AN ASSESSMENT OF POTENTIAL GROUNDWATER CONTAMINATION FROM SEPTIC TANKS IN INDIANA

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ACKNOWLEDGEMENT

Special thanks are due to those sanitarians, environmentalists and planners of the Health Departments, and Planning Commissions of the counties considered in this report, and who are listed under personal communication in the references. Without their alacritous contributions, especially those relating to high density septic tank sites, this report could not have been written.

INTRODUCTION

Septic tank (on-site) systems are used by approximately 25 percent of the U.S. population. The goal of these systems is to remove pathogens and to reduce the concentrations of other wastewater constituents so that no adverse effects occur from public consumption of pertinent receiving water.

In many cases, given adequate and proper design, installation, and operation, on-site systems will perform satisfactorily; however, failures do occur and can result in the contamination of local water resources. Two basic types of septic tank failure are recognized. One type of failure generally is caused by soil clogging. This type severely restricts or even eliminates the waste water flow into the absorption field, and is manifested either by surface seepage of partially treated effluent above the drainfield, or by wastewater backing up into the plumbing fixtures in the house. In the first case, the seepage can create standing pools of effluent that can cause odors, attract insects, and pose health risks to playing children, or that can be carried with surface run-off into nearby domestic wells, lakes and streams.

The second type of failure which is potentially more serious and less obvious, occurs when septic tank effluent reaches the groundwater without sufficient treatment. This, too, can result in contamination of groundwater supplies or nearby surface waters fed by groundwater sources.

The contamination of ground or surface waters from domestic wastewater may create both public health and environmental hazards. Outbreaks of waterborne disease have been traced to microbial or viral contamination of groundwater by malfunctioning septic tanks. Moreover it would seem likely that inadequately treated wastewater that surfaces above a drainfield could cause disease from direct contact or vector transmission. However, no reports of such outbreaks were encountered in the literature reviewed. In addition, nitrogen, in the form of nitrate, has been linked with cases of methemoglobinemia in infants. Although volatile organic chemicals (VOC) have recently been discovered in groundwaters and are known to be carcinogenic to laboratory animals and in some cases to man, the waterborne transmission of these materials has not to date been traced to any human pathology.

From the environmental standpoint, accelerated eutrophication can result if excessive nutrient concentrations reach surface waters. Lake shorelines are particularly sensitive. In some lakes, growth of aquatic plants in shallow waters has been blamed on shore emerging groundwater plumes containing septic tank effluent. Other chemical constituents in household wastewater pose potential health and environmental problems if not degraded and rendered harmless in the soil before reaching receiving waters. The latter constituents include the daily used household cleaners and cosmetics. The major toxic compounds found in household cleaners are solvents such as benzene, toluene, dichlorobenzene, trichloroethane, phthalates, dichloropropanes, dichloropropylene, and trichloroethylene, and disinfectants such as phenols and chlorophenols. The main toxic ingredients of cosmetics are heavy metals and aromatic organics. Moreover a home having difficulty with the septic tank system or sewer pipe clogging is likely to have a high wastewater concentration of benezene, trichloroethane, and/or trichloroethylene since drain and pipe cleaners contain these solvent ingredients, along with a highly caustic inorganic such as sodium hydroxide to help solubilize grease and microbial slimes.

High chloride concentrations are also found in groundwaters near on-site disposal systems. Much like nitrate, chloride is a mobile ion that is typically present in domestic wastewaters in concentrations much greater than background levels. At excessive concentrations, in the range of 250 to 500 mg/l, chlorides may impart a salty taste to drinking water, interfere with agricultural processes, or accelerate corrosion. In addition, in that they are normally associated with the sodium ion in domestic wastewaters, chlorides would be detrimental to a significant portion of the population, including persons suffering from hypertension, edema associated with congestive heart failure, and women with toxemias of pregnancy. Chlorides, like nitrates, are not removed readily from the soil and concentrations for both are reduced primarily by dilution.

Up until the last few years the only known problems associated with septic tanks were those of soil-clogging and effluent ponding with possible ambient surface water degradation. The tighter (more clayey) the soil, the poorer the drainage and the greater the likelihood of ponding. However, during the last few years, abetted by a growing sophistication in micro-analysis, groundwater organics contamination from septic tanks located in highly permeable soils and naturally high water tables, has been recognized as a significant water resources problem.

Several factors would appear to affect the potential for groundwater contamination from septic tank systems. These factors include septic tank and population densities, depth of water table, bedrock condition (fractures), contaminant biodegradability and/or absorbability, and soil type. With respect to the latter, and in order to give regulatory guidance to the placement of successfully operating (non-ponding) on-site systems, the Soil Conservation Service has classified soils based upon the soils ability to move water through the soil profile (percolation rate). Upon this basis, soils are classified as slight (faster than 45 minutes per inch), moderate (45 - 75 minutes per inch), and severe (slower than 75 minutes per inch). It can be seen that a soil classified in the slight category, which would be most appropriate for placement of non-ponding on-site systems, would also be most likely to easily pass toxicants (biologically unalterred or otherwise) from septic tank effluents to underlying aquifers. This characteristic of the slight soil category of course, is not limited to septic tank effluent. Leachate from any and all waste repositories would be passed in the same facile manner.

This report will suggest areas in Indiana that can be expected to have the highest potential for groundwater contamination with coliform organisms, nutrients, chlorides, and volatile organic chemicals originating from on-site (septic tank) systems. The areas are located primarily in the outskirts of urban centers, and are serviced by relatively large or many on-site systems to accomodate fairly dense populations (hospitals, hotels, subdivisions, mobile home courts, restaurants, etc.). The on-site systems discharge to absorption beds or drainage fields located over fairly permeable or porous soil.

BACKGROUND

Based upon discussion with State Department of Health personnel, high density non-sewered areas (septic tanks) are located in at least a dozen Indiana counties. In most instances these counties include more than one (1) such area. In and of themselves, high density non-sewered areas do not guarantee groundwater contamination from septic tank effluents. For this type of contamination to occur, it is necessary that septic tank absorption or drainage fields overlay permeable or porous soils, and/or that the area water tables be high. The latter criterion, of course, indicates a large groundwater availability, and/or a flood plain area.

In the discussion to follow, each suspect county will be addressed separately. Should the geology be similar, two (2) contiguous counties may be simultaneously considered with potential problem definition related not only to high density, but also to area soil type and depth of water table. Moreover only those high density non-sewered areas with appropriate geology and hydrology for groundwater contamination will be considered. A sandy soil and a high water table almost invite groundwater contamination from septic tank effluents. Data with respect to septic tank density and site location from Lake and Tippecanoe Counties were not forthcoming from the contacted local sources, therefore these counties were not considered in this report.

The soil conditions described below are general in nature and may be indicative of conditions below a particular drain field, or several drainfields. However, since the general categorization describes the major soils primarily, and since the considered landscape also includes minor soils of varying and undefined character, it is not a foregone conclusion that a high density non-sewered area located over a generally described sandy loam, for example, would actually contribute to groundwater contamination in the pertinent aquifer. Nevertheless, where the general characterizations define a high groundwater availability, indicating highly permeable and thick bedrock overlay, more likely than not, those indicating conditions will exist in the area being considered and potential groundwater contamination would be a likelihood. For positive identification of soils in a local area, it would be necessary to refer to the county detailed maps of the Soil Conservation Service.

GENERAL INDIANA GEOLOGY

The groundwater resource of Northern Indiana can be classified as good to excellent and exclusive of some areas in the northwestern part of the State, well yields of from 200 to 2000 gpm can be expected in most areas. Major areas of groundwater availability are found where the productive Silurian-Devonian bedrock aquifer system underlies large areas, and where deposits of glacial material up to 500 feet in thickness contain highly productive inter-till sand and gravel aquifers. A number of major outwash plain and "valley train" sand and gravel deposits are associated with the St. Joseph, Elkhart, Pidgeon, Fawn, Eel, and Tippecanoe River Valleys.

In the central portion of the State, groundwater availability ranges from fair to good. Well yields from 100 to 400 gpm are typical for large diameter wells. Major groundwater sources of outwash sand and gravel are located in the valleys of the West Fork of the White, Whitewater, Eel, and Wabash Rivers, and in portions of the valleys of Eagle, Fall and Brandywine Creeks, and the Blue River. Bedrock aquifers in the Silurian-Devonian limestone sequence yield up to 600 GPM to large diameter wells. Locally thicker inter-till sand and gravel aquifers are normally capable of yielding up to 300 GPM.

Many areas of the southern part of the State are particularly lacking in groundwater and only limited amounts, generally less than 10 GPM are available to properly constructed wells. In these areas, the major sources of groundwater are present in the sand and gravel deposits of the stream valley aquifers. The valleys of the Eel, East and West Forks of the White, Ohio, Wabash, Whitewater, and the main stem of the White are underlain by thick deposits of outwash sand and gravel capable of supplying over 1000 GPM to properly constructed large diameter wells.

Figure 1 is a map showing the general distribution of unconsolidated deposits in Indiana. Based upon location coincidence with groundwater availability (see Figure 2), the sand and gravel in outwash deposits are the most permeable or porous of all parent soil materials. In order of permeability (most to least), the remaining Indiana uncon - solidated deposits are till, sand in windblown dune and sheet deposits, silt in windblown sheet deposits, till with deep soil lapped by thin windblown silt, till in hummocky moraine form, clay, silt, and sand in lakebed and shorelines deposits, and finally red clay. Generally the availability of groundwater in Indiana decreases from north to south (except for the aquifers under the outwash sand and gravel found in stream beds). Conversely, precipitation in Indiana is greatest in the southern part of the State (average annual north 36 in. - average annual south 44 in.). The generally greater permeability of soils in the north allows for the more efficient percolation of the precipitation to groundwater aquifers below. The generally tighter soil of the southern part of the State decreases the efficiency of percolation causing greater run-off to area surface waters. These differences in geology account for the general difference in groundwater availability from north to south.

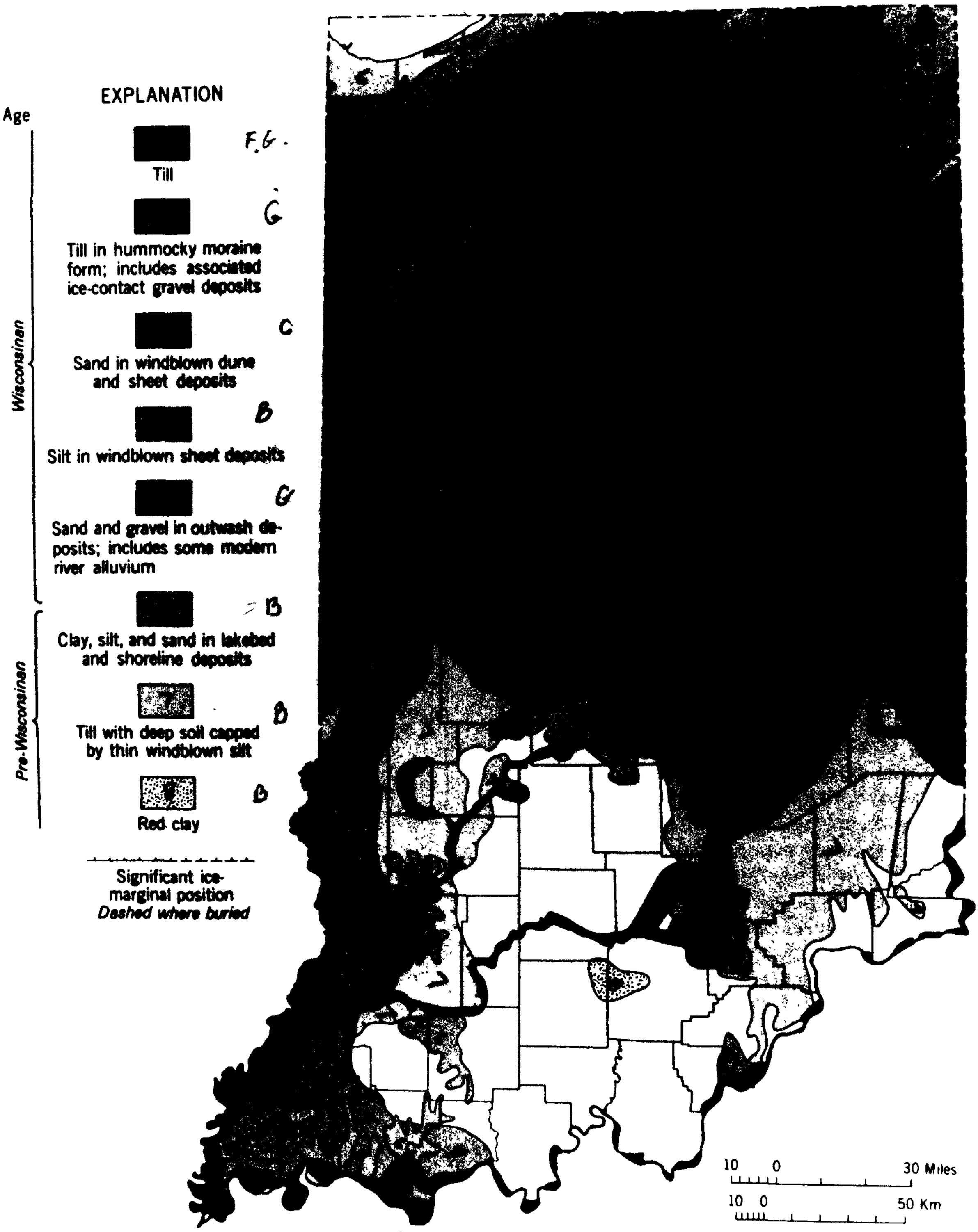

Figure 1

Map of Indiana showing general distribution of unconsolidated deposits. The uncolored areas in southern Indiana represent areas with little or no unconsolidated deposits.

ALLEN COUNTY

Mulitiple glacial advances have left a thick mantle composed of till, with scattered deposits of ice-contact sand and gravel, lake bed deposits, and some outwash sand and gravel throughout Allen County. Several moraines are present lying diagonally accross Allen County. The combined Fort Wayne - Wabash moraines served in blocking melt waters from the receding glacier and created ancient Lake Maumee which at one time covered most of the east-central part of the county. In general glacial drift ranging in thickness from 50 to 200 feet is common, with the thickest materials occurring in northwestern Allen County.

Exclusive of an area in the east-central part of the county, large diameter wells will yield from 200 to 600 GPM. Major groundwater supplies are present in the thick inter-till sand and gravel aquifers located in northwestern Allen County. Examination of Figure 3 reveals that there are many high density non-sewered (septic tank) areas in the immediate periphery of Fort Wayne and especially to the west and to the north. Lesser numbers of high density septic tank areas are found in the southeast outskirts of Fort Wayne. The entire metropolitan area of Fort Wayne is situated in a generally high soil permeability, high groundwater availability area; an area that would be described as slight (percolation faster than 45 minutes per inch) by the Soil Conservation Service. While the slight category is ideal for efficient effluent drainage and the prevention of surface ponding, it will also allow for a quicker

ALLEN COUNTY
HIGH-DENSITY NON-SEWERED AREAS

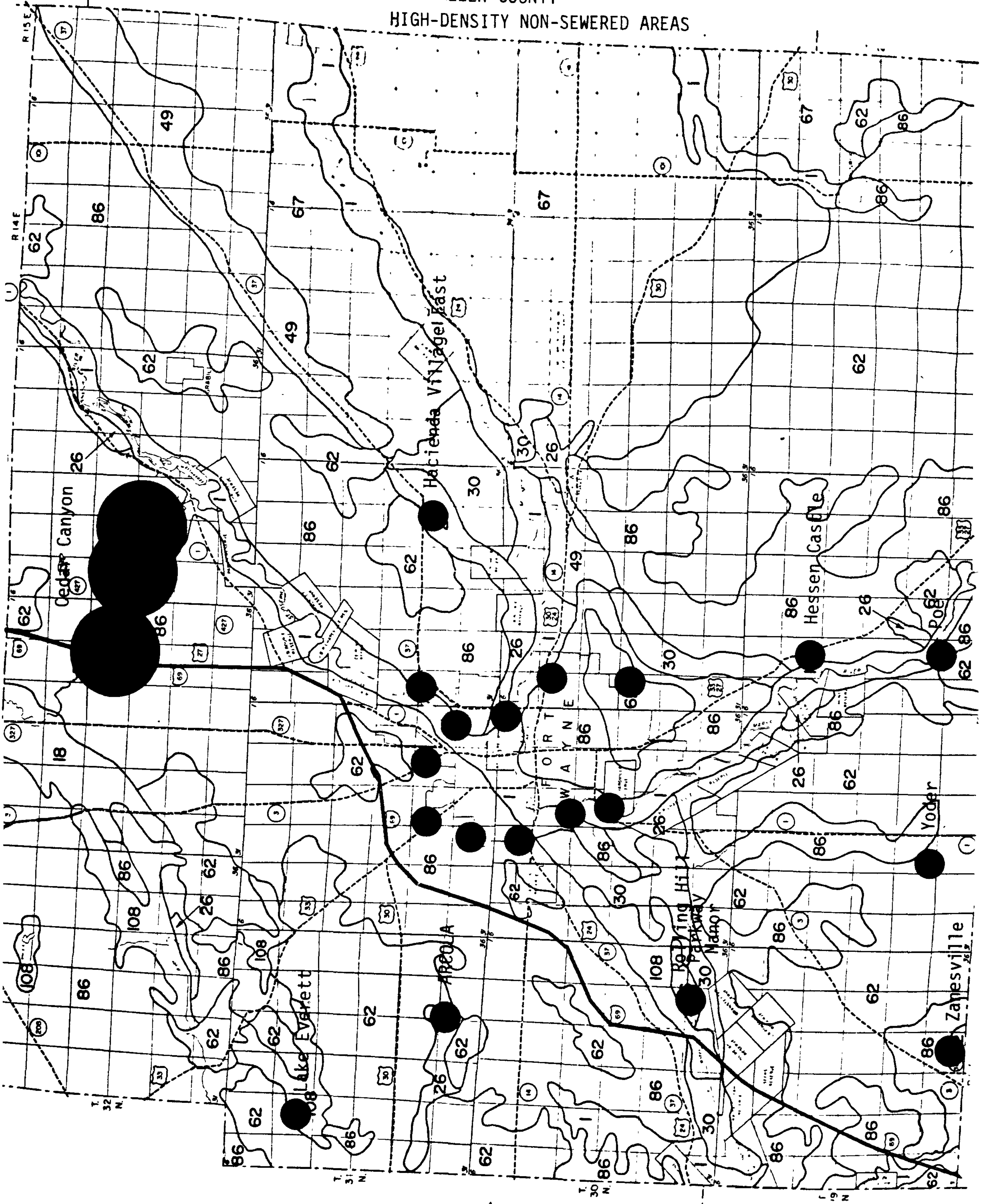

FIGURE 3

and easier contamination of any susceptible groundwater aquifer. In addition, Figure 3 shows other Allen County high density septic tank areas where, for the same reasons, potential groundwater contamination is likely. Table 1 lists these high density areas along with the number of septic tank units in each area.

Although the Cities of Fort Wayne and New Haven directly to the east are serviced by a public water supply that obtains water from the St. Joseph River and reservoirs (area groundwater is high in hardness, iron, and manganese), that distribution system does not extend beyond city lines. The high density septic tank areas on the periphery of Fort Wayne and in the rest of Allen County resort to private wells for water requirements. Any potential groundwater contamination would take on added significance in these peripheral areas and especially in the areas, north, west, and south of Fort Wayne to the county boundaries.

CLARK COUNTY

Much of Clark County is located within the driftless portion of Indiana which was untouched by continental glaciation. The bedrock overlay in the northeastern part of the County is composed of till capped by thin windblown silt. Along the Ohio River, to the deep south, and to the far north, the valleys are underlain with sand and gravel in outwash deposits, although some modern river alluvium can also be found. Groundwater availability is quite limited in Clark County with a substantial number of dry holes being reported in the eastern portion. However, major groundwater sources occur in the thick deposits of sand and gravel in the Ohio River Valley (southeastern border) where wells yield in excess of 1000 GPM.

TABLE 1

Entity	Direction From Fort Wayne	Septic Tank Density
FORT WAYNE PERIPHERY		
(1) Limberlost and Mardego	(N)	150
(2) Northway Gardens	(N)	55
(3) Aldale Acres	(NW)	100
(4) Hollywood	(NW)	230
(5) Waterswolde and Northwood	(NE)	110
(6) Briar Rose	(N)	60
(7) Mayhew Park	(NE)	60
(8) Cinderella Village	(NE)	100
(9) Concordia Gardens	(N)	350
(10) Parkerdale	(NE)	120
(11) Golfview and Gerding Woods	(W)	80
(12) Lexington Heights	(NE)	110
(13) Ranchwood	(E)	400
(14) State and Leesburg Rds	(W)	150
(15) Riverhaven	(E)	280
(16) Covington and Washington Rds	(W)	100
(17) Fort Wayne Country Club	(W)	250
(18) Fairfax	(E)	120
(19) Ridgeview	(E)	90

TABLE 1
(CONT.)

Entity	Direction From Fort Wayne	Septic Tank Density
ALLEN COUNTY		
(1) Cedar Canyons	(N)	500
(2) Lake Everett	(NW)	125
(3) Arcola	(W)	100
(4) Hacienda Village	(E)	100
(5) Rolling Hill, Parkway and Manor Woods	(SW)	200
(6) Zanesville	(SW)	(90)
(7) Yoder	(S)	150
(8) Hessen Cassel	(S)	100
(9) Poe	(S)	70
(10) Hoagland	(SE)	260

Clark County is serviced by 18 municipal and rural water supplies. These supplies, whose only sources are groundwater, serve approximately 61,000 people. Since the county population is a approximately 82,000 people, it is indicated that 21,000 people satisfy their water requirements through private wells.

Figure 4 illustrates the high density septic tank areas in Clark County. As can be seen most of these areas are in the southern part of the county, in the Clarksville - Jeffersonville area and environs. The areas border on, or are in close proximity to, the Ohio River, where the bedrock overlay consists of permeable sand and gravel in outwash deposits. While much of the area is composed of rolling knobs and rugged hills, and precipitation can be expected to run-off to the nearest watercourse, the soil associations are such that septic tank effluent distributed under the surface would percolate rapidly to aquifers below with the distinct possibility of groundwater contmination, especially in the high water availability areas. Table 2 lists the high density non-sewered areas in the Villages of Clarksville and Jeffersonville proper.

ELKHART COUNTY

Of particular importance in Elkhart County are the glacially derived unconsolidated deposits which contain the major sources of groundwater. The deposits consist of glacial till, inter-till sand and gravel, outwash-plain and valley-train sand and gravel, lake clays, dune sand and ice stratified drift. These materials range in thickness from about 100 to 500 feet. Significant outwash-plain and valley-train sand and gravel deposits are located along the Elkhart river system. In addition, complex inter-till

CLARK COUNTY

HIGH-DENSITY NON-SEWERED AREAS

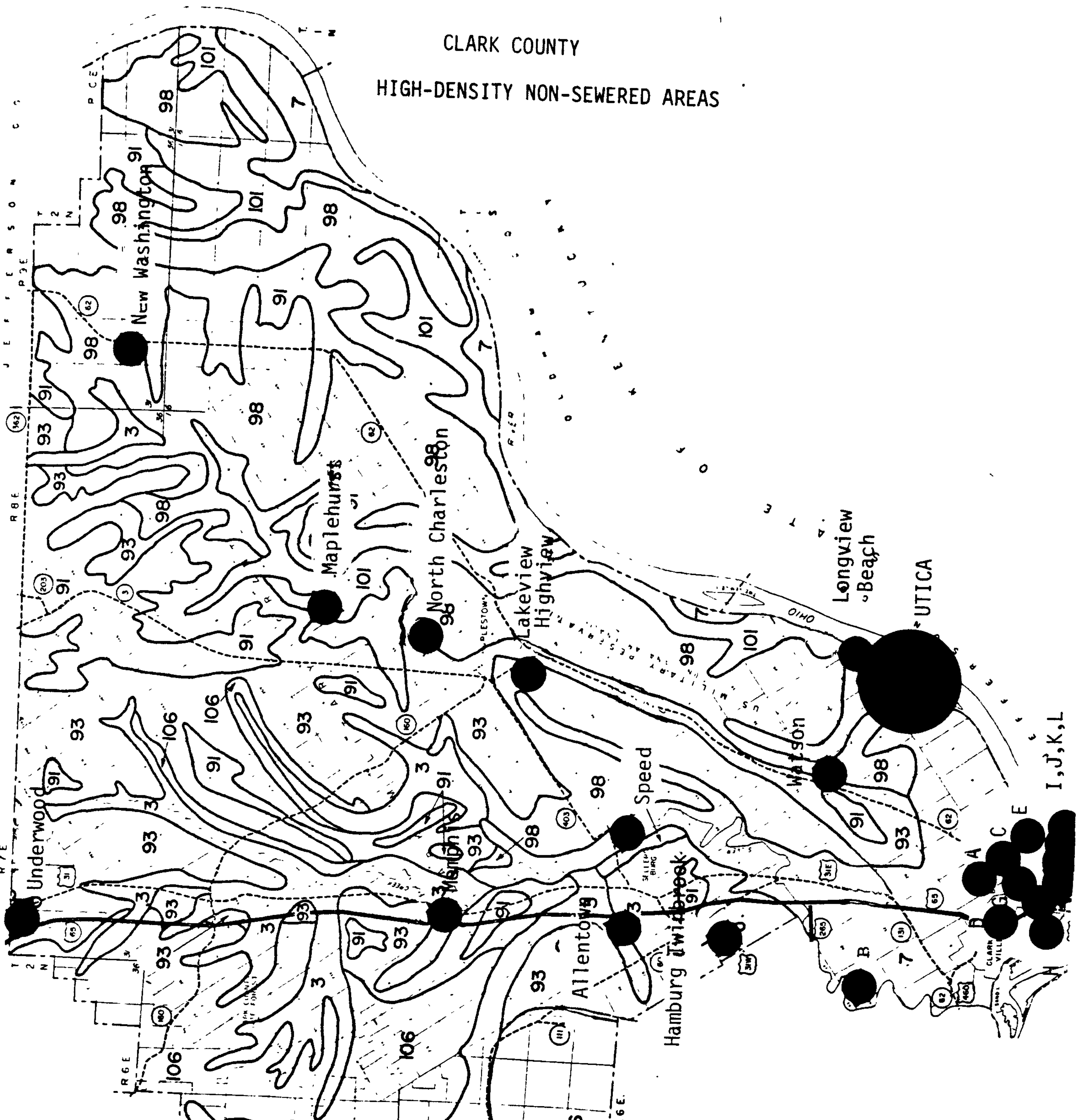

FIGURE 4

TABLE 2

JEFFERSONVILLE TOWNSHIP HIGH DENSITY NON-SEWERED AREAS

A. Carr Circle

B. Centralia Subdivision

C. Evergreen Acres

D. Walnut Ridge

E. Sellers Court

F. Thompson and Hoskins Lane

G. Edgewood

H. Loma Vista

I. Cherokee Terrace

J. Wathen Heights

K. McBride Heights

L. Riverview Drive

sand and gravel aquifer systems are present in the moraines located in Elkhart County, making Elkhart County an area of major groundwater availability. Estimated recharge rates of 500,000 gallons per day per square mile are applicable to much of the area testifying to the permeability or porosity of the soils, and to the thickness of the bedrock overlay in the area.

The County of Elkhart is serviced by eight (8) public water utilities each of which totally uses groundwater as its source of supply. The largest utility is the city of Elkhart which pumps more than eleven (11) MGD and services approximately 41,000 customers. The other seven (7) public utilities serve another 20,000 people. Since the county population is approximately 138,000, it is indicated that approximately 78,000 people satisfy their water needs through the use of private wells.

Examination of Figure 5 reveals the location of the high density non-sewered areas in Elkhart County. All illustrated high density areas are located over well drained loamy soils overlying outwash sand and gravel. The largest concentration of the high density areas is located southeast of the City of Elkhart in the Dunlap area. Other high density areas are located on the entire periphery of Elkhart City especially along the St. Joseph River east and west of Elkhart City, and to the north surrounding Simonton Lake, the north Bristol area, Indiana Lake, the north and south-west Middlebury area, and the area east of Waterford Mills. Since in each instance the soils would be rated as slight under Soil Conservation Service guidelines, it is indicated that the illustrated areas all have a high potential for groundwater contamination from septic tank effluents.

ELKHART COUNTY

HIGH-DENSITY NON-SEWERED AREAS

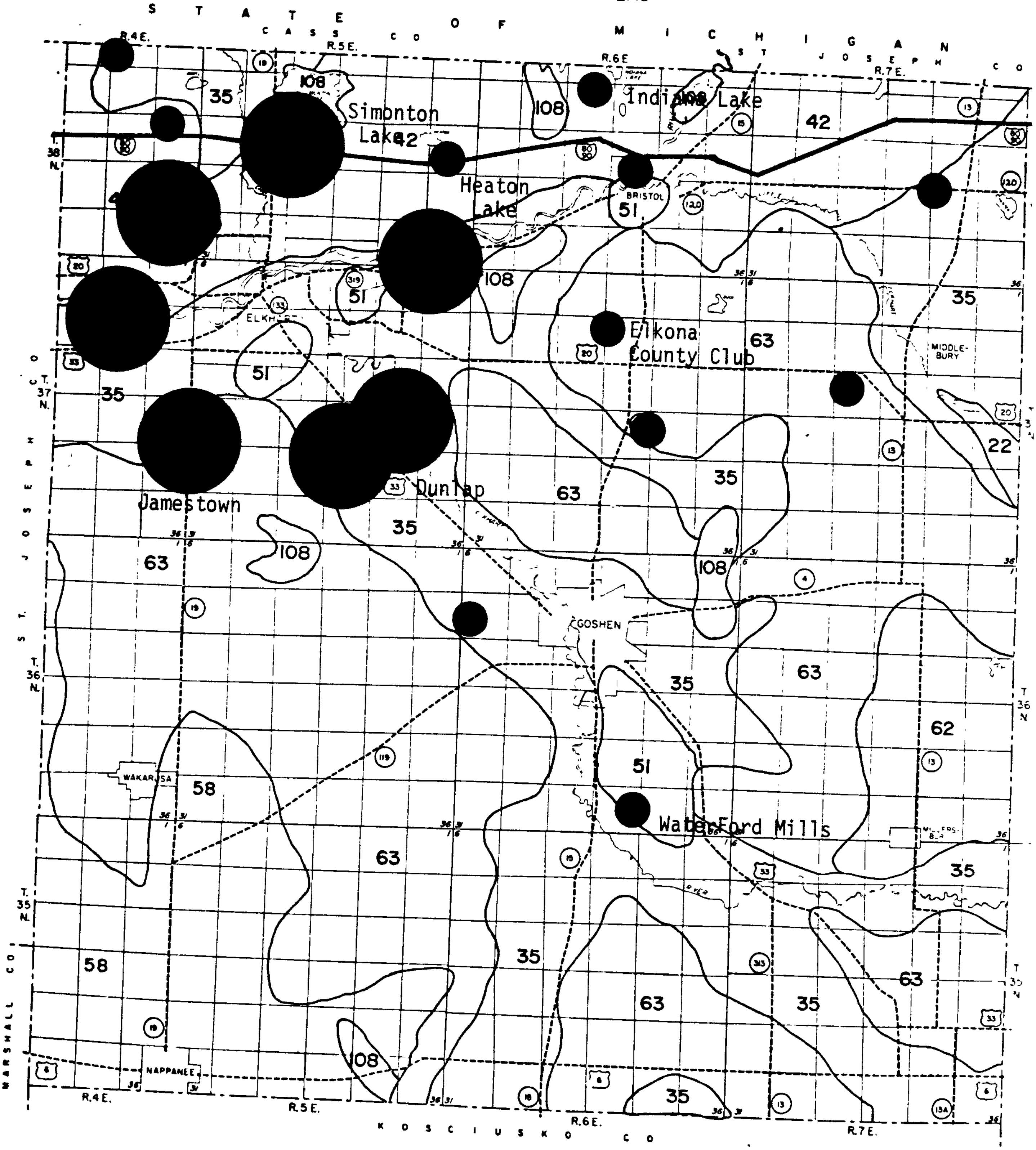

FIGURE 5

FLOYD COUNTY

Most of Floyd County is located within the "driftless" portion of Indiana which was untouched by continental glaciation. The topography is varied with high rolling knobs and rolling hills occurring in the eastern two-thirds of the county and sink-hole dotted limestone plain in the remainder. Groundwater availability is quite limited in much of Floyd County with a substantial number of "dry holes" being reported in the northeastern part. However, major groundwater sources occur in the thick deposits of sand and gravel in the Ohio River Valley which is the southeastern border of the County.

Figure 6 shows the high density non-sewered areas that are located in well drained soils; soils that would be classified as slight, for percolation test purposes, by the Soil Conservation Service. High density areas located in "severe" soils are not shown, since these areas would not be considered as having likely potential to contaminate groundwater aquifers. The illustrated areas are to the west, northwest, and north of the City of New Albany and include the Towns of Georgetown, Greenville, and Lafayette. Additionally the high density areas in Lafayette Township are located over bedrock with high water table characteristics.

While the Villages of Georgetown in the Town of Georgetown, and Greenville in the Town of Greenville are serviced by public water supplies that primarily obtain water from surface sources, the Village of Georgetown supply is a mix of both groundwater and surface water. Moreover those areas outside the distribution

FLOYD COUNTY

HIGH-DENSITY NON-SEWERED AREAS

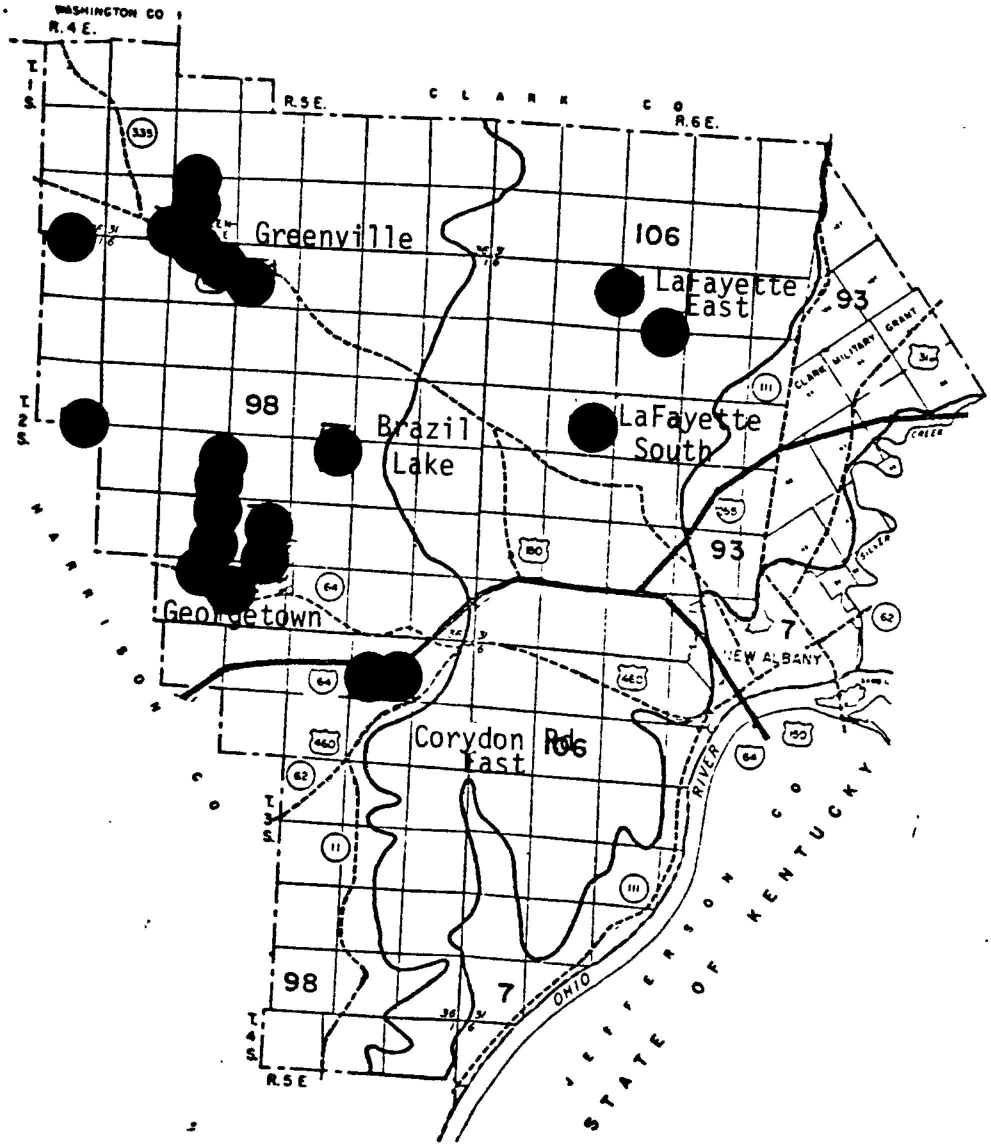

FIGURE 6

system serving these villlages and the high density areas in Lafayette Township must resort to private wells. Based upon 1980 figures, it is estimated that some 12,000 Floyd County citizens obtain water from private wells.

LAPORTE COUNTY

The glacial deposits in LaPorte County consist of glacial till, inter-till sand and gravel, outwash-plain and valley-train sand and gravel, lake clays, dune sand, and ice-contact stratified drift. These materials range in thickness from 100 to 500 feet. Significant outwash-plain and valley-train sand and gravel deposits are located adjacent to the Valparaiso Moraine and along the Kankakee Valley. Lake clays and wind-blown dune sand are found along Lake Michigan. Beneath the thick cover of glacial materials are bedrock formations composed of siltstone, shale, dolomite, and limestone. The bedrock aquifers are not considered to be an important source of water because of their depth, low yielding character, and the general occurrence of good aquifers within the glacial drift.

The area of lowest potential groundwater yield capability is located in the northwestern part of the county where fine sand deposits are not likely to yield more than 50 GPM. Southeast of this area conditions begin to improve as sand and gravel deposits become more prevalent and yields up to 400 GPM are possible. South of the City of LaPorte and to the Kankakee River Valley, groundwater availability increases substantially and well yields of 1000 GPM and more are possible.

Figure 7 shows the high density septic tank and private water supply areas in LaPorte County. High density non-sewered areas include Trail Creek in the southeastern part of Michigan City, a corridor in Central Township between Trail Creek and Pine Lake northwest of LaPorte City, Hudson Lake, Saugany Lake, Upper Fish Lake, Lower Fish Lake, Rolling Prairies, Kingsbury, and Union Mills. Two other disconnected corridors, one north and the other south of the Center Township corridor are also high density septic tank areas.

Although the general geology of LaPorte County defines a soil that is conducive to the promotion of groundwater contamination from septic tanks, those high density areas located on loamy, well-drained soils overlying outwash sand and gravel appear to have the most potential for groundwater contamination. These areas include Trail Creek, Pine Lake, the Center Township corridor between Trail Creek and Pine Lake, Union Center, Rolling Prairies, Kingsbury, South LaPorte and Springville.

MARION COUNTY

All of Marion County was covered by the Wisconsin Glacier that advanced through Indiana some 20,000 years ago. The deposits left by the glaciers consist predominantly of glacial till, ice contact sand and gravel, silt, lake clays, outwash sand and gravel, and alluvial materials. Of particular importance are the permeable sand and gravel deposits found in the valleys of the West Fork of the White River, Fall Creek, and Eagle Creek. Also contained within the glacial drift are numerous thin, inter-till sand and gravel zones.

LAPORTE COUNTY
HIGH-DENSITY NON-SEWERED AREAS

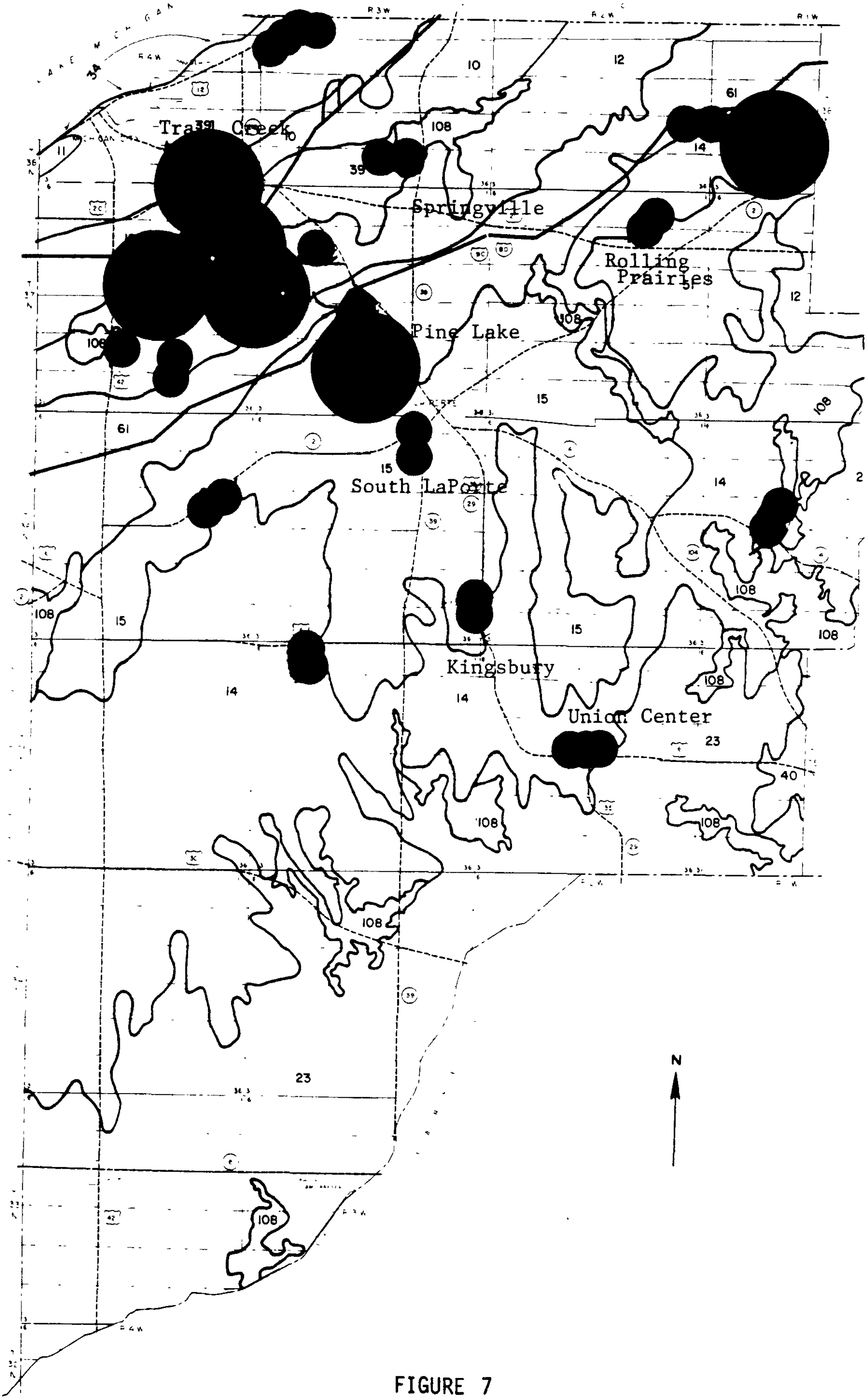

FIGURE 7

Beneath the glacial and alluvial materials to the west are sedimentary rock formations of siltstone, shale, and limestone. A black carbonaceous shale underlies western Indianapolis. Further east, the region is underlaid by limestone, dolomite, and thin interbedded shale and limestone. Major groundwater sources occur in the West Fork of the White River Valley sand and gravel system and the underlying limestone and dolomite bedrock aquifers. Well yields from 250 to 1500 GPM are obtained from these aquifer systems. The Marion County aquifers are easily recharged and the water table is high because of the porosity or permeability of the unsaturated zone and because of the adequate precipitation in the area. Examination of Figure 8 reveals that there are many high density non-sewered areas in the immediately periphery of Indianapolis. In fact the high density areas, which are too numerous to "pinpoint" or to tablelist, are located in every direction around the city, and in some instances within the city proper.

Most of Marion County is serviced by the Indianapolis Water Company which supplies water to approximately 85 to 90 percent of the population. While a preponderance of the water distributed by the Indianapolis water company is obtained from surface supplies (reservoirs), approximately four (4) percent of the total daily pumpage is obtained from groundwater supplies located in the northwestern part of the county. In addition, the remaining 10 to

MARION COUNTY

HIGH-DENSITY NON-SEWERED AREAS

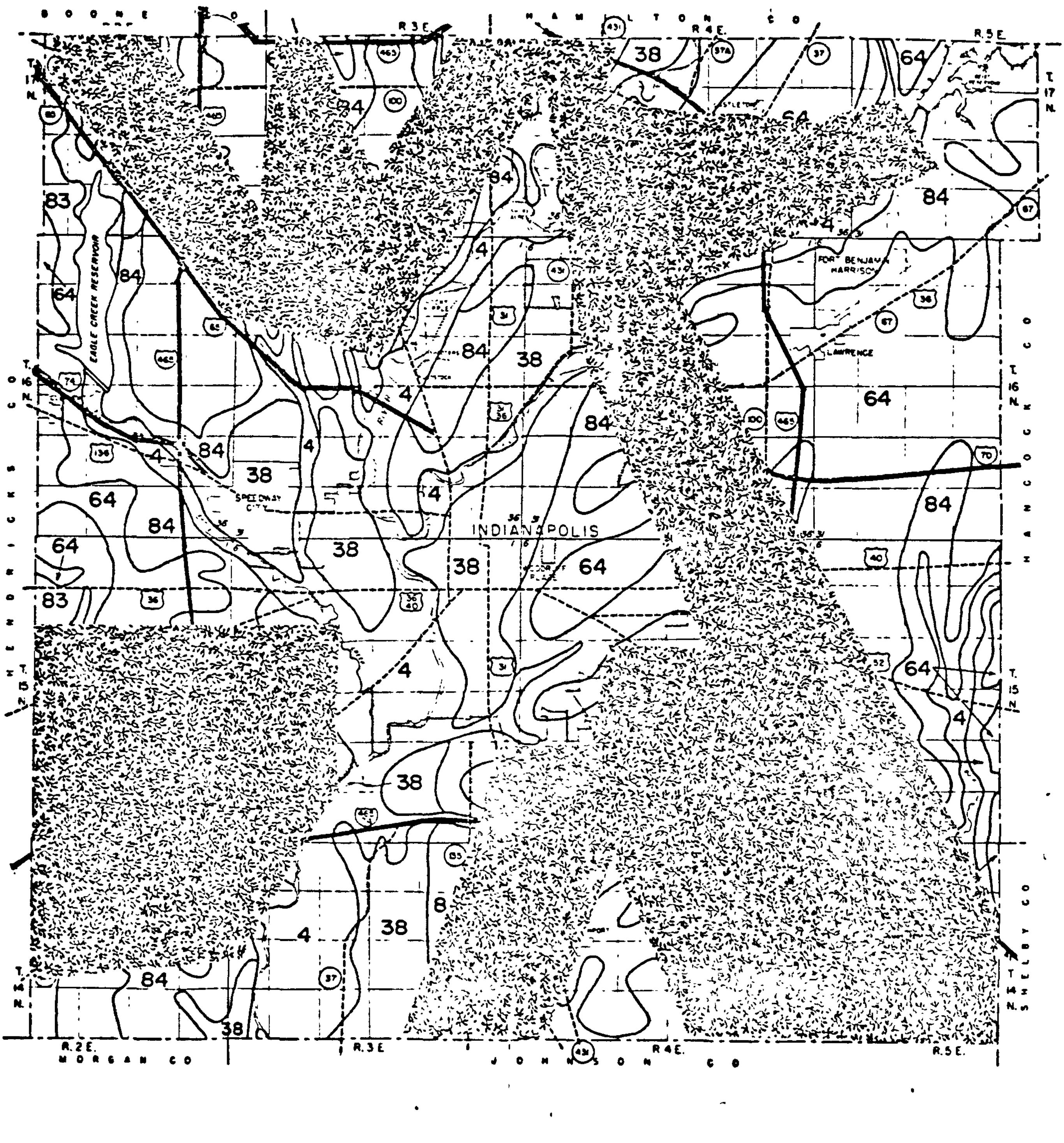

FIGURE 8

15 percent of the Marion County population not serviced by the Indianapolis water company, obtains water from approximately 15,000 private wells or the public wells of the Speedway and Lawrence water companies. It is obvious that any groundwater contamination could affect, in an insidious way, a significant portion of the Marion County population.

Most of the soils, with some exceptions, are well drained loamy soils on outwash sand and gravel and in glacial till. The areas most likely to promote groundwater contamination are directly south and slightly west of Indianapolis and a large area generally north and northwest of the city limits to the county boundaries.

PORTER COUNTY

The unconsolidated deposits located in Porter County vary in thickness from less than 50 feet to over 300 feet, and include lake clays, glacial till, dune sand, and outwash sand and gravel. Sand and gravel deposits serve as important aquifers in much of the county particularily south of the Valparaiso Horaine (41°40'). The lake clays, which along with fine sand predominate in areas near Lake Michigan, are not readily permeable; therefore, groundwater availability near Lake Michigan is not great. However, any contamination in these low availability areas would be more severe because of the lesser dilution available in the pertinent aquifers.

Figure 9 and Table 3 reveal high density non-sewered Porter County areas in the Towns of Porter, Pleasant, Morgan, Washington, Portage, Westchester, and Pine. The high density areas away from Lake Michigan are located above porous sand and gravel in outwash deposits, and in porous ice-contact gravel deposits. Closer to Lake Michigan, the high density areas are generally in clay, silt, and sand in lakebed and shorelines deposits. Each of the areas illustrated is located in soils classified by the Soil Conservation Service as "slight" meaning soils that have little water attenuation capability. Groundwater contamination in these areas is highly possible. Except for Ogden Dunes, which is supplied Lake Michigan water by the Gary-Hobart Water Company, all high density areas in Porter County are serviced by public or private wells.

ST. JOSEPH COUNTY

The unconsolidated deposits in St. Joseph County, which contain major sources of groundwater, consist of glacial till, intertill sand and gravel, outwash-plain and valley-train sand and gravel, lake clays, dune sand, and ice-contact stratified drift. These materials range in thickness from about 100 to 500 feet. Significant outwash-plain and valley-train sand and gravel deposits are located adjacent to the Valparaiso Moraine and along the Kankakee and St. Joseph Rivers. The bedrock aquifers are not considered to be an important source of water in St. Joseph County because of their depth, low yielding character, and the general occurrence of good aquifers within the glacial drift.

PORTER COUNTY

HIGH-DENSITY NON-SEWERED AREAS

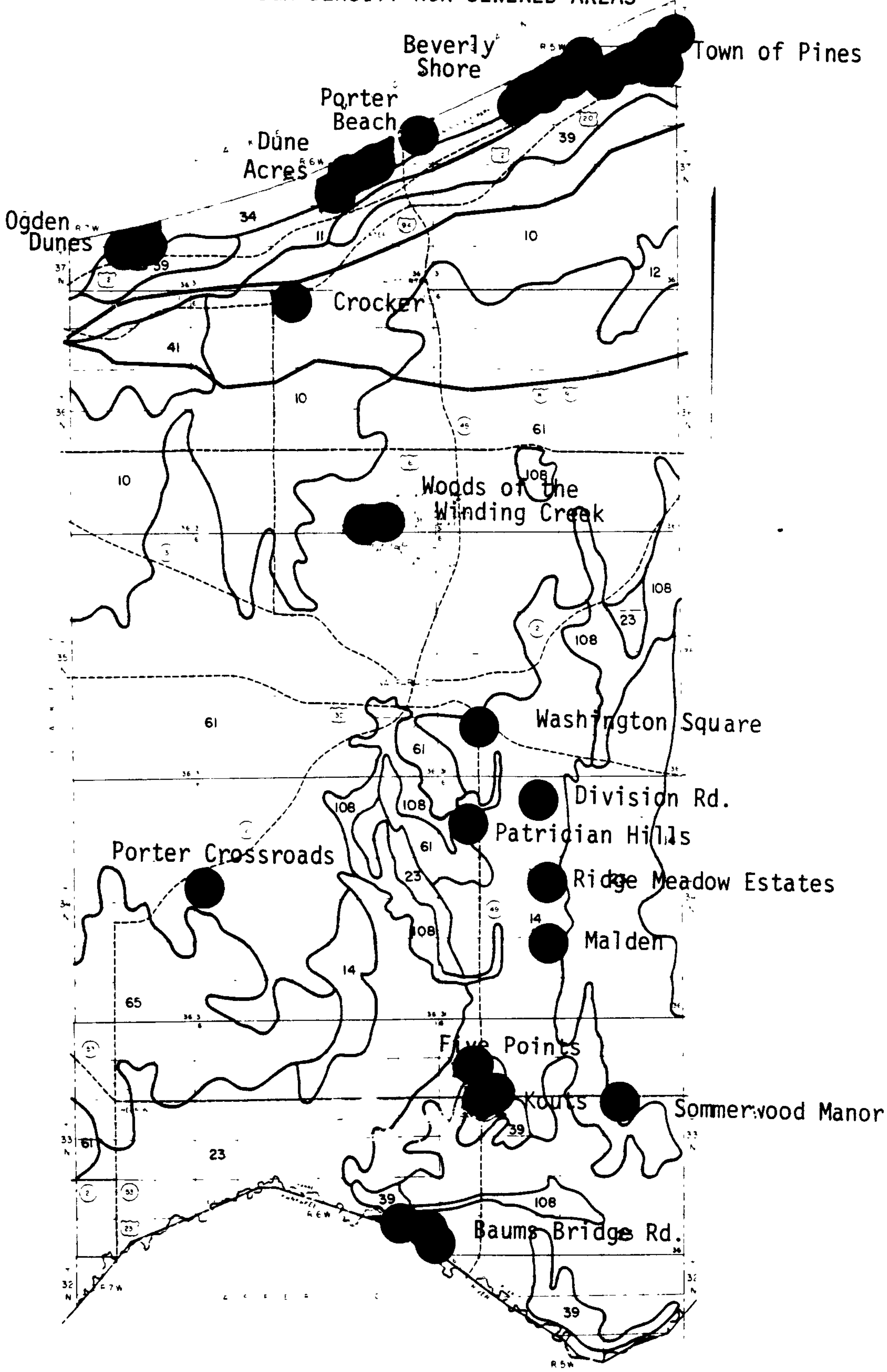

FIGURE 9

TABLE 3

PORTER COUNTY HIGH DENSITY

SEPTIC TANK AREAS

Locality	Township	Septic Tank Density
(1) Ogden Dunes	Portage	120
(2) Dune Acres	Westchester	120
(3) Porter Beach	Westchester	70
(4) Beverly Shores	Pine	95
(5) Pines	Pine	120
(6) Crocker	Liberty	50
(7) Woods of the Winding Creek	Liberty	95
(8) Washington Square	Washington	35
(9) Porter Crossroads	Porter	50
(10) Division Road	Morgan	45
(11) Patrician Hills	Morgan	40
(12) Ridge Meadow Estates	Morgan	50
(13) Malden	Morgan	50
(14) Fivepoints Subdivision	Pleasant	40
(15) Kouts	Pleasant	35
(16) Sommerwood Manor	Pleasant	30
(17) Baums Bridge Road	Pleasant	35

Outwash plain deposits of sand and fine gravel occurring in western St. Joseph County constitute one of the major aquifer systems in the State. This system, the Kankakee aquifer, is capable of producing 600 to 1000 GPM to properly constructed wells. Further east, extensive outwash sand and gravel aquifers form another area of major groundwater availability. Estimated recharge rates of 500,000 gallons per day per square mile are applicable to most of the area and testify to the permeability or porosity of the soil in this area.

The largest single water utility operating in the county is the South Bend Public Utility. This utility served approximately 120,000 people in 1980 and withdrew an average of 30 MGD. Seven other public utilities in the county served another 20,000 customers. The largest of the seven, which pumps more than 6 MGD, is located in Mishawaka. No surface supplies are used for drinking water purposes in St. Joseph County; all utilities are supplied from groundwater sources. Since approximately 150,000 people are served by the eight (8) public utilities, based upon population estimates, it is indicated that approximately 90,000 people satisfy their water needs from private wells.

Figure 10 and Table 4 illustrate the high density septic tank areas in St. Joseph County. It can be seen that most of these areas are located in the periphery of South Bend and Mishawaka. Except for areas in the far northwest and the far southeast, all soils in St. Joseph County would be classified in the slight category using Soil Conservation Service guidelines. The high density areas where potential groundwater contamination from septic tank effluent is likely include the entire area north and east of Notre Dame University to the County Line, the

ST. JOSEPH COUNTY

HIGH-DENSITY NON-SEWERED AREAS

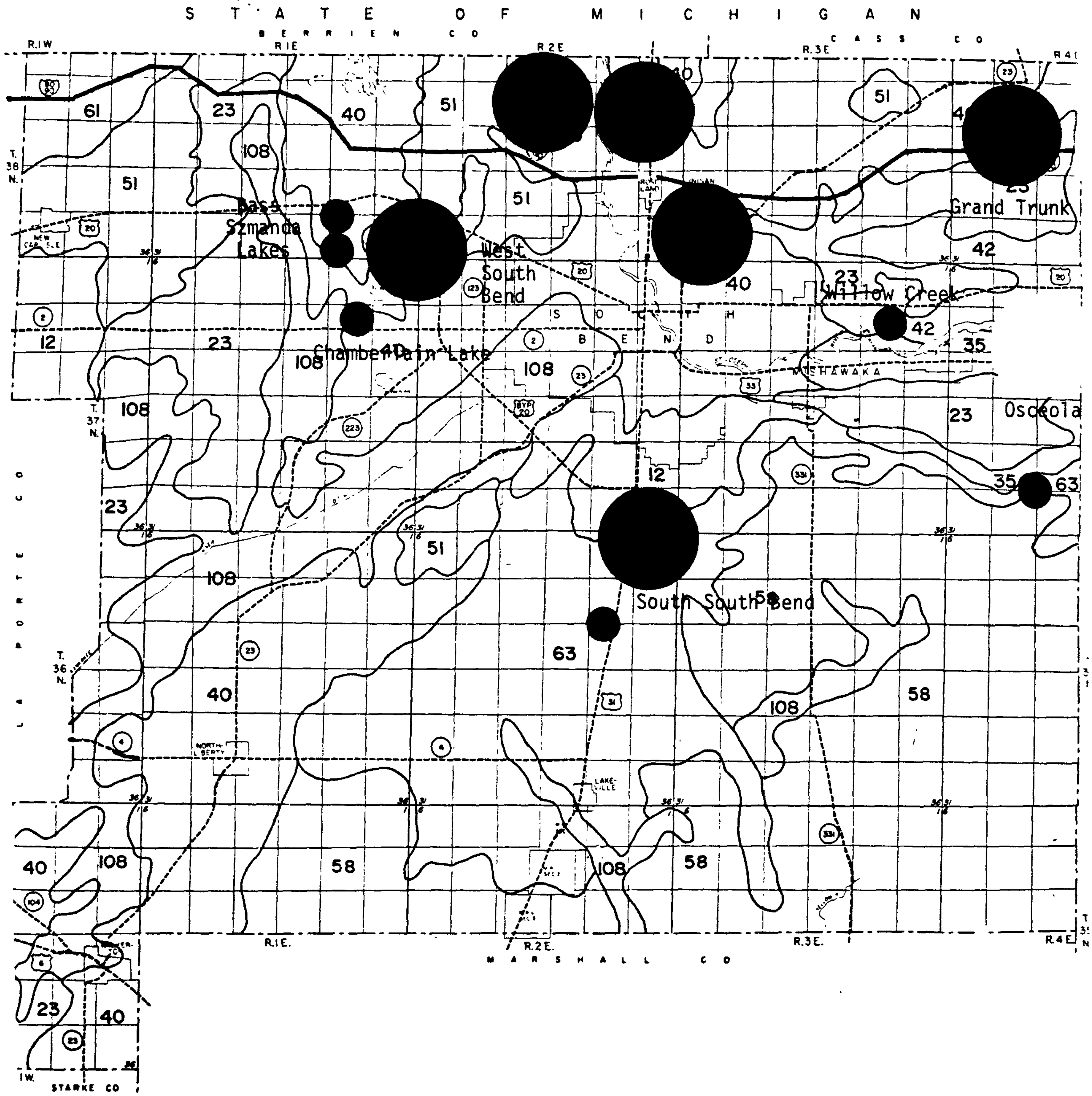

FIGURE 10

TABLE 4

HIGH DENSITY SEPTIC TANK AREAS IN ST. JOSEPH COUNTY

1) Grant Trunk RR - Tollway Area
2) Chapel Hill Subdivision
3) Osceola Area
4) Trail-Beech Roads Subdivision
5) Willow Creek Subdivision
6) Area North and East of Notre Dame to County Line
7) West South Bend
8) Bass-Szmanda Lakes Area
9) Area North of Chamberlain Lake
10) South South Bend

northeastern part of the county east of the Grant Trunk Railroad and north of the Indiana tollway, the Bass-Szmanda Lakes Area, the area north of Chamberlain Lake, the area south of South Bend between Roosevelt and Jackson Roads, and a large area west of South Bend to Pine Road between Grant Street and Lincolnway.

VIGO COUNTY

The unconsolidated deposits in Vigo County consist of glacial till, outwash sand and gravel, dune sand and large clays. The thickness of the glacial drift ranges from 100 to 200 feet. The most important water bearing formations are the outwash sand and gravel aquifers associated with the Wabash River Valley and its tributaries. Properly constructed wells in the permeable sand and gravel aquifers of the Wabash Valley are capable of yields exceeding 2000 GPM. In most of the county, to the northwest and southeast, groundwater availability is quite limited. Most wells in these low availability areas are located in Pennsylvania bedrock and yield less than 50 GPM, 10 GPM being the highest expected yield in many areas.

Vigo County is serviced by seven (7) public water supply systems. All systems withdraw their water from groundwater sources. In addition, the largest, Terre Haute, augments its seven (7) MGD groundwater supply with two (2) MGD from the Wabash River. The 1980 population of Vigo County was approximately 113,000. The service population of the seven (7) public water supply systems is approximately 72,000, indicating that about 40,000 people in the county get their water from private wells. Most of the private wells are located in the southern part of the county.

Figure 11 and Table 5 show the high density non-sewered areas in Vigo County. All areas are located in the sand and gravel deposits associated with the Wabash River Valley. In addition all illustrated areas are located in soils that would be characterized as slight by the Soil Conservation Service. These areas include the Villages of Shepardsville, Atherton, Meltonville, Spelterville, North and West Terre Haute, Prairieton, and the subdivisions of Springwood, Osmar Estates, Bartley, Spring Hill, and Ferguson Hill.

WAYNE COUNTY

The thickness of glacial deposits in Wayne County ranges from less than 10 feet in the southeast to over 350 feet in a buried pre-glacial valley in the west. The types of deposits include glacial till, valley train outwash sand and gravel, ice contact sand and gravel, and alluvium. The outwash sand and gravel deposits, located under the Whitewater River and tributaries, constitute the major groundwater source in the county. Elsewhere sand and gravel units occur as scattered deposits contained within the glacial till. Wayne County is rich in groundwater resources. The only limited groundwater areas are in the southeastern and extreme southwestern sections. From 400 to 1000 GPM are available in the sand and gravel deposits in the valleys of the East Fork, and main stem of the Whitewater River, Martindale Creek, Greens Fork, and Nolands Fork.

Wayne County is served by seven (7) water utilities with a connected population of approximately 54,000 people. Groundwater is the exclusive source for the county's public water systems with the exception of the City of Richmond. Richmond is serviced by the American Water Works which

VIGO COUNTY
HIGH-DENSITY NON-SEWERED AREAS

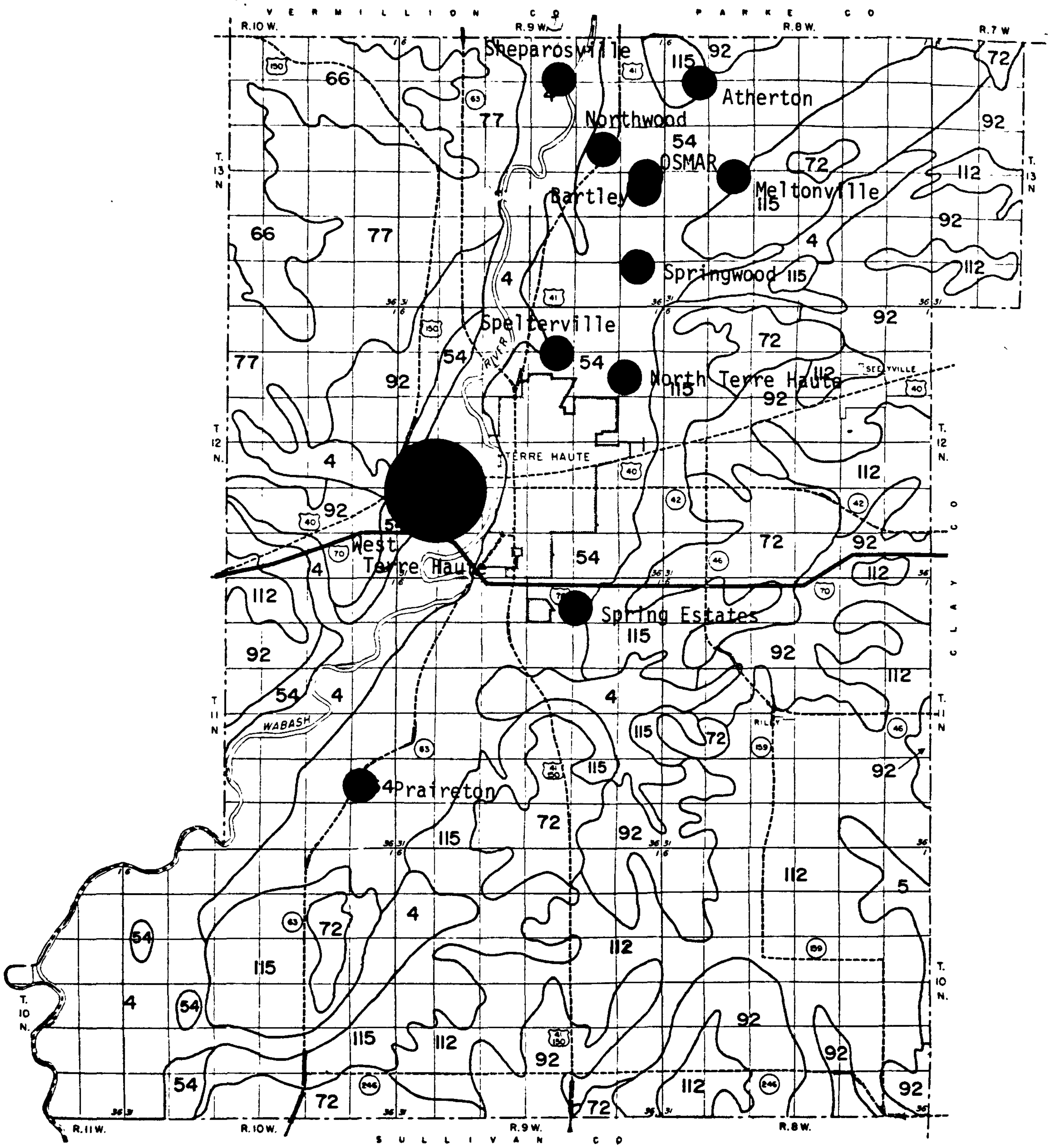

FIGURE 11

TABLE 5

HIGH DENSITY SEPTIC TANK AREAS IN VIGO COUNTY

1) Spelterville
2) Springwood
3) Bartley
4) Northwood
5) Shepardsville
6) Atherton
7) Meltonville
8) Osmar Estates
9) Shawvelle
10) North Terre Haute
11) West Terre Haute
12) Ferguson Hill
13) Spring Estates
14) Prairieton
15) Springhill

obtains 60 percent of its supply from the Middle Fork Reservoir. The remaining 40 percent is withdrawn from groundwater sources located in sand and gravel aquifers.

Figure 12 illustrates the high density non-sewered areas in Wayne County where groundwater contamination from septic tanks is a likely possibility. These areas are located over the permeable outwash sand and gravel deposits composing the major river valleys in the county. Moreover the soils have been classified as slight by the Soil Conservation Service indicating rapid percolation to groundwater aquifers. The suspect high density septic tank areas include the Villages of Milton, East Germantown, Pennville, Jacksonburg, Greens Fork, and Economy, and sub-divisons to the northeast of the City of Richmond; namely, Pow Wow Ridge, Highland KOA, Grand Pa's Farm, and an area northeast of Indiana Highways 121 and 227.

SUMMARY

1) Septic tank systems are used by about 25 percent of the U.S. population
2) Two (2) basic types of septic tanks failure are recognized. One type is caused by soil clogging, resulting in "ponding" above the drainfield or by wastewater backup into the home plumbing fixtures. A second type occurs when septic tank effluent reaches the groundwater without sufficient treatment, contaminating water wells in the area.
3) Several factors appear to affect the potential for groundwater contamination from septic tank systems. These factors include septic tank and population densities, depth of water table, bedrock condition (fractures), contaminant biodegradability and/or absorbability, and soil type.

WAYNE COUNTY

HIGH-DENSITY NON-SEWERED AREAS

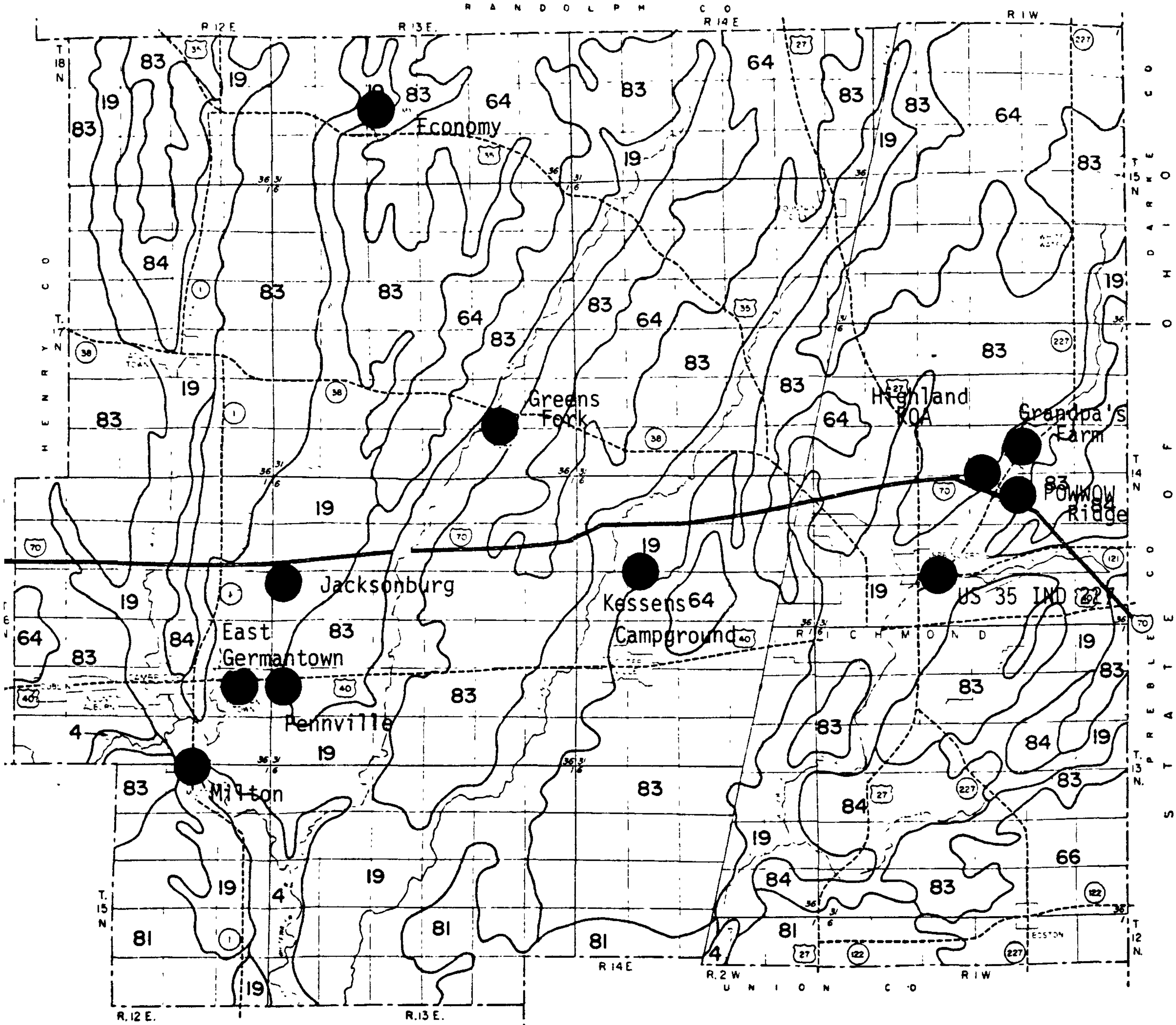

FIGURE 12

4) While septic tanks placed in a soil classified by the Soil Conservation Service as "slight" would be most appropriate to prevent surface ponding or effluent backup into home plumbing fixtures, this type of soil would also be most likely to easily pass toxicants from septic tank effluents to underlying aquifers.
5) The description of soils in the report are general in nature. Since the general categorization describes the major soils primarily, and since the report considered landscapes also include minor soils of varying and undefined character, it is not a foregone conclusion (only a likelihood) that a high density non-sewered area located over a generally described permeable soil would actually contribute to groundwater contamination.
6) Groundwater in Indiana occurs in a variety of both unconsolidated and bedrock aquifer systems. The most significant of these aquifers are the various outwash sand and gravel deposits associated with glacial drift, and the limestone, dolomite, and sandstone bedrock formations.
7) Generally the most productive groundwater aquifers are in the northern part of Indiana and get progressively less productive north to south, exclusive of major river aquifers.
8) The generally greater permeability of soils in the north allows for the more efficient percolation of precipitation to groundwater aquifers below. THe generally tighter soil of the southern part of the State decreases the efficiency of percolation causing greater run-off to area surface waters. These differences in geology account for the general difference in ground water availability from north to south.

9) There are many high density non-sewered areas in Allen County, primarily in the east, west, and north outskirts of Fort Wayne. In the rest of the county these areas incude Lake Everett, Cedar Canyon, Hacienda Village East, Hessen Castle, Poe, Yoder, Zanesville, Rolling Hill Manor, and Arcola. All high density areas are located over permeable or porous soils - soils that have high percolation rates, and that are prone to promote a facile passage of any contaminants to aquifers below.

10) Most of the high density non-sewered areas in Clark County are located in the southern part -- in the Clarksville - Jeffersonville area, close to the Ohio River where the bedrock overlay consists of permeable sand and gravel in outwash deposits. Other suspect high-density septic tanks areas include Utica, Long Beach, Watson, Lakeview, Highview, North Charlestown, Maplehurst, New Washington, Underwood, Memphis, Allentown, Speed, and Hamburg Twinbrook.

11) Elkhart County is an area of permeable soils and major groundwater availability. All suspect high density septic tank areas in Elkhart County are located over well drained loamy soils overlying outwash sand and gravel. The largest concentration of high density septic tanks in the county is in the Dunlap area. Other high density areas are located adjacent to the St. Joseph River east and west of the City of Elkhart, Simonton Lake, the area north of Bristol, Indiana Lake, the north and southwest Middlebury area, and the area east of Waterford Mills.

12) Groundwater availability is quite limited in much of Floyd County with a substantial number of "dry holes" being reported in the northeastern part. However, the high density non-sewered areas west, northwest, and north of the City of Albany, which are located over well drained soils and bedrock with high water characteristics, can be suspected of the likelihood of groundwater contamination. These areas include the Towns of Georgetown, Greenville, and LaFayette.

13) Although the general geology of LaPorte County defines a soil that is conducive to the promotion of groundwater contamination from septic tanks, those high density areas located over loamy, well-drained soils overlying outwash sand and gravel have the most potential. These areas include Trail Creek, Pine Lake, the Center Township corridor between Trail Creek and Pine Lake, Union Center, Rolling Prairies, Kingsbury, South LaPorte, and Springville.

14) There are many high density non-sewered areas in the immediate periphery of Indianapolis. In fact, the high density areas, which are too numerous to "pinpoint" or to tablelist, are located in every direction around Indianapolis and in some instances within Indianapolis proper. Most of the Marion County soils, with some exception, are well drained loamy soils on outwash sand and gravel, and in glacial till. The areas most likely to promote groundwater contamination are directly south and slightly west of Indianapolis, and a large area generally north and northwest of the Indianapolis city limits to the Marion county boundaries.

15) The Porter County high density non-sewered areas are located in the towns of Porter, Pleasant, Morgan, Washington, Portage, Westchester and Pine. These illustrated areas are all sited over soils classified by the Soil Conservation Service as slight indicating the likelihood of a high potential for groundwater contamination from septic tanks.

16) St. Joseph County is one of the richest counties in groundwater availability in the State, indicating a very thick and permeable bedrock overlay. In such a setting, groundwater contamination from high density septic tanks areas is a distinct likelihood. Among others, these areas include the entire area north and east of Notre Dame University to the county line, the Grant Trunk Railroad - Indiana Tollway area in the northeast, the Bass-Szmanda Lakes area, the area north of Chamberlain Lake, south South Bend, and west South Bend.

17) The Vigo County high density non-sewered areas are located in the Villages of Shepardsville, Atherton, Meltonville, Spelterville, north and west Terre Haute, Prairieton, and the subdivisions of Springwood, Osmar Estates, Bartley, Spring Hill, and Ferguson Hill. These areas are all located in the highly permeable sand and gravel deposits of the Wabash River Valley and in soil classified as slight by the Soil Conservation Service, indicating a high potential for groundwater contamination.

18) The suspect high density non-sewered areas in Wayne County are located in the major river valleys composed of permeable outwash sand and gravel and in soils classified as "slight" by the Soil Conservation Service. These areas include the Villages of Milton, East Germantown, Pennville, Jacksonburge, Greens Fork, and Economy, and subdivisions

to the northeast of the City of Richmond; namely Pow Wow Ridge, Highland KOA, Grand Pa's Farm, and an area northeast of the junction of Indiana highways 121 and 227.

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