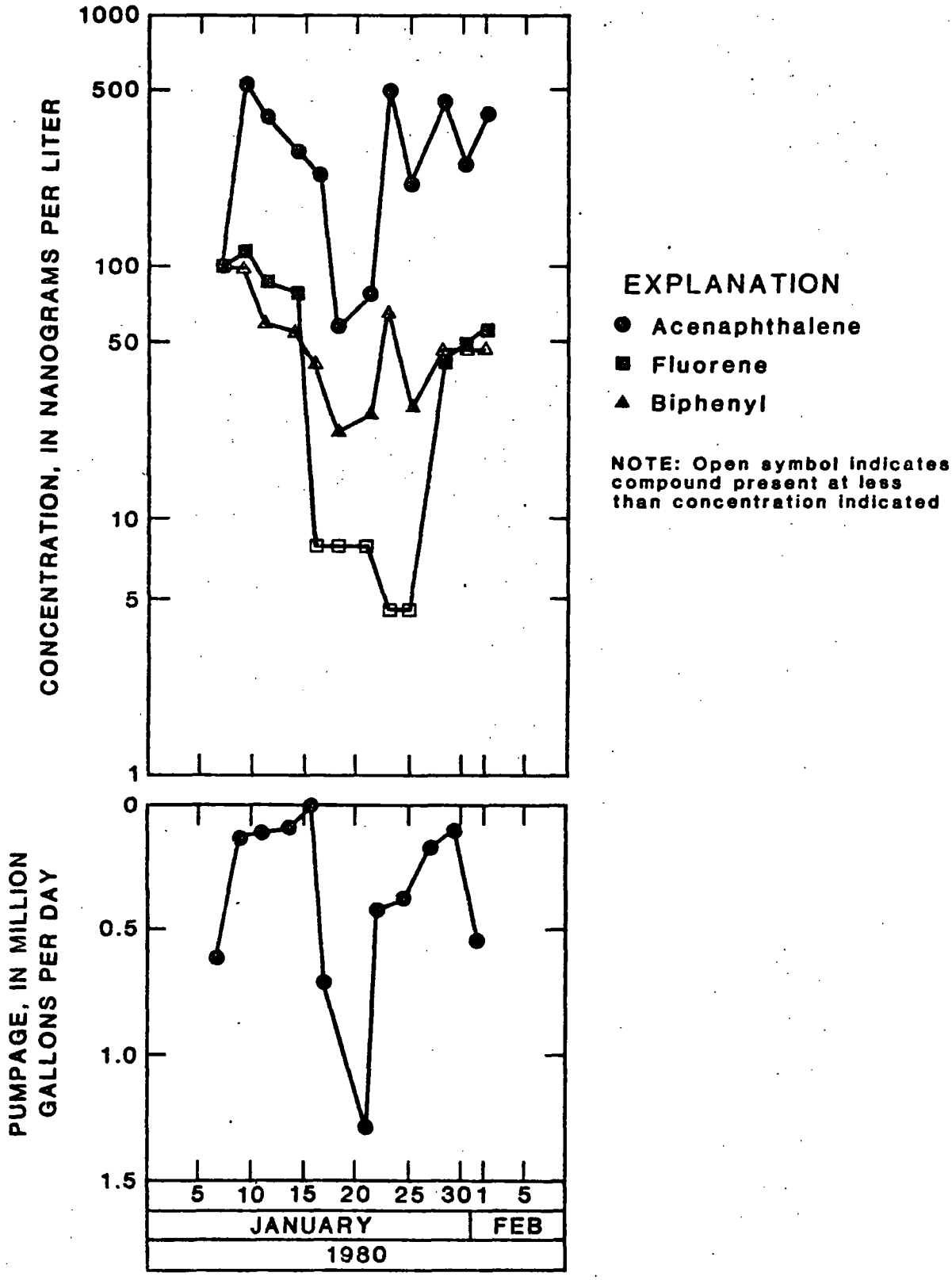


Figure 2.--Changes in water quality in St. Louis Park Municipal Well 4 and pumpage from Well 6, January 1980. Both wells are completed in the Prairie du Chien-Jordan aquifer (from Hult, 1981a)

Continued detailed evaluation of the contaminant source in the drift and Platteville aquifer and of movement of contaminants through the St. Peter, Ironton-Galesville, and Mount Simon-Hinckley aquifers is beyond the scope of the proposed project. However, some additional work on aspects of the problem have been incorporated into the proposed project, which will aid in designing and evaluating the source-management strategies shown in table 1. Results of ongoing basic research by the Geological Survey will be directly applicable to the St. Louis Park problem, but some outstanding questions are sitespecific and will require additional fieldwork. The scope of the proposed project could be expanded to include additional work if funds become available. The relationship between past projects, the proposed project, and possible future projects is shown in table 2.

Table 2.--Relationship of proposed project to past and possible future projects

USGS project	Dates	Principal objectives	Related activities by other agencies	USGS publications
Project MN-79-061	July 1978-June 1979	Develop an understanding of the transport of coal-tar derivatives through aquifers in the St. Louis Park area.	Well abandonment program by MDH	Hult and Schoenberg, 1980
	July 1979-Sept. 1980			Hult, 1981a; 1981b
Proposed project	Oct. 1980-Sept. 1982	Develop an improved understanding of contaminant distribution and transport in the Prairie du Chien-Jordan aquifer.	Design of proposed remedial action by consultants to MDH	1982
Possible future projects	Oct. 1981-Sept. 1982	Continue collection of time-series data in all aquifers. If additional funds become available, refine understanding of transport in the drift, Platteville, St. Peter, Ironton-Galesville, and Mount Simon-Hinckley aquifers, as needed to evaluate proposed remedial measures.	Implementation of remedial actions by State and local agencies	
	Oct. 1982-Sept. 1983	Attempt calibration of transport models based on 4 years of time-series chemical data and response of the ground-water system to remedial actions. Design a long-term strategy to monitor and evaluuate the effectiveness of remedial measures.		

APPROACH

The principal activities needed to meet the objectives are (1) a mass sampling of wells in the Prairie du Chien-Jordan aquifer to determine the areal extent of measureable contamination, (2) refinement and maintenance of the network used to monitor water levels, water quality, and pumpage, (3) additional coring, sampling, and chemical analyses to better define the composition and physical characteristics of the contaminant sources in the drift and well W23, (4) continued work on identifying, locating, testing, and sealing or reconstructing multiaquifer wells; this work will be coordinated with the MDH and (5) refinement of transport models of the Prairie du Chien-Jordan aquifer to reflect hydrogeologic boundaries and hydraulic and chemical stresses. As funding, time, and the availability of wells permit, attempts will be made to obtain additional time-series data on water quality in the Prairie du Chien-Jordan and to continue monitoring water quality in other aquifers.

The Regional Water-Quality Specialist will be consulted to develop a quality-assurance program. This is needed to ensure the validity of chemical analyses from the various laboratories involved. Continued support will be available from the Geological Survey laboratories in developing the quality-assurance program and in chemical characterization of the contaminants. A complete description of the quality-assurance program will be developed as part of the proposed project.

Mass Sampling of Prairie du Chien-Jordan Aquifer

Mass sampling of water from wells in the Prairie du Chien-Jordan aquifer is needed to obtain more complete information on the distribution of individual organic and inorganic constituents within the aquifer at a single time. No additional wells will be installed for this sampling effort. Many wells in the area are used for air conditioning and irrigation and may not be available for sampling during the winter. An attempt will be made to coordinate this sampling with the ongoing monitoring by MDH. Specifically, MDH could help by making arrangements for sampling of wells that are not usually available. It would also be highly desirable for MDH to analyze the concentration of PAH compounds by HPLC in samples taken at the same time as those collected by the Survey for analysis by an EPA contractor. Because MDH intends to continue monitoring, this approach will require no additional laboratory work by MDH. It will, however, help in the evaluation of the compatibility and reproducibility of analytical results from the various laboratories.

Tasks:

1. Compile available information on water quality and wells.
2. Identify areas where additional wells are needed.
3. Compile list of candidate wells for sampling.
4. Field locate new wells and make necessary arrangements.
5. Sample approximately 40 wells within 2- to 4-week period.

Refinement and Maintenance of Monitoring Network

Water quality, water levels, and(or) pumpage from about 300 wells in the St. Louis Park area were measured as part of the previous project. This network will be reevaluated, modified, and maintained as necessary to best meet the data needs of the proposed project and future activities.

About four additional recorders will be installed to monitor pumpage and water levels in the Prairie du Chien-Jordan aquifer. The frequency of measurement will be reduced at most wells in the drift and Platteville aquifers. Attempts will continue to locate additional wells in areas where data are sparse.

Physical and Chemical Characterization of the Drift and Platteville Aquifers and Contaminants in Well 23

Cores will be obtained from at least two additional test holes in the most highly contaminated volume of drift and from the coal tar in Well 23. These samples, some previously collected cores, and fluid pumped from selected wells will be analyzed for individual organic compounds. The samples will be analyzed by an EPA contractor and by the Geological Survey to obtain a complete chemical characterization of coal-tar derivatives in the source volume of contaminants. Fluid samples collected from a mass-sampling program will be analyzed by MDH and the EPA contractor for selected compounds to aid in delimiting the areal extent and severity of contamination in the aquifers. Continued work on the chemical and biological fate of the organic contaminants in the drift and Platteville aquifers will be coordinated with the Survey research group.

Aquifer tests in the drift and Platteville aquifers are needed to better evaluate strategies. Pumping tests will be made if MPCA can obtain necessary permits (if any) for discharge of contaminated water. Additional testing may include slug-testing of piezometers and laboratory analyses of cores for porosity and hydraulic conductivity.

Evaluation of Multiaquifer Wells

As additional wells are located in the field, the Geological Survey will log the wells geophysically and measure water levels and vertical flow within the well bore (if any). The MDH will provide for removal of obstructions in the well bore (if any), collect and analyze water samples, log with downhole television camera, and permanently seal or reconstruct as monitoring wells, if needed and as funding permits.

Model Development

The purpose of a ground-water solute-transport model is to (1) provide a framework for quantitative accounting of the major processes in and properties of the ground-water system that govern the transport of contaminants and (2) provide a tool that can be used in evaluating the effectiveness of remedial actions for reducing contamination in the Prairie du Chien-Jordan aquifer.

Tasks:

1. Expand and refine present two-dimensional transport model (Konikow and Broedehoeft code) to better reflect actual conditions. Test parameter sensitivities.
2. Using SWIP, incorporate separate layers for Prairie du Chien and Jordan and realistic boundary conditions. Attempt calibration by matching head changes (steady-state and transient).

2a. If necessary to reduce computer costs, construct and use three-dimensional flow model (Trescott code) to evaluate flow problem. Transfer refinements to SWIP and retest.

3. Using SWIP, add simplified history of contaminant introduction to evaluate transport rates and directions, parameter sensitivities, and uncertainties that may be caused by unlocated multiaquifer wells.
4. Using SWIP and the measured distribution of contaminants, evaluate effect of manipulating pumpage, including municipal wells, industrial wells, and hypothetical gradient-control wells.
5. Using SWIP, and as time and time-series data permit, attempt calibration of transient transport of selected contaminants.

Model data needs and source of information

1. Aquifer and confining bed geometry - from Hult and Schoenberg, 1980; Guswa, 1981.
2. Aquifer and confining bed hydraulic properties - from previous pumping and laboratory tests in St. Louis Park and elsewhere in the Twin Cities basin - Guswa, 1981; and ATES project.
3. Hydrogeologic boundaries - from Guswa, 1981 (Twin Cities project).
4. Time-series data on hydraulic head - from Hult and Schoenberg, 1980; Guswa, 1981, and from monitoring network refined and operated for the current project.
5. Adsorption isotherms - from batch experiments to be conducted by the University of Minnesota for phenol, naphthalene, and acenaphthene.
6. Time-series data on ground-water withdrawals - compiled for previous project (061) and from monitoring network refined and operated for current project.
7. Hydraulic effect of multiaquifer wells - from Hult, 1981a; 1981b; and from measurements made for the current project.
8. Chemical effects of multiaquifer wells - from Hult and Schoenberg, 1980; Hult, 1981a; 1981b; and from measurements made for the current project.
9. Present distribution of selected contaminant compounds - from Hult, 1981a, and from chemical mass measurements made for the current project.
10. Time-series data on concentration of selected contaminant compounds - from Hult, 1981a. Some additional measurements may be made for the current project.

TIME SCHEDULE AND REPORT PLANS

The project will take 2 years to complete. Fieldwork (other than network maintenance), model development, and report preparation will be completed in FY 81. The report will be submitted to the Region by April 1, 1982. Because of the need for speedy publication, the report will be published in the WRI series. At some later time, however, the report could be considered for WSP publication.

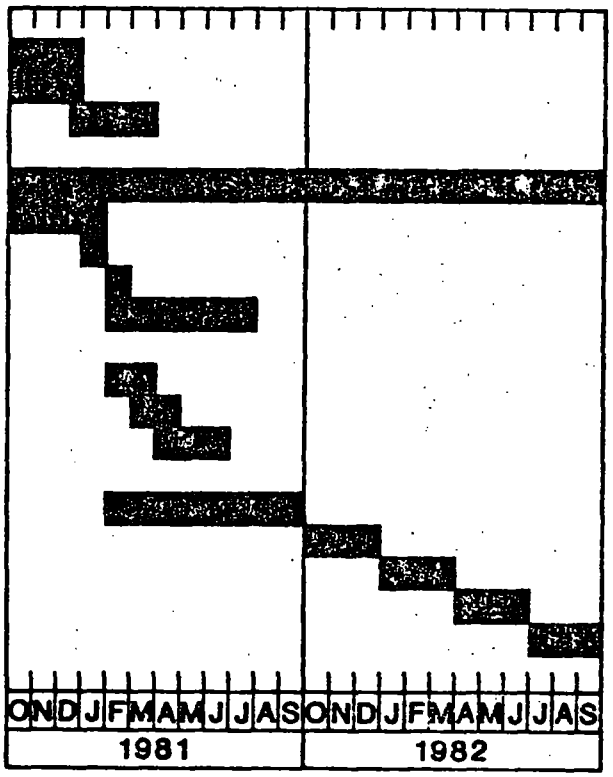
SUMMARY WORK PLAN

Project Proposal and Plan
Previous Reports to District
Design Quality Assurance Program

Maintain Hydrologic Data Network
Initial Fieldwork
Initial Sampling
Mass Sampling
Additional Fieldwork

Refine Transport Model
SWIP Model Functional
SWIP Model Well-posed

Report Preparation
District Review
Colleague Review
Region Review and Headquarters
Drafting and Printing



COST SCHEDULE

The costs for this project (Federal FY 81 and 82) will be shared by the city of St. Louis Park, MDH, MPCA, EPA and the USGS. The MDH will collect and analyze samples from municipal wells, provide downhole television camera surveys, and prepare selected wells for geophysical logging (through the well-abandonment program) in the amount of $36,000 in lieu of funds that will be matched by the Survey. The city of St. Louis Park will assist in monitoring pumpage, water levels, and water quality in municipal wells, and will provide landscaping of monitoring-well sites in the amount of $10,000 in lieu of funds that will be matched by the Survey. Proposed funding and expenditures are as follows.

St. Louis Park Proposed Funding for FY 81

	Cash	Services	USGS match	WOTSC[1]	DOTSC[2]	Net cash
EPA	$50,000	$ —	$ —	$ 7,250	$12,750	$30,000
SLP	5,000	10,000	15,000	2,700	5,100	12,200
MPCA	14,000[3]	—	14,000	2,520	7,140	18,340
MDH	5,000	36,000	41,000	7,380	11,730	26,890
Total	74,000	46,000	70,000	19,850	36,720	87,430

[1] EPA - 14.5 percent; all others at 9 percent.
[2] 25.5 percent of all cash and matching; 0 percent on direct services.
[3] Funds may come from either MPCA or MDH.

Itemized expenditures for FY 1981

Salaries	$ 48,430
Travel	3,000
Supplies	2,500
Equipment	5,000
Vehicles	2,800
Computer	10,700
Laboratory	5,000
Drilling and physical analyses of cores	7,000
Analytical services (University of Minnesota)	3,000
District support	36,720
Headquarters support	19,850
Direct services	46,000
Total	190,000

Proposed Funding for FY 82--Report processing and publication

Salaries	$ 19,000
Printing and reproduction	2,500
District support	8,500
Headquarters support	3,000
Total	$ 33,000

PERSONNEL REQUIREMENTS AND AVAILABILITY

District personnel needed for the project are as follows:

	FY 81	FY 82
Hydrologist GS-11	full time	1/2 time
Hydrologist GS-11	1/5 time	---
Hydrologist GS-7	1/4 time	---
Hydrologic Technician	3/4 time	1/4 time

These personnel are presently available in the District.

The assistance of the Regional Water-Quality Specialist will be requested to help develop a quality-assurance program in coordination with the Central Laboratory and the research group. Ongoing research on biotransformation will probably continue. District assistance in the use of the SWIP code is available, but additional consultants may be required.

REFERENCES

Guswa, J. H., 1981, A preliminary evaluation of the ground-water flow system in the Twin Cities metropolitan area, Minnesota: U.S. Geological Survey Water-Resources Investigations 81-___ (in review).

Hult, M. F., 1978, Letter to R. L. Wade: Dated November 16, 1978.

____ 1981a, Assessment of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota: U.S. Geological Survey Water-Resources Investigations 81-___ (in preparation).

____ 1981b, Effect of multiaquifer wells on transport of contaminants, southeast Minnesota: U.S. Geological Survey Water-Resources Investigations 81-___ (in preparation).

Hult, M. F., and Schoenberg, M. E., 1980, Preliminary evaluation of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota: U.S. Geological Survey Open-File Report 81-72.

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
CENTRAL REGIONAL LABORATORY
1819 W. PERSHING RD.
CHICAGO, ILLINOIS 60609

April 26, 1977

Mr. Roman Koch
Minnesota Department of Health
Division of Environmental Health
717 Delaware South Court
Minneapolis, Minnesota 55440

Dear Mr. Koch:

Pursuant to our telephone conversation two weeks ago, the sample extract from Well #13, St. Louis Park, was re-analyzed specifically for the objectives you specified to me. The results of the analysis (using gas chromatography.mass spectroscopy) revealed that over 50% of the sample extract consists of polynuclear aromatic hydrocarbons.

Some of the compounds tentatively identified are as follows:

naphthalene*	acenaphthene
pyrene*	dibenzofuran
anthracene & phenanthrene*1	fluorine
fluoranthrene*	benzophenanthene
methyl naphthalenes	benzofluoranthene

The CRL could have saved considerable time and provided an analysis more consistent with your needs for all the samples submitted if a brief memo had been included with the samples outlining your objectives, history of the samples, and whom to contact for questions. We would appreciate it very much if this is done for future requests.

If you have any questions regarding the re-analysis or any other subject matter, do not hesitate to call me (FTS 8-353-8370).

*These compounds are present in higher concentrations relative to the others.
*1 We could not differentiate between the two.

Sincerely,

Emilio Sturino

Emilio Sturino, Ph.D.
Chief, Organic Section

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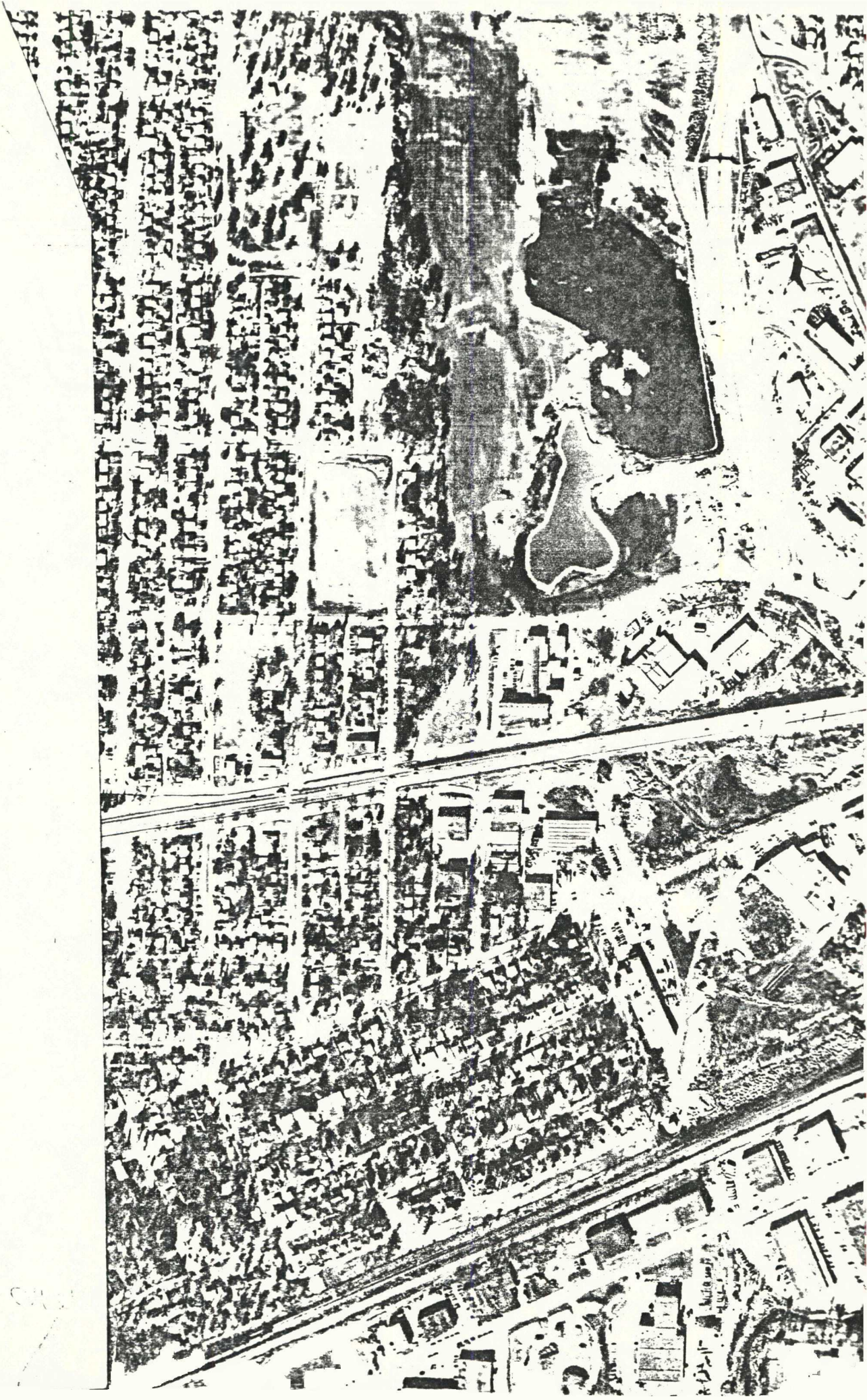
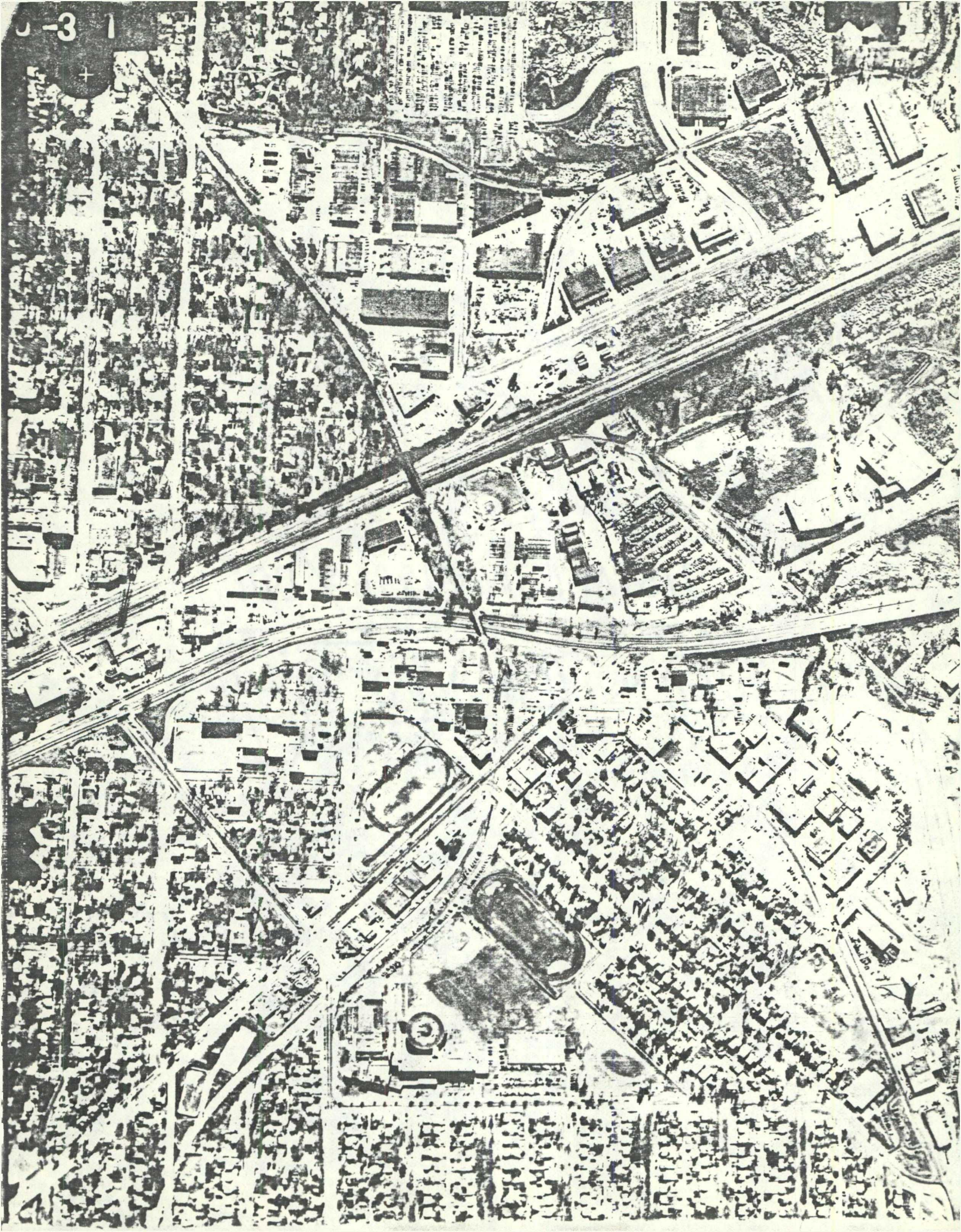




The analyses of the coal tar distillation / wood preserving site in St. Louis Park, Minnesota preformed by Barr Engineering Co. has shown that contamination has occurred to the glacial drift ground water systems and ~~that the waste in the drift is a potential that~~ also and has slightly contaminated the underlying bedrock ground water aquifers. As part of the redemial actions a major recommendation of the report is that the identified coal-tar wastes in the glacial drift and Platteville aquifer be controlled by gradient ~~control~~ wells. Under this technique, a system of pumpout wells are placed in the aquifer to intercept the wastes. Water from the gradient control wells can be discharged to the sanitary sewer system, ~~or~~ treated and discharged to MINNEHAHA Creek, or a of these two disposal locations can be used.

Besides contamination to the upper aquifers, the deeper aquifers in the Mt. Simon - Hinckley FORMATION have been slightly contaminated by the waste. The community of St Louis Park and various industries have ~~had~~ abandon wells in the area. Realizing the purpose of this evaluation is to develop an order-of-magnitude cost estimate for the redemial activities at the site a number of assumptions must be made to complete the estimate. The first major assumption is that the deeper aquifers identified above must also have redemial actions. The following sections develo the is necessa

to complete THE order-of-magnitude cost estimate for treatment and disposal of the CONTAMINATED ground water ~~below the site~~.

Wastewater Quantities and Characteristics

Characteristics of the waste water from the glacial drift gradient control wells have been preliminarily developed ~~by~~ in the Barr Engineering report. In lieu of the study presently being preformed by the USGS these values are the best available. Table #1 column A attached summarizes the wastewater quantities and characteristics for the glacial drift control wells. The report projected the ground water quality from data collected during the study and over the previous few years. A range for the characteristics is presented in the Barr however for purposes of this report the maximum value will be used because a treatment ~~plant~~ sy must be designed for the maximum loading. In accordance with this philosophy of being conservative the projected flow of 45 gpm was increased to 100 gpm.

P11 Also on table 1 in column B the characteristics of the Platteville (100 gpm), St. Peter (100 gpm), and Prairie du Chien-Jordan (225 gpm) are projected using values from the same report. The values are the low end of the range presented for THE down gradient control wells ~~for~~ FROM the glacial drift and are DEINF ~~to~~ conservative. The applied to these (which are in ~~the~~ brackets) were developed

from experience and using good engineering judgement. ~~The~~ Column D on the same table combines the two (shallow aquifer) projected waste streams. These two streams have been combined because they are the most contaminated streams ~~which~~ and will ~~have a~~ probably have a high degree of variability. ~~Their disposal will be discussed later in the report.~~ The Polynuclear Aromatic Hydrocarbons that have been tentatively identified are as follows:

naphthalene*	acenaphthene
pyrene*	dibenzofuran
anthracene ~~or~~ phenanthrene*1	fluorine
fluoranthrene*	benzophenanthene
methyl naphthalenes	benzofluoranthene

This streams disposal will be discussed later in this report.

The characteristics of the ~~deep~~ Mt. Simon-Hamilton aquifer are projected ~~as~~ in column C on ~~the same~~ table 1. Lacking other data ~~an~~ (The following) assumption was made: The deep aquifers ~~of~~ are contaminated with the same waste as the glacial aquifer therefore the pollution characteristics will be similar (to the same degree) just diluted by a factor. The dilution factor was applied ~~developed~~ using the ~~following~~ methodology that if the concentration of similiar pollutants are know for both aquifers then the ratio between the two can be applied to ~~the other variables~~ unknown parameters. ~~This~~ Even tho this is not theoritically accurate, it will produce an (approximate) order of magnitude value. After the 100 minute

pumping test conducted on the on-site Mt. Simon-Hinckley well there was a phenolic concentration of 0.005 mg/l. Taking the ratio between this value and the 3 mg/l projected ~~by B~~ for the glacial drift yields a dilution factor of 0.00167. Applying this factor to the remaining ~~values~~ parameters in column A on table 1 yielded the remaining values in column C. for the Mt. Simon-Hinckley aquifers. It must be stated that before any remedial actions are actually suggested for this aquifer it must be characterized by an extensive sampling program. However, in order to develop a cost estimate the values on table 1 which are felt to be conservative will be assumed representative for the source. To control the pollution in this ~~well~~ aquifer by gradient control wells, the maximum drawing force of 1500 gpm from the municipal wells must be equalized by a cone of depression created by the new wells. Therefore a pumpingrate of 1500 gpm is assumed to be the flow necessary for ~~that~~ the deepest gradient control wells.

Discharge of gradient control wells

The disposal of the ground water can be ~~handled~~ by two routes – discharge to the sanitary sewer or discharge to the Minnehaha Creek after appropriate treatment if necessary. Alternatives can be devised that will combine these two routes.

Since the discharge of the 1500 gpm from the Mt. Simon-Hinckley aquifer is ~~the easiest~~ easier, the report will address ~~the~~ its disposal first. Table 2 presents the standards for discharge of storm water from the site to the Minnehaha Creek (these values were abstracted from the Barr Engineering Report). Comparison of these values to those projected in column C on table 1 shows that the waste can be discharged directly to the creek.

The discharge of 525 gpm (0.756 MGD) from the gradient wells is not ~~as easy~~ quite as easy. Due to regulatory constraints the water quality parameters of most interest in the discharge from the ground water gradient control wells include phenolic substances, polynuclear aromatic hydrocarbons, chemical oxygen demand, and oil and grease. Even tho a majority of the identified organic pollutants are reported to be biodegradable it is not recommended that the waste be discharged directly to the sanitary sewer system because of the concern

to the system a

(and has a toxic effect on the microorganisms)
undiluted waste reaches the plant. Therefore pretreatment is necessary before discharge to the sewer.

To date the development and sizing of the treatment alternatives for the waste streams has been based upon theory, and a few preliminary tests using samples obtained from a ~~few~~ couple of wells. Initially the ~~pumps and~~ gradient control wells are expected to have a highly variable wastewater pollutant loading where the potential for upsets, equipment failure, and other unusual non-equilibrium conditions are great. Therefore, any waste treatment system must ~~be able~~ provide maximum flexibility and adaptability to handle wide fluctuating conditions. ~~Therefore~~, This would eliminate biological treatment which is prone to upsets during non-equilibrium conditions. ~~and direct~~ The most attractive approach to insure reliability and compliance of treatment facilities would be a physical/chemical treatment approach with discharge to the sanitary sewer system which reportedly can handle an additional flow of 0.756 MGD (with minimal problems). After continual operation it is feasible ~~possible~~ that after treatment the waste could be discharge ~~to~~ directly to the river.

HYPOTHETICAL

Potential Facilities for Treatment of the Waste Stream

A brief description of a treatment facility which theoritically should be able to handle the projected waste stream from the shallow aquifers is as follow:

The initial unit process would be a equilization tank of 0.756 mG ~~to be~~ necessary to homogenize the waste, handle surges, and act as a buffer for equipment failure further down the treatment train. Next will facilities to break the emulsified organics and remove the oil and grease from the wastewater. This can be preformed by chemical oxidants and coagulants followed by either gravity or filtration. Chemical selection must realize that, it is preferrable to avoid or minimized oxidants which contain chlorine because of the possible production of chlorinated hydrocarbons. For purposes of this study it will be assumed that the chemical addition will be at one-half the oil ~~and~~ and grease concentration (producing a suspended solids concentration of 540 mg/l) and filtration will be ~~required~~ at a rate of ~~4~~ lbs/sq ft/hr. The discharge from the filtration unit will ~~be~~ be pumped to Activated Carbon columns which will absorb 0.05 lbs of phenol substances per lb of carbon (along with certain polynuclear aromatic hydrocarbons ~~[illegible]~~). The sludge produce by the facility will be transported to an approved ~~disposal~~ landfill and the effluent wastewater should initially be discharged to the city sewer.

P The above treatment facility is based on the PRELIMINARY bench scale tests as reported by Barr Engineering, the characteristics coal tar waste, and

good engineering judgement. Further information and testing is required before any decisions are ~~made on~~ finalized. The tests to date have only touched the surface and this ~~the~~ treatment train was developed only for an order-of-magnitude cost estimate ~~only~~.

Facilities for the gradient control wells from the deep aquifers only requires an equalization basin to handle any unusual circumstances that might require the diversion of the waste to the city sewer systems and an effluent monitoring station.

CONCEPTUAL COST ESTIMATES

PREPARED BY E/E PERSONNEL

The capital cost was developed on a process-by-process basis using vendor estimates, Means Building Construction Cost Data, unit cost values from prior ~~completed~~ projects, and the like. The costs came from different sources, but all costs were escalated to 1st quarter 1988 dollars using the Engineering News-Record Construction Cost Index of 2000. The capital costs of the individual processes were added for a total installed cost. Auxiliary costs (piping, electrical, instrumentation, and site preparation) are based on prior ~~Woodson~~ DESIGN experience and are calculated as a percentage of the installed costs. Engineering and contingencies are calculated as a percentage of the total construction cost and added to give the total capital cost.

Using the procedures described above, the total capital costs should be understood as accurate to +50% to -40%. This estimate does not allow for unusual site preparation, ~~additional power facilities, disposition of existing ponds or their contents, or a final outfall pipe and structure.~~ OR OTHER UNUSUAL CIRCUMSTANCES INCLUDING LEGALITIES.

The conceptual capital and O&M costs estimates are presented on Tables 3 and 4. The total estimated conceptual capital cost is approximately 5,000,000 and the estimated operation and maintenance cost is _____.

Table

COAL TAR DISTILLATION / WOOD PRESERVING SITE
ST. LOUIS, MINNESOTA

Summary of Conceptual Operation & Maintenance Cost Estimate for Treatment of Gravitine Control Wells Wastewater

ITEM	YEARLY COST	35 YEAR COST IN 1981 DOLLARS
Power	80,000	2,800,000
Labor	320,000	11,200,000
Material	100,000	3,500,000
Chemicals	400,000	14,000,000
User Charge & Industrial Cost Recovery (1)	1,200,000	12,000,000
SLUDGE DISPOSAL	20,000	700,000
Taxes & Insurance	50,000	1,750,000
		~~45,950,000~~

TOTAL 35 year O/M 45,950,000
SAY 46,000,000

(1) The effluent will only be discharged for the first 10 years to the City treatment plant, the remaining years it will be discharged directly to the MINNEHAHA Creek

Table 1

COAL TAR DISTILLATION & WOOD PRESERVING SITE
ST. LOUIS PARK, MINNESOTA

ESTIMATED ANTICIPATED ~~PARK~~ PARAMETERS FROM THE GRADIENT CONTROL WELLS

	A GLACIAL DRIFT AQUIFER	B PLATEVILLE ST. PETER PRAIRIE du CHEN JORDAN	C DEEPER AQUIFERS	D A+B COMBIN
Phenolic Substances, mg/l	3	0.2	0.005 (2)	0.733
lbs/day	3.60	1.02		
Chemical Oxygen Demand, mg/l	1800	40	3	375
lbs/day	2161.73	204.16		
Oil and Grease, mg/l	1700	6	3	329
lbs/day	2041.63	30.62		
Polynuclear Aromatic Hydrocarbons, mg/l	100	10	0.170	27.14
lbs/day	120.00	51.04		
Biochemical Oxygen Demand, mg/l	300	330	0.5	81.43
lbs/day	360.29	153.12		
Flow, gpm	100	425	1500	525
MGD	0.144	0.612		0.756

(1) THE HIGHEST VALUE ON TABLE 8 IN "Soil and Ground Water Investigation" June, 1977, Prepared by the State of Minnesota, and authored by Barr Engineering Co.

(2) From page III-34 of report referenced in footnote #1, concentration after 60 minutes of pumping from MT. SIMON-HINCKLEY well on site.

(3) Report referenced in footnote #1 estimated 45 gpm, 135 gpm is an assumed safety factor

TABLE ~~10~~ 2

STANDARDS FOR DISCHARGES OF STORM WATER FROM SITE TO MINNEHAHA CREEK[a]

Substance or Characteristic	Permissible Concentration With Dilution	Permissible Daily Maximum Concentration
Oil and Grease, mg/l	0.5x[b]	15
Phenols, mg/l	0.01x	0.1
5-Day Biochemical Oxygen Demand, mg/l	5x	45
Total Suspended Solids, mg/l	5x	45
Total Chlorine Residual, mg/l	0.01x	0.2
Zinc, mg/l	0.12x	1.0
Cadmium, mg/l	0.03x	0.2
Copper, mg/l	0.01x	0.5
Nickel, mg/l	0.52x	2.0
Lead, mg/l	0.03x	1.0
Ammonia, mg/l as N	1.0x	2.0
Benzo-α-pyrene, mg/l	--	0.00001
Chrysene, mg/l	--	0.00001
pH, units	--	6.5-8.5

[a]Source: NPDES Permit No. MN 0045489. Refer to permit for additional detail.

[b] $$x = \frac{(0.25)(\text{flow in Minnehaha Creek})+(\text{effluent flow rate})}{(\text{effluent flow rate})}$$

Flows used in calculation of dilution ratio "x" shall be the daily total effluent flow rate and the daily total flow rate for Minnehaha Creek.

A P P E N D I X F

TREATABILITY OF COAL-TAR DERIVATIVES IN EFFLUENT FROM GRADIENT CONTROL WELLS

APPENDIX F

TREATABILITY OF COAL-TAR DERIVATIVES IN EFFLUENT FROM GRADIENT CONTROL WELLS

Due to regulatory constraints, the water quality parameters of most interest in the discharge from the ground water gradient control wells include phenolic substances, polynuclear aromatic hydrocarbons, chemical oxygen demand, and oil and grease. Concentrations of these organic parameters can be reduced by a variety of physical, chemical and biochemical processes which are described in the literature. In this appendix, some of these processes are briefly described. The results of laboratory tests undertaken to investigate the feasibility of several simple treatment operations are also presented.

Physical Treatment

Gravity separation, the simplest form of physically removing oily material from water, is comparable to primary treatment of wastewater in conventional sewage treatment plants. This approach is often successful, especially where oily wastes are highly concentrated, and can result in removal of a variety of organic and oxygen-demanding substances and in recovering economically useful materials. However, it has been observed that hydrocarbon mixtures in effluent from the gradient control wells will not separate readily, either because of a highly emulsified condition or because of interaction with soluble organic material, such as phenols. Upon standing for periods in excess of 24 hours, a degree of separation did occur among samples from Well 13, with a heavier dark brown sludge settling below a tan to brown supernatant. However, the sludge fraction still contained a significant amount of water. Therefore, it is likely that gravity separation processes are not feasible for efficient removal of organic materials from the effluent. Thus, if physical treatment is to be useful, more sophisticated technology must be introduced. Flotation, filtration and coagulation processes have been successful in separating oil/water emulsions (Patterson, 1975; Reynolds and Shack, 1976).

Preliminary tests, which will be described in more detail in the discussion of chemical treatment, indicated that partial chemical oxidation and coagulation successfully broke the emulsions to produce a heavy sludge, leaving a reasonably clear supernatant. Other methods of physical treatment--such as volatilization, flotation, filtration and centrifugation--were not examined.

Chemical Treatment

A variety of chemical oxidants and coagulants are available that will participate in chemical reactions to remove oily or emulsified organics from wastewater by oxidation and/or coagulation. Oxidants such as chlorine, hypochlorite, chlorine dioxide, ozone, and potassium permanganate have been used successfully in pilot and plant scale operations for the removal of phenolic and other organics (Armco et al., 1951; White, 1972; Patterson, 1975; Reynolds and Shack, 1976). Coagulants such as various polyelectrolytes, manganese dioxide, alum and lime can also break emulsions and enhance gravity separation.

Of the oxidants mentioned above, chlorine and hypochlorite are very commonly used because of their application to disinfection of drinking water and sewage. The literature indicates that oxidation of phenolics by chlorine occurs most readily in the pH range of 7 to 10 (Armco et al., 1951). When dosage and/or reaction time are insufficient for complete oxidation, partial chlorination using chlorine or hypochlorite has the danger of producing chlorophenols, which tend to increase taste and odor problems (Morris, 1975). There also is a general concern that chlorination of some hydrocarbons may result in a release of potentially harmful compounds in the effluent (Kelley, 1975; Morris, 1975).

Chlorinated hydrocarbon production can be minimized or avoided by use of other oxidants either in combination with or in place of chlorine and hypochlorite. Ozone, chlorine dioxide and potassium permanganate have been found to oxidize aromatic hydrocarbons without the production of undesirable products (Armco et al., 1951; Carus, 1971; White, 1972; Johnson, 1975). Of these, ozone has the disadvantage of requiring on-site generation with

expensive capital and operating costs. Oxidation by potassium permanganate will result in the formation of manganese dioxide, a coagulant, and the production of significant quantities of sludge.

Although some investigations have identified trace chlorinated aromatic compounds produced by oxidation of phenolics with chlorine dioxide (Lindgren and Ericsson, 1969), pilot and plant scale operations using chlorine dioxide have shown that partial or complete oxidation of phenolics and COD can be achieved without formation of significant chlorophenols. Control of phenolic tastes and odors has required dosages of 0.3 to 10 pounds of sodium chlorite per million gallons of wastewater (White, 1972). Sodium chlorite is oxidized by Cl_2 to generate ClO_2 in most operations. Experimental oxidation of coke plant wastes showed that use of chlorine dioxide in combination with chlorine gas improved efficiency of using chlorine dioxide alone. Substantial elimination of phenolics appeared to be achieved in a period of 5 minutes or less (Armco et al., 1951).

Literature information and theoretical half-reaction stages for oxidation of organic compounds by chlorine dioxide indicate that a drop in pH can be anticipated as a result of the use of chlorine dioxide. Experimental use of chlorine dioxide to remove phenolics from coke plant waste with phenolic concentrations in the range of 80 to 200 mg/l resulted in a drop of up to 9.8 pH units. It appears that creation of both organic and inorganic acids is likely responsible for this change. Of the inorganic acids that may be produced, some have low dissociation constants, indicating they are strong acids. For example, $HClO_3$ could be produced during oxidation with chlorine dioxide and has a dissociation constant greater than 1, indicating it is a very strong acid (Johnson, 1975). HOCl, which is produced during conventional chlorination, is a weak acid by comparison with a dissociation constant of 2.9×10^{-8}.

To indicate the degree to which chemical oxidants might be effective in removing organics from the effluent from the gradient control system, several preliminary tests were conducted using sodium hypochlorite and potassium permanganate as oxidizing agents. Chlorine dioxide supplies for limited laboratory experiments could not be located.

For the oxidation experiments, ground water from Well 13 was diluted by 50% and by 98% with deionized water in an attempt to produce concentrations likely to be representative of effluent from the gradient control wells. Diluted samples were then oxidized with sodium hypochlorite (NaOCl) and potassium permanganate ($KMnO_4$) at concentrations based on literature information (Reynolds and Shack, 1976; Carus, 1971). A one-hour contact time was used to guarantee relatively complete oxidation reactions. After oxidation, NaOCl-oxidized samples were analyzed for phenolics, COD and pH. In addition, the most heavily oxidized sample from each dilution was analyzed for suspended solids and oil and grease, and each sample in the 50% dilution series was analyzed for biochemical oxygen demand. One sample was oxidized with $KMnO_4$ for comparison with NaOCl. This sample was analyzed for phenolics.

The results of these experiments are summarized in Table F-1 and show that both sodium hypochlorite and potassium permanganate were capable of oxidizing the organics from the middle drift aquifer. Phenolic removals were 12% or less where NaOCl dosages were not significantly greater than the theoretical requirement for complete decomposition. This is in agreement with the findings of others (Reynolds and Shack, 1976). Phenolic removals improved significantly with increased NaOCl dosage. On the other hand, COD removal appears to improve slightly with oxidant concentrations and with dilution. Since COD analyses do not measure aromatic hydrocarbons, this may reflect COD generation by the cleavage of aromatic rings partially compensating for COD destruction by chlorination. Oxidation efficiency appears to have been significantly higher with potassium permanganate than with sodium hypochlorite. This may have occurred because of a more specific affinity of $KMnO_4$ for phenolics, because of reaction pH, or for some other reason.

An undesirable byproduct of oxidation is the formation of suspended solids, especially with $KMnO_4$. After oxidation, suspended solids concentrations were measured in the samples oxidized with the highest hypochlorite dosages and were found to have increased by a factor of about two or more. Solids production in the sample oxidized with $KMnO_4$ was much more dramatic, with formation of a heavy sludge which occupied about 10% of the volume after a settling period of about 1 hour. Visual inspection of the remaining

oxidized samples the next day revealed that quiescent settling had removed substantially all turbidity from the samples.

In conclusion, experiment data indicate that the organics under study are amenable to treatment by chemical oxidation in a manner that is consistent with experience reported by others. High dosage requirements and sludge generation must be assumed if this is the only method of treatment employed. These processes appear to be helpful in breaking emulsions and enhancing gravity clarification.

Biological Treatment

Biological oxidation of phenolics and other organic wastes have received a tremendous amount of attention over the years. Trickling filters, activated sludge, oxidation ponds and other applications have been used on experimental and plant scale to remove COD, phenolics and aromatic hydrocarbons. In most cases, removal of emulsified oils to about 100 mg/l is necessary prior to biological treatment (Reynolds and Shack, 1976). This could complicate the use of biological treatment for direct oxidation of organics in the undiluted effluent from the gradient control wells. Examination of microbial degradation of these materials has led to isolation of various common microbes that are capable of oxidizing specific organics (McKenna and Heath, 1976; Cobb, 1973) and to the suggestion that toxic metabolic byproducts may be responsible for failure of unacclimated microbes to degrade some organics (Baird et al., 1974). Patterson (1975) and Reynolds and Shack (1976) present brief reviews of applications of biological treatment to oxidation of phenolics and creosote wastes. Removals of phenolics and COD ranging from poor to substantially complete removal are reported.

Several aspects of biological treatment must be considered in the treatment of organic wastes. First, all biological systems are susceptible to upsets due to variations in influent quality and to seasonal factors. Changes in waste strength, microbial nutrient balance, toxic chemical concentrations, hydraulic loadings, sunlight and temperature may affect the efficiency of the process. The production of biological solids can result in the need for sludge handling, although extended aeration can be used to

reduce the volume of sludge. To maintain aerobic conditions, oxygen supply systems are often needed. Biological treatment will need regular attention by trained personnel to control and maintain the treatment efficiency.

To examine the effluent from the gradient control wells for biological treatability, several tests were made using various ground water samples. These tests are summarized in Table F-2. They were conducted to indicate the biochemical oxygen demand of the raw water and to indicate whether or not prior chemical oxidation would seriously affect biodegradation.

Variations in 5-day BOD of samples taken June 2, 1977 may reflect variations in organic species found among the different sources. Failure of BOD tests to yield results for most samples probably reflects a combination of dilution in the BOD bottles and toxic effects due to the complex nature of organics present in the ground water. As the data indicates, the 5-day BOD's of samples taken June 2 from Well 13 and Well 17 were about 2,000 mg/1 and 30 mg/1, respectively.

Other BOD experiments were run with samples collected June 22, 1977 after 50% dilution with deionized water and oxidation with NaOCl. The 5-day BOD's of these samples were in the range of 2,000 to 3,000 mg/1, indicating that the 5-day BOD of the raw ground water obtained June 22 may have been in the range of 4,000 to 6,000 mg/1. This conclusion is supported by the fact that raw water COD was significantly higher on June 22 than on June 2. Reduction of toxic compounds due to chemical oxidation and variations in microbial seed or nutrient availability may also have been responsible for this change in BOD. While a sample of domestic sewage was used as the seed on June 2, water taken from the storm water pond south of Lake Street in the study area was used as the seed source in the second set of experiments, on the theory that these microbes might be better acclimated to metabolize phenolics and other aromatic hydrocarbons.

Data from the BOD tests of June 22 provide sufficient information to estimate BOD kinetic parameters for the oxidized ground water. Once initiated, microbial activity was vigorous and results indicated first order BOD reaction rate constants, K (base e), in the range of 0.6 to 1.2. The ultimate

carbonaceous BOD, L, was estimated to range from 2,500 mg/l to 3,200 mg/l. Both K and L may increase with better acclimated microbes or other factors. Values of both K and L were found to decrease somewhat with heavy applications of NaOCl during pretreatment, probably as a result of the chemical oxidation. Compared with "strong wastewater"--where K and L values of about 0.4 and 250 might be expected (Fair et al., 1968)--this indicates an extremely strong wastewater and very rapid microbial response. Based on this information, substantially complete removal of metabolizable BOD should take place within about 4 to 8 days.

These BOD analyses are consistent with the complexity of the organic chemicals present in the ground water, the variations in water quality parameters throughout the study area, the high concentrations of oxygen-demanding substances in various ground water samples and the difficulties inherent in analyses of biodegradation where unusual compounds and potential toxins are present. Results do indicate that these organics should be biodegradable, especially when acclimated microbes are available, and that pre-treatment by oxidation with hypochlorite does not seriously inhibit biodegradation. Additional testing would be necessary to define the biodegradability of these organics more accurately.

TABLE F-1

EFFECTS OF CHEMICAL OXIDANTS ON QUALITY OF GROUND WATER[a]

Oxidant Dosage (mg/mg phenols)	Dilution Ratio[b]	Approximate Initial Phenols (mg/l)[c]	Final Phenols (mg/l)	Percent Removal	Approximate Initial COD (mg/l)[c]	Final COD (mg/l)	Percent Removal	Approximate Initial Suspended Solids (mg/l)[c]	Final Suspended Solids (mg/l)	Final pH[d]
2.9 NaOCl	1:2	25	22	12	20,100	11,300	44	--	--	8.0
	1:50	1.0	2.5[e]	None	800	384	52	--	--	7.1
11.4 NaOCl	1:2	25	7.5	70	20,100	11,000	45	--	--	8.5
	1:50	1.0	0.38	62	800	376	53	--	--	7.9
52.2 NaOCl	1:2	25	2.2	91	20,100	10,500	48	240	463	9.1
	1:50	1.0	0.088	91	800	384	52	10	61	8.5
14 $KMnO_4$	1:2	25	3.0	88	--	--	--	--	--	--

[a]All samples reacted for 1 hour prior to chemical analyses.

[b]Raw water was diluted with deionized water. Raw water had 50 mg/l phenols, 40,200 mg/l COD, 486 mg/l suspended solids, and pH 7.5. Source of raw water was sample taken from Well 13.

[c]Initial concentrations estimated based on dilution factors.

[d]pH was primarily influenced by the pH of the concentrated oxidant (12.6). Little or no change was observed during reaction.

[e]Inconsistent data. Probably reflects uneven distribution of organics in raw water prior to dilution or an error in analysis. Raw water was shaken thoroughly before samples were withdrawn.

TABLE F-2

SUMMARY OF BIOCHEMICAL OXYGEN DEMAND DATA

A. 5-Day BOD of Samples Taken June 2, 1977

	Volume of Sample in 303 ml BOD Bottle (ml)*					
Source	0.03	0.5	1.0	3.0	10.0	30.0
Well 5	ND	ND	ND	ND	ND	ND
Well 6	ND	ND	ND	ND	ND	ND
Well 9	ND	ND	ND	ND	ND	ND
Well 13	ND	2,200	1,700	ND	ND	ND
Well 17	ND	ND	ND	ND	ND	30

B. 5-Day BOD of Well 13 Samples Taken June 22, 1977 After 50% Dilution With Deionized Water and Chemical Oxidation With NaOCl

NaOCl Dosage (mg/l)	Volume of Sample in 303 ml BOD Bottle (ml)*			
	3.0	1.0	0.5	0.1
72	>460	>1,400	>1,500	3,000
280	>460	>1,400	>1,400	1,800
1,300	>460	>1,400	>1,600	2,400

*Balance of bottle was filled with deionized water.

ND means "non detected."

ecology and environment, inc.
223 WEST JACKSON BLVD., CHICAGO, ILLINOIS 60606, TEL. 312-663-9415
International Specialists in the Environmental Sciences

DATE: December 8, 1980

TO: File

FROM: Rod Bloese RTB

SUBJECT: Minnesota/TDD# F5-8012-3
St. Louis Park/Reilly Tar and Chemical Co.

On December 3, 1980, the author met with Melanie Toepler (USEPA - Region V Enforcement) to obtain background information concerning the subject site. Areas to be addressed in developing cost estimates for clean-up of groundwater and soil in the subject site area were discussed. Subsequently, background information was reviewed and the following scope of work was determined.

Cost estimates for the following areas will be determined:

1. Water treatment of all fifteen (15) St. Louis Park Municipal wells and a number of additional wells.

2. Remedial activity (clean-up) regarding on-site well #23.

3. Remedial activity regarding approximately fifteen (15) "multiaquifer" wells.

4. Contaminated soil treatment, clean-up, and/or disposal.

5. Well field management plan.

Presently, background review is continuing and cost estimate work for the above five (5) areas are being initiated.

RB/df

recycled paper

Minnesota Pollution Control Agency

September 16, 1980

G. Robert Johnson
Popham, Haik, Schnobrich, Kaufman and Doty, Ltd.
4344 IDS Center
80 South Eighth Street
Minneapolis, Minnesota 55402

Dear Mr. Johnson:

Enclosed please find several items as you requested at our September 11, 1980, meeting at the Minnesota Pollution Control Agency (MPCA) office in Roseville.

The "Draft List of Pollutants of Concern - Wood Treating Plants" is a compilation of pollutants reported in wastewater or sludges associated with wood treating plants. Several of the sources report pollutants from unnamed plants. Other sources are reports of analyses conducted on samples from Minnesota plants by the Serco Laboratory or the Minnesota Department of Health Laboratory. The sources used are:

1. Proposed Development Document for Effluent Limitations, Guidelines, and Standards for the Timber Products Processing Point Source Category, U.S. EPA, Effluents Guideline Division, October, 1979

2. Wood Treating Industry Multimedia Emission Inventory, June 1980 Draft, Acurex Corporation, prepared for the US EPA Cincinnati Research Laboratory

3. Phenolics in Aquatic Ecosystems, Buikema, A. L., McGinnis, M. J. and Cairns, J., Marine Environment Research (2) 1979, 87-189

4. Serco Laboratory analyses of the St. Regis pond water

5. Minnesota Department of Health Laboratory analyses of St. Regis pond and ditch waters

6. Minnesota Department of Health Laboratory analyses of Burlington Northern pond water

7. Serco Laboratory analyses of Joslyn well water

Phone: _____
1935 West County Road B2, Roseville, Minnesota 55113
Regional Offices · Duluth/Brainerd/Detroit Lakes/Marshall/Rochester
Equal Opportunity Employer

8. Twin City Testing Laboratory analyses of Onan - Medtronics samples

9. Priority Pollutant Consent Decree

As was discussed at the September 11 meeting, the operational history of each facility will determine which of the listed pollutants are of concern at that particular facility.

The list of pollutants of concern represent our present understanding of the toxic materials present in wastes from wood treating processes. Additions or deletions of pollutants may of course be necessary, if wastewater samplings in Minnesota or reports in the research literature reveal presence or absence of other toxic materials. We look forward to receiving comment from your clients on the list developed by the MPCA staff; members of Wood Treaters Association may also know of other important materials which deserve investigation.

Also enclosed please find a "Summary of Available Standards/Criteria, Wood Treatment Sites". The sources for this listing are:

FDWS Federal Primary and Secondary Drinking Water Standards
MDHDWS Minnesota Department of Health Drinking Water Standards
MPCA Minnesota Rules WPC 14 and 22
FWQC Federal Water Quality Criteria published March 15, July 25, and October 15, 1979
NYGWS New York Ground Water Standards

The "Summary of Standards and Criteria" represents a compilation of the scientifically derived levels of concern available to MPCA staff at this time. As more information and research becomes available, the levels may change. We solicit your clients' comments and encourage them to furnish us with any similarly derived appropriate standards or criteria. As we have discussed, the levels presented will be used by the MPCA staff and Minnesota Department of Health staff to evaluate data generated at the sites.

The Standards and Criteria discussed thus far deal with water quality. For sludges and soil, we will apply the State and Federal Hazardous Waste Rules when possible. Our approach for evaluation of soils will involve subjecting soils to a solvent extraction procedure to estimate total contamination levels and to leaching tests to investigate apparent contaminant mobility. These procedures each contribute valuable information, neither procedure alone can suffice.

Bill Scruton, of the Minnesota Department of Health Laboratory has suggested that all analysts likely to become involved in site investigations coordinate their efforts before analytical work proceeds. To this end John Davenport of the MPCA is arranging a meeting between Bill Scruton, Daryle Thingvold of Serco, Bill Wellbus of Twin City Testing, and MPCA

staff. If you are aware of other analysts or laboratories likely to become involved in site investigation efforts, please so inform Stephen Lee of my staff.

We look forward to your prompt response to the enclosed materials. To speed maters along we are sending copies of this letter to each of the firms represented at our September 11, 1980 meeting. As you requested, I am also enclosing a copy of the New York State Ground Water Standards.

Sincerely,

Tim Scherkenbach, Chief
Enforcement Section
Division of Water Quality

TKS/dc

Enclosures

cc: Tom Doten, Bell Pole
Bill Westerdahl, St. Regis
John Shamp, PCI
W. Schoenholz, Joslyn Manufacturing
Howard Olson, Sonford Products
Bob Baglo, G. M. Stewart
Robert Norgard, MacGillis and Gibbs
Daryle Thingvold, Serco Laboratories
Mark Stehly, Burlington Northern
Ralph Nelsen, Burlington Northern

List of Pollutants of Concern-Wood Treatment Plants

1. Flouranthene
2. Pyrene
3. Phenanthrene
4. Anthracene
5. Benzo (a) anthracene
6. Naphthalene
7. Acenaphthene
8. Acenaphthylene
9. Flourene
10. Chrysene
11. 1, 2, Benzanthracene
12. Benzo (a) pyrene
13. Benzo (e) pyrene
14. Benzo (k) Flouranthene
15. Ideno (123 cd) pyrene
16. Benzo (ghi) perylene
17. Benzo (b) Flouranthene
18. 2,4, dimethylphenol
19. 2 chlorophenol
20. 2,4,6 trichlorophenol
21. pentachlorophenol
22. dinitrophenol
23. tetrachlorophenol isomers
24. 3,5 xylenol
25. o-cresol
26. m-cresol
27. 2,4, dichlorophenol
28. Dibenzo(ah)anthracene
29. 2,4 dinitrophenol
30. 2 nitrophenol
31. polychlorinated dibenzo dioxin
32. copper
33. Arsenic
34. Chromium
35. Oil and Grease
36. Phenols

Development Document 1,2,3,4,5,6,7,8,9,10,12,14,15,16,17,18,19,20,21,33,34, 35,36,37
Multimedia Inventory 2,3,4,5,7,8,12,18,19,20,21,32,33,34,35,36
St. Regis Pond-Serco 1,2,3,4,5,8,9,10,12,16,21,36
St. Regis Pond, ditch-MDH 1,3,9,10,11,12,13,17
BN Pond-MDH 1,3,9,11,13
Joslyn-Serco 10,12,14,16,21,32,33,34,35,36
Phenolics in Aquatic Ecosystems 21,23,24,25,26
Onan-Medtronics Study 1,2,3,4,6,7,8,9,10,18,19,20,21,25,26,27,28,29,30,36
Priority Pollutants 1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,17,18,19,20,21,27, 28,29,30,31,32,33,34

WOOD TREATMENT SITE
STANDARDS/CRITERIA
SUMMARY

Parameter	Human Health	Aquatic Life	Reference
Arsenic	For maximum protection of human health from the carcinogenic effects of exposure to arsenic through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. (FWQC)		
	.05 mg/l (ppm)		FDWS, MDH
	.01 mg/l (ppm)		MPCA, Class 1A,B,C
	.05 mg/l (ppm)		MPCA, Class 1D
	.025 mg/l (ppm)		NYGWS
	.02 ng/l (ppt) @ 10^{-5}	.057 mg/l av., .130 mg/l max.	FWQC
Chromium (total)	.05 mg/l (ppm)		FDWS, MDH
		.02 mg/l (ppm)	MPCA, Class 2A
		.05 mg/l (ppm)	MPCA, Class 2B,C
Chromium (+3)	.05 mg/l (ppm)		FWQC
Chromium (+6)	For maximum protection of human health from the carcinogenic effects of exposure to hexavalent chromium through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. (FWQC)		
	.05 mg/l (ppm)		MPCA, NYGWS
	8 ng/l (ppt) @ 10^{-5}		FWQC
Copper	1 mg/l (ppm)	.01 mg/l (ppm)	FDWS, NYGWS, MPCA
Phenols	1 µg/l (ppb)		MPCA, NYGWS
		10 µg/l (ppb)	MPCA, Class 2A,B
		100 µg/l (ppb)	MPCA, Class 2C
Pentachlorophenol	21 µg/l (ppb)		NYGWS
	140 µg/l (ppb)	6.2 µg/l av., 14 µg/l max.	FWQC

Parameter	Human Health	Aquatic Life	Reference
Carcinogenic PAH	For maximum protection of human health from the carcinogenic effects of exposure to polynuclear aromatic hydrocarbons (PAH) through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. (FWQC)		
	9.7 ng/l (ppt) total @ 10^{-5}		FWQC
Benzo(a)pyrene	not detectable		NYGWS
TCDD (tetra-dioxin)	4.5×10^{-7} µg/l (ppb)		FWQC
	3.5×10^{-5} µg/l (ppb)		NYGWS
Flouranthene	200 ug/l (ppb)	250 ug/l av., 560 ug/l max.	FWQC
2,4,6 Trichlorophenol	100 µg/l (ppb)	52 µg/l av., 150 µg/l max.	FWQC
Naphthalene	143 µg/l (ppb)		FWQC
2 nitrophenol		2700 µg/l av., 6200 µg/l max.	FWQC
2,4 dinitrophenol	68.6 µg/l (ppb)	79 µg/l av., 180 µg/l max.	FWQC
2 chlorophenol	.3 µg/l (ppb)	60 µg/l av., 180 µg/l max.	FWQC
2,4 dichlorophenol	.5 µg/l (ppb)	.4 µg/l av., 110 µg/l max.	FWQC
2,4 dimethylphenol		38 µg/l av., 86 µg/l max.	FWQC

Ongoing and Future Work

1) Interagency project proposal for fiscal year 1981 (November 1980, Attached)
Agencies: SLP, MDH, MPCA, U.S.G.S., U.S. EPA

2) U.S.G.S. hydrogeologic report further defining the nature and dynamics of the ground water pollution of SLP. The report will include data collected in 1979-80. To be published in January or February 1981.
Author: Marc Hult

3) U.S.G.S. report assessing the effects of multi-aquifer wells in southeastern Minnesota. To be published in 1981.
Author: Marc Hult

4) U.S.G.S. computerized dispersion, transport model will attempt to predict pollutant movement as affected by pumping stress, well location, and many other hydrogeologic parameters. Transport of certain chemicals will be predicted from the model. Those chemicals which will be used to identify the pollutant plume have not yet been chosen. It is anticipated that the report will be published in October 1981. The model will be operational by late summer 1981.
Author: Marc Hult

5) H.O. Pfannkuch (University of Minnesota) has been subcontracted to conduct column studies for the U.S.G.S. dispersion model. The column studies will generate experimental data which will be used to calculate dispersion and sorbtion coefficients (parameters) to be plugged into the computer model. The study will be completed within the next 6 months.

6) Hickock & Associates - Contract with SLP for carbon adsorption pilot studies. Four pilot studies have been completed to date. Analyses are completed on two of the studies. Results to be sent to M. Toefper as of 11/14/80. Expect the final report within the next several months.

7) Hickock & Associates - Contract with MDH for remedy evaluation
To be completed mid 1981.
Outline of work products to be sent to M. Toepfer as of 11/14/80.
Work products will be short reports discussing individual alternative remedies. First report due mid December 1980.

United States Department of the Interior

GEOLOGICAL SURVEY

702 Post Office Building
St. Paul, Minnesota 55101
February 6, 1979

Dr. Richard L. Wade
Director, Division of Environmental Health
Minnesota Department of Health
717 Delaware St. S.E.
Minneapolis, Minnesota 55440

Dear Dr. Wade:

This letter accompanies four copies of a report tabulating information on existing wells in the St. Louis Park area as required by our cooperative agreement.

Additional detailed information on individual wells is available from the U.S. Geological Survey which may be useful to you in your decisions concerning well reconstruction or permanent abandonment. Please contact me if you have questions concerning this or any other aspect of our study.

Sincerely,

FOR THE DISTRICT CHIEF

Marc Hult
Hydrologist

Enclosure

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

INTRODUCTION

The U.S. Geological Survey is conducting a study of drift and bedrock aquifers contaminated by coal-tar in the St. Louis Park area in cooperation with the Minnesota Department of Health. As part of that study, wells which may contribute to the spread of contaminants between aquifers are to be identified for possible reconstruction or abandonment by the Minnesota Department of Health. The purpose of this report is to summarize information obtained to date on the location and construction of such wells. A list of 13 multi-aquifer wells has already been provided to the Minnesota Department of Health.

Approach

Data on wells were initially obtained from the files of the U.S. Geological Survey, the Minnesota Geological Survey, the St. Louis Park Department of Public Works, and previous reports (Sunde, 1974; Barr, 1977). Additional information was obtained from personal interviews with area residents, employees of local businesses, and drillers. Piezometers, sand points, and uncased soil borings are not considered in this report. Only two municipal wells, old St. Louis Park No. 1 and St. Louis Park No. 3 are considered.

The general region of investigation was divided into two areas based on the approximate extent of known contamination in the drift and Platteville limestone (pl. 1). Greatest priority was given to an area immediately surrounding the site in which attempts were made to locate and test all wells. Data for 114 wells are summarized in table 1 and plates 7, 8, and 9. It is assumed that many old abandoned wells remain undetected.

Where possible, water levels and depths of wells were measured and the wells were geophysically logged to verify well construction, stratigraphy and to measure possible vertical flow. These geophysical logs, and other detailed information such as driller's logs, water level measurements, location sketches, and surveying results are available from the U.S. Geological Survey. It was found, however, that the majority of private and industrial wells which were physically located contain obstructions such as pumps, liners or debris which prevent logging and inspection by downhole television

camera. Where possible, such obstructions should be removed to permit more complete evaluation and reconstruction or abandonment. Moreover, the well heads of many wells could not be physically located in the field. Excavation or additional field work and interviews will be required to locate such wells. It is assumed that some of these wells will never be located.

The second area of investigation extends beyond the area of known contamination in the glacial drift and Platteville limestone to Golden Valley to the north, Minneapolis to the east, Edina to the south and Hopkins and Minnetonka to the west. The aquifer(s) penetrated and location of wells in this larger area are shown in plates 1, 2, 3, 4, and 5. In this area, only those wells which were identified in previous reports on ground-water contamination in St. Louis Park or which penetrate aquifers below the Jordan Sandstone are listed in table 1.

Although most of these data have been field checked by the U.S. or Minnesota Geological Surveys, no additional effort was made to field check or locate wells in the larger area during this portion of the study. Additional areas for intensive field location of wells may be identified as the study progresses. Periodic water-level measurements are being made and sampling for water quality is anticipated in some of these wells. These wells are identified by the Minnesota Unique Well number and driller's logs are available from the U.S. or Minnesota Geological Surveys.

Potential effect of multiaquifer wells

Uncased or ungrouted wells which penetrate more than one aquifer provide avenues for the transport of contaminants. The effect of an individual well depends on (1) the rate of flow down the well bore, (2) the local and regional ground-water flow patterns on which the well is superimposed and itself modifies, and (3) contaminant concentration.

The rate of flow down the well bore depends primarily on the permeability of the aquifers, the head differences between them, and well construction and condition. For a given well of known original construction, the most difficult factor to estimate is well condition because multiaquifer wells tend to be unstable and casing deteriorates with time.

For example, W23 ("Hinckley" well on the site; figure 1, table 1) was originally constructed so as to permit the flow of water out of the Prairie du Chien-Jordan aquifer and into the underlying Ironton-Galesville and Mt. Simon-Hinckley aquifers. Now, however, water is moving into the Prairie du Chien-Jordan aquifer from the overlying St. Peter aquifer. A down-hole television camera survey and geophysical logging have shown that the well is now 595 feet deep, visibly contaminated, and that water is entering the well bore through leaks in the casing adjacent to the St. Peter sandstone and flowing downward at a rate of approximately 100 gallons per minute. Periodic water-level measurements and a second television survey confirm that this flow is sustained.

A multiaquifer well changes the direction of groundwater flow. A cone of depression is created in the aquifer with the higher head by withdrawal of water from it; conversely, injection of water into the lower aquifer creates a cone of impression. The shape and area of influence of these cones depends on aquifer characteristics and other stresses and boundaries such as pumping wells, other multiaquifer wells, and buried bedrock valleys.

A cone of impression caused at least in part by well W23 occurs in the Prairie du Chien-Jordan aquifer at the site. Static water levels measured by the U.S. Geological Survey on August 23, 1977 at four St. Louis Park municipal wells completed in the Prairie du Chien-Jordan aquifer are shown in figure 1. The water level in well W23 is the water level in the Prairie du Chien-Jordan aquifer at that point and reflects the cone of impression created on the potentiometric surface by water moving through the well bore from the overlying St. Peter aquifer. The water level in well W23 shown on figure 1 was not measured in August 1977, but an estimate was made for this date from 18 measurements since April 1978 and a water level in the spring of 1977 inferred from the Barr report (Phase II, 1977; p.III-34).

The data indicate that water in the Prairie du Chien-Jordan aquifer was moving away from W23 in all directions, but that the gradient was steepest between W23 and the municipal well field to the north. The gradient to the north has decreased since August 1977 in apparent response to the closing of four municipal wells completed in the Prairie du Chien-Jordan aquifer. However, of 27 Prairie du Chien-Jordan aquifer wells measured in St. Louis Park, Edina, and Hopkins on January 30 and 31, 1979, the highest levels were recorded in the 3 wells closest to the site (the "Hinckley" well on the site, W23; Crib Diaper Service, W34; and old St. Louis Park No. 1, W112).

EXEMPTION 9-WELL

These facts support the conclusion by the Minnesota Department of Health that previous studies indicating that water cannot move from the site to the well fields to the north through the Prairie du Chien-Jordan aquifer may be in error (Health Implications of Polynuclear Aromatic Hydrocarbons in St. Louis Park Drinking Water, Nov. 1978; p. 3).

Other multiaquifer wells on and near the site (notably W105 and W59, table 1) also may be contributing to the potentiometric high and contamination in the Prairie du Chien-Jordan aquifer. Moreover, there exist natural pathways for contaminant transport such as leakage through confining beds and buried bedrock valleys. Adequate prediction of the effects of possible remedial action depends on an understanding of each pathway based on measurements made in the field.

The previous estimate of the direction of ground-water flow cited by the Minnesota Department of Health was based on generalized, regional flow patterns. Description of local flow directions requires actual measurement of water levels in wells which are stress points (pumping wells and multiaquifer wells) and in wells which themselves do not create a significant stress (observation wells).

Well abandonment and reconstruction

Highest priority for well abandonment or reconstruction might be given to those wells which are:

(1) Known to be pathways for contaminant transport; for example, W23.
(2) Nearest the site; proximity to the site is a general indicator of the possible contaminant concentration in the uppermost aquifer: 15 multiaquifer or ungrouted wells penetrating the Prairie du Chien-Jordan aquifer and 18 multiaquifer wells penetrating both the Platteville and St. Peter aquifers are listed in approximate order of distance from site in tables 2 and 3.
(3) Open to deep aquifers; in particular, W105 and W38 are known to penetrate the Mt. Simon-Hinckley aquifer.
(4) Multiaquifer; other nearby, deep wells such as W34, which are ungrouted single aquifer wells may be considered because of possible leakage in the annular space around the casing.

(5) Unused wells presently in use such as W40, W45, W46, and W62 tend to intercept contaminants leaving the area and should be replaced with properly constructed wells before abandonment.

Where possible, wells to be abandoned should be reconstructed into observation wells. This accomplishes three objectives: (1) flow between aquifers is stopped, (2) an observation point is made available to monitor the effectiveness of the reconstruction and evaluation whether flow is occurring in other nearby multiaquifer wells, and (3) data are obtained for descriptive and predictive ground-water modeling. Hydrogeologic cross-sections showing the effect of a Plattevillle-St. Peter multiaquifer well on the ground-water flow system and conversion of the well into two single-aquifer observation wells are shown in figures 2 and 3.

Eleven private and industrial wells in the area of intensive investigation have been added to and are now part of the project monitoring network (table 4). Of these, 13 are ungrouted or multiaquifer; the cost of drilling observation wells to replace them is estimated at $130,000. The cost of conversion to observation wells is estimated at $15,000 above the cost of sealing them without provision for monitoring.

As physical access to other wells in the area is obtained, they will be added to the network where feasible. Highest priority should be given those wells which are deepest, and therefore most expensive to replace, and those which are known to have had a significant effect on the flow system.

Table 2--Multiaquifer or ungrouted wells penetrating the Prairie du Chien-Jordan aquifer listed in approximate distance from site.

W 23	Republic "Hinckley" Well (on site)
W105	Minnesota Sugar Beet Co. (on site)
W 29	Flame Industries
W 34	Crib Diaper Service
W 46	Black Top Service - Deep Well
W 49	Strom Block - Deep Well
W112	Old St. Louis Park Well #1
W 38	Milwaukee Railroad Well
W 40	Minnesota Rubber
W 32	Texatonka Shopping Center
W 45, W 46	S & K #1, S & K #2
W 62	McCourtney Plastics
W 74	Lander's Gravel
W 69	Hedberg-Friedheim Block Co.
W107	Interior Elevator Co.
W 70	Park Theatre

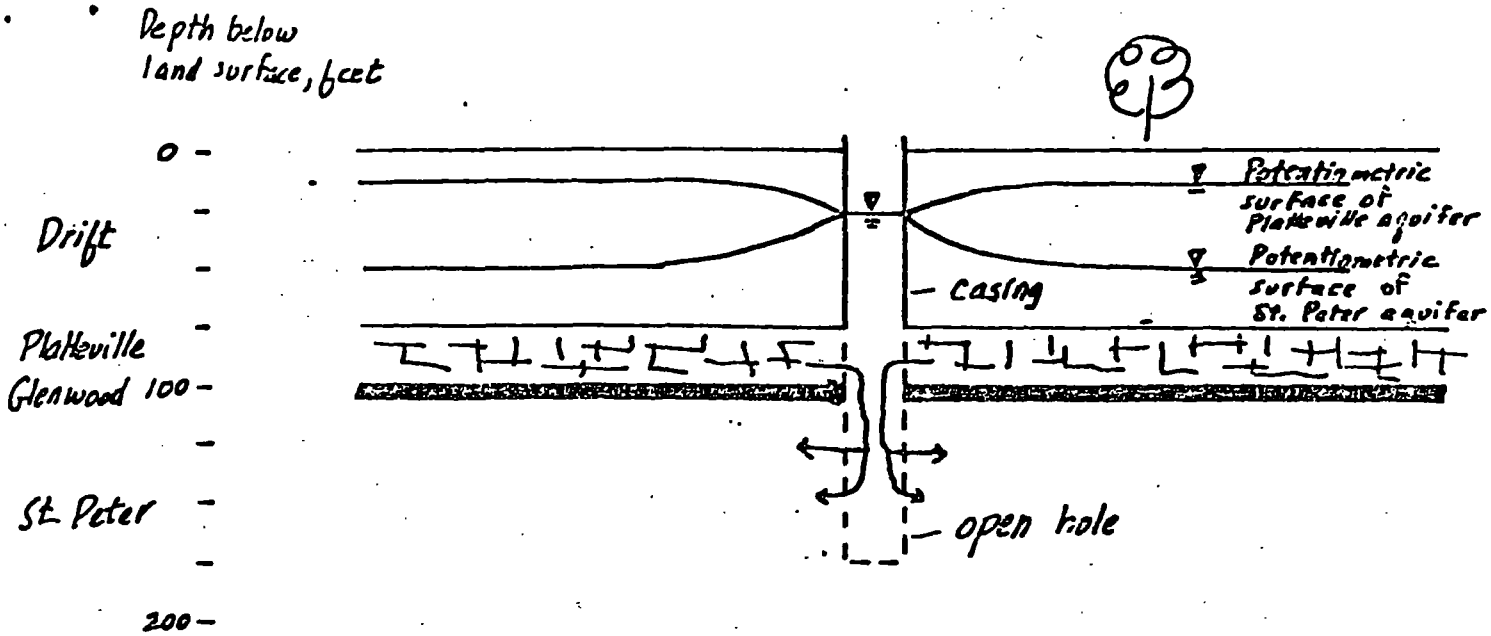


Figure 2.-- Generalized hydrogeologic cross-section showing a multiaquifer well completed in the St. Peter and Platteville aquifers, flow through the well bore, and the effect of this flow on the potentiometric surfaces of the two aquifers

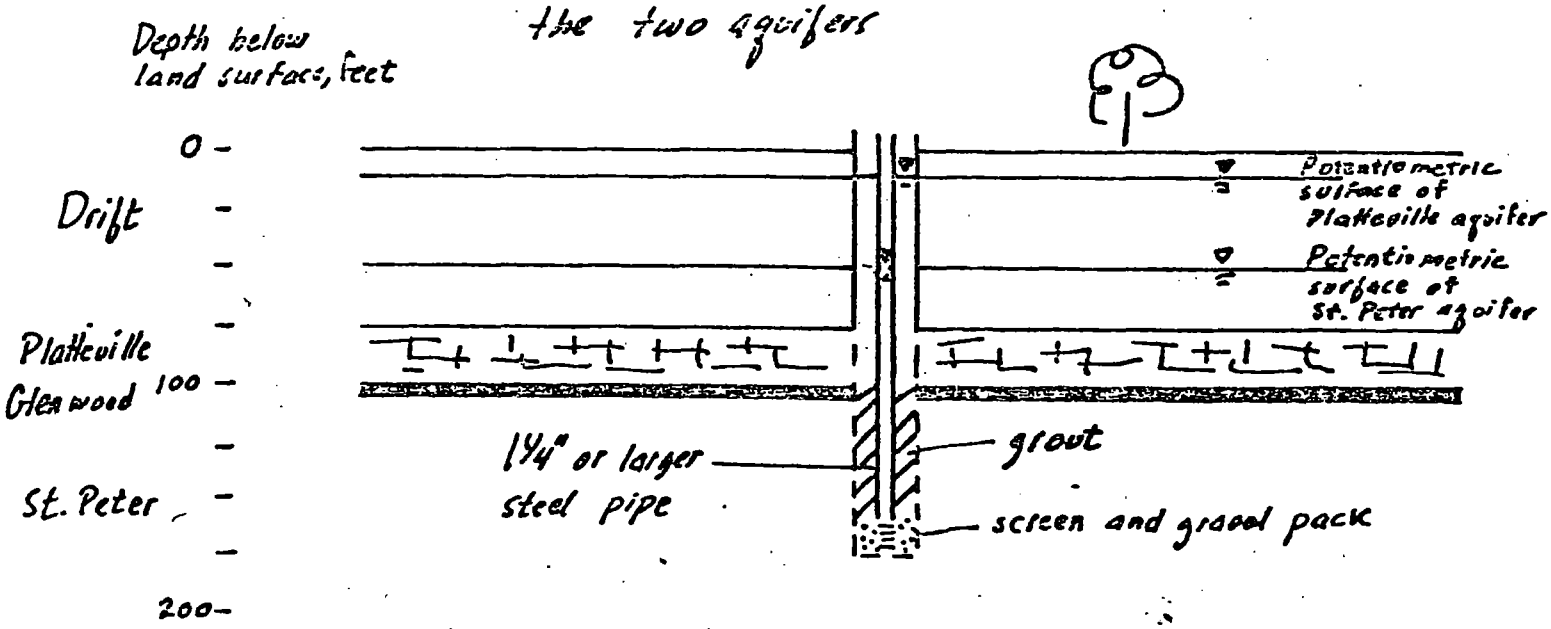


Figure 3.-- Generalized hydrogeologic cross section showing a well originally completed in the St. Peter and Platteville aquifers which has been converted into two single-aquifer observation wells

PAH in Drinking Water
(Nanograms/Liter)

Well	Depth (feet)	Aquifer	A	P	FI	BaP	BghiPE	OPP	N
SLP #3	236	PSP	< 1.9	< 47	<0.9	<1.1	< 4.4	< 1.1	<10
SLP #4	500	SJ	< 1.9	< 47	4.5	<1.1	< 4.4	< 1.1	<10
SLP #5	465	SJ	< 1.9	< 47	7.4	<1.0	< 4.1	< 1.2	<10
SLP #6	480	SJ	< 1.9	< 47	<1.0	<1.0	< 4.8	< 1.5	<10
SLP #7	446	SJ	11.4	104	7.4	<1.1	< 4.4	< 1.1	<10
SLP #8	507	SJ	< 1.9	< 47	<0.8	<1.1	< 4.4	< 1.1	<10
SLP #9	473	SJ	12.2	199	21.1	<1.1	< 4.4	< 1.1	<10
SLP #10	500	SJ	100	800	450	<1.1	< 9.8	< 2.1	-
SLP #10	500	SJ	54	486	152	1.3	4.4	< 1.2	80
SLP #11	1000	H	< 1.9	< 47	< 0.9	<1.1	< 4.5	< 1.1	<10
SLP #12	1095	H	< 1.9	< 47	< 0.9	<1.1	< 4.5	< 1.1	<10
SLP #13	1040	H	< 1.9	< 47	1.0	<1.1	< 4.5	< 1.2	<10
SLP #13	1040	H	< 1.9	< 47	< 0.9	<1.2	< 4.9	< 1.1	<10
SLP #14	485	SJ	6.3	< 47	4.2	1.8	5.5	2.2	<10
SLP #14	485	SJ	6.3	< 47	2.4	<1.2	5.4	< 1.1	<10
SLP #15	503	SJ	190	750	390	<1.2	<10.7	< 2.4	-
SLP #15	503	SJ	241	1221	292	1.5	6.8	2.0	160
SLP #16	500	SJ	< 1.9	< 47	< 0.8	<1.1	< 4.4	< 1.1	<10
Edina #2	460	SJ	< 1.9	< 47	3.1	<1.1	< 4.6	< 1.1	<10
Edina #3	475	SJ	< 1.9	< 47	1.0	<1.1	< 4.6	< 1.1	<10
Edina #4	495	SJ	< 1.9	< 47	0.9	<1.1	< 4.6	< 1.1	<10
Edina #7	547	SJ	< 1.9	< 47	<0.8	<1.1	< 4.7	< 1.1	<10
Edina #15	405	SJ	< 1.9	< 47	<0.8	<1.1	< 4.6	< 1.1	<10
Edina #17	461	SJ	< 1.9	< 47	<0.8	<1.1	< 4.7	< 1.1	<10
R #1	624	SJ	< 1.9	< 48	2.8	<1.2	< 4.9	< 1.1	<10
R #2	624	SJ	< 1.9	< 47	2.1	<1.2	< 4.9	< 1.1	<10
R #4	402	SJ	< 1.9	< 47	0.9	<1.2	< 4.9	< 1.1	<10
WBL #3	289	SJ	< 1.9	< 48	<1.0	<1.0	< 5.1	< 1.6	<10
F #13	332	SJ	< 1.9	< 48	1.5	<1.2	< 6.3	< 2.0	<10
Edina P #1	-	-	< 1.8	< 45	2.1	<0.8	5.6	< 1.2	<10
Edina P #2	-	-	< 1.8	< 45	1.2	<0.8	< 3.4	< 1.2	<10

2. Dates of Well Closures

(a) Well 7 - September 29, 1978 (last run)

Well 9 - September 29, 1978 (last run)

Well 10 - November 10, 1978

Well 15 - November 10, 1978

Well 4 - November 20, 1979

(b) Reasons for Well Closures:

During the period May 8 - August 9, 1978, water samples were analyzed for seven polynuclear aromatic hydrocarbons (anthracene, pyrene, fluoranthene, benzo(a)pyrene, benzo (ghi) perylene, o-phenylenepyrene, and naphthalene) for municipal wells serving St. Louis Park, Edina, Robbinsdale, White Bear Lake, Fridley, for four private wells in Edina, and for the Glenwood-Inglewood well in Robbinsdael. Samples were analyzed using High Performance Liquid Chromatography (HPLC), and positive results for pyrene, fluoranthene, anthracene, and naphthalene were confirmed by gas chromatography/mass spectrometry. Wells 10 and 15 were found to be most heavily contaminated and wells 7 and 9 were less heavily contaminated. All of these wells are Prairie du Chien-Jordan wells. Levels for pyrene, fluoranthene, anthracene, and naphthalene were well above detection limits, while levels for benzo (a) pyrene, benzo (ghi) perylene, and o-phenylenepyrene were just above detection for St. Louis Park wells 7, 9, 10, and 15. Please refer to Table 1 for specific values. These four wells were closed because the potential intake of PAH compounds by St. Louis Park residents via water supply would be significantly increased over other sources (i.e. dietary). Secondly, the only standards on PAH levels in water at the time were World Health Organization standards, setting a level of 200 ng/l for the sum of six PAH compounds, including fluoranthene.

Well #4 was closed in the Autumn of 1979, because of the appearance of acenaphthalene, biphenyl, fluoranthene, phenanthrene, and benzo(a)pyrene during October and November samplngs. Please refer to Table 2 for analytical data.

(c) Well 4 was pumped on May 1 (311,000 gallons), May 3 (264,000 gallons), and May 5 (244,000 gallons) of 1980 in order to provide adequate pressure in the distirbution system of St. Louis Park for fire protection.

Wells 7, 9, 10, and 15 have never been in service. Well 15 has provided water to analyze the effectiveness of powdered activated carbon slurry treatment. Tests were conducted during July and October of 1979. All waters from Well 15 were discharged to wastes.

(d) Well 4 was placed into service because the City was facing a low-pressure condition in the distribution system in the southeast corner of St. Louis Park. This condition presented a particular problem in providing adequate fire protection. The well was operated on three (3) separate days.

3. (a) A brief study was conducted on treatment of contaminated water utilizing a small-scale, pilot treatment plant using powdered activated carbon (PAC) Tests were conducted during July (7/16/79 - 7/20/79) and October (10/2/79) of 1979.

(b) Powdered activated carbon (PAC) served as a media for absorption of PAH compounds. PAC was mixed with water to form a slurry, which was then pumped into the well head of well 15. The well was pumped at 1000 gpm. PAC levels of 1-2 mg/l, 4-5 mg/l and 9-12 mg/l were analyzed. PAC was removed on sand filters and the waters discharged to waste.

(c) The treatment studies conducted to date have indicated strong removal of PAH compounds, and have been very encouraging. Reductions of greater than an order of magnitude have been found, particularly for PAC concentrations of 9-12 mg/l. However, some of the results have been erratic and clearly a well-structured and intense study is required to determine the long-term effectiveness of the treatment system.

(d) The treatment studies have not had any impact on the water supply to date. The studies that were conducted were preliminary and further work is required before allowing treated water into the distribution system. The waters pumped from well 15 have been discharged to waste following treatment and sampling. Water from wells 7, 9, 10, 15, have never been used for supply and from well 4 for a brief period in early May.

TABLE 6

GROUND WATER QUALITY DATA
MUNICIPAL WELLS

Well	CW-1			CW-3			
Lowest Formation	St. Peter			St. Peter			
Sampling Date	9/73-2/74 (1)	4/1/76	9/73-2/74 (1)	4/1/76	5/26/77	5/26/77 (2)	6/9/77 (3)
Phenolics, mg/l	<.002-.035	<.002	<.002-.006	<.002	.002	<.002	<.002

Well	CW-10				
Lowest Formation	Prairie du Chien-Jordan				
Sampling Date	9/73-2/74 (1)	4/1/76	5/26/77	5/26/77 (2)	6/9/77 (3)
Phenolics, mg/l	<.002-.013	<.002	.005	.0059	<.002

(1) Data from Minnesota Department of Health (1974).
(2) Data from Minnesota Department of Health (1977).
(3) Three samples collected--all values <.002 mg/l.

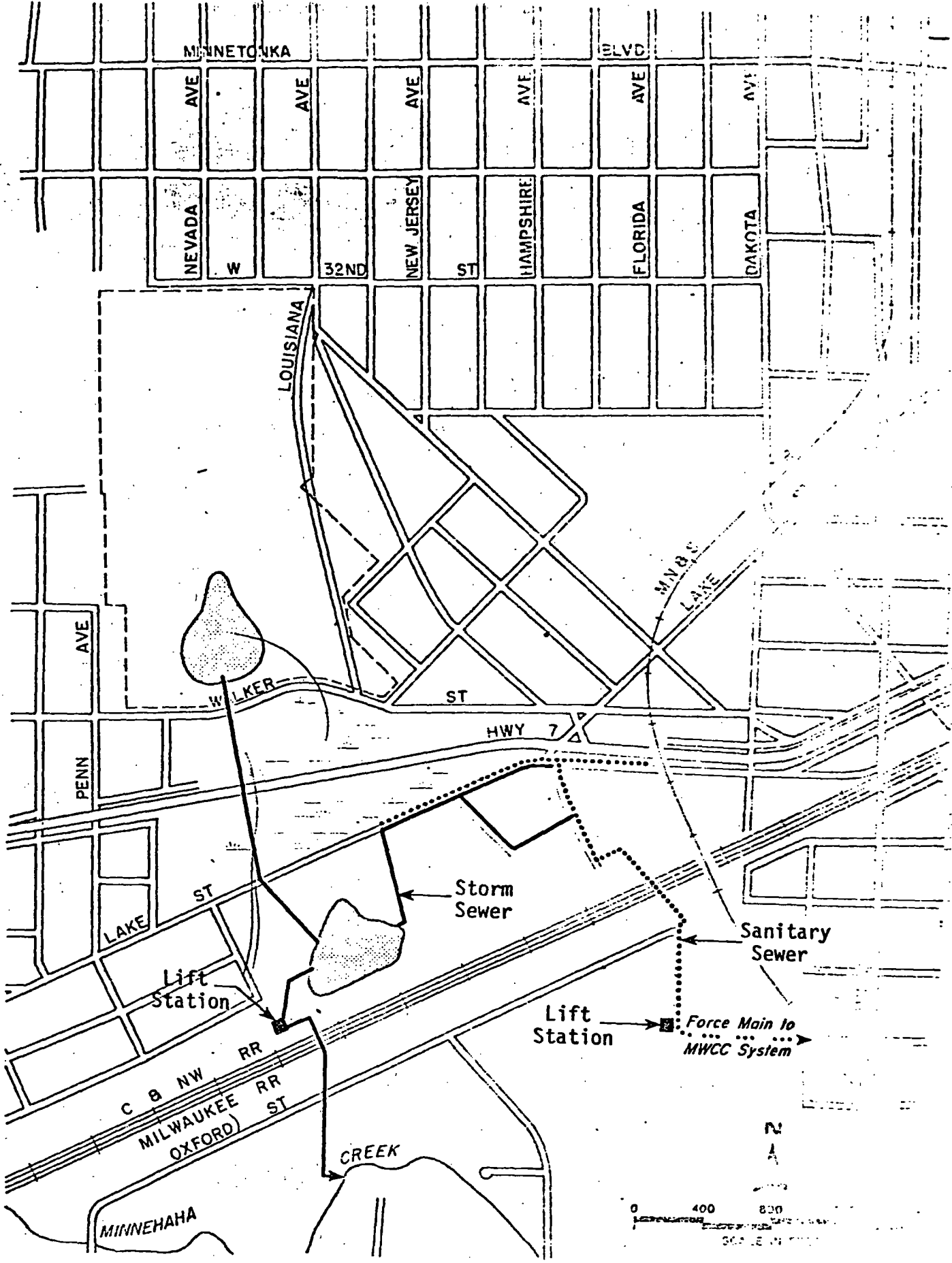


FIGURE 24

EXISTING STORM SEWER AND SANITARY SEWER SYSTEMS

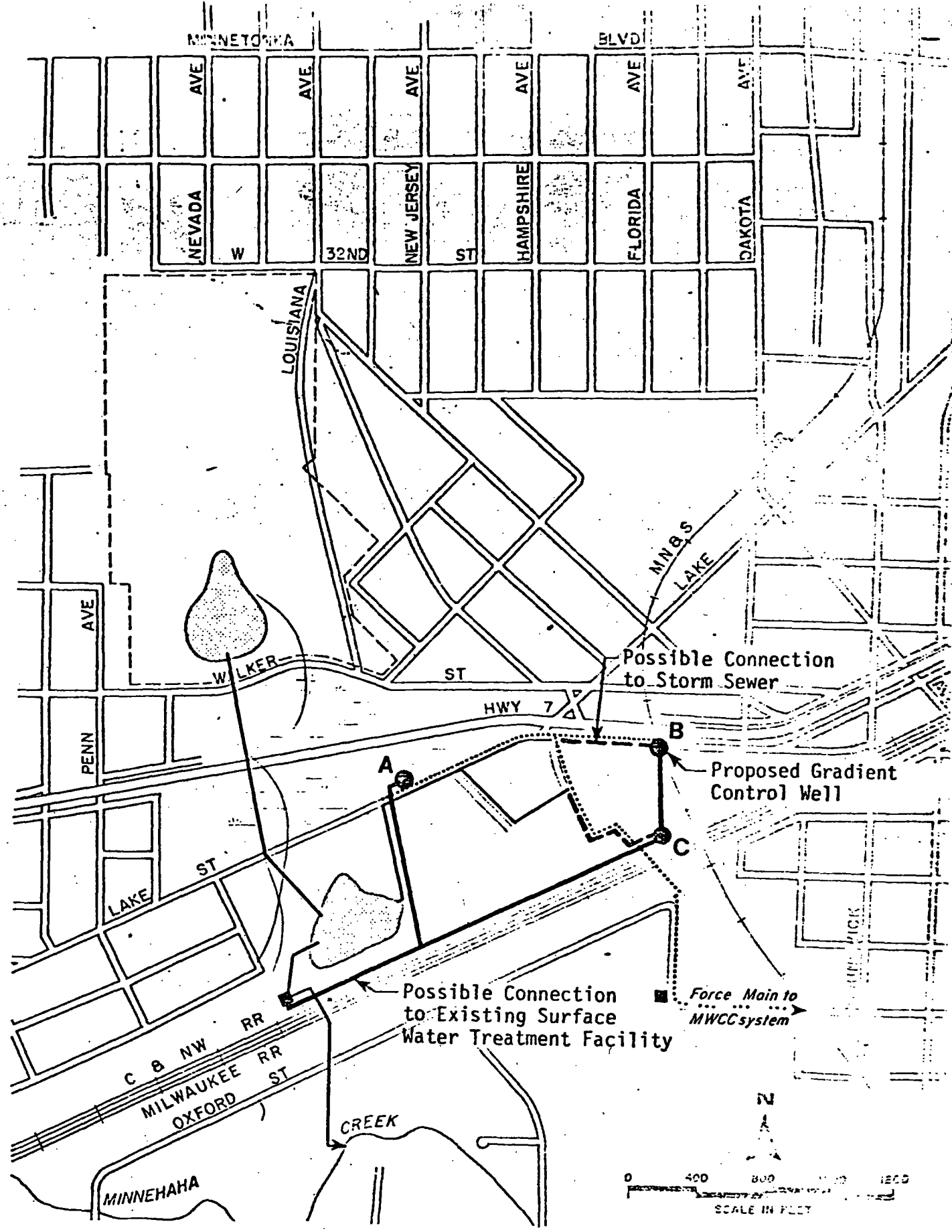


FIGURE 25

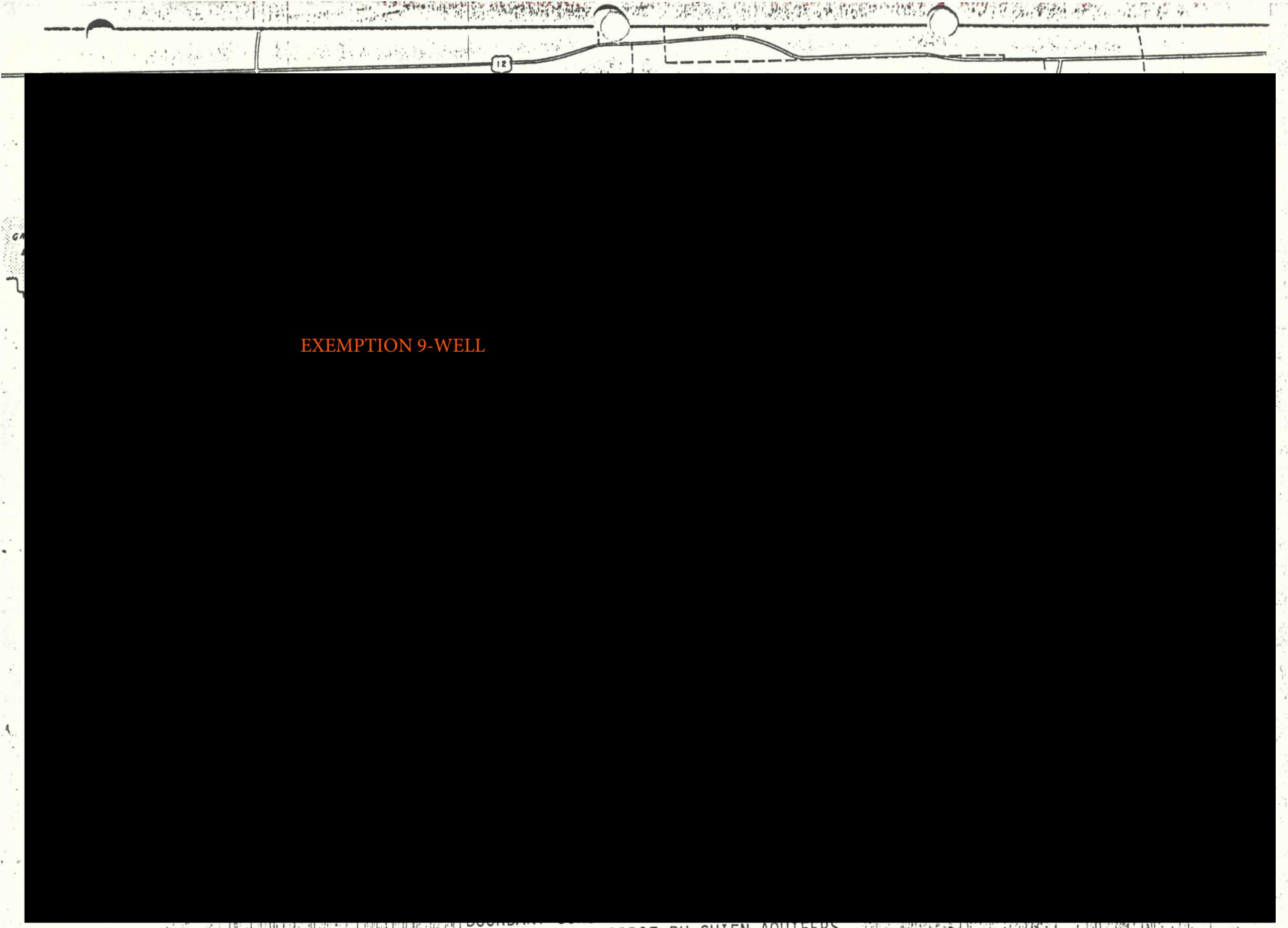
ALTERNATIVE GRADIENT CONTROL SYSTEMS

EXEMPTION 9-WELL

FIGURE 12

MUNICIPAL, INDUSTRIAL AND PRIVATE WELLS SAMPLED DURING THIS STUDY

● - Glacial Drift
△ - Platteville
▲ - St. Peter
□ - Prairie du Chien-Jordan
■ - Mt. Simon-Hinckley



ST. PETER-PRAIRIE DU CHIEN AQUIFERS

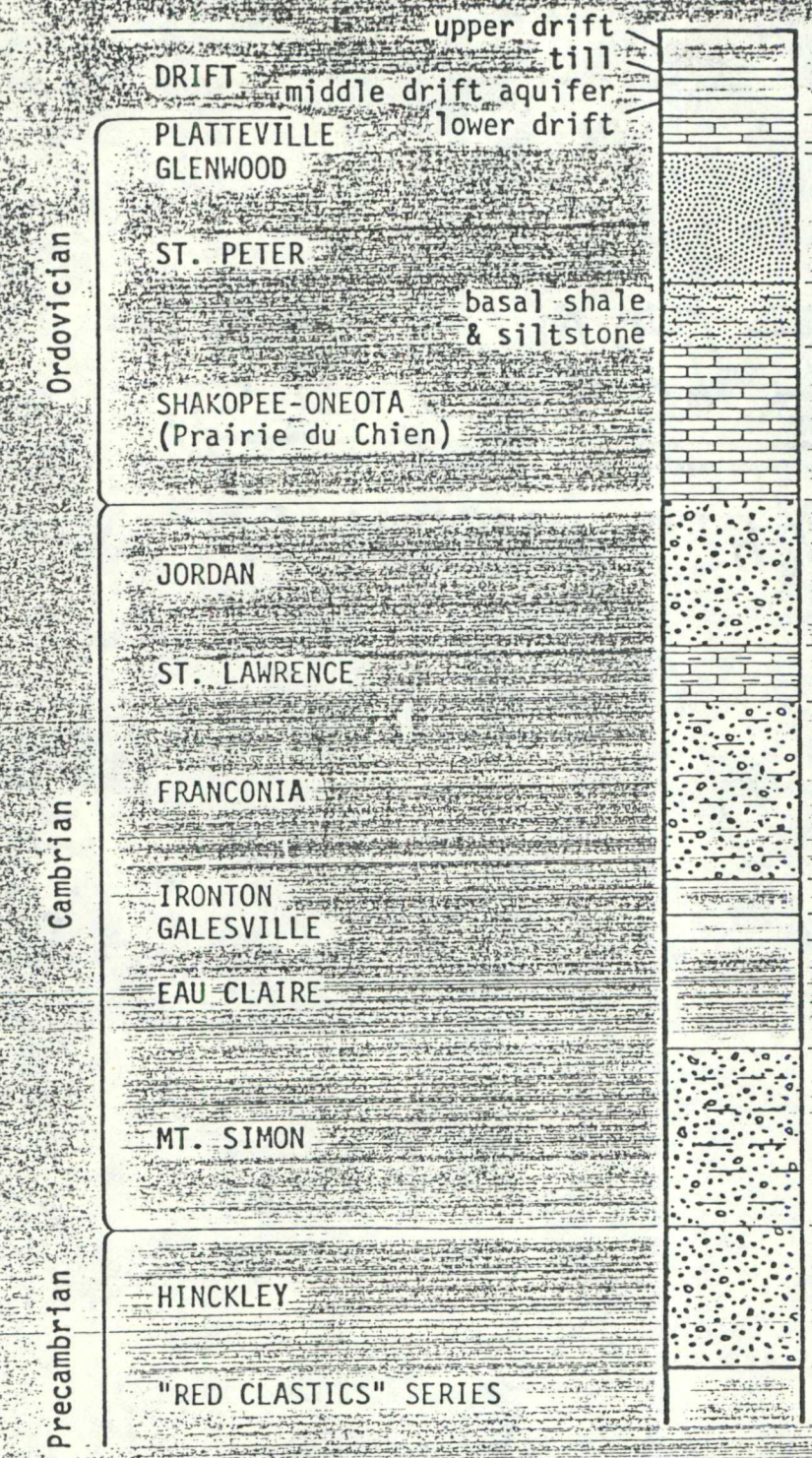


FIGURE 5

GENERALIZED GEOLOGIC COLUMN

Adopted from Sunde, Hydrogeologic Study of the Republic Creosote Site (1974).

TABLE 9

MWCC LIMITATIONS FOR
DISCHARGES TO THE SANITARY SEWER*

Substance or Characteristic	Limit
Cadmium, mg/l	2.0
Chromium (total), mg/l	25.0
Chromium (hexavalent), mg/l	10.0
Copper, mg/l	5.0
Cyanide (total), mg/l	10.0
Cyanide (readily released at 150°F and pH = 5.5), mg/l	2.0
Iron, mg/l	50.0
Lead, mg/l	0.5
Mercury, mg/l	None at levels acutely toxic to humans or other animals or plant life.
Nickel, mg/l	10.0
Zinc, mg/l	15.0
Temperature (except where higher temperatures are required by law), °F	≤150
pH, units	5.5-9.5
Oil and Grease (hexane soluble), mg/l	100

*Source: "Sewage and Waste Control Rules and Regulations for the Metropolitan Disposal System," Metropolitan Sewer Board, December 1, 1971.

TABLE 10

STANDARDS FOR DISCHARGES OF STORM WATER FROM SITE TO MINNEHAHA CREEK[a]

Substance or Characteristic	Permissible Concentration With Dilution		Permissible Daily Maximum Concentration
Oil and Grease, mg/l	0.5x[b]		15
Phenols, mg/l	0.01x		0.1
5-Day Biochemical Oxygen Demand, mg/l	5x		45
Total Suspended Solids, mg/l	5x		45
Total Chlorine Residual, mg/l	0.01x		0.1
Zinc, mg/l	0.12x		1.0
Cadmium, mg/l	0.03x		0.3
Copper, mg/l	0.01x		0.1
Nickel, mg/l	0.52x		2.0
Lead, mg/l	0.03x		1.0
Ammonia, mg/l as N	1.0x		2.0
Benzo-α-pyrene, mg/l	--	10 ppt	0.000001
Chrysene, mg/l	--	10 ppt	0.000001
pH, units	--		6.5 8.5

[a] Source: NPDES Permit No. MN 0045489. Refer to permit for additional detail.

$$b_x = \frac{(0.25)(\text{flow in Minnehaha Creek})+(\text{effluent flow rate})}{(\text{effluent flow rate})}$$

Flows used in calculation of dilution ratio "x" shall be the daily total effluent flow rate and the daily total flow rate of Minnehaha Creek.

TABLE 1

ST. LOUIS PARK
PILOT CARBON TREATMENT STUDY
JULY 16-20, 1979
WELL NUMBER 15
MINNESOTA DEPARTMENT OF HEALTH's RESULTS
SERCO Laboratories January 9, 1980

Test Condition	Partial List of Parameters (ng/l)					
	Acenapthene	Anthracene	Phenanthrene/Pyrene*	Fluorene	Fluoranthene	Chrysene
Untreated Samples						
7/16 11:00 AM	3200	-	1700	-	510	<25
7/18 11:00 AM	2400	-	1800	-	440	<25
7/19 5:00 AM	2800	-	1900	-	380	<25
7/20 5:00 AM	<2.2	60	1400	-	190	-
Post Sand-Filter Untreated						
7/16 11:05 AM	<140	-	6.1	-	3.6	<25
7/16 11:00 PM	2500	-	1900	-	84	<25
7/16 5:00 PM	1600	-	440	-	91	<25
7/19 3:00 AM	4800	-	1100	-	32	<25
7/19 3:00 AM (Dupl.)	3900	-	1000	-	32	<25

* co-eluting compounds
< means "less than"

TABLE 1

ST. LOUIS PARK
PILOT CARBON TREATMENT STUDY
JULY 16-20, 1979
WELL NUMBER 15
MINNESOTA DEPARTMENT OF HEALTH's RESULTS
SERCO Laboratories January 9, 1980

Test Condition	Partial List of Parameters (ng/l)					
	Acenapthene	Anthracene	Phenanthrene/Pyrene*	Fluorene	Fluoranthene	Chrysene
Post Sand-Filter Treated, 1-2 mg/l						
7/17 11:00 AM	910	-	430	-	89	<25
7/17 11:00 AM (Dupl.)	1200	-	360	-	81	<25
7/17 5:00 PM	1300	-	300	-	62	<25
7/17 11:00 PM	170	<8.0	180	-	39	<25
7/17 11:00 PM (Dupl.)	2700	-	190	-	30	<25
7/18 5:00 AM	1500	-	180	-	28	<25
7/18 11:00 AM	2600	-	210	-	41	<25
7/18 5:00 PM	190	<8.0	210	-	17	-
7/18 9:00 PM	190	<8.0	240	-	15	-

* co-eluting compounds
< means "less than"

TABLE 1

ST. LOUIS PARK
PILOT CARBON TREATMENT STUDY
JULY 16-20, 1979
WELL NUMBER 15
MINNESOTA DEPARTMENT OF HEALTH's RESULTS
SERCO Laboratories January 9, 1980

Test Condition	Partial List of Parameters (ng/l)					
	Acenapthene	Anthracene	Phenanthrene/Pyrene*	Fluorene	Fluoranthene	Chrysene
Post-Sand Filter Treated, 9-12 mg/l						
7/19 5:00 AM	110	<8.0	510	-	14	<25
7/19 11:00 AM	21	<8.0	10	-	7.0	-
7/19 5:00 PM	<2.2	<8.0	27	-	3.6	-
7/19 11:00 PM	<2.2	<8.0	<1.0	-	1.0	-
7/20 5:00 AM	<2.2	<8.0	<1.0	-	1.2	-
May-August 1978	-	190	750[1]	-	390	-
	-	241	1221[1]	-	292	-

* co-eluting compounds

[1] Pyrene only

< means "less than"

INTER-OFFICE MEMORANDUM

ST. LOUIS PARK MINNESOTA

JUL 1979 RECEIVED SERCO ROSEVILLE

Dick Koppy DATE July 10, 1979

Vern Tollefsrud

ECT Pilot Study - Carbon Treatment of Well Water Deep Well #15

On July 11, 1979, a meeting was held at the St. Louis Park City Hall. In attendance were Dick Koppy, Director of Public Works; Vern Tollefsrud, Water Superintendent; Bill Scruggins, Minnesota Health Department; Larry Briemhurst, Serco Labs and Darrel Thingvold of Serco.

The testing should begin on Monday, July 16, 1979. There will be two separate runs at different settings for the addition of the powdered carbon.

The M.H.D. will take about 20 to 25 samples.

Serco Laboratories will take about 7-10 samples plus P.H. and S.S. and temperature samples.

Some of these samples will be split samples. There will be two runs conducted. The first run will be with a projected 5 P.P.M. of carbon added to 1,000 G.P.M. of water. Sampling will be as follows:

First Run -- 5 P.P.M.

1. Raw water at Pump Head
2. Raw water effluent after filters
3. Six hour intervals for 48 hours of water effluent
4. Six hour intervals for 48 hours of suspended solids - carbon
5. Six hour intervals for 48 hours of temperature and P.H.
6. Backwash sample - composite of several cells.
7. Record pressure differentials in filter banks

Second Run -- 25 P.P.M.

1. Raw water at Pump Head
2. Raw water effluent after filters
3. Six hour interval for 48 hours of water effluent
4. Six hour intervals for 48 hours of suspended solids - carbon
5. Six hour intervals for 48 hours of temperature and P.H.
6. Backwash sample - composite of several cells.
7. Record pressure differentials in filter banks.

All effluent to be run into storm sewer system.
Turn around time for reading of samples about one week
Sample size to be 4 litre

If a third run is necessary to fine tune the application of carbon slurry, the same sampling times would be used.

A post testing meeting will be held at City Hall to review the results of this testing and further testing, using new carbon concentrations, may be conducted

Carbon Costs - $0.42 per pound
Samples Serco - $100.00 per sample - approximate
Deep Well #15 - Pumping 1,000 G.P.M.

Coordination of sampling and runs will be by Vern Tollefsrud

jme

CARBON TREATMENT PROCEDURES

1. Initial test run to be at least six days.

2. Set up equipment series 44 W & T slurry feeder

   slurry pump) - slurry mixer - flush lines - etc.
   slurry tank)

3. Start with initial dosage of 5 P.P.M.

   Recommended by Dr. Russ Frazier S.B.H. - may need more or less P.A.C.

4. Take sample after sand filter is completely purged.

   First sample about two hours into run

5. Take samples on set times - State Board of Health

   Samples to be taken at well head and after filtering.
   Bill Scrugging S.B.H. to do samples and timing of samples to be taken

6. Decrease or increase dosage to reach desired results.

   P.A.C. added or decreased as needed to bring P.A.H. into acceptable limits.

Federal regs on PAH may be out in June or July

Preliminary
Subject to Revision

NOV 7 1979
Minn. Dept. of Health
Div. of Env. Health

Table 3.—Summary of ground-water use in the St. Louis Park area, Minnesota

Site identification (latitude and longitude)	Aquifer	Well name	Date of installation	Period of monthly pumpage records	Pump capacity (gal/min)	1976 Total reported pumpage, summary (gallons)
		INDUSTRIAL WELLS				
445615093212301	Prairie du Chien-Jordan	Minnesota Rubber (W40)	8/50	1968-78	300	81,778,840
445604093223801	Prairie du Chien	Flame Industries (W29)	4/63	1968-78	100	11,923,868
445618093210001	St. Peter-Prairie du Chien	S & K Products #1(W45)	7/63	1968-78	175	Not in use
445617093210201		#2(W46)	2/73	1973-78	175	6,582,000
445646093214601	Prairie du Chien-Jordan	Methodist Hospital	1958	1973-78	—	228,170,300
445721093221601	St. Peter-Prairie du Chien	McCourtney Plastics (W62)	9/66	1975-78	250	59,976,131
445733093214301	Prairie du Chien	Food Producer	—	1969-78	—	66,281,040
445608093240301	Prairie du Chien-Jordan	Red Owl	10/46	1973-78	—	81,752,286
		ST. LOUIS PARK MUNICIPAL WELLS				
445701093215803	Platteville-St. Peter	# 3	8/39	1947-48, 1961-64, 1975-78	1200	125,878,400
445548093202201	Prairie du Chien-Jordan	# 4	9/46	1948-64, 1975-78	1000	91,747,970
445631093230301	Prairie du Chien-Jordan	# 5	8/47	1948-64, 1975-78	1200	151,458,650
445626093211401	do	# 6	1/48	1948-64, 1975-78	1200	349,558,260
445727093221701	Prairie du Chien-Jordan	# 7	5/52	1953-64, 1975-78	1200	21,806,970
445806093241101	Jordan	# 8	10/55	1956-64, 1975-78	1200	375,317,050
445730093222601	Prairie du Chien-Jordan	# 9	1955	1960-64, 1976-78	1200	21,807,170
445701093215804	do	#10	1955	1956-64, 1975-78	1200	86,162,850
445701093215805	Mount Simon-Hinckley	#11	11/60	1961-78	1200	315,796,700
445526093211402	do	#12	8/63	1964-78	1400	108,437,660
445756093211701	Hinckley	#13	7/64	1965-78	1400	101,826,750
445756093211702	Jordan	#14	2/65	1965-78	1200	102,363,770
445701093215806	do	#15	1969	1970-78	1200	232,574,200
445750093234801	do	#16	7/73	1974-78	1200	442,279,000
445614093204101	Prairie du Chien	Wolfe Lake (W69) (Hedburg-Friedheim)	7/47	1970-79	—	None

ecology and environment, inc.
recycled paper

PRELIMINARY
Subject to Revision

NOV 7 1979

Minn. Dept. of Health
Div. of Env. Health

445730093193801	St. Peter-Prairie du Chien	Twin Lakes	5/60	—	—	None

EDINA MUNICIPAL WELLS

445442093202601	Jordan	# 2	—	1958-64, 1969-77	900	426,534,700
445430093194701	Prairie du Chien-Jordan	# 3	1947	do	800	39,110,800
445356093203801	do	# 4	1950	do	700	167,694,300
445245093194001	do	# 5	5/54	do	1000	86,845,700
445345093204801	Prairie du Chien-Jordan	# 6	6/54	do	1000	348,150,000
445355093212201	Prairie du Chien-Jordan	# 7	1955	do	1000	72,571,400
445301093213701	Jordan	# 8	1953	do	1000	64,247,200
445349093222501	Mount Simon-Hinckley	# 9	1957	do	1000	74,014,800
445153093195801	do	#10	9/63	1964, 1969-77	1000	256,503,900
445153093195802	Jordan	#11	1963	do	1000	397,258,000
445513093231201	Hinckley	#12	9/64	do	1000	57,581,000
445513093231202	Jordan	#13	9/64	do	1000	385,594,000
445202093230201	Prairie du Chien-Jordan	#14	1964	do	1000	46,417,800
445443093222901	Prairie du Chien	#15	11/67	1969-77	1000	169,428,000
445317093225801	Prairie du Chien-Jordan	#16	11/67	do	1000	306,421,000
445345093200801	—	#17	1970	1971-77	1000	117,494,200
445206093191401	Jordan	#18	1973	1974-77	1000	49,789,000

HOPKINS MUNICIPAL WELLS

445514093244301	Prairie du Chien-Jordan	# 1	—	1958-78	850	268,984,400
445550093230801	Prairie du Chien-Jordan	# 3	—	1958-78	1250	71,314,500
445607093250501	do	# 4	5/54	1958-78	2300	
—	Jordan	# 5	1967	1967-78	2050	573,860,000
445559093243501	do	# 6	1977	1977-78	2200	

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Record pressure differentials on sand filters.

To be sure that filters are operating at peak efficiency and as to how fast P.A.C. builds up on the filters.

8. Backwash when differential reaches #4 - #6 or the maximum time of 10 days.

9. All affluent shall be pumped to waste until given permission by the Health Department to place plant back into operation.

   It may require us to have more than one test run of two days or more.

Aquifer	A	P	Fl	BaP	BghiPE	oPP	N
-	< 1.8	<45	2.3	<0.8	3.9	< 1.2	< 10
-	< 1.8	<45	< 0.8	<0.8	< 3.4	< 1.2	< 10
-	< 1.9	<47	< 0.9	<1.2	6.8	1.6	< 10
-	< 7.0	<210	9.3	<3.6	<13.0	< 1.7	-
-	< 7.0	<210	4.7	<3.6	<13.0	< 1.7	-

ection limit, A = anthracene, P = pyrene, Fl = fluoranthene,
e, BghiPe = benzo[ghi]perylene, oPP = o-phenylenepyrene,
k, R = Robbinsdale, F = Fridley, WBL = White Bear Lake,
t. Peter, SJ = Shakopee-Jordan, H = Hinkley

PAH in Drinking Water
(Nanograms/Liter)

Well	Depth (feet)	Aquifer	A	P	FI	BaP	BghiPE	OPP	N
SLP #3	236	PSP	< 1.9	< 47	< 0.9	< 1.1	< 4.4	< 1.1	< 10
SLP #4	500	SJ	< 1.9	< 47	4.5	< 1.1	< 4.4	< 1.1	< 10
SLP #5	465	SJ	< 1.9	< 47	7.4	< 1.0	< 4.1	< 1.2	< 10
SLP #6	480	SJ	< 1.9	< 47	< 1.0	< 1.0	< 4.8	< 1.5	< 10
SLP #7	446	SJ	11.4	104	7.4	< 1.1	< 4.4	< 1.1	< 10
SLP #8	507	SJ	< 1.9	< 47	< 0.8	< 1.1	< 4.4	< 1.1	< 10
SLP #9	473	SJ	12.2	199	21.1	< 1.1	< 4.4	< 1.1	< 10
SLP #10	500	SJ	100	800	450	< 1.1	< 9.8	< 2.1	-
SLP #10	500	SJ	54	486	152	1.3	4.4	< 1.2	80
SLP #11	1000	H	< 1.9	< 47	< 0.9	< 1.1	< 4.5	< 1.1	< 10
SLP #12	1095	H	< 1.9	< 47	< 0.9	< 1.1	< 4.5	< 1.1	< 10
SLP #13	1040	H	< 1.9	< 47	1.0	< 1.1	< 4.5	< 1.2	< 10
SLP #13	1040	H	< 1.9	< 47	< 0.9	< 1.2	< 4.9	< 1.1	< 10
SLP #14	485	SJ	6.3	< 47	4.2	1.8	5.5	2.2	< 10
SLP #14	485	SJ	6.3	< 47	2.4	< 1.2	5.4	< 1.1	< 10
SLP #15	503	SJ	700	750	390	< 1.2	< 10.7	< 2.4	-
SLP #15	503	SJ	241	1321	292	1.5	6.8	2.0	160
SLP #16	500	SJ	< 1.9	< 47	< 0.8	< 1.1	< 4.4	< 1.1	< 10
Edina #2	460	SJ	< 1.9	< 47	3.1	< 1.1	< 4.6	< 1.1	< 10
Edina #3	475	SJ	< 1.9	< 47	1.0	< 1.1	< 4.6	< 1.1	< 10
Edina #4	495	SJ	< 1.9	< 47	0.9	< 1.1	< 4.6	< 1.1	< 10
Edina #7	547	SJ	< 1.9	< 47	< 0.8	< 1.1	< 4.7	< 1.1	< 10
Edina #15	405	SJ	< 1.9	< 47	< 0.8	< 1.1	< 4.6	< 1.1	< 10
Edina #17	461	SJ	< 1.9	< 47	< 0.8	< 1.1	< 4.7	< 1.1	< 10
R #1	624	SJ	< 1.9	< 48	2.8	< 1.2	< 4.9	< 1.1	< 10
R #2	624	SJ	< 1.9	< 47	2.1	< 1.2	< 4.9	< 1.1	< 10
R #4	402	SJ	< 1.9	< 47	0.9	< 1.2	< 4.9	< 1.1	< 10
WBL #3	289	SJ	< 1.9	< 48	< 1.0	< 1.0	< 5.1	< 1.6	< 10
F #13	332	SJ	< 1.9	< 48	1.5	< 1.2	< 6.3	< 2.0	< 10
Edina P #1	-	-	< 1.8	< 45	2.1	< 0.8	5.6	< 1.2	< 10
Edina P #2	-	-	< 1.8	< 45	1.2	< 0.8	< 3.4	< 1.2	< 10

(Table 2)

TABULATION SHEET

TOPIC: St. Louis Park Municipal Wells.

		date of sample	lab number	total volume pumped in previous 24 hours	2-methylnaphthalene	acenaphthalene	biphenyl	anthracene	phenanthrene	pyrene	1,2,6,7-tetrahydropyrene	fluorene	fluoranthene	1,2-benzanthracene	chrysene	benzo (a) pyrene	9,10-benzphenanthrene	benzo (e) pyrene	perylene	benzo (g,h,i) perylene	benzo (k) fluoranthene	benzo (j) fluoranthene
	2																					
	3																					
	4																					
	5																					
	6																					
	7																					
	8			x 1000 gal.		nanograms/liter = parts per trillion																
St. Louis Park #4	9	10-19-79	6563			230.	47.		66.	87.			5.8	<3.8	3.6	<5.4			<2.2			
St. Louis Park #6	10	10-19-79	6564			<24.	<5.5		<2.4	<14.			<3.7	<3.8	<3.6	<5.4			<2.2			
St. Louis Park #8	11	10-19-79	6565			<24.	<5.5		5.8	<14.			<3.7	<3.8	<3.6	<5.4			<2.2			
St. Louis Park #11	12	10-19-79	6566			<24.	<5.5		<2.4	<14.			<3.7	<3.8	<3.6	<5.4			<2.2			
St. Louis Park #12	13	10-19-79	6567			<24.	<5.5		<2.4	<14.			<3.7	<3.8	<3.6	<5.4			<2.2			
St. Louis Park #13	14	10-19-79	6568			<24.	<5.5		<2.4	<14.			<3.7	<3.8	<3.6	<5.4			<2.2			
	15																					
St. Louis Park #4	16	11-8-79	7114			<120.	34.		36.	<17.			3.3	<4.0	<4.0	<6.0			<3.4			
St. Louis Park #15	17	11-8-79	7115			<600.	1300.		1000.	<84.			450.	40.	<20.	30.			<17.			
	18																					
St. Louis Park #4	19	11-16-79	7386			300.	19.		43.	<14.			1.9	<3.2	<3.8	7.4			<4.2			
St. Louis Park #4	20	11-16-79	7387			290.	18.		44.	<14.			2.0	<3.2	<3.8	12.			<4.2			
St. Louis Park #4	21	11-16-79	7388			290.	16.		40.	<14.			2.4	<3.2	<3.8	<6.4			<4.2			
St. Louis Park #4	22	11-16-79	7389			280.	17.		42.	<14.			3.1	<3.2	<3.8	<6.4			<4.2			
	23																					
St. Louis Park #7	24	11-5-79	7396			<100.	<24.		<10.	←			<17.	<24.	<15.	<24.			<16.			
St. Louis Park #9	25	11-5-79	7397			<100.	<24.		<10.	←			<17.	<24.	<15.	<24.			<16.			
St. Louis Park #10	26	11-5-79	7398			<100.	930.		690.	←			810.	65.	<15.	44.			<16.			
St. Louis Park #15	27	11-5-79	7399			<100.	1140.		1000	←			550	53.	<15.	38.			<16.			
	28																					
	29																					
St. Louis Park #14	30	10-19-79	6569			39.	11		12.	<14.			<3.7	<3.8	<3.6	<5.4			<2.2			
St. Louis Park #15	31	10-19-79	6570			<120.	<7[illegible]		1300	<70.			830.	39.	<18.	<27.			<11			
St. Louis Park #16	32	10-19-79	6571			<24.	<5.5		6.0	<14.			<3.7	<3.8	<3.6	<5.4			<2.2			
	33																					
St. Louis Park #15	34	7-16-79	55087		<67.	3200	[illegible]		1700	←			510.	<52.	<25.	<2.2	<15.		<1.0			
St. Louis Park #15	35	7-18-79	55095		<67.	2400	[illegible]		1800	←			440.	<52.	<25.	<2.2	<15.		<1.0			
St. Louis Park #15		7-19-79	55102		<67.	2800	[illegible]		1900	←			380.	<52.	<25.	<2.2	<15.		<1.0			
St. Louis Park #15		7-20-79	55123			<2.2.	[illegible]	60.	1400	←			190.			<2.2			<1.0			

City Atty Hal
copy 11/16/78

Donald E. Nichols

MN-01-06

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ASSESSMENT OF POSSIBLE HUMAN HEALTH EFFECTS RESULTING FROM THE CONTAMINATION OF THE FORMER REPUBLIC CREOSOTE SITE

MINNESOTA DEPARTMENT OF HEALTH
DIVISION OF ENVIRONMENTAL HEALTH

BY

HEALTH RISK ASSESSMENT UNIT
SECTION OF HEALTH RISK ASSESSMENT
AND
ANALYTICAL SERVICES

OCTOBER 1977

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PREFACE

This report will examine and make recommendations relative to those aspects of the St. Louis Park-Republic Creosote problem which relate to public health. For the past two years, significant effort has gone into hydrological investigations; however, little has been done to identify and measure the magnitude of the potential hazards to human health created by the coal-tar and creosote waste contamination.

Seems True

Based on the limited amount of information available on the extent of contamination in St. Louis Park, this report will serve as a starting point for an ongoing process of risk assessment.

ASSESSMENT OF RISK BASED ON EXISTING INFORMATION

The objective of this section of the report is to quantitatively assess, to the extent possible given the information currently available, the existing and potential human health risk resulting from the contamination of the Republic Creosote site. The focus of concern over human exposures to creosote and coal-tar wastes has been the possibility that the polynuclear aromatic hydrocarbon (PAH) compounds contained therein will contaminate water supplied and in turn have adverse human health effects. Of special concern is the possibility of such products inducing carcinogenesis. This evaluation will, therefore, address the problem of carcinogenesis exclusively.

A complete assessment of existing and potential health risk would require the following information, little of which is available at this time:

1. To what extent is the groundwater, and more specifically the municiple water supplies, in the area contaminated with carcinogenic PAH compounds? There are no quantitative data available on specific PAH compounds in groundwater in the area of the site.

2. What are the directions and speed of the spread of the contamination from the site? This question must be addressed for the vertical travel of the material to

the deep aquifers and for the flow leaving the site area laterally. A complete treatment of this problem would also involve a determination of which fraction of the material is actually in a water solution and which is moving as an independent phase. Also needed would be information on the position of the buried bedrock valley to the east of the site and the porosity of the material within it. Although Barr Engineering Phase II Report (78) was an in-depth treatment of certain aspects of the problem, many geohydrologic questions remain unanswered.

3. What population groups are presently or potentially exposed to drinking water contaminated with PAH compounds from the site?

4. Are there significant exposures to airborne PAH compounds? Although the creosote and coal-tar are contained in the soil, the soil does not present an absolute barrier to PAH vapors.

5. Is there a potential exposure from external contact with the contaminated soil by future residential populations or to those involved in construction activities on the site?

This assessment will use the information currently available to provide an initial step in an ongoing process of risk

evaluation. Our analysis will deal only with the contamination of the drinking water supplies of St. Louis Park and Edina. The contamination of other drinking water supplies as well as airborne and direct contact exposures are possibilities which may have a greater impact on the public's health than what we are able to attribute to the municiple drinking water supplies. Because of the lack of information, these problems cannot be dealt with at this time.

purposts not to deal w/air

The St. Louis Park and Edina supplies have been shown to contain trace quantities of phenols, a major constituent of creosote. The presence of phenols suggests the presence of other more harmful components of creosote and coal-tar such as the carcinogens benzo(a)pyrene*, benzo(a)antracene, dibenze(a,h)anthoracene, benzo(b)fluoranthene, benzo(i)-fluoranthene and chrysene. Because of the absence of any measured concentrations of these carcinogenic PAH compounds, this analysis makes use of an estimated benzpyrene concentration in the water supplies of the two communities. These supplies may, of course, contain many other carcinogenic PAH compounds.

Key

*The nomenclature for the above listed compounds is the official nomenclature designated by the Intl. Union of Pure and Applied Chemistry (I.U.P.A.C.). Other more common names are often used in the literature, e.g., benzo(a)pyrene is also called 3,4-benzpyrene, benzpyrene, and abbreviated BP. In this report the more familiar common name benzpyrene or the abbreviation BP will be used.

This assessment should then be considered a conservative estimate to the true risk since there are other possible routes of human exposure to benzpyrene and other carcinogenic PAH compounds present in the contaminated soil.

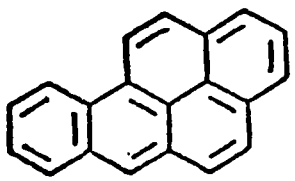
Preceding the detailed analysis of risk is a review of the current literature on the physiochemical properties, occurrence, toxicity and epidemiology of PAH compounds and related topics affecting their role in carcinogenesis. This general section is intended to assist the reader in understanding the results of the assessment.

Physiochemical Characteristics of PAH Compounds.

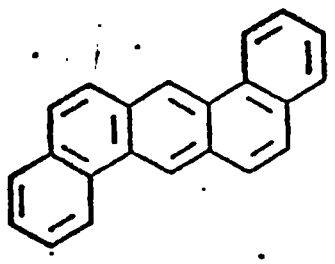
1. Description.

Polynuclear aromatic hydrocarbons are planer condensed multi-ring structures, based on benzene, possessing little or no substitution by alkyl groups and the total absence of polar groups. The chemical structures of two typical PAH are as follows:

Typical polynuclear aromatic hydrocarbons



benzpyrene



dibenzanthracene

These relatively high molecular weight compounds have chemical properties intermediate between those of the aromatic and olefinic hydrocarbons.(1) The condensed ring structure provides a molecular stability that makes decomposition or disruption of the compound quite difficult. The compounds themselves are universally hydrophobic, insoluble, non-polar, non-ionic and quite stable.(2) ?

2. Solubility.

PAH are quite insoluble in distilled water and may not be present in a purely dissolved phase to any great extent in an aqueous system. However, it has been established that surface, ground and runoff water can, to a great extent, solubilize PAH compounds in colloidal form.[3]

Andelman and Suess, and Schmidt-Colleries (4,3) have presented a review of factors known to enhance solubilization of PAH. One factor of particular interest is solubilization of PAH by the formation of small colloidal particles called micelles. Micelles are formed in water by synthetic detergents. If the concentration of the anionic detergent is sufficiently high, PAH solubility is increased. The solubilization of PAH in water may also be enhanced by the salts of polynuclear acids, (e.g., deoxycholic acid) probably by inclusion of the aromatic hydrocarbon in the micellar form of these cholic acids.

Solubilization of PAH is also enhanced by the presence of various inorganic salts which may play an important role in the transportation of PAH compounds from soils (rich in soluble salts) by runoff water or seepage water.

Another factor to consider is the phenomenon of hydrotropy, that is, the increase in PAH solubility in

water as a result of the introduction of other organic chemicals not associated with a collodal form. For example, PAH may be dissolved in a water-organic solvent mixture, such as water and methyl or ethyl alcohol, dioxane, or acetone. Consequently, highly polluted waters containing emulsions or organic solvents would be capable of containing relatively large quantities of PAH. PAH compounds commonly encountered in the aqueous environment are listed in Table 1.

TABLE 1

PAH Compounds Found in the Aqueous Environment [1,3]

I.U.P.A.C. NAME	EARLIER NAME	MOL. WT.
Anthracene	Anthracene	178
Benzo(a)anthracene	1,2-Benzanthracene	228
Benzo(b)fluoranthene	3,4-Benzfluoranthene	252
Benzo(j)fluoranthene	10,11-Benzfluoranthene	252
Benzo(k)fluoranthene	11,12-Benzfluoranthene	252
Benzo(a)pyrene	3,4-Benzpyrene	252
Benzo(e)pyrene	1,2-Benzpyrene	252
Benz(ghi)perylene	1,12-Benzperylene	276
Chrysene	Chrysene	228
Dibenz(a,h)anthracene	1,2,5,6-Dibenzanthracene	278
7,12-Dimethybenz(a)-anthracene	9,10-Dimethy-1,2-benzanthracene	256
Fluoranthene	Fluoranthene	202
Indeno(1,2,3-Cd)pyrene	2,3-Phenylene pyrene	276
Phenanthrene	Phenanthrene	178
Perylene	Perylene	252
Pyrene	Pyrene	202

3. Sorption.

Being quite insoluble in agueous systems, PAH are readily adsorbed on and are found on all varieties of bottom sediments and solid materials. The sorption of PAH onto

surfaces is an important characteristic in relation to their presence in environmental waters. The presence of minerals and other suspended and settled particulates is an important factor in the transport of PAH in environmental waters.

4. Biological Accumulation of PAH.

PAH are drawn to and readily dissolve and accumulate in the non-polar fatty material of biological matter.[2] This results in significant accumulation and biomagnification of PAH in the body tissues of a variety of organisms.

5. Vapor Pressure of PAH.

Several investigators have experimentally determined the equilibrium vapor concentrations (EVC's) of some PAH.[5,6] The EVC's at ambient temperatures can be derived by extrapolation from the vapor pressure results obtained experimentally at higher temperatures. Table 2 shows EVC's for several PAH at common winter and summer temperatures.

TABLE 2

The Equilibrium Vapor Concentrations (EVC's) for a Common Winter Temperature (-10°C, 14°F) and a Common Summer Temperature (30°C, 86°F).

Compound (Pure PAH)	Winter EVC $\mu g\ 10^{-3}\ m^{-3}$	Summer EVC $\mu g\ 10^{-3}\ m^{-3}$
Pyrene	580	140,000
Benzanthracene	3.4	2,800
Benzpyrene	0.15	160
Benzo(k)fluoranthene	0.013	30
Benz(ghi)perylene	1.8×10^{-3}	3.4
Coronene	1.8×10^{-5}	0.058

It can be seen that, as expected, PAH exhibit decreasing vapor pressure as the temperature decreases and as the number of carbon atoms increases. The EVC's of PAH given in Table 2 are all, except coronene and Benz(ghi)-perylene, equal to or larger than concentrations commonly found in ambient air.(6) i.e. — They will therefore [illegible]

6. Degradation of PAH.

Degradation of PAH compounds in the environment can occur either by physical oxidation or biological reduction. Quantitatively, the most important process is photo-oxidation, both in atmospheric and aquatic environments.(7) The highly reactive PAH photodecompose very readily in the atmosphere by reaction with ozone, various other oxidants, nitrogen oxides and sulfur oxides. Degradation of PAH in surface waters by photooxidation will depend on water depth, on daily and seasonal fluctuations of solar radiation, and on ambient temperature and dissolved oxygen. As would be expected, photooxidation is not an important factor in the degradation of PAH in soil or ground water.

There exists some controversy with respect to the degradation of PAH by microorganisms. Hydrocarbons are degraded by a large number of organisms.[8,9] However, these studies indicate that as the hydrocarbons become more complex, they also become more resistant to microbial degradation. This is particularly true for the carcinogenic PAH. Little is known about the rate of reduction (except that in the biosphere microbial removal of PAH is clearly much slower than in a controlled laboratory experiment) or the environmental factors that might influence the process. No information is available on the metabolites of PAH. It is possible that they are just as hazardous and may be water soluble.

Formation, Sources and Levels of PAH in the Environment.

1. Formation of PAH.

The majority of PAH in the environment is formed during incomplete combustion of organic matter at high temperatures and pyrolytic conditions. They are also to a much lesser extent products of organic decomposition.

Recently, a number of investigators have suggested that there is endogenic formation of PAH by plants and microorganisms, which accounts for a low-level "background" of PAH in unpopulated areas.[4] Others have not found this to be true and have suggested that these low levels are probably due to natural world-wide dispersion of man-made PAH and of PAH formed by forest fires and organic decomposition.[10,11]

The production of PAH by combustion depends, to a large degree, upon the temperature and the composition of the parent materials themselves. Hydrogen, carbon and CH radicals are released through the cracking of the parent materials at temperatures which range from 450-1600°C and with an atmosphere deficient in oxygen.[12,13] Polymerization of the free CH radicals may then occur with the formation of condensed ring compounds.

High temperature combustion of natural organic matter produces large quantities of PAH. Lower temperatures

produce mostly paraffins, cycloparaffins, olefins and phenols. Also the number of alkyl carbon atoms present as side chains on PAH compounds correlates closely with the temperature at which the compounds are formed. At high temperatures, typical of gas flames, side chains are virtually absent, (i.e., higher temperatures produce the more biologically active compounds).

2. Sources of PAH.

The most significant sources of PAH are man-induced and/or man-controlled combustion processes. Industrial processes are major sources of PAH.[7,14] Sources include coke production in the iron and steel industry, distillation of the coke by-product coal-tar, catalytic cracking in the petroleum industry, general chemical pyrolytic processes involving the production of acetylene, benzene, toluene and other organic solvents, heating and power generation (coal), and refuse burning. Other major sources of PAH released to the environment are the various forms of transportation and related activities.[1,6] Incomplete combustion of fuel by automobiles, airplanes, boats, etc., results in the production of PAH. Carbon black, which is used in the manufacturing of automobile tires, contains PAH and, consequently, the wear of tires on road surfaces is a

source of PAH. Asphalt used in road construction also contains PAH.

Two other sources of PAH are food and tobacco smoke.[14,15] Numerous reports have been published on the existence and concentration of carcinogenic PAH in various fried, roasted, grilled and smoked fish and meat products as well as in coffee. Carcinogenic PAH have also been identified in tobacco smoke and are probably the source of the lung cancer risk associated with cigarette smoking. ?

3. Levels of PAH in the Environment.

In recent years, polynuclear aromatic hydrocarbons have been found widely distributed in the human environment. This section is a discussion of levels of PAH found in the air, soil and water environments which are attributable to man-made sources. These levels are compared to natural "background" levels of PAH.

Sawicki[16] conducted a year long study of the benzpyrene content of the air in urban and non-urban U.S. communities. The benzpyrene concentration of composite samples for January-March 1959 for 94 urban cities ranged from $<1 ng/m^3$ to around $60 ng/m^3$. In comparison, the non-urban sites for the same period ranged from 0.01 to $1.9 ng/m^3$. In European cities, where industrial density is greater, PAH levels are higher, ranging from 4 - $244 ng/m^3$.[17]

The data from these studies indicates that BP and probably total PAH levels are higher in urban than in non-urban sites.

Benzpyrene and probably other PAH are ubiquitous in the soil environment. However, "background" levels and concentrations in polluted soil differ significantly. The main source of PAH in soil is from the sedimentation of particulate PAH from the air. Localized soil contamination is frequently a result of industrial spills or discharges.

Extensive research was done by Shabad[18] to determine the "background" level of BP in soil. In order to study an area not exposed to some known source of carcinogenic PAH, the vast uninhabited stretches of the Soviet Union were selected for study. Shabad found the "background" level of BP in soils averages 1-3 μg/kg and not more than 10 μg/kg. In urban and suburban areas, widely varying quantities of BP were detected. New building areas gave about 100 μg/kg and old ones about 250-350 μg/kg. Special industrial sites had very high levels of BP. For example, the soil surrounding an oil refinery plant contained up to 200,000 μg/kg of BP.

Key

Automotive, railway and aircraft exhausts are significant sources of PAH. Consequently, soil along roadways, railroad right-of-ways, and airport runways contain

high levels of PAH.

For this discussion, PAH in environmental waters will be divided into four different categories: (1) marine waters, (2) surface waters, (1 and 2 include flora, fauna, and sediments), (3) ground water, and (4) drinking water. In this discussion the distinction between total PAH, carcinogenic PAH, and BP often becomes confusing. What might appear to be inconsistencies in stated concentrations is a result of the investigator's choice of compounds upon which to do research.

BP is ubiquitous in the oceans.[1,8] Highest concentrations have been found along populated coasts and shipping lanes. Lower concentrations have been detected in the more isolated ocean areas. BP has also been found in ocean flora and fauna, (e.g., plankton and mussels).

Carcinogenic PAH have been detected in many surface waters. Concentration ranges of BP and PAH in various fresh surface waters are given in Table 3.[15] The presence of PAH in areas remote from any exogenous sources confirms the existence of a natural level of PAH in surface waters. Il'nitskii concluded that this level did not exceed 10^{-5} to 10^{-4} $\mu g/l$ of BP for surface waters.[19] Levels in excess of these amounts can be taken as indications of environmental pollution.

Investigations of PAH in groundwater were performed with the conclusion that, in general, uncontaminated groundwater has the lowest concentration of carcinogenic PAH of all natural waters, ranging from 0.001 μg/l to 0.01 μg/l.[20,21] Concentrations will generally not exceed 0.05 μg/l.

TABLE 3

Typical Concentration Ranges of BP and PAH in Various Fresh Surface Waters (15)

	Concentration (μg/l)		
SOURCE	BP	CARCINOGENIC PAH	TOTAL PAH
Rhine River at Various Points	0.05-0.11	0.01-0.73	0.73-1.50
Various German Rivers	0.001-0.04	0.04-1.30	0.12-3.1
One American River	0.078-0.150	-	-

Borneff and Kunte noted that concentrations up to 0.10 μg/l of PAH are found in drinking water.[21] They concluded that values between 0.15 and 0.20 μg/l should trigger some action to locate and reduce the source of the PAH. A water supply containing PAH in excess of 0.20 μg/l should not be used for human consumption under any circumstances. Studies summarized by Andelman and Suess[4] show that, in general, PAH in drinking water does not exceed 0.025 μg/l.

Key

PAH in Creosote and Coal-Tar.

The concentrations of the specific PAH found in creosote and coal-tar vary considerably due to the various temperatures and materials used for carbonization and distillation.

Benzpyrene was the first PAH to be isolated from coal-tar. Many other carcinogenic PAH are now known to be present, including dibenzepyrenes, benzfluoranthenes, dibenzanthracene, anthracene, pyrene, and chrysene.[22,23] Bonnet's quantitative analysis of a coal-tar indicates that the solid tar contains 3.0 percent benzpyrene.[23]

A study by Wood[24] showed that about 60 percent of a coke-oven road tar consisted mainly of aromatic compounds. Some of the PAH identified in this tar include benzpyrene, benzfluoranthene, benzperylene, pyrene and perylene.

In a study by Lijinsky, et.al.,[25] carcinogenic PAH benzanthracene, chrysene, fluoranthene, anthracene, pyrene and phenanthrene were isolated from creosote.

A later study by Lijinsky, et.al.,[26] extensively analyzed commercial creosote and medicinal coal-tar for PAH content. Table 4 shows the types and concentrations of PAH identified. The concentrations of tricyclic and tetracyclic hydrocarbons were higher in creosote than in coal-tar, the reverse being true for pentacyclic hydrocarbons.

TABLE 4

Polynuclear Hydrocarbons in Creosote and Medicinal Coal-Tar.

	CONCENTRATION IN CREOSOTE (g/kg)		CONCENTRATION IN COAL-TAR (g/kg)	
	(1)	(2)	(1)	(2)
Anthracene	12.1	12.0	2.88	4.35
Benz(a)anthracene	2.77	2.94	6.24	6.98
Benzo(b)chrysene	0.03	0.06	0.93	0.80
Benzo(i)fluoranthene	0.29	0.29	0.63	0.45
Benzo(k)fluoranthene	0.30	0.11	1.08	1.07
Benzo(ghi)perylene	...	...	1.23	1.89
Benzo(a)pyrene	0.14	0.22	2.08	1.76
Benzo(e)pyrene	0.18	0.15	1.85	1.88
Carbazole	2.20	1.42	1.32	1.27
Chrysene	1.34	0.94	2.13	2.86
Dibenz(ah)anthracene	...	...	0.30	0.23
Fluoranthene	24.8	22.2	17.7	17.8
Perylene	0.04	0.04	0.70	0.76
Phenanthrene	39.9	33.3	13.6	17.5
Pyrene	9.1	6.8	7.95	10.5

Wallcave, et.al.,[14] determined the PAH content of coal-tar pitches obtained from coke-oven production and of the grade commonly used in roofing. The two coal-tar samples studied had benzpyrene concentrations of 0.84 and 1.25 percent. The coke-oven coal-tar benzpyrene concentration was 5 times higher than that found in Lijinsky's study on medicinal coal-tar.

In summary, creosote and coal-tar have been shown to contain large and variable quantities of polynuclear aromatic hydrocarbons.

Experimental Carcinogenesis Studies.

1. The Use of Animal Models.

Many compounds known to cause cancer in humans were first identified as carcinogens in animal studies. Such compounds or mixtures of compounds include coal and tobacco tar extracts and the individual PAH compounds formed by incomplete combustion of organic material. Today, animals are used extensively to determine the cancer causing potential of suspected carcinogens.

A common concern of those who do not favor the use of animal systems to test carcinogenicity is that the doses of the chemical in question are larger than would be encountered in the human environment. However, testing at relatively high doses is essential because of the small size of animal groups tested. To illustrate this, assume that humans are as sensitive to a particular carcinogen as the rat or mouse. Assume further that the chemical of interest, at a certain low level environmental concentration, carries a risk of producing cancer in 1 of 10,000 humans exposed. This would result in approximately 20,000 cancers in the U.S. population. The chances of detecting a tumor in a group of 50 rats or mice tested at the same level of exposure, would be 1 in 200. It would, in fact, require a study involving about 100,000 animals to achieve statistical significance.

Animal studies of this size are not economically feasible. The validity of animal studies is also sometimes questioned because of biological, metabolic, and biochemical differences between humans and test animals. However, the genetic material DNA is found in every living cell. It is the ability of a carcinogen to alter DNA which gives it its cancer causing properties. Although uptake and transport processes differ from species to species at the cellular level, carcinogens behave similarly throughout the animal kingdom.

Although there may be wide variations in the susceptibility of different species to a carcinogen, a chemical that causes cancer in one animal species is very likely to do so in most other species. For example, of the 30 chemicals known to cause cancer in man, all, with the exception of trivalent arsenic which is still under study, have been shown to cause cancer in more than one species of test animal.[27]

Although questions have been raised and uncertainties exist with regard to animal studies, the only possible prudent public health policy relating to environmental carcinogens dictates that any chemical agent found, after appropriate testing, to be carcinogenic in one or more animal species, should be presumed to be carcinogenic in humans in the absence of conclusive evidence to the contrary.

There is a considerable amount of literature concerning the effects of PAH compounds and PAH-containing-materials on various tissues and organs of laboratory animals. A representative portion of this literature will be presented in order to provide a complete picture of the potential health problems which might result from PAH exposure.

2. Coal-Tar Animal Studies.

Crude coal-tar was first shown to be carcinogenic experimentally by Yamagiwa and Ichikawa[28] who painted it on rabbits' ears for several months. Later, Murray[29] produced similar results on the skin of mice.

In 1960, Hueper and Payne[30] reported the results of their study on the carcinogenic effect of coal-tar by inhalation of coal-tar fumes into the lungs, by applying coal-tar fume condensate to the skin and by injecting this condensate into the muscle tissue of experimental animals. The coal-tar used was obtained from a producer of coke-oven tar. The results of the administration of condensates of the coal-tar fumes demonstrate the distinct carcinogenicity of this material to the skin and soft tissues of mice, yielding a cancer rate by both routes of about 50 percent of the treated animals. None of the animals which inhaled coal-tar fumes developed any cancers of the lung or of the skin.

More recently, Wallcave[14] studied skin tumorigenesis in mice by coal-tar pitches of known PAH content. The two coal-tar pitches were from coke-oven production and of the grade commonly used in roofing. In addition to other PAH, the coal-tar samples contained high concentrations of BP, one containing 0.84 percent and the other 1.25 percent. Treatment of the mice involved painting the shaved skin on their backs twice a week with 25 µl of a solution of coal-tar dissolved in benzene. This resulted in an application of 1.7 mg of coal-tar pitch each treatment. The results indicated 45 percent of the mice treated with the pitch containing 0.89 percent BP developed carcinomas; 62 percent of the mice treated with the pitch containing 1.25 percent BP developed carcinomas. No carcinomas and only one papillomatous growth developed in the control group painted with benzene only.

3. Creosote Animal Studies.

Two animal studies have been conducted using creosote. The resulting data supports the contention that creosote is carcinogenic.

Poel and Kammer[31] conducted a study to determine experimentally the relative potencies of industrial tar distillates. Two creosote oils were used, both were fractions from coke-oven tar, but one was a light and the other was a heavy creosote oil. The difference

between the light and heavy oil is that the light creosote oil is recovered from the tar at a lower distillation temperature than the heavy oil. The fractions with the higher boiling points contain a greater concentration of carcinogenic constituents. For the skin application of heavy creosote on mice, dilution levels of 20 and 80 percent in toluene were used. Light creosote was tested at 50 percent. Applications were made 3 times a week for the life span of the animal or until a persistent papilloma developed at the site of application. Approximately 90 percent of all animals subjected to the two concentrations of the heavy creosote oil developed cancers of the exposed skin and a substantial fraction had metastatic growths. However, induction time for tumor development was considerably shorter for the higher concerntration test group. The 50 percent solution of light creosote oil produced tumors on all mice in this group.

Lijinsky, et.al., conducted a similar study.[25] Analysis of the creosote oil used in this study demonstrated that the major carcinogenic constituent was benzanthracene, with a concentration of 2.75 gm/l. Applying undiluted creosote twice weekly to the skin of mice resulted in carcinomas in 50 percent of the mice.

4. Summaries of Animal Data on Specific PAH.

A majority of animal studies involving PAH have been done with the individual pure compounds. The enormity of the literature dealing with specific polynuclear aromatic hydrocarbon compounds does not permit a complete review in this report. However, a comprehensive review of the literature pertaining to 13 individual PAH compounds has been prepared by the International Agency for Research on Cancer.[32] The following animal data summaries on selected PAH compounds are excerpted from the IARC monograph:

Benzpyrene.

BP has produced tumors in nine species (rabbit, duck, monkey, mouse, rat, hamster, newt, guinea pig, tree shrew) for oral, skin and intratracheal routes of administration. It has both a local and a systemic carcinogenic effect. In sub-human primates, there is convincing evidence of the ability of BP to produce local sarcomas following repeated subcutaneous injections and lung carcinomas following intratracheal instillation.

Benz(a)anthracene.

BA given by several routes of administration has proved to be carcinogenic in the mouse. It produced hepatomas and lung adenomas following repeated oral administration to young mice.

BA produced tumors in mice following s.c. injections. Fifty μg BA was the lowest dose tested, and it was effective in newborn and in adult animals. It produced bladder tumors in mice following implantation.

It has not been adequately tested in other species.

Dibenz(a,h)anthracene.

DBA has produced tumors by different routes of administration in mice, rats, guinea pigs, frogs, pigeons and chickens. It has both local and systemic carcinogenic effects.

On oral administration it produced tumors of the forestomach in the mouse; intratracheal administration to hamsters produced lung tumors.

In repeated skin painting experiments in mice, DBA and BP appeared to be equally effective.

DBA induced local sarcomas and increased the incidence of lung adenomas following a single s.c. injection in newborn mice.

It has not been adequately tested in other species.

Other polynuclear aromatic hydrocarbons have exhibited

carcinogenic properties in animal studies; however, they have not been tested extensively. These include benzo(b)-fluoranthene, benzo(j)fluoranthene, chrysene, dibenzo(a,h)-pyrene, dibenzo(a,i)pyrene, dibenzo(a,l)pyrene, Indo-(1,2,3-Cd)pyrene, 7,12-Dimethy benz(a)anthracene and methylcholanthrene.

It is evident from the literature that a number of PAH compounds and creosote and coal-tar containing PAH are carcinogenic to one or more species of animals. On the basis of this information alone, these compounds should be considered carcinogenic to humans.

Epidemiological Studies.

The following section provides a review of epidemiological studies that have examined the relationship of exposure to PAH to the risk of developing cancer. The majority of these studies are of occupational exposures.

1. Occupational Skin Cancer.

Much of the following literature dealing with occupational skin cancer is now mainly of historic interest, either because the occupation has fallen on hard times or because preventive measures have minimized or removed the skin cancer hazard.

The first tumor associated with a specific occupation was scrotal cancer, which Percivall Pott found in London chimney sweeps just over 200 years ago.[33]

Go back to the chimney sweeps

Leitch[34] observed that 4 to 10 percent of all chimney sweeps in England ultimately developed skin cancer. Although soot was established as the carcinogenic agent, it was not until 1949 that a PAH, benzpyrene, was shown to be a constituent of soot.[35] Sawicki was later able to obtain 2 mg of benzpyrene per gram of soot.[36]

Skin cancers can result from occupational exposures to a number of combustion and distillation products of

carbonaceous materials (see Table 5).[37] The tumors occur on areas of the skin which are directly exposed to the carcinogen. The hands are usually the most frequently involved, but the scrotum seems to be particularly vulnerable.

Cancer of the skin in workers in the coal-tar and pitch industry was first described in 1892.[38] By 1907 the Workman's Compensation Act in England officially recognized that cancer of any cutaneous site could be caused by commercial pitch, tar and tarry products.[38]

Henery[39] noted that during the period from 1920 to 1945, 2,229 of 3,753 reported cases of industrial skin cancers were associated with exposures to pitch and tar.

Of these, 43 percent occurred in tar-distilling, creosoting timber and storage of creosote. During the decade 1946-1955, 2,041 new cases of occupational skin cancers occurred in Great Britain, of which 1,053 were attributed to tar and pitch.[40]

TABLE 5

Selected Occupational Exposures to Polynuclear Aromatic Hydrocarbons Associated With Skin Cancer.. (37)

SELECTED ETIOLOGIC AGENT	OCCUPATIONS
Pitch, tar or tar products	Tar distilling, coal gas manufacturing, pitch loading Briquette Manufacturing (from pitch)
Fractionation and distillation products of oils	Shale oil workers, cotton mule spinners, Paraffin wax workers (Crude or Slack wax), mineral cutting oil users, refinery workers
Creosote	Timber picklers, brick tile or pipe pressers
Anthracene	Chemical workers
Soot	Chimney sweeps

Creosote oils have also been found to produce skin cancers in man. Reports include epitheliomas in timber picklers and pipe pressers and occupations involving the handling of creosote.[38] Henery[39] reported cases between 1920 and 1945 in 34 workmen, of whom 14 were employed in creosoting timber, 8 in creosote storage, 11 at brick or pottery presses, and one in the manufacture of a creosote disinfectant.

2. Occupational Respiratory Cancer.

The decline in the incidence of skin cancer caused by occupational exposure to PAH has been followed by an increase in respiratory cancers associated with PAH exposure. Several investigators have conducted extensive

mortality studies of occupational groups with heavy exposure to BP and other PAH in the air of their work environment. These groups include coke-oven workers, gas workers, roofers and water proofers.

Hammond, et.al.,[41] studied the members of a roofers and water proofers union. Analysis of air samples of a coal-tar roofing area revealed a concentration of 6,000,000 μg BP per 1,000 M^3.[42]

Hammond found that this exposure is, after a lapsed time of more than 20 years, associated with elevated death rates from lung cancer and cancer of several other sites. The ratio of observed to expected deaths due to cancer increased with the number of years of exposure. With 20 or more years of exposure, the observed to expected ratio of deaths from cancer of all sites was 1.45, 1.59 from cancer of the lung, 1.95 for the combined sites of the buccal cavity, pharynx, larynx and esophagus, 1.68 for the bladder, and 1.67 for the stomach.

A study by Doll, et.al.,[43] spanning a period of 12 years, provides evidence that respiratory exposures to coal carbonization workers results in excess deaths from carcinoma of the lung. Age standardized annual death rates per 1,000 men, for this period, are 3.82

for coal carbonizing process workers and 2.13 for the control group. This study also indicated an increased risk for the development of skin and bladder tumors.

In Japan, an excess of lung tumors has been found in men exposed to coal-tar fumes in generator-gas plants.[44] Kawai, et.al.,[45] observed that the longer the exposure the greater the mortality from lung cancer, and that the excess mortality occurred at least 10 years after exposure to coal-tar fumes.

A long-term mortality study of steel workers in Pennsylvania showed that those working in coke plants had an incidence of lung cancer approximately 2 1/2 times that of steel workers as a whole.[46] Furthermore, the greatest excess of respiratory cancer is experienced by the men working on the tops of coke-ovens. A 7-10 fold risk of lung cancer is observed for men employed 5 or more years at full-time topside jobs.[46,47]

The gaseous discharge (coal-tar pitch volatiles) of coke-ovens of the steel industry has been analyzed by several investigators. Smith[48] sampled the emissions of 20 coking plants and analyzed for PAH. Benzpyrene, benzanthracene, fluoranthene, pyrene and chrysene were found in significant quantities. It has been roughly estimated that 1.8 grams of BP are emitted per ton of coke produced.[49] Fannick, et.al.,[50] identified BP in 75 percent of 212

coal-tar pitch volatile samples.

It has been observed that all of the "coal-tar" occupations are subject to an increased risk of developing cancer at one or more sites.[46] The broad response over so many diverse groups suggests a common causative factor. The data further indicates that the common factor is responsible for cancers at a number of anatomical sites and that the common factor is one or more PAH compounds.

3. Exposure to Ambient Air Containing PAH.

i.e. non-occupational

Although most epidemiological data relating human cancer to PAH involve occupational exposures, there are some studies supporting an association between exposure to ambient air containing PAH and human cancer.

A study of the male residents of 13 counties in the Los Angeles area indicates a 40 percent excess risk of developing lung cancer associated with living in areas with high PAH levels.[51] A similar study by Stokes[52] in Great Britain also attributed an excess lung cancer risk to PAH in ambient air. This study attributes an excess of 28/1,000,000 lung cancer deaths in urban non-smokers compared to rural non-smokers. Pike, et.al.,[53] analyzed the data from Stokes' study and compared it with the data from a study of British gas workers by Doll, et.al. [43] He concluded that the risk of

respiratory cancer (lung) per ng/m^3 in ambient air is equal to the risk per ng/m^3 of air in an occupational setting suggesting a simple linear relation between dose and response. He also concluded that in the United States, each 10 $micrograms/meter^3$ in ambient air created the same lung cancer risk as the smoking of one cirgarette. ?

Factors Affecting Carcinogenesis

The preceding sections on experimental carcinogenesis and epidemiology have shown materials containing PAH (e.g., creosote and coal-tar) are carcinogenic to humans. However, carcinogenesis is a multifactorial process and many things in addition to exposure to PAH may influence the tumor production.

In this section some of these factors will be discussed. For more detailed examination of these factors the reader will be referred to specific references. This section is intended to give the reader an appreciation of the difficulty encountered in predicting the outcome of human exposure to carcinogenic material.

1. Single vs. Repeated Exposures.

Human exposure to carcinogenic agents is generally low-level, long term exposures encountered in the environment (air, water, food, etc.). To assess the impact of environmental carcinogens, it is necessary to understand the effect of small recurring doses, typical of environmental exposures, as contrasted with a single relatively high exposure, as might result from an accident. This problem has been examined by several investigators.[54,55]

These investigators found that for mice, a given amount

of carcinogen (PAH) is more effective when it is administered in small increments over a long period of time than when it is administered in a single dose. It appears that a low-level recurring exposure to a carcinogen may be more hazardous than a single exposure to the same total amount. If this phenomenon holds true in human exposures to environmental carcinogens, the true risk may be even greater than that which is calculated by extrapolation from short term animal studies.

2. Tumor-Promotion and Co-carcinogenesis.

Whether found in polluted urban air, in cigarette smoke, or in some products derived from coal-tar and petroleum, environmental carcinogens usually occur in a complex mixture. The mixture of chemicals can multiply the risk of cancer that would be encountered from one carcinogen alone. This may result from the summation of the effects of several carcinogens or from exposure to tumor promoters and co-carcinogens.

= the "carcinogenic" agg

Various types of carcinogens can be defined as follows:[56] (1) procarcinogen - can be metabolically activated to a proximate carcinogen; (2) proximate carcinogen - is effective in its immediate chemical form in inducing cancer at the target cells; (3) Co-carcinogen - requires the presence of another chemical substance to become operative in inducing cancer; and (4) tumor accelerator

or promoter - may be inactive by itself but also accelerates or magnifies the power of another carcinogen.

A considerable amount of research has been conducted on tumor-promotion and co-carcinogenesis using mouse skin as a model.[57] Phenol, anthralin (a phenolic compound) and n-dodecane (a long-chain aliphatic hydrocarbon) have been shown to promote the tumorogenic activity of BP. Also anthralin, n-dodecane, and several non-carcinogenic PAH have shown a co-carcinogenis response with BP. Creosote and coal-tar, in addition to containing PAH, also contain these promoters and co-carcinogens, increasing the potential hazard from exposure. The effect was most noticeable when the concentration of the carcinogen was low, (i.e., similar to an environmental exposure).

Key

3. Latent Period.*

Animal studies and observations of human carcinogenesis have revealed that the induction of cancer, in addition to other factors, is dependent on a dose-time relationship. The latent period is defined as the time that elapses between exposure to a carcinogen and the appearance of cancer. The relationship between dose and time has been studied extensively by a number of investigators.[58,59,60] The following formula is but one that fits the animal

*Latent period is also commonly referred to as induction period.

data which has been collected to study the dependence of latent period on dose.[58]

$$dt^n = K$$

Where d - daily dose, t - latent period, K is a constant and N is greater than 1. The parameter n varies with the carcinogenic agent but is usually between a value of 2 and 3.

The time-effect relationship then is such that alteration of the dose by a thousand fold usually causes an approximately tenfold change in time of tumor induction. For example, when the dose of methylcholantrene (a PAH) is increased from 1 $\mu g/g$ of body weight to 1000 $\mu g/g$, the latent period of appearance of cancers in mice is reduced from 15 months to 1.5 months.[60] Of course, the latent period varies between individuals and is normally distributed about the mean latent period. A result of the time-dose relationship is that the younger the animal population exposed to a carcinogen, the greater the tumor production since more animals will have the latent period requirements satisfied before the end of their normal lifespan.

A latent period is also known to exist for human carcinogenesis and it has been suggested that it may create a kind of a threshold dose below which there is no tumor production. If the exposure level is low enough there will be no cancer because the latent

period is longer than the lifespan of the exposed person. This means that exposures to the general population are particularly important because of the long period available for tumor production after childhood exposures.

The quantitative relationship between dose and time for human carcinogenesis is unknown and, therefore, the existence of such a threshold is speculation.

4. Host Factors.

Factors inherent to the individual play an important part in the genesis of cancer. Host factors include genetic determinants, cultural influences and health status.[61] Genetic determinants include, for example, skin pigmentation (shown to be protective against skin cancer), enzyme activity (association of lung cancer to high inducible levels of aryl hydrocarbon hydroxylase), immune defense system (a weak immune system may allow rapid development of cancer), and hormone imbalances, (experimental use of phenolic estrogens to shrink canine prostate tumors).

Cultural influences include the familiar examples of diet and smoking. Smoked and grilled foods are known sources of PAH compounds. Key

The general health status of a population may influence its exposure to carcinogens. For example, in our drug-oriented society, the widespread use of medications may play a major role in carcinogenesis. Drugs may become carcinogenic through enzyme activation.

5. Agent Factors.

The significance of exposures to carcinogenic mixtures was discussed in the section on promoters and co-carcinogens where it was shown that an increased risk of cancer may result from exposure to a mixture. It is also possible that combinations of carcinogens and other chemicals (anti-carcinogens) could produce an inhibitory action. Recent studies show an inhibition of respiratory cancer in animals, from exposure to PAH, associated with high dietary levels of vitamin A.[62,63]

6. Environmental Factors.

It is estimated that as much as 90 percent of human cancers are environmental in origin.[64] This conclusion is the result of observations of cancer risk in migrant populations and of the extreme variation in both incidence and distribution of different kinds of cancers throughout the world, and within the U.S. If one accepts the lowest incidence observed anywhere in the world for a given cancer as representing the natural background rate for that cancer site, the excess observed elsewhere is logically attributed to local and regional

Logic

environmental factors, since migrant studies have shown that there are few cancers for which true racial or ethnic differences in susceptability exist.

The environment then is the most important factor in carcinogenesis. If a particular material is not allowed to enter the environment, or, if the material can be contained or removed after being introduced into the environment, there will be no exposure and, therefore, no excess cancers.

QUANTITATIVE ANALYSIS OF RISK

There are a number of techniques available to assess the health impact of carcinogens in the environment. In this report, methods will be used which have gained the widest degree of acceptance in the scientific community. As previously mentioned the analysis will be limited to benzpyrene in the St. Louis Park and Edina municiple water supplies.

The approach will be to calculate a maximum acceptable benzpyrene concentration in the water supplies of the two communities, estimate the existing concentrations of benzpyrene in the water supplies, and evaluate the significance of the difference between the two values.

Calculation of the Maximum Acceptable Concentration.

1. Acceptable Risk.

The first step in the calculation of an acceptable concentration is to define some level of risk for the induction of cancer in an individual as acceptable. The risk of 1 in 100 million has been suggested as essentially "safe".[65] At this level of risk to an individual there would be a chance of 10^{-8} x 100,000 (the approximate population of St. Louis Park and Edina) = 10^{-3} = 0.1% of inducing a single cancer in the combined population of the two communities. The

selection of this parameter is somewhat arbitrary. A different acceptable risk will affect our final calculation of a maximum acceptable concentration proportionally.

For this risk analysis we will adopt 1 in 100 million as an acceptable risk for the induction of cancer in an individual over his entire lifetime as a result of exposure to benzpyrene in drinking water.

2. Animal Study.

We now must select one from the many animal studies which has been done with benzpyrene to show us what the dose response relationship is in the high dose region. We have selected a study by Neal and Rigdon.[66] Briefly, the study involved feeding several groups of mice laboratory mice show impregnated with various concentrations of benzpyrene. Table 6 shows selected results from this study.

TABLE 6

Gastric Tumors in Mice Fed Benzpyrene.[66]

NO. OF MICE	mg BP/g FOOD	NO. OF DAYS FED BP	TOT. AMT. BP(mg)FED MOUSE	% MICE WITH GASTRIC TUMORS
24	0.01	110	4.48	0
37	0.03	110	13.38	0
40	0.04	110	17.76	2.5
34	0.05	107-197	21.4-29.4	70.0

For reasons which will be discussed in the section on extrapolation, the value we need is the maximum dose for which no gastric tumors were found. The data show that 13.38 mg of benzpyrene is the maximum no-effect total dose for this study. This is essentially equivalent to the maximum no-effect level found in a similar study by Poel.[67]

In experiments with BP, producing gastric tumors in mice, the tumors are produced in the mouse forestomach and not the mouse glandular stomach. The mouse glandular stomach is a more suitable model of human stomach cancer.[67,68] Because it takes larger doses to produce carcinoma of the glandular mouse stomach, it has been proposed that the maximum no-effect level for the mouse forestomach be multiplied by a factor of seventy to correct for this.[68] Therefore, the maximum no-effect total dose value that will be used in the extrapolation section is:

$$13.38 \text{ mg} \times 70 = 936.6 \text{ mg of BP}$$

3. Mathematical Models.

Of necessity, animal studies are performed at high dosages to induce a response in a small number of animals. Various models have been proposed to extrapolate dose-response relationships measured in laboratory animals to those resulting from human

exposures to environmental levels of carcinogenic material. Since response to low level exposures cannot be quantitatively measured in either human or animal populations, the actual shape of the dose-response curve in the low dose region is indeterminable. Models which have been proposed include the linear or single hit model, the multievent or multistage model, the probit model, and several others. All these models can be made to fit the animal data and are somewhat biologically plausible. The quality of the fit to the animal data does not, however, provide a statistical basis upon which to prefer one model over the others.[69]

= "Single Hit" Model

The linear model provides the most conservative estimate of the true relationship between dose and response. The concave upwards nature of the dose-response curves at high doses suggests that a linear extrapolation will provide an upper bound to the true risk at environmental concentrations. Because the linear model is theoretically the most conservative, it has been stated that its use will tend to offset the possible influence of synergistic agents in the environment (those agents capable to enhancing the effect of a carcinogen).[65]

We shall briefly examine some of the current arguments as to why the use of the linear model does not add a great deal of conservatism to low dose extrapolations.

Recent work by Crump, et.al.,[70] has shown that for carcinogens which produce tumors at sites for which there is a baseline incidence of tumor production as a result of either exposures to other carcinogens or spontaneous tumor production, the dose response relationship is <u>essentially linear</u> in the low dose region for any of the models which have been proposed. The only major assumptions necessary to this important concept is that the tumors arise from a single transformed cell and that at least some of those agents or processes producing cancer at a specific site are mechanistically related and act additively. The significance of Crump's work is that the linear no-threshold model is appropriate for environmental risk assessment not because it is the most conservative model but because it approximates the true dose response within a few percent for low level exposures.

Of course, the linear no-threshold extrapolation will not approximate the true risk if agents are present which act synergistically with the carcinogen of interest. In this case, the linear model will underestimate the true risk.

Also implicit in Crump's explanation of dose response relationships at low levels is the absence of the

typical dependence of induction period* on dose. This means that the induction period for the production of a tumor by an environmental carcinogen will only depend on those extrinsic carcinogenic processes with which it is additively interacting. It will, therefore, be much less likely that a pseudo threshold will exist, created by an induction period which is longer than the human lifespan.

A recent study by Pike, et.al.,[53] showed that the excess risk of lung cancer per nanogram of benzpyrene per meter^3 of air is identical for non-smokers in an industrial setting (2000 ng/m^3) and in an urban setting (70 ng/m^3). These data suggests a linear relationship between dose and response. ?

The preceding discussion has provided a reasonable basis for selecting the linear no-threshold model over other possible models. The linear no-threshold model has also been recommended for use in the assessment of risk from low levels of carcinogens in the environment by staff of the National Cancer Institute, the National Institutes of Environmental Health Sciences, and the Food and Drug Administration.[71]

*Induction period is the time between exposure to a disease producing agent (e.g., a carcinogen) and the onset of disease.

We have selected the linear no-threshold model for use in this risk assessment.

4. Extrapolation to a Maximum Acceptable Concentration.

Using the linear no-threshold model and the maximum no-effect total dose of 936.6 mg (obtained from the animal study section), the maximum acceptable benzpyrene concentration in drinking water can now be calculated.

We must first obtain an actual incidence for tumor from our no-effect dose. Since tumor production follows the law of probability, there is a certain likelihood that no-effect was seen at our no-effect dose because of chance alone. We obtain an incidence from our no-effect dose by calculating the true incidence which would yield, with a confidence level of 99%, given the number of animals used at our no-effect dose rate, an observed incidence of greater than zero. That is to say while the observed rate of tumor occurrence is 0 percent, we will take, as an upper limit on the true rate, that rate for which the probability for occurrence of as few as zero tumors is 1 percent (100% less the assurance level of 99%).

This incidence is given for our no-effect dosage level which involved 37 animals, by the solution

for P to the equation:

$$(1-P)^{37}=0.01$$

solving, we have P=0.12 or 12%

This tells us that the observed outcome of no tumors in 37 animals is consistent with a probability of 1% that the true risk was, in fact, as high as 0.12 or 12%. This procedure of obtaining an incidence for extrapolation to lower doses is widely recommended.[65,71] The next step is to linearly extrapolate from an incidence of 12% at a dose of 936.6 mg, to a dose that will produce as an upper limit a chance of developing a tumor of less than 1 in 100,000,000 (an incidence of 10^{-8}). This is done by solving a simple ratio.

$$\frac{936.6 \text{ mg}}{0.12} = \frac{X}{10^{-8}}$$

We now need only adjust this value for differences between exposures to laboratory mice and humans. We will not adjust for the differences in the duration of exposure, since there is evidence that for carcinogens, a lifetime of exposure to a mouse is about equivalent to a lifetime of exposure to a human.[72] To adjust for the size difference we will use the surface-area method recommended by Mantel and Schneiderman.[65] The basic assumption is that the locus of action of any drug is on some surface area. If we accept an essential similarity except for size between different mammalian organisms and about equal densities, then it

follows that any appropriate surface area in an organism will be proportional to the 2/3 power of its weight. This permits extrapolating between species, as from a mouse with weight W_1=25g to a man with weight W_2=70kg; W_2/W_1=2800, $(W_2/W_1)^{2/3} \approx 200$. Than our maximum acceptable lifetime dose for man is:

$$7.8 \times 10^{-5} \text{ mg} \times 200 = 1.6 \times 10^{-2} \text{mg}$$

To arrive at the maximum acceptable concentration of BP for drinking water, all that is necessary is to divide the maximum allowable lifetime dose by the amount of water consumed in a lifetime. Our maximum acceptable concentration of benzpyrene in drinking water is then:

$$\frac{1.6 \times 10^{-2} \text{mg}}{70 \text{ yrs.} \times 365 \text{ days} \times 2 \text{ liters/day}} =$$

$$3.1 \times 10^{-4} \text{ micrograms/liter}$$

"Acceptable" Concentration in Drinking Water

.00031 micrograms per liter (= much smaller than milligrams ???)

Estimation of Existing Exposure to Benzpyrene.

Now that we know what an acceptable concentration of benzpyrene in drinking water is, we only need to determine the concentration which is actually present to complete our analysis of the existing risk. If the existing concentration is greater than that which we have deemed acceptable, we can state that something should be done to reduce it.

Unfortunately, no one knows the concentration of benzpyrene in the St. Louis Park or Edina water supplies. We must then use some method of estimating the true concentration. To this end, we will assume the low levels of phenols which have been measured in the St. Louis Park and Edina water supplies are associated with total PAH in the same ratio as has been measured for groundwater samples collected in the site area. We will also assume that the resulting estimated total PAH values are associated with benzpyrene in the same ratio as has been found by Borneff and Kunte[73] in samples of unpolluted European groundwater. The inaccuracy of our assumption relating to the PAH to phenol ratio will, of course, influence our final subjective comparison of maximum acceptable concentration and the estimated exposure.

We first must determine the concentration of phenols in the drinking water of the average resident of St. Louis Park and Edina. Phenol analyses were performed on the

1974, by the Minnesota Department of Health.[74]

Using specific well pump rates[75,76] for the same period it can be calculated that the average resident received a concentration of 3.66 micrograms of phenols/liter in his drinking water. A similar analysis of phenol concentrations on samples collected from the Edina system during July of 1975 show an average of 4.33 micrograms/liter.[77]

We next must estimate the amount of benzpyrene associated with these phenol concentrations. The ratio of PAH to phenol for Well 17 from the Barr Phase II Report[78] is 10.6. The ratio of benzpyrene to PAH as determined by Borneff and Kunte[72] for unpolluted groundwater is 0.01 (average to two samples). The value of 0.01 is consistent with BP/PAH ratios which have been measured for a wide variety of environmental samples as well as for creosote and coal-tar in the pure state. The average concentration of benzpyrene in the water supplies of the two communities can then be calculated as follows:

BP(St. Louis Park)=(3.66 µg phenol/l)
x(10.6 PAH/phenol)
x(0.01 BP/PAH)=0.39 µg/l

BP(Edina)=(4.33 µg/phenol/l)
x(10.6 PAH/phenol)
x(0.01 BP/PAH)=0.46 µg/l

Fluctuation of BP in drinking water

Significance of Estimated Exposure.

Upon examination of the results of the calculations in sections one and two of this analysis, several things become apparent. First, the estimated exposure is about 1,000 times higher than the maximum acceptable exposure, suggesting the existence of a serious public health problem. Secondly, the maximum acceptable concentration is very low (3.1×10^{-4} $\mu g/l$).

Key Conclusion

Let us first consider the validity of the calculation of the maximum acceptable concentration. The maximum acceptable exposure was calculated using those extrapolation techniques (i.e., surface area conversion from mouse to man, linear no-threshold dose response relationship, x 70 forestomach conversion factor) which are currently recommended by leading experts in environmental risk assessment. Our maximum acceptable concentration for benzpyrene also appears reasonable because it is consistent with maximum permissible concentration for PAH compounds which has been proposed by leading researchers in the field.[4]* The fact that our maximum acceptable concentration is higher than levels of benzpyrene which have been found in unpolluted environmental waters also adds to the credibility of our calculation.[19]

*From Andelman and Suess MPC for PAH = 0.017 $\mu g/l$
Our calculated BP to PAH ratio = 0.01
$0.017 \times 0.01 = 1.7 \times 10^{-4} \approx 3 \times 10^{-4}$ (our maximum acceptable concentration)

If, then, the large difference between the maximum acceptable concentration and the estimated exposure is in error, the problem is probably with estimate of exposure. There is no question that this estimate is the weakest part of the assessment. Because phenol is very soluble in water and benzpyrene is not, it is unlikely that the ratio of the concentrations of the two compounds would be identical for on-site locations and for locations distant from the site. This equality was the underlying assumption behind the estimate of exposure. As a matter of fact, the estimated concentration of about 0.3 µg/l exceeds the solubility of benzpyrene (0.01 µg/l) in water. There is no assurance, however, that benzpyrene could not be solubilized by other organic chemicals either present naturally or in the waste. The benzpyrene could also travel with the groundwater as small colloidal particles called micelles.

CAVEAT

Additional potential flaw in reasoning

However, even if the estimated concentrations in the wells of Edina and St. Louis Park are in error on the high side because of the difference in solubilities of phenol and benzpyrene, there is no reason to believe that benzpyrene could not be present at or near the limit of solubility of 0.01 µg/l, a concentration that is still about thirty times our maximum acceptable concentration.

One must then conclude, that even if there are sizable errors in the estimates that have been made for this

assessment, the magnitude of the difference between the maximum acceptable concentration and what could reasonably be the true concentration of benzpyrene in the water supplies of the two communities, is so large that there exists a significant potential impact on human health.

Conclusion

FUTURE STUDIES NECESSARY FOR A COMPLETE ASSESSMENT OF RISK

There are a number of possible adverse human health effects which may result as consequence of the contamination of the Republic site and which have not been dealt with in this risk analysis. Additionally, further work is necessary to quantify the extent of human exposure to carcinogenic PAH compounds in the drinking water supplies of St. Louis Park and Edina. There is clearly a need for an assessment of risk which will include a complete analysis of all potential health effects resulting from the St. Louis Park-Republic creosote problem. Such an assessment will be necessary to make future decisions relating to the control of the contamination and the development of the site. Major areas of concern which should be addressed in the near future include the following:

1. Airborne exposure to PAH compounds.

   Benzpyrene has sufficient vapor pressure at ambient temperatures to exceed proposed maximum permissible concentrations in air.[5,6,68] There is no reason to believe the soil will provide an absolute barrier to the volatilization of benzpyrene or other harmful PAH compounds. There is a need to quantify the extent of human exposure to airborne PAH compounds in the site area and to determine, by the use of epidemiological

Air Pollution

methods, the presence of any existing health impact.

2. Existing Exposures to PAH in drinking water.

Low level exposures to carcinogenic PAH compounds in drinking water should be measured by laboratory analysis. Again, epidemiological methods should be used to measure any existing health impact.

3. Future exposures to PAH in drinking water.

The wastes which are flowing out of the site area have the potential for creating serious contamination of some of the most important drinking water supplies in the state. Projections as to the likelihood, location, and extent of future contamination should be made once more is known about the geohydrological characteristics of the site area.

Key

Barr went only a little way toward predicting this.

4. Exposures to PAH compounds resulting from the development of the site.

Key Issue for MPCA

There is the possibility that the proposed construction will result in direct skin contact with the creosote and coal-tar wastes. This type of exposure has been shown to cause skin cancer.(37) Also, the disturbance of the soil will increase the volatilization of PAH compounds, increasing the exposure of the nearby residents and the construction workers.

The studies listed below will provide the necessary information relating to these major areas of concern. These studies are divided into the general areas of environmental monitoring, epidemiology, and geohydrology.

The recommendations for additional geohydrological studies have been made after a careful analysis of Barr Engineering's Phase II Report.[78] The data resulting from these additional studies along with that contained in the Barr report should provide a basis for predictions of the rate and direction of the flow of the contamination leaving the site. The environmental monitoring data will provide an accurate estimate of existing exposure for use in the risk assessment. The epidemiological studies will, hopefully, detect any measurable health effects which have already occurred.

Environmental Monitoring.

This is job for MHD — are they doing it?

1. Selected wells in the immediate area of the site plus all St. Louis Park and Edina municiple wells plus other, yet to be determined, downstream monitoring wells should be analyzed for trace PAH contamination quarterly for one year.

AQ Division — can they do this

2. Air samples should be taken in the immediate site area and analyzed for PAH to determine what level of exposure, if any, occurs from volatilization of coal-tar waste in

the soil. If excavation or construction activities are undertaken, samples should also be collected after the soil has been disturbed.

Epidemiology.

MHD Tanks

1. A compilation of wells downstream of the site should be gathered, listing information regarding the number of people which may be exposed, the anticipated time of travel for contaminated water to reach the well, and as much pertinent demographic data characterizing the exposed population as is available. The well locations may extend well beyond the boundries of St. Louis Park and Edina.

Barr Report didn't seem to say this

2. A detailed statistical analysis of the Third National Cancer Survey data should be done to check for any clustering in the site areas for cancers of specific sites.

The Cancer Map.

Has this been done?

3. If the environmental monitoring studies can identify an area with a population which is likely to have been exposed to PAH for a number of years, a statistical analysis of the death certificates of people residing in this area should be done to determine the presence or absence of any excess cancer mortality.

Local Epidemiological Study

Geohydrology.

MPCA

1. Further work should be done to establish the assumed presence of the glenwood shale in the erosional channel immediately south of the site. Absence of the shale would provide a connection between the drift and the St. Peter allowing rapid contamination of this aquifer.

Check for Glenwood

2. The piezometric head gradients, the porosity and the amount of solution channeling should be determined for the platteville formation. An analysis should then be done of the direction and rate of flow in the platteville for all seasons and a variety of local pumping conditions. A system of monitoring wells should then be designed to establish the existing extent and future movement of contamination in the platteville.

3. Further work should be done to determine the possible source of the coal-tar taste in old city well #1 which was apparently abandoned in 1932. This well extends into the St. Lawrence shale and is cased to the top 60 feet of the Shakopee limestone. The presence of a coal-tar taste in this well could possibly indicate that the Prairie du Chien-Jordon is seriously contaminated in the study area.

Key

This does seem possible & need careful study

4. The buried bedrock valley to the east of the site should be examined to determine the presence of absence

of a high permeability "pipeline" at the bottom of the valley. A pipeline at the bottom of a buried bedrock valley can provide a rapid travel path for contaminated groundwater. If this condition exists in the valley east of the site it could accelerate the spreading of the coal-tar wastes areally and vertically into bedrock aquifers through which the valley has cut. The exact location of any bedrock valleys in the site area should be determined.

Yes — but must find out where the waste will go from the bedrock valley down east?

5. Solubility studies should be done on coal-tar wastes to determine to what extent constituents of these material are soluble in groundwater under environmental conditions. This solubility data as well as data on the desorption of these materials from soil particles are necessary to predict their future concentration and movement through the underground.

6. The source of the high concentrations of phenols in the Robinson Rubber Co. well should be determined. Identification of the aquifer which is responsible for the contamination of this well would be useful in determining the directions of flow of contaminated water leaving the site.

CONCLUSIONS AND RECOMMENDATIONS

The assessment contained herein supports the conclusion that there exists a significant potential impact on human health resulting from the contamination of the Republic Creosote site. The following recommendations will, hopefully, provide a basis for a course of action to protect the public's health.

CONCLUSION

1. The studies contained in the second section of this report should be initiated as soon as possible. There is a need for further environmental, epidemiological, and geohydrological studies to provide the information necessary for a complete assessment of health risk and for future decisions regarding corrective measures. The necessity for these studies is independent of whatever mitigating measures are taken at this time since no such measures are capable of removing contamination which has left the site area.

MHD Plans

At this time, the Minnesota Department of Health plans to conduct environmental monitoring and health studies related to the St. Louis Park problem during the current biennium. If resources become available these programs could be expanded to provide all the needed information, with the exception of the geohydrological data.

i.e. only geohydrology would be left to the MPCA

2. The plan for the location and abandonment of inter-

connecting wells and St. Louis Park wells 1, 2, and 3, contained in the Barr Phase II Report,[80] should be implemented with the exception of the abandonment of the Robinson Rubber Company well. This well is approximately 180 feet deep and is highly contaminated. Rather than grouting the well at this time, the well should be studied to determine which aquifer is the source of the contamination. This information will be valuable in assessing the depth which the contamination has reached. Upon completion of the study, the well should, of course, be grouted and abandoned.

differs from Barr recommendation

3. That a pumpout and barrier well system be designed and implemented which is capable of removing and halting the spread of contaminated water in the drift and platteville aquifers and any deeper aquifer which the geohydrologic studies show to be significantly contaminated. This system differs from the pumpout and barrier well system recommended by the Barr report which only dealt with the drift aquifer. There is strong evidence that the platteville is contaminated and this limestone formation may contain solution channels which could hasten the spread of not only the water soluble portion of creosote and coal-tar wastes, but also the thicker fractions which are not in solution.

How do you pump out of the Platteville? Do you stick the well down & hope you strike a fissure!!?

The effluent of the pumpout and barrier well system

must receive sufficient treatment to remove a large portion of the PAH compounds contained therein. The Barr Phase II Report recommended the discharge of this effluent to the sewer. A review of the available literature indicates that conventional sewage treatment processes will be ineffective in the removal of benzpyrene and other PAH compounds.[2,3,4] Since any discharge of this material to the sewer will eventually result in the addition of carcinogenic material to the drinking water of downstream communities, the waste should receive as much extensive treatment as is feasible while the harmful components of the waste are concentrated enough to be efficiently removed.

Boys don't just send to sewer

Differ from Barr

Crucial Point

4. That if, upon completion of the geohydrologic studies contained in the second section of this report, there is no reasonable assurance that the waste will remain in place and will not spread, either in the groundwater or as a separate non-soluble phase, either vertically to aquifers below the platteville or laterally beyond the control of the pumpout and barrier well system, the contaminated soil (as defined in the Barr Phase II Report >1 mg/kg phenol) should be removed from the site and disposed of in such a way as to not create a significant hazard to human health.

The most substantive excavation mentioned by Barr

Unfortunately, these wastes are threatening some of

the state's most heavily used groundwater resources. If the spread of this material cannot be completely controlled by the pumpout and barrier well system, the continuing presence of the highly contaminated material on site will only make control of the situation difficult, if not impossible, for future generations.

5. Any construction activity on the site which will interfere with future corrective measures (e.g., removal of the contaminated material) should not be permitted.

Don't allow any construction which would interfere w/ corrective measures.

6. If studies of the ambient air show significant existing human exposures to PAH compounds, the impact on human health resulting from the development of the site should be immediately reevaluated; and, all feasible measures to reduce human exposure to airborne PAH compounds should be implemented as soon as possible (e.g., removal of the contaminated material).

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INFORMATION SUMMARY
TO ACCOMPANY REQUESTS FOR PROPOSAL FOR
CREOSOTE CONTAMINATION STUDY IN ST. LOUIS PARK

The area to be studied surrounds and includes the site previously occupied by Reilly Tar and Chemical Corporation's Republic Creosote Works, which engaged in the distillation of coal tar products and creosote impregnation for over 50 years, ending in 1971. As a result of the company's operation and waste disposal practices, substantial portions of the soils on and about the plant site and one or more underlying aquifers have been contaminated with coal tar wastes. The area to be studied lies in St. Louis Park, Minnesota, a suburb located directly west of Minneapolis. The Republic Creosote Works was located west of the present Louisiana Avenue estension, south of West 32nd Street, east of Pennsylvania Avenue, and north of Walker Street. The site is now owned by the St. Louis Park Housing and Redevelopment Authority and a portion has been developed as a residential complex.

WELLS AT SITE:

An 8-inch well drilled to a depth of approximately 900 to 1,000 feet located on the site is reported to have been severely contaminated with creosote that inadvertently flowed into the casing from a tank car spill. This well is cased to a depth of about 250 feet. The well has not been permanently abandoned but is maintained for monitoring purposes. Another well on the site was drilled in 1946 to a depth of about 100 feet and terminated in the Platteville limestone. The upper termination was completed below grade in the basement of one of the plant buildings. In 1975 this below grade well was covered by a temporary storage pond

in which contaminated water was impounded. There are a number of additional wells in the vicinity which produce contaminated water. Although the total number of wells in the area that cross connect aquifers is unknown, the U.S.G.S. in 1979, submitted a report identifying all wells of record.

DEPARTMENT OF HEALTH INVOLVEMENT:

In 1932, the City drilled a 16-inch, 540 foot deep well, cased to 280 feet, to provide water for its public water supply. Several water tests showed bacterial contamination, and a disagreeable taste and odor had developed and persisted in the water. Because the water showed persistent bacterial contamination and because the State Health Department could recommend no solution to the taste and odor problem, the department recommended that the City abandon the well. This was done later in the year.

In December Of 1973, the department reported that low levels of phenols had been detected in some municipal wells and in several industrial wells near the site.

In September, 1974, the department issued a "Report on Investigation of Phenol Problem in Private and Municipal Wells in St. Louis Park, Minnesota." Findings of the report indicated the following:

1. Determinable amounts ($\geq$ 0.002 milligrams per liter) of phenolic compunds as phenol in varying concentrations and frequency were found in both private and municipal wells in the St. Louis Park area.

2. Considering the reported depths of the affected wells, it is estimated that phenols can be found in well waters from

the shallower drift wells down to the Pre-cambrian Red Clastics at approximately 900 feet. Spatially, the geographical boundaries of the well sampling pattern extend over much of the St. Louis Park area.

3. Wells in this survey showing the highest concentrations and most consistent phenol levels are located close to the former Republic Creosote property.

4. Chemical analysis of soil borings made south of the former Republic Creosote property indicated that at the test site a black viscous material with a strong creosote odor was found at a depth of 45 feet. Water pumped from a bore test hole in this area also showed a high phenol content at 45 feet. Cores from a depth of 67 feet have a tar-like odor.

Conclusions of the report were:

1. The analyses of the well water samples indicated the presence of a determinable amount of phenol compounds.

2. A review of the wells tested indicated that a majority of these wells contained phenol compounds.

3. From dimensional and construction data of the affected wells, it has been shown that phenols can be found in all formations of the aquifer from the drift formation down to the Pre-cambrian Red Clastics at 900 feet.

4. Consideration of the large amount of waste material discharged on the surface, the extended length of time over which discharge has occurred and the spatial arrangement of affected wells can lead to the conclusion that widespread contamination has

taken place extending perhaps to the farthest tested wells in St. Louis Park and surrounding communities.

Recommendations indicated that:

1. A comprehensive geological and hydrological study should be made to determine the effects of the previous waste disposal practices of the former Republic Creosote Company on the aquifers in the area.

2. A study to determine the feasibility of rehabilitation of the aquifers should be undertaken. If rehabilitation is not possible, a program to confine the contaminants should be considered.

3. An ongoing epidemiological study should be made to see if there are possible public health hazards resulting from the pollution of the affected aquifers.

4. A monitoring system should be established to determine if contamination is spreading with time, and if so, to determine the direction and rate of spread.

5. Contingency plans to protect the present or existing sources of ground water should be developed. Removal of contaminated materials may be necessary to alleviate the chronic source of contamination. Remedial treatment of water before use may also be necessary.

POLLUTION CONTROL AGENCY, ROLE AND EVALUATION OF BARR REPORTS

A report prepared by the staff of the Minnesota Pollution Control Agency in November, 1977, summarized the involvement of the Agency up to that time. The report included an analysis of a report prepared by Barr Engineering Co. Inc., a consultant to the Agency.

In the fall of 1974, storm sewer project plans were submitted by the City of St. Louis Park which would serve the site and surrounding area. The Minnesota Pollution Control Agency determined that a National Pollutant Discharge Elimination System (NPDES) permit would be required. In February of 1975 a hearing on the permit was held and in April, 1975, a permit was issued. One of the hearing officer's recommendations was that a study be conducted to determine the extent and severity of pollution of underground waters. A study plan was jointly prepared by the City, the Minnesota Department of Health and the Minnesota Pollution Control Agency. The Minnesota Legislature included funds for such a study in the Minnesota Pollution Control Agency's Fiscal Year 1976-1977 appropriation. In November of 1975, the Agency contracted with Barr Engineering, of Bloomington, Minn., to conduct the study. The first phase was completed in May, 1976. The Phase II report was completed in July, 1977.

The Phase I study was to determine the amount and location of coal tar derivatives in the surficial deposits at and near the site. Fourteen soil borings (typically 60 feet deep) were analyzes every five feet in depth for phenols and benzene extrac= tables. In general, the data indicated low levels of benzene extractable and phenol materials in the top 10-15 feet, over most of the site. Highest concentrations of these materials

were found to the south of the Republic Creosote works site between Walker and Lake Streets. Concentrations in these glacial soils generally increased with depth, with high concentrations as deep as 50 feet.

Eleven soil samples were analyzed using thin layer chromatography to determine the presence of polynuclear aromatic hydrocarbons (PAHs). PAH compounds were present in all 11 samples. Of particular importance were the high concentrations of PAH at 32 and 50 feet in the soil columns south of the site between Highway 7 and LakeStreet. Gas chromatograph analyses were then carried out on five of the 11 samples to determine concentrations of various PAHs. The gas chromatograph data indicated detectable amounts of benz(a) pyrene and relatively large amounts of chrysene in two samples. Both of these subatances are known or suspected carcinogens.

The results of the Phase I study guided the design of the final phase. The large quantities of coal tar wastes which were present at depths of 50 and 60 feet and over a relatively large area made excavation of the wastes a financially undesireable solution. The Agency then decided to concentrate its efforts on collecting data on the hydrology of the surface and bedrock aquifers and on their chemical quality. This information would be used to predict future impacts on ground water and to evaluate the feasibility of gradient control as a corrective measure.

The major emphasis of the second phase was the definition of the vertical and horizontal ground water flow through the various glacial and bedrock aquifers. Well logs and deep soil borings were analyzed in order to develop a more detailed bedrock map of the area.

Soil samples obtained in Phase I and Phase II were physically analyzed to determine the permeability of the various glacial materials. Literature was reviewed to determine permeabilities for the bedrock aquifers. Ground water level information was collected. A ground water model for the area was then developed using the information.

In addition to the ground water movement studies, data was collected on the chemical quality of the ground water in the various aquifers. As in Phase I, the samples were analyzed for phenols and benzene extractable material. Selected samples were also analyzed for the presence of PAH compounds. This information was evaluated to get a general idea about the behavior of the various coal tar derivatives in ground water. The information was also used to test theories on how contamination has taken place and to predict future spread of contamination.

Ground water movement in the upper drift is assumed to be primarily in the vertical direction as lateral flow to the east and west is restricted by the clay layer which nearly rises to the surface. Lateral flow in the middle drift aquifer is to the south and east. In addition there is substantial vertical recharge to the lower drift aquifer. Direction of movement in the lower drift aquifer is not clear, but appears to be primarily vertical. Movement to the east appears minimal due to the thick sequence of silts which make up the lower drift to the east. If this is correct, leakage from the middle drift aquifer to the lower drift aquifer must travel vertically to the underlying Platteville Limestone.

The upper-most bedrock unit underlying most of the study area is the Platteville Limestone. Flow in the Platteville is generally to the east toward a buried bedrock valley. As with most limestones, flow is predominately through fractures and fissures which have become solution channels.

The Platteville may be underlain by a thin formation called the Glenwood shale. The Glenwood, where present, is a confining layer between the Platteville and the St. Peter sandstone. Where present the shale layer is impermeable enough to maintain an 18 foot head difference between the Platteville and the St. Peter. The Barr report indicates that ground water movement in the St. Peter appears to be to the east. This flow, however, is greatly influenced by the bedrock valley and existing wells. [redacted] The Terry Excavating and Midco Register wells are only cased into the Platteville and terminate in the St. Peter. This means that there is an open hole direct connection from the Platteville through the Glenwood shale to the St. Peter. During periods of non-use, these wells function as recharge points since the head is higher in the Platteville than in the St. Peter.

The second source of recharge is the presence or chance of a bedrock valley. Understanding the bedrock valley and how it affects ground water movement is an important part of the study. The Platteville is generally 33 feet thick in the study area. As a result of erosion prior to the most recent glaciation, part or all of the Platteville was removed.

Data used in the report indicate that at least in the area of Excelsior Boulevard and Highway 100, the erosion also removed the underlying Glenwood shale. Therefore, water reaching the valley through the Platteville or the drift can rapidly recharge the St. Peter since there is no Glenwood to restrict the downward flow. This recharge is quite extensive where the piezometric levels in the southeast are approximately 20 feet higher than levels on the eastern edge of the study area.

Recharge from the St. Peter to the underlying Prairie duChien - Jordan aquifers is limited by a series of siltstones which make up approximately the bottom one-third of the 150 foot thick St. Peter. Under existing conditions, it is estimated it would take 55 years for water to travel vertically through the siltstones. Beneath the Jordon is a series of sandstones, dolomites and shales. The next major aquifers are Mt. Simon - Hinckley sandstones. To simplify calculations only the Eau Claire formation was considered to be limiting flow from the Jordan to the Mt. Simon. Flow time through the Eau Claire is estimated at 34,000 years.

Chemical analysis of surfical ground waters indicate high concentrations of benzene extractables and PAH compounds in the

middle drift aquifer, south of Highway 7. Detectable amounts of PAH were also found at the base of the lower drift aquifer. Previous analyses of existing wells in the area indicated the presence of phenolic compounds in various industrial and municipal wells. These wells are of varying construction and terminate in the major aquifers previously discussed.

From the hydrologic and chemical data, the following general conclusions were drawn by the technical staff of the Minnesota Pollution Control Agency:

1) Ground water in the glacial drift is moving both laterally out of the area and vertically into the Platteville. Water in the Platteville is moving toward the bedrock valley.

2) Coal tar wastes have moved from the surface downward due to water movement and the fact that they are heavier than water. High concentrations of the wastes were found 50 feet deep. These wastes have moved laterally at least 1000 feet. This information suggests that the PAH compounds are present in water reaching the Platteville over a portion of the study area.

3) Phenol concentrations in the drift are likely to be moving southeastward at rates of 30 to 150 feet per year. Water in the Platteville limestone is moving toward the buried valley and will take 20 to 50 years to reach the valley. Water in the drift and the Platteville are not at steady state conditions and concentrations of pollutants will continue to increase further from the site.

4) The buried bedrock valley southeast of the site is a recharge area to the St. Peter. Ground water reaches the valley through the drift and the Platteville. Movement out of the valley will likely be to the east.

5) The uncased wells in the area provide pathways for contaminated water from the drift and Platteville to reach the lower aquifers.

6) Data developed in this study supports earlier findings that low concentrations of phenolic compounds are present in the bedrock wells surrounding the site and at the municipal well field north of the site. Contamination of St. Peter wells south and southeast of the site can be attributed to leakage through the Glenwood or down uncased wells. The available information does not, however, explain the contamination of the St. Peter and Prairie duChien - Jordon wells at the municipal well field. Contamination of the Mt. Simon - Hinckley well on the site and at the well field are attributed to wastes which have moved down the Hinckley well on the site.

7) Since the quality of the St. Peter is controlled by recharge from the drift and the Platteville, which are not at a steady state condition, it is reasonable to assume that concentrations of contaminants will increase in the St. Peter.

8) The coal tar wastes in the glacial drift represent a potential threat to underlying ground water aquifers due to uncased wells, flow to the bedrock valley, seepage through the Glenwood and due to the fact that down gradient industrial wells that acted as barriers are being abandoned.

Several measures to correct or control this threat were reviewed to varying degrees. These included treatment of municipal water, excavation of contaminated soils, well abandonment and gradient control wells. A preliminary investigation of additional water treatment found this to be extremely costly in comparison to gradient control. Costs to modify the existing treatment to include activated carbon absorption would be approximately $180,000. Costs for carbon alone would run $.34 to $17.00 per thousand gallons or about .75 to 35 million dollars per year if the total water use of the City were treated. This treatment would, of course, not prevent the spread of contamination to wells in other areas.

Excavation of contaminated soils was investigated. This could not be a complete solution since contaminants have moved in the ground waters out of the area of contaminated soils. The depths and amount of excavation required depends upon what concentration of contamination one wishes to remove. For example, the area and depth of excavation necessary to remove soils with 10,000 milligrams per kilogram of benzene extractable material would involve approximately 200,000 cubic yards of excavation. Problems that were not investigated with regard to excavation were disposal of removed material and the

fact that several industries and Highway 7 are situated above the area to be excavated. No costs were calculated for the excavation alternatives.

Abandonment of all wells which could be potential pathways for contaminated ground water to reach the deeper aquifers is an obvious corrective measure. Several such wells are identified in the study. It is reasonable to assume that many more wells might exist and efforts should be made to locate them. It is estimated that it would cost from $35,000 to $52,000 to abandon the wells which have been located to date. (Since the Barr report was written many wells have been abandoned. This activity is described in detail later in this summary.)

The principal control measure investigated in the Barr report was the use of gradient control wells. The primary purpose of such a system is to control the movement of contaminated ground water such that the size of the affected area does not increase. Although a system of gradient control wells would remove some of the contaminants, gradient control should not be viewed as a method for pumping contamination out of the ground.

Several alternatives were investigated for disposal of the contaminate ground water. These were discharge of all or part of the water to the sanitary sewer and various treatment options prior to discharge to Minnehaha Creek. The design of a treatment system would be difficult at the present time since the quality of the water to be treated is not known. After gradient control the wells are operational, a better idea of the type and cost of treatment facilities could be determined. The capital cost of hooking the wells up to the sewer was then estimated to be $8,000.

Barr Engineering made the following recommendations for corrective action and future studies:

1. All bedrock wells constructed so as to provide pathways for ground water to move between the drift/Platteville and St. Peter and between the St. Peter or Prairie du Chien-Jordan and Mt. Simon-Hinckley aquifers should be grouted and abandoned. Highest priority should be given to locating and abandoning wells in the area bounded by Texas Avenue on the west; Minnetonka Boulevard on the north, Highway 100 on the east and Minnehaha Creek and Excelsior Boulevard on the south. Wells in this area should be located and abandoned immediately. The investigations summarized in this report indicate that these wells present potential pathways for the movement of coal-tar derivatives to the lower aquifers and, in fact, represent the only reasonable means by which ground water in the Prairie du Chien-Jordan and in the Mt. Simon-Hinckley formation could be contaminated with waste from the site of the former coal-tar distillation and wood-preserving facility.

2. Since the abandonment of uncased wells near the site will likely result in the movement of recharge from the buried valley to the St. Louis Park municipal well field to the north, St. Louis Park wells 1, 2 and 3 should also be abandoned.

3. The potential impact of the identified high concentrations of coal-tar derivatives in the glacial drift ground water are significant enough that mitigative measures are recommended to halt the movement of these wastes.

4. The control of ground water gradients in the glacial drift ground water system is technically feasible and the system presented in this report or a similar system should be implemented. It is recommended that design of the gradient control wells begin immediately. The first step in the design will be to place the additional wells and borings needed to define the exact location of gradient control wells. The next step will be to place one or more test wells to verify the aquifer characteristics needed to complete the design. The third step will be to complete the design and construct the wells.

5. Water pumped from the gradient control wells should be discharged to the sanitary sewer, at least initially. After the more highly contaminated ground water has been removed from the glacial drift or after treatability of the waste has been better defined, it may be possible to discharge the effluent from the wells to Minnehaha Creek after appropriate treatment.

6. Bench scale and pilot scale studies should be conducted to define the treatability of the ground water using either the existing surface water treatment facility or a new treatment concept.

7. The effectiveness of the gradient control system should be monitored both in terms of the ability of the wells to capture coal-tar derivatives through the glacial drift and Platteville limestone and, if the effluent is discharged to Minnehaha Creek, the ability of the treatment facility to meet effluent limitations prior to discharge.

8. Two additional wells should be placed in the St. Peter formation beneath the area of elevated coal-tar derivative at the drift/Platteville contact to monitor the quality of water in the St. Peter. If the average concentration of the phenolics, as measured by the MBTH Method, exceeds a concentration on the order of 20 micrograms per liter, significant change will have occurred and gradient control or some other appropriate mitigative measure should be required to control movement of the wastes in the St. Peter.

9. Further information is needed regarding the effect of the trace phenolic concentrations measured in the municipal wells in St. Louis Park. It is recommended that studies be carried out to define the potential public health effect of these trace phenolics.

10. A better definition of hydrogeology is needed in the buried bedrock valley located near Highway 100 and Excelsior Boulevard. Specifically, soil borings and piezometers should be placed in the valley to define its extent and to estimate gradients and likely vertical flow rates. In addition, monitoring wells should be

placed near the western edge of the valley to define the quality of water discharged to the valley from the site area through the glacial drift, Platteville and St. Peter units. A monitoring well should also be placed in the St. Peter north of the valley to monitor the quality of the water in the aquifer between the valley and the City well field to the north.

The staff of the Minnesota Pollution Control Agency recommended that the following steps be taken:

1) The Barr Engineering recommendations 1 and 2 regarding well abandonment should be carried out immediately.

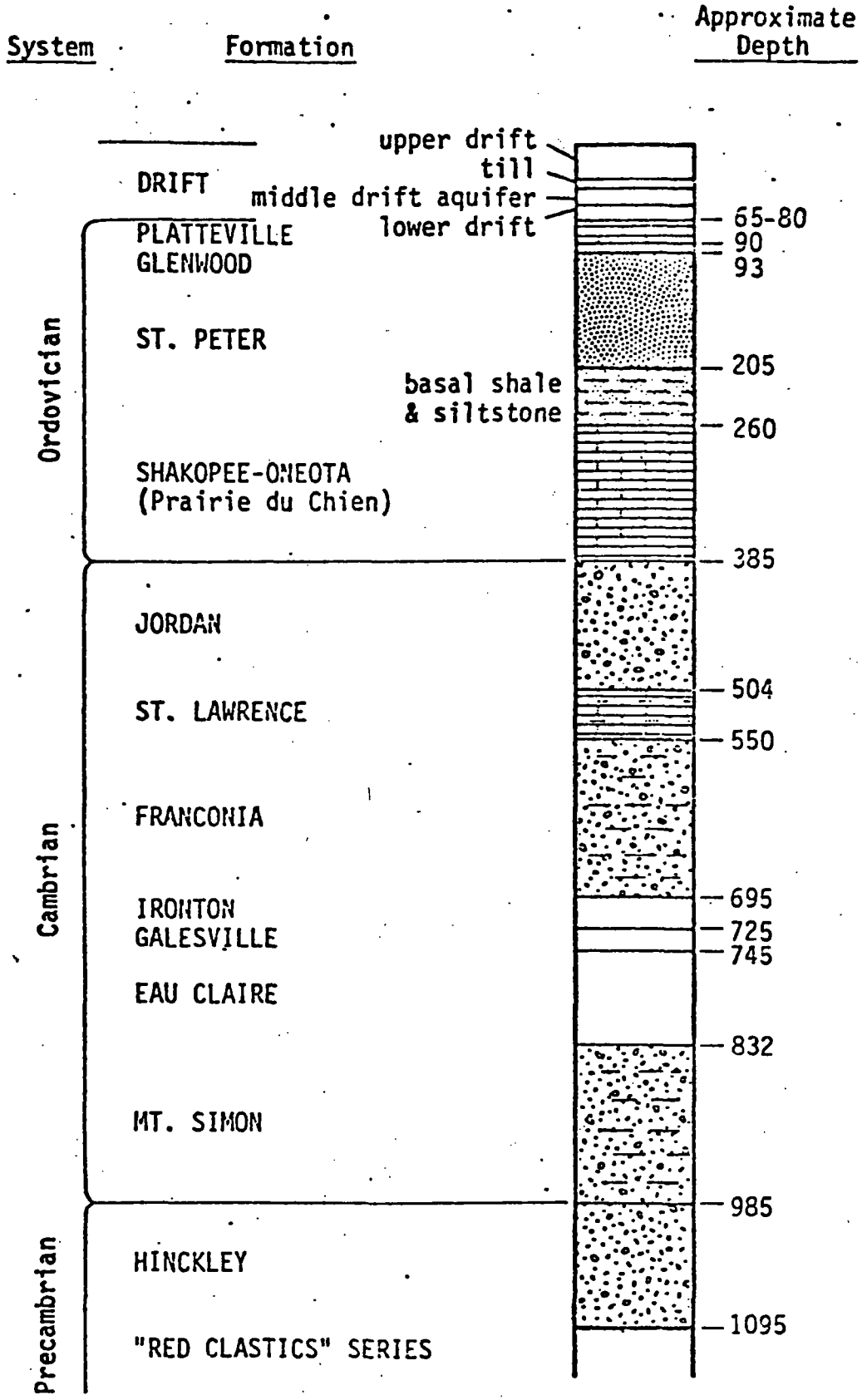
2) The barrier well system as outlined by Barr Engineering should be designed and constructed. The design should be preceeded by the studies outlined in the report. In addition, studies to determine the possible existence of a buried valley immediately south of the site which is eroded through the Glenwood shale should be conducted. The studies should commence immediately with construction as soon as design is complete.

3) Water pumped from the gradient control wells should be either pretreated for removal of PAH compounds prior to discharge to the sewer system or should be treated to allow discharge to Minnehaha Creek. Limited untreated discharges to the sewer system should be allowed in order to collect sufficient data for treatment plant design.

4) Monitoring the effectiveness of the gradient control system should be conducted.

5) Barr Engineering's recommendation 8 with regard to the construction and operation of two wells to monitor quality of water in the St. Peter beneath the site should be implemented.

6) Barr Engineering's recommendation 10 for additional monitoring of the St. Peter near the bedrock valley southeast of the site, should be carried out. If the additional study in staff recommendation 2 locates a comparable valley south of the site, similar monitoring should be carried out in the St. Peter in that area.



GENERALIZED GEOLOGIC COLUMN

Adopted from Sunde, Hydrogeologic Study

WELL ABANDONMENT--MINNESOTA DEPARTMENT OF HEALTH:

EXEMPTION 9-WELL

[redacted]

EXEMPTION 9-WELL

RISK ASSESSMENT -- MINNESOTA DEPARTMENT OF HEALTH:

In October, 1977, the department released a report entitled "Assessment of Possible Health Effects Resulting from the Contamination of the Former Republic Creosote Site." In part, the report contained an assessment of the existing and potential human health risk resulting from the contamination of the Republic Creosote site based on information which was then available. The focus of concern over human exposures to creosote and coal tar wastes is the possibility that the polynuclear aromatic hydrocarbon compounds contained therein will induce cancer. A complete assessment of existing and potantial health risk would require the following information, none of which is available at this time:

1. To what extent is the groundwater, and more specifically the municipal water supplies, in the area contaminated with carcinogenic PAH compounds? There are no data available on specific PAH compounds in groundwater in the area of the site.

2. What are the directions and speed of the spread of the contamination from the site? This question must be addressed for the vertical travel of the material to the deep aquifers and for the flow leaving the site area laterally. A complete treatment of this problem would also involve a determination of which fraction of

the material is actually in a water solution and which is moving as an independent phase. Also needed would be information on the position of the buried bedrock valley to the east of the site and the porosity of the material within it. Although Barr Engineering Phase II report was an in-depth treatment of certain aspects of the problem, many geohydrologic questions remain unanswered.

3. What population groups are presently or potentially exposed to drinking water contaminated with PAH compounds from the site?

4. Are there significant exposures to airborne PAH compounds? Although the creosote and coal-tar are contained in the soil, the soil does not present an absolute barrier to PAH vapors.

5. Is there a potential exposure from external contact with the contaminated soil by future residential populations or to those involved in construction activities on the site?

Since this information was unavailable, the department assessment was necessarily limited. The analysis dealt only with the contamination of the drinking water supplies of St. Louis Park and Edina, Minn. The contamination of additional municipal drinking water supplies, and exposure to these contaminants in the air or by direct contact may create greater risks to the public's health than the contamination identified in the two drinking water supplies studied.

The St. Louis Park and Edina supplies have been shown to contain trace quantities of phenols, a major constituent of creosote. The presence of phenols suggests the presence of other more harmful components of creosote and coal tar such as the carcinogens benzo(a)pyrene,* benzo(a)anthracene, dibenz(a,h)anthracene, benzo-(b)fluoranthene, benzo(j)fluoranthene and chrysene. Because the analytical methods in use at that time did not show any detectable concentrations of these carcinogenic PAHs, this assessment makes use of an estimated benzpyrene concentration in the water supplies of the two communities. It was assumed that the low levels of phenols which have been measured in the St. Louis Park and Edina water supplies are associated with total PAHs in the same ratio as has been measured for ground water samples collected in

*The nomenclature for the above listed compounds is the official nomenclature designated by the Intl. Union of Pure and Applied Chemistry (I.U.P.A.C.). Other more common names are often used in the literature, e.g., benzo(a)pyrene is also called 3,4-benzpyrene, benzpyrene, and abbreviated BP. In this report the more familiar common name benzpyrene or the abbreviation BP will be used.

the site area. It was also assumed that the resulting estimated total PAH values are associated with benzpyrene in the same ratio as has been found by Borneff and Kunte in samples of unpolluted European ground water. The imprecision of the assumption relating to the PAH to phenol ratio will influence the final comparison of maximum acceptable concentration vs. the estimated exposure.

Using specific well pump rates, it was calculated that the average St. Louis Park resident received a concentration of 3.66 micrograms of phenols/liter in his drinking water. A similar analysis of phenol concentrations on samples collected from the Edina system during July of 1975 show an average of 4.33 micrograms/liter.

The amount of benzpyrene associated with these phenol concentrations was estimated. The ratio of PAH to phenol for Well 17 from the Barr Phase II Report is 10.6. The ratio of benzpyrene to PAH as determined by Borneff and Kunte for unpolluted ground water is 0.01 (average of two samples). The value of 0.01 is consistent with BP/PAH ratios which have been measured for a wide variety of environmental samples as well as for creosote and coal tar in the pure state. The average estimated concentration of benzpyrene in the water supplies of the two communities can then be calculated as follows:

BP(St. Louis Park)=(3.66 µg phenol/l)(10.6 PAH/phenol)
(0.01 BP/PAH) = 0.39 µg/l

BP (Edina)=(4.33 µg phenol/l) (10.6 PAH/phenol)
(0/01 BP/PAH) = 0.46 µg/l

A maximum acceptable level for humans of 3.1×10^{-4} micrograms per liter in drinking water was derived based on data obtained from animal studies.

Upon examination of the results of the calculations of the assessment, it was apparent the estimated exposure is about 1,000 times higher than the maximum acceptable exposure, suggesting the existence of a serious public health problem. Secondly, the maximum acceptable concentration is very low (3.1×10^{-4} µg/l).

The health risk assessment report recommended that a number of additional studies would be necessary to quantify the extent of human exposure to carcinogenic PAH compounds in drinking water supplies of St. Louis Park and Edina.

Geohydrology studies and related environmental monitoring recommended in the assessment included the following items:

1. Further work should be done to establish the assumed presence or absence of the Glenwood shale in the erosional valley immediately south of the site. Absence of the shale would provide a connection between the drift and the St. Peter allowing rapid contamination of this aquifer.
2. The piezometric head gradients, the porosity and the amount of solution channeling should be determined for the Platteville formation. An analysis should then be done of the direction and rate of flow in the Platteville for all seasons and under a variety of local pumping conditions. A system of monitoring wells should then be designed to establish the existing extent and future movement of contamination in the Platteville.

3. Further work should be done to determine the possible source of the coal tar taste in old city well #1 which was apparently abandoned in 1932. This well extends into the St. Lawrence shale and is cased to the top 60 feet of the Shakopee limestone. The presence of a coal tar taste the water from in this well could possibly indicate that the Prairie du Chien-Jordon is seriously contaminated in the study area.

4. The buried bedrock valley to the east of the site should be examined to determine the presence or absence of a high permeability "pipeline" at the bottom of the valley. A pipeline at the bottom of a buried bedrock valley can provide a rapid travel path for contaminated ground water. If this condition exists in the valley east of the site it could accelerate the spreading of the coal tar wastes areally and vertically into bedrock aquifers through which the valley has cut.

5. Solubility studies should be done on coal tar wastes to determine to what extent constituents of these material are soluble in groundwater under environmental conditions. This solubility data as well as data on the desorption of these materials from soil particles are necessary to predict their future concentration and movement through the underground.

6. The source of the high concentrations of phenols in the Robinson Rubber Company well should be determined. Identification of the aquifer which is responsible for the contamination of this well would be useful in determining the directions of flow of contaminated water leaving the site.
7. Selected wells in the immediate area of the site plus all St. Louis Park and Edina municipal wells plus other, yet to be determined, downstream monitoring wells will be analyzed for trace PAH contamination quarterly for one year.

The Minnesota Department of Health health risk assessment concluded that there exists a significant potential impact on human health resulting from the contamination of the Republic Creosote site. However, future studies may indicate that no health risk exists. The following recommendations will, hopefully, provide a basis for a course of action to protect the public's health.

1. There is a need for further environmental, epidemiological, and geohydrological studies to provide the information necessary for a complete assessment of health risk and for future decisions regarding corrective measures.

The necessity for these studies is independent of whatever mitigating measures are taken at this time since no such measures are capable of removing contamination which has left the site area.

At this time, the Minnesota Department of Health plans to attempt to conduct all the environmental monitoring and epidemiological studies during the 78-80 biennium. The scarcity of available resources may prevent sufficient progress to complete the expanded risk assessment within this time period.

2. The plan for the location and abandonment of interconnecting wells and St. Louis Park wells 1, 2, and 3, contained in the Barr Phase II Report, should be implemented with the exception of the abandonment of the Robinson Rubber Company well. This well is approximately 180 feet deep and is highly contaminated. Rather than grouting the well at this time, the well should be studied to determine which aquifer is the source of the contamination. This information will be valuable in assessing the depth which the contamination has reached. Upon completion of the study, the well should, of course, be grouted and abandoned.

3. That a pumpout and barrier well system be designed and implemented which is capable of removing and halting the spread of contaminated water in the drift and

Platteville aquifers and any deeper aquifer which the geohydrologic studies show to be significantly contaminated. This system is more extensive than the pumpout and barrier well system recommended by the Barr report which only dealt with the drift aquifer. There is strong evidence that the Platteville is contaminated and this limestone formation may contain solution channels which could hasten the spread of not only the water soluble portion of creosote and coal tar wastes, but also the thicker fractions which are not in solution.

The effluent of the pumpout and barrier well system must receive sufficient treatment to remove a large portion of the PAH compounds contained therein. The Barr Phase II Report recommended the discharge of this effluent to the sewer. A review of the available literature indicates that conventional sewage treatment processes will be ineffective in the removal of benzpyrene and other PAH compounds. Since any discharge of this material to the sewer will eventually result in the addition of carcinogenic material to the drinking water of downstream communities, the waste should be treated to remove harmful components.

4. That if, upon completion of the geohydrologic studies there is no reasonable assurance that the waste will remain in place and will not spread, either in the ground water or as a separate non-soluble phase, either vertically to aquifers below the Platteville or laterally beyond the control of the pumpout and barrier well system, the contaminated soil (as defined in the Barr Phase II Report 1 mg/kg phenol) should be excavated from the site and disposed of in such a way as to not create a significant hazard to human health.

MINNESOTA GEOLOGICAL SURVEY -- EVALUATION OF BARR REPORT:

The Minnesota Geological Survey provided a review of the Barr Engineering report indicating that subsurface data permit several interpretations of the bedrock geologic and hydrologic conditions near the creosote site in St. Louis Park. The Minnesota Geological Survey review tends to question the hydrologic modeling and ground water gradient control wells recommended in the Barr report. Also questioned were the assumptions suggested or proposed to predict contamination migration. The Minnesota Geological Survey review is provided herewith in its entirety.

UNIVERSITY OF MINNESOTA
TWIN CITIES

Minnesota Geological Survey
1633 Eustis Street
St. Paul, Minnesota 55108
(612) 373-3372

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MINN. POLLUTION CONTROL AGENCY

October 17, 1977

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DEC. 5 1977
Minn. Dept. of Health
Div. of Env. Health

Mr. Dale L. Wikre
Minnesota Pollution Control Agency
1935 West County Road B-2
Roseville, MN 55113

Dear Dale:

We have reviewed the Barr Engineering report entitled "Soil and Groundwater Investigation of the Coal Tar Distillation and Wood Preserving Site, St. Louis Park, MN." Upon reviewing the available geological information, we suggest that another interpretation of the bedrock topography and geology can be postulated particularily for the areas east and southeast of the site of investigations.

Our records of borings ST-1 and ST-53 located at the extension of Louisianna Avenue over the Chicago, Milwaukee, St. Paul, and Pacific Railroad tracks do not indicate the presence of the Platteville limestone as do the records of these borings shown graphically in figure 3 of the Barr report. Our copy of ST-1 indicates the Glenwood Formation was penetrated at a depth of 84 feet and the St. Peter Sandstone at 87 feet. ST-53 encountered St. Peter Sandstone at a depth of 84 feet with no Platteville but possibly some Glenwood overlying it. ST-64, a boring near these other two which is not presented in the Barr report, penetrated only St. Peter Sandstone at a depth of 98 feet. If our copies of borings ST-1, ST-53, and ST-64 are accurate, then the bedrock river channel southeast of the creosote site (p.III-9 and figure 7, Barr report) is cut into the St. Peter Sandstone and not just into the Glenwood Formation as postulated. We are enclosing duplicates of our copies of these borings which we obtained from the Minnesota Department of Transportation.

Additional evidence favoring a St. Peter channel southeast of the old creosote site can be obtained through another interpretation of the log for the Methodist Hospital well. The Barr report implies that since their calculated average thickness for the St. Peter Sandstone (165 feet, p. III-11) was nearly penetrated by the well (163 feet), Glenwood shale could be assumed to be present but not described (p. III-10). It is not uncommon for the St. Peter to be reported as two to four feet thicker than the Barr Engineering calculated average and so it may be possible that more than 163 feet of sandstone may have existed at the well site.

The log of a test hole for the elevator shaft at Methodist Hospital indicates that the Platteville limestone was encountered at a depth of

60 feet. The log of the Methodist Hospital well reports penetrating St. Peter Sandstone as the first bedrock at 94 feet. If the difference in land surface elevation between the elevator shaft and the waterwell site was no more than five feet during construction of the hospital, then there would be about 29 feet of bedrock eroded between the elevator shaft and the well (94 minus 65).

Well logs about one half mile north of the hospital indicate 20 to 23 feet of Platteville remaining. Well logs in Edina about three quarters of a mile southwest of the hospital report about two to ten feet of Platteville while the record of St. Louis Park Well No. 6 about five eighths of a mile to the southeast reports about 32 feet. If well logs closest to Methodist Hospital are any indication of the thickness of remaining Platteville, then about 20 to 23 feet of Platteville should underly the site for the hospital elevator shaft and about the same amount should have been eroded at the hospital well site. This estimate would leave six to nine feet of bedrock or about three feet of Glenwood and about three to six feet of St. Peter Sandstone to be eroded in order to have St. Peter occur under 94 feet of glacial deposits at the hospital well site. Therefore, it is possible that the well log for Methodist Hospital is accurate in reporting the St. Peter Sandstone as the first bedrock and that its upper three to six feet have been eroded. This interpretation would indicate that Methodist Hospital overlys the lip of a buried river channel cut into the St. Peter Sandstone. I am enclosing copies of the geologic logs for the elevator shaft and for the waterwell at Methodist Hospital.

A bedrock geologic and topographic map based upon our copies of borings ST-1, ST-53, and ST-64 and our interpretation of the Methodist Hospital data indicates that a bedrock channel cut into the St. Peter Sandstone extends at least as far north toward the old creosote site as the extension of Louisiana Avenue over the Chicago Milwaukee, St. Paul, and Pacific Railroad tracks. We are enclosing a copy of this map. The generalized bedrock topography compiled from waterwell records and test boring logs lends support to the existence of a southeastern bedrock channel. The width of this channel cut into the St. Peter Sandstone could be approximately one city block or about as wide as the gorge cut into the St. Peter Sandstone just downstream from Minnehaha Falls. The southeast channel shown in figure 7 of the Barr report is similar in width but they interpret the bottom of this channel as lined with Glenwood shale.

Observations of channels cut through Platteville limestone such as at Minnehaha Falls do not indicate that these channels bottom in the Glenwood Formation. The Glenwood is easily eroded and especially subject to waterfall recession which is believed to have been the mechanism which formed channels cut through the Platteville in the Twin City area. Assuming a St. Peter channel is present southeast of the old creosote site, probably about 10 to 15 feet of St. Peter Sandstone has been removed at the waterfall but progressively more sandstone would have been removed by water action downstream if surface observations such as at Minnehaha Falls are an accurate analogue.

In addition to the southeastern channel, we suggest the channel underlying Wooddale Avenue (figure 7) is also probably cut into the St. Peter Sandstone and not just into the Glenwood Formation. Records for the abandoned St. Louis Park well at 6021 West 36th Street and for the Minnesota Rubber Company well at 3630 Wooddale Avenue each report St. Peter Sandstone as the first bedrock penetrated. The record of the Milwaukee Railroad well at Wooddale Avenue and the railroad tracks reports only four feet of limestone and shale overlying the St. Peter Sandstone and suggests the area between these three wells may mark the northern edge of a St. Peter channel whose center would lie to the southeast. We are enclosing copies of the three well logs.

The results of the hydrogeologic model in the Barr report will change if the above geologic interpolations are accepted. The buried bedrock channels southeast and east of the creosote site would create a larger recharge area for the St. Peter than depicted in the Barr Report. This situation would be especially important if valley fill deposits in the southeastern channel were permeable and hydrologically connected to the middle drift aquifer. The Platteville limestone might also discharge into the southeastern bedrock valley particularly along the Platteville-Glenwood shale contact, thereby permitting contaminants from other areas to recharge the St. Peter in addition to those directly recharging above the buried valley through the middle drift aquifer. The piezometric levels for the St. Peter in figures 18 and 19 would also be different possibly resulting in steeper gradients from the axes of the buried bedrock valleys to the city wells 1, 2, and 3. Groundwater flow lines, velocities, and travel times in the St. Peter will also change. The piezometric lines for the Prairie du Chien-Jordan aquifer in figures 20 and 21 might change, but this would have to be checked by the model. Because the presence of the two St. Peter channels will have a major impact on present hydrogeologic modeling and upon future groundwater gradient control measures, we suggest that additional test borings be placed to establish the lithology of the first bedrock at the bottom of each channel, to define channel morphology, and to determine channel hydrology.

We also have questions regarding boundary conditions established for the hydrogeologic model. The eastern and western piezometric levels of the St. Peter and the Prairie du Chien-Jordan aquifers were taken from piezometric contours illustrated in the Norvitch report (1973) as cited by Barr. The Norvitch report used 1:250,000 scale maps with 25 to 50 foot contour intervals. If the placement of these piezometric contours was not precise or if locations of those contours had shifted by the time the Barr report was initiated, then it is possible that the resultant gradients for the bedrock aquifers in the Barr report could be different. Also, on pages III-27 and III-28 of the Barr report, four wells are discarded as affecting bedrock boundary conditions. We question the assumptions and reasons used to eliminate these wells and suggest that Barr should first include these four wells and eliminate them only when the model verifies that they have a negligible affect upon defining peizometric levels in the bedrock aquifers. The model also uses aquifer parameters to compute flow rates and travel times. The source of some of [illegible] given or explained; however, there is no explanation

for the specific storage (page E-1) or the porosity (page IV-14) assigned to the Glenwood shale.

Another aspect of the Barr report which needs clarification is the assumptions used to predict contaminant migration. Barr postulates that the contaminants and the groundwater move as a single-phase flow rather than a possible multiple-phase flow system. Information regarding the solubilities of the various contaminants is necessary to investigate this, but no such information is presented in the Barr report. The contaminants could be moving at different velocities and directions than the groundwater and could possibly be trapped in areas of changing grain size creating stagnant pockets. Groundwater might continue to leach soluble parts of these trapped contaminants for longer periods than those determined by the results in figure 23. This could greatly alter the effectiveness of gradient control wells. We suggest that more information regarding the mobility of the contaminants be presented before initiating a gradient control well system.

In conclusion, the information we are presenting demonstrates that the available subsurface data permits several interpretations of the bedrock geologic and hydrologic conditions near the creosote site in St. Louis Park. Our opinion is that the bedrock channels depicted in the Barr report, and modified in our interpretation, probably cut into the St. Peter Sandstone. This interpretation of the geology would greatly add potential recharge areas to the St. Peter and could alter present hydrologic modeling. We also suggest that a re-evaluation of the data used in modeling might also alter the present interpretation of bedrock hydrology. We recommend that future remedial measures, particularly groundwater gradient controls, would be more effective if the geology and hydrology of the buried bedrock channels east and southeast of the creosote site were precisely defined.

Sincerely,

Bruce Olsen

Bruce Olsen

Gilbert Gabanski

Gilbert Gabanski

Encl.

BO/GG/jh

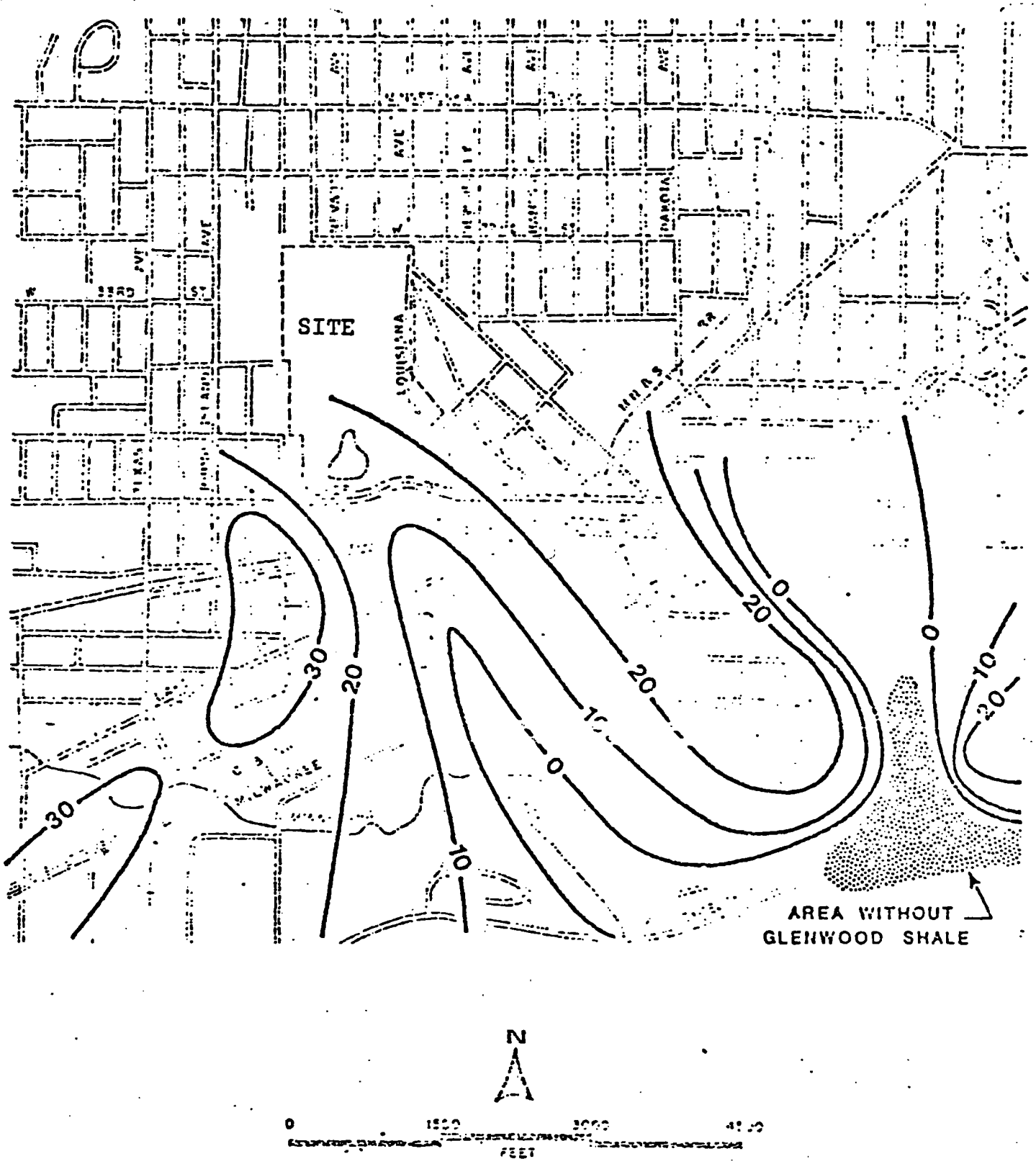

FIGURE 7 Barr Report

THICKNESS OF THE PLATTEVILLE LIMESTONE FORMATION (FEET)

(indicating approximate limits of buried bedrock valleys)

U.S. GEOLOGICAL SURVEY STUDY:

The U.S. Geological Survey, under contract to the Minnesota Department of Health, has been conducting a hydrological and geochemical study of the St. Louis Park area, to develop a detailed understanding of the groundwater flow system and transport of organic contaminants. The study is to be completed by June 1980. The general area of study extends three miles east and two miles south of the site. A preliminary report outlining the information gathered through June 1979 was released November 1979, containing 55 figures describing the geologic and hydrologic conditions of the study area.

Preliminary results of this report indicate that there appear to be three major sources of contamination:

1. infiltration of hydrocarbons spilled on site;
2. runoff of contaminants from the site and discharge of wastewaters into disposal ponds south of the site; and
3. introduction directly through the deep, multiaquifer well (909') on the site.

In addition, at least 25 ungrouted or partially cased wells exist in the vicinity of the site and these may permit contaminated water from near-surface aquifers to flow downward into deeper bedrock aquifers. Flow rates estimated by geophysical logging and inspection with downhole television cameras range from 20 to 150 gpm. Most of these wells have been logged with a downhole television camera by the Minnesota Department of Health or geophysically logged by the U.S.G.S. This information, along with drillers' logs, water level measurements, and survey reports are available from the U.S.G.S.

Dissolved constituents in the drift and the Platteville Limestone have moved at least 4,000 feet down the hydraulic gradient (east-southeast) towards a drift-filled valley. Soil borings and well logs indicate two branches associated with the buried bedrock valley, which are ½-1 mile southeast of the site. The extent of this valley

is currently being better defined by the U.S.G.S. The valley appears to be a recharge area for the lower aquifers from the upper bedrock units.

Due to heavy and extensive groundwater utilization by municipal and industrial users, the groundwater flow systems in the Prairie du Chien aquifer are extremely complex. The distribution of contaminants is likewise complex.

The extent of contamination in the Mt. Simon-Hinckley aquifer is unknown. Contaminants have been introduced through the well on the site, so there remains a potential of further contamination spread.

The U.S.G.S. has also investigated the distribution of sodium, nitrate, ammonia, dissolved organic carbon, and total organic carbon in the Middle Drift and Platteville aquifers. Further work remains to be completed, but the current data indicate that these components are migrating to the east-southeast, with the exception of nitrates, which are decreasing (due to microbial utilization).

Studies are currently being conducted measuring dispersivity of NaCl and phenol in column packs of sand. In addition, a three-dimensional dispersivity-diffusion computer model is being developed and calibrated by the U.S.G.S. This model will be available to the consultant(s) for use.

ecology and environment, inc.
223 WEST JACKSON BLVD., CHICAGO, ILLINOIS 60606, TEL. 312-663-9415
International Specialists in the Environmental Sciences

DATE: December 8, 1980

TO: File

FROM: Rod Bloese RTB

SUBJECT: Minnesota/TDD# F5-8012-3
St. Louis Park/Reilly Tar and Chemical Co.

On December 3, 1980, the author met with Melanie Toepler (USEPA - Region V Enforcement) to obtain background information concerning the subject site. Areas to be addressed in developing cost estimates for clean-up of groundwater and soil in the subject site area were discussed. Subsequently, background information was reviewed and the following scope of work was determined.

Cost estimates for the following areas will be determined:

1. Water treatment of all fifteen (15) St. Louis Park Municipal wells and a number of additional wells.

2. Remedial activity (clean-up) regarding on-site well #23.

3. Remedial activity regarding approximately fifteen (15) "multiaquifer" wells.

4. Contaminated soil treatment, clean-up, and/or disposal.

5. Well field management plan.

Presently, background review is continuing and cost estimate work for the above five (5) areas are being initiated.

RB/df

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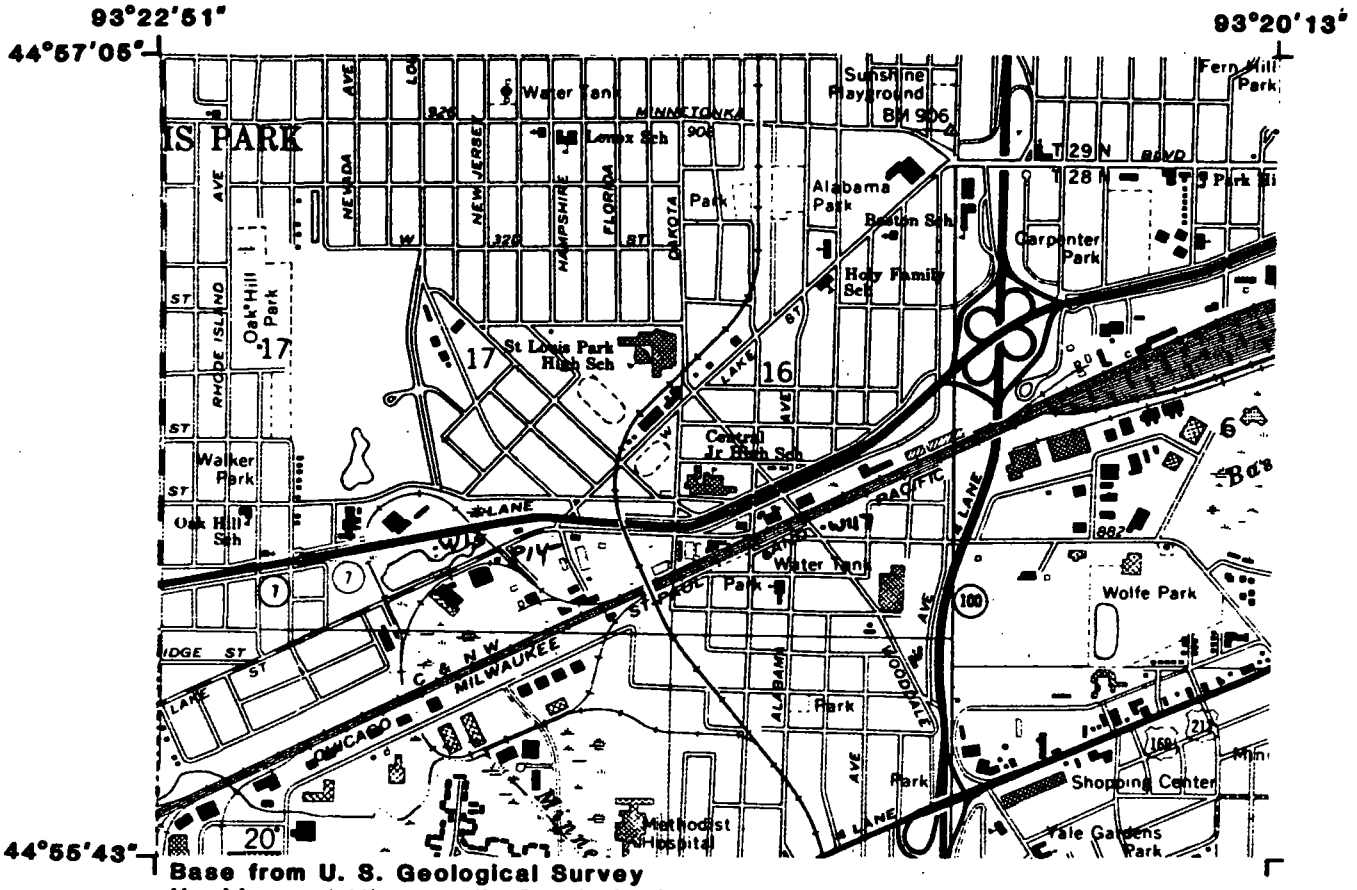

Base from U. S. Geological Survey
Hopkins and Minneapolis South; both maps
1:24,000, 1967 (Photorevised 1972)

0 1/2 1 MILE

0 1000 2000 3000 4000 5000 FEET

0 .5 1 KILOMETER

UNITED STATES GOVERNMENT

memorandum

DATE: June 10, 1981

REPLY TO ATTN OF: Chief, Central Laboratory, WRD, Denver, CO

SUBJECT: REPORTS AND STATISTICS - Water Quality: Results of the St. Louis Park water samples

TO: District Chief, WRD, Minneapolis MN
Attn: Marc Hult, WRD, St. Paul, MN

The custom analysis on six water samples from the St. Louis Park area have been completed.

The methods, procedures, and results for polynuclear aromatic hydrocarbons (PNA) by liquid chromatography are described in Chemist's Report I and by gas chromatography/mass spectrometry (GC/MS) in Chemist's Report II. Other organic compounds tentatively identified by GC/MS are reported in Chemist's Report II.

CHEMIST'S REPORT I

Six water samples (SLP #4, SLP #15, W-117, Flame Ind., W-13, and P-14) from Minnesota were each extracted with three - 40 mL portions of high performance liquid chromatographic (HPLC)-grade methylene chloride. The sample and the bottle were weighed before and after extraction. The methylene chloride extract was dried over sodium sulfate in a dark, explosion-proof refrigerator, for 2 hours or longer. (Previously, the sodium sulfate had been burned at 350°C for approximately 12 hours.) One-half milliliter HPLC-grade acetonitrile was added to the organic extract which was reduced to approximately 4 mL in a Kuderna-Danish (K-D) concentrator.

Special treatment was required with sample W-13. The interface between the methylene chloride and the aqueous layer on W-13 was not clearly discernable. A maximum amount of methylene chloride was removed from the separatory funnel without collecting any of the emulsified aqueous portion. Since some methylene chloride remained emulsified with the discarded aqueous layer, a portion of some constituents were lost. Therefore the reported values on W-13 are considered "minimum" values.

Sample P-14 was not concentrated after the K-D concentration step. The other samples were concentrated below 4 mL using an evaporative concentrator with dry, inert nitrogen flowing over the surface. After concentrating to 500 µL., 250 µL. were transferred to a micro-insert vial in the autoinjector and 100 µL. were injected into the high performance liquid chromatograph.

The instrument, column, and gradient conditions are as follows:

Instrument: Waters Associates - Model 440 (uv) detector at 254 nm. and 313 nm.

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(REV. 7-76)
GSA FPMR (41 CFR) 101-11.6
5010-112

Accessories: "Wisp" 710B auto-injector and the Model 720 System Controller with Data Module.

Column: Reversed phase, Beckman "Ultrasphere" - ODS - (C_{18}) - 5 micron - 25 cm. x 4.6 mm. I.D.

Conditions: 40-100% CH_3CN/H_2O - 55 min. run - 1.0 mL/min. flow rate; Chartspeed: 1.0 cm./min.

Fourteen polynuclear aromatic hydrocarbon (PNA) stock standards were prepared individually from pure standard material in methylene chloride. Three working solutions (0.2-11.0 ng/µL concentration) were prepared in acetonitrile by diluting appropriate amounts of the stock solutions. The working solutions were injected preceding and following the six sample analysis run.

The fourteen PNA's prepared were:

1) Naphthalene
2) Acenaphthylene
3) Fluorene
4) Acenaphthene
5) Phenanthrene
6) Anthracene
7) Fluoranthene
8) Pyrene
9) Chrysene
10) 1,2-Benzanthracene
11) Benzo(a)pyrene
12) 1,2:5,6-Dibenzanthracene
13) Indeno (1,2,3-c,d) pyrene
14) Benzo [g,h,i] perylene

Each PNA has a characteristic absorbance peak response ratio between 254 nm. and 313 nm. This ratio, in addition to the retention times, was used to identify the PNA. The results on the six water samples showing their corresponding PNA concentrations were tabulated using integrated area counts or peak-height measurements. The results are shown on the attached table.

The reported concentrations for some PNA's are higher from the analyses performed by HPLC than those performed by GC/MS. The values reported from the HPLC analyses are probably high due to two or more compounds being present under one peak.

W. R. White

W. R. White
Chemist

PNA Concentrations of Minnesota (St. Louis Park) samples
(μg/L)

Sample	Naphthalene	Acenaphthylene	Fluorene	Acenaphthene	Phenanthrene	Anthracene	Fluoranthene
W-13	*220,000	**<5,250	*110,000	*D-I (interference)	*630,000	66,000	*420,000
P-14	*270	<2.0	*6.3	*20	*1.8	0.10	<0.30
Flame Ind.	**<0.019	<0.02	**<0.002	**<0.036	*0.01	<0.001	0.04
W-117	**<0.018	<0.02	<0.002	*4.9	<0.001	<0.001	<0.007
SLP #15	0.07	**<0.02	*0.73	**<0.035	*0.11	0.07	0.07
SLP #4 (GC/MS did not analyze this sample)	<0.018	<0.02	<0.002	<0.036	<0.001	<0.001	<0.007

* Detected by GC/MS and by LC
** Detected by GC/MS, not by LC
< Less than minimum detectable limit. Dilution factors are included where applicable.

PNA Concentrations of Minnesota (St. Louis Park) samples (con.)
(μg/L)

Sample	Pyrene	Chrysene	1,2 Benzanthracene	Benzo(a) pyrene	1,2:5,6 Di-benzanthracene	Indeno-(1,2,3-c,d) pyrene	Benzo [g,h,i,] Perylene
W-13	*500,000	**<360	*300,000	*160,000	16,000	27,000	*92,000
P-14	0.85	<0.14	<0.12	<0.18	<0.27	<0.09	<0.29
Flame Ind.	<0.006	<0.001	<0.003	<0.005	<0.012	<0.002	<0.007
W-117	<0.006	<0.001	<0.003	<0.004	<0.012	<0.002	<0.007
SLP #15	<0.006	<0.001	<0.003	<0.005	<0.012	<0.002	<0.007
SLP #4	<0.006	<0.001	<0.003	<0.005	<0.012	<0.002	<0.007

* Detected by GC/MS and by LC
** Detected by GC/MS, not by LC
< Less than minimum detectable limit. Dilution factors are included where applicable.

CHEMIST'S REPORT II

Six samples were received from the Minnesota District for acid/base-neutral extractables and volatiles analyses (one sample, SL #4, for acid/base-neutral extractables was received broken). The samples for acid/base-neutral extractables were adjusted to pH 11 and extracted with three 50 mL portions of methylene chloride (extracts for each sample were composited). The samples were then adjusted to pH 2, saturated with 50 mL di-ethyl ether, and extracted as above with three 50 mL portions of methylene chloride. (NOTE: Sample W-13 contained a visible organic layer which was emulsified and co-extracted with the water phase. Due to the dark coloration of this sample, the interface between the extraction solvent and the water phase was difficult to determine. Consequently, the extracts containing the base-neutral components were conservatively withdrawn leaving an ambiguous emulsion. The emulsion was withdrawn into a separate flask to avoid contamination during the acid component extractions. This emulsion was not composited with the base-neutral extracts, but is believed to contain a great deal of the base-neutral components. Therefore, estimated concentration figures listed should be presumed to be minimum values.)

The composited extracts were reduced using a Kuderna-Danish concentrator and further reduced to approximately 0.5 mL using a nitrogen evaporator. Sample nos. P-14 and W-13 were known to be heavily contaminated and were diluted 1:10 and 1:2000 respectively for base-neutral analyses and 1:10 and 1:20 respectively for acid analyses. The extracts were submitted for gas chromatography/ mass spectrometric analysis.

10 µg of the internal standard, d_{10}-biphenyl, were added to each extract (or 0.5 mL aliquot of the diluted extract). Approximately 1 µL of the extract was injected onto a 25m x 0.25mm i.d. SE-54 coated fused silica capillary column using the Grob (splitless) injection technique. The gas chromatograph was temperature programmed as follows: Initial temperature 50°C hold for 5 min., program to 300°C at 6°C/min., hold 300°C for 15 min. The mass spectrometer was scanned from 35 to 450 amu at 1 sec/scan. Peaks of interest were determined using the Biemann-Biller search routine. Spectra were tentatively identified using a computer assisted search of the National Bureau of Standards (NBS) mass spectral library. Those spectra meeting specified "Purity" and "Fit" criteria are given tentative identification in the accompanying tables. "Purity"and "Fit" are indicators of how closely the unknown spectrum resembles the library spectrum with the best possible value for each beins "1000". Concentrations were estimated by comparing the base peak of the internal standard (m/e 164) with the base peak of the identified spectrum, assuming a relative response factor of 1.0. The concentration estimates may be considered to be accurate to the nearest order of magnitude. The detection limit for this method is on the order of 1 µg/L for all compounds except for diluted samples P-14

and W-13, for which the detection limits for the base-neutral analyses would be 10 μg/L and 2000 μg/L respectively and for the acid analyses would be 10 μg/L and 20 μg/L respectively.

Samples for volatiles analyses were analyzed per "Determination of Selected Volatile Organic Priority Pollutants in Water by Computerized Gas Chromatography-Quadrapole Mass Spectrometry" by W. Pereira and B. Hughes as published in the Journal of the American Water Works Association, April, 1980. The samples were analyzed quantitatively for the following compounds and qualitatively for all others reported: (— on the volatiles tables indicates no quantitation was done.)

Methylene Chloride
Cyclohexane
Benzene
Trichloroethene
Toluene
Ethylbenzene

The detection limit for volatile compounds is on the order of 1 μg/L for all samples analyzed.

Michael Brooks

Michael Brooks
Chemist

There is no cost for these analyses in accordance with the agreement made by our previous laboratory chief. Rolly Grabbe had recommended that we request samples from you to test our new PNA method on waters containing detectable quantities of PNA's and to test our GC/MS method, used for oil shale retort waters, on the coal tar waste waters.

If you have questions, please call Rolly Grabbe at FTS 234-4992.

Howard E. Taylor
Chief, Denver Central Laboratory

rw

Attachments

cc: H. Feltz, WRD, Reston, VA
Analytical Services Coordinator, Reston, VA
Chief, Atlanta Central Laboratory
Regional Hydrologist, NE, Reston, VA
Regional Hydrologist, CR, Denver, CO

Table 1.

SLP #15

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
629	2,3 dihydro-1H-indene	922	992	1
841	4-methyl-2,3-dihydro-1H-indene	920	950	<1
1203	biphenyl	885	898	<1
1259	dimethylnaphthalene	913	926	<1
1300	acenaphthylene	931	954	1
1349	acenaphthene	978	989	1
1390	dibenzofuran	943	980	1
1477	fluorene	915	955	1
1715	phenanthrene	664	858	<1
Acid:				
541	phenol	922	962	4
Volatiles:				
59	methylene chloride	975	993	9
154	pentane	939	958	--
220	benzene	457	985	1
220	trichloroethene	490	996	2

Table 2

Flame Ind.

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
639	2,3-dihydro-1H-indene	824	954	<1
901	naphthalene	976	996	1
917	1-(2-butoxy ethoxy)ethanol	855	984	15
1350	acenaphthene	910	924	<1
1479	fluorene	881	915	<1
1716	phenanthrene	709	818	<1
Acid:				
534	phenol	940	982	1
Volatiles:				
58	methylene chloride	800	976	5
169	1,1,1-trichloroethane	498	743	—
219	benzene	669	986	1
219	trichloroethene	---	---	<1
304	tetrachloroethene	396	794	<1

Table 3

W-117

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
224	tetrachloroethene	974	998	25
360	xylene	942	992	2
423	(1-methylethyl)benzene	919	970	<1
532	ethylmethylbenzene	915	985	1
640	2,3-dihydro-1H-indene	910	994	30
722	dihydrobenzofuran	815	896	<1
734	methyl-2,3-dihydro-1H-indene	867	994	3
756	7-methylbenzofuran	906	978	2
763	3-phenyl-2-propenal	915	994	1
772	2-methylbenzofuran	871	967	1
845	methyl-2,3-dihydro-1H-indene	813	955	2
854	1,2,3,4 tetrahydro-1,4-methano-naphthalen-9-one	868	933	1
902	naphthalene	920	973	<1
910	dimethyl-2,3-dihydro-1H-indene	851	895	<1
927	dimethyl-2,3-dihydro-1H-indene	869	925	<1
1018	2,3-dihydro-benzo/B/thiophene	917	996	2
1059	2,3 dihydro-1H-indene-1-one	847	992	<1
1068	methylbenzo/B/thiophene	919	984	1
1102	methylbenzo/B/thiophene	888	966	<1
1157	diethylphenol	807	916	1
1164	dimethyl(methylethyl)benzene	785	953	<1
1184	2-(2 methyl-2-propenyl)phenol	804	929	<1
1254	pentamethylbenzene	840	928	<1
1350	acenaphthene	942	992	2
1688	3-methyl-2(1H)-quinolinone	813	906	<1
1755	4-methyl-2(1H)-quinolinone	803	876	<1
Acid:				
529	phenol	926	981	1

Table 3 (con.)

W-117

Volatiles:

69	methylene chloride	821	981	9
87	dichloroethene (3 isomers)	784	990	—
124	dichloroethene	971	997	—
134	dichloroethene	978	997	—
154	pentane	787	907	—
169	cyclohexane	854	961	2
219	benzene	—	—	10
220	trichloroethene	922	995	500
305	tetrachloroethene	976	995	280
316	toluene	882	956	<1
363	ethylbenzene	834	969	<1

Table 4

P-14

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
259	cyclohexanone	867	890	<10
291	ethylbenzene	944	998	500
305	xylene	922	987	400
319	dimethylthiophene	893	961	<10
351	xylene	922	983	250
415	(1-methylethyl)benzene	941	997	30
438	methyl cyclohexanol	848	972	<10
459	2-propenylbenzene	907	947	<10
491	ethylmethylbenzene	899	997	100
505	trimethylbenzene	920	996	50
525	aniline	929	998	10
527	ethylmethylbenzene	849	925	30
539	benzonitrile	835	996	30
555	ethylmethylbenzene	905	975	300
562	benzo furan	863	958	400
612	trimethylbenzene	893	994	50
639	2,3-dihydro-1H-indene	910	994	300
659	1H-indene	914	981	700
680	2-methylphenol	931	997	150
723	3-methylphenol	894	983	300
744	trimethyl-2-cyclopenten-1-one	794	967	<10
756	methylbenzofuran	902	978	50
766	3-phenyl-2-propenal	926	994	100
775	dimethylphenol	873	997	300
828	1-methyl-2,3-dihydro-1H-indene	795	823	20
830	ethylphenol	686	950	100
836	ethylphenol	933	995	100
846	3-methylindene	904	959	50
854	dimethylphenol	891	993	350
858	1,2,3,4-tetrahydro-1,4-methano-naphthalen-9-one	845	864	50
866	dimethylphenol	830	935	500
894	ethylphenol	848	947	250
911	naththalene	852	923	850
915	dimethylphenol	831	937	150
937	1,6-dimethyl-2,3-dihydro-1H-indene	720	773	<10

Table 4 (con.)

P-14

Base-Neutral:

948	trimethylphenol	881	988	200
963	dimethylbenzo furan	825	921	<10
983	ethylmethylphenol	853	989	150
988	trimethylphenol	866	982	200
1001	ethylmethylphenol	890	998	350
1007	ethylmethylphenol	844	985	250
1039	ethylmethylphenol	835	997	350
1047	trimethylphenol	893	996	150
1054	trimethylphenol	878	994	200
1063	diethylphenol	720	919	<1
1071	2,3-dihydro-1H-indene-1-one	929	997	50
1087	2-methylnaphthalene	868	997	500
1112	2-methylnaphthalene	873	978	400
1155	dimethylbenzaldehyde	797	993	200
1209	biphenyl	914	989	100
1214	p-(2 methylallyl)phenol	811	948	20
1220	pentamethyl benzene	806	956	50
1229	2-ethylnaphthalene	808	972	30
1244	dimethylnaphthalene	803	948	20
1265	dimethylnaphthalene	637	951	30
1270	dimethylnaphthalene	813	864	20
1292	dimethylnaphthalene	835	967	10
1313	dimethylnaphthalene	870	979	10
1321	hexamethylbenzene	780	921	20
1356	acenaphthene	934	990	20
1368	triethylbenzene	696	944	10
1388	2-naphthalenol	795	984	50
1395	1,1'-biphenyl-2-ol	774	936	30
1397	dibenzofuran	808	876	100
1399	1-naphthalenol	868	980	100
1429	fluorene	896	974	40
1456	2-methylnaphthalenol	865	967	10
1477	1-methylnaphthalenol	618	910	10
1503	4-methylnaphthalenol	665	911	<10
1657	phenanthrene	933	970	100
1721	9-H-carbazole	885	989	30
1759	dibenzo/B,E/1,4/dioxin	804	891	<10

Table 4 (con.)

Acid:

	536	phenol	958	976	10
	675	methylphenol	927	993	40
	719	methylphenol	892	979	150
	766	dimethylphenol	870	991	<10
	824	2-ethylphenol	951	995	20
	843	dimethylphenol	898	992	100
2,4	884	? dimethylphenol	887	987	150
	916	dimethylphenol	913	995	100
2-chlor	925	? 3-chlorophenol	921	998	30
	991	ethylmethylphenol	740	951	10
	1025	ethylmethylphenol	866	987	40
	1050	benzene acetic acid	900	968	30
	1089	3-methylbenzoic acid	872	985	20
	1095	4-methylbenzoic acid	699	776	<10
	1246	dimethylbenzoic acid	608	917	<10
	1411	methylpropylphenol	705	883	10
	1604	2-naphthalencarboxylic acid	841	970	<10
	1621	1-naphthalencarboxylic acid	845	927	30
					720

Volatiles:

	58	methylenechloride	885	992	8
	169	cyclohexane	691	908	<1
	182	thiophene	840	985	--
	195	cyclohexene	928	975	--
	219	benzene	948	972	110
	220	trichloroethene	---	---	1
	242	cycloheptene	891	907	--
	259	methylcyclohexane	777	981	--
	268	tetrahydro-2-methyl thiophene	754	983	--
	278	3-methyl thiophene	868	975	--
	305	tetrachloroethene Perchloroethylene	573	957	<1
	315	toluene	928	994	56
	332	ethylthiophene	833	980	--
	362	ethylbenzene	865	949	160
	367	dimethylthiophene	603	870	--
	373	dimethylthiophene	874	960	--
					283

Table 5

W-13

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Base-Neutral:				
314	ethylbenzene	954	996	2,000
328	xylene = dimethylbenze	937	995	6,000
370	xylene	938	983	2,000
502	ethylmethylbenzene	907	994	2,000
514	trimethylbenzene	931	991	2,000
536	ethylmethylbenzene	886	907	2,000
562	trimethylbenzene	921	991	4,000
567	benzofuran	852	919	4,000
576	hydrocarbon			*
616	trimethylbenzene	938	993	2,000
624	2-propenylbenzene	893	920	<2,000
640	2,3-dihydro-1H-indene	915	988	20,000
656	1-H-indene	947	987	20,000
681	methylphenol	924	982	<2,000
685	isopropylmethyl benzene	912	977	<2,000
720	methylphenol	767	978	2,000
754	7-methylbenzofuran	930	970	<2,000
760	hydrocarbon			*
763	3-phenylpropenal	946	993	2,000
786	tetramethylbenzene	937	967	<2,000
825	4-methyl-2,3-dihydro-1H-indene	897	996	2,000
845	5-methyl-2,3-dihydro-1H-indene	699	948	4,000
847	dimethylphenol	881	950	2,000
853	methylindene	897	955	2,000
885	dimethylphenol	875	986	2,000
907	naphthalene	896	993	230,000
930	hydrocarbon	---	---	*
933	5,6-dimethyl-1H-benzeneimidazole	842	911	<2,000
952	hydrocarbon	---	---	*
954	4,7-dimethylbenzofuran	856	949	<2,000
964	hydrocarbon	---	---	*
992	ethylmethylphenol	775	940	<2,000
1008	1,3-dimethyl-2,3-dihydro-1H-indene	869	938	<2,000
1031	4,7-dimethyl-2,3-dihydro-1H-indene	625	846	<2,000
1046	hydrocarbon	---	---	*

Table 5 (con.)

W-13

Base-Neutral:

1067	5-methyl-benzo/B/thiophene	943	984	2,000
1080	2-methylnaphthalene	914	997	120,000
1085	hydrocarbon	---	---	*
1091	6-methyl-benzo/B/thiophene	897	944	2,000
1105	1-methylnaphthalene	898	977	4,000
1204	biphenyl	927	988	20,000
1224	2-ethylnaphthalene	856	972	10,000
1230	hydrocarbon	---	---	*
1239	dimethylnaphthalene	924	994	20,000
1250	3,6-dimethylbenzo/B/thiophene	720	900	<2,000
1261	dimethylnaphthalene	915	995	10,000
1265	dimethylnaphthalene	924	994	10,000
1287	dimethylnaphthalene	918	993	6,000
1300	acenaphthylene	912	982	4,000
1308	dimethylnaphthalene	878	966	4,000
1316	hydrocarbon	---	---	*
1352	acenaphthene	931	988	8,000
1366	hydrocarbon	---	---	*
1395	dibenzofuran	913	990	60,000
1410	trimethylnaphthalene	819	944	4,000
1483	fluorene	884	964	40,000
1494	hydrocarbon	---	---	*
1503	1-(2-propenyl)naphthalene	849	932	2,000
1526	methyldibenzofuran	837	963	8,000
1543	methyldibenzofuran	902	978	10,000
1554	hydrocarbon	---	---	*
1596	dehydrophenanthrane	912	974	6,000
1611	dihydrophenanthrene	815	973	2,000
1615	hydrocarbon	---	---	*
1620	methylfluorene	890	982	6,000
1622	hydrocarbon	---	---	*
1629	methylfluorene	684	916	4,000
1642	methylfluorene	697	959	2,000
1668	hydrocarbon	---	---	*
1678	hydrocarbon	---	---	*
1685	dibenzothiophene	780	966	10,000
1722	phenanthrene	939	984	110,000
1731	hydrocarbon	---	---	*
1733	anthracene	899	957	2,000
1741	hydrocarbon	---	---	*

35-12-2

Table 5 (con.)

W-13

Base-Neutral:

1781	9-H-carbazole	813	973	10,000
1804	1-phenylnaphthalene	754	905	2,000
1820	methyldibenzothiophene	734	940	2,000
1840	hydrocarbon	---	---	*
1845	methylphenanthrene	908	974	8,000
1852	methylphenanthrene	895	980	8,000
1877	methylphenanthrene	722	879	6,000
1926	2-phenylnaphthalene	869	967	4,000
1946	hydrocarbon	---	---	*
1962	dimethylphenanthrene	766	926	<2,000
1972	dimethylphenanthrene	715	946	<2,000
1991	dimethylphenanthrene	771	959	2,000
2025	fluoranthene	956	994	4,000
2046	hydrocarbon	---	---	*
2077	pyrene	944	985	2,000
2168	methylpyrene	844	964	4,000
2185	methylpyrene	890	943	2,000
2190	methylpyrene	605	857	2,000
2212	methylpyrene	808	955	<2,000
2220	methylpyrene	797	933	<2,000
2235	hydrocarbon	---	---	*
2279	1,1':2',1" terphenyl	713	860	<2,000
2321	benzo/B/naphtho/2,1-D/thiophene	858	938	<2,000
2332	benzo/C/phenanthrene	783	851	<2,000
2383	benz/A/anthracene	917	981	4,000
2393	chrysene	856	952	4,000
2644	benzo/K/fluoranthene	848	883	<2,000
2701	perylene	879	891	<2,000
3017	benzo/g,h,i/perylene	752	813	<2,000

*"hydrocarbon" refer to a series of alkanes which cannot be distinguished by mass spectrometry - Total estimated concentration 70,000 μg/L.

29-4:25

Table 5 (con.)

W-13

Acid:

539	phenol	958	991	50
679	methylphenol	911	992	60
720	methylphenol	895	981	300
846	dimethylphenol	602	992	20
884	dimethylphenol	895	984	100
921	dimethylphenol	651	852	<20
1028	ethylmethylphenol	756	915	<20
1030	benzeneacetic acid	876	960	20
1036	methylbenzoic acid	694	923	40
1096	methylbenzoic acid	762	911	100
1604	2-naphthalene carboxylic acid	771	987	20

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Volatile:

58	methylene chloride	758	976	5
154	pentane	945	960	--
170	cyclohexane	917	972	8
182	thiophene	831	938	—
215	methylcyclopentene	820	859	--
218	benzene	921	950	240
242	cyclo heptene	838	885	—
259	methylcyclohexane	892	994	—
268	tetrahydro-2-methyl-thiophene	794	879	—
278	methylthiophene	837	962	--
312	toluene = methylbenzene	866	980	270
332	dimethylcyclohexane	754	923	--
359	trimethylcyclohexane	532	963	—
361	ethylbenzene	788	912	370
365	dimethylthiophene	708	823	—
367	methylheptane	897	979	—
372	dimethylthiophene	694	954	—
394	dimethylheptane	925	992	--

18

Table 6

SLP #4

Scan #	Tentative Identification	Purity	Fit	Est. Conc. (µg/L)
Volatiles:				
58	methylene chloride	890	995	12
153	pentane	911	949	—
219	benzene	742	987	1
220	trichloroethene	---	---	<1
304	tetrachloroethene	265	818	<1
325	trimethylbenzene	837	965	—
395	trimethylbenzene	883	993	—
397	trimethylbenzene	820	994	—

Acid/Base-neutral (sample received broken).

Introduction

This report presents a summary of all pertinent technical information concerning the Reilly Tar and Chemical case in St. Louis Park, Minnesota. It is divided into the following four sections:

1. Summaries of all reports, interoffice memos, and letters pertaining to the technical aspects of the case including data presented therein;
2. List of possible witnesses;
3. Presentation of all ground water data pertaining to this case;
4. Information concerning ongoing work and work planned for the future.

The report summaries in Section 1 are generally arranged according to the following topics: a description of Reilly's operational and site conditions hydrogeologic reports, environmental contamination studies, potential pollutant sources other than Reilly, assessment of risk, and remedial measures. Many of the reports contain information on more than one topic. Those reports are placed according to their major topic.

The following agency/municipality files were searched to provide for a complete and comprehensive summary:

1. Minnesota Department of Health (MDH)
2. Minnesota Pollution Control Agency (MPCA)
3. City of St. Louis Park (SLP)
4. U.S. Geological Survey (U.S.G.S.)
5. U.S. Environmental Protection Agency - Chicago, IL
6. U.S. Environmental Protection Agency - Washington, D.C.

This summary report will be updated as new information becomes available.

ecology and environment, inc.
International Specialists in the Environmental Sciences

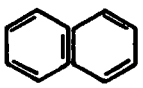
Technical Brief

Number 11 3 October 1980

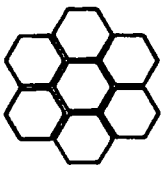
ANALYSIS OF POLYNUCLEAR AROMATIC HYDROCARBONS

The Analytical Services Center of Ecology and Environment, Inc., performs analyses to determine the presence and extent of polynuclear aromatic hydrocarbons in air, water, soil, sediment, and particulate matter.

Polynuclear aromatic hydrocarbons—also called polycyclic aromatic hydrocarbons, PNAs, or PAHs—comprise a large class of organic compounds containing carbon and hydrogen combined in two or more condensed (joined) rings. The lowest member of this class is naphthalene (moth balls):



One of the highest members is coronene:



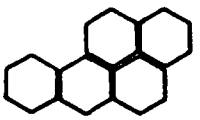
In nature, these ring structures are found in a number of products including coffee, clove stems, eucalyptus oil, and in smoke from open burning such as forest fires.

These compounds also occur in such diverse sources as fossil fuel combustion products, motor vehicle exhaust, fumes from coke ovens, refuse incineration, and cigarette smoke. Recently about 1,000 different PAHs were identified in cigarette smoke.

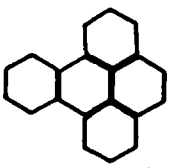
Since PAHS occur so often and because many are known carcinogens or cocarcinogens, there is now justifiable concern regarding their measurement and control. The PAH dibenz [a,h]-anthracene was, in fact, the first chemical substance of known structure to be identified as a carcinogen almost 50 years ago. The relative carcinogenic potency of PAHs as a class is second only to alfatoxins, yet the variation of PAH molecular structure can profoundly influence carcinogenic activity which ranges from inactive (e.g., anthracene), through borderline (e.g., benz[a] anthracene), to highly carcinogenic (e.g. BP, 7, 12 dimethyl benz [a]anthracene). The study of PAHs is further complicated by the fact that significant differences in biological activity are seen in structurally related compounds.

A good example of this difference is provided by comparing the structures of benzo [a] pyrene (B[a]P) and benzo [e] pyrene (B[e]P).

Benzo [a] pyrene
B[a]P



Benzo [e] pyrene
B[e]P



Although both are widely distributed throughout the environment, only B[a]P is of marked environmental concern, owing to its much greater carcinogenicity. Analytically, these two compounds are very difficult to separate and identify.

Concern for the deposition of PAHs in

the environment is further increased by recent discoveries that PAHs in the atmosphere are concentrated on the surface of particulate matter. Additionally, it has been determined that most of the mass of PAH is associated with aerosol in the respirable size range.

Consequently, new technologies, especially those involving combustion, must be looked at closely in regard to possible PAH generation.

Identification and determination of PAH components in complex organic mixtures found in industrial emissions or environmental samples is a challenging task owing to the complexity of the components present even in relatively simple samples. Early methods of PAH analysis concentrated on the measurement of only one PAH, benzo [a] pyrene, as an indicator of PAH contamination. Recent advances in chromatography have allowed investigators to gain further insight into the nature and extent of PAH contamination. The advent of computerized Gas Chromatography/Mass Spectrometry (GC/MS) has been instrumental in the identification of many new PAHs in the environment.

E & E's Analytical Service Center utilizes its GC/MS system to identify and quantify PAHs in environmental samples. Its Hewlett Packard 5993 GC/MS can accept capiliary columns, greatly enhancing its ability to separate complex PAH mixtures. E & E's ASC can perform PAH analysis on air, water, soil, sediment, and in particulate matter collected from mobile and stationary sources.

Figures 1, 2, and 3 are read-outs from E & E's GC/MS system, showing the processes whereby several PAHs were identified in an air and a sediment sample. Figure 1 gives the results of the analysis of the standard used to compare against sample results. Figure 2 shows the analysis of an air sample collected on highvol filters at a hazardous dump site in Pennsylvania. Figure 3 is the analysis of a sediment sample collected in the Buffalo River at the point where it enters Lake Erie.

Naphthalene, fluorene, anthracene pyrene, and fluoranthene were found in the air sample. These same compounds plus chaysene and benzo(K)-fluoranthene were detected in the Buffalo River sediment.

ANALYSIS OF POLYNUCLEAR AROMATIC HYDROCARBONS
(Cont.)

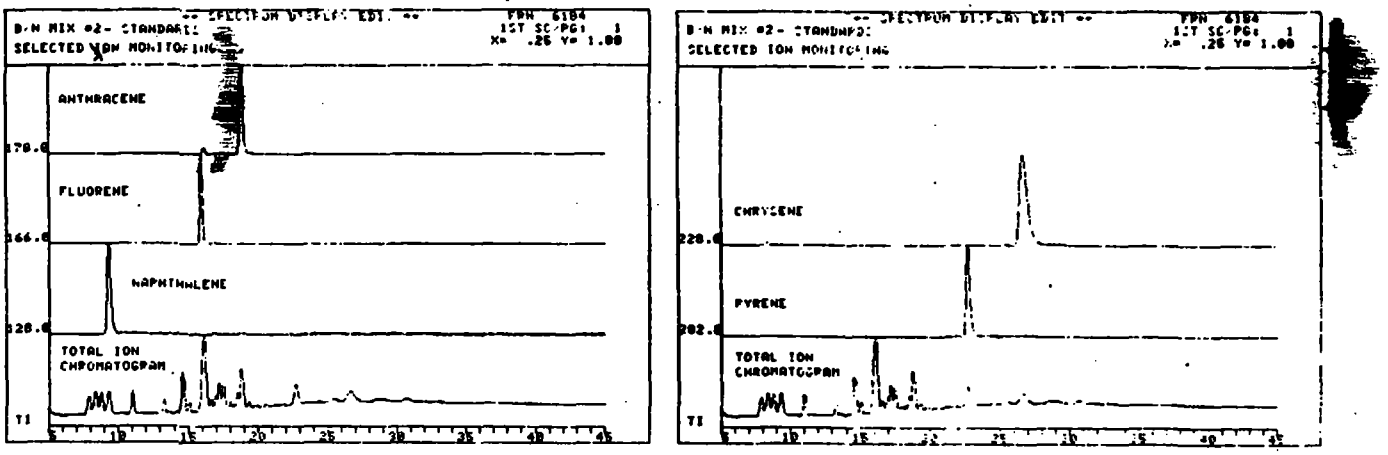


Figure 1 GC/MS STANDARDS

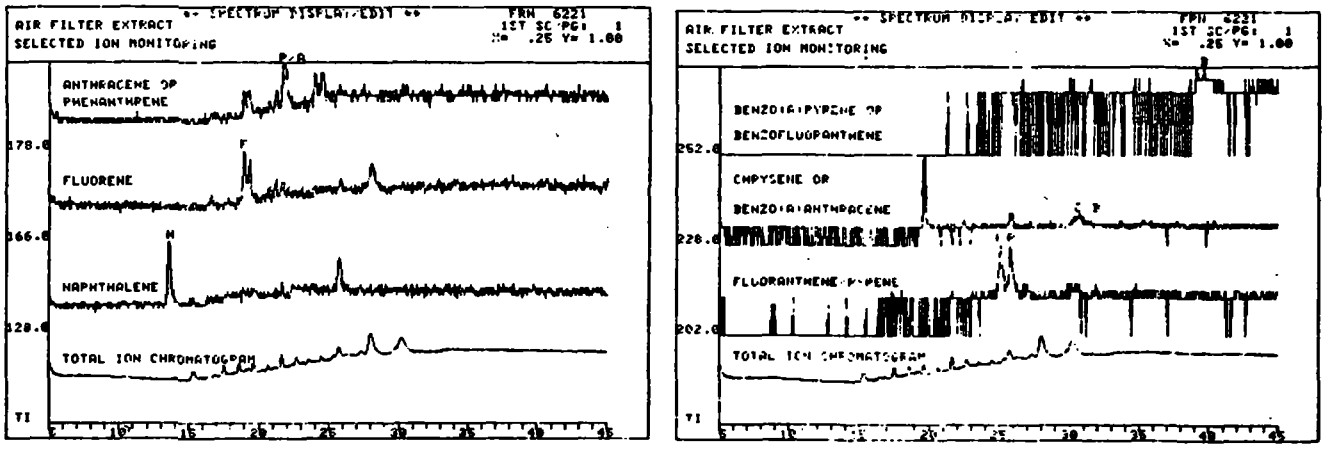


Figure 2 GC/MS ANALYSIS OF AN AIR SAMPLE

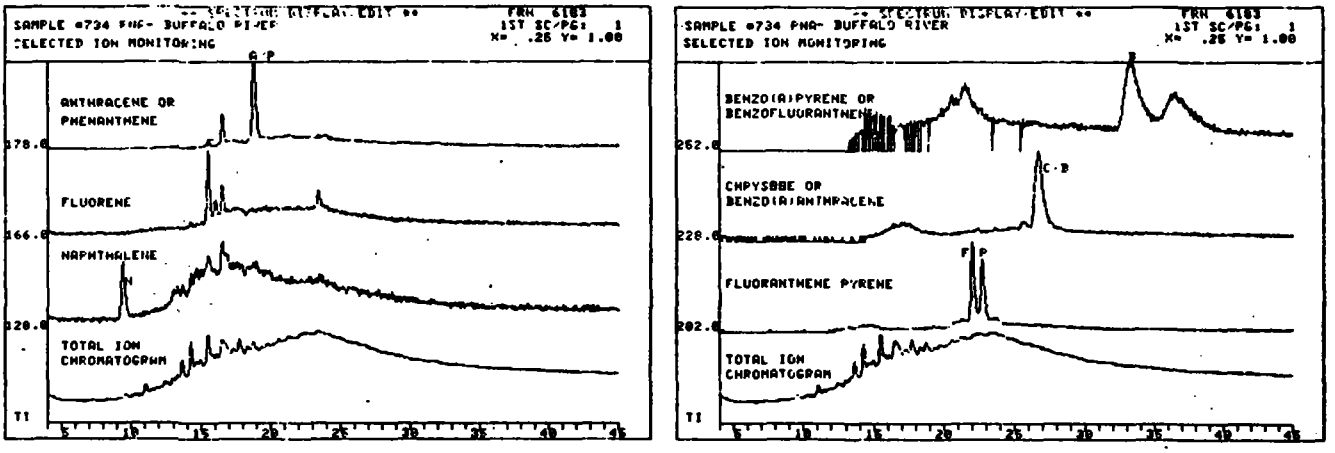


Figure 3 GC/MS ANALYSIS OF A SEDIMENT SAMPLE

R. Malcom

TRANSPORT OF COAL-TAR DERIVATIVES IN THE PRAIRIE DU CHIEN-JORDAN AQUIFER, ST. LOUIS PARK, MINNESOTA

A Project Proposal

by the

Minnesota District
U.S. Geological Survey

February 1981

INTRODUCTION

Operation of a coal-tar distillation and wood-preserving plant during 1918-72 in St. Louis Park, a suburb of Minneapolis, resulted in contamination of ground water. The severity of the contamination, and the efforts of local, State, and Federal agencies to define and resolve the technical, management, and legal issues involved, have made the matter highly visible. The Minnesota Pollution Control Agency and Region V of the EPA agree that coal-tar derivatives in ground water in St. Louis Park is the most significant single example of ground-water contamination identified to date within their jurisdictions.

In July 1978, the U.S. Geological Survey, in cooperation with the Minnesota Department of Health (MDH), began a 2-year project to develop a detailed understanding of the transport of coal-tar derivatives through the ground-water system in the St. Louis Park area. Information on multiaquifer wells in the area was provided to the MDH in February 1979. Hult and Schoenberg (1980) summarize data obtained during the first year of the study and present preliminary conceptual models of the mechanisms and pathways of contaminant transport. Hult (1981a) interprets these and additional data in greater detail and presents the results of preliminary analytical and computer modeling of transport in the Prairie du Chien-Jordan aquifer. Hult (1981b) evaluates the effect of multiaquifer wells on the spread of contaminants between aquifers.

As stated in the project proposal for the first 2-year project (December 1978, p. 2):

> "The problem is complex... The first two-year study (MN 79-061) will provide valuable insight into the problem and will aid decisions on probable continuation of the project for at least two more years. Development and application of a calibrated ground-water transport model to evaluate the possible effects of remedial actions proposed by State and local agencies will require extension of this project."

The new 2-year project now being proposed is in agreement with the timing and purpose of the project foreseen in 1978 and cited in the previous paragraph. The major effort will be to help resolve the contamination problem. Research by the Geological Survey of the St. Louis Park problem will have significant transfer value to similar problems elsewhere.

> "Because of intense local concern, considerable Federal interest, complexity of the problem, and difficulty of effective remedial action, it is anticipated that continued funding will be available. The approach to the problem must therefore balance the immediate needs of the cooperators with the longer-term requirements of a more definitive study." (1978 project proposal, p. 4).

THE PROBLEM

The problem of most immediate concern to the city and to State and Federal regulatory agencies is the presence of toxic organic compounds in water withdrawn from some municipal wells. When the first municipal well was drilled in 1932, the Prairie du Chien-Jordan aquifer contained water having a coal-tar taste at least 3,500 feet from the plant site. During 1978-80, use of five more St. Louis Park municipal wells completed in this aquifer was discontinued because the wells yielded water containing trace amounts of coal-tar compounds, including benzo(a)pyrene, a carcinogen.

Contaminants in the Prairie du Chien-Jordan aquifer have moved at least 2 miles northeast and southeast of the plant site. The direction and rate of contaminant movement changes with time because the bedrock ground-water flow system continually adjusts to hydraulic stresses caused by ground-water withdrawals and flow through wells that connect more than one aquifer. Contaminants can move rapidly through the Prairie du Chien-Jordan because the upper part of the aquifer is a carbonate rock having fracture and solution-channel permeability and low effective porosity. Consequently, the concentration and composition of contaminants in water pumped from individual industrial and municipal wells completed in the aquifer fluctuates with time.

The Prairie du Chien-Jordan aquifer is the region's major ground-water resource. About 75 percent of ground-water withdrawals in the St. Louis Park and Minneapolis-St. Paul metropolitan areas are from this aquifer. The aquifer is relatively well protected from near-surface sources of contamination. In the St. Louis Park area, it is 250 to 500 feet below land surface and is overlain by drift, two bedrock confining beds (Glenwood and basal St. Peter), and two bedrock aquifers (Platteville and St. Peter). Nonetheless, it is now contaminated. The project now being proposed will focus on the Prairie du Chien-Jordan aquifer because of its local and regional importance and the significance of the contamination to municipal water supplies.

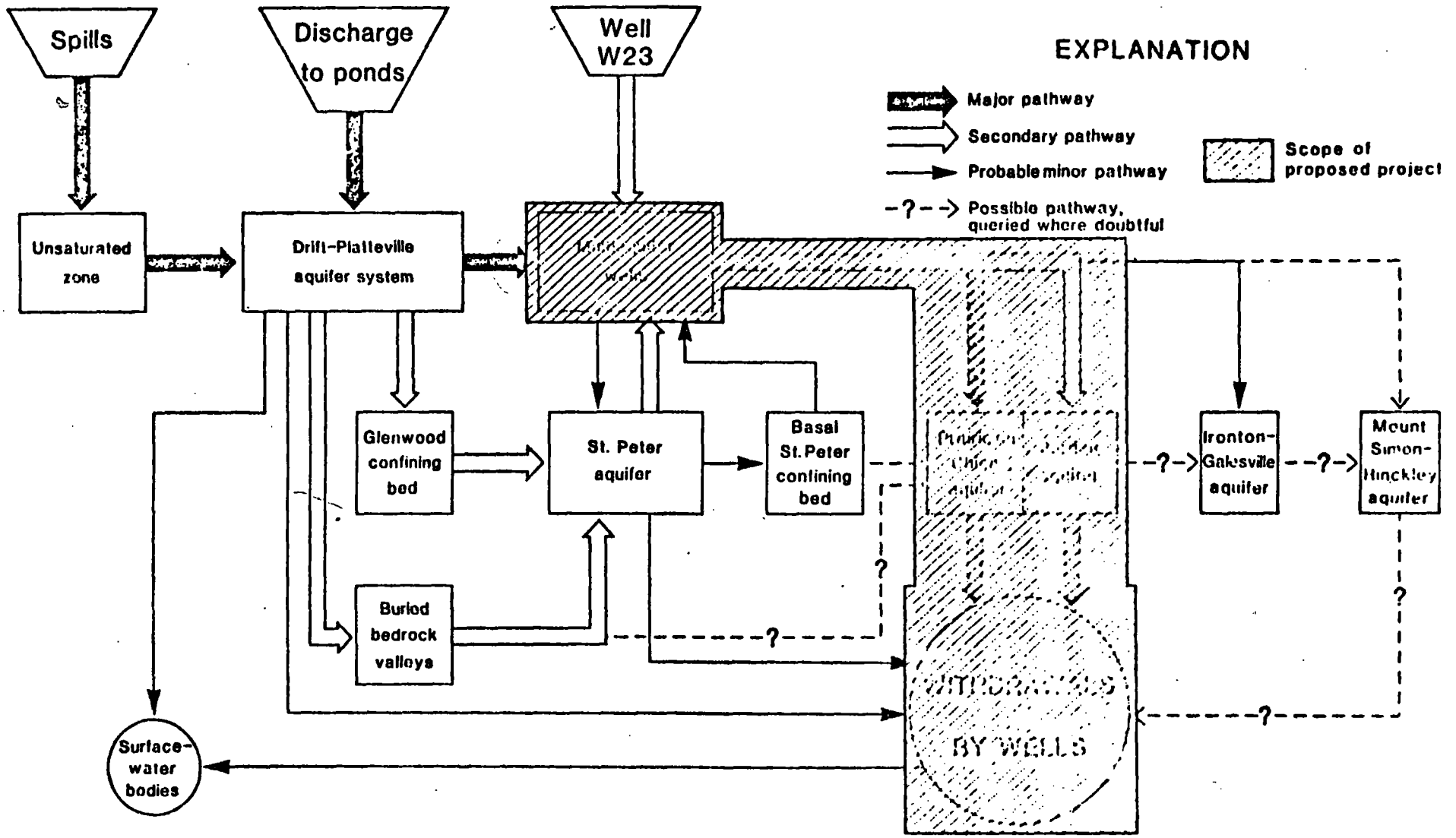


Figure 1.--Flow chart showing conceptual model of introduction and transport of coal-tar derivatives through the ground-water system, St. Louis Park area, Minnesota and scope of proposed project (modified from Hult, 1981a)

The greatest mass of contaminants is in the drift and uppermost bedrock aquifer (Platteville) near the site. Figure 1 shows the conceptual model of the introduction and transport of contaminants through the ground-water system. Coal-tar derivatives reached the water table by percolation through the unsaturated zone and through ponds that received surface runoff and process water from the plant (fig. 1). Parts of the drift contain an undissolved liquid mixture of many individual coal-tar compounds. In June 1980, a sample of this liquid from a monitoring well completed in the drift 50 feet below the water table contained 97,000 mg/L total organic carbon. The hydrocarbon fluid has moved vertically downward essentially perpendicular to the direction of ground-water flow because it is more dense than water. It is moving more slowly than the ground water because it is more viscous. Ground water entering the area of the plant site through the drift is contaminated by partial solution of the hydrocarbon fluids and by release of compounds sorbed on the drift materials. The contaminated water moves laterally to the east and southeast and downward into the Platteville aquifer. Water in the drift 4,000 feet from the site contains less than 10 mg/L dissolved organic carbon, but has a distinct "chemical" odor and contains a large proportion of coal-tar compounds of high solubility in water relative to compounds of low solubility. It seems that some organic compounds moving through the drift are being degraded by anerobic bacteria to other organic compounds and to methane. The USGS research group, with the assistance of the District, is continuing to investigate the rates of degradation, the compounds being degraded, and the nature of intermediate degradation products.

Contaminants entered the uppermost bedrock aquifer, the Platteville, directly from the drift and have moved at least 7,000 feet from the site. The contaminants reached deeper bedrock aquifers, primarily the Prairie du Chien-Jordan, through wells that hydraulically connect the aquifers (fig. 1). Coal-tar compounds have moved to a depth of at least 650 feet in the bore of a multiaquifer well 4,000 feet from the site. Locally, the contaminants have reached the St. Peter aquifer through the Glenwood confining bed and (or) through bedrock valleys where the confining bed has been removed by erosion (fig. 1). In addition, coal-tar has entered bedrock aquifers, possibly from a spill, directly through a well on the site that was drilled in 1917 to a depth of 909 feet (well W23; fig. 1).

OBJECTIVES

The goal of this and the previous study is to obtain a detailed understanding of the transport of coal-tar derivatives through the Prairie du Chien-Jordan aquifer in the St. Louis Park area. This understanding will be used to test management strategies suggested by the cooperators or their consultants and will have considerable transfer value to similar problems elsewhere.

The specific objectives are to:

1. Improve understanding of the distribution and movement of selected coal-tar derivatives in the Prairie du Chien-Jordan aquifer.
2. Provide for consultation between the USGS, EPA, MDH, MPCA, the city of St. Louis Park, and the private consultants to MDH.

3. Provide for continued geophysical logging and evaluation of multiaquifer wells as they are located in the field.
4. Obtain additional information on the physical and chemical characteristics of the source volume of contaminants in the drift and in well W23.
5. Preserve continuity in the collection of time-series, water-level, and pumpage data from all aquifers.
6. Provide continuing support for related, but separately funded, research by the Geological Survey, such as the study of biodegradation of coal-tar derivatives.

SCOPE

A major emphasis in the proposed project is development of a method for evaluating the effectiveness of measures proposed to minimize both the concentration of coal-tar derivatives in municipal wells and the continued spread of contaminants in the Prairie du Chien-Jordan aquifer. Hult (1981a) has shown that manipulation of withdrawals from industrial and municipal wells, in conjunction with a continued effort to locate, evaluate, and seal multiaquifer wells that permit contaminated water to flow into the aquifer, may be effective in minimizing the concentration of contaminants reaching municipal wells. Preliminary solute-transport computer models have proven to be useful tools in evaluating the problem. The proposed project focuses on refining these tools to better reflect hydrogeologic conditions and on using them to evaluate the hydrologic effects of future management.

Multiaquifer wells are the major pathways identified, to date, of contaminant transport to the Prairie du Chien-Jordan aquifer (Hult, 1981a; 1981b). Continuing evaluation of multiaquifer wells, in conjunction with the well-abandonment program of MDH, is within the scope of the proposed project. Reconstruction of multiaquifer wells as monitoring wells would be highly desirable but would require additional funding.

Evaluation of other pathways of contaminant transport to the aquifer, such as those shown in figure 1, will depend mostly on previously collected data. Coal tar entered the Prairie du Chien-Jordan aquifer through a deep well on the site (well W23; "Hinckley well on the site"). The coal tar in and around the well may be a continuing source of contaminants to the aquifer (Hult, 1978; 1981a; 1981b; Hult and Schoenberg, 1980). Tar and water samples from the well will be collected and analyzed for the proposed project. Additional steps needed to evaluate this source have been suggested to the MDH and would require additional funding. Contaminants may also be entering the Prairie du Chien-Jordan from the overlying St. Peter aquifer (fig. 1). The mass of contaminants entering the aquifer through this path seems to be small compared with entering through multiaquifer wells (Hult 1981a). Additional monitoring wells would be needed to further test this hypothesis and would require additional funding.

Management strategies aimed at minimizing the impact of the contaminants are summarized in table 1. Each of the three user alternatives have been implemented or are being evaluated by the city of St. Louis Park. The quality of water withdrawn from municipal wells is being monitored by the city and the MDH. Pilot studies by the city and their consultants have shown that organic contaminants can be partly removed by treatment with activated carbon. The city has increased withdrawals from deeper wells in the Mount Simon-Hinckley aquifer and is evaluating the cost and desirability of deepening wells, drilling new deeper wells, and (or) obtaining water from Minneapolis.

Table 1.--Summary of management strategies to minimize the impact of ground-water contaminants (modified from Hult, 1981a)

1. USER ALTERNATIVES

   a. Monitor the quality of water at the well head. If quality is unacceptable,

   b. Treat, or

   c. Develop alternative supplies.

2. AQUIFER MANAGEMENT

   a. Prevent or reduce movement of contaminants into the aquifers. For example, locate and seal multiaquifer wells that permit contaminated water to flow into the Prairie du Chien-Jordan aquifer.

   b. Control the movement of contaminants within the aquifers, so that the concentration of contaminants at each withdrawal well does not exceed acceptable limits. In the Prairie du Chien-Jordan, this might be accomplished by manipulating pumpage from municipal and industrial wells and by pumping wells installed for controlling hydraulic gradients.

3. SOURCE MANAGEMENT

   a. Intercept contamination leaving the source with withdrawal wells, treat (if necessary), and reinject or discharge.

   b. Immobilize the contaminants in the source either with hydraulic or physical barriers or by chemically reducing contaminant solubility.

   c. Convert contaminant compounds in the source to other compounds that are less toxic by encouraging insitu degradation by anerobic bacteria or by providing oxygen for degradation by aerobic bacteria.

   d. Remove (partly) the source by excavation and pumpout wells.

The proposed project will focus on using a solute-transport model to evaluate the hydrologic effects of the aquifer-management strategies for the Prairie du Chien-Jordan indicated in table 1. The MDH began a program of well abandonment in February 1979, based on information provided by the USGS. This program has been effective in reducing the amount of contaminants entering the Prairie du Chien-Jordan aquifer. Manipulating pumpage from wells may be effective in reducing the contaminant concentration at any given well and in preventing further spread of contaminants. Figure 2 shows changes in the concentration of some coal-tar compounds in water from St. Louis Park municipal well 4 and pumpage from municipal well 6. Well 4 was pumped only for obtaining samples. Both wells are completed in the Prairie du Chien-Jordan aquifer; no other nearby wells were known to have been pumping during the period indicated. The data from wells 4 and 6 support the tentative conclusion that manipulating pumpage may be effective in reducing contaminant concentrations at individual withdrawal wells. However, additional time-series data on contaminant concentration, pumpage, and water levels are needed to test whether the correlation between pumpage and chemical concentration is coincidental or whether there is a causal relationship.

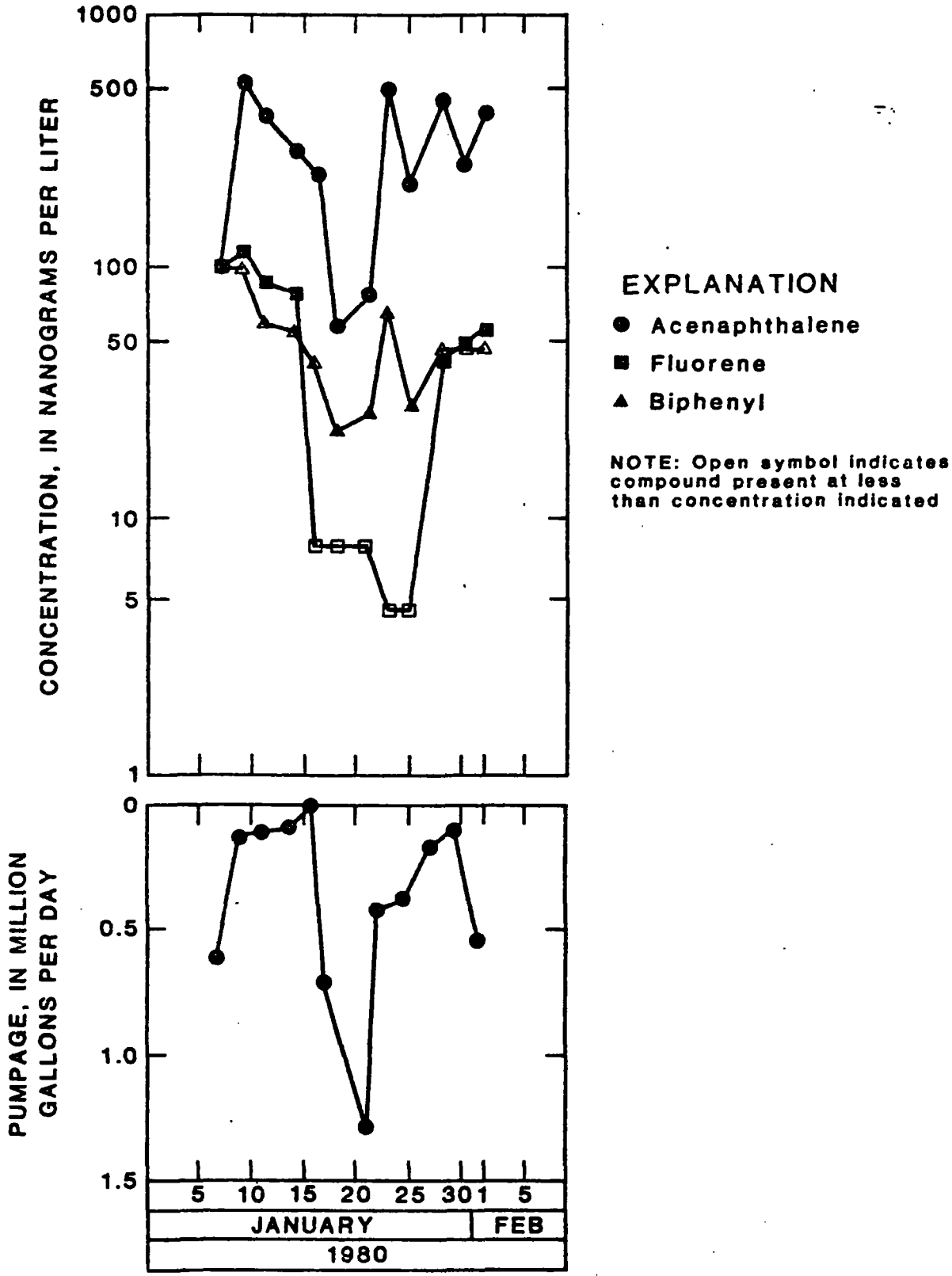


Figure 2.--Changes in water quality in St. Louis Park Municipal Well 4 and pumpage from Well 6, January 1980. Both wells are completed in the Prairie du Chien-Jordan aquifer (from Hult, 1981a)

Continued detailed evaluation of the contaminant source in the drift and Platteville aquifer and of movement of contaminants through the St. Peter, Ironton-Galesville, and Mount Simon-Hinckley aquifers is beyond the scope of the proposed project. However, some additional work on aspects of the problem have been incorporated into the proposed project, which will aid in designing and evaluating the source-management strategies shown in table 1. Results of ongoing basic research by the Geological Survey will be directly applicable to the St. Louis Park problem, but some outstanding questions are sitespecific and will require additional fieldwork. The scope of the proposed project could be expanded to include additional work if funds become available. The relationship between past projects, the proposed project, and possible future projects is shown in table 2.

Table 2.--Relationship of proposed project to past and possible future projects

USGS project	Dates	Principal objectives	Related activities by other agencies	USGS publications
Project MN-79-061	July 1978-June 1979	Develop an understanding of the transport of coal-tar derivatives through aquifers in the St. Louis Park area.	Well abandonment program by MDH	Hult and Schoenberg, 1980
	July 1979-Sept. 1980			Hult, 1981a; 1981b
Proposed project	Oct. 1980-Sept. 1982	Develop an improved understanding of contaminant distribution and transport in the Prairie du Chien-Jordan aquifer.	Design of proposed remedial action by consultants to MDH	1982
Possible future projects	Oct. 1981-Sept. 1982	Continue collection of time-series data in all aquifers. If additional funds become available, refine understanding of transport in the drift, Platteville, St. Peter, Ironton-Galesville, and Mount Simon-Hinckley aquifers, as needed to evaluate proposed remedial measures.	Implementation of remedial actions by State and local agencies	
	Oct. 1982-Sept. 1983	Attempt calibration of transport models based on 4 years of time-series chemical data and response of the ground-water system to remedial actions. Design a long-term strategy to monitor and evaluuate the effectiveness of remedial measures.		

APPROACH

The principal activities needed to meet the objectives are (1) a mass sampling of wells in the Prairie du Chien-Jordan aquifer to determine the areal extent of measureable contamination, (2) refinement and maintenance of the network used to monitor water levels, water quality, and pumpage, (3) additional coring, sampling, and chemical analyses to better define the composition and physical characteristics of the contaminant sources in the drift and well W23, (4) continued work on identifying, locating, testing, and sealing or reconstructing multiaquifer wells; this work will be coordinated with the MDH and (5) refinement of transport models of the Prairie du Chien-Jordan aquifer to reflect hydrogeologic boundaries and hydraulic and chemical stresses. As funding, time, and the availability of wells permit, attempts will be made to obtain additional time-series data on water quality in the Prairie du Chien-Jordan and to continue monitoring water quality in other aquifers.

The Regional Water-Quality Specialist will be consulted to develop a quality-assurance program. This is needed to ensure the validity of chemical analyses from the various laboratories involved. Continued support will be available from the Geological Survey laboratories in developing the quality-assurance program and in chemical characterization of the contaminants. A complete description of the quality-assurance program will be developed as part of the proposed project.

Mass Sampling of Prairie du Chien-Jordan Aquifer

Mass sampling of water from wells in the Prairie du Chien-Jordan aquifer is needed to obtain more complete information on the distribution of individual organic and inorganic constituents within the aquifer at a single time. No additional wells will be installed for this sampling effort. Many wells in the area are used for air conditioning and irrigation and may not be available for sampling during the winter. An attempt will be made to coordinate this sampling with the ongoing monitoring by MDH. Specifically, MDH could help by making arrangements for sampling of wells that are not usually available. It would also be highly desirable for MDH to analyze the concentration of PAH compounds by HPLC in samples taken at the same time as those collected by the Survey for analysis by an EPA contractor. Because MDH intends to continue monitoring, this approach will require no additional laboratory work by MDH. It will, however, help in the evaluation of the compatibility and reproducibility of analytical results from the various laboratories.

Tasks:
1. Compile available information on water quality and wells.
2. Identify areas where additional wells are needed.
3. Compile list of candidate wells for sampling.
4. Field locate new wells and make necessary arrangements.
5. Sample approximately 40 wells within 2- to 4-week period.

Refinement and Maintenance of Monitoring Network

Water quality, water levels, and(or) pumpage from about 300 wells in the St. Louis Park area were measured as part of the previous project. This network will be reevaluated, modified, and maintained as necessary to best meet the data needs of the proposed project and future activities.

About four additional recorders will be installed to monitor pumpage and water levels in the Prairie du Chien-Jordan aquifer. The frequency of measurement will be reduced at most wells in the drift and Platteville aquifers. Attempts will continue to locate additional wells in areas where data are sparse.

Physical and Chemical Characterization of the Drift and Platteville Aquifers and Contaminants in Well 23

Cores will be obtained from at least two additional test holes in the most highly contaminated volume of drift and from the coal tar in Well 23. These samples, some previously collected cores, and fluid pumped from selected wells will be analyzed for individual organic compounds. The samples will be analyzed by an EPA contractor and by the Geological Survey to obtain a complete chemical characterization of coal-tar derivatives in the source volume of contaminants. Fluid samples collected from a mass-sampling program will be analyzed by MDH and the EPA contractor for selected compounds to aid in delimiting the areal extent and severity of contamination in the aquifers. Continued work on the chemical and biological fate of the organic contaminants in the drift and Platteville aquifers will be coordinated with the Survey research group.

Aquifer tests in the drift and Platteville aquifers are needed to better evaluate strategies. Pumping tests will be made if MPCA can obtain necessary permits (if any) for discharge of contaminated water. Additional testing may include slug-testing of piezometers and laboratory analyses of cores for porosity and hydraulic conductivity.

Evaluation of Multiaquifer Wells

As additional wells are located in the field, the Geological Survey will log the wells geophysically and measure water levels and vertical flow within the well bore (if any). The MDH will provide for removal of obstructions in the well bore (if any), collect and analyze water samples, log with downhole television camera, and permanently seal or reconstruct as monitoring wells, if needed and as funding permits.

Model Development

The purpose of a ground-water solute-transport model is to (1) provide a framework for quantitative accounting of the major processes in and properties of the ground-water system that govern the transport of contaminants and (2) provide a tool that can be used in evaluating the effectiveness of remedial actions for reducing contamination in the Prairie du Chien-Jordan aquifer.

Tasks:

1. Expand and refine present two-dimensional transport model (Konikow and Broedehoeft code) to better reflect actual conditions. Test parameter sensitivities.
2. Using SWIP, incorporate separate layers for Prairie du Chien and Jordan and realistic boundary conditions. Attempt calibration by matching head changes (steady-state and transient).

2a. If necessary to reduce computer costs, construct and use three-dimensional flow model (Trescott code) to evaluate flow problem. Transfer refinements to SWIP and retest.

3. Using SWIP, add simplified history of contaminant introduction to evaluate transport rates and directions, parameter sensitivities, and uncertainties that may be caused by unlocated multiaquifer wells.
4. Using SWIP and the measured distribution of contaminants, evaluate effect of manipulating pumpage, including municipal wells, industrial wells, and hypothetical gradient-control wells.
5. Using SWIP, and as time and time-series data permit, attempt calibration of transient transport of selected contaminants.

Model data needs and source of information

1. Aquifer and confining bed geometry - from Hult and Schoenberg, 1980; Guswa, 1981.
2. Aquifer and confining bed hydraulic properties - from previous pumping and laboratory tests in St. Louis Park and elsewhere in the Twin Cities basin - Guswa, 1981; and ATES project.
3. Hydrogeologic boundaries - from Guswa, 1981 (Twin Cities project).
4. Time-series data on hydraulic head - from Hult and Schoenberg, 1980; Guswa, 1981, and from monitoring network refined and operated for the current project.
5. Adsorption isotherms - from batch experiments to be conducted by the University of Minnesota for phenol, naphthalene, and acenaphthene.
6. Time-series data on ground-water withdrawals - compiled for previous project (061) and from monitoring network refined and operated for current project.
7. Hydraulic effect of multiaquifer wells - from Hult, 1981a; 1981b; and from measurements made for the current project.
8. Chemical effects of multiaquifer wells - from Hult and Schoenberg, 1980; Hult, 1981a; 1981b; and from measurements made for the current project.
9. Present distribution of selected contaminant compounds - from Hult, 1981a, and from chemical mass measurements made for the current project.
10. Time-series data on concentration of selected contaminant compounds - from Hult, 1981a. Some additional measurements may be made for the current project.

TIME SCHEDULE AND REPORT PLANS

The project will take 2 years to complete. Fieldwork (other than network maintenance), model development, and report preparation will be completed in FY 81. The report will be submitted to the Region by April 1, 1982. Because of the need for speedy publication, the report will be published in the WRI series. At some later time, however, the report could be considered for WSP publication.

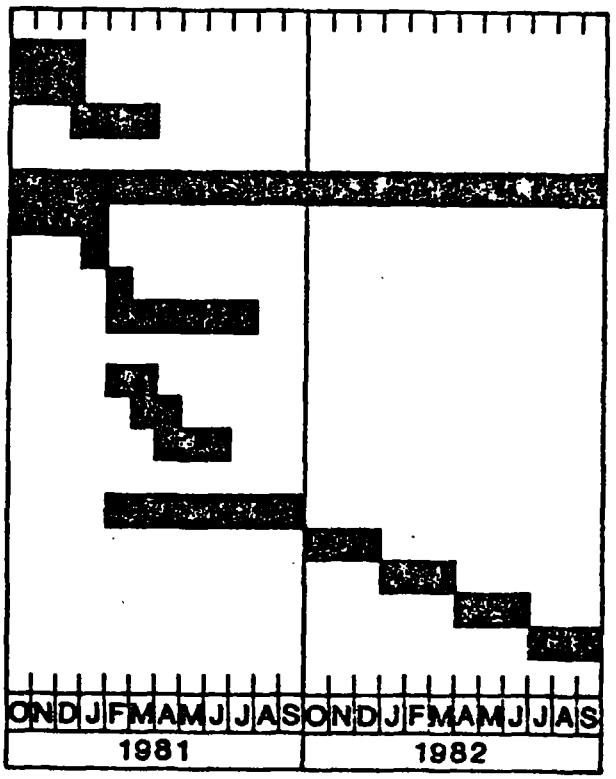
SUMMARY WORK PLAN

Project Proposal and Plan
Previous Reports to District
Design Quality Assurance Program

Maintain Hydrologic Data Network
Initial Fieldwork
Initial Sampling
Mass Sampling
Additional Fieldwork

Refine Transport Model
SWIP Model Functional
SWIP Model Well-posed

Report Preparation
District Review
Colleague Review
Region Review and Headquarters
Drafting and Printing



COST SCHEDULE

The costs for this project (Federal FY 81 and 82) will be shared by the city of St. Louis Park, MDH, MPCA, EPA and the USGS. The MDH will collect and analyze samples from municipal wells, provide downhole television camera surveys, and prepare selected wells for geophysical logging (through the well-abandonment program) in the amount of $36,000 in lieu of funds that will be matched by the Survey. The city of St. Louis Park will assist in monitoring pumpage, water levels, and water quality in municipal wells, and will provide landscaping of monitoring-well sites in the amount of $10,000 in lieu of funds that will be matched by the Survey. Proposed funding and expenditures are as follows.

St. Louis Park Proposed Funding for FY 81

	Cash	Services	USGS match	WOTSC[1]	DOTSC[2]	Net cash
EPA	$50,000	$ —	$ —	$ 7,250	$12,750	$30,000
SLP	5,000	10,000	15,000	2,700	5,100	12,200
MPCA	14,000[3]	—	14,000	2,520	7,140	18,340
MDH	5,000	36,000	41,000	7,380	11,730	26,890
Total	74,000	46,000	70,000	19,850	36,720	87,430

[1] EPA - 14.5 percent; all others at 9 percent.
[2] 25.5 percent of all cash and matching; 0 percent on direct services.
[3] Funds may come from either MPCA or MDH.

Itemized expenditures for FY 1981

Salaries	$ 48,430
Travel	3,000
Supplies	2,500
Equipment	5,000
Vehicles	2,800
Computer	10,700
Laboratory	5,000
Drilling and physical analyses of cores	7,000
Analytical services (University of Minnesota)	3,000
District support	36,720
Headquarters support	19,850
Direct services	46,000
Total	190,000

Proposed Funding for FY 82--Report processing and publication

Salaries	$ 19,000
Printing and reproduction	2,500
District support	8,500
Headquarters support	3,000
Total	$ 33,000

PERSONNEL REQUIREMENTS AND AVAILABILITY

District personnel needed for the project are as follows:

	FY 81	FY 82
Hydrologist GS-11	full time	1/2 time
Hydrologist GS-11	1/5 time	---
Hydrologist GS-7	1/4 time	---
Hydrologic Technician	3/4 time	1/4 time

These personnel are presently available in the District.

The assistance of the Regional Water-Quality Specialist will be requested to help develop a quality-assurance program in coordination with the Central Laboratory and the research group. Ongoing research on biotransformation will probably continue. District assistance in the use of the SWIP code is available, but additional consultants may be required.

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UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
CENTRAL REGIONAL LABORATORY
1819 W. PERSHING RD.
CHICAGO, ILLINOIS 60609

April 26, 1977

Mr. Roman Koch
Minnesota Department of Health
Division of Environmental Health
717 Delaware South Court
Minneapolis, Minnesota 55440

Dear Mr. Koch:

Pursuant to our telephone conversation two weeks ago, the sample extract from Well #13, St. Louis Park, was re-analyzed specifically for the objectives you specified to me. The results of the analysis (using gas chromatography.mass spectroscopy) revealed that over 50% of the sample extract consists of polynuclear aromatic hydrocarbons.

Some of the compounds tentatively identified are as follows:

naphthalene*	acenaphthene
pyrene*	dibenzofuran
anthracene & phenanthrene*1	fluorine
fluoranthrene*	benzophenanthene
methyl naphthalenes	benzofluoranthene

The CRL could have saved considerable time and provided an analysis more consistent with your needs for all the samples submitted if a brief memo had been included with the samples outlining your objectives, history of the samples, and whom to contact for questions. We would appreciate it very much if this is done for future requests.

If you have any questions regarding the re-analysis or any other subject matter, do not hesitate to call me (FTS 8-353-8370).

*These compounds are present in higher concentrations relative to the others.
*1 We could not differentiate between the two.

Sincerely,

Emilio Sturino

Emilio Sturino, Ph.D.
Chief, Organic Section

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
CENTRAL REGIONAL LABORATORY
1819 W. PERSHING RD.
CHICAGO, ILLINOIS 60609

April 26, 1977

Mr. Roman Koch
Minnesota Department of Health
Division of Environmental Health
717 Delaware South Court
Minneapolis, Minnesota 55440

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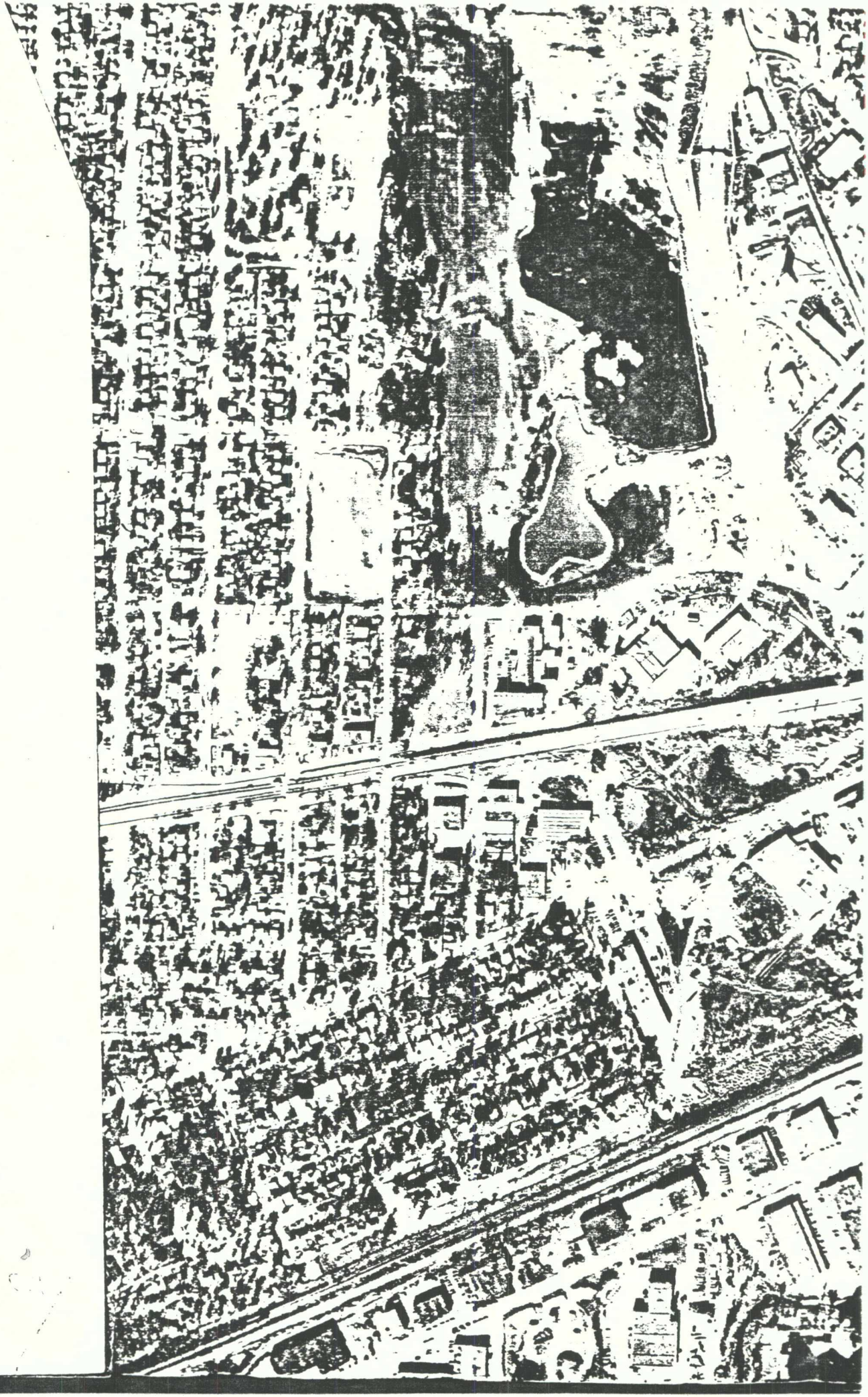

-3

The analyses of the coal tar distillation / wood preserving site in St. Louis Park, Minnesota preformed by Barr Engineering Co. has shown that contamination has occurred to the glacial drift ground water systems and ~~that the waste in the drift is a potential that~~ also and has slightly contaminated the underlying bedrock ground water aquifers. As part of the redemial actions a major recommendation of the report is that the identified coal-tar wastes in the glacial drift and Platteville aquifer be controlled by gradient control wells. Under this technique, a system of pumpout wells are placed in the aquifer to intercept the wastes. Water from the gradient control wells can be discharged to the sanitary sewer system, treated and discharged to Minnehaha Creek, or a combination of these two disposal locations can be used.

Besides contamination to the upper aquifers, the deeper aquifers in the Mt. Simon - Hinckley FORMATION have been slightly contaminated by the waste. The community of St Louis Park and various industries have ~~had~~ abandon wells in the area. Realizing the purpose of this evaluation is to develop an order-of-magnitude cost estimate for the redemial activities at the site a number of assumptions must be made to complete the estimate. The first major assumption is that the deeper aquifers identified above must also have redemial actions. The following section develops the information necessary

to complete THE order-of-magnitude cost estimate for treatment and disposal of the CONTAMINATED ground water ~~below the site~~.

Wastewater Quantities and Characteristics

Characteristics of the waste water from the glacial drift gradient control wells have been preliminarily developed ~~by~~ in the Barr Engineering report. In lieu of the study presently being preformed by the USGS these values are the best available. Table #1 column A attached summarizes the wastewater quantities and characteristics for the glacial drift control wells. The report projected the ground water quality from data collected during the study and over the previous few years. A range for the characteristics is presented in the Barr report, however for purposes of this report the maximum value will be used because a treatment ~~plant~~ system must be designed for the maximum loading. In accordance with this philosophy of being conservative the projected flow of 45 gpm was increased to 100 gpm.

P11 Also on table 1 in column B the characteristics of the Platteville (100 gpm), St. Peter (100 gpm), and Prairie du Chien-Jordan (225 gpm) are projected using values from the same report. The values are the low end of the range presented for THE down gradient control wells ~~for~~ FROM the glacial drift and are being applied to these aquifers (THIS BEING ~~in order to be~~ conservative. The flows (which are in ~~the~~ brackets) were developed

from experience and using good engineering judgement. ~~The~~ Column D on the same table combines the two (shallow aquifer) projected waste streams. These two streams have been combined because they are the most contaminated streams ~~which~~ and will ~~have~~ a probably have a high degree of variability. ~~Their disposal will be elaborated in the report.~~ The Polynuclear Aromatic Hydrocarbons that have been tentatively identified are as follows:

naphthalene*	acenaphthene
pyrene*	dibenzofuran
anthracene ~~or~~ phenanthrene*1	fluorine
fluoranthrene*	benzophenanthene
methyl naphthalenes	benzofluoranthene

This streams disposal will be discussed later in this report.

The characteristics of the ~~deep~~ Mt. Simon-Hamilton aquifer are projected ~~on~~ in column C on ~~the same~~ table 1. Lacking other data ~~an~~ (The following) assumption was made: The deep aquifers ~~g~~ are contaminated with the same waste as the glacial aquifer therefore the pollution characteristics will be similar (to the same degree) just diluted by a factor. The dilution factor was applied ~~developed~~ using the ~~following~~ methodology that if the concentration of similiar pollutants are know for both aquifers then the ratio between the two can be applied to ~~the other variables~~ unknown parameters. ~~Though~~ Even tho this is not theoritically accurate, it will procduce an (approximate) order of magnitude value. After the 100 minute

pumping test conducted on the on-site Mt. Simon-Hinckley well there was a phenolic concentration of 0.005 mg/l. Taking the ratio between this value and the 3 mg/l projected ~~by B~~ for the glacial drift yields a dilution factor of 0.00167. Applying this factor to the remaining ~~values~~ parameters in column A on table 1 yielded the remaining values in column C. for the Mt. Simon-Hinckley aquifers. It must be stated that before any remedial actions are actually suggested for this aquifer it must be characterized by an extensive sampling program. However, in order to develop a cost estimate the values on table 1 which are felt to be conservative will be assumed representative of the source. To control the pollution in this ~~well~~ aquifer by gradient control wells, the maximum drawing force of 1500 gpm from the municipal wells must be equalized by a cone of depression created by the new wells. Therefore a pumpstrate of 1500 gpm is assumed to be the flow necessary for ~~that~~ the deepest gradient control wells.

Discharge of gradient control wells.

The disposal of the ground water can be ~~handled~~ by two routes – discharge to the sanitary sewer or discharge to the Minnehaha Creek after appropriate treatment if necessary. Alternatives can be devised that will combine these two routes.

Since the discharge of the 1500 gpm from the Mt. Simon-Hinckley aquifer is ~~the easiest~~ easier, the report will address ~~the~~ its disposal first. Table 2 presents the standards for discharge of storm water from the site to the Minnehaha Creek (these values were abstracted from the Barr Engineering Report). Comparison of these values to those projected in column C on table 1 shows that the waste can be discharged directly to the creek.

The discharge of 525 gpm (0.756 MGD) from the gradient wells is not ~~as easy~~ quite as easy. Due to regulatory constraints the water quality parameters of most interest in the discharge from the ground water gradient control wells include phenolic substances, polynuclear aromatic hydrocarbons, chemical oxygen demand, and oil and grease. Even tho a majority of the identified organic pollutants are reported to be biodegradable it is not recommended that the waste be discharged directly to the sanitary sewer system because of the possibility of upset to the municipal system if a concentrated slug of

(and have a toxic effect on the microorganisms)

undiluted waste reaches the plant. Therefore pretreatment is necessary before discharge to the sewer.

To date the development and sizing of the treatment alternatives for the waste streams has been based upon theory, and a few preliminary tests using samples obtained from a ~~few~~ couple of wells. Initially the ~~pumping and~~ gradient control wells are expected to have a highly variable wastewater pollutant loading where the potential for upsets, equipment failures, and other unusual non-equilibrium conditions are great. Therefore, any waste treatment system must ~~be able~~ provide maximum flexibility and adaptability to handle wide fluctuating conditions. ~~Therefore~~, this would eliminate biological treatment which is prone to upsets during non-equilibrium conditions. ~~and direct~~ The most attractive approach to insure reliability and compliance of treatment facilities would be a physical/chemical treatment approach with discharge to the sanitary sewer system which reportedly can handle an additional flow of 0.756 MGD (without minimal problems). After continual operation it is feasible ~~possible~~ that after treatment the waste could be discharged ~~to~~ directly to the river.

HYPOTHETICAL

Potential Facilities for Treatment of the Waste Stream

A brief description of a treatment facility which theoritically should be able to handle the projected waste stream from the shallow aquifers is as follow:

The initial unit process would be a equilization tank of 0.756 mG ~~to be~~ necessary to homogenize the waste, handle surges, and act as a buffer for equipment failure further down the treatment train. Next will facilities to break the emulsified organics and remove the oil and grease from the wastewater. This can be preformed by chemical oxidants and coagulants followed by either gravity separation or filtration. Chemical selection must realize that, it is preferrable to avoid or minimize oxidants which contain chlorine because of the possible production of chlorinated hydrocarbons. For purposes of this study it will be assumed that the chemical addition will be at one-half the oil ~~and~~ and grease concentration (producing a suspended solids concentration of 540 mg/l) and filtration will be ~~required~~ preformed at a rate of 4 lbs/sq ft/hr. The discharge from the filtration unit will be pumped to Activated Carbon columns which will absorb 0.05 lbs of phenol substances per lb of carbon (along with certain polynuclear aromatic hydrocarbons ~~[illegible]~~). The sludge produce by the facility will be transported to an approved ~~disposal~~ landfill and the effluent wastewater should initially be discharged to the city sewer.

P The above treatment facility is based on the PRELIMINARY bench scale tests as reported by Barr Engineering, the treatability characteristics of coal tar waste, and

good engineering judgement. Further information and testing is required before any decisions are ~~are~~ finalized. The tests to date have only touched the surface and the ~~treat~~ treatment train was developed only for an order-of-magnitude cost estimate ~~only~~.

Facilities for the gradient control wells from the deep aquifers only requires an equalization basin to handle any unusual circumstances that might require the diversion of the waste to the city sewer systems and an effluent monitoring station.

CONCEPTUAL COST ESTIMATES

PREFORMED BY E/E PERSONNEL

The capital cost was developed on a process-by-process basis using vendor estimates, Means Building Construction Cost Data, unit cost values from prior ~~completed~~ projects, and the like. The costs came from different sources, but all costs were escalated to ~~1st~~ 1st quarter 1988 dollars using the Engineering News-Record Construction Cost Index of ~~2008~~. The capital costs of the individual processes were added for a total installed cost. Auxiliary costs (piping, electrical, instrumentation, and site preparation) are based on prior ~~Weston~~ DESIGN experience and are calculated as a percentage of the installed costs. Engineering and contingencies are calculated as a percentage of the total construction cost and added to give the total capital cost.

Using the procedures described above, the total capital costs should be understood as accurate to +50% to -40%. This estimate does not allow for unusual site preparation, ~~additional power facilities, disposition of existing ponds or their contents, or a final outfall pipe and structure.~~ OR OTHER UNUSUAL CIRCUMSTANCES INCLUDING LEGALITIES.

The conceptual capital and O/M costs estimates are presented on Tables 3 and 4. The total estimated conceptual Capital Cost is approximately 5,000,000 and the estimated Operation and Maintenance cost is _____.

Table

COAL TAR DISTILLATION / WOOD PRESERVING SITE
ST. LOUIS, MINNESOTA

Summary of Conceptual Operation & Maintenance Cost Estimate for Treatment of Creosote Contact Wells Wastewater

ITEM	YEARLY COST	35 YEAR COST IN 1981 DOLLARS
Power	80,000	2,800,000
Labor	320,000	11,200,000
Material	100,000	3,500,000
Chemicals	400,000	14,000,000
User Charge & Industrial Cost Recovery (1)	1,200,000	12,000,000
SLUDGE DISPOSAL	20,000	700,000
Taxes & Insurance	50,000	1,750,000
		~~45,950,000~~

TOTAL 35 year O/M 45,950,000
SA-146,000,000 capital

(1) The effluent will only be discharged for 10 years to the City treatment plant, the remaining years it will be discharged directly to the MINNEHAHA Creek

Table 1

COAL TAR DISTILLATION & WOOD PRESERVING SITE
ST. LOUIS PARK, MINNESOTA

ESTIMATED ANTICIPATED ~~PEAK~~ PARAMETERS FROM THE GRADIENT CONTROL WELLS

	A GLACIAL DRIFT AQUIFER	B PLATEVILLE ST. PETER PRAIRIE du CHEN JORDAN	C DEEPER AQUIFERS	D A & B COMBINED
Phenolic Substances mg/l	3	0.2	0.005 (2)	0.733
lbs/day	3.60	1.02		
Chemical Oxygen Demand, mg/l	1800	40	3	375
lbs/day	2161.73	204.16		
Oil and Grease, mg/l	1700	6	3	329
lbs/day	2041.63	30.62		
Polynuclear Aromatic Hydrocarbons, mg/l	100	10	0.170	27.14
lbs/day	120.00	51.04		
Biochemical Oxygen Demand, mg/l	300	30	0.5	81.43
lbs/day	360.29	153.12		
Flow, gpm	100	425	1500	525
MGD	0.144	0.612		0.756

(1) THE HIGHEST VALUE ON TABLE 8 IN "Soil and Ground Water Investigation" June, 1977, Prepared by the State of Minnesota, and authored by Barr Engineering Co.

(2) From page III-34 of report referenced in footnote #1, concentration after 60 minutes of pumping from MT. SIMON-HINCKLEY well on site.

(3) Report referenced in footnote #1 estimated 45 gpm, 135 gpm is an assumed safety factor

TABLE ~~10~~ 2

STANDARDS FOR DISCHARGES OF STORM WATER FROM SITE TO MINNEHAHA CREEK[a]

Substance or Characteristic	Permissible Concentration With Dilution	Permissible Daily Maximum Concentration
Oil and Grease, mg/l	0.5x[b]	15
Phenols, mg/l	0.01x	0.1
5-Day Biochemical Oxygen Demand, mg/l	5x	45
Total Suspended Solids, mg/l	5x	45
Total Chlorine Residual, mg/l	0.01x	0.2
Zinc, mg/l	0.12x	1.0
Cadmium, mg/l	0.03x	0.2
Copper, mg/l	0.01x	0.5
Nickel, mg/l	0.52x	2.0
Lead, mg/l	0.03x	1.0
Ammonia, mg/l as N	1.0x	2.0
Benzo-α-pyrene, mg/l	--	0.00001
Chrysene, mg/l	--	0.00001
pH, units	--	6.5-8.5

[a]Source: NPDES Permit No. MN 0045489. Refer to permit for additional detail.

$$b_x = \frac{(0.25)(\text{flow in Minnehaha Creek})+(\text{effluent flow rate})}{(\text{effluent flow rate})}$$

Flows used in calculation of dilution ratio "x" shall be the daily total effluent flow rate and the daily total flow rate for Minnehaha Creek.

A P P E N D I X F

TREATABILITY OF COAL-TAR DERIVATIVES IN EFFLUENT FROM GRADIENT CONTROL WELLS

APPENDIX F

TREATABILITY OF COAL-TAR DERIVATIVES IN EFFLUENT FROM GRADIENT CONTROL WELLS

Due to regulatory constraints, the water quality parameters of most interest in the discharge from the ground water gradient control wells include phenolic substances, polynuclear aromatic hydrocarbons, chemical oxygen demand, and oil and grease. Concentrations of these organic parameters can be reduced by a variety of physical, chemical and biochemical processes which are described in the literature. In this appendix, some of these processes are briefly described. The results of laboratory tests undertaken to investigate the feasibility of several simple treatment operations are also presented.

Physical Treatment

Gravity separation, the simplest form of physically removing oily material from water, is comparable to primary treatment of wastewater in conventional sewage treatment plants. This approach is often successful, especially where oily wastes are highly concentrated, and can result in removal of a variety of organic and oxygen-demanding substances and in recovering economically useful materials. However, it has been observed that hydrocarbon mixtures in effluent from the gradient control wells will not separate readily, either because of a highly emulsified condition or because of interaction with soluble organic material, such as phenols. Upon standing for periods in excess of 24 hours, a degree of separation did occur among samples from Well 13, with a heavier dark brown sludge settling below a tan to brown supernatant. However, the sludge fraction still contained a significant amount of water. Therefore, it is likely that gravity separation processes are not feasible for efficient removal of organic materials from the effluent. Thus, if physical treatment is to be useful, more sophisticated technology must be introduced. Flotation, filtration and coagulation processes have been successful in separating oil/water emulsions (Patterson, 1975; Reynolds and Shack, 1976).

Preliminary tests, which will be described in more detail in the discussion of chemical treatment, indicated that partial chemical oxidation and coagulation successfully broke the emulsions to produce a heavy sludge, leaving a reasonably clear supernatant. Other methods of physical treatment--such as volatilization, flotation, filtration and centrifugation--were not examined.

Chemical Treatment

A variety of chemical oxidants and coagulants are available that will participate in chemical reactions to remove oily or emulsified organics from wastewater by oxidation and/or coagulation. Oxidants such as chlorine, hypochlorite, chlorine dioxide, ozone, and potassium permanganate have been used successfully in pilot and plant scale operations for the removal of phenolic and other organics (Armco et al., 1951; White, 1972; Patterson, 1975; Reynolds and Shack, 1976). Coagulants such as various polyelectrolytes, manganese dioxide, alum and lime can also break emulsions and enhance gravity separation.

Of the oxidants mentioned above, chlorine and hypochlorite are very commonly used because of their application to disinfection of drinking water and sewage. The literature indicates that oxidation of phenolics by chlorine occurs most readily in the pH range of 7 to 10 (Armco et al., 1951). When dosage and/or reaction time are insufficient for complete oxidation, partial chlorination using chlorine or hypochlorite has the danger of producing chlorophenols, which tend to increase taste and odor problems (Morris, 1975). There also is a general concern that chlorination of some hydrocarbons may result in a release of potentially harmful compounds in the effluent (Kelley, 1975; Morris, 1975).

Chlorinated hydrocarbon production can be minimized or avoided by use of other oxidants either in combination with or in place of chlorine and hypochlorite. Ozone, chlorine dioxide and potassium permanganate have been found to oxidize aromatic hydrocarbons without the production of undesirable products (Armco et al., 1951; Carus, 1971; White, 1972; Johnson, 1975). Of these, ozone has the disadvantage of requiring on-site generation with

expensive capital and operating costs. Oxidation by potassium permanganate will result in the formation of manganese dioxide, a coagulant, and the production of significant quantities of sludge.

Although some investigations have identified trace chlorinated aromatic compounds produced by oxidation of phenolics with chlorine dioxide (Lindgren and Ericsson, 1969), pilot and plant scale operations using chlorine dioxide have shown that partial or complete oxidation of phenolics and COD can be achieved without formation of significant chlorophenols. Control of phenolic tastes and odors has required dosages of 0.3 to 10 pounds of sodium chlorite per million gallons of wastewater (White, 1972). Sodium chlorite is oxidized by Cl_2 to generate ClO_2 in most operations. Experimental oxidation of coke plant wastes showed that use of chlorine dioxide in combination with chlorine gas improved efficiency of using chlorine dioxide alone. Substantial elimination of phenolics appeared to be achieved in a period of 5 minutes or less (Armco et al., 1951).

Literature information and theoretical half-reaction stages for oxidation of organic compounds by chlorine dioxide indicate that a drop in pH can be anticipated as a result of the use of chlorine dioxide. Experimental use of chlorine dioxide to remove phenolics from coke plant waste with phenolic concentrations in the range of 80 to 200 mg/l resulted in a drop of up to 9.8 pH units. It appears that creation of both organic and inorganic acids is likely responsible for this change. Of the inorganic acids that may be produced, some have low dissociation constants, indicating they are strong acids. For example, $HClO_3$ could be produced during oxidation with chlorine dioxide and has a dissociation constant greater than 1, indicating it is a very strong acid (Johnson, 1975). HOCl, which is produced during conventional chlorination, is a weak acid by comparison with a dissociation constant of 2.9×10^{-8}.

To indicate the degree to which chemical oxidants might be effective in removing organics from the effluent from the gradient control system, several preliminary tests were conducted using sodium hypochlorite and potassium permanganate as oxidizing agents. Chlorine dioxide supplies for limited laboratory experiments could not be located.

For the oxidation experiments, ground water from Well 13 was diluted by 50% and by 98% with deionized water in an attempt to produce concentrations likely to be representative of effluent from the gradient control wells. Diluted samples were then oxidized with sodium hypochlorite (NaOCl) and potassium permanganate ($KMnO_4$) at concentrations based on literature information (Reynolds and Shack, 1976; Carus, 1971). A one-hour contact time was used to guarantee relatively complete oxidation reactions. After oxidation, NaOCl-oxidized samples were analyzed for phenolics, COD and pH. In addition, the most heavily oxidized sample from each dilution was analyzed for suspended solids and oil and grease, and each sample in the 50% dilution series was analyzed for biochemical oxygen demand. One sample was oxidized with $KMnO_4$ for comparison with NaOCl. This sample was analyzed for phenolics.

The results of these experiments are summarized in Table F-1 and show that both sodium hypochlorite and potassium permanganate were capable of oxidizing the organics from the middle drift aquifer. Phenolic removals were 12% or less where NaOCl dosages were not significantly greater than the theoretical requirement for complete decomposition. This is in agreement with the findings of others (Reynolds and Shack, 1976). Phenolic removals improved significantly with increased NaOCl dosage. On the other hand, COD removal appears to improve slightly with oxidant concentrations and with dilution. Since COD analyses do not measure aromatic hydrocarbons, this may reflect COD generation by the cleavage of aromatic rings partially compensating for COD destruction by chlorination. Oxidation efficiency appears to have been significantly higher with potassium permanganate than with sodium hypochlorite. This may have occurred because of a more specific affinity of $KMnO_4$ for phenolics, because of reaction pH, or for some other reason.

An undesirable byproduct of oxidation is the formation of suspended solids, especially with $KMnO_4$. After oxidation, suspended solids concentrations were measured in the samples oxidized with the highest hypochlorite dosages and were found to have increased by a factor of about two or more. Solids production in the sample oxidized with $KMnO_4$ was much more dramatic, with formation of a heavy sludge which occupied about 10% of the volume after a settling period of about 1 hour. Visual inspection of the remaining

oxidized samples the next day revealed that quiescent settling had removed substantially all turbidity from the samples.

In conclusion, experiment data indicate that the organics under study are amenable to treatment by chemical oxidation in a manner that is consistent with experience reported by others. High dosage requirements and sludge generation must be assumed if this is the only method of treatment employed. These processes appear to be helpful in breaking emulsions and enhancing gravity clarification.

Biological Treatment

Biological oxidation of phenolics and other organic wastes have received a tremendous amount of attention over the years. Trickling filters, activated sludge, oxidation ponds and other applications have been used on experimental and plant scale to remove COD, phenolics and aromatic hydrocarbons. In most cases, removal of emulsified oils to about 100 mg/l is necessary prior to biological treatment (Reynolds and Shack, 1976). This could complicate the use of biological treatment for direct oxidation of organics in the undiluted effluent from the gradient control wells. Examination of microbial degradation of these materials has led to isolation of various common microbes that are capable of oxidizing specific organics (McKenna and Heath, 1976; Cobb, 1973) and to the suggestion that toxic metabolic byproducts may be responsible for failure of unacclimated microbes to degrade some organics (Baird et al., 1974). Patterson (1975) and Reynolds and Shack (1976) present brief reviews of applications of biological treatment to oxidation of phenolics and creosote wastes. Removals of phenolics and COD ranging from poor to substantially complete removal are reported.

Several aspects of biological treatment must be considered in the treatment of organic wastes. First, all biological systems are susceptible to upsets due to variations in influent quality and to seasonal factors. Changes in waste strength, microbial nutrient balance, toxic chemical concentrations, hydraulic loadings, sunlight and temperature may affect the efficiency of the process. The production of biological solids can result in the need for sludge handling, although extended aeration can be used to

reduce the volume of sludge. To maintain aerobic conditions, oxygen supply systems are often needed. Biological treatment will need regular attention by trained personnel to control and maintain the treatment efficiency.

To examine the effluent from the gradient control wells for biological treatability, several tests were made using various ground water samples. These tests are summarized in Table F-2. They were conducted to indicate the biochemical oxygen demand of the raw water and to indicate whether or not prior chemical oxidation would seriously affect biodegradation.

Variations in 5-day BOD of samples taken June 2, 1977 may reflect variations in organic species found among the different sources. Failure of BOD tests to yield results for most samples probably reflects a combination of dilution in the BOD bottles and toxic effects due to the complex nature of organics present in the ground water. As the data indicates, the 5-day BOD's of samples taken June 2 from Well 13 and Well 17 were about 2,000 mg/1 and 30 mg/1, respectively.

Other BOD experiments were run with samples collected June 22, 1977 after 50% dilution with deionized water and oxidation with NaOCl. The 5-day BOD's of these samples were in the range of 2,000 to 3,000 mg/1, indicating that the 5-day BOD of the raw ground water obtained June 22 may have been in the range of 4,000 to 6,000 mg/1. This conclusion is supported by the fact that raw water COD was significantly higher on June 22 than on June 2. Reduction of toxic compounds due to chemical oxidation and variations in microbial seed or nutrient availability may also have been responsible for this change in BOD. While a sample of domestic sewage was used as the seed on June 2, water taken from the storm water pond south of Lake Street in the study area was used as the seed source in the second set of experiments, on the theory that these microbes might be better acclimated to metabolize phenolics and other aromatic hydrocarbons.

Data from the BOD tests of June 22 provide sufficient information to estimate BOD kinetic parameters for the oxidized ground water. Once initiated, microbial activity was vigorous and results indicated first order BOD reaction rate constants, K (base e), in the range of 0.6 to 1.2. The ultimate

carbonaceous BOD, L, was estimated to range from 2,500 mg/l to 3,200 mg/l. Both K and L may increase with better acclimated microbes or other factors. Values of both K and L were found to decrease somewhat with heavy applications of NaOCl during pretreatment, probably as a result of the chemical oxidation. Compared with "strong wastewater"--where K and L values of about 0.4 and 250 might be expected (Fair et al., 1968)--this indicates an extremely strong wastewater and very rapid microbial response. Based on this information, substantially complete removal of metabolizable BOD should take place within about 4 to 8 days.

These BOD analyses are consistent with the complexity of the organic chemicals present in the ground water, the variations in water quality parameters throughout the study area, the high concentrations of oxygen-demanding substances in various ground water samples and the difficulties inherent in analyses of biodegradation where unusual compounds and potential toxins are present. Results do indicate that these organics should be biodegradable, especially when acclimated microbes are available, and that pre-treatment by oxidation with hypochlorite does not seriously inhibit biodegradation. Additional testing would be necessary to define the biodegradability of these organics more accurately.

TABLE F-1

EFFECTS OF CHEMICAL OXIDANTS ON QUALITY OF GROUND WATER[a]

Oxidant Dosage (mg/mg phenols)	Dilution Ratio[b]	Approximate Initial Phenols (mg/l)[c]	Final Phenols (mg/l)	Percent Removal	Approximate Initial COD (mg/l)[c]	Final COD (mg/l)	Percent Removal	Approximate Initial Suspended Solids (mg/l)[c]	Final Suspended Solids (mg/l)	Final pH[d]
2.9 NaOCl	1:2	25	22	12	20,100	11,300	44	--	--	8.0
	1:50	1.0	2.5[e]	None	800	384	52	--	--	7.1
11.4 NaOCl	1:2	25	7.5	70	20,100	11,000	45	--	--	8.5
	1:50	1.0	0.38	62	800	376	53	--	--	7.9
52.2 NaOCl	1:2	25	2.2	91	20,100	10,500	48	240	463	9.1
	1:50	1.0	0.088	91	800	384	52	10	61	8.5
14 $KMnO_4$	1:2	25	3.0	88	--	--	--	--	--	--

[a]All samples reacted for 1 hour prior to chemical analyses.

[b]Raw water was diluted with deionized water. Raw water had 50 mg/l phenols, 40,200 mg/l COD, 486 mg/l suspended solids, and pH 7.5. Source of raw water was sample taken from Well 13.

[c]Initial concentrations estimated based on dilution factors.

[d]pH was primarily influenced by the pH of the concentrated oxidant (12.6). Little or no change was observed during reaction.

[e]Inconsistent data. Probably reflects uneven distribution of organics in raw water prior to dilution or an error in analysis. Raw water was shaken thoroughly before samples were withdrawn.

TABLE F-2

SUMMARY OF BIOCHEMICAL OXYGEN DEMAND DATA

A. 5-Day BOD of Samples Taken June 2, 1977

	Volume of Sample in 303 ml BOD Bottle (ml)*					
Source	0.03	0.5	1.0	3.0	10.0	30.0
Well 5	ND	ND	ND	ND	ND	ND
Well 6	ND	ND	ND	ND	ND	ND
Well 9	ND	ND	ND	ND	ND	ND
Well 13	ND	2,200	1,700	ND	ND	ND
Well 17	ND	ND	ND	ND	ND	30

B. 5-Day BOD of Well 13 Samples Taken June 22, 1977 After 50% Dilution With Deionized Water and Chemical Oxidation With NaOCl

NaOCl Dosage (mg/l)	Volume of Sample in 303 ml BOD Bottle (ml)*			
	3.0	1.0	0.5	0.1
72	>460	>1,400	>1,500	3,000
280	>460	>1,400	>1,400	1,800
1,300	>460	>1,400	>1,600	2,400

*Balance of bottle was filled with deionized water.

ND means "non detected."

ecology and environment, inc.
223 WEST JACKSON BLVD., CHICAGO, ILLINOIS 60606, TEL. 312-663-9415

International Specialists in the Environmental Sciences

DATE: December 8, 1980

TO: File

FROM: Rod Bloese RTB

SUBJECT: Minnesota/TDD# F5-8012-3
St. Louis Park/Reilly Tar and Chemical Co.

On December 3, 1980, the author met with Melanie Toepler (USEPA - Region V Enforcement) to obtain background information concerning the subject site. Areas to be addressed in developing cost estimates for clean-up of groundwater and soil in the subject site area were discussed. Subsequently, background information was reviewed and the following scope of work was determined.

Cost estimates for the following areas will be determined:

1. Water treatment of all fifteen (15) St. Louis Park Municipal wells and a number of additional wells.

2. Remedial activity (clean-up) regarding on-site well #23.

3. Remedial activity regarding approximately fifteen (15) "multiaquifer" wells.

4. Contaminated soil treatment, clean-up, and/or disposal.

5. Well field management plan.

Presently, background review is continuing and cost estimate work for the above five (5) areas are being initiated.

RB/df

recycled paper

Minnesota Pollution Control Agency

September 16, 1980

G. Robert Johnson
Popham, Haik, Schnobrich, Kaufman and Doty, Ltd.
4344 IDS Center
80 South Eighth Street
Minneapolis, Minnesota 55402

Dear Mr. Johnson:

Enclosed please find several items as you requested at our September 11, 1980, meeting at the Minnesota Pollution Control Agency (MPCA) office in Roseville.

The "Draft List of Pollutants of Concern - Wood Treating Plants" is a compilation of pollutants reported in wastewater or sludges associated with wood treating plants. Several of the sources report pollutants from unnamed plants. Other sources are reports of analyses conducted on samples from Minnesota plants by the Serco Laboratory or the Minnesota Department of Health Laboratory. The sources used are:

1. Proposed Development Document for Effluent Limitations, Guidelines, and Standards for the Timber Products Processing Point Source Category, U.S. EPA, Effluents Guideline Division, October, 1979

2. Wood Treating Industry Multimedia Emission Inventory, June 1980 Draft, Acurex Corporation, prepared for the US EPA Cincinnati Research Laboratory

3. Phenolics in Aquatic Ecosystems, Buikema, A. L., McGinnis, M. J. and Cairns, J., Marine Environment Research (2) 1979, 87-189

4. Serco Laboratory analyses of the St. Regis pond water

5. Minnesota Department of Health Laboratory analyses of St. Regis pond and ditch waters

6. Minnesota Department of Health Laboratory analyses of Burlington Northern pond water

7. Serco Laboratory analyses of Joslyn well water

Phone: _____
1935 West County Road B2, Roseville, Minnesota 55113
Regional Offices · Duluth/Brainerd/Detroit Lakes/Marshall/Rochester
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8. Twin City Testing Laboratory analyses of Onan - Medtronics samples

9. Priority Pollutant Consent Decree

As was discussed at the September 11 meeting, the operational history of each facility will determine which of the listed pollutants are of concern at that particular facility.

The list of pollutants of concern represent our present understanding of the toxic materials present in wastes from wood treating processes. Additions or deletions of pollutants may of course be necessary, if wastewater samplings in Minnesota or reports in the research literature reveal presence or absence of other toxic materials. We look forward to receiving comment from your clients on the list developed by the MPCA staff; members of Wood Treaters Association may also know of other important materials which deserve investigation.

Also enclosed please find a "Summary of Available Standards/Criteria, Wood Treatment Sites". The sources for this listing are:

FDWS Federal Primary and Secondary Drinking Water Standards
MDHDWS Minnesota Department of Health Drinking Water Standards
MPCA Minnesota Rules WPC 14 and 22
FWQC Federal Water Quality Criteria published March 15, July 25, and October 15, 1979
NYGWS New York Ground Water Standards

The "Summary of Standards and Criteria" represents a compilation of the scientifically derived levels of concern available to MPCA staff at this time. As more information and research becomes available, the levels may change. We solicit your clients' comments and encourage them to furnish us with any similarly derived appropriate standards or criteria. As we have discussed, the levels presented will be used by the MPCA staff and Minnesota Department of Health staff to evaluate data generated at the sites.

The Standards and Criteria discussed thus far deal with water quality. For sludges and soil, we will apply the State and Federal Hazardous Waste Rules when possible. Our approach for evaluation of soils will involve subjecting soils to a solvent extraction procedure to estimate total contamination levels and to leaching tests to investigate apparent contaminant mobility. These procedures each contribute valuable information, neither procedure alone can suffice.

Bill Scruton, of the Minnesota Department of Health Laboratory has suggested that all analysts likely to become involved in site investigations coordinate their efforts before analytical work proceeds. To this end John Davenport of the MPCA is arranging a meeting between Bill Scruton, Daryle Thingvold of Serco, Bill Wellbus of Twin City Testing, and MPCA

staff. If you are aware of other analysts or laboratories likely to become involved in site investigation efforts, please so inform Stephen Lee of my staff.

We look forward to your prompt response to the enclosed materials. To speed maters along we are sending copies of this letter to each of the firms represented at our September 11, 1980 meeting. As you requested, I am also enclosing a copy of the New York State Ground Water Standards.

Sincerely,

Tim Scherkenbach, Chief
Enforcement Section
Division of Water Quality

TKS/dc

Enclosures

cc: Tom Doten, Bell Pole
Bill Westerdahl, St. Regis
John Shamp, PCI
W. Schoenholz, Joslyn Manufacturing
Howard Olson, Sonford Products
Bob Baglo, G. M. Stewart
Robert Norgard, MacGillis and Gibbs
Daryle Thingvold, Serco Laboratories
Mark Stehly, Burlington Northern
Ralph Nelsen, Burlington Northern

List of Pollutants of Concern-Wood Treatment Plants

1. Flouranthene
2. Pyrene
3. Phenanthrene
4. Anthracene
5. Benzo (a) anthracene
6. Naphthalene
7. Acenaphthene
8. Acenaphthylene
9. Flourene
10. Chrysene
11. 1, 2, Benzanthracene
12. Benzo (a) pyrene
13. Benzo (e) pyrene
14. Benzo (k) Flouranthene
15. Ideno (123 cd) pyrene
16. Benzo (ghi) perylene
17. Benzo (b) Flouranthene
18. 2,4, dimethylphenol
19. 2 chlorophenol
20. 2,4,6 trichlorophenol
21. pentachlorophenol
22. dinitrophenol
23. tetrachlorophenol isomers
24. 3,5 xylenol
25. o-cresol
26. m-cresol
27. 2,4, dichlorophenol
28. Dibenzo(ah)anthracene
29. 2,4 dinitrophenol
30. 2 nitrophenol
31. polychlorinated dibenzo dioxin
32. copper
33. Arsenic
34. Chromium
35. Oil and Grease
36. Phenols

Development Document 1,2,3,4,5,6,7,8,9,10,12,14,15,16,17,18,19,20,21,33,34, 35,36,37
Multimedia Inventory 2,3,4,5,7,8,12,18,19,20,21,32,33,34,35,36
St. Regis Pond-Serco 1,2,3,4,5,8,9,10,12,16,21,36
St. Regis Pond, ditch-MDH 1,3,9,10,11,12,13,17
BN Pond-MDH 1,3,9,11,13
Joslyn-Serco 10,12,14,16,21,32,33,34,35,36
Phenolics in Aquatic Ecosystems 21,23,24,25,26
Onan-Medtronics Study 1,2,3,4,6,7,8,9,10,18,19,20,21,25,26,27,28,29,30,36
Priority Pollutants 1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,17,18,19,20,21,27, 28,29,30,31,32,33,34

WOOD TREATMENT SITE
STANDARDS/CRITERIA
SUMMARY

Parameter	Human Health	Aquatic Life	Reference
Arsenic	For maximum protection of human health from the carcinogenic effects of exposure to arsenic through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. (FWQC)		
	.05 mg/l (ppm)		FDWS, MDH
	.01 mg/l (ppm)		MPCA, Class 1A,B,C
	.05 mg/l (ppm)		MPCA, Class 1D
	.025 mg/l (ppm)		NYGWS
	.02 ng/l (ppt) @ 10^{-5}	.057 mg/l av., .130 mg/l max.	FWQC
Chromium (total)	.05 mg/l (ppm)		FDWS, MDH
		.02 mg/l (ppm)	MPCA, Class 2A
		.05 mg/l (ppm)	MPCA, Class 2B,C
Chromium (+3)	.05 mg/l (ppm)		FWQC
Chromium (+6)	For maximum protection of human health from the carcinogenic effects of exposure to hexavalent chromium through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. (FWQC)		
	.05 mg/l (ppm)		MPCA, NYGWS
	8 ng/l (ppt) @ 10^{-5}		FWQC
Copper	1 mg/l (ppm)	.01 mg/l (ppm)	FDWS, NYGWS, MPCA
Phenols	1 µg/l (ppb)		MPCA, NYGWS
		10 µg/l (ppb)	MPCA, Class 2A,B
		100 µg/l (ppb)	MPCA, Class 2C
Pentachlorophenol	21 µg/l (ppb)		NYGWS
	140 µg/l (ppb)	6.2 µg/l av., 14 µg/l max.	FWQC

Parameter	Human Health	Aquatic Life	Reference
Carcinogenic PAH	For maximum protection of human health from the carcinogenic effects of exposure to polynuclear aromatic hydrocarbons (PAH) through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. (FWQC)		
	9.7 ng/l (ppt) total @ 10^{-5}		FWQC
Benzo(a)pyrene	not detectable		NYGWS
TCDD (tetra-dioxin)	4.5×10^{-7} µg/l (ppb)		FWQC
	3.5×10^{-5} µg/l (ppb)		NYGWS
Flouranthene	200 ug/l (ppb)	250 ug/l av., 560 ug/l max.	FWQC
2,4,6 Trichlorophenol	100 µg/l (ppb)	52 µg/l av., 150 µg/l max.	FWQC
Naphthalene	143 µg/l (ppb)		FWQC
2 nitrophenol		2700 µg/l av., 6200 µg/l max.	FWQC
2,4 dinitrophenol	68.6 µg/l (ppb)	79 µg/l av., 180 µg/l max.	FWQC
2 chlorophenol	.3 µg/l (ppb)	60 µg/l av., 180 µg/l max.	FWQC
2,4 dichlorophenol	.5 µg/l (ppb)	.4 µg/l av., 110 µg/l max.	FWQC
2,4 dimethylphenol		38 µg/l av., 86 µg/l max.	FWQC