EXH. 1

THE USE OF OIL FIELD BRINE ON MICHIGAN ROADWAYS

GEOLOGICAL SURVEY DIVISION

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

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INTRODUCTION

Saltwater known as oil field brine is produced as a consequence of the exploration for and extraction of oil and natural gas. Brine is naturally occurring nonpotable water laden principally with dissolved sodium, calcium, magnesium, and chloride. Found in the pore space within sedimentary formations, brine will normally be fossil water that was entrapped at the time of the rocks' deposition. In penetrating porous formations, oil and gas operations provide a pathway for this water to move out of the rock and up to the surface.

Oil and gas exploration is one of the two sources of the fluids collectively referred to as oil field brine. During the drilling of an oil or gas well, brine may flow into the borehole from strata beneath the zone of potable groundwater. In part to prevent this influx of brine, most oil and gas drilling operations in Michigan utilize hydraulic rotary equipment. Such equipment requires the circulation of drilling muds down the borehole to provide the hydrostatic pressure necessary to counterbalance the inflow of formation waters or natural gas. These muds normally contain brine to prevent the solutioning of the massive salt beds that overlie many Michigan oil pools. The brine in the drilling mud will eventually empty into a lined pit or other surface containment along with rock cuttings that result from the drilling. The resulting supernatant in the lined pit must be disposed of upon completion or abandonment of the well. Thus, exploration may produce brine both from the formations being drilled through and from the muds being utilized in the drilling operation.

Oil and gas extraction, commonly called production, is the second source of oil field brine. Brine exists in the interstices of each of the nineteen formations from which oil and/or natural gas are produced in Michigan. This brine mixes with the oil or gas being produced and must be separated from the fluid mixture brought to the surface. Separation by gravity, heat, chemical reaction, or a combination of methods will result in crude oil or natural gas (the valuable product) and oil field brine (the undesirable by-product).

Whether generated by drilling activities or separated from produced oil or natural gas, oil field brine is a waste product requiring disposal. Oil field brine is many times more saline than seawater (Table I). As a result, its disposal necessitates responsible planning to assure that it does not enter and pollute drinking water resources. Oil field brine is typically disposed of either through return to subsurface formations or through application upon roadways for dust control or ice removal. A small amount may also find reuse as a constituent in recycled drilling muds. In the past little concern existed as to the manner in which oil and gas producers disposed of their brine. In the 1970s, with the rise in public concern over environmental degradation, attention became focussed upon the dumping of waste brine on Michigan lands. Allegations began to surface that widespread abuses by the transporters of brine were occurring that might adversely impact the waters of the state. Reports indicated that these haulers were dumping oil field brine into streams, in woodlots, and onto roadways. The Geological Survey Division of the Michigan Department of Natural Resources responded to these growing concerns by developing instructions to regulate the spreading of oil field brine. Ultimately the Supervisor of Wells issued Special Order Number 1-81

TABLE I

A COMPARISON OF SEAWATER TO MICHIGAN OIL FIELD BRINE

SEAWATER*

Ion	Average Value (mg/l)
Sodium (Na^+)	10,760
Calcium (Ca^{++})	413
Magnesium (Mg^{++})	1,294
Chloride (Cl^-)	19,375

MICHIGAN OIL FIELD BRINE+

Ion	Average Value (mg/l)	Approximate Maximum Value (mg/l)
Sodium (Na^+)	50,000	90,000
Calcium (Ca^{++})	28,000	75,000
Magnesium (Mg^{++})	6,000	16,000
Chloride (Cl^-)	160,000	250,000

* A. Gene Collins, 1975, Geochemistry of Oilfield Waters, Developments in Petroleum Science Series, Volume 1, Elsevier Scientific Publishing Co., Amsterdam, The Netherlands, page 194.

\+ Michigan Geological Survey Division, United States Bureau of Mines, and Cory Laboratory, Inc., 1976, Oil Field Brine Collection and Analysis Program, unpublished analyses of 319 samples.

under the authority of Act 61 (P.A. 1939, as amended), the Supervisor of Wells Act. Special Order 1-81 was issued to specify approved brine disposal methods and to more tightly regulate the use of oil field brine in road maintenance practices.

This report seeks to delineate the types of problems that are occurring due to the use of oil field brine on Michigan roadways. The fundamentals of road brining will be introduced along with the rationale underlying the use of oil field brine in road maintenance practices. The past history of the regulation of oil field brine disposal will be summarized with an emphasis upon the origin and implementation of the Supervisor of Wells' order. The status of public and private sector compliance with Special Order 1-81 will then be examined in an attempt to define problem areas. Current Divisional responsibilities in regulating brine disposal for the Department of Natural Resources will be reviewed with particular attention paid to the legal and procedural bases behind existing arrangements. Finally, recommendations will be made concerning changes that could be made in the current regulatory framework to improve its effectiveness.

ROAD BRINING FUNDAMENTALS

Under Section 6(c) of Act 61 (P.A. 1939, as amended), the Supervisor of Wells holds the authority to regulate the disposal of oil field brine:

> (T)he supervisor...is specifically empowered...to require the disposal of salt water and brines and oily wastes produced incidental to oil and gas operations, in such manner and by such methods and means that no unnecessary damage or danger to or destruction of surface or underground resources, to neighboring properties or rights, or to life, shall result.

Rule 601 promulgated under Act 61 states: "Brine or salt water resulting from oil and gas drilling and producing operations shall be stored, transported and disposed of in such manner as may be approved by the supervisor." Rule 602 further states that such brine "shall be returned to an approved underground formation or otherwise disposed of as approved by the supervisor..."

On March 3, 1981 the Supervisor of Wells issued Special Order Number 1-81 to govern the disposition of oil field brine. The author has compiled the provisions of this order and its subsequent amendments in Appendix A.[1] Special Order 1-81 establishes the approved methods of oil field brine disposal. The five principal methods are as follows:

1. injection to an approved subsurface formation by means an approved brine disposal well;
2. injection to a subsurface formation pursuant to an approved secondary recovery plan;[2]
3. use as a constituent in hydraulic drilling muds;

4. use on oil and gas production facility access roads for dust control, ice removal, or road stabilization upon annual written authorization from a District Supervisor of the Geological Survey Division; and

5. use on public roads and private properties for dust control, ice removal, or road stabilization in accordance with a brine management plan approved pursuant to procedures adopted by the Water Resources Commission.

This report represents the culmination of a project initiated on July 25, 1983 to investigate the management of oil field brine under Special Order 1-81. Particular attention was paid to examining the use of brine for dust control and ice removal on public roads and private properties. In the mid-1970s reports appeared alleging abuses by individuals spreading oil field brine. These statements reported observations of brine dumping on the public roads and presented the conjecture that road brining would produce widespread groundwater contamination. Prior to examining the substance of these reports, the fundamentals of brine spreading must be reviewed.

During the summer months, oil field brine is applied on unpaved roads and parking lots to provide dust suppression. Summertime heat often evaporates the moisture that bonds together the soil particles of an unpaved road or parking lot. In addition, traffic tends to reduce both the clay and the moisture content of the road surface, leaving it drier and more friable.[3] The action of tires can then erode the dried road, producing dust which may adversely impact people in several ways. Dust produced by a passing vehicle can reduce visibility, creating a hazard for following and oncoming traffic. Road dust can settle on and damage crops or dirty laundry hung outside to dry. The airborne particles can also make breathing more difficult for nearby

people and livestock. In general, residents living along unpaved roads find road dust to be a continual nuisance. In a larger sense, most Michiganians are affected by dusty roads. Traffic causes the loss of fine soil particles from the surfaces of unpaved roadways, material which must eventually be replaced. The costs of required road maintenance - grading, stabilization, or paving - will be borne by Michigan taxpayers.

An application of oil field brine reduces road dust in two ways. First, brine wets the road surface, binding fine soil particles to one another. Until the water in the brine evaporates, dust cannot form. Second, brine acts as a dust palliative due to the nature of its constituents. Oil field brine contains sodium, calcium, and chloride ions; as brine evaporates, these ions bond to form sodium and calcium chlorides. These compounds are hygroscopic - they attract, absorb, and retain moisture from the air surrounding the road surface. Simply put, an application of brine improves the ability of the road surface to retain moisture. Not only does this action delay the formation of dust but it also aids in the retention of road materials, particularly in the case of a gravel road.

Oil field brine may also be used in the maintenance practice known as road stabilization. When an unpaved road is graded or resurfaced, brine can be incorporated into the top layer of road materials to improve soil retention. The hygroscopic nature of sodium and calcium chlorides helps the road surface retain moisture, reducing erosion and lowering future maintenance costs. An application of brine for stabilization purposes is normally made at volumes double that which would be applied for dust control.[4]

During the winter months, oil field brine is used to remove ice and snow from roadways. Sodium and calcium ions in the brine lower the freezing point of water, thereby allowing ambient heat to melt ice and prevent its reformation.[5] The sodium and calcium compliment one another. Sodium ions will melt ice and snow when the air temperature is between ten and thirty-two degrees Fahrenheit; calcium ions work in temperatures down to minus thirty degrees Fahrenheit.[6] A mixture of the two can provide ice and snow removal from freezing down to zero degrees.[7] However, brine is not the most efficient choice for ice or snow removal. Brine has a tendency to refreeze, leaving a highly slippery coating on the pavement. Also, solid granules of sodium chloride (halite or rock salt) will penetrate through ice or snow to break the bond of ice with the pavement; brine does not accomplish this. In general, for snowfalls greater than two or three inches mechanical removal becomes necessary. "Aqueous solutions are not suitable for treatment of thick layers of pure ice or hardened or packed snow."[8]

More than 90% of the oil field brine applied to Michigan roads is spread to control dust. The utility of oil field brine as a dust palliative therefore bears closer examination. Calcium concentration will be the most important parameter in assessing the effectiveness of a given volume of oil field brine as a dust palliative. Calcium and sodium chlorides are both hygroscopic. However, calcium chloride attracts and retains water much more readily than does sodium chloride. Whenever the relative humidity exceeds 29%, calcium chloride will pull moisture from the atmosphere.[9] For sodium chloride to be hygroscopic, the relative humidity must exceed 80%.[10] Thus, superior dust suppression will be provided by an oil field brine with a relatively high

calcium concentration. However, the effectiveness of oil field brine as a dust palliative will generally be less than a commercially produced brine. As shown in Table I above, Michigan oil field brine may contain up to 75,000 milligrams per liter (mg/l) of calcium ions. On the other hand LIQUIDOW, a calcium chloride brine sold throughout Michigan as a dust palliative, contains approximately 190,000 mg/l of calcium.[11] A field study by the Dow Chemical Company in Midland County found that LIQUIDOW may provide three times better dust suppression than will a typical oil field brine.[12]

Aside from the Dow study, few studies have been undertaken to document the effectiveness of natural brine as a dust palliative. University of Arkansas researchers conducted field tests using waste brine from a bromide extraction operation.[13] This brine contained 66,800 mg/l of sodium and 32,000 mg/l of calcium, values quite similar to a typical Michigan oil field brine.[14] The Arkansas researchers found that, when applied at a rate of 1800 gallons per mile per road lane, the waste brine provided dust control for thirty or more days.[15] The experience of county road commissions also suggests that thirty days is the upper limit of effective dust suppression provided by the typical Michigan oil field brine. Consequently, oil field brine may be applied four to six times during the May through September dust control season. This rate may be compared to the suggested one or two applications of commercial calcium chloride brine that would be made in the same period.[16]

Cost is the principal factor underlying the disposal of oil field brine on the public roads. Commercial calcium chloride brine sells for about 27¢ per gallon delivered in most areas of the Southern Peninsula.[17] For an

additional 3¢ per gallon, the supplier will apply the brine on his customer's property.[18] Conversely, county road commissions can obtain oil field brine at little or no cost. In 1981 the Manistee County Road Commission paid 25¢ for each barrel of brine loaded into county vehicles at a well site.[19] This cost is equivalent to 0.6¢ per gallon, considerably less than would be paid for a commercially produced brine. In 1983 the average price of brine had increased slightly to 30¢ per barrel.[20] Southwestern Michigan Dust Control, a company which spreads oil field brine in several counties, charges road commissions 7¢ for each gallon applied.[21] Nonetheless, in many counties oil field brine can be obtained for free at well sites; a road commission need only incur the costs of transporting and spreading the brine.

In all cases examined by the author, oil field brine from drilling pits has been spread upon the public roads at no charge to county road commissions. Brine removed from a drilling pit contains suspended solids from the drilling mud held in the pit. These particulates tend to clog the pores of subsurface formations when drilling pit brine is placed down a brine disposal well. Consequently, disposal well owners are normally reluctant to accept fluids from drilling pits. Filtration can remove the solids but this operation adds to disposal costs. To minimize incurred costs, oil and gas producers seek to dispose of drilling pit brine on roadways near to their well sites. In return for a road commission's permission to spread pit fluids on county roads, producers and the waste haulers they hire will spread the brine for free. In this manner a producer can empty a drilling pit at a minimal cost while a road commission can gain a degree of dust control on some county roads without spending any tax dollars.

Since oil field brine has a very low dollar value, the cost of transporting the brine to a disposal site normally outweighs the profit that can be gained through its sale. This fact underscores the brine transporter's desire to haul oil field brine a minimal distance from a well site. That desire in turn may lead to illegal disposal of brine through outright dumping into streams, in woodlots, or onto roadways. Since the mid-1970s reports of road brining abuses have centered upon the actions of licensed industrial waste haulers. Anyone seeking to haul liquid industrial wastes, which include oil field brine, from the premises of another must be licensed under the provisions of Act 136 (P.A. 1969), the Liquid Industrial Wastes Act. Licensed waste haulers transport much of the oil field brine taken for disposal.

The most important consequence of brine dumping by these waste haulers would be the contamination of drinking water supplies. Several incidences of water well contamination in Michigan have been linked to road brining activities. Table II lists sites where water supply wells are believed to have been contaminated by road brining activities. In each case oil field brine has been repeatedly spread on nearby roads. Well water contaminated as a result of road brining will normally contain less than 600 mg/l of chloride. This contaminated water may be characterized by a salty taste but will not necessarily pose a hazard to the health of its users. The Environmental Protection Agency has recommended that 250 mg/l be the maximum concentration of chloride in water for domestic use.[22] This standard was based upon palatability and not upon adverse health effects. Given time for the body to adjust, a healthy person can consume water with up to 2,000 mg/l of chloride with no ill effect.[23] However, a high concentration of chloride in a well's

TABLE II

SITES OF WATER WELL CONTAMINATION POSSIBLY ATTRIBUTABLE TO THE USE OF OIL FIELD BRINE UPON MICHIGAN ROADWAYS

(1) Peterson and other residences
Mill and Fouch Roads
Section 28, Blair Township
Grand Traverse County

(2) Harper, Peterson, and Wolfinger residences
Chula Vista Drive
Section 22, Big Rapids Township
Mecosta County

(3) Potter and Quinn residences
U.S. Route 131
City of Big Rapids
Mecosta County

(4) Adams and Jewett residences
72nd Avenue
Section 6, Weare Township
Oceana County

(5) Depew residence
Colfax Street
City of Cadillac
Wexford County

(6) Forsgren residence
$41\frac{1}{2}$ Road
Section 4, Cedar Creek Township
Wexford County

(7) seven residential or business wells
Plett Road
Section 34, Haring Township
Wexford County

water may indicate the presence of sodium and excessive sodium can be harmful to individuals suffering from cardiovascular or kidney diseases. In the seven cases listed in Table II, no well sampled contained more than 550 mg/l of chloride and no health effects have been reported to date.

In brief, through Special Order 1-81, the Supervisor of Wells has declared that the waste brine generated by oil and gas operations may legitimately be used for road maintenance purposes. This brine may be spread to control dust on unpaved roads, incorporated into the surfaces of unpaved roads to provide soil stabilization, or applied to roadways to remove ice and snow. Much of the oil field brine annually spread on Michigan roads is applied to control dust. Although commercial brine can provide superior dust suppression, individuals often opt to use oil field brine because it can be obtained at little or no cost. Continual applications of oil field brine on particular roads have probably been responsible for a number of cases of known water well contamination. To date, however, no adverse health effects have been observed as a result of these incidences.

PAST REGULATORY ACTIONS

Michigan's petroleum industry has enjoyed a relatively long and properous history. Exploration began in the 1860s soon after the initial North American oil discoveries in Pennsylvania and Ontario. Twenty years passed before a driller, while searching for natural gas, struck oil near Port Huron in 1886. Sporadic exploration continued until the first commercially successful oil operation began in the City of Saginaw in 1925, marking the emergence of a new industry in the state. By the late 1930s Michigan had become one of the nation's leading oil producers.[24]

During the years that followed the opening of the Saginaw Field, oil field brine was often held in large surface lagoons or smaller earthen pits prior to disposal. While some of these storage sites were lined with clayey soils, many provided no barrier to impede the seepage of brine into the waters of the state. The Michigan Geological Survey, working within the standards of the day, fostered a gradual abandonment of these types of brine storage. The use of brine lagoons faded by the late 1940s. Earthen pits declined in number, replaced by tanks of wood or steel. By the beginning of the 1980s open pits could only be used to temporarily hold brines produced during drilling operations. Also, impervious plastic liners were now required for nearly all of these drilling pits.

While brine storage facilities evolved towards improved containment, the ultimate destinations of waste brine also changed. The Geological Survey

Division compiled statistics on the disposition of oil field brine through 1968 (Appendix B). In 1937, the first year of recordkeeping, one-half of the brine generated by oil and gas operations was returned to subsurface formations. Of the remainder, approximately half was used by the chemical industry, usually as a source of sodium or calcium chloride. The rest was left in pits to evaporate or seep away. Figure 1 illustrates the trends in brine disposal throughout the years of recordkeeping. The year 1952 marked a sharp decrease in the use of oil field brine by chemical companies and a corresponding initiation of its recorded use on roadways. Furthermore, as the use of earthen pits declined in the early 1960s, the amount of brine used on roads increased.

In 1982 more than 3.1 billion gallons of brine were generated by Michigan oil and gas operations.[25] Approximately 97% of this total was returned to subsurface formations.[26] Nonetheless, based upon the most accurate data presently available, at least 53 million gallons of oil field brine were spread on Michigan roadways in 1982. Table III shows the quantity of oil field brine used for road maintenance in 1982 in each of the six Geological Survey Division Districts (Figure 2). The statewide totals reported in this table are likely to be highly conservative due to the imprecision of the Division's data collection procedures and the use of estimates in making brine quantity calculations. In reality the amount of oil field brine used on Michigan roadways annually may well be much greater than 53 million gallons. In one county, Isabella, more than four million gallons of oil field brine has been spread annually. In addition, road commissions in thirty-nine other counties use oil field brine in varying and undocumented quantities.

Figure I

OIL FIELD BRINE DISPOSAL (1937-1968)

Excluding brine returned to subsurface formations

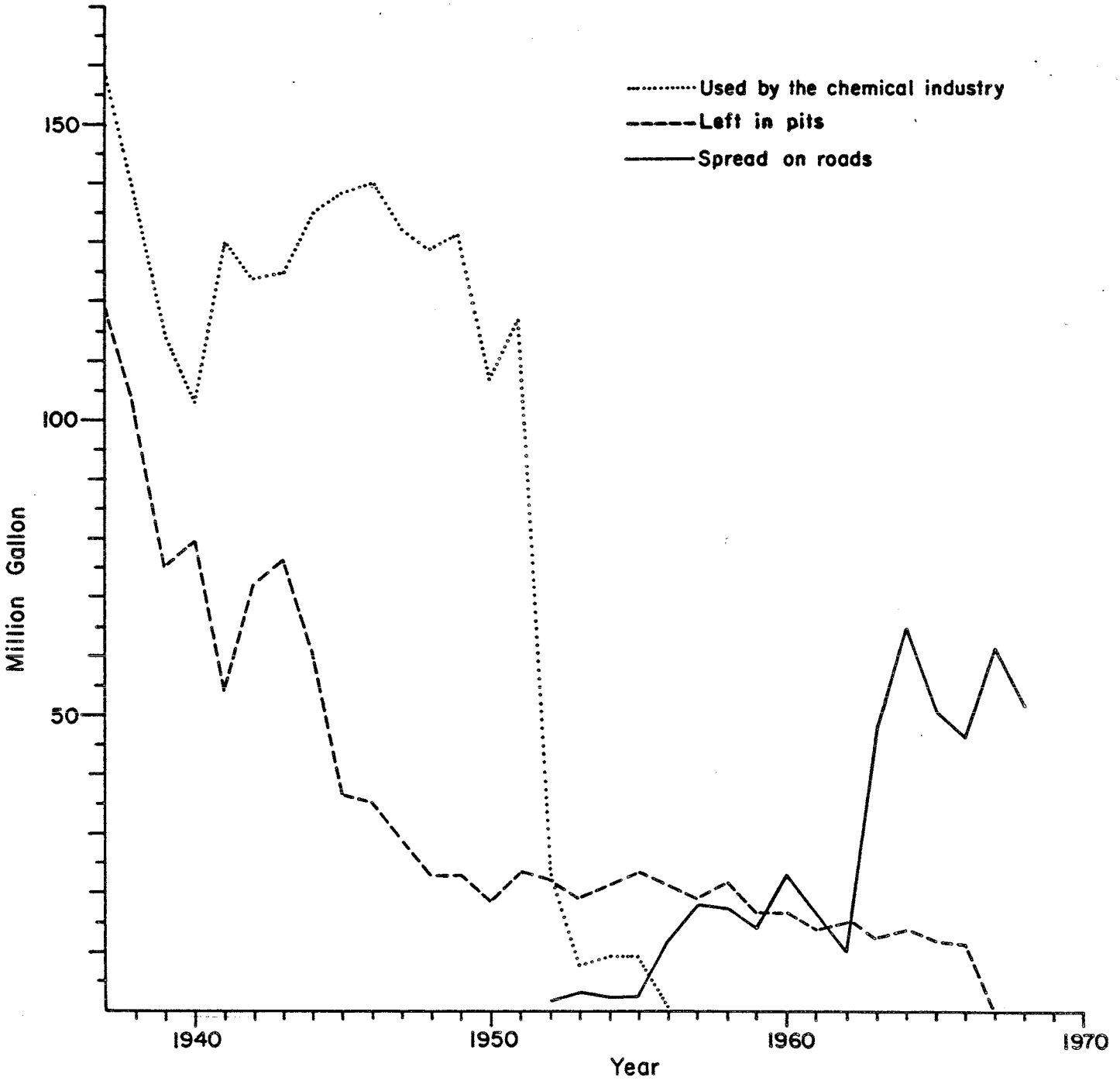

TABLE III

OIL FIELD BRINE USED FOR ROAD MAINTENANCE IN 1982

District	Brine Separated From Produced Oil or Gas* (gallons)	Brine Taken From Drilling Pits+ (gallons)	Total (gallons)
Cadillac	1,027,110	10,920,000	11,947,110
East Lansing	168,630	1,320,480	1,489,110
Gaylord	45,990	5,913,600	5,959,590
Imlay City	2,146,200	2,177,280	4,323,480
Mt. Pleasant	9,366,630	3,064,320	12,430,950
Plainwell	15,973,860	814,800	16,788,660
STATEWIDE:	28,728,420	24,210,480	52,938,900

* Figures for the quantity of brine separated from produced oil and gas derive from information found in the 1982 annual oil, gas, and brine production reports compiled for each Geological Survey Division District (Herrold, 1983a).

\+ Data on the quantity of brine taken from drilling pits are based upon an estimate of the volume of brine received by the typical drilling pit in a District multiplied by the number of wells drilled in that District in 1982. Based upon information provided by field geologists, the author assumed that 80% of the brine held by each pit is spread upon roadways and, using this assumption, derived the calculations reproduced in this column (Herrold, 1983b).

Figure 2

GEOLOGICAL SURVEY DIVISION DISTRICTS

1 - Gaylord

2 - Cadillac

3 - Mt. Pleasant

4 - Plainwell

5 - East Lansing

6 - Imlay City

The Geological Survey Division is not districted in the Northern Peninsula but has offices in Escanaba and Marquette.

Geological Survey statistics first record the disposal of oil field brine on roads in 1952. Waste brine has in fact been spread on Michigan roads since the infancy of the oil industry. The first allegations of adverse impacts resulting from brining also date from this period. Reports surfaced as early as 1936 of injury to roadside trees caused by the use of oil field brine as a dust palliative.[27] Forrest C. Strong of the Michigan State College (now University) examined these reports and did find evidence of foliage damage attributable to the spreading of oil field brine.[28] He discovered that when a road surface dries after brining, a fresh layer of dust containing salts could be lifted by the wind to coat nearby foliage. The salt in turn caused leaf browning (necrosis) detrimental to the trees' vigor.

Although forty years have since passed, one factor governing the disposal of oil field brine has remained constant. In 1944 Strong wrote: "As the brines represent waste products and are consequently cheap, they have sometimes been applied too heavily so that there was a considerable run-off [sic] which killed vegetation."[29] In recent years the runoff of applied brine to low-lying areas is believed to have killed roadside maple trees in Kent County and a stand of poplars in Gladwin County. A more serious concern to arise recently was speculation that brine runoff or seepage was contaminating drinking water supplies. Beginning in 1976 several Department of Natural Resources employees expressed the belief that road brining adversely impacted the groundwater in many areas of the state. Particular attention was drawn to the actions of brine haulers who were believed to be dumping loads of oil field brine on roads adjacent to well sites. Interest was sparked within the Geological Survey Division to more carefully examine road brining practices.

In early 1978 Douglas L. Daniels, a field geologist in the Geological Survey's Plainwell District, became concerned about the misuse of oil field brine on roads in Allegan County. Industrial waste haulers were rumored to be dumping large quantities of oil field brine on the county's roads. Allegan County lies in one of the state's older oil producing areas. Older wells often produce brine in volumes much greater than the oil they produced; for each barrel of oil, operators in the Allegan fields may have several barrels of brine requiring disposal. After discovering that no one knew how much brine was being spread on the county roads, Daniels discussed the situation with an Allegan County Road Commissioner and a representative from the Department's Water Quality Division. He then developed and circulated a set of guidelines to govern the use of oil field brine on roads within the Plainwell District. These guidelines were later incorporated in a formal "Notice to All Oil and Gas Producers" issued on June 19, 1978 by the Assistant Supervisor of Wells Arthur E. Slaughter (Appendix C).

The Assistant Supervisor's Notice contained many of the stipulations embodied in subsequent attempts to regulate brine disposal. The Notice prohibited brine applications during or immediately after rainfall and required spreading vehicles to be in motion while applying brine. Producers were asked to keep records of the amount of brine taken from their facilities for use on roads. Most important, the Notice stipulated that brine spreading must be done in a manner which prevented runoff to ditches or watercourses and also guarded against the contamination of groundwater resources. Through these and other provisions, the intent of the Notice was made very clear - oil field brine was not to be disposed of through dumping disguised as road maintenance work.

Despite some excellent provisions, the Notice failed to curb road brining abuses due primarily to a lack of commitment on the part of Geological Survey personnel. As noted previously, haulers of oil field brine were deemed to be responsible for the brine disposal problems being encountered. Since the Water Quality Division then regulated waste hauler activities, Geological Survey field staff believed that Water Quality personnel, rather than themselves, should be responsible for overseeing road brining activities. In the absence of a firm commitment to monitor these activities, the Geological Survey Division did not effectively regulate the disposal of oil field brine. A new, more forceful approach was needed.

In the later part of 1980, faced with growing concern about brining abuses, the Supervisor of Wells contemplated the issuance of an order to control the disposition of oil field brine. A public hearing was held on December 22 to receive testimony concerning the need for such an order. Oral or written statements were presented by the Michigan Oil and Gas Association, the Dow Chemical Company, the Michigan Environmental Council, numerous industry representatives, and several county road commission officials. A position statement was read by the Engineer-Director of the County Road Association of Michigan, the organization which represents the state's eighty-three county road commissions. Personnel from the Geological Survey and Water Quality Divisions also testified. From the evidence presented, the Supervisor reached two conclusions. First, oil field brine has utility when properly used for drilling or road maintenance purposes. Second, the misuse of brine poses a potential threat to fresh water resources which requires that its disposal be carefully controlled. Based upon these conclusions, the Supervisor issued

Special Order Number 1-81 on March 3, 1981. The intent of the Special Order was two-fold: to designate acceptable methods of oil field brine disposal and to more tightly regulate the use of that brine on the public roads.

Shortly after the issuance of Special Order 1-81, the Geological Survey Division began to receive inquiries from oil and gas producers. They were confused by the Order's provision permitting the brining of their facility access roads and asked that the language of this provision be clarified.[30] Comments were also received during this time from industrial waste haulers and other parties. These individuals complained that the Supervisor's Order precluded the use of oil field brine on private property. These concerns were addressed in a public hearing on October 13, 1981. After the hearing, the Supervisor concluded that the use of oil field brine on facility access roads and private properties was appropriate for dust and ice control. Paragraphs 7 and 8 were added to the original Order on November 3, 1981 (see Appendix A).

Through Special Order 1-81 and its amendments the Supervisor of Wells has defined the approved methods of disposal for oil field brine. These methods include the use of oil field brine for dust control, ice removal, and road stabilization on public roads and on private properties. The Supervisor's Order necessitated the creation of an administrative process through which these uses could be properly regulated. At the heart of that process lies a document known as a brine management plan.

Under Paragraph 1 of Special Order 1-81, the use of oil field brine on the public roads must be "in accord with a plan approved pursuant to procedures

adopted by the Water Resources Commission." In the months following the issuance of Special Order 1-81, personnel in the Department's Water Quality Division drafted a set of procedures for the Commission's consideration. In the minutes of the June 18, 1981 meeting of the Water Resources Commission appears the following statement:

> "The Executive Secretary [Robert J. Courchaine] presented the following draft procedures for obtaining approval of road brining management plans for use of oil field brines:
>
> > 'The March 3, 1981 Special Order No. 1-81 of the Supervisor of Wells allows the use of oil field brines by governmental units for ice and dust control if done in accordance with a plan approved pursuant to procedures adopted by the Water Resources Commission.
> >
> > Approval of management plans is contingent on compliance with Act No. 136, Public Acts of 1969, the Liquid Industrial Waste Haulers Act [sic] and the following Rules of the Water Resources Commission to prevent pollution of the waters of the state in the transporting, storage, handling and use of such brines:
> >
> > > Part 4 Rules, Water Quality Standards
> > > Part 5 Rules, Spillage of Oil and Polluting Materials
> > > Part 22 Rules, Ground Water Quality Standards
> >
> > A management plan should detail the manner in which brines will be transported, [sic] equipment or contract services to be used; ownership of vehicles; the storage facilities to be used including a Pollution Incident Prevention Plan (PIPP); the manner in which road brining will be carried out to prevent runoff into surface drains and water courses [sic]; application rates and equipment to be used; and the manner and facilities to be used to prepare salt/sand mixtures to prevent contamination of groundwaters.
> >
> > Failure to operate in accordance with the approved management plan may result in loss of approval to accept oil field brines.'"

By an unanimously carried motion, the Water Resources Commission chose to "concur" with these draft procedures. This action may have constituted a formal adoption of procedures as required by Special Order 1-81.

From these procedures personnel in the Water Quality Division developed "Guidelines for Preparation of an Interim Brine Management Plan under Supervisor of Wells Order 1-81." Commission meeting minutes contain no reference to an adoption of these "Guidelines;" we may infer their acceptability on the basis of their development from the above procedures. The "Guidelines" set forth the required contents of a brine management plan. Five topics must be fully addressed by an applicant in order for a submitted management plan to be approved. An applicant must:

1. describe the location and owner of each well from which brine will be taken for use by the applicant;
2. describe the location, construction, and operation of the applicant's brine storage facilities;
3. provide a Pollution Incident Prevention Plan (PIPP) for each brine storage facility owned by the applicant;
4. describe the vehicles which transport and spread brine for the applicant; and
5. describe the method, quantity, and frequency of brine applications for dust control and for ice removal.

The "Guidelines" also contain several caveats. Brine must be applied "in a manner to prevent direct runoff to any water course [sic] or from the road surface."[31] Brine applications may be made only when the spreading vehicle is in motion and all spills must be promptly reported to the Department of Natural Resources. Furthermore, brine may not be used for snow removal when effective removal can be attained by plowing. Most important, management plan recipients are required to maintain up-to-date records of their activities. These records must show the date, volume, and specific location of each brine

application as well as a listing of the brine source and transporter. Records must be kept for a three-year period and be available to Department personnel for inspection upon demand.

The brine management plan serves as the keystone of the Department's administration of the Supervisor's Order. Under Special Order 1-81 as amended, management plan approval must be obtained prior to any use of oil field brine on public roads or private properties. Only a governmental body or agency, such as a county road commission, may hold a management plan permitting the spreading of brine on the public roads. Conversely, any party with a legitimate need for dust control or ice removal on private property may submit a brine management plan for approval. The first brine management plans, for the City of Standish and the Kalkaska County Road Commission, were approved on December 15, 1981. To date ninety-one management plans have been approved under the "Guidelines;" the majority of these plans were approved from May through August in 1982.

One further administrative action was taken subsequent to the issuance of Special Order 1-81. To examine and improve brine handling practices under the Department's new brine management program, David M. Dennis, a Section Chief in the Water Quality Division, initiated a Brine Task Force in May of 1982. Its charge was to develop a "brine handling/disposal management system including Water Quality Division policies and procedures... [that is] consistent with existing Department statutes and regulations."[32] With members drawn from the Environmental Enforcement, Geological Survey, and Water Quality Divisions, this Task Force met from June 24 through November 1, 1982. Although the Task

Force was not formally dissolved, no report was issued and no new brine management system was proposed or implemented. Task Force members did however reach a concensus on several issues.

Task Force members concluded that the use of oil field brine on roads was "adequately regulated by the terms of Special Order 1-81" but that current staffing was insufficient for proper monitoring and enforcement of the Order's provisions.[33] They recommended increased staffing to counter the Department's inability to adequately monitor brine management plan compliance, particularly in areas of accelerated drilling activity. Another important recommendation suggested that Act 61 be amended to place governmental agencies under the Supervisor of Wells' jurisdiction. Through such an amendment, the Geological Survey Division would then gain the authority to directly regulate the use of oil field brine by city and county governments.

Discovering that brine spills on lease sites need not be reported to the Department, Task Force members adopted a recommendation that Rule 907 under Act 61 be amended to require the reporting of such spills by oil and gas facility operators. Members also recommended that the Supervisor of Wells issue an order requiring impervious secondary containment for all lease site storage and loading facilities. Finally, to aid in the enforcement of management plans, they suggested that information concerning brine spreaders operating under another party's management plan should be entered into the Law Enforcement Information Network (LEIN). Once in the LEIN system, management plan information could be speedily accessed by enforcement personnel statewide.

EXISTING PROBLEMS

To investigate the status of public and private sector compliance with Special Order 1-81, the author conducted a series of interviews with individuals familiar with oil field brine disposal practices. A questionnaire was developed to elicit detailed responses from these individuals on a wide range of brine management topics (Appendix D). Through use of the questionnaire, the author attempted to determine the scope of existing problems throughout the Southern Peninsula.[34] Of special importance, the questionnaire also provided an opportunity for the interviewees to state their opinions and make useful recommendations concerning the current and future regulation of oil field brine. The author interviewed forty-seven Michigan Department of Natural Resources employees from six Divisions: Environmental Enforcement, Geological Survey, Groundwater Quality, Hazardous Waste, Law Enforcement, and Surface Water Quality.[35] Interviews were conducted in Cadillac, Gaylord, Imlay City, Lansing, Mt. Pleasant, Plainwell, and Roscommon.

A number of problem areas were indeed delineated during the interviews. Interviewees cited their own observations as well as citizen compliants in detailing existing problems. Improper road brining practices were found to occur throughout the Southern Peninsula and most especially in areas where new oil and gas wells were being drilled. The most frequently cited problem involved excessive brining by licensed industrial waste haulers and by oil and gas producers who hauled and spread their own brine. These individuals, operating under the auspices of city or county governmental bodies, appear to

have been applying oil field brine at a frequency many times greater than cited in the management plans under which they operate. In areas where drilling operations are active, haulers and producers have been applying brine from drilling pits to adjacent roadways in quantities believed to greatly exceed permitted application rates. In sum, waste haulers and producers appear to be dumping oil field brine rather than applying it in accordance with an approved brine management plan.

Two factors lie at the root of excessive brining by agents of city and county governments. First, inclusion of these parties in a brine management plan affords them an avenue for disposing of oil field brine at a minimum cost. As noted previously, oil field brine as a commodity has a very low dollar value. The transportation of waste brine to a disposal site costs more money than can be gained through its sale. Consequently waste haulers and producers can maximize their profits by disposing of brine as close as possible to its place of origin. Authorization to spread brine for a city or county provides them with this opportunity. Second, to compound the problem, city and county officials have frequently failed to adequately supervise the activities of their agents. Nearly all county road commissions have failed to designate roads to be brined by producers and waste haulers; this failure in turn allows the less scrupulous to repeatedly dump brine on roads close to well sites.

A related problem surfaced during the interview process. When the frequency of brine applications was closely scrutinized, the author learned that some waste haulers have been claiming that separate brine spreadings by their vehicles constitute one "application." In two separate incidences, haulers

reportedly spread brine on the same section of road on three different days in one week. Each hauler recorded those three passes as one application. In another case, a waste hauler used two trucks spreading in tandem to make "one" application; in reality double the prescribed quantity of brine was being spread. In the absence of proper supervision or recordkeeping by local governmental officials, contracted brine spreaders have continually violated the provisions of the management plans under which they operate.

Overapplication of oil field brine by waste haulers and producers was the only problem found to occur statewide. However, more localized problems exist in many regions of the state. Road commisions in several counties, most notably Montcalm and Tuscola, have been spreading oil field brine without having obtained approval of a brine management plan from the Department. In the central basin cities of Clare, Mt. Pleasant, and Roscommon, excessive amounts of oil field brine appear to have been used for snow and ice removal. In each of these cities, brine-laden meltwaters have been observed entering storm sewers or running directly into local streams. The City of Mt. Pleasant in particular appears to use oil field brine as a substitute for mechanical snow removal rather than as an adjunct to plowing. As a crowning irony, none of these cities operates under an approved brine management plan. Finally, in some northern and southwestern counties, road commissions and their agents have been spreading brine during or immediately after rainfall throughout the dust control season. Such spreading is superfluous since the rain itself acts as a dust palliative. Furthermore, applying brine during or just after a rainfall increases the possibility that the brine will run off of the roadway and enter local watercourses.

Brining during rainfall is symptomatic of a philosophy that prevails in many areas of the state. Numerous county road commissions operate under what may be termed as a "no dust" policy. They believe that their duty lies in assuring that secondary roads remain relatively dust-free during the dry months of summer. This philosophy is analogous to the "bare pavement" policy practiced every winter by state highway agencies nationwide. Similar to the use of large quantities of solid salt to maintain ice-free roads, the county road commissions use frequent doses of oil field brine in order to attain what they feel is adequate dust control. In practice, this policy increases the possibility of excessive road brining and the related opportunity for oil field brine to enter the waters of the state.

The "no dust" philosophy finds its genesis and strength in the desire expressed by some county residents for increased dust control. County road commission officials attest to the fact that many rural residents demand dust-free roads. Department personnel questioned by the author concurred. Department field offices received more citizen compliants concerning a perceived restriction of road brining by the state than complaints of excessive brining or other abusive practices. Six of every ten citizens calling about road brining complained that not enough brine was being spread near their residences. Interviewees did add that county officials were apt to urge citizens to complain to the Department about insufficient brining and to suppress complaints about abuses by the road commission or its agents. Nevertheless, given a vocal citizenry and diminishing budgets, county road commissions are likely to pursue their "no dust" policy in the most cost effective manner: frequent applications of low-cost oil field brine.

The brining of public roads was not the only topic discussed during the interviews. Department personnel were also questioned about brine spreading on private properties and production facility access roads. Few problems appear to have arisen from either practice. Interviewees did cite incidences of illegal dumping of oil field brine in gravel pits but, in each case, the violator was successfully prosecuted. In general, the use of oil field brine on private property is very limited in terms of the quantity of brine spread and the acreage brined. Several individuals did express the belief that the demand for private property brine applications will increase in the immediate future and cautioned that monitoring such applications will be difficult.

When questioned about production facility access road brining, Department personnel stated that some violations of Special Order 1-81 have occurred. Under the Supervisor's Order, an oil or gas production facility operator must have written authorization from the Geological Survey Division prior to the use of oil field brine on his access roads. To date no permits have been applied for or issued anywhere in the state. Operators claim that the permit requirements established by the Division are too burdensome and some have chosen not comply with the Supervisor's Order. Field personnel have been able to stop several incidences of illegal access road brining but some operators continue the practice.

To summarize, through interviews with the Department's most knowledgeable personnel, the author sought to examine the status of public and private sector compliance with Special Order 1-81. The key problem uncovered was excessive brine spreading by licensed industrial waste haulers and oil and gas

producers operating as agents of city and county governmental bodies. In other words, the problem centers upon abuses by private sector parties allowed to spread oil field brine under a public sector brine management plan. Both waste haulers and producers have sought to dispose of oil field brine at the lowest cost possible. County road commissions have sought to provide their citizens with dust-free secondary roads at the lowest cost possible. These goals have combined to produce an uneven distribution of brine spread upon Michigan roadways. Overly frequent applications of oil field brine are made to roads near well sites while little is spread in areas distant from oil and gas fields. This problem is most acute in areas where drilling operations are active. Haulers and producers empty drilling pits by spreading the collected fluids upon nearby roads. At the crux of the hauler-producer problem is brine disposal in the guise of acceptable road maintenance. Haulers and producers have a monetary incentive to dump their brine on local roads and county road commissions have little incentive to discourage this practice.

PRESENT DIVISIONAL RESPONSIBILITIES

At present the regulation of oil field brine involves four Department of Natural Resources Divisions: Geological Survey, Groundwater Quality, Hazardous Waste, and Law Enforcement. Of these four divisions, Geological Survey and Groundwater Quality play the leading roles in the current brine management program.

The Geological Survey Division monitors all aspects of oil field brine disposal under Special Order 1-81 except the use of brine on public roads and private properties. Survey personnel issue permits for brine disposal wells and periodically inspect these facilities. The Division approves secondary recovery plans under which a producer may inject oil field brine into an oil-bearing formation to increase production. Also, a District Supervisor of the Geological Survey Division may authorize the reuse of oil field brine in recycled drilling muds. Of greatest interest to this study, this Division regulates road brining on oil and gas lease sites.

Under Paragraph 7 of Special Order 1-81, the Geological Survey Division oversees the use of oil field brine on oil and gas production facility access roads. A District Supervisor, acting as the representative of the Supervisor, may grant annual written authorization to an operator allowing the brining of his production facility access roads. Applications for this authorization must follow provisions set forth in a November 9, 1981 memorandum from the Division Chief of the Geological Survey. To date no such applications have

been submitted to any District Supervisor and, therefore, no access road brining has been authorized in the state.

Groundwater Quality is currently the lead Division in administering the Department's program governing the use of oil field brine on public roads and private property. For oil field brine to be spread on public property, a governmental agency must submit and obtain approval of a brine management plan. Private property brine spreading can begin after the Division has approved a management plan submitted by an individual, company, or cooperative association. From June 1, 1981 through June 30, 1983 the circulation and review of management plan applications was accomplished by one centrally located contact person within the Water Quality Division. On August 1, 1983 this person's application review responsibilities were transferred to the District Supervisors within the newly formed Groundwater Quality Division. The brine management plan files kept in Lansing were disseminated and arrived at each District Headquarters by September 23. To date all approved brine management plans and subsequent addenda have received that approval from one of two individuals - Gene L. Hall or Daniel W. Darnell.

As the third Division involved in oil field brine management, Hazardous Waste is responsible for the licensing of brine transporters and their vehicles. Once a function of the defunct Water Quality Division, the administration of Act 136 under which these liquid industrial waste haulers are licensed is now handled by Hazardous Waste personnel. Licensed waste haulers must maintain trip records for each load of brine transported, with a two-month record to be carried on the transporting vehicle. Trip records from all of the licensee's

vehicles must be preserved for two years. Hazardous Waste personnel do not yet inspect vehicle-carried records. Licensee facilities are to be inspected annually, at which time the two-year records may be checked. Vehicles that transport brine will not be inspected unless they are present during this inspection visit. Under Section 8 of Act 136, the outside of the hauling vehicle and its accessory equipment must be kept clean but the Division has not yet issued any additional vehicle maintenance requirements.

Law Enforcement is the fourth Division involved in the current oil field brine management program. Law Enforcement personnel assist the other three Divisions in implementing and enforcing orders, rules, and laws relevant to brine management. Conservation officers can aid in the collection of evidence against and observation of suspected brine management plan violators. Conservation officers play a vital role in field enforcement because the stopping of a suspected violator on a public road must by law be done by a uniformed officer in a vehicle equipped with a light and a siren. Thus, of the Department personnel involved in brine management, only a conservation officer may stop a brine spreader who the officer has probable cause to believe is improperly applying oil field brine on a county road. Environmental Conservation Officer Glen T. Hare has taken an active role in enforcing Special Order 1-81 as have several conservation officers, most notably Mary C. Sherzer in Isabella County.

Under the current regulatory framework, the field staffs of the Geological Survey and Groundwater Quality Divisions carry the bulk of responsibility for monitoring road brining activities. Both brine management plan applications

and access road brining proposals must be submitted to field offices for review and approval. Field personnel interviewed by the author stated that they have been acting under the following supposition: the Geological Survey Division will be responsible for overseeing the handling of brine on oil and gas lease sites while the Groundwater Quality Division will assume this responsibility after the brine has been removed from a lease site. As will be demonstrated, this is a false supposition.

Under Department Policy Number 2305, effective January 1, 1977, the Supervisor of Wells "shall be responsible for...all handling and disposal of oil-field brines." By this policy the Geological Survey Division, which acts as the Supervisor's representative, would appear to have been designated as the Division responsible for regulating oil field brine. Furthermore, under Department Procedures Number 4505.5, effective July 1, 1977:

> The Geology Division is responsible for all investigations, clean-up, and enforcement action for losses resulting from oil and gas well operations. This includes...the handling, storage and disposal of produced brines.

These policy and procedures statements indicate an intent by the Department of Natural Resources to delegate oil field brine management responsibilities to the Geological Survey Division. Furthermore, contrary to the interviewee supposition cited above, the Groundwater Quality Division has <u>not</u> been assigned the task of regulating the handling of oil field brine after its removal from a lease site. The Supervisor of Wells' Order does not assign brine management plan administration responsibilities to a specific Division.

A review of past events leads to the conclusion that Groundwater Quality personnel administer the Department's management plan program for two reasons. The Water Quality Division, predecessor of today's Groundwater Quality Division, traditionally acted as the representative of the Water Resources Commission, which had been asked by the Supervisor to adopt procedures to govern road brining activities. Water Quality personnel drafted the procedures adopted by the Commission; one would logically expect the same personnel to assist in the development of the management plan program which was to be based upon those procedures. Also, at the time of the Order's issuance, the Water Quality Division was responsible for regulating the activities of liquid industrial waste haulers. These waste haulers not only transported much of the oil field brine taken for disposal but were also held to be responsible for most incidences of improper road brining. Water Quality personnel could naturally be expected to take an active part in any new program designed to more tightly monitor the disposal of oil field brine by licensed waste haulers.

The brine management plan approach has received little active support from either Geological Survey or Groundwater Quality personnel. Due to the supposition cited previously, Geological Survey field personnel have largely avoided direct involvement in monitoring road brining activities. In only one district have Survey personnel assumed a more active role in regulating brine spreading practices. Coincidentally, in only one Groundwater Quality District have personnel actively monitored compliance with plans approved by their own Division. In fairness to field personnel in both Divisions, no effort had been made until recently to distribute copies of approved management plans to

field offices even though the program has been in operation for the past two years. Furthermore, only Groundwater Quality District personnel received the management plans recently distributed to the field; Geological Survey and Law Enforcement field staffs do not yet have ready access to approved plan files. Without access to management plan particulars, Department field personnel face difficulties in determining whether illegal brine spreading is occurring in a given situation.

RECOMMENDATIONS

The brine management plan approach has been the keystone of the Department of Natural Resources' regulation of the surface disposal of oil field brine. Has this approach been effective in curbing road brining abuses? Interviewees believed that conditions in the field have improved substantially since the issuance of Special Order 1-81. The fact that the State has taken an active interest in regulating the spreading of oil field brine has lead to a certain degree of self-regulation by those parties handling brine. However, problems do exist that have not yet been rectified by the current management plan approach. Should the Department replace this approach with a new regulatory format? Interviewees did not favor such a change. The majority of interviewed individuals felt that fine-tuning could improve the effectiveness of the current program. One pointed to the fact that brine management plans have existed for only two dust control seasons. Department regulatory efforts during these two years have largely been confined to the circulation of management plan applications to all interested parties. Many interviewees believed that, given more time, the brine management plan approach would run smoothly.

How can the Department's regulation of road brining activities be made more effective? Personnel interviewed by the author offered several suggestions, listed here in the order of their frequency of mention:

1. eliminate oil and gas producers from all brine management plans.

2. eliminate industrial waste haulers from all brine management plans.

3. require county road commissions to schedule the brining of specific road sections if brine applications by waste haulers are to continue.

4. increase the number of personnel responsible for monitoring road brining activities and enforcing management plan provisions.

5. distribute photocopies of approved brine management plans to all appropriate Department field offices.

In every office visited by the author, Department personnel recommended that Special Order 1-81 be amended to prohibit brine spreading by oil and gas producers. Such an amendment may not be necessary to attain this goal. Special Order 1-81 does not now make reference to producers spreading oil field brine under the auspices of a city or county government. Rather, the Order speaks of producers providing brine to "a hauler if the hauler can verify his authorization to receive brines on behalf of a governmental unit."[36] Normally, "hauler" refers to an industrial waste hauler licensed under Act 136, an act which excludes from regulation oil and gas producers who haul their own brine. Allowing waste haulers to spread brine under public sector management plans appears to have come about through an intrepretation of Special Order 1-81 by a small number of employees in the Water Quality Division. This interpretation may not accurately reflect the original intent of the Supervisor of Wells. In turn, allowing producers to spread brine appears to have come about through a failure by Water Quality personnel to differentiate between licensed waste haulers and producers who are not licensed under Act 136. Regardless, producers remain one of the two parties identified as the prime sources of the brine spreading problems that have occurred in recent years. In fact, they are not even covered by the standards

that govern the actions of all other oil field brine transporters. Management plan authorization now acts as a license allowing producers to dispose of their brines on Michigan roadways. Elimination of oil and gas producers from approved brine management plans would be a sensible step towards correcting existing problems.

The second most-cited recommendation centers upon the elimination of industrial waste haulers from approved brine management plans. Reports spanning the past decade have consistently pointed to these individuals as the cause of many brine disposal abuses. Like the producers who haul their own brine, waste haulers operate under a powerful incentive to get rid of the brine they transport as quickly as possible. Brine haulers garner the highest profits by minimizing the distance travelled to disposal sites and maximizing the number of loads hauled in a given period of time. Faced with such constraints, the less scrupulous have dumped brine into streams, in woodlots, and onto roads adjacent to well sites.

Tighter control over waste hauler activities is crucial to the success of the Department's regulation of oil field brine spreading. As in the case of oil and gas producers, Special Order 1-81 does not state that industrial waste haulers are permitted to spread oil field brine for cities or counties. Paragraph 5 of the Supervisor's Order speaks only of allowing haulers to receive brine on behalf of a governmental unit. No mention is made in the Order of authorization for haulers to spread this brine. Nor do the Water Quality Division's "Guidelines" specify such authorization. Under the "Guidelines," a brine management plan must describe "transportation and

spreader vehicles" "privately owned under terms of a written contract (copy to DNR) with governmental unit..."[37] This language is quite imprecise. Does this statement refer to privately owned vehicles spreading brine under a written contract with a governmental body or merely hauling brine for that city or county? One item is clear. In almost every case to date, the public sector holder of a management plan failed to supply to the Department copies of the written contracts between itself and its agents. Under the terms of their own "Guidelines," Water Quality personnel should have denied approval of these plans. A legally-binding contract would set forth the conditions under which a waste hauler could apply oil field brine for a governmental body. A chain of responsibility would thus be established and recognized by all participants.

Although interviewees recommended the elimination of waste haulers from all brine management plans, they recognized that such an action may not be taken. Given the large volumes of brine transported by waste haulers, the safest course to pursue may be to allow the continued inclusion of waste haulers in public sector management plans. Interviewees speculated that outright prohibition of road brining by haulers could lead to an increase in illegal dumping of oil field brine. Brine transporters operate twenty-four hours a day every day of the week; round-the-clock surveillance of their activities is virtually impossible. Thus, by permitting haulers to dispose of their loads on roads, the Department channels hauler activities towards a setting where effective enforcement is more easily achieved. However, if haulers are to continue applying brine for county road commissions, the interviewees insist that the Department require those commissions to schedule brining by specific

road section. In fact, this stipulation has already been implicitly incorporated into the recordkeeping requirements set forth in the management plan "Guidelines." Public sector holders of approved management plans must maintain records of the date, amount, and specific location of each application of oil field brine. Groundwater Quality personnel, except in the Cadillac District, have not insisted upon this recordkeeping. Save for in a few counties such as Allegan, road commissions have not bothered to schedule road brining and thereby better control the activities of their agents. In the absence of pressure from the Department, road commissions have found that they can simply turn their agents loose to brine roads without any supervision.

The failure to supervise the activities of private sector agents was the chief indictment leveled at county road commissions by the Department personnel interviewed by the author. Elimination of these agents from approved management plans or increased enforcement of recordkeeping requirements should substantially reduce existing road brining problems. However, the Department may still face a related problem in dealing with county road commissions. The authority to issue and enforce Special Order 1-81 resides in Act 61 but governmental units are not defined as "persons" subject to the provisions of the Act. This means that government agencies at all levels may fall outside of the jurisdiction of the Supervisor of Wells, the ultimate administrator of Act 61. Thus, the Supervisor has decided to allow county road commissions to use oil field brine on the public roads but maintains only two means of controlling their activities. Department personnel can attempt to persuade county road commissioners to act within the terms of a brine management plan. If persuasion fails, the Geological Survey Division does have the authority to

demand that producers stop releasing brine to a commission that has violated management plan stipulations. Such an order would not only be politically unpopular with both the road commission and the people served by it but might also be slow to take effect due to the Division's formal non-compliance procedures.

A further problem can occur in cases where a county road commission operates its own brine supply well. Again, these wells will fall outside of the purview of the Supervisor of Wells. Even when permitted under the Act 315 (P.A. 1969), the Mineral Well Act, such wells remain beyond the jurisdiction of the Supervisor since governmental units are not "persons" subject to this Act's provisions. In attempting to regulate road commission brine wells, the Department again faces two possibilities. Department personnel can attempt to persuade county officials to properly operate and maintain their brine supply facilities. If problems do arise, the Department can then attempt to prosecute the offending road commission under the general provisions of Act 245 (P.A. 1929, as amended), the Water Resources Commission Act, or bring suit under Act 127 (P.A. 1970), the Michigan Environmental Protection Act.[38] In either case, the Department would be relying upon an indirect means of regulating county road commission activities. In order for the Supervisor of Wells to obtain direct control over road commission activities, the Michigan legislature would have to amend Acts 61 and 315 to define governmental bodies as "persons" subject to the provisions of these Acts.

Regulating the activities of county road commissions may pose continuing problems for Department personnel. Nevertheless, the Department can

substantially improve the brine management program through an increased emphasis upon the enforcement of management plan provisions. The author's interviews highlighted several abuses warranting more attention: waste haulers and producers who spread brine too frequently, county officials who fail to maintain adequate records of brine applications, and a city government which spreads brine as a substitute for mechanical snow removal. Every one of these problems can be attacked through strict enforcement of existing brine management plans. Difficulties may arise - knowing that a section of road is brined too often is not the same as catching a brine spreader in the act of violating an approved management plan. Yet no explanation should excuse allowing the continued use of oil field brine by county road commissions which do not have approved management plans. The management plan approach was designed with a central purpose: to govern the manner in which oil field brine is spread upon Michigan roads. To fulfill this purpose, the activities of brine spreaders must be monitored and the provisions of brine management plans must be enforced.

When discussing program enforcement with the author, many field employees recommended that the Department increase the number of personnel responsible for monitoring road brining activities. Given current budgetary constraints, increases in the number of field personnel may prove impractical. Another alternative lies in increasing the <u>emphasis</u> upon enforcement rather than increasing the <u>size</u> of the Department's field staff. Based upon the responses made during the interviews, many individuals in the responsible Divisions do not want to assume an active role in monitoring road brining activities under Special Order 1-81. Indeed they have shown a marked reluctance to involve

themselves in brine management matters in the two years that have passed since the approval of the first brine management plans. Aside from a small number of cases, Department personnel have not pursued management plan violations. In the absence of a firm commitment from their superiors, field personnel are likely to continue this course of inaction. Decision makers within the Department must resolve whether or not the spreading of oil field brine warrants attention. If they conclude that continued regulation is valuable, then they should stress the need for better enforcement of the objectives of the brine management program.

Even with a heightened emphasis upon enforcement, Department personnel cannot effectively monitor road brining activities without ready access to the information contained in approved management plans. Many interviewees, when asked about their roles in the brine management program, excused their non-participation by pointing to the absence of access to management plan information. Many stated that photocopies of approved brine management plans need to be distributed to all appropriate field offices. While definitely a step in the right direction, disseminating photocopied files is not the only means available for improving field staff access to brine management plan particulars. Both the 1982 Brine Task Force and Environmental Conservation Officer Glen T. Hare have recommended entering management plan information into the Law Enforcement Information Network (LEIN) system. If practical, this recommendation would provide Department personnel with speedy access to information while in the field. They could check for possible management plan violations while actually observing a vehicle in the act of spreading brine. Whether distributed as photocopies or entered into the LEIN system, management

plan information must be made more accessible if the Department's program is to succeed.

In addition to the recommendations made by Department personnel, the author suggests several further changes in the current brine management program. A revised set of brine management plan instructions should be introduced. Field experiences indicate that the time has come to reassess the contents of the current "Guidelines." Minor changes can correct a number of the problems delineated by this study. For example, a stipulation should be included in a revised version of the "Guidelines" to prohibit brine spreading during or immediately after rainfall. As has been described in an earlier section of this report, this activity increases the risk that brine will wash from the road surface into a nearby watercourse. Another caveat should plainly state that all brine spreading not performed by the management plan applicant must be done by a party under written contract to that applicant. A copy of the written contract would then have to be submitted with the proposed management plan. Through this provision, a contracted brine spreader will be required to sign a legal document stating his willingness to adhere to the terms of the applicant's management plan. Finally, the revised instructions should specify that applications of brine for dust control may only be made by means of a fully operational spreader bar. Current management plan instructions do not forbid brining by means of an open valve or splash plate, methods conducive to brine dumping in the guise of dust control. With this new stipulation in place, individuals who dump oil field brine on a public road can be more easily prosecuted than has proved possible with management plans approved under the present "Guidelines."

Revising the "Guidelines" is a first step towards improving the existing brine management plan approach. However, many management plans that have already been approved contain flaws that need to be corrected. Many plans were approved despite the fact that the information they provided was incomplete. Some do not list the names and addresses of contracted brine spreaders; others do not name the well sites from which brine is taken for use upon the public roads. A number of plans do not state whether oil field brine will be used to control dust, to melt ice, or to do both. In several cases, two different plans submitted by a county road commission have received approval and no one within the Department can say which approved plan takes precedence. Because of such discrepancies, a complete review of existing brine management plans is in order.

To improve the current management plan format, emphasis should be placed upon producing consistent, enforceable brine management plans. The repetition of some road brining problems under future management plans can be prevented through the introduction of revised instructions as discussed above. To correct deficiencies in existing plans, the recipients of approved management plans should be asked to submit new brine spreading proposals that conform to the revised "Guidelines." This process would entail Department review of all brine spreading proposals prior to granting new approval of management plans. In this manner the Department can correct past mistakes by requiring the submission of information missing from current brine management plans. All current management plans are plainly labeled as "interim" plans. Furthermore, no provision in either Special Order 1-81 or the "Guidelines" states that management plan approval continues in perpetuity. A review and reapproval

process can also help to assure more consistency in approved management plans statewide. At present, the brine management program is plagued by a confusing array of differing plans. A myriad of spreading volumes and frequencies proliferate throughout the counties of the Southern Peninsula. Dissimilar applicant needs can not explain these variations. Instead, most management plans were approved in the form in which they were submitted, with little cross-referencing to previously approved plans. In addition, two different application forms have been used for the submission of brine management plan proposals. The earlier version produced management plans that, although few in number, contain less essential information than later plans. Requiring all brine management plans to be written under one set of revised instructions, on one standard form, will produce a uniformity which will make plans easier to compare and enforce. More consistent plans could also better protect the waters of the state from brine pollution by curbing the wide variations in application volumes and frequencies that now exist.

The foundation of a revised brine management program could rest upon a standard set to govern brine application rates so that the state's water resources are adequately protected. Neither the Water Resources Commission nor the Groundwater Quality Division has proposed or adopted standards to govern the application of oil field brine on roadways. The August 18, 1983 meeting of the Groundwater Quality Division Supervisory Staff did result in informal agreement with the following standard: the maximum permissible rate of application of oil field brine to Michigan roads should be 1000 gallons per mile per road lane. The suggested maximum frequency of application agreed upon was six applications per dust control season. These standards were deemed to

provide a reasonable assurance that the State's groundwater resources would not be adversely impacted by road brining activities. If such standards were formally adopted, the Department would foster a statewide uniformity in brine application rates and frequencies. Of added interest, the Department's Air Quality Division recently initiated a fugitive dust control program to require the use of a "dust suppressant" at sites where dust is a continual problem. Interest in the use of oil field brine to meet this program's requirements indicates a future increase in brine management plan proposals and further points to the desirability of an application standard.

Adopting interviewee recommendations and revising management plan instructions alone will not solve road brining problems. For these changes to be truly effective, stronger cooperation among the responsible Department Divisions will be needed. Field staff confusion over monitoring responsibilities and the failure to properly distribute management plan information highlight the need for program coordination. A number of interviewees stressed the desirability of designating a contact person in Lansing to coordinate the Department's brine management program. This person could coordinate the review of brine management plans submitted under the revised instructions and thereby insure the use of consistent criteria in approving management plans. A central contact position could also serve as a focal point for obtaining or distributing information concerning approved management plans. Clearly, since several Divisions play a part in the Department's brine management program, cooperation and coordination of effort are essential to effective enforcement. At the least, a memorandum of understanding between the Geological Survey and Groundwater Quality Divisions would be useful in

promoting stronger program coordination. These two Divisions play the largest roles in the current brine management program. A formal memorandum could delineate the roles each Division must play in the brine management program, helping to end the confusion that has prevailed in the past several years. This memorandum could also lead to a broader reorganization of the brine management program.

Many of the individuals interviewed by the author commented upon what they perceived to be the critical weakness in the Department's brine management program. Most interviewees felt that there has been no coordination between the Divisions responsible for regulating the surface disposal of oil field brine. They strongly believed that the Department would be better served if one Division was made responsible for the program. All interviewees except Geological Survey personnel stated that this lead Division should be the Geological Survey. Many Geological Survey interviewees held this opinion also.

Several strong reasons support the designation of the Geological Survey Division as the lead Division responsible for the brine management program. First, the Geological Survey Division has a larger field staff than do either the Groundwater Quality or Hazardous Waste Divisions. Furthermore, the duties of Geological Survey field personnel include regular visits to oil and gas production facilities throughout the state. Survey personnel are familiar with the facilities which serve as the sources of oil field brine and they know the individuals who are involved in the handling and disposal of that brine. Second, the Geological Survey and Law Enforcement Divisions recently signed a formal memorandum of understanding. As discussed in the preceding

section of this report, conservation officers are the key to the effective monitoring of road brining activities and enforcement of brine management plan provisions. Under the new agreement, conservation officers are to receive special training so that they may assist Survey personnel in enforcing the provisions of Act 61. That assistance could include enforcing compliance with Special Order 1-81. Third, and perhaps most important, Geological Survey personnel administer the provisions of Act 61. In Act 61 lies the authority under which the program to regulate oil field brine spreading was initiated. The review and approval of brine management plans now relies upon Groundwater Quality personnel acting under the authority of Special Order 1-81 without the Supervisor of Wells having designated their Division as his representative in these matters. On the other hand, the Geological Survey Division already administers all other provisions of Special Order 1-81. And, under current Department policy and procedures statements, the Geological Survey should be the lead Division in regulating the handling and disposal of oil field brine. The authority to enforce management plan provisions resides in Act 61, authority that has not been vested upon the Groundwater Quality Division. Clearly, enforcement of the Supervisor's Order would be on firmer legal grounds if brine management plan responsibilities were tied to the Geological Survey Division, which by both precedent and Department policy acts as the Supervisor of Wells' representative in matters concerning oil field brine handling and disposal.

SUMMATION

Oil field brine is highly saline water produced as a by-product during oil and gas drilling and production operations. Most of this waste brine will be returned to underground formations; however, more than 50 million gallons will be spread each year upon Michigan roadways and other properties. Much of the oil field brine that is spread on the public roads is applied to suppress the formation of dust. A strong suspicion exists that this road brining will cause long-term, low-level contamination of the state's groundwaters but no proof of this trend currently exists. In recent years the continual use of oil field brine on several roads has probably been the cause of a number of cases of well water contamination. No adverse health effects have been reported as a result of any of these incidences.

The Supervisor of Wells holds the authority to regulate the disposal of oil field brine under Act 61 (P.A. 1939, as amended). Through Special Order 1-81 and its amendments, the Supervisor has declared that this brine may be used for dust control, ice removal, and road stabilization on public roads, private properties, and production facility access roads. The Supervisor's Order resulted in the creation of an administrative process through which these uses could be properly regulated. At the heart of this process lies the brine management plan. Approval of a brine management plan must be obtained from the Department prior to any use of oil field brine on public roads or private properties. In the two years that have passed since the inception of the management plan program, ninety-one plans have received approval.

Through interviews with the Department's most knowledgeable personnel, the author examined road brining practices under Special Order 1-81. The key problem uncovered by this study involved excessive brine spreading by licensed industrial waste haulers and by oil and gas producers who hauled and spread their own brine. These individuals, operating for county, township, or city governments, have been applying oil field brine at a frequency many times greater than cited in the management plans under which they operate. In areas where new drilling operations are active, haulers and producers have been applying brine from drilling pits to adjacent roadways in quantities believed to greatly exceed permitted application rates. In sum, waste haulers and producers appear to be dumping oil field brine rather than applying it in accordance with an approved brine management plan.

At the crux of this problem is brine disposal in the guise of acceptable road maintenance. Waste haulers and producers want to dispose of oil field brine at the lowest possible cost. County road commissions want to provide their citizens with dust-free secondary roads at the lowest possible cost. In essence, haulers and producers have a monetary incentive to dump their brine on local roads and county road commissions have little incentive to discourage this practice. As a result, overly frequent applications of oil field brine are made to roads near well sites while little is spread in areas distant from oil and gas fields.

The keystone of the Department of Natural Resources' regulation of oil field brine spreading has been the brine management plan. In the two years since its inception, the brine management plan approach has received limited support

from personnel in the Department Divisions responsible for administering this program. Regulatory efforts during these two years have largely been confined to the circulation of management plan applications to all interested parties. Furthermore, Department personnel have not adequately monitored road brining activities, in part due to a failure to distribute management plan information to District offices. Department decision makers in turn have not delineated the roles to be played by each Division in the enforcement of brine management plans. In the absence of coherent Department policy, county road commissions and their agents have been able to ignore those management plan restrictions that they deemed to be inconvenient.

Because of lethargy and indecision within the Department of Natural Resources, the brine management plan approach has not yet been truly tested. Both the author and most interviewees have concluded that the management plan approach can be improved but need not be abandoned. Based upon the findings of this study, the author recommends that the following actions be taken:

1. The Geological Survey Division should be designated as the lead Division in administering the Department's brine management plan program.

2. A memorandum of understanding between the Geological Survey and Groundwater Quality Divisions should be drafted to delineate the roles each Division should play in the brine management program.

3. A revised set of brine management plan instructions should be introduced. Current holders of approved management plans should be required to resubmit their brine spreading proposals for Department approval under the revised instructions.

4. Oil and gas producers should no longer be permitted to spread their brine on the public roads.

5. Licensed industrial waste haulers should not be permitted to spread oil field brine on the public roads unless the governmental unit for whom they operate specifies exactly where and how that brine will be applied, under a written contract signed by both parties.

6. The Department should increase the emphasis placed upon monitoring road brining activities and enforcing management plan provisions.

7. The information contained in approved brine management plans should be made readily accessible to personnel at all appropriate Department field offices.

8. A centrally located contact person should be assigned the responsibility of coordinating the statewide implementation of the brine management program.

APPENDIX A

SPECIAL ORDER NUMBER 1-81 (as amended)

Paragraph 1. All brines shall be disposed of by injection to approved subsurface formations through approved brine disposal wells, injected pursuant to an approved secondary recovery plan, reused for drilling purposes, or use[d] in accord with a plan approved pursuant to procedures adopted by the Water Resources Commission, except as provided in paragraphs 2 and 7 below.

Paragraph 2. The field representative of the Supervisor of Wells may authorize the disposal of on-site drilling fluids to dry holes under controlled conditions as part of the plugging operations, or[,] in the event that production casing is run on a well, may, under special conditions, authorize annular space disposal of injectable drilling fluids generated during the drilling of that well, provided in both cases that drilling fluids are injected in permeable formations below the fresh water horizons and that disposal pressure gradients do not exceed 0.7 psi per foot at the surface casing seat.

Paragraph 3. Producers shall be responsible for the proper handling of all brines on their lease site, central tank battery, or other proximate loading site [facilities] irrespective of the ownership of storage or loading facilities.

Paragraph 4. Producers shall maintain records for two years of the disposition of all brines. The records shall indicate dates, volumes, recipient, transporter, destination, and proof of delivery.

If an authorized hauler receives brines at an unattended loading site the hauler shall provide the producer a signed record describing the volume, time, date, destination, and proof of delivery.

Paragraph 5. Producers may provide brine to governmental units or a hauler if the hauler can verify his authorization to receive brines on behalf of a governmental unit. After September 15, 1981, all uses of oil field brines by units of government will be in accord with a management plan approved pursuant to procedures adopted by the Water Resources Commission.

Paragraph 6. The governmental unit receiving brine shall be responsible for the safe handling and use of brines from the point of loading, and for separate storage and place of use, regardless of ownership of hauling vehicles.

Paragraph 7. A District Supervisor of the Geological Survey Division, as a representative of the Supervisor of Wells, may grant an annual written authorization to an operator to use oil field brines for dust or ice control and [road] stabilization on oil and gas production facility access roads that are maintained and controlled by the operator. The application shall be made to the District Supervisor providing such data as is required. Failure by the operator to use the brine as required by the Supervisor of Wells may result in the revoking of the Supervisor of Wells' written authorization.

Paragraph 8. Oil field brines may be used on private roads and property (i.e. parking lots, construction projects) for dust or ice control and road stabilization. The application on private property shall be pursuant to a management plan approved by the Water Resources Commission.

Paragraph 9. No brines shall be used as drilling fluid for the drilling and workover of any kind of well or test hole without written approval from the field representative of the Supervisor of Wells. In no case will such approval be granted if brines are derived from oil and/or gas wells containing more than 20 ppm of H_2S in the gas stream unless it can be shown that there is less than 500 ppm concentration present in the brine.

Paragraph 10. Brines used for road purposes:

(a) Brines containing H_2S may be used in accord with an approved plan under Special Order 1-81 for road dust, ice control, or [road] stabilization purposes.

(b) All brines from oil and/or gas wells known to contain H_2S shall be tested for their H_2S concentration by September 30, 1982 and annually thereafter.

(c) Those using brines containing H_2S should implement training programs for their employees in the safe handling of these materials. The Michigan Department of Public Health and Michigan Department of Labor should be consulted in developing programs. It should be noted that existing regulations concerning occupational health and safety are applicable to exposure to H_2S and must be complied with.

Paragraph 11. All testing for H_2S shall be done by methods approved by the Supervisor of Wells. The attached instructions for testing H_2S in brine [not included here] are to be followed and are incorporated in this order by reference. Results of all tests shall be filed with [the] appropriate field representative of the Supervisor.

APPENDIX B

OIL FIELD BRINE DISPOSAL STATISTICS

Appendix Table I records the disposition of oil field brine from 1937 through 1968, the last year in which the Geological Survey Division compiled these statistics. Since 1968 the only statistical data available concerning oil field brine has been brine production figures for each oil and gas well in the state. This information can be found in the annual oil, gas, and brine production reports for each Geological Survey District. The accuracy of the recorded statistics varies between Districts due to differences in data collection and recording procedures.

Appendix Table II contrasts brine production data from the past twenty years with the number of brine disposal wells completed in each of those years. To produce this table, the author calculated the quantities of brine applied to Michigan roads for the years not covered by Geological Survey Division brine disposition records. In the years preceding 1968, the last year of complete recordkeeping, an average of 2.38% of the total quantity of brine produced each year was spread upon roadways. Since brine use on roads during this period was relatively constant, a reasonable assumption can be made that in the years following 1968 a similar percentage of the total brine produced was applied to roads. However, a dramatic increase in the number of new disposal well completions occurred in 1976 and this increase continued through 1982. In addition, when interviewed by the author, members of the Geological Survey field staff mentioned observing a shift towards increased subsurface disposal in recent years. In the absence of documented statistics, the author assumed that this trend led to a one-half percent drop in the proportion of brine being spread upon roads. Thus, he calculated that 1.88% of the total quantity of brine produced after 1976 was spread upon roads. Note that, based upon this assumption, an estimated 58 million gallons of brine would have been spread on roads in 1982. This figure is 5 million gallons greater than the figure derived from the most accurate production data presently available. Given the inherent conservatism of that production data, the estimates produced in Appendix Table II may fairly represent road brining volumes for the past several years.

APPENDIX TABLE I

THE DISPOSITION OF OIL FIELD BRINE, 1937 - 1968

Year	Pits (gallons)	Roads (gallons)	Chemical Companies (gallons)	Subsurface Formations (gallons)	Total (gallons)
1937	127,882,860	0	159,048,750	334,945,170	621,876,780
1938	103,446,840	0	136,743,600	478,464,630	718,655,070
1939	75,132,330	0	114,453,780	744,716,070	934,302,180
1940	79,807,980	0	103,109,580	1,055,041,260	1,237,958,820
1941	54,268,200	0	129,569,160	1,203,159,720	1,386,997,080
1942	72,434,250	0	123,897,060	1,283,458,260	1,479,789,570
1943	76,082,790	0	125,246,100	1,367,543,310	1,568,872,200
1944	60,768,120	0	134,566,740	1,565,039,700	1,760,374,560
1945	36,056,160	0	137,847,360	1,655,226,090	1,829,129,610
1946	35,366,310	0	140,284,830	1,860,832,050	2,036,483,190
1947	28,866,390	0	131,516,070	2,036,498,520	2,196,880,980
1948	22,918,350	0	129,231,900	2,276,459,010	2,428,609,260
1949	23,623,530	0	131,347,440	2,486,096,760	2,641,067,730
1950	18,579,960	0	106,528,170	2,759,675,940	2,884,784,070
1951	24,880,590	0	116,967,900	2,913,834,420	3,055,682,910
1952	21,845,250	2,253,510	22,995,000	3,130,631,280	3,177,725,040
1953	18,901,890	2,682,750	7,051,800	2,896,588,170	2,925,224,610
1954	21,063,420	1,839,600	9,412,620	2,942,900,100	2,975,215,740

APPENDIX TABLE I continued

THE DISPOSITION OF OIL FIELD BRINE, 1937 - 1968

Year	Pits (gallons)	Roads (gallons)	Chemical Companies (gallons)	Subsurface Formations (gallons)	Total (gallons)
1955	23,914,800	2,468,130	9,335,970	3,066,475,230	3,102,194,130
1956	21,293,370	10,685,010	30,660	2,981,301,750	3,013,310,790
1957	19,085,850	17,813,460	0	2,962,108,590	2,999,007,900
1958	20,971,440	16,694,370	0	2,709,945,420	2,747,611,230
1959	15,912,540	14,471,520	0	2,615,650,590	2,646,034,650
1960	15,621,270	23,178,960	0	2,582,583,780	2,621,384,010
1961	13,950,300	16,249,800	0	2,389,257,150	2,419,457,250
1962	15,054,060	10,071,810	0	2,265,605,370	2,290,731,240
1963	13,275,780	47,982,900	0	2,233,581,000	2,294,839,680
1964	13,735,680	65,075,850	0	2,204,929,230	2,283,740,760
1965	11,880,750	50,573,670	0	2,161,959,240	2,224,413,660
1966	10,792,320	45,959,340	0	2,156,624,400	2,213,376,060
1967	0	61,136,040	0	2,161,300,050	2,222,436,090
1968	0	51,309,510	0	2,264,103,030	2,315,412,540

SOURCE: Geological Survey Division, Michigan Department of Natural Resources, 1969, Michigan Oil and Gas Fields, 1968, Annual Statistical Summary 10, Table 17, page 63.

APPENDIX TABLE II

OIL FIELD BRINE APPLIED TO ROADS, 1963 - 1982

Year	Total Quantity of Oil Field Brine (gallons)	Quantity Recorded As Applied To Roads (gallons)	Brine Disposal Well Completions
1963	2,294,839,680	47,982,900	1
1964	2,283,740,760	65,075,850	1
1965	2,224,413,660	50,573,670	0
1966	2,213,376,060	45,959,340	0
1967	2,222,436,090	61,136,040	2
1968	2,315,412,540	51,309,510	0

Year	Total Quantity of Oil Field Brine (gallons)	Estimated Quantity Being Applied To Roads (gallons)	Brine Disposal Well Completions
1969	2,049,973,590	48,790,000*	1
1970	2,290,899,870	54,525,000*	0
1971	2,075,252,760	49,390,000*	2
1972	1,832,977,440	43,625,000*	2
1973	1,855,052,640	44,150,000*	1
1974	1,688,890,770	40,195,000*	1
1975	1,659,104,580	39,485,000*	1
1976	1,666,416,990	39,660,000*	12

APPENDIX TABLE II continued

OIL FIELD BRINE APPLIED TO ROADS, 1963 - 1982

Year	Total Quantity of Oil Field Brine (gallons)	Estimated Quantity Being Applied To Roads (gallons)	Brine Disposal Well Completions
1977	2,087,854,020	39,250,000**	4
1978	1,915,130,910	36,000,000**	3
1979	2,178,163,050	40,950,000**	4
1980	2,846,765,670	53,520,000**	5
1981	3,273,491,550	61,540,000**	6
1982	3,106,302,570	58,400,000**	8

*This figure equals approximately 2.38% of the annual brine production total.

**This figure equals approximately 1.88% of the annual brine production total.

NOTE: Brine production totals and disposal well completion figures for 1963 through 1981 were derived from information found in Michigan Oil and Gas Fields (Annual Statistical Summaries 10 through 36) produced by the Geological Survey Division. Brine production figures for 1982 were derived by the author from a review of the 1982 annual oil, gas, and brine production reports filed by each Geological Survey District staff. The disposal well completion total for 1982 was derived from information on file at the Division's Lansing headquarters.

APPENDIX C

NOTICE TO

ALL OIL AND GAS PRODUCERS

Rules 601 and 602 of the Administrative Rules promulgated pursuant to Act 61, P.A. 1939 provides that brine or salt water produced in the drilling for or production of oil and gas shall be returned to an approved underground formation or otherwise disposed of as approved by the Supervisor of Wells. Most brine is returned to the subsurface but some is in demand for beneficial uses.

Employment of produced brines for the drilling of other wells or for secondary recovery projects are highly regarded and approved practices. Utilization of brines for dust control, road stabilization, or ice removal is acceptable if ground surface spreading is performed in a careful manner and will not cause ground water contamination.

Authorization by the Supervisor of Wells for surface use of oil field brines is subject to owners, operators, and haulers compliance with the criteria which follow:

1. Brine may be used only for road stabilization, dust control and ice removal.

2. Permission and authorization for brine application must first be obtained from each owner of the surface on which the brine is to be applied.

3. Devices, such as a spreader bar or sprayer, must be used for even distribution of brine. Dump valves are not acceptable. The truck must be in motion during the spreading process.

4. Brine is not to be applied during or immediately after rains or while the road surface is wet.

5. Brine is to be applied only in a manner where runoff to ditches or watercourses will not occur.

6. Brine application shall be performed in a manner that will prevent the contamination of ground waters. Brine dumping or spreading to the ground surface, as a disposal method, is not approved.

7. Brine application to other than roadways or parking areas is not approved.

8. Producers are expected to keep records of the quantities of brine employed in ground surface applications.

Dated June 19, 1978

Arthur E. Slaughter

ARTHUR E. SLAUGHTER
ASSISTANT SUPERVISOR OF WELLS

APPENDIX D

BRINE INTERVIEW QUESTIONNAIRE

1. Do the following occur in your district?

   a. Too frequent brine applications at some sites?

   b. Too much brine per application?

   c. Improper spreading techniques? (such as?)

   d. Application when unnecessary? (why unnecessary?)

   e. Application on roads not designated for brining?

   f. Application on roads not suitable for brining (due to slope, drainage, or other factors)?

   g. Application by unlicensed waste haulers?

2. Is there misuse of brine in applications on private roads? Is this a major problem?

3. Is there misuse of brine in applications on lease sites? Is this a major problem?

4. In which areas of this district have road brining problems occurred? Have attempts been made to prosecute individuals or companies for improper or unauthorized brine spreading? To what result?

5. Do you have figures for the quantity of brine annually spread in each county in your district? (If not, who does?) Do you believe these figures to be accurate?

6. What environmental impacts do you foresee as a result of road brining?

7. Have any of these impacts occurred? Do you have documentation of those occurrences?

8. Do you have records of complaints from residents about too much brining?
" " " " " " " " about not enough brining?

9. Which county road commissions do their own brining?

10. Which county road commissions contract to have brine spread?

11. Which county road commissions request or receive date, location, and quantity information prior to brine applications by contracted waste haulers? Would such information be useful if submitted to you?

12 If brine is properly applied in accordance to an approved brine management plan, would we still have problems? (if YES, would you recommend any changes in the current BMP program?)

13. Where should we attack current brine disposal problems?

    a. The oil & gas producers?

    b. The waste haulers?

    c. The county road commissions?

14. Which division should be responsible for overseeing brine disposal practices? Why? Should we try joint enforcement?

15. Which counties in your district obtain brine from their own wells or from mineral wells (under Act 315)?

16. Are waste brines free to the county road commissions? If not, how much do they cost?

17. Do we have a problem with the following? (How severe?)

    a. Brines contaminated with oil?

    b. Brine contaminated with hydrogen sulfide?

    c. Brines contaminated with toxic chemicals?

    d. Brine spills on lease sites?

    e. Brine spills off lease sites?

    f. Brine disposal wells?

    g. Brine from drilling pits?

FOOTNOTES

[1] Special Order Number 1-81 was amended on June 15, 1981 (a change of date in paragraph 5), on November 3, 1981 (the addition of paragraphs 7 and 8), and again on June 2, 1982 (the addition of paragraphs 9 through 11).

[2] Secondary recovery involves the injection of a fluid such as oil field brine into an oil-bearing formation in order to drive the oil from the rock's pore space so that it may be pumped to the surface.

[3] Hassan A. Sultan and Peter Fleming, 1974, Soil Erosion and Dust Control on Arizona Highways: Part I. State of the Art Review, Arizona Transportation and Traffic Institute, The University of Arizona, Research Project HPR-1-10(141), The Arizona Department of Transportation, page 92.

[4] P.J. Moses, 1981, "An Environmental Review of Calcium Chloride in Road Dust Control and Stabilization Applications," The Dow Chemical Company, June 1981.

[5] Franklin S. Adams, 1973, "Highway Salt: Social and Environmental Concerns," Environmental Degradation by De-Icing Chemicals and Effective Countermeasures, Highway Research Record Number 425, Highway Research Board, National Academy of Sciences - National Academy of Engineering, page 5.

[6] J. Hode Keyser, 1973, "De-Icing Chemicals and Abrasives: State of the Art," Environmental Degradation by De-Icing Chemicals and Effective Countermeasures, Highway Research Record Number 425, Highway Research Board, National Academy of Sciences - National Academy of Engineering, page 37 (Table 2).

[7] Keyser, 1973, page 37 (Table 2).

[8] Keyser, 1973, page 40.

[9] Sultan, 1974, page 96.

[10] Sultan, 1974, page 96.

[11] Based upon an assumed LIQUIDOW specific gravity of 1.34 and a calcium chloride content of 38% by weight.

[12] P.J. Moses, 1982, "A Study on Dust Control Effectiveness of Calcium Chloride and Waste Brine," The Dow Chemical Company, April 1982.

[13] James W. Moore and Robert C. Welch, 1977, Environmental Aspects of Brine Usage for Highway Purposes, College of Engineering, University of Arkansas, Highway Research Project 44, Arkansas State Highway and Transportation Department, page 2.

[14] Moore and Welch, 1977, page 31, Table I.

[15] Moore and Welch, 1977, page 118, Figure 61.

[16] P.J. Moses, 1982.

[17] Henry W. Kirchner, 1983, December 19, 1983 correspondence with the author.

[18] Ibid

[19] Testimony given by Micheal K. Dillenbeck, Engineer-Manager of the Manistee County Road Commission, at the October 13, 1983 public hearing before the Supervisor of Wells on Cause (A) 18-10-81.

[20] Information supplied by Douglas L. Daniels, Area Geologist, Plainwell District, Geological Survey Division during an interview conducted by the author on August 30, 1983.

[21] Ibid

[22] 40 C.F.R. 143.3 (1983). This recommended standard has not been adopted in Michigan and is therefore not enforceable for public or private water supplies (Michigan Environmental Health Association, 1978, Sanitarian's Ready Reference, page 47h).

[23] R.E. Hanes, L.W. Zelazny, and R.E. Blaser, 1970, Effects of Deicing Salts on Water Quality and Biota: Literature Review and Recommended Research, National Cooperative Highway Research Program Report 91, Highway Research Board, National Academy of Sciences - National Academy of Engineering, page 5.

[24] Information in this paragraph was derived from Daniel H. Pollard, 1964, "Michigan: Oil State of the Great Lakes, Origin and Early Development 1860-1935," Doctor of Philosophy Thesis, University of Michigan.

[25] Jeffrey E. Herrold, 1983, "Oil Field Brine Statistics," October 14, 1983 memorandum to Allen F. Crabtree, Assistant Division Chief, Geological Survey Division.

[26] Ibid

[27] Forrest C. Strong, 1944, "A Study of Calcium Chloride Injury to Roadside Trees," Quarterly Bulletin, Volume 27, Number 2, Michigan State College, Agricultural Experiment Station, page 216.

[28] Strong, 1944, pages 216 - 217.

[29] Strong, 1944, page 217.

[30] Paragraph 2 of Special Order 1-81 originally included the following:

> The field representative may also authorize limited quantity application of brine for ice or dust control to a drilling site access road which is not a part of a governmental road system. Such applications shall be done with the permission of the property owner or his representative and at rates and in a manner to prevent contamination of ground or surface waters.

Compare this language with Paragraph 7 of the amended Order (Appendix A).

[31] Water Quality Division, Michigan Department of Natural Resources, 1981, "Guidelines for Preparation of an Interim Brine Management Plan under Supervisor of Wells Order 1-81."

[32] David M. Dennis, 1982, undated memorandum entitled "Special Assignments for Ron Shaver, Unit Chief, Emergency Response & Waste Hauler Licensing Section, Water Quality Division."

[33] Water Quality Division, Michigan Department of Natural Resources, Brine Task Force, 1982, Minutes of the September 20, 1982 meeting at Mt. Pleasant, Alice Cantu, recording secretary.

[34] Oil or natural gas are not produced in Michigan's Northern Peninsula and no oil field brine is presently spread upon Northern Michigan roads.

[35] The author also spoke with Michigan Department of Transportation employees and county road commission officials to gain addition information related to the use of brines on roadways.

[36] Paragraph 5, Supervisor of Wells' Special Order 1-81 as amended.

[37] Water Quality Division, Michigan Department of Natural Resources, 1981, "Guidelines for Preparation of an Interim Brine Management Plan under Supervisor of Wells Order 1-81," page 3.

[38] Legal actions can be brought against a governmental body alleged to be violating the provisions of either Act. Pertinent sections of each Act are as follows:

> Section 6(a) of Act 245 (P.A. 1929, as amended): "It shall be unlawful for any [governmental body] directly or indirectly to discharge into the waters of the state any substance which is or may become injurious to the public health, safety, or welfare..."
>
> Section 10(2) of Act 245 (P.A. 1929, as amended): "A person [governmental body] who discharges a substance into the waters of the state contrary to the provisions of this act...is guilty of a misdemeanor and shall be fined not less than $2,500.00 nor more than $25,000.00 for each violation."
>
> Section 2(1) of Act 127 (P.A. 1970): The State "may maintain an action in the circuit court having jurisdiction where the alleged violation occurred or is likely to occur for declaratory and equitable relief against...any political subdivision [of the state]...for the protection of the air, water and other natural resources and the public trust therein from pollution, impairment or destruction."

BIBLIOGRAPHY

1. Adams, Franklin S., 1973, "Highway Salt: Social and Environmental Concerns," Environmental Degradation by De-Icing Chemicals and Effective Countermeasures, Highway Research Record Number 425, Highway Research Board, National Academy of Sciences - National Academy of Engineering, pages 3 - 13.

2. Collins, A. Gene, 1975, Geochemistry of Oilfield Waters, Developments in Petroleum Science Series, Volume 1, Elsevier Scientific Publishing Co., Amsterdam, The Netherlands.

3. Dennis, David M., 1982, undated memorandum entitled "Special Assignments for Ron Shaver, Unit Chief, Emergency Response & Waste Hauler Licensing Section, Water Quality Division."

4. Edison Water Quality Laboratory, 1971, Environmental Impact of Highway Deicing, Project 11040GKK, Office of Water Quality Research, United States Environmental Protection Agency.

5. Geological Survey Division, Michigan Department of Natural Resources, 1969, Michigan Oil and Gas Fields, 1968, Annual Statistical Summary 10.

6. Geological Survey Division, Michigan Department of Natural Resources, 1970, Michigan Oil and Gas Fields, 1969, Annual Statistical Summary 12.

7. Geological Survey Division, Michigan Department of Natural Resources, 1971, Michigan Oil and Gas Fields, 1970, Annual Statistical Summary 14.

8. Geological Survey Division, Michigan Department of Natural Resources, 1972, Michigan Oil and Gas Fields, 1971, Annual Statistical Summary 16.

9. Geological Survey Division, Michigan Department of Natural Resources, 1973, Michigan Oil and Gas Fields, 1972, Annual Statistical Summary 18.

10. Geological Survey Division, Michigan Department of Natural Resources, 1974, Michigan Oil and Gas Fields, 1973, Annual Statistical Summary 20.

11. Geological Survey Division, Michigan Department of Natural Resources, 1975, Michigan Oil and Gas Fields, 1974, Annual Statistical Summary 22.

12. Geological Survey Division, Michigan Department of Natural Resources, 1976, Michigan Oil and Gas Fields, 1975, Annual Statistical Summary 24.

13. Geological Survey Division, Michigan Department of Natural Resources, 1977, Michigan Oil and Gas Fields, 1976, Annual Statistical Summary 26.

14. Geological Survey Division, Michigan Department of Natural Resources, 1978, Michigan Oil and Gas Fields, 1977, Annual Statistical Summary 28.

15. Geological Survey Division, Michigan Department of Natural Resources, 1979, Michigan Oil and Gas Fields, 1978, Annual Statistical Summary 30.

16. Geological Survey Division, Michigan Department of Natural Resources, 1980, Michigan Oil and Gas Fields, 1979, Annual Statistical Summary 32.

17. Geological Survey Division, Michigan Department of Natural Resources, 1982, Michigan Oil and Gas Fields, 1980, Annual Statistical Summary 34.

18. Geological Survey Division, Michigan Department of Natural Resources, 1983, Michigan Oil and Gas Fields, 1981, Annual Statistical Summary 36.

19. Groundwater Geology Unit, Geological Survey Division, Michigan Department of Natural Resources, 1983, Brine Investigation Report Summary, October 1, 1982 - September 30, 1983.

20. Groundwater Quality Division, Michigan Department of Natural Resources, 1982, Assessment of Groundwater Contamination: Inventory of Sites, Task 3(a)(2) & 3(b) of the Groundwater Management Strategy for Michigan, July 1982.

21. Groundwater Quality Division, Michigan Department of Natural Resources, 1983, Michigan Sites of Environmental Contamination Proposed Priority List, prepared pursuant to Act 307 (P.A. 1982), the Michigan Environmental Response Act, November 16, 1983.

22. Hanes, R.E., Zelazny, L.W., and Blaser, R.E., 1970, Effects of Deicing Salts on Water Quality and Biota: Literature Review and Recommended Research, National Cooperative Highway Research Program Report 91, Highway Research Board, National Academy of Sciences - National Academy of Engineering.

23. Herrold, Jeffrey E., 1983, "Oil Field Brine Statistics," October 14, 1983 memorandum to Allen F. Crabtree, Assistant Division Chief, Geological Survey Division (cited as Herrold, 1983a).

24. Herrold, Jeffrey E., 1983, "The Quantity of Brine in Drilling Pits," November 28, 1983 memorandum to Allen F. Crabtree, Assistant Division Chief, Geological Survey Division (cited as Herrold, 1983b).

25. Keyser, J. Hode, 1973, "De-Icing Chemicals and Abrasives: State of the Art," Environmental Degradation by De-Icing Chemicals and Effective Countermeasures, Highway Research Record Number 425, Highway Research Board, National Academy of Sciences - National Academy of Engineering, pages 36 - 51.

26. Kirchner, Henry W., 1983, December 19, 1983 correspondence with the author.

27. Michigan Environmental Health Association, 1978, Sanitarian's Ready Reference, Lansing, Michigan.

28. Michigan Geological Survey Division, United States Bureau of Mines, and Cory Laboratory, Inc., 1976, Oil Field Brine Collection and Analysis Program, unpublished analyses of 319 samples.

29. Moore, James W. and Welch, Robert C., 1977, Environmental Aspects of Brine Usage for Highway Purposes, College of Engineering, University of Arkansas, Highway Research Project 44, Arkansas State Highway and Transportation Department.

30. Moses, P.J., 1981, "An Environmental Review of Calcium Chloride in Road Dust Control and Stabilization Applications," The Dow Chemical Company, June 1981.

31. Moses, P.J., 1982, "A Study on Dust Control Effectiveness of Calcium Chloride and Waste Brine," The Dow Chemical Company, April 1982.

32. Mulholland, R.W., 1972, Evaluation of Selected Dust Palliatives on Secondary Highways, Saskatchewan Department of Highways Technical Report 18.

33. Pollard, Daniel H., 1964, "Michigan: Oil State of the Great Lakes, Origin and Early Development 1860-1935," Doctor of Philosophy Thesis, University of Michigan.

34. Rich, Avery E., 1973, "Some Effects of De-Icing Chemicals on Roadside Trees," Environmental Degradation by De-Icing Chemicals and Effective Countermeasures, Highway Research Record Number 425, Highway Research Board, National Academy of Sciences - National Academy of Engineering, pages 14 - 16.

35. Segall, R. Thomas, 1981, "Dust and ice control on oil and gas lease roads," November 9, 1981 memorandum to Regional & District Geologists, Regions II & III.

36. Strong, Forrest C., 1944, "A Study of Calcium Chloride Injury to Roadside Trees," Quarterly Bulletin, Volume 27, Number 2, Michigan State College, Agricultural Experiment Station, pages 209 - 224.

37. Sultan, Hassan A., and Fleming, Peter, 1974, Soil Erosion and Dust Control on Arizona Highways: Part I. State of the Art Review, Arizona Transportation and Traffic Institute, The University of Arizona, Research Project HPR-1-10(141), The Arizona Department of Transportation.

38. Sultan, Hassan A., 1974, Soil Erosion and Dust Control on Arizona Highways: Part II. Laboratory Testing Program, Arizona Transportation and Traffic Institute, The University of Arizona, Research Project HPR-1-10(141), The Arizona Department of Transportation.

39. Sultan, Hassan A., 1974, Soil Erosion and Dust Control on Arizona Highways: Part III. Progress Report - Field Testing Program, Arizona Transportation and Traffic Institute, The University of Arizona, Research Project HPR-1-10(141), The Arizona Department of Transportation.

40. Sultan, Hassan A., 1976, Soil Erosion and Dust Control on Arizona Highways: Part IV. Final Report - Field Testing Program, Arizona Transportation and Traffic Institute, The University of Arizona, Research Project HPR-1-10(141), The Arizona Department of Transportation.

41. Supervisor of Wells, State of Michigan, 1980, recording tape of the December 22, 1980 public hearing before the Supervisor of Wells on Cause (A) 21-12-80.

42. Supervisor of Wells, State of Michigan, 1981, Special Order Number 1-81, March 3, 1981.

43. Supervisor of Wells, State of Michigan, 1981, Special Order Number 1-81 Amended, June 15, 1981 (amendment of Paragraph 5).

44. Supervisor of Wells, State of Michigan, 1981, recording tape of the October 13, 1981 public hearing before the Supervisor of Wells on Cause (A) 18-10-81.

45. Supervisor of Wells, State of Michigan, 1981, Amendment of Special Order Number 1-81, November 3, 1981 (addition of Paragraphs 7 and 8).

46. Supervisor of Wells, State of Michigan, 1982, Special Order 1-81, Amended (re Use of Sour Brine), June 2, 1982.

47. Water Quality Division, Michigan Department of Natural Resources, 1981, "Guidelines for Preparation of an Interim Brine Management Plan under Supervisor of Wells Order 1-81."

48. Water Quality Division, Michigan Department of Natural Resources, 1982, Minutes of the Brine Task Force meetings held from June 24, 1982 through November 1, 1982, Alice Cantu, recording secretary.

49. Water Resources Commission, State of Michigan, 1981, Minutes of the 1981 Commission meetings.