ENVIRONMENTAL PROTECTION AGENCY

[FRL-3670-8]

Proposing the Granting of an Exemption to Upjohn Company for the Continued Injection of Hazardous Waste Subject to the Land Disposal Restrictions of the Hazardous and Solid Waste Amendments of 1984

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of intent to grant an exemption to the Upjohn Company of Kalamazoo, Michigan for the continued injection of certain hazardous wastes.

SUMMARY: The United States Environmental Protection Agency (USEPA or Agency) today is proposing to grant an exemption from the ban on disposal of hazardous wastes through injection wells to the Upjohn Company (Upjohn), Kalamazoo, Michigan. Upjohn may therefore continue to inject Resource Conservation and Recovery Act (RCRA) regulated hazardous wastes, if the exemption is granted. Upjohn submitted a petition to the USEPA under 40 CFR Part 148, which allows any person to petition the Administrator to determine whether its continued injection of certain hazardous wastes is protective of human health and the environment. After a comprehensive review of all material submitted, the USEPA has determined, with a reasonable degree of certainty, that Upjohn's injected wastes will not migrate out of the injection zone over the next 10,000 years.

DATE: The USEPA is requesting public comments on today's proposed decision. Comments will be accepted until November 20, 1989. Comments post-marked after the close of the comment period will be stamped "Late" A public hearing will be scheduled for this proposed action and notice will be given in a local paper and to all people on a mailing list developed by the Underground Injection Control (UIC) program. If you wish to be notified of the date and location of the public hearing please contact the person listed below.

ADDRESSES: Submit written comments, by mail, to: United States Environmental Protection Agency Region V Underground Injection Control Section (5WD-TUB-9), 230 South Dearborn Street, Chicago, Illinois 60604, Attn: Edward P Watters.

FOR FURTHER INFORMATION CONTACT: David Werbach, Lead Petition Reviewer, UIC Section, Water Division, Office Telephone Number: (312) 886-4242, 9th floor Trans Union Building, 111 West Jackson Street, Chicago, Illinois.

SUPPLEMENTARY INFORMATION:

I. Background

A. *Authority*—The Hazardous and Solid Waste Amendments of 1984 (HSWA), enacted on November 8, 1984, impose substantial new responsibilities on those who handle hazardous waste. The amendments prohibit the continued land disposal of untreated hazardous waste beyond specified dates, unless the Administrator determines that the prohibition is not required in order to protect human health and the environment for as long as the waste remains hazardous (RCRA section 3004(d)(1), (e)(1), (f)(2), (g)(5)). The statute specifically defined land disposal to include any placement of hazardous waste in an injection well (RCRA section 3004(k)). After the effective date of prohibition, hazardous waste can only be injected under two circumstances:

(1) When the waste has been treated in accordance with the requirements of 40 CFR part 268 pursuant to section 3004(m) of RCRA, (the USEPA has adopted the same treatment standards for injected wastes in 40 CFR part 148, subpart B); or

(2) When the owner/operator has demonstrated that there will be "No Migration" of hazardous constituents from the injection zone for as long as the waste remains hazardous. Applicants seeking an exemption from the ban must demonstrate either:

(a) That the waste undergoes a chemical transformation so as to no longer pose a threat to human health and the environment; or

(b) That fluid flow is such that injected fluids would not migrate vertically upward out of the injection zone or to a point of discharge in a period of 10,000 years by use of mathematical models (40 CFR 148.20(a), 53 FR 28118 (July 26, 1988)).

B. *Facility Operation and Process*—The Upjohn facility in Kalamazoo, Michigan (See Figure 1) produces pharmaceutical chemicals used for both intermediate and finished products. All of the manufacturing processes are carried out in batch operations where individual production processes are combined to form a waste stream of variable composition. The liquid waste managed at the Upjohn facility is segregated into the following disposal categories:

(1) Spent solvents for on-site reclamation and reuse;

(2) Spent solvents for off-site reclamation;

(3) Waste waters to the Kalamazoo Public Owned Treatment Works (POTW); and

(4) Waste waters for deep well injection.

Part of the waste stream is currently injected into Well Numbers 3 and 4, which are Class I Hazardous Waste injections wells completed in the Munising Formation. Wastewater for deep well injection is generated at a rate of approximately 13 to 15 million gallons per year. The majority of the injected waste results from equipment rinses, extractions and crystallization operations conducted as part of the production process. This waste is typically composed of water mixed with organic solvents which constitute 2 to 5 percent of the wastestream. The facility previously injected 300 million gallons of waste into two shallower wells which were completed in the Traverse Limestone, Dundee Limestone and the Detroit River Group. In 1977 these two wells were taken off primary injection and were allowed to serve as emergency back-up to the two newer wells until they were plugged. Well Number 1 was plugged in 1984, and Well Number 2 was plugged in 1979. Approximately 900 million gallons per year consisting mainly of process water and sanitary wastewater is discharged to the Public Owned Treatment Works.

C. *Waste Minimization*—The Resource Conservation and Recovery Act (RCRA) emphasized the preeminence of source reduction and recycling as a strategy for managing solid waste. There are four major components of waste minimization—(1) Inventory Management and Improved Operations, (2) Modification of Equipment, (3) Production Process Changes, and (4) Recycling and Reuse. The Upjohn facility recovers approximately 10 million gallons per year of acetone, methanol, and methylene chloride as spent solvent for reuse at the facility. Approximately 2.7 million gallons of spent solvent are recovered and sent off-site as a part of a spent solvent waste fuels program. Upjohn plans to add additional equipment to recover tetrahydrofuran and the company will continue to assess waste minimization and identify and implement cost effective approaches to reduce the volume and toxicity of the waste generated.

D. *Submission*—On February 22, 1988, Upjohn submitted a petition for exemption from the land disposal restrictions on hazardous waste injection under the HSWA Amendments of RCRA (40 CFR part 148). This submission was reviewed for completeness and revised documents were received on September 21, 1988, and May 24, 1989. Several subsequent supplemental submissions were made thereafter to resolve minor deficiencies. The total submission was reviewed by staff at the USEPA and by consultants hired by the Agency to assist in their determination.

II. Basis for Determination

A. *Waste Description and Analysis (148.22)*—The wastes to be injected are spent halogenated and non-halogenated solvents, and are defined under 40 CFR Part 261 as F001, F002, and F005. These wastes are also characteristically ignitable and characteristically toxic for chromium, and therefore listed as D001 and D007 respectively, under part 261.

B. *Well Construction and Operation (148.22)*—The construction of the two Upjohn wells consists of four strings of casing for each well; the casing is cemented to the surface to preclude potential avenues for the injected fluid to escape the injection zone (See Figure 2a and 2b). Injection takes place through a tubing set on a packer and isolated from the casing by a fluid-filled annulus which is continuously monitored. The monitoring system is designed to trigger alarms and shut off if the injection or annulus pressure exceeds the maximum permitted levels, of if the annulus pressure falls below the minimum permitted level. Injection pressure is limited to 700 pounds per square inch (psi), which is below the value yielded by the equation in 40 CFR 147.1153 and below the value obtained from tests on the wells designed to determine the minimum fracture pressure of the injection interval. The injection pressure limit is conservative based on the aforementioned criteria and assures that the injection pressure provides insufficient energy to initiate or propagate existing fractures in the injection zone.

C. *Mechanical Integrity Test Information*—To assure that the waste does not leak prior to reaching the injection zone, Mechanical Integrity Tests (MIT) of the wells are required. Section 148.20(a)(2)(iv) requires submission of a satisfactory MIT performed within one year of petition submission, including Radioactive Tracer Test results. The Upjohn wells were tested in early December of 1987 The Standard Pressure Test as described in 40 CFR 146.8, the Radioactive Tracer Test, and the Temperature Log were performed. Results of these tests confirmed that the wells have mechanical integrity. They confirmed the positive results recorded on the continuous monitoring equipment. From both a construction and operation standpoint, the Upjohn injection wells ensure, with a reasonable degree of certainty, transmission of the injected fluid to the injection zone without leakage.

D. *Site Description*—Both of the injection wells at the Upjohn facility have approximately 3972 feet of separation between the lowermost underground source of drinking water (USDW) and the top of the injection zone (Munising Formation). This separation zone is composed of shales, limestones, dolomites, and evaporites.

The Michigan basin into which Upjohn injects is an almost circular sedimentary basin which extends to a depth of 14,000 feet in the center of the basin. The geologic strata generally dips less than 1 degree toward the center of the basin. The sedimentary formations can be classified into four general sequences—(1) the Cambrian sandstone sequence, (2) the Ordovician to middle Devonian carbonate-evaporite sequence, (3) the late Devonian to Mississippian shale-sandstone sequence, and (4) the Pennsylvanian coal bearing sequence. The Cambrian sandstone sequence (Munising Formation), the lowermost sedimentary unit in the basin, has the most favorable properties for the disposal of liquid waste because of its high permeability and porosity. There are very few historical seismic occurrences in the Michigan basin and a tectonic stress analysis revealed that the injected fluid is unlikely to cause an earthquake.

1. *Injection Zone Description*—The injection zone must have sufficient permeability, porosity, thickness and areal extent to prevent migration of fluids into USDWs. The injection zone consists of 1315 feet of the Munising Formation at a depth of 4302 to 5617 feet below the surface. The Munising Formation extends throughout the Michigan basin and reaches the surface near Munising, Michigan, several hundred miles from the Upjohn facility. Upjohn has subdivided the injection zone into an injection interval and a containment interval.

The injection zone is composed of the entire Munising formation, which contains four members, the Dresbach and Franconia sandstone Members, the Eau Claire dolomite-shale-sandstone Member, and the Mt. Simon sandstone Member. The Dresbach Member is composed of sandstone, is 4428 feet deep and 102 feet thick, and has a porosity ranging from 3 to 16 percent and permeability ranging from 0.1 millidarcies (md) to 180 md. The Franconia Member is composed mainly of sandstone and is 4302 feet deep and 126 feet thick, has a porosity ranging from 5 to 15 percent, and permeability ranging from 0.001 md to 10 md. The Eau Claire Member has been subdivided into two units by Upjohn, the upper Eau Claire dolomite-shale unit and the lower Eau Claire sandstone unit. Injection occurs into the lower Eau Claire sandstone unit and the Mt. Simon Member, at depths between 4837 feet and 5617 feet. Both wells were completed to inject solely into the Mt. Simon Member; however, in 1985, a hole in the casing of Well Number 4 was identified at a depth of 4837 feet (53 feet above the top of the Mt. Simon) by a noise log. The injection zone was expanded to include the Eau Claire Member by the USEPA through a permit modification in October, 1987 Approximately 5 percent of the 13–15 million gallons per year being injected flows into the Eau Claire Member through Well Number 4. The Mt. Simon Member is approximately 727 feet thick, and is composed mainly of massive sandstone. The porosity of the Mt. Simon ranges from 4 to 16 percent, and the permeability ranges from 2 md to 160 md. The Eau Claire Member is 360 feet thick; the lower 140 feet are composed of sandstone and minor amounts of dolomite, has a porosity range of 2 to 10 percent, and permeability ranging from 0.1 md to 100 md. The upper portion of the Eau Claire is composed of thinly bedded dolomite, shale, and sandstone, is 220 feet thick, has a porosity range of 2 to 13 percent and a permeability range from 0.0001 md to 10 md. The injection interval, consisting of the Mt. Simon and the lower Eau Claire, has generally high porosity and permeability which allow the waste to be injected without the use of a high injection pressure.

The containment interval is a portion of the injection zone, above the injection interval, which contains confining units (dolomites/shales) and pressure bleed-off units (sandstones). The upper Eau Claire, Dresbach, and Franconia Members are defined as the containment interval at Upjohn. The upper Eau Claire at a depth of 4530 to 4750 feet has a low permeability (0.0001 md to 10 md) which makes this unit a very effective barrier against the upward migration of waste. The Dresbach and Franconia Members are composed mainly of standstone and have higher permeabilities and porosities which act as pressure bleed-off units to allow any pressure build-up in the upper Eau Claire to be dissipated. No fractures or faults are known to exist in the containment interval.

2. *Confining Zone Description*—The confining zone must be (1) laterally continuous, (2) free of transecting, transmissive faults or fractures over an area sufficient to prevent fluid movement and, (3) of sufficient thickness and lithologic and stress characteristics to prevent vertical propagation of fractures. The immediate confining zone above the injection zone is composed of the Trempealeau Dolomite (See Figures 2A and 2B), which has an average thickness of 240 feet in the area adjacent to the Upjohn facility, is at a depth of 4062 feet below the surface, and is 3732 feet below the lowermost USDW. Geophysical logs indicate that the Trempealeau Dolomite has low porosity and permeability; porosity ranges from 1 to 7 percent and permeability ranges from less than 0.001 md to 10 md. The Trempealeau Dolomite is found throughout the Michigan basin as indicated in numerous lithologic logs. No faults or fractures are known to exist in the Trempealeau Dolomite in the Area of Review. A study of the tectonic stresses shows that the formation is understressed, and no fractures are likely to be propagated because the injection pressure is strictly regulated to prevent overpressuring the formations.

The confining zone must be separated from the lowermost USDW by at least one sequence of permeable and less permeable strata that will provide added layers of protection by either providing additional confinement (low permeability units) or allowing pressure bleed-off (high permeability units). Overlying the Trempealeau Dolomite at the Upjohn site is an alternating sequence of thick, low permeability units such as the Utica Shale, Detroit River Group, and the Antrim-Coldwater-Ellsworth Shales, and more permeable units such as the Salina Group, Dundee Limestone, and the Traverse Limestone. Some of the low permeability layers are up to 500 feet thick and are continuous for hundreds of square miles. Numerous oil and gas deposits in the Michigan basin are confined by these low permeability units, which suggests that these units would serve as secondary confining zones for any escaped injection fluid.

Geochemical Conditions—The characteristics of the injection and confining zone fluids and lithologies must be adequately described in order to determine the wastestream's compatibility with the zones. The injection zone is composed mainly of quartz sandstone, with minor amounts of siltstone and dolomite. These rocks are generally very resistant to chemical degradation, and therefore little, if any, compatibility problems are expected. Upjohn has injected approximately 110 million gallons of wastewater during the period from 1977 to 1987 and during this time, no adverse pressure response has occurred to indicate that the wells have suffered from a compatibility problem. The confining zone is composed of dolomite and should have little compatibility problems with the injected fluid, because it has low porosity and permeability which will inhibit any reaction between the rocks and the injected fluid.

4. *Area of Review*—The area of review (AOR) is the area within which the petitiner must identify all wells which penetrate the confining zone and demonstrate whether they have been properly completed or plugged and abandoned. For the Upjohn facility, the USEPA has designated an AOR of 2.5 miles, based on a flow model which shows that the pressure build-up 2.5 miles from the wells is no more than 10 psi. This is less than 2 percent of the maximum pressure build-up at the well bore. There are no wells within the AOR that penetrate the confining zone, and the nearest identified well that penetrates the confining zone is located approximately 40 miles from the injection facility. Accordingly, no corrective action is required for this facility.

E. *Model Demonstration of No Migration*—Over the past 20 years, mathematical modeling has emerged as the preeminent tool for the predictive analysis of hydrogeologic systems. It is appropriate then that the demonstration of no migration of hazardous constituents from the injection zone involves the use of predictive mathematical models. A combination of analytical and numerical models were used in Upjohn's demonstration.

Models used for the "no-migration" demonstration must be adequately verified and validated. The verification process has two principal objectives: (1) to ensure that the simulation code is mathematically accurate, and (2) to ensure tht the various features of the code are used correctly. The objective of model validation is to demonstrate that the model adequately represents the type of rock layers, the physical processes of the injection zone, and the boundary conditions of the modeled interval.

The Upjohn modeling demonstration used a numerical code known as SWIFT III (Sandia Waste-Isolation Flow and Transport Model) to predict the buildup of pressure and the lateral flow of waste from the Upjohn injection wells. The SWIFT III code has been used and verified extensively, as reported in various federal publications. The long history of development and successful use of SWIFT for sites similar to Upjohn provide confidence that the basic processes are accurately represented by the model.

The vertical migration of waste was modeled using a stochastic approach, designed to assign a range of probable permeabilities to a layered interval in which the waste is contained, in order to evaluate the model uncertainty through probabilities of vertical migration distance. The model calculates migration velocity based on an analytical solution using pressures predicted by SWIFT as the initial drive mechanism. Other analytical models were also used to demonstrate various components of the waste migration. All of the models used have been verified and validated as recorded in the model documentation, or in references to methods or techniques tht are widely accepted by the technical community.

1. *Model Development and Calibration*—The development of the Upjohn model was a two-step process. First, a conceptual model was developed from well logs and cores for the rock layers of the Munising Formation, extending from the base of the Mt. Simon Member through the Franconia Member, which included hydrogeologic information such as porosity, permeability and thickness. Next, this initial set of hydraulic parameters was calibrated or "fine-tuned" by comparing injection histories predicted by these parameters to records of injectivity tests on both wells run during the week of November 6, 1987 Hydaulic parameters for the Mt. Simon Member which were developed from the calibration exercise include a permeability of 27 md, a porosity of 7.2 percent and an effective, or modeled, thichness of 100 feet. Other model parameters, such as skin factor, viscosity, and diffusion coefficients, were assigned from site-specific information when possible, and otherwise based on accepted literature values. For those parameters most affecting pressure build-up and waste migration, such as permeability, a range of values was modeled so that pressure and migration under conservative conditions could be determined. Where parameters were uncertain, reasonably conservative values were chosen.

2. *Model Predictions*—Two simulation time periods were considered in the demonstration: a 40 year operational period and a 10,000 year post-operational period. For the operational period, pressure build-up due to injection and the lateral and vertical

migration due to this pressure were modeled. For the post-operational period, additional lateral migration due to the natural flow gradient and additional vertical migration due to molecular diffusion were modeled. Modeling results, and the parameter choices which ensure that these results represent reasonably conservative conditions, are presented below.

For the operational period, an average monthly injection rate of 38 gallons per minute or approximately 20 million gallons per year, was used to predict pressure build-up in the injection zone. This exceeds the actual average injection rate of 13 to 15 million gallons per year and provides a conservative cushion to the demonstration by causing an over-prediction of modeled pressure build-up and waste migration. The modeling predicts that at the end of the 40 year operational period, the maximum pressure build-up at the wellbore is approximately 550 psi. Adding this build-up to the original reservoir pressure of approximately 2650 psi, the estimated maximum pressure in the Mt. Simon Sandstone at the end of the operational period would be 3200 psi. This is below the calculated fracture propagation pressure of 3870 psi. This pressure buildup is greatest near the injection wells and decreases outward, declining to less than 10 psi at a distance of 2.5 miles (the edge of the Area of Review).

The stochastic model described briefly above was used to predict vertical waste migration. The predicted pressure profile at the end of the operational period was used as a basis for calculating vertical waste migration velocity. This is a conservative approach because it will over-predict waste movement by ignoring (1) the lower vertical pressures that will exist in the early part of the operational period and (2) the smaller migration velocity further from the top of the injection interval. A modeled range of vertical permeabilities of the Eau Claire Member of 10^{-6} to 10^{3} md and a most probable permeability of 10^{-4} md, resulted in a vertical migration of waste at this site during its operational life between 95 feet (2 percent chance) and less than five (5) feet (77 percent chance). During the post-operational period, molecular diffusion is the primary migration mechanism. Using a conservative coefficient of molecular diffusion of 1×10^{-10} meter squared per second, the maximum vertical transport of the waste front during the post-operational period is 186 feet. This is a conservative estimate because it assumes the waste front extends to a point where the ratio of modeled concentration to original waste concentration (concentration ratio) is 10^{-12} whereas a concentration ratio of 10^{-7} is sufficient to reduce all hazardous constituents injected by Upjohn to below health-based levels or detection limits, as documented following page VII–94 of Volume 3 of Upjohns' September 21, 1988, submittal. The total vertical migration at the Upjohn site would be a maximum of 281 feet above the permitted injection interval, or 41 feet below the top of the Dresbach Member. Therefore, the waste will be contained within the permitted injection zone.

Lateral migration of the waste plume during the operational period is mainly driven by injection and is modeled to extend 1576 feet, using realistic site-specific parameters deduced from the calibration exercises mentioned above. During the post-operational period, the modeled movement of the waste plume also considered the natural flow gradient of the Mt. Simon

Member, by buoyancy forces resulting from a lighter waste being injected into a more dense formation water, and molecular diffusion. Molecular diffusion and buoyancy forces result in the movement of the waste front of 5000 feet in 10,000 years, when a concentration ratio of 10^{-7} is used to define the edge of the waste plume. At this distance, all hazardous constituents will be below the health-based levels or detection limits. The groundwater flow velocity in this formation is estimated at 0.47 ft/yr at this site. Because the direction of this flow is uncertain, it is conservatively estimated to exist in every direction from the Upjohn site. This results in an additional drift of the waste plume of 4745 feet in 10,000 years. Therefore, the maximum predicted lateral migration of waste at the Upjohn site is 11,321 feet. This is within the permitted injection zone and within the Area of Review of 2.5 miles.

F *Quality Assurance and Quality Control*—The Upjohn Company and its consultants have demonstrated that adequate quality assurance and quality control plans were followed in preparing the petition. Upjohn has followed appropriate protocol for locating records for penetrations in the area of review, for collection and analyses of geologic and hydrogeologic data, for waste characterization, and for all tasks associated with the modelling demonstration.

III. Conditions of Petition Approval

As a condition of granting this exemption to the ban on injection of certain hazardous wastes, the USEPA will require the following conditions to be met through modification of the well permits:

(1) The combined annual injection volume for Well Numbers 3 and 4 must not exceed 20 million gallons;

(2) The injection zone must be comprised of the Franconia, Dresbach, Eau Claire, and Mt. Simon Members of the Munising Formation; and

(3) Injection shall occur only into the Mt. Simon Member and into that portion of the Eau Claire Member which is below 4750 feet.

Dated: October 5, 1989.

Charles H. Sutfin,

Director, Water Division, Region V U.S. Environmental Protection Agency.

BILLING CODE 6560-50-M

FIGURE 1

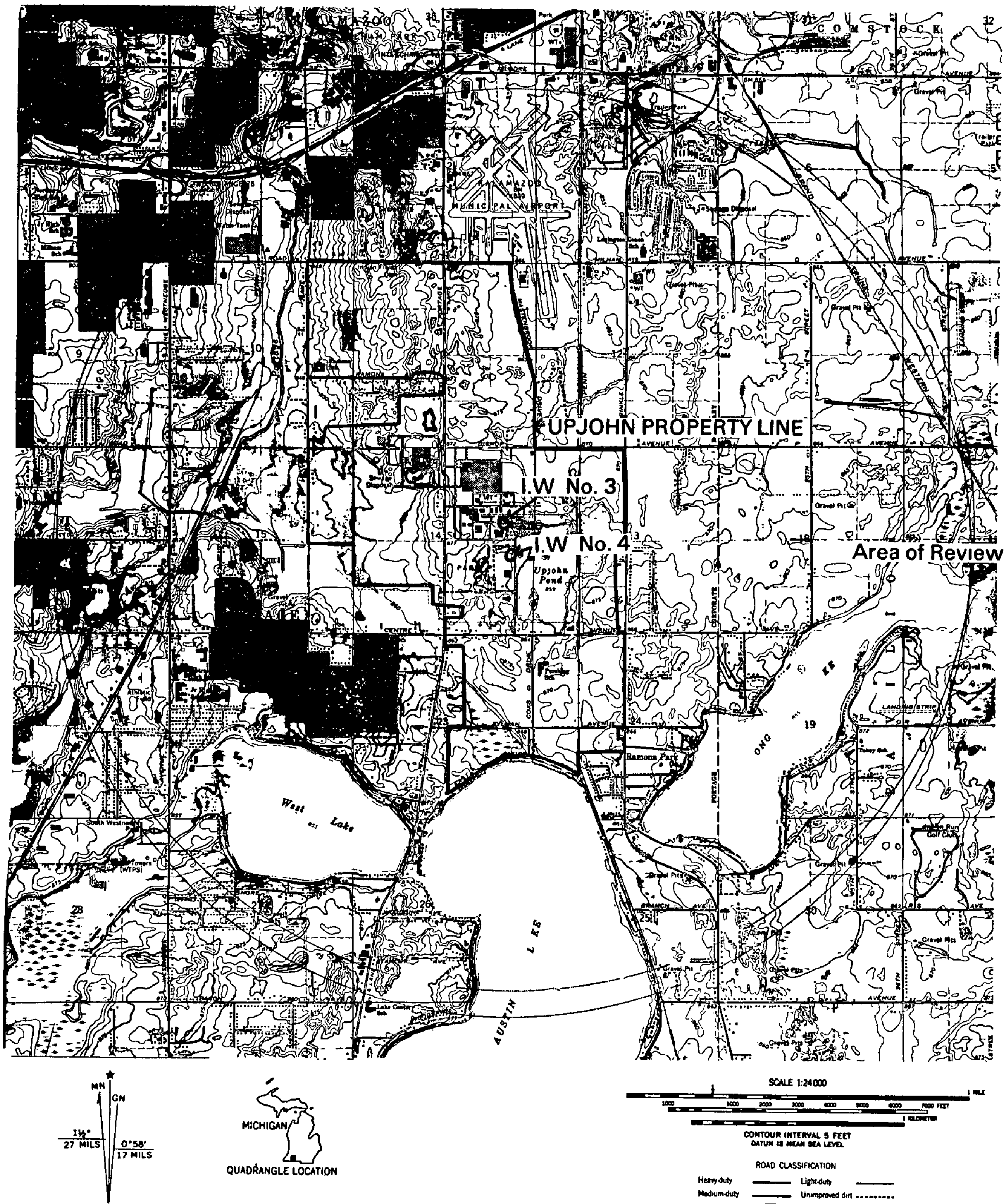
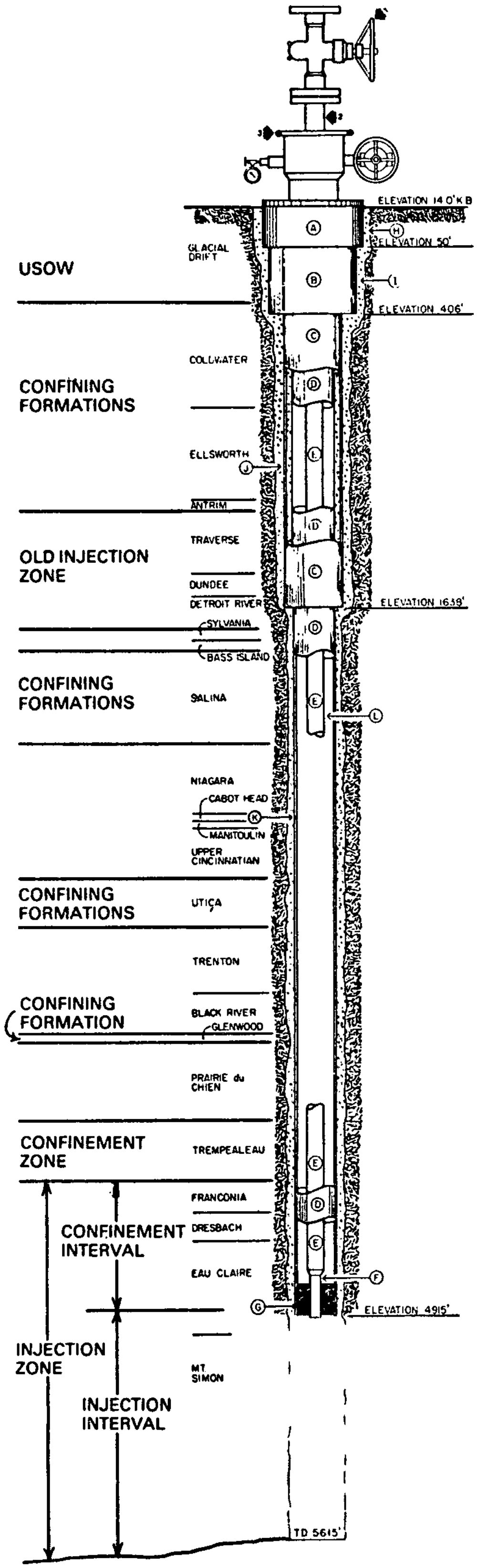

UPJOHN PROPERTY LINE
I.W No. 3
I.W No. 4
Area of Review
Upjohn Pond
West Lake
AUSTIN LAKE
Ramona Park
MICHIGAN
QUADRANGLE LOCATION
SCALE 1:24 000
CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
Interstate Route
MN
GN
1½°
27 MILS
0°58'
17 MILS
UTM GRID AND 1973 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

FIGURE 2A



DESCRIPTION OF MATERIAL

A. 24" O.D. unknown weight, ungraded steel conductor pipe set at 50' K.B. and cemented to surface.

B. 16" O.D. 65 lbs/ft, H-40, R-2, ST&C API casing set @ 406' K.B. and cemented to surface.

C. 10¾" O.D., 40.5 lbs/ft, K-55 R-8, ST&C API casing set @ 1638' K.B. and cemented to the surface in two stages.

D. 7" O.D., 23 lbs/ft, K-55, r-2, LT&C API casing set @ 4915' K.B. and cemented in two stages.

E. 3½" O.D. × 0.350" wall, Fibercast Epoxy chemical disposal tubing with Model "F" 316 SS non-ported seating nipple. 8.40' seal assembly with 7 seal units, 0.82'-3½" AST × 3½" API XO sub, 3.15' tubing sub above seal assembly, subs on top, total length 4861.40' to No Go.

F 80-32 Model "GBH" 316SS Locator tubing Seal Assembly with 7-70 Hard Nitrile Bond Seal Units.

G. Baker Model "A" Retrieva D packer set at 4860 feet.

H. 24" conductor casing cemented to surface with 125 sx Class A with 3% $CaCl_2$ circulated.

I. 16" surface casing cemented to surface with 200 sx. Class A with 3% $CaCl_2$ and 375 sx. prozmix A with 4% gel and 3% $CaCl_2$ cement circulated.

J. 10¾" intermediate casing cemented in two stages with DV tool at 840' First stage cemented with 900 sx. Class A with 3% $CaCl_2$ and second stage with 600 sx. pozmix A with 3% $CaCl_2$. Both stages circulated to surface.

K. 7" long string casing cemented in two stages with DV tool at 2492" First stage cemented with 970 sx. Class A with 3% $CaCl_2$ and second stage with 940 sx. pozmix with 6% gel and 3% $CaCl_2$. Neither stage circulated to surface.

L. Annular fluid — fresh water with added corrosion inhibitor.

1. 3" Mohawk, Fig. 6, with ASA 600 RF Flanges. Carpenter-20 gate valve.

2. 3"Nom. Sch. 40 Carpenter 20 tube with ASA 600 RF flange top and 3" NPT Females 3½" ASTM male thread on bottom, 4 feet long.

3. 7" × 3" Hercules tubing head, Model with 2-2" NPT side openings.