Appendixes

Appendix One

PUBLIC WATER SUPPLIES

Inventory

Average Daily Use — Water Sources The Indiana State Board of Health has from time to time published data on Indiana public water supplies. These appear as "Bulletin SE-10, Data on Indiana Public Water Supplies." Issues of this bulletin have been published in 1957, 1960, and 1968. This bulletin contains data on the population served, source of supply, rated plant capacity, average and maximum daily use, treatment, and physical and chemical water characteristics for each public water supply in the state.

The data on average daily use (and maximum daily use) and water sources came from an in-house update of the 1968 SE-10 which is maintained in the offices of the Indiana State Board of Health. This in-house update generally reflects 1975 use data. It was necessary in some instances to use additional outside data, usually from the utility itself.

Population Served It has been the practice of the Board of Health to assume that all persons living in an incorporated area are served by the public utility in that community. Therefore, census data has been used to establish served populations. It should be noted that very few utilities have any data on populations served. They do maintain files on the number of service connections, but this is not directly related to population served.

Although the 1975 in-house SE-10 contains population estimates for 1975, this data was discarded in favor of Indiana "Population Estimates and Projections" (Series P-25, No. 662, issued May 1977) by the Bureau of the Census which contains 1975 population estimates. Where service areas did not coincide with a political boundary, as in a rural water system, the board of health population estimates were used. The population-served figure for the Indianapolis Water Company was established by an analysis of census tract data from the 1970 census.

Service Areas The service area maps were drawn from maps furnished by the utilities in a questionnaire survey conducted in the spring of 1978 and from the data the Farmers Home Administration and several of the regional planning and development offices. A follow-up field interview was conducted in the fall of 1978 to obtain data from those utilities that failed to respond to the spring mail survey.

Projections

Population Projections The county population projections used were taken from *Indiana County Population Projections, 1975 – 2000* prepared by the Division of Research, School of Business, Indiana University and published by the Indiana State Board of Health in 1976. These projections were recommended for all types of ongoing state planning by the State Planning Services Agency. Population values for 1975, however, were taken from the Series P-25, No. 662 census report.

Shortly after the initial publication of this study, the Board of Health published revised population estimates under the title "Indiana County Population Projections, 1980 – 2000." It was not possible to incorporate these values into this study, but the following estimates of the population in each region in the year 2000 are furnished for purposes of comparison.

Table 215
Comparison of estimated regional population projections for the year 2000.

Region	*Projections Published In 1976*	*Projections Published In 1978*
One-A	767,000	735,600
One-B	98,200	81,400
Two	694,100	609,000
Three-A	200,300	173,700
Three-B	493,800	462,700
Four	292,200	269,000
Five	283,300	250,000
Six	527,000	487,900
Seven	221,900	214,300
Eight	1,531,100	1,440,700
Nine	170,700	151,900
Ten	133,000	123,200
Eleven	192,400	185,000
Twelve	116,300	102,400
Thirteen-A	164,200	139,500
Thirteen-B	303,000	276,600
Fourteen	281,600	258,900
Fifteen	112,300	99,000
Total	6,582,400	6,061,000

Population Served In order to estimate the probable future populations that will be served by public water utilities, the histories of all utilities now serving over one thousand persons were constructed using the published SE-10 data. Population data was taken from the 1950, 1960, and 1970 census and the aforementioned 1975 estimates. These individual utility histories were combined to form a series of county historical data summaries. In order to establish the population served, estimates to coincide with the SE-10 water data years (or vice versa), mathematical growth curves were constructed through the data points. In all but a few cases, extremely high correlation coefficients were achieved. It was then possible to compute the percentage of population served (by larger systems) in any given county and to establish past trends of growth or decline in the percentage of the population served.

Detailed analysis of the past service characteristics was made for seventeen counties scattered across the state. There were three distinct growth patterns revealed in the study. In the majority of counties, the percent served was stable over the study period, but there were a few cases where percent served was declining and in a few more cases the percent served was rising.

This percentage served was stable in the large urban counties such as Lake and Marion, where the bulk of the population lived in urban areas served by public water systems. It was also stable in smaller counties where the ground-water availability map indicated that wells yielding from under 50 to 800 gallons-per-minute (gpm) could be developed.

The percent served figure was declining only in those few counties where ground water was abundant, such as Elkhart County. The trend line analysis showed a modest decline in percent served, on the order of about seven percent by the year 2000. There were no rural water systems in these counties.

There were two classes of counties experiencing growth in terms of percent population served. These were the rapidly growing suburban counties such as Hamilton and Porter, and the counties with poor ground-water conditions and rural water systems. When a growth trend was found, it was usually strong. The composite growth trend line for the counties analyzed showed an 11.5 percent growth in population served by the year 2000.

The population served by public water supplies in the future was calculated by: (1) computing the percent population served in that county in 1975; (2) determining by inspection whether that percentage will decrease, remain the same or increase, as outlined above; (3) making appropriate adjustments to this percentage for the years 1980, 1990, and 2000; and finally (4) multiplying these adjusted percentages by the future estimated total county population.

It should be noted that the water used for all of the future population not served by a public water supply appears as "Rural Self-Supplied Water," so the water use for all future residents in the state has been accounted for.

Per Capita and Estimated Water Use Three different per capita use projections were made for this study. These can be identified as the constant per capita method, the regional trend method, and the thirteen cities method. The total population served and its water use are given in the following table.

Table 216
The 1975 water use in gallons-per-capita-per-day.

Region	*Population Served*	*Average Daily Use (million gallons)*	*GCD*
One-A	572,570	77.35	135
One-B	20,770	2.57	124
Two	345,810	61.30	178
Three-A	50,520	6.85	136
Three-B	258,840	38.03	147
Four	157,960	25.27	160
Five	132,180	27.37	207
Six	306,290	50.77	166
Seven	127,340	15.99	126
Eight	883,480	120.24	136
Nine	91,180	17.31	190
Ten	67,020	12.06	180
Eleven	78,530	12.35	157
Twelve	62,950	7.54	120
Thirteen-A	98,040	15.82	161
Thirteen-B	183,980	38.07	207
Fourteen	140,280	16.48	117
Fifteen	54,080	6.40	118
Total	3,631,820	551.77	152

Future water use figures were computed by assuming that the regional per capita figure would remain constant and by multiplying that figure by the projected population served for that region.

The second, the regional trend, method involved compiling the historical data for all public utilities now serving over one thousand persons. This data was then added together to obtain regional per capita use going back to 1950. A least squares linear equation was then fit through the data and projected out to the year 2000. Because the data in a few regions appeared to be rising at an unreasonable rate, the 1990 use was "capped" at 250 gallons-per-capita-per-day (gcd) and the 2000 figure was "capped" at 260 gcd. The computed values for future per capita use from this analysis are listed below.

Table 217
Future water use in gallons-per-capita-per-day.

Region	*1980*	*1990*	*2000*	*Region*	*1980*	*1990*	*2000*
One-A	141	152	163	Eight	137	139	141
One-B	136	160	183	Nine	207	243	260
Two	187	205	224	Ten	191	213	236
Three-A	148	172	196	Eleven	163	174	186
Three-B	154	170	185	Twelve	126	138	150
Four	183	215	247	Thirteen-A	169	186	202
Five	231	250	260	Thirteen-B	221	250	260
Six	173	188	202	Fourteen	130	148	168
Seven	133	147	160	Fifteen	123	131	139

The future water use was then computed by multiplying these per capita uses by the estimated population served for the appropriate year.

At is meeting on June 22, 1978, several of the commissioners expressed the view that the per capita use of the larger systems was rising slowly, not at the higher rates shown in the regional trend method. These commissioners suggested that the projected growth (in per capita use) trend from the larger, more stable public water supplies would furnish the best method of forecasting future per capita use for the state as a whole.

Accordingly, the histories of the larger cities in the state were reviewed and the following thirteen cities were chosen: Anderson, Columbus, Evansville, Fort Wayne, Hammond, Kokomo, Lafayette, Madison, Muncie, Richmond, Terre Haute, Valparaiso, and Vincennes. The Indianapolis Water Company and the Gary-Hobart Water Company were not used because of the difficulty in establishing past-population-served data.

The per capita uses for all thirteen utilities were averaged for the years 1950, 1960, 1970, and 1975 and projected forward to the year 2000. The results of these projections are as follows:

Table 218
Thirteen-cities method, past and future uses, in gallons-per-capita-per-day.

Year	*Average Use*	*Projected Use*	*Percentage of 1975 Use*
1950	132		
1960	135		
1970	143		
1975	155		
1980		155	100.0
1990		165	106.5
2000		173	111.6

The anticipated water use was then calculated by: (1) computing the average 1975 per capita use for each region as outlined above; (2) adjusting these per capita figures by the percentages shown in the above table for the years 1980, 1990, and 2000; then (3) multiplying these adjusted figures by the projected population served as previously outlined. The values from this method are the values presented in the main body of this report.

The constant per capita method produced the lowest future water use estimates. With the exception of Region Eight, the regional trend method produced the highest estimate, and the thirteen-cities method produced the midline estimate.

Water Consumed The definition of consumed water as used in this study is water that is extracted from the environment, used, and then not returned to a surface stream. Consumed water is not lost. It could be evaporated, spilled, placed into the soil profile, incorporated into a manufactured product, or otherwise used. This water will eventually work its way back into the hydrologic cycle, but will do so either at some point other than its point of extraction or at some time other than its time of extraction.

Because of the inevitable mix of self-supplied and public-supplied water users in a community and areal differences in water utility and sewer utility service areas, no attempt was made to actually measure the water consumed by public water systems in this study. Instead, it was assumed that ten percent of the water pumped by an urban utility and eighty-five percent of the water pumped by rural water systems are considered consumed water. The eighty-five percent value is a figure commonly assigned to these systems. Since most of the households served by rural water systems utilize septic tanks for wastewater disposal, and these systems do not (it is hoped) return this water to the point of extraction in a timely manner, this value is considered reasonable.

The consumed figures applying in this report reflect the mix of urban and rural systems and their pumpage rates. For the purpose of projecting future consumption rates, this mixture was assumed to remain constant throughout the study period.

Table 219
Public water supplies, projected future withdrawals and consumption in million-gallons-per-day.

Region	*Population Served*	*1980 Low*	*1980 Mid*	*1980 High*	*Population Served*	*1990 Low*	*1990 Mid*	*1990 High*	*Population Served*	*2000 Low*	*2000 Mid*	*2000 High*
One-A												
Withdrawal	593,800	80.22	83.73	83.73	642,900	86.86	92.50	97.72	690,000	93.22	104.03	112.47
Consumed		10.43	10.43	10.69		11.29	12.03	12.48		12.12	13.52	14.37
One-B												
Withdrawal	22,700	2.81	2.81	3.09	25,300	3.13	3.34	4.05	27,800	3.44	3.84	5.09
Consumed		0.28	0.28	0.31		0.31	0.33	0.41		0.34	0.38	0.51
Two												
Withdrawal	355,100	62.96	62.96	66.40	359,900	63.81	67.96	73.78	360,400	63.90	71.31	80.73
Consumed		7.24	7.24	7.63		7.28	7.81	8.47		7.35	8.20	9.27
Three-A												
Withdrawal	52,400	7.11	7.11	7.76	56,200	7.62	8.12	9.67	59,700	8.10	9.03	11.70
Consumed		0.71	0.71	0.78		0.76	0.81	0.97		0.81	0.90	1.17
Three-B												
Withdrawal	273,900	40.24	40.24	42.18	309,100	45.41	48.36	52.54	340,400	50.00	55.81	62.97
Consumed		4.02	4.02	4.22		4.54	4.84	5.25		5.00	5.58	6.30
Four												
Withdrawal	164,000	27.31	27.31	30.01	174,100	28.99	30.87	37.43	181,700	30.25	33.76	44.88
Consumed		2.73	2.73	3.00		2.90	3.09	3.74		3.03	3.38	4.49
Five												
Withdrawal	139,400	28.87	28.87	32.20	150,800	31.23	33.27	37.70	160,800	33.30	37.16	41.81
Consumed		2.89	2.89	3.22		3.12	3.33	3.77		3.33	3.72	4.18
Six												
Withdrawal	316.700	52.51	52.51	54.79	330,800	54.85	58.41	62.19	339,700	56.32	62.86	68.62
Consumed		5.51	5.51	5.74		5.76	6.13	6.52		5.91	6.60	7.19

Table 219 (continued)

Region	1980 Population Served	1980 Low	1980 Mid	1980 High	1990 Population Served	1990 Low	1990 Mid	1990 High	2000 Population Served	2000 Low	2000 Mid	2000 High
Seven												
Withdrawal	130,700	16.48	16.48	17.38	131,200	16.54	17.62	19.29	131,400	16.57	18.49	21.02
Consumed		2.14	2.14	2.27		2.15	2.29	2.52		2.15	2.40	2.75
Eight												
Withdrawal	931,900	126.83	126.83	127.67	1,047,700	142.59	145.63	151.86	1,175,600	160.00	165.76	178.56
Consumed		13.32	13.32	13.37		14.97	15.25	15.95		16.80	17.36	18.75
Nine												
Withdrawal	95,200	18.07	18.07	19.71	102,700	19.49	20.76	24.96	105,600	20.04	22.37	27.46
Consumed		1.99	1.99	2.14		2.14	2.28	2.71		2.20	2.46	2.91
Ten												
Withdrawal	72,700	13.09	13.09	13.89	87,400	15.73	16.18	18.61	101,800	18.32	20.46	24.02
Consumed		2.55	2.55	2.71		3.06	3.27	3.63		3.57	3.99	4.68
Eleven												
Withdrawal	83,300	13.10	13.10	13.58	96,500	15.18	16.17	16.79	110,700	17.41	19.43	20.59
Consumed		3.01	3.01	3.12		3.49	3.76	3.86		4.00	4.47	4.73
Twelve												
Withdrawal	66,400	7.95	7.95	8.37	76,300	9.14	9.73	10.53	86,500	10.36	11.56	12.98
Consumed		2.31	2.31	2.48		2.65	2.92	3.11		3.00	3.47	3.84
Thirteen A												
Withdrawal	103,200	16.66	16.66	17.44	110,300	17.80	18.96	20.52	116,900	18.87	21.06	23.61
Consumed		3.50	3.50	3.67		3.74	3.98	4.32		3.96	4.42	4.97
Thirteen B												
Withdrawal	187,200	38.73	38.73	41.37	196,400	40.60	43.28	49.10	208,300	43.10	48.10	54.16
Consumed		4.26	4.26	4.57		4.47	4.76	5.43		4.74	5.29	5.99
Fourteen												
Withdrawal	153,900	18.08	18.08	20.01	188,200	22.11	23.55	27.85	225,300	26.47	29.50	37.85
Consumed		4.16	4.16	4.59		5.08	5.42	6.39		6.09	6.79	8.68
Fifteen												
Withdrawal	58,200	6.89	6.89	7.16	67,700	8.01	8.53	8.87	77,800	9.20	10.27	10.81
Consumed		1.17	1.17	1.21		1.36	1.45	1.50		1.56	1.75	1.82

Appendix Two

INDUSTRIAL WATER

Inventory

For the purposes of this study the term *industry* is defined as a manufacturing facility engaged in the fabrication of durable and nondurable goods. This term does not include farming, mining, construction, wholesale or retail trade, transportation, utilities, finance, services, or government.

Industrial operations extract water from the environment either by means of their own facilities, from public water supplies, or a combination of both. This water is then used in the manufacturing process. Usually water is reused within the plant, often several times over. Water is finally discarded to the outside environment, either untreated, treated by the industry, discharged into a locally available sanitary sewer, or some combination of the foregoing. It is not the purpose of this study to deal with the water use and reuse within the manufacturing operation, defined as total water use. (This will be a factor in some computations, however.) We are concerned with the water extracted from the environment, labeled water intake, and the difference between water taken into the plant and water discharged, labeled consumptive use. Consumptive use accounts for water spilled, evaporated, incorporated into the product, or occasionally chemically broken down in the process. Future time frames for study purposes are the years 1980, 1990, and 2000.

There is a parallel, ongoing study of anticipated future demands on public water supplies. Some industrial water comes from the public source. Since it is not possible at this time to disaggregate the industrial component from other components of public water supplies, the projections made for future demands on these supplies will account for the publicly supplied industrial water. This study will deal with self-supplied industrial water, although some publicly supplied water will be used for computational purposes.

This study was made by means of a survey of current industrial water use, projections of future levels of economic activity, and projections of future levels of industrial efficiency in the use of water.

There are several assumptions that have been made for the purposes of this study. In all probability none of these assumptions are totally true. All are believed accurate enough to produce the desired results; besides, in the absence of significant amounts of historical data, we have no choice. These assumptions are: (1) industrial water use is directly proportional to production; (2) earnings by industry are directly proportional to production, hence directly proportional to water use, (3) value added by industry is directly proportional to production and water use; (4) the future character of industrial water use will be an extrapolation of past industrial performance; and (5) 1977 (the survey year) does not represent an unusual industrial year.

The Survey The survey represents one hundred percent of all industries in Indiana employing over fifty persons and about a ten percent sample of industries employing less than fifty. The list of industries comes from *The Indiana Industrial Directory, 1976–77* published by the Indiana State Chamber of Commerce. Industries are divided by county, employment, and a two-digit standard, industrial classification (SIC) code. The questionnaire contains questions on type of industry (to verify the SIC code), employment, amount of water used in a year, annual operating days, and source of the water. These forms are confidential and will be treated as such. Data from responding industries will be used to "fill in" for nonresponding industries. These predictions require a reasonable and accurate survey.

Projections

Indiana industries, for the most part, function in a national economy, that is to say their activity rises and falls as the national demand for goods and services expands or contracts. Much of Indiana's industrial output is consumed in the state and still more is used within the mid-west, but there seems to be no evidence that the state's economy is independent of the national economy. Projections for future Indiana industrial activity will be more solid if they represent a diaggregation of national projections, rather than an extrapolation of past state activity.

Because of the limitations imposed by available data and the time frame provided for the study, projections will be made on the two-digit SIC code for SIC-20 through SIC-39. Also, an all industry growth curve will be developed for use in those industries with an inadequate data base.

A data base exists for making projections of future industrial growth. Probably the most important component of this base is the census of manufacture which collected data at ten-year intervals from 1809 through 1899 and five-year intervals thereafter.

This and other data have been analyzed, and projections of future economic activity have been made by the U.S. Department of Commerce and U.S. Department of Agriculture acting jointly under contract to the U.S. Water Resources Council. These projections are known as the OBERS Projections (an acronym made from outdated U.S. DOC and USDA agency names) and occur in several series. The latest series is known as the Series E population set and was published in 1974. Series E is based on a projected national population of 263.8 million in the year 2000 with a total personal income of $2,154,266,000,000. The OBERS projections also are based on a series of assumptions such as no major wars, a decline of 0.35 percent per year in hours worked, a somewhat smaller military establishment, a 2.9 percent per year increase in productivity, and past historical data can be used to project future trends.

These OBERS projections are made in terms of industrial earnings which, for the purposes of this study, must be assumed to be directly proportional to both industrial production and industrial water use.

The OBERS projections were made on a national basis and then disaggregated into several subnational classifications. These classifications are the states, clusters of counties forming a megalopolis (known as Standard Metropolitan Statistical Areas or SMSA's), larger clusters of counties representing substate regions (known as Business and Economic Areas or BEA's), water resource regions, and non SMSA's of BEA's. All of these classifications, with the exception of the states themselves can cross state lines.

Population Adjustment The Indiana State Board of Health has published a document entitled *Indiana County Population Projections 1975–2000* (1976). This document was prepared by the Division of Research, School of Business, Indiana University. These projections have gained general acceptance as the best available estimates of future population patterns in the state and are now being used for most ongoing state-level studies. Because of the quality and overall acceptability of these projections, this study will use these figures as the "most probable" estimates of future populations.

A decision has been made to use OBERS, Series E, as the basis for future industrial projections, because the Series E projections do not quite agree with the Indiana State Board of Health (ISBH) projections. To bring these studies into agreement was necessary to apply an adjustment factor based on population differences to the OBERS projections. These differences can be seen in the following table which compares the ISBH projections with those used as a basis for the OBERS projections.

Table 220
A comparison between the ISBH and OBERS Population Projections.

	1970	*1980*	*1985*	*1990*	*2000*
ISBH	5,193,700	5,575,400	5,828,600	6,086,600	6,582,100
OBERS	5,208,000	5,783,600	6,066,900	6,364,200	6,837,000
Ratio (ISBH/OBERS)	.9973	.9640	.9607	.9564	.9627

The actual adjustments will be made on the basis of the ratio of expected residents of each region to the "closest fit" OBERS area, be it SMSA, BEA, or another. This figure will be labeled γ and will be computed for each region for each time frame.

Industrial Growth and Its Distribution

Growth The statewide industrial growth was taken from the data presented in *Volume 4—States* of the OBERS Series E projections. This data was displayed as an all industry curve for each two digit SIC classification from SIC-20 through SIC-39 with the exceptions of 21, 26, 30, 31, 32, and 38 for which no data exists. A term, labeled (α was computed, defined as the ratio of the industry's 1980 (and 1990 and 2000) earnings to the 1977 earnings. The 1977 earnings were estimated by straight-line interpolation between the 1970 and 1980 values.

Distribution of Growth Industrial growth across the state will not be even, with some regions growing faster than others. In order to take this into account, an all-industry growth curve for each region will be compared to an all-industry growth curve for the state. A factor labeled Ω incorporating this ratio was developed for each region in each time frame. These individual regional growth curves were developed from the "closest fit" OBERS areas, with some values being better than others, mostly because of the fact that some regions fit OBERS areas better.

Note This approach is sound as long as Indiana industries are evenly dispersed around the state, that is, each region has its reasonable "share" of a particular industrial group within its boundaries. An example would be the steel industry along Lake Michigan. Here, the industry growth rates will not be affected by the growth distribution coefficient Ω

Industrial Efficiency Factor An analysis of available data shows two seemingly contradictory pronounced trends in American industry with respect to water. These are: (1) the water taken into the plant, on a per unit of production basis, is dropping; and (2) the total water used in the manufacturing process is increasing. American industry is able to do this by recycling water within the plant, using the same gallon over again instead of discarding that water after a single use. This trend is expected to accelerate because of PL 92-500 and other similar pollution abatement laws. Some industries are more efficient than others. In general, the more abundant the water supply (less cost per unit) the less efficient the industry tends to be. One might expect, for certain industries, this increase in water use efficiency will cause the overall water intake to fall in spite of substantial increase in production.

A coefficient ϕ was computed for each two-digit SIC group. ϕ is defined as the ratio of the water intake in the year 1980 (1990, 2000) to the water intake in 1977, per unit of production. Since census data was used for this computation, it must be assumed that production is directly proportional to value added by industry.

Data Base As hereinbefore noted, the Bureau of the Census has conducted censuses of manufactures since 1809. In the 1954 Census, the bureau first began to ask questions about industrial water use. From 1954 on, a report entitled something like "Water Use in Manufacturing" is available for each census. Industrial censuses are therefore available for the years 1954, 1958, 1963, 1967, and 1972.

There is one serious complication with this data. From the 1958 census on, each industry inventoried was asked, "Do you use twenty million gallons of water per year or more?" If the response was positive, that industry was sent a detailed questionnaire covering water use for the following year. We therefore have water use figures for the years 1954, 1959, 1964, 1968, and 1973. A problem arises because the bureau reported economic activity (as measured by value added by industry) for the census years and water use for the following year. The bureau claimed that its twenty-million-gallon-per-year criteria accounted for ninety-seven percent of the industrial water withdrawn in spite of the fact that only 4.2 percent of the industrial establishments were surveyed in detail.

The bureau published data on total water withdrawn, total water used in the process, total water discharged, how the water was used within the plant, where it came from, how it was treated, and the treatment cost. Of all this information, only the intake, use, discharge, and value added were used in this study. This data is published on the national, state, and major river basin levels. By combining the Great Lakes Basin data with the Ohio River Basin data a "regional" data base can be established. The Indiana State Library carries a full set of necessary census reports.

The Bureau of the Census has been very careful to protect the confidentiality of its respondents. This does lead to gaps in data, particularly at the state and regional levels. Also since this data is presented in terms of billions of gallons, the data at the state (and sometimes the national) level does not contain a sufficient number of significant figures to permit meaningful analysis.

The next problem that must be addressed is placing all the economic data on a common dollar basis. In this case, 1977 was chosen as the survey year. The initial attempt to do this involved the use of the Consumer Price Index published by the Department of Labor. Upon further reflection and research, it was decided that use of the DOL's "Wholesale Prices and Price Indices" would be more realistic. In order to use these indices, two tasks were necessary. The first was to find a "Major Commodity Group" that corresponded to the SIC classifications. The second was to get these wholesale price indices to a common base. In the eighteen years covered by the census surveys, DOL had used three different years for data bases.

The Computation of ϕ Two intermediate values must be computed, these are R, the recirculation ratio, defined as the ratio of water intake to the total water used, and Z, the total water used per dollar of value added. (The value added has been adjusted for inflation by the process described above.) The R factor represents industrial efficiency while the Z represents the actual water used in the process. In all cases, R is decreasing (indicating more efficient use) and in most cases Z is found to be rising. It must be noted that Z is based on the mixed year economic data and hence a weaker value than R which is not so afflicted. Next, a least square fit for a curve following the equation was fit through the data. This data was extrapolated to the year 2000 with intermediate values at 1977, 1980, and 1990 picked off. Also, this data was plotted and, in some cases, visual adjustments were made.

$$(R \text{ or } Z) = ae^{bx}$$

where a and b are constant, x = number of years, and e is the natural logarithm.

National data was plotted in all cases. This has the best data base and should give the best results. Regional and state data were also plotted where the data base was available. In general, state data either agreed with national data, exhibited similar trends but at different levels, or showed movement toward national trends. In some cases the state or regional data was more "regular" than the national and in a few cases the state or regional data was so erratic as to be useless. In general, the data showed:

(1) Indiana industries generally use more water for the same function than national data indicates, probably reflecting the relative abundance of water in Indiana. This is especially true of the primary metal industry.
(2) While Indiana uses more water, it consumes a lesser percentage of that water than national data would indicate.
(3) The most visible and easily verified trend in industrial water use is that R is dropping, showing a pronounced trend toward industrial recycling. In some cases, a linear extrapolation of existing data will pass through zero in the near future.
(4) While recycling is going up, the actual water used per unit of production is also rising. If one trend is strong enough to offset the other, then the intake per unit of production will fall. In all cases, the fall in R was sufficient to offset the increase (if any) in Z.

It was then possible to complete ϕ defined as the ratio of industrial water intake in a given year to the 1977 value per unit of production. The intermediate value, θ, is defined as $(Ry \times Ry) \div R_{1977} = \theta$. This is a somewhat awkward term which is, in effect, the Z for a particular year divided by a constant. Since ϕ, the term sought, is simply a ratio of the θ for a given year to the θ for 1977, this constant dropped out of the equation.

Basic Equations Self-supplied, industrial water use projections will be made for each basic industry group (by two-digit SIC code) by each region for the years 1980, 1990, and 2000.

The basic equation is:

$$[WW_{(YEAR \times SIC \times REGION)}] = [WW_{(1977 \times SIC \times REGION)}] [\alpha_{(SIC \times YEAR)}] [\Omega_{(REGION \times YEAR)}] [Y_{(REGION \times YEAR)}] [\Phi_{(SIC \times YEAR)}]$$

Where

$WW_{(YEAR \times SIC \times REGION)}$ = Self-supplied industrial water withdrawn for a given industrial group in a given region for a specific future year.

$WW_{(1977 \times SIC \times REGION)}$ = Inventoried water withdrawn in 1977.

$\varphi_{(SIC \times YEAR)}$ = The ratio of industrial economic activity (earnings) for the Year to comparable industrial economic activity in 1977.

$\Omega_{(REGION \times YEAR)}$ = Industrial growth adjustment factor to allow for anticipated differences in industrial growth rates in the regions.

$Y_{(REGION \times YEAR)}$ = A factor to adjust the OBERS growth projections to the ISBH projections (strictly a ratio of the populations).

$\Phi_{(SICxYEAR)}$ = Industrial water use efficiency factor which accounts for an anticipated lesser amount of water withdrawal necessary to support a comparable level of industrial activity (value added by industry).

The equation can be simplified to:

$$[WW_{(YEARxSICxREGION)}] = [\Gamma_{(SICxYEAR)}] \quad [\Lambda_{(REGIONxYEAR)}]$$

Where:

$$\Gamma_{(SICxYEAR)} = [\alpha_{(SICxYEAR)}] \quad [\Phi_{(SICxYEAR)}]$$

$$\Lambda_{(REGIONxYEAR)} = [\Omega_{(REGIONxYEAR)}] \quad [\Upsilon_{(REGIONxYEAR)}]$$

It should be noted that these equations represents water withdrawn from the environment and not total water industrial use.

Table 221
Computation of Γ, the factors relating to industrial groups.

Industry Group	SIC	α *1980*	α *1990*	α *2000*	Φ *1980*	Φ *1990*	Φ *2000*	Γ *1980*	Γ *1990*	Γ *2000*
All Industries		1.1025	1.4813	1.9881	.942	.771	.630	1.0386	1.1421	1.2525
Food	20	1.0612	1.2652	1.5241	.924	.713	.549	.9805	.9021	.8367
Tobacco	21	1.1025	1.4813	1.9881	.942	.771	.630	1.0386	1.1421	1.2525
Textiles	22	1.0457	1.1787	1.3879	.942	.771	.630	.9850	.9088	.8744
Apparel	23	1.0872	1.3007	1.5906	.942	.771	.630	1.0241	1.0028	1.0021
Lumber	24	1.0950	1.3799	1.7542	.901	.637	.451	.9866	.8790	.7911
Furniture	25	1.1042	1.4974	2.0260	.901	.637	.451	.9949	.9538	.9137
Paper	26	1.1025	1.4813	1.9881	.943	.774	.635	1.0397	1.1465	1.2624
Printing	27	1.1169	1.5547	2.1502	.942	.771	.630	1.0521	1.1987	1.3546
Chemicals	28	1.1293	1.6984	2.4813	.947	.732	.574	1.0694	1.2432	1.4243
Petrol-Coal	29	1.0838	1.3485	1.6824	.900	.650	.470	.9754	.8765	.7907
Rubber	30	1.1025	1.4813	1.9881	.947	.732	.574	1.0441	1.0843	1.1412
Leather	31	1.1025	1.4813	1.9881	.942	.771	.630	1.0386	1.1421	1.2525
Stone, Glass	32	1.1025	1.4813	1.9881	.898	.626	.437	.9900	.9273	.8688
Pri. Metals	33	1.0675	1.2747	1.5275	.978	.914	.863	1.0440	1.1651	1.3182
Fab. Metals	34	1.0851	1.4706	1.9699	.920	.696	.525	.9983	1.0235	1.0342
Machinery	35	1.0838	1.4104	1.8328	.920	.696	.525	.9971	.9816	.9622
Elect. Mach.	36	1.1536	1.7259	2.5407	.838	.449	.234	.9667	.7749	.5945
Trans.	37	1.0984	1.4648	1.9326	.865	.544	.331	.9501	.7969	.6397
Instruments	38	1.1025	1.4813	1.9881	.942	.771	.630	1.0386	1.1421	1.2525
Misc.	39	1.0866	1.4760	2.0120	.942	.771	.630	1.0236	1.1380	1.2676

Table 222
Computation of Λ, the factors relating to regions.

Region	Ω *1980*	Ω *1990*	Ω *2000*	Υ *1980*	Υ *1990*	Υ *2000*	Λ *1980*	Λ *1990*	Λ *2000*
One-A	.9790	.8937	.8708	.928	.925	.925	.9085	.8267	.7592
One-B	.9994	1.0084	1.0232	1.077	1.081	1.088	1.0764	1.0901	1.1132
Two	.9855	.9619	.9396	1.012	1.020	1.045	.9973	.9811	.9819
Three-A	1.0130	1.0638	1.0986	1.023	1.029	1.064	1.0363	1.0947	1.1689
Three-B	1.0130	1.0638	1.0986	.967	.951	.949	.9796	1.0117	1.0426
Four	1.0035	1.0270	1.0511	1.014	1.019	1.020	1.0175	1.0465	1.0721
Five	1.0118	1.0425	1.0652	.949	.903	.870	.9602	.9414	.9267
Six	.9996	.9415	.9137	.956	.965	.961	.9556	.9085	.8781
Seven	1.0115	1.0757	1.1299	.972	.936	.909	.9832	1.0069	1.0271
Eight	.9934	.9893	.9798	.969	.970	.994	.9626	.9596	.9739
Nine	.9875	.9668	.9506	.959	.928	.909	.9470	.8972	.8641
Ten	1.0118	1.0425	1.0652	.990	.982	.978	1.0017	1.0237	1.0418
Eleven	1.0118	1.0425	1.0652	.971	.960	.970	.9825	1.0008	1.0332
Twelve	.9875	.9668	.9506	1.012	1.022	1.050	.9994	.9881	.9981
Thirteen-A	1.0181	1.0678	1.0994	.942	.911	.901	.9591	.9728	.9906
Thirteen-B	1.0181	1.0678	1.0994	.921	.901	.917	.9377	.9621	1.0081
Fourteen	1.0155	1.1077	1.1756	1.016	1.002	1.014	1.0317	1.1099	1.1921
Fifteen	1.0181	1.0678	1.0994	.952	.948	.964	.9692	1.0123	1.0598

Table 223
The SIC codes.

01	Agricultural Production
07	Agricultural Services and Hunting and Trapping
08	Forestry
09	Fisheries
12	Bituminous Coal and Lignite Mining
13	Crude Petroleum and Natural Gas
14	Mining and Quarrying of Nonmetallic Minerals, Except Fuels
15–17	Contract Construction
19	Ordnance and Accessories
20	Food and Kindred Products
21	Tobacco Manufactures
22	Textile Mill Products
23	Apparel and Other Finished Products Made from Fabrics and Similar Materials
24	Lumber and Wood Products, Except Furniture
25	Furniture and Fixtures
26	Paper and Allied Products
27	Printing, Publishing, and Allied Industries
28	Chemicals and Allied Products
29	Petroleum Refining and Related Industries
30	Rubber and Miscellaneous Plastic Products
31	Leather and Leather Products
32	Stone, Clay, Glass, and Concrete Products
33	Primary Metal Industries
34	Fabricated Metal Products, Except Ordnance Machinery, and Transportation Equipment
35	Machinery, Except Electrical
36	Electrical Machinery, Equipment, and Supplies
37	Transportation Equipment
38	Professional, Scientific, and Controlling Instruments: Photographic and Optical Goods: Watches and Clocks
39	Miscellaneous Manufacturing Industries

Table 224
Consumption of industrial self-supplied water.

Year	Consumption as a Percentage of Intake: Measured Value	Projection
1954	2.43	
1959	1.41	
1964	1.54	
1968	3.019	
1973	3.568	
1977	4.91	4.18
1980		4.55
1990		5.77
2000		6.98

Table 224 indicates the percentage of intake consumed in 1980 will be 1.089 times greater than the 1977 rate, 1990 will be 1.38 times greater, and 2000 will be 1.67 times greater. The industrial consumption figures are computed as follows:

1. The percentage of industrial water consumed in 1977 is computed for each planning region.
2. This factor is multiplied by 1.089 for 1980, 1.38 for 1990 and 1.67 for 2000 (see Table 229).
3. The resulting coefficients are multiplied by the estimated self-supplied industrial water intake for 1980, 1990, and 2000 to obtain the estimated consumption for the respective years.

Table 225
Consumptive use of industrial self-supplied water in million-gallons-per-day.

	1977		1980		1990		2000	
Region	Intake	Consumed	Intake	Consumed	Intake	Consumed	Intake	Consumed
One-A	3,093.00	89.70	2,920	92.22	2,928	117.18	3,010.00	145.78
One-B	0.59	0.18	0.65	0.22	0.69	0.29	0.74	0.38
Two	53.15	6.38	54.85	7.17	56.23	9.31	59.12	11.85
Three-A	2.76	0.33	2.88	0.37	3.03	0.50	3.25	0.65
Three-B	39.75	6.36	39.93	6.96	43.65	9.64	47.81	12.77
Four	30.00	3.60	31.64	4.13	34.91	5.78	38.54	7.72
Five	15.44	2.47	15.13	2.64	15.46	3.41	15.94	4.26
Six	33.43	4.68	32.35	4.93	31.42	6.07	31.28	7.31
Seven	34.77	6.95	36.01	7.84	41.44	11.43	47.25	15.77
Eight	92.94	16.73	91.57	17.95	95.95	23.85	102.80	30.90
Nine	8.15	0.55	7.98	0.59	8.20	0.76	8.55	0.96
Ten	6.02	1.26	6.18	1.41	6.67	1.93	7.19	2.51
Eleven	4.86	1.12	4.80	1.20	4.83	1.54	5.00	1.92
Twelve	3.20	0.29	3.20	0.32	3.12	0.39	3.15	0.48
Thirteen-A	12.53	1.75	12.44	1.89	13.70	2.64	15.14	3.53
Thirteen-B	12.01	1.44	11.67	1.52	12.83	2.12	14.62	2.93
Fourteen	9.60	2.02	10.27	2.35	12.00	3.48	13.98	4.91
Fifteen	4.74	0.90	4.74	.98	5.32	1.39	5.99	1.90
Total	3,456.94	146.71	3,286.29	154.69	3,317.45	201.71	3,430.35	256.53

Appendix Three

RURAL WATER USE

Inventory

There were no direct inventories of rural water use made for the Commission, but the 1975 livestock population and self-supplied rural populations (the consumers of such water) were measured directly. Water use rates were assigned to livestock populations.

The livestock population was obtained from a statistical series published by Purdue University and the U.S. Department of Agriculture, *Annual Crop and Livestock Summary 1975*. The rural, self-supplied populations were taken as the 1975 county populations as reported by the Bureau of the Census less the populations served by public water systems (see "Methodology: Public Water Supplies," Appendix 2).

Per capita rural water-use rates and livestock-use rates were obtained from estimates published by the Great Lakes Basin Commission, *Great Lakes Basin Framework Study: Water Supply —Municipal, Industrial and Rural, Appendix 6.*

Projections

Projections for the year 2000 were made directly. Since there was only a modest growth in rural water use, values for 1977, 1980, and 1990 were made by straight line interpolation.

The projections for self-supplied, rural residents in the year 2000 were developed by subtracting the estimated population served by public water supplies in the year 2000 from the estimated year 2000 population for each region. Per capita use rates were taken from the Great Lakes Basin Commission report cited above. These rates are somewhat higher than the 1975 rates, which reflect an anticipated growth in income levels.

The projections for future livestock populations were based on the *OBERS Projections of Economic Activity in the United States, Series E* which is the same volume used to estimate future industrial activity. The future livestock population was distributed in proportion to the 1975 population. The 1975 livestock water use rates were projected for the year 2000 livestock populations, in million-gallons-per-day (mgd).

Table 226

Rural residential and livestock water use for the years 1975 and 2000, in million-gallons-per-day.

Region	1975 Population	1975 Residential Water Use (mgd)	1975 Livestock (head)	1975 Poultry (head)	1975 Livestock Water (mgd)	1975 Total Water Use (mgd)	2000 Population	2000 Residential Water Use (mgd)	2000 Livestock (head)	2000 Poultry (head)	2000 Livestock Water (mgd)	2000 Total Water Use (mgd)
One-A	70,515	4.15	56,400	106,000	0.49	4.64	77,000	5.79	60,200	116,700	0.54	6.33
One-B	48,607	2.86	260,000	545,400	1.81	4.68	70,400	5.30	310,700	600,000	2.06	7.36
Two	222,592	13.11	453,500	2,100,900	3.87	16.98	333,700	25.11	493,000	2,310,500	4.06	29.17
Three-A	87,980	5.18	386,100	1,070,500	3.16	8.34	140,600	10.58	417,400	1,179,000	3.30	13.88
Three-B	114,322	6.73	305,800	896,500	2.06	8.79	153,400	11.54	350,500	993,900	2.38	13.92
Four	96,540	5.69	744,700	611,100	3.61	9.30	110,500	8.31	900,800	733,500	5.41	13.72
Five	104,486	6.15	608,900	994,400	3.23	9.38	122,500	9.22	724,600	1,091,100	4.45	13.67
Six	178,661	9.91	492,700	440,400	2.86	12.77	187,300	14.09	575,900	528,800	3.82	17.91
Seven	86,597	5.10	305,700	185,300	1.97	7.07	90,500	6.81	360,100	204,000	2.59	9.40
Eight	255,271	15.03	514,600	383,700	3.04	18.07	355,500	26.75	600,600	461,200	4.13	30.88
Nine	58,788	3.46	497,000	108,100	2.80	6.26	65,100	4.90	591,800	119,000	3.77	8.67
Ten	35,196	2.07	67,900	10,300	0.56	2.63	31,200	2.35	75,900	11,000	0.69	3.04
Eleven	69,577	4.10	304,400	1,613,000	2.01	6.11	81,700	6.15	357,800	1,776,000	2.61	8.76
Twelve	29,806	2.47	190,200	508,000	1.64	4.11	29,800	2.24	211,400	559,000	1.88	4.12
Thirteen-A	47,683	2.81	386,600	441,300	3.16	5.97	47,300	3.56	449,800	466,500	3.49	7.05
Thirteen-B	79,223	4.67	182,100	260,500	1.22	5.89	94,700	7.12	213,100	282,000	1.57	8.69
Fourteen	61,924	3.65	269,400	354,000	2.32	5.97	56,300	4.24	300,900	387,000	2.66	6.90
Fifteen	39,973	2.36	369,000	1,701,600	2.57	4.93	34,500	2.60	432,800	1,789,400	3.30	5.90

Appendix Four

IRRIGATION WATER

A survey was made of identified 1978 irrigators. County agricultural agents, district soil conservationists, and irrigation equipment dealers assisted in this identification.

A survey instrument, with a letter explaining the purpose, was sent to each of the irrigators. On the initial mailing there were 297 sent, with over a seventy-five percent return. The county agents were requested to contact non respondents to determine their status. A second mailing of 139 produced an additional seventy-five returns; however the acreage involved from this second mailing was rather small, indicating that replies from the major irrigators were received on the initial return. The following questions were included on the survey:

1. Total acres irrigated in 1976 ____________ acres
   in 1977 ____________ acres
2. Do you expect to increase, decrease, or no change in irrigated acres the next five years?
   How many acres change __________?
3. Crops irrigated
   Corn __________ acres Soybeans ______ acres
   Potatoes ________ acres Other (please list)
   ______________ acres ______________ acres
   ______________ acres ______________ acres
4. Water Supply
   Well ______________ Pond or lake ________
   Stream or River ______ Other ______________
5. Power Source
   Gasoline Engine ______ Diesel Engine ________
   L.P. Engine __________ Electric Motor ______
   Farm Tractor ________ Portable ______
6. Type of System
   Portable ________ acres
   Solid Set ______ acres
   Hose Pull ______ acres
   Center Pivot ____ acres
   Other, list ______ acres

Croplands From the survey, irrigated acreages were obtained by crop. When and how much water irrigators apply is dependent on weather, the stage of growth of the crop, and the type of soil on which the crop is grown. Normally water is not metered when irrigating nor does the irrigator keep accurate records of the time or amount applied. Research has shown fairly accurately the total amount of water that plants will transpire during the season. Knowing the rainfall pattern, the irrigation needs can be estimated with reasonable accuracy. Three levels of irrigation are considered in making the estimates: (1) below average rainfall, (2) average rainfall, (3) above average rainfall. Crops vary somewhat in water needs, primarily in the length of their growing season.

Table 227
The estimated irrigation requirements for corn, soybeans, potatoes, and mint.

Month	*Below average Rainfall (inches)*	*Average Rainfall (inches)*	*Above average Rainfall (inches)*
May	0	0	0
June	2	2	1.0
July	4	3	2.5
August	4	3	2.5
September	0	0	0
Total	10	8	6.0

Table 228
The estimated irrigation requirement for hay.

Month	*Below average Rainfall (inches)*	*Average Rainfall (inches)*	*Above average Rainfall (inches)*
June	2	2	1.0
July	4	3	2.5
August	4	3	2.5
September	2	2	1
Total	12	10	7.0

Table 229

The projected total withdrawals and ground-water withdrawals for the years 1980, 1990, and 2000 during the peak July–August cropland irrigation season, in million-gallons-per-day.

Region	*1977 Irrigated Acreage*	*1980 High*	*1980 Medium*	*1980 Low*	*1990 High*	*1990 Medium*	*1990 Low*	*2000 High*	*2000 Medium*	*2000 Low*	*2000 Irrigated Acreage*
One-A	2,000										5,500
Total Withdrawal		8.60	6.58	5.38	13.92	10.63	18.70	19.25	14.69	12.03	
Ground-water Withdrawal		1.42	1.08	.88	3.13	2.37	1.94	4.84	3.67	3.01	
One-B	12,050										23,500
Total Withdrawal		47.45	35.59	29.65	64.91	48.70	40.56	82.38	61.80	51.47	
Ground-water Withdrawal		20.98	15.79	13.10	32.93	24.74	20.58	44.87	33.69	28.06	
Two	21,100										45,100
Total Withdrawal		84.86	63.64	47.74	121.31	90.99	73.34	157.76	118.33	98.94	
Ground-water Withdrawal		54.92	41.19	34.36	86.17	64.63	53.99	117.41	88.07	73.62	
Three-A	14,850										23,800
Total Withdrawal		56.16	42.13	33.78	69.94	52.48	38.02	83.72	62.82	42.25	
Ground-water Withdrawal		33.20	24.91	19.82	47.21	35.42	25.50	61.21	45.93	31.19	
Three-B	839										2,000
Total Withdrawal		3.90	2.60	2.16	5.96	3.92	3.26	8.03	5.24	4.36	
Ground-water Withdrawal		.99	.66	.55	2.50	1.65	1.37	4.02	2.63	2.18	
Four	960										11,000
Total Withdrawal		7.94	5.99	4.97	23.22	17.53	14.55	38.50	29.07	24.12	
Ground-water Withdrawal		3.24	2.48	2.03	11.69	8.84	7.32	20.14	15.20	12.61	
Five	1,560										9,200
Total Withdrawal		8.99	7.17	5.57	20.77	16.62	12.78	32.55	26.07	19.98	
Ground-water Withdrawal		3.24	2.54	2.01	9.76	7.79	6.05	16.28	13.04	10.09	
Six	400										3,600
Total Withdrawal		2.99	2.17	1.80	8.30	5.85	4.86	13.60	9.54	7.92	
Ground-water Withdrawal		1.25	.90	.74	4.23	3.01	2.48	7.22	5.11	4.22	
Seven	2,122										10,000
Total Withdrawal		11.00	8.29	6.91	22.94	17.34	14.45	34.88	26.39	21.98	
Ground-water Withdrawal		9.71	7.32	6.10	17.33	13.10	10.92	24.96	18.89	15.74	
Eight	867										26,000
Total Withdrawal		4.35	3.60	2.79	9.02	7.26	5.94	13.69	10.92	9.08	
Ground-water Withdrawal		2.79	2.32	1.73	5.67	4.55	3.41	8.54	6.78	5.08	
Nine	0										29,500
Total Withdrawal		1.51	1.14	.95	6.53	4.95	4.10	11.55	8.75	7.26	
Ground-water Withdrawal		.88	.67	.55	3.82	2.89	2.40	6.76	5.12	4.24	
Ten	130										1,000
Total Withdrawal		.53	.40	.33	.79	.59	.49	1.06	.79	.65	
Ground-water Withdrawal		.05	.04	.03	.24	.18	.15	.42	.32	.26	
Eleven	1,115										23,000
Total Withdrawal		5.89	4.47	3.71	12.57	9.59	7.94	19.25	14.72	12.18	
Ground-water Withdrawal		4.10	3.09	2.59	10.08	7.61	6.37	16.05	12.14	10.16	
Twelve	64										800
Total Withdrawal		.29	.22	.18	.50	.37	.31	.70	.53	.44	
Ground-water Withdrawal		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Thirteen-A	6,188										15,500
Total Withdrawal		23.05	17.28	14.40	27.60	20.69	17.25	32.16	24.10	20.10	
Ground-water Withdrawal		3.56	2.67	2.22	15.41	11.55	9.63	27.27	20.44	17.04	
Thirteen-B	6										600
Total Withdrawal		.30	.22	.18	1.25	.91	.73	2.20	1.59	1.28	
Ground-water Withdrawal		.16	.12	.10	.70	.51	.41	1.24	.91	.73	
Fourteen	233										300
Total Withdrawal		.81	.56	.47	.78	.56	.47	.75	.56	.47	
Ground-water Withdrawal		.07	0.0	0.0	.07	0.0	0.0	.07	0.0	0.0	
Fifteen	120										0
Total Withdrawal		.42	.32	.26	.42	.32	.26	.42	.32	.26	
Ground-water Withdrawal		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
State	64,604										157,300
Total Withdrawal		269.04	202.37	161.23	410.73	309.30	248.01	552.45	416.23	334.77	
Total Ground-water Withdrawal		140.56	105.78	86.81	250.94	188.84	152.52	361.30	271.94	218.23	

*Consumption of irrigation water equals the total withdrawal.

Table 230

The total water withdrawals and ground-water withdrawals for croplands during the July–August irrigation season, in million-gallons-per-day.

Region	Acreage	Amount of Precipitation High	Medium	Low
One-A	2,000			
Total Withdrawal		7.00	5.36	4.38
Ground-water Withdrawal		.91	.69	.56
One-B	12,050			
Total Withdrawal		42.21	31.66	26.38
Ground-water Withdrawal		17.40	13.10	10.86
Two	21,100			
Total Withdrawal		73.92	55.44	40.07
Ground-water Withdrawal		45.55	34.16	28.47
Three-A	14,850			
Total Withdrawal		52.03	39.03	32.51
Ground-water Withdrawal		29.00	21.76	18.11
Three-B	839			
Total Withdrawal		3.28	2.20	1.83
Ground-water Withdrawal		.53	.37	.31
Four	960			
Total Withdrawal		3.36	2.53	2.10
Ground-water Withdrawal		.70	.57	.44
Five	1,560			
Total Withdrawal		5.46	4.34	3.41
Ground-water Withdrawal		1.28	.96	.80
Six	400			
Total Withdrawal		1.40	1.06	.88
Ground-water Withdrawal		.35	.27	.22
Seven	2,122			
Total Withdrawal		7.42	5.58	4.65
Ground-water Withdrawal		7.42	5.58	4.65
Eight	867			
Total Withdrawal		2.96	2.50	1.85
Ground-water Withdrawal		1.93	1.65	1.23
Nine	0.0			
Total Withdrawal		0.0	0.0	0.0
Ground-water Withdrawal		0.0	0.0	0.0
Ten	130			
Total Withdrawal		.46	.34	.28
Ground-water Withdrawal		0.0	0.0	0.0
Eleven	1,115			
Total Withdrawal		3.89	2.93	2.44
Ground-water Withdrawal		2.31	1.73	1.45
Twelve	64			
Total Withdrawal		.23	.17	.14
Ground-water Withdrawal		0.0	0.0	0.0
Thirteen-A	6,188			
Total Withdrawal		21.68	16.26	13.55
Ground-water Withdrawal		0.0	0.0	0.0
Thirteen-B	6			
Total Withdrawal		.02	.02	.01
Ground-water Withdrawal		0.0	0.0	0.0
Fourteen	233			
Total Withdrawal		.82	.56	.47
Ground-water Withdrawal		.07	0.0	0.0
Fifteen	120			
Total Withdrawal		.42	.32	.26
Ground-water Withdrawal		0.0	0.0	0.0
State	64,598			
Total Withdrawal		226.56	170.30	135.21
Ground-water Withdrawal		107.45	80.84	67.10

Golf Courses Golf course irrigation projections are based upon 1977 regional data supplied by the Department of Natural Resources, Division of Outdoor Recreation. This data supplied the number of golf courses, number of holes and the number irrigated, and was forwarded to Purdue University where 1977 irrigation figures were compiled according to region.

After the 1977 golf course irrigation figures were obtained, the Department of Natural Resources, Division of Water, established future growth rates of regional golf courses using Division of Outdoor Recreation projections from the year 1979 to the year 1995. Since values for this report were to be projected to the year 2000, the growth rates for the year 2000 had to be obtained by linear regression. Once the growth rates for 1980, 1990, and 2000 were developed the irrigation rates for those years were solved by multiplying the 1977 regional use by the proper regional growth rate.

It should be noted that irrigation figures reflect medium cropland and golf course irrigation and do not reflect irrigation of parks or cemeteries.

Table 231

Current and projected golf course irrigation from 1977 to 2000, during the average July–August season in million-gallons-per-day.

Region	1977 Withdrawal	1980 Withdrawal	1990 Withdrawal	2000 Withdrawal
One-A	2.01	2.97	3.12	3.32
One-B	.29	.29	.29	.29
Two	4.67	4.67	4.90	5.32
Three-A	.94	.94	.94	.94
Three-B	2.23	2.32	2.63	2.94
Four	1.54	1.54	1.54	1.54
Five	1.26	1.42	1.50	1.61
Six	2.58	2.58	2.58	2.58
Seven	1.19	1.19	1.19	1.19
Eight	5.54	7.65	8.59	10.42
Nine	.70	.70	.70	.70
Ten	.53	.60	.66	.69
Eleven	.68	.68	.80	.86
Twelve	.12	.14	.14	.16
Thirteen-A	.38	.38	.38	.38
Thirteen-B	1.01	1.34	1.34	1.41
Fourteen	.32	.46	.52	.59
Fifteen	.48	.48	.48	.48
Total	26.47	30.35	32.30	35.42

Appendix Five

ENERGY

Inventory

The water used (1) in steam turbine, electric generating stations, (2) to wash the coal mined in southwestern Indiana, and (3) in the future coal gasification or liquefaction was measured by the methodology discussed herein. The water used by refineries, however, is accounted for as industrial water.

Two questionnaires were sent to each utility, municipality, or corporation known to operate electric generating facilities with steam turbines. The first questionnaire (Form A) requested the following specific data for each generating station for the year 1977: (1) plant location; (2) size of plant (mw), both gross and net; (3) fuel, (4) water intake into plant; (5) water discharged from plant; (6) type of condenser cooling; (7) age of units; (8) nominal or projected retirement date for units; and (9) evaporation rate from cooling water system (if known).

The second questionnaire (Form B) requested the following data for each company: (1) net system generating capacity in megawatts (mg); (2) retail sales in Indiana in kilowatt hours (kwh); (3) estimated or projected growth rates in retail sales, both through 1990 and for 1990 to 2000; and (4) a question on future cooling methods.

Data on out-of-state plants came from information provided by the East Central Area Reliability Coordination Agreement (a group of major mid-western utilities) or from the ongoing Ohio River Basin Energy Study.

Historical data on power generation (both state and national) load factors and energy sources came from various issues of the *Statistical Year Book of the Electric Utility Industry*, by the Edison Electric Institute. Data on hydroelectric power came from the Indiana Department of Commerce and other sources. Service area information was obtained from the major utilities.

A questionnaire was sent to all companies operating coal washing facilities in Indiana. These companies were asked to provide data on: (1) location of the plant; (2) tonnage of coal washed in 1976, (3) water used to wash coal; (4) percentage of water recycled from slurry ponds; (5) source of water, (6) method of washing; and (7) the company's estimate of future water needs per ton washed.

Projections

In order to estimate the future shortfall or surplus capacity, it was first necessary to estimate the probable future in-situ generating capacity in Indiana. In order to do this, a retirement-replacement schedule was developed showing the probable retirement of existing units and the anticipated start up of those new generating facilities already announced by the utilities.

Retirement dates were those furnished by the utilities or, in the absence of such data, based on an assumed forty-year life of each unit. Whether these units will be actually retired after forty years will depend on many factors such as the overall system capacity and the cost of operation of that unit. For the purposes of this study, it was assumed that all existing units utilizing once-through cooling facilities would continue to use these facilities until retirement.

Since it requires a minimum of eight years to construct a major generating facility, most utilities announce their plans for new units or new plants well in advance of the proposed start-up dates. Usually in order to secure the necessary permits, an environmental impact statement is prepared. Data on future utility facilities was derived from those announcements or statements available in early 1978.

The load factor is the relationship between the installed electric generating capacity and the total kilowatt hours of energy produced during a given year. Historical data on both national and state load factors was plotted and reviewed. The plot showed that Indiana utilities are more efficient with their equipment use than the national average, that this efficiency has declined somewhat recently and that past performance has gone through distinct cycles. There was no real trend in load factor that could be projected forward with confidence. It was then decided to use the existing load factor of about fifty percent as a reasonable approximation of future utility load factors to the year 2000.

Projecting the growth rate for future electric energy generation is fraught with uncertainty. In the first place, it is no longer possible to isolate the consumption of electric energy from other forms of energy consumption. For example, in the last decade, electric energy has been widely used for space heating, a field traditionally dominated by fossil fuels. Many factors affecting the availability and price of energy now lie outside American control. The political instability of the major energy producing regions in the world is of particular concern. Further, there are a number of federal mandates, often working at cross purposes, which could have a radical impact on the production and consumption of energy. Many believe, however, that in the future, the electric utilities will provide an increasing share of the nation's energy requirements.

Several projection methods were considered. A 1973 study by the Department of Natural Resources suggests that a 6.9 percent growth rate will prevail until 1980, and then a 6.3 percent growth rate will prevail to the end of the century. The growth estimates from the utilities themselves, weighted to reflect utility size, amount to 5.9 percent through the year 2000. The Ohio River Basin Commission in their 1978 Ohio River Main Stem Study reviewed a number of energy projections and finally selected a growth rate slightly over five percent as the "most representative of the anticipated future conditions." Another method might be based on the recent growth trends in Indiana as shown on the following table.

Table 232
Historical data for electric energy generation.

Year	*Total U.S.* Generation (KWH × 10⁶)*	*Moving 5 Year Growth Rate (Percent)*	*Total Indiana* Generation (KWH × 10⁶)*	*Moving 5 Year Growth Rate (Percent)*
1930	91,112	8.20	na	na
1940	141,837	8.28	na	na
1950	329,141	8.15	na	na
1960	753,350	6.61	na	na
1962	852,314	6.18	34,648	na
1964	983,990	6.74	38,968	na
1966	1,144,350	7.64	45,685	6.81
1968	1,329,443	7.72	48,024	5.61
1970	1,531,609	7.74	51,890	3.99
1972	1,747,323	7.55	54,228	4.16
1974	1,866,436	5.29	56,863	1.65
1976	2,036,503	4.78	62,411	3.34

*Source: *Statistical Yearbook of the Electric Utility Industry*, by the Edison ELectric Institute, various issues.
na: not available.

The future, required generating capacity was computed by permitting the 1977 installed generating capacity to grow at the specified growth rate (compounded). The estimated, available capacity came from the retirement replacement schedule described above. The anticipated shortfall in generating capacity is simply the difference between the required and available capacities.

The estimates of future water withdrawals were made for three conditions. First, those generating stations currently in service; the withdrawal and consumption rates shown on the utility questionnaire were assumed to remain constant over the life of the station (or units in that station). Second, withdrawal and consumption rates for those units or stations now under construction or announced for future construction came from published environmental impact statements or other industry sources. Since the location of all of these facilities is known, it is possible to assign the appropriate water use figures to the planning and development regions.

The third condition was the probable future water needed to meet the anticipated shortfall outlined above. This was accomplished by assuming: (1) all unannounced generating facilities will be provided with some form of wet cooling devices; (2) eighty percent of these plants will be coal-fired, consuming 5.8 million-gallons-per-day (mgd) withdrawal per 1000 mw of installed capacity; (3) the remaining twenty percent will be nuclear-fueled plants with require about fifty percent more water intake, and finally (4) fifty percent of the water brought into these stations will not be returned to the source but will be lost through evaporation and drift off of the towers.

Table 233
Steam turbine electric generating stations.

Year	*Annual Growth Rate (percent)*	*Existing Stations: Nameplate Rating (mw)*	*Existing Stations: Intake (mgd)*	*Existing Stations: Consumption (mgd)*	*Announced Additional Capacity: Nameplate Rating (mw)*	*Announced Additional Capacity: Intake (mgd)*	*Announced Additional Capacity: Consumption (mgd)*	*Total Required Capacity (mw)*	*Additional Required Capacity: Nameplate Rating (mw)*	*Additional Required Capacity: Intake (mgd)*	*Additional Required Capacity: Consumption (mgd)*
1976		14,761	9,493	48.1							
					Low Range Projection						
1980	3.5	14,620	9,445	47.6	3,357	45.5	30.1	16,300	0	0	0
1990	3.5	14,136	9,063	47.1	12,403	296	158	23,000	0	0	0
2000	3.5	8,812	4,403	43.1	12,935	302	161	32,400	10,653	140	68.2
					Mid Range Projection						
1980	5.0	14,620	9,445	47.6	3,357	45.5	30.1	17,000	0	0	0
1990	5.0	14,136	9,063	47.1	12,403	296	158	27,700	1,161	15.3	7.4
2000	5.0	8,812	4,403	43.1	12,935	302	161	45,100	23,353	308	150
					High Range Projection						
1980	6.5	14,620	9,445	47.6	3,357	45.5	30.1	17,800	0	0	0
1990	6.5	14,136	9,063	47.1	12,403	296	158	33,300	6,761	89.2	43.3
2000	6.5	8,812	4,403	43.1	12,935	302	161	62,600	40,853	539	261

Coal Future water requirements for coal washing were estimated by assuming the growth in coal production will parallel the growth in electrical energy in Indiana.

No estimates were made for future water requirements for processes that convert coal to liquid or gaseous hydrocarbons. At present there are no such facilities operating commercially in Indiana (except for incidental production of gas as part of other industrial uses of coal). No announcements have been made concerning the construction of such facilities.

Most authorities agree that the future construction of these facilities is related closely to the price of gas or liquid hydrocarbons. Because Indiana's coal fields are located near adequate sources of water, Indiana should be considered an attractive location for such facilities.

There are a number of commercial coal conversion practices now in existence. The water requirements for representative processes are shown below.

Table 234

Water requirements for selected coal conversion processes, based on plant capacity of 250 million standard cubic feet per day of gas or 50,000 barrels per day of liquid hydrocarbon.

Process	*Hydrocarbon Produced*	*Water Requirements (mgd)*
BCR Bi-Gas	Gas	24
CO_2 Adapter	Gas	17
H-Coal	Liquid	17
IGT Hygas	Gas	29
Synthane	Gas	24
Synthoil	Liquid	20
SRC Liquid Fuels	Liquid	22

Appendix Six

AREAS WITH IRRIGATION POTENTIAL, AGRICULTURAL DRAINAGE, AND SOIL EROSION

The identification and location of areas with irrigation potential, soil erosion, and wetness characteristics are based upon the soil associations as shown in Figure 8. The map of soil associations provides a broad perspective of the soils and landscapes in Indiana. It provides a basis for comparing the potential and limitations of large areas. Because of the small scale, Figure 8 does not show the kind of soil at a specific site. Thus, it is not suitable for planning the management of a form or field or for selecting a site for a road, building, or other structure.

Irrigation Potential

When mapping irrigable soils, it is necessary to look at the soil associations based on the water holding capacity and the surface texture of the soils. Each state soil association was assigned an irrigation index number based on how profitable it would be to irrigate a particular soil association, as shown below.

Table 235
The relationship between the irrigation index and the response to irrigation.

Irrigation Index	*Rating of Response to Irrigation*
1. Low	Little or no profitable response
2. Medium	1–2 years in 5.
3. High	3–4 years in 5.
4. Very High	yearly.

Once the irrigation index was determined a percent of potentially irrigable soils within the soil association were grouped as shown on the following table.

Table 236
Potential irrigable soils within soil associations.

Group	*Criteria*
A	100-70 percent of soils have irrigation indices of 2, 3, and 4.
B	69-40 percent of soils have irrigation indices of 2, 3, and 4.

Table 236 (continued)

Group	*Criteria*
C	39-25 percent of soils have irrigation indices of 2, 3, and 4.
D	24 percent or less soils have irrigation indices of 2, 3, and 4.

An additional criterion, greater than fifteen percent of the soils, must be in irrigation classes 3 and 4.

The groups of soil associations that were mapped for potential irrigation were groups A, B, and C. Soil associations having greater than fifty percent, poorly or somewhat poorly drained soils, were dropped one group, e.g., from A to B. The associations which fall within these groupings are shown in the table below.

Table 237
Percent of each soil association with an irrigation potential.

Group	*Soil Association*	*Percent of Association that has Irrigation Potential*
A	Plainfield – Maumee – Oshtemo	90
	Riddles – Tracy – Chelsea	84
	Elston – Shipshe – Warsaw	80
	Oakville – Adrian	73
B	Sebewa – Gilford – Homer	78
	Maumee – Gilford – Oshtemo	73
	Oshtemo – Fox	64
	Tracy – Door – Lydick	56
	Princeton – Bloomfield – Ayrshire	47
	Fox – Ockley – Westland	37
	Fox – Genesee – Eel	32

The irrigation indices for the sixteen regions with irrigation potential are listed below.

Table 238
The potential irrigation acreage by region.

Region	*Irrigation Indexes*			
	1	*2*	*3*	*4*
One-A	408,800	49,800	75,600	66,500
One-B	604,500	121,100	253,500	118,400
Two	641,800	338,800	254,100	80,400
Three-A	864,600	127,400	147,600	27,900
Three-B	1,068,200	13,900	32,400	3,500
Four	1,923,200	50,300	208,900	30,500

Table 238 (continued)

Region	Irrigation Indexes 1	2	3	4
Five	1,091,600	152,000	102,500	20,600
Six	1,407,200	7,000	45,900	1,100
Seven	1,417,800	32,100	100,200	10,800
Eight	1,843,600	15,400	91,900	2,600
Nine	945,700	7,300	64,500	0
Ten	503,600	200	4,700	–
Eleven	1,213,700	14,400	38,700	5,600
Twelve	906,300	0	3,000	0
Thirteen-A	1,400,300	44,500	15,000	12,800
Thirteen-B	1,170,000	19,200	6,900	5,400

Agricultural Drainage

Natural soil drainage as used in this report includes soil associations with severe, moderate, and slight soil wetness characteristics. A percentage of soils with the same wetness characteristics was calculated in order to determine the classification of a particular soil association. The classification of wetness characteristics of the soil associations is as follows.

Table 239
Classification of soil wetness characteristics.

Wetness Characteristic	Criteria
Slight	Less than 30 out of every 100 acres need drainage in order to maximize crop yields.
Moderate	30 to 69 out of every 100 acres need drainage.
Severe	More than 70 out of every 100 acres need drainage.

These are natural drainage classes and do not reflect the completeness of artificial drainage installed to correct wetness in crop field or in construction.

State soil associations which were mapped as having severe wetness characteristics are shown in the following table.

Table 240
Soil associations with severe wetness characteristics.

Houghton – Adrian	Iva – Vigo
Maumee – Gilford – Sebewa	Brookston – Odell – Corwin
Rensselaer – Darroch – Whitaker	Crosier – Brookston
Sebewa – Gilford – Homer	Crosby – Brookston
Lyles – Ayrshire – Princeton	Blount – Pewamo
Milford – Bono – Rensselaer	Hoyville – Nappanee
Patton – Lyles – Henshaw	Bartle – Peoga – Dubois
Ragsdale – Raub	Avonburg – Clermont
Sable – Ipava	Fincastle – Ragsdale
Reelsville – Ragsdale	

State soil associations mapped as having moderate wetness characteristics are shown in the following table.

Table 241
Soil associatrions with moderate wetness characteristics.

Sloan – Ross – Vincennes – Zipp	Parr – Brookston
Stendal – Haymond – Wakeland – Nolin	Miami – Crosier – Brookston – Riddles
Zipp – Markland – McGary	Miami – Crosby – Brookston
Fox – Ockley – Westland	Markham – Elliott – Pewamo
Oakville – Adrian	Morley – Blount – Pewamo
Plainfield – Maumee – Oshtemo	Weinbach – Wheeling
Princeton – Bloomfield – Ayrshire	

All other state soil associations are mapped as having slight wetness characteristics.

The number of acres included within the wetness characteristics classification system for each region is shown on the following table.

Table 242
The soil wetness characteristics by region.

Region	Wetness Characteristic Slight	Moderate	Severe
One-A	31,000	354,000	215,000
One-B	13,000	214,000	594,000
Two	463,000	755,000	396,000
Three-A	263,000	683,000	222,000
Three-B	77,000	455,000	570,000
Four	613,000	553,000	1,041,000
Five	220,000	496,000	650,000
Six	151,000	429,000	1,136,000
Seven	969,000	161,000	428,000
Eight	404,000	563,000	985,000
Nine	500,000	265,000	253,000
Ten	460,000	27,000	22,000
Eleven	801,000	219,000	252,000
Twelve	706,000	20,000	183,000
Thirteen-A	900,000	371,000	203,000
Thirteen-B	660,000	451,000	84,000
Fourteen	908,000	135,000	57,000
Fifteen	983,000	221,000	35,000
Total	9,128,000	6,372,000	7,326,000

Potential Erosion

In order to map state soil associations with a potential erosion hazard it was necessary to use the Universal Soil Loss Equation. This equation is written A = R K L S C P where:

"A" is the computed soil loss (sheet and rill erosion) in tons-per-acre-per-year;

"R," the rainfall factor, is the number of erosion-index units in a normal year's rain;

"K," the soil-erodibility factor, is the erosion rate per unit of erosion index for a specific soil in cultivated, continuous fallow, on a nine percent slope 72.6 feet long;

"L," the slope length factor, is the ratio of the soil loss from the field slope length to that from a 72.6 foot length on the same soil type and gradient;

"S," the slope-gradient factor, is the ratio of soil loss from the field gradient to that from a nine percent slope;

"C," the cropping management factor, is the ratio of soil loss from a field with specified cropping and management to that from the fallow condition on which the factor K is evaluated; and

"P," the erosion-control practice factor, is the ratio of soil loss with contouring, strip cropping, or contour irrigated furrows to that with straight-row farming, up-and-down slope.

It should be noted that the "C" and "P" factors relating to land use in the Universal Soil Loss Equation have been excluded since the cropping management and erosion control practices are beyond the scope of this study.

After the soil loss was determined for each association, the associations were grouped according to ranges in order to simplify mapping. The ranges for these groups are as shown on the following table.

Table 243
Potential soil loss hazard.

Group	*Potential Soil Loss Hazard*	*Soil Loss Range (tons/acre/year)*
A	Low	0 – 30
B	Medium	31 – 80
C	High	81 – 350
D	Very High	351 – and up

State soil associations that have a very high erosion potential (Group D) are shown on the following table.

Table 244
Soil associations with a very high erosion potential.

Parke – Negley
Welston – Zanesville – Berks
Berks – Gilpin – Weikert
Corydon – Weikert – Berks
Eden – Switzerland

State soil associations that have a high erosion potential (Group C) are shown on the following table.

Table 245
Soil associations with a high erosion potential.

Alford	Cincinnati – Vigo – Ava
Miami – Hennepin – Crosby	Cincinnati – Rossmoyne
Miami – Russell – Fincastle – Ragsdale	Crider – Hagerstown – Lawrence
Russell – Henepin – Fincastle	Crider – Hagerstown – Bedford
Hosmer	Crider – Baxter – Corydon
Zanesville – Wellston – Tilsit	

State soil associations that have a medium soil erosion potential (Group B) are shown on the following table.

Table 246
Soil associations with a medium erosion potential.

Wheeling – Huntington – Lindsdale	Princeton – Bloomfield – Ayrshire
Zipp – Markland – McGary	Miami – Crosier – Brookston – Riddles
Fox – Ockley – Westland	

Table 246 (continued)

Miami – Crosby – Brookston	Bartle – Peoga – Dubois
Markham – Elliot – Pewamo	Weinback – Wheeling
Morley – Blount – Pewamo	Avonburg – Clermont

All other state soil associations are rated as having a low soil erosion potential (Group A).

Table 247
The soil erosion potential in acres for each region.

Region	*Soil Erosion Potential in Acres*			
	Slight	*Moderate*	*High*	*Very High*
One-A	337,000	364,000	0	0
One-B	1,065,000	3,000	0	0
Two	32,000	1,584,000	0	0
Three-A	502,000	666,000	0	0
Three-B	727,000	392,000	0	0
Four	1,417,000	332,000	465,000	0
Five	807,000	493,000	7,000	0
Six	1,110,000	350,000	0	0
Seven	764,000	76,000	702,000	16,000
Eight	1,183,000	592,000	158,000	39,000
Nine	326,000	285,000	356,000	51,000
Ten	71,000	21,000	229,000	188,000
Eleven	332,000	255,000	382,000	306,000
Twelve	37,000	218,000	437,000	218,000
Thirteen-A	472,000	103,000	501,000	398,000
Thirteen-B	361,000	217,000	626,000	0
Fourteen	143,000	110,000	639,000	209,000
Fifteen	160,000	136,000	346,000	593,000

Appendix Seven

STATE WATER LAWS

Instream Uses

Recreation The water in all streams, lakes, and other natural bodies of water in the state is a natural resource and public water subject to the control and regulations for the public welfare (I.C. 13-2-1-2).

In 1973, the general assembly created the Recreational Development Commission with purposes of providing for the health and welfare of the citizens of the state through the acquisition, construction, improvement, and operation of public recreational facilities, and promoting the development and use of parks throughout the state (I.C. 14-3-12-1). Also the Natural Resources Commission has the authority to acquire, maintain, and make available to the public, parks, and other suitable places for recreation (I.C. 14-3-2-9).

The Natural Resources Commission is empowered to lease state-owned lands, which are under its management and control, to any local government; and to contract for the construction and operation of lodging, food, and other outdoor recreation, water resources, or service facilities that the commission deems appropriate (I.C. 14-3-8-2). The commission is also authorized to prepare, maintain, and keep up to date a comprehensive plan for the development of state outdoor recreation resources, and to coordinate its activities with and represent the interest of all agencies of the state, county, city, and other government units (I.C. 14-3-5-1).

The state, municipalities, special taxing districts, and public utilities may acquire reservoir sites to meet present and future needs for storage of water for purposes that include recreational uses (I.C. 13-2-9-1). These reservoir sites must be approved by the board of health and the Natural Resources Commission before condemnation can be used in acquisition of those sites (I.C. 13-2-9-7), and if the dam meets certain criteria it must be inspected annually by the Department of Natural Resources (I.C. 13-2-20-4).

Cities have the authority to regulate, license, and prohibit recreational uses on water courses within their jurisdiction (I.C. 18-1-15-9).

Approval must be acquired from the Natural Resources Commission prior to the construction of a channel connecting to streams and rivers, for the purpose of providing access by boat or otherwise to public or private recreational facilities (I.C. 13-2-18.5-3).

Conservancy districts can be established for purposes that include the developing of parks and recreational facilities where feasible in connection with beneficial water management (I.C. 19-3-2-1).

The state has consented to the acquisition by the United States of lands within the state for the establishment, maintenance, and development of fish hatcheries, wildlife or forest preserves, or for agricultural, recreational, or experimental uses (I.C. 4-21-8-1).

Fish and Wildlife The Department of Natural Resources has the responsibility and authority to protect the fish and wildlife resources of the state (I.C. 14-2-1-2). This includes the setting of seasons, limits, methods of taking, selling, transporting, and the proper management of wild animals in any designated water and land areas of the state, and setting aside and designating any lands or waters owned or controlled by the state for conservation purposes as public hunting and fishing areas (I.C. 14-2-3-3). The Natural Resources Commission is to establish and maintain areas for public fishing within all port areas created by the Port Commission (I.C. 8-10-1-7.5).

All wild animals, except those legally owned or held in captivity under license or permit, are property of the people of the state (I.C. 14-2-1-2).

It is illegal to place an obstruction, other than a dam, in a waterway of the state that prevents fish from ascending or descending, and the owner of a dam with a watershed greater than fifty square miles may be required to maintain a downstream discharge, during periods of low flow, equal to the inflow into the impoundment; and he may be required to construct and maintain fish ladders (I.C. 14-2-5-9).

It is unlawful to deposit into the waters of the state any substance deleterious to public health, or that which destroys or jeopardizes any beneficial animal, fish, or vegetable life in the water (I.C. 16-1-26-1). Also, it is unlawful, with certain exceptions, to chemically treat aquatic vegetation in any water of the state without first obtaining a permit from the director of the Department of Natural Resources (I.C. 14-2-5-10).

It is also unlawful to perform construction activities on any floodway of a stream in Indiana that would result in unreasonably detrimental effects upon the fish, wildlife, and botanical resources (I.C. 13-2-22-13).

The United States may acquire land in the state for the establishment, maintenance, and development of fish hatcheries, wildlife, or forest preserves, or for agricultural, recreational, or experimental uses (I.C. 4-21-8-1).

The state, municipalities, special taxing districts, and public utilities may secure needed reservoir sites to meet present and future needs for storage of water for purposes that include power (I.C. 13-2-9-1). Sites for impoundments must be approved by the board of health and the Natural Resources Commission before condemnation can be used in acquisition of those sites (I.C. 13-2-9-7), and if the dams meet certain criteria they must be inspected annually by the Department of Natural Resources (I.C. 13-2-20-4).

Any person may divert flood waters of any water course for any useful purpose upon the approval of the Natural Resources Commission (I.C. 13-2-1-6). Also any construction activity that would take place in the floodway of any stream in Indiana must be approved by the Natural Resources Commission (I.C. 13-2-22-1).

Commercial Navigation The Indiana Port Commission is authorized and empowered to construct, maintain, and operate, in cooperation with the federal government, modern ports on Lake Michigan or the Ohio or Wabash Rivers with terminal facilities and traffic exchange points for all forms of transportation (I.C. 8-10-1-1).

A municipal corporation, county, or any combination, has the authority to create a port authority (I.C. 8-10-5-1), and the county commissioners upon the petition of twenty-four freeholders of the county in the vicinity of the streams may declare any stream or water course in the county navigable (I.C. 13-2-4-1).

The state, municipalities, special taxing districts, and public utilities may secure needed reservoir sites to meet present and future needs for storage of water for purposes that include transportation (I.C. 13-2-9-1).

Any riparian owner may, in aid of navigation and commerce, build, maintain, and use piers, wharves, docks, or harbors. But these works shall not extend further into the stream than necessary to accommodate navigation, and in no case may these structures obstruct navigation (I.C. 13-2-4-5). Also, prior to the construction of any channel connecting to any river or stream for the purpose of providing access by boat or otherwise, approval must be acquired from the Natural Resources Commission (I.C. 13-2-18.5-3).

Any construction that would occur in the floodway of a stream must first meet the approval of the Natural Resources Commission (I.C. 13-2-22-13).

The state has consented to the acquisition by the United States of any lands, buildings, or other property for the purpose of improvement of any navigable river within or bordering Indiana (I.C. 4-21-3-1). Also, consent is given to the United States to purchase any tract, piece, or parcel of land on the banks of the Ohio or Wabash Rivers within the limits of the state in connection with the improvements of those rivers (I.C. 4-21-4-1).

Noncommercial Navigation The water in all streams, lakes, and other natural bodies in the state is a natural resource and is water subject to control and regulation for the public welfare (I.C. 31-2-1-2).

Full power and control of all public, fresh-water lakes is vested in the state, which shall hold these lakes in trust for the citizens of the state for all purposes, including boating; and no person owning lands bordering such lakes shall have the exclusive right to the use of the water of the lakes (I.C. 13-2-11-1). The citizens of the state have a vested right in the preservation and enjoyment of all public, fresh-water lakes and the use of such waters for recreational purposes (I.C. 13-2-14-1).

The Natural, Scenic, and Recreational Rivers System is administered by the Natural Resources Commission for the purpose of setting aside and preserving rivers of unusual natural, scenic, or recreational significance for the benefit of present and future generations (I.C. 13-2-26-1). Also, the Natural Resources Commission is authorized to establish and participate in river commissions to protect the natural integrity of rivers designated in the system (I.C. 13-2-27-1).

The Natural Resources Commission has general charge of the management of the state's water resources (I.C. 14-3-1-14; I.C. 13-2-22-1 *et seq.*), and cities and towns have exclusive power over water courses within their jurisdiction except when otherwise provided by law (I.C. 18-5-10-4).

County commissions may declare any stream or water course in the county navigable upon the petition of twenty-four freeholders of the county within the vicinity of the stream (I.C. 13-2-4-1).

The state, municipalities, special taxing districts, and public utilities can acquire sites for the storage of water for purposes that include recreation (I.C. 13-2-9-1). Impoundment sites must be approved by the Natural Resources Commission and the board of health (I.C. 13-2-9-7).

Approval must be received from the Natural Resources Commission for the construction of a channel connecting any river or stream to a recreational facility for the purpose of providing access by boat or otherwise (I.C. 13-2-18.5-3). Also, any construction that might occur in the floodway of any stream in the state must be approved by the Natural Resources Commission.

All watercraft in Indiana must be registered with the Department of Natural Resources (I.C. 14-1-2-3).

The owner of a dam with a watershed greater than fifty square miles may be required to maintain a downstream discharge, during periods of low flow, equal to the inflow into the impoundment, and he may be required to construct and maintain a passageway around and over the dam to allow the hand carrying of small boats for the purpose of navigation (I.C. 13-2-5-1 *et seq.*).

Natural Lakes The water in all streams, lakes, and other natural bodies in the state is a natural resource and is water subject to control and regulation for the public welfare (I.C. 13-2-1-2). Also, full power and control of all public fresh-water lakes is vested in the state, which shall hold these lakes in trust for the citizens of the state, and no person owning lands bordering such lakes have the exclusive right to the use of the waters of the lake (I.C. 31-2-11-1).

The public has a right to the preservation, protection, and enjoyment of all public, fresh-water lakes (I.C. 13-2-14-1).

The Natural Resources Commission has the authority to become a party to any drainage proceeding in the courts which might injuriously affect the water levels of any lake, river, or stream in the state (I.C. 13-2-12-3).

Any filling, construction, or other activities affecting the shoreline of a public, fresh-water lake must be approved by the Natural Resources Commission (I.C. 13-2-11-2, I.C. 13-2-14-5).

Sewage disposal facilities for housing developments of five or more houses which are an integral part of any change of a shoreline must be approved by the Stream Pollution Control Board prior to any action by the Natural Resources Commission (I.C. 13-2-11-4 and I.C. 13-2-14-4).

Lake Michigan The water in all streams, lakes, and other natural bodies in the state is a natural resource and is water, subject to the control and regulation for the public welfare (I.C. 13-2-1-2).

The Stream Pollution Control Board has been granted the authority to control and prevent pollution of water in the state (I.C. 13-1-3-4), and the Department of Natural Resources is empowered to protect the lakes, streams, and springs of the state against impurities or pollution by industrial, municipal, or other sewage waste (I.C. 14-3-1-14) and to protect and properly manage the fish and wildlife resources of the state (I.C. 14-2-1-1).

The Natural Resources Commission has also been given charge and supervision of the navigable waters of the state. Therefore, one must seek the commission's approval prior to performing any construction activities in Lake Michigan (I.C. 14-3-1-14). An owner or owners of land abutting upon the shore of Lake Michigan may fill in or construct any dock or wharf upon the approval of the Natural Resources Commission and the Governor (I.C. 4-18-13-3).

The Indiana Port Commission is authorized to construct, maintain, and operate, in cooperation with the federal government, modern ports on Lake Michigan (I.C. 8-10-1-1), as well as grant private agencies or corporations the privilege, upon application, to establish a foreign trade zone (I.C. 8-10-3-2).

Finally, commercial fishermen are required to have licenses to operate and are required to keep monthly records (I.C. 14-2-5-5) when catching, curing, cleaning, or shipping fish. They are required to pursue their trade in a manner that is sanitary and nonpolluting (I.C. 14-2-5-6).

Reservoirs: Impoundments and Discharges The State of Indiana, municipalities, special taxing districts, and public utilities may secure needed reservoir sites to meet present and future needs for the storage of water (I.C. 13-2-9-1). These sites must be approved by the Natural Resources Commission and the State Board of Health before condemnation can be used in acquisition of those sites (I.C. 13-2-9-7); and any dam that meets certain criteria must be inspected annually by the Department of Natural Resources (I.C. 13-2-20-4).

The Natural Resources Commission may contract to provide minimum quantities of streamflow or sell water directly from impoundments financed by the state (I.C. 13-2-1-7).

Land owners who are adjacent to a water course have the right to impound water after receiving the approval of the Natural Resources Commission (I.C. 13-2-1-3). Also, any person may divert floodwater from any water course for any useful purpose upon the approval of the Natural Resources Commission (I.C. 13-2-1-6). However, the owner of a dam, levee, dike, floodwall, or appurtenance is required to maintain the structure in safe operating condition (I.C. 13-2-20-2).

If a person constructs a dam across a water course with a drainage area greater than fifty square miles, the impoundment should have enough storage head to provide the stream with a minimum flow downstream from the dam. It is unlawful to prevent fish from ascending or descending the waterway, so the construction of a fish ladder may be necessary, and passageways around and over the dam may be required to allow hand carrying of small boats for purposes of navigation (I.C. 14-2-5-9).

The Natural Resources Commission is authorized to prevent and limit flooding by regulating, supervising, and coordinating the construction, operation, and design of flood control works or structures (I.C. 13-2-22-1). This includes the regulation of all construction activities within the floodways of the streams in the state (I.C. 13-2-22-13).

Withdrawal Uses

Ground-Water Withdrawals It is the policy of the state to conserve and protect ground-water resources and provide regulations for their most beneficial use and disposition (I.C. 13-2-2-2); and the Natural Resources Commission is authorized to require reduced flow from water wells to prevent the loss or waste of potable water not being put to beneficial use (I.C. 13-2-3-1).

The Natural Resources Commission can designate "restricted use" areas, so the withdrawal of ground water does not exceed the natural replenishment of that source (I.C. 13-2-2-3).

Water well drilling contractors are required to obtain a renewable, annual license from the Department of Natural Resources (I.C. 25-39-1-1), and are required to keep accurate records of wells and file the drilling logs with the department (I.C. 25-39-1-2).

County commissioners may enact ordinances and regulations to control the location, construction, or repair of all wells within the county. Cities and towns may do the same within their jurisdiction (I.C. 17-2-22-4.5), and any water that is sold or consumed by the public must meet standards established by the Environmental Management Board (I.C. 13-7-14-1).

Surface-Water Withdrawals Water in streams, lakes, and other natural bodies in the state is a natural resource and is water subject to control and regulation for the public welfare (I.C. 13-2-1-2).

Individual riparian land owners have the right to the use of water in quantities necessary to satisfy their needs for domestic purposes, and this shall have priority and be superior to any and all uses. Also, the riparian land owner may impound water from the course after receiving permission from the Natural Resources Commission (I.C. 13-2-1-3). Any construction that would occur in the floodway of a stream requires a permit from the Natural Resources Commission (I.C. 13-2-22-13).

Any person may divert flood waters of any water course for any useful purpose upon the approval of the Natural Resources Commission (I.C. 13-2-1-6).

The state, municipalities, special taxing districts, and public utilities may secure needed reservoir sites to meet present and future needs for storage of water for purposes that include domestic and municipal use (I.C. 13-2-9-1). Sites for water supply storage must meet the approval of the Natural Resources Commission and the board of health before condemnation can be used in acquisition of those sites (I.C. 13-2-9-7), and if the impoundment exceeds certain criteria as to minimum drainage area, volume of storage or height of dam, it must be inspected annually by the Department of Natural Resources (I.C. 13-2-20-4). The state may contract to supply minimum quantities of streamflow or to sell water for supply purposes from impoundments financed by the state (I.C. 13-2-1-7).

Before water can be withdrawn from a navigable stream in Indiana, a permit must be acquired from the Natural Resources Commission (I.C. 14-3-14). Similarly, cities may regulate the withdrawal of water from courses within a distance of ten miles from their corporate limits, but not into a county other than the one in which the city hall is located (I.C. 18-1-15-9).

Concerning ground water, county commissioners may enact ordinances and regulations to control the location, construction, or repair of all wells located within the county, and cities and towns may do the same within their jurisdiction (I.C. 17-2-22-4.5). The Natural Resources Commission can designate "restricted use areas" so the withdrawal of ground water does not exceed the natural replenishment of that source (I.C. 13-2-2-3).

The Environmental Management Board (EMB) has a broad mandate to develop long-term environmental control programs including standards and regulations for the accomplishment of such programs (I.C. 13-7-1-1). The EMB is to classify all water and wastewater treatment plants as to qualification for their operation (I.C. 3-1-6-1), establish requirements for permits for the construction of public water supply facilities (I.C. 13-7-10-1); approve the plans and specifications prior to the construction of a public water supply facility and require its safe operation (I.C. 13-7-14-1); inspect public water supplies (I.C. 13-7-3-1); require the submission of water supplies for analysis (I.C. 13-7-14-4); and establish and enforce standards for water that is sold or consumed by the public (I.C. 13-7-14-1).

Also, the EMB is to encourage and advise local governmental units in developing facilities or establishing minimum standards for: air, water, odor, and noise pollution control, water or wastewater treatment, water resource development, and solid waste disposal. If local governmental units do not develop plans to meet minimum state requirements, the EMB may order the affected local governmental units to form regional water and sewage districts (I.C. 13-7-15-1).

Any public utility, except in third-class cities engaged in specific activities including the furnishing of water, is authorized and empowered, with the approval of the public service commission, to appropriate and condemn lands or any easements necessary to carry out its objectives (I.C. 8-1-8-1).

Cities, towns, and other municipal corporations can purchase and acquire waterworks (I.C. 19-3-10-1).

Conservancy districts may be established for purposes that include providing water supply, including treatment and distribution for domestic, industrial, and public use (I.C. 19-3-2-1). Also, any area of the state may be organized as a regional water and sewage district for reasons that include providing a water supply for domestic, industrial, and public use to consumers within and without the district (I.C. 19-3-1.1-1).

Industrial Water Supply Water in streams, lakes, and other natural bodies in the state is a natural resource and is water subject to control and regulation for the public welfare (I.C. 13-2-1-2).

The state, municipalities, special taxing districts, and public utilities may secure needed reservoir sites to meet present and future needs for storage of water for purposes that include commercial and industrial use (I.C. 13-2-9-1). Sites for water supply storage must meet the approval of the Natural Resources Commission and the State Board of Health before condemnation can be used in acquisition of those sites (I.C. 13-2-9-7), and if the dam and the impoundment meet certain minimum size criteria they must be inspected annually by the Department of Natural Resources (I.C. 13-2-20-4). The state may contract to provide minimum quantities of streamflow or to sell water for supply purposes from impoundments financed by the state (I.C. 13-2-1-7).

Individual riparian land owners have the right to the use of water in quantities necessary to satisfy their needs for domestic purposes, and this shall have priority over any and all uses. Also, the riparian land owner may impound water from the course after receiving permission from the Natural Resources Commission (I.C. 13-2-1-3). Any construction that would occur in the floodway of a stream must first meet the approval of the Natural Resources Commission (I.C. 13-2-22-13).

Any person may divert flood waters of any course for any useful purpose upon the approval of the Natural Resources Commission (I.C. 13-2-1-6).

Before water can be withdrawn from a navigable stream in Indiana, a permit must be acquired from the Natural Resources Commission (I.C. 14-3-1-14), and cities may regulate the withdrawal of water from courses within a distance of ten miles from their corporate limits, but not into a county other than that in which the city hall is located (I.C. 18-1-1.5-9).

Conservancy districts may be established for purposes that include providing water supply including treatment and distribution for domestic, industrial, and public use (I.C. 19-3-2-1). Also any area of the state may be organized as a regional water and sewage district for reasons that include providing water supply for domestic, industrial, and public use to consumers within and without the district (I.C. 19-3-1.1-1).

Concerning ground water, county commissioners may enact ordinances and regulations to control the location, construction, or repair of all wells located within the county. Cities and towns may also adopt their own ordinances to control the location, construction, or repair of all wells within their jurisdiction (I.C. 17-2-22-4.5). The state Natural Resources Commission can designate "restricted use areas" so the withdrawal of ground water does not exceed the natural replenishment of that source (I.C. 13-2-2-3).

Water that is sold to or consumed by the public must meet standards established by the Environmental Management Board (I.C. 13-7-14-1).

Agricultural Water Water in streams, lakes, and other natural bodies in the state is a natural resource and is water subject to control and regulation for the public welfare (I.C. 13-2-1-2).

The state municipalities, special taxing districts, and public utilities may secure reservoir sites to meet present and future needs for storage of water for purposes such as agricultural uses including irrigation (I.C. 13-2-9-1). The Natural Resources Commission and the State Board of Health must approve the impoundment sites before condemnation can be used in acquisition of those sites (I.C. 13-2-9-7), and if the dam meets certain criteria it must be annually inspected by the Department of Natural Resources (I.C. 13-2-20-4). The state may contract to supply minimum quantities of streamflows or to sell water for supply purposes from impoundments financed by the state (I.C. 13-2-1-7).

Individual riparian land owners have the right to the use of water in quantities necessary to satisfy their needs for domestic purposes, and this shall have priority over any and all uses. Also, the riparian land owner may impound water from the course after receiving permission from the Natural Resources Commission (I.C. 13-2-1-3). Any construction that occurs in the floodway of a stream requires a permit from the Natural Resources Commission (I.C. 13-2-22-13).

Any person may divert flood water of any course for any useful purpose upon the approval of the Natural Resources Commission (I.C. 13-2-1-6).

Before water can be withdrawn from a navigable stream in Indiana a permit must be acquired from the Natural Resources Commission (I.C. 14-3-1-14), and cities may regulate the withdrawal of water from courses within a distance of ten miles from their corporate limits, but not into a county other than the one in which the city hall is located (I.C. 18-1-1.5-9).

Conservancy districts may be established for purposes that include providing water for irrigation and water supply, including treatment and distribution for domestic, industrial, and public use (I.C. 19-3-2-3). Also, any area of the state may be organized as a regional water and sewage district for reasons that include providing a water supply for domestic uses to consumers within and without the region.

As for ground water and agricultural use, county commissioners may enact ordinances and regulations to control the location, construction, or repair of all wells located within the county (I.C. 17-2-22-4.5).

Water that is sold to or consumed by the public must meet standards established by the Environmental Management Board (I.C. 13-7-14-1).

Production of Energy Surface waters of the state are to be put to beneficial use for the welfare of the people, and all water in natural bodies in the state is a natural resource and is public water (I.C. 13-2-1-1.2).

Land owners contiguous to a public water course may impound water from the course after receiving permission from the Natural Resources Commission (I.C. 13-2-1-3), and any person may divert flood waters of any course for any useful purpose upon the approval of the Natural Resources Commission (I.C. 13-2-1-6).

The state, municipalities, special taxing districts, and public utilities may secure needed reservoir sites to meet present and future needs for storage of water for purposes that include the production of energy (I.C. 13-2-9-1). The impoundment site must be approved by the Natural Resources Commission and the board of health before condemnation can be used in acquisition of those sites (I.C. 13-2-9-7), and if the dam meets certain criteria it must be inspected annually by the Department of Natural Resources (I.C. 13-2-20-4). Also, any construction which would occur in the floodway of a stream must be approved by the Natural Resources Commission (I.C. 12-2-22-13).

Excess Water

Flood Control In 1945 the general assembly determined that it was in the best interest of the citizens of the state to prevent and limit floods by regulating; supervising; coordinating the construction, operation, and design of flood control works and structures; alteration of streams; and keeping floodways free and clear (I.C. 13-2-22-2). The Natural Resources Commission has been given the primary authority concerning flood control activities in the state which includes jurisdiction over all public and private waters of the state and all lands adjacent to these waters necessary for flood control purposes or the prevention of flood damages and the responsibility of establishing a master plan for flood control in all areas. The commission may also construct flood control works. It is illegal to construct any permanent place of residence in a floodway. Any structure, obstruction, deposit, or excavation in the floodway of any stream in the state must first be approved by the Natural Resources Commission; however, approval is not needed when the project will take place within the upper ten miles of the streams or legal open drain in rural access (I.C. 13-2-22-13).

The state has also established minimum standards for the delineation and regulation of all flood hazard areas within the state, and has provided the means by which local units of government, based on these minimum standards, can regulate the flood hazard areas within their jurisdiction (I.C. 13-2-22.5-1 *et seq.*).

No individual, partnership, association, corporation, municipal corporation or political subdivision, of the state may do any work designed to regulate or control the waters for flood control purposes without the approval of the Natural Resources Commission (I.C. 13-2-24-1 and I.C. 13-2-22-15).

The state, municipalities, special taxing districts, and public utilities may secure needed reservoir sites for the storage of surface water for purposes that include flood prevention and control (I.C. 13-2-9-1); and all impoundment sites must be approved by the board of health and the Natural Resources Commission before condemnation can be used in acquisition of those sites (I.C. 13-2-9-7); and if the dam meets certain criteria it must be inspected annually by the Department of Natural Resources (I.C. 13-2-20-4).

The Natural Resources Commission and the State Board of Finance may loan up to $100,000 to any municipality for flood control purposes (I.C. 13-2-23-3).

Cities and towns may petition in the circuit court of the county for specific or general relief for the purpose of lessening or preventing the inundation by flood water (I.C. 19-4-17-1).

Cities of the second, third, fourth, and fifth classes may, by petition to the circuit court of the county, establish districts for the purpose of undertaking flood control and relief projects (I.C. 19-4-18-1). Cities of the first class (Indianapolis) may create a department of flood control (I.C. 19-4-21-1).

Cities of the second, third, fourth, and fifth classes may construct levees when the board of public works or the common council determines that this action is necessary for the protection of the city (I.C. 18-1-10-1).

Any person lawfully authorized to maintain, protect, or repair any levee shall have the right to purchase for the use of the levee whatever ground may be necessary to protect, maintain, or repair the levee (I.C. 13-2-19-1).

The owner(s) of any dam, levee, dike, floodwall, or appurtenance is required to maintain the structure in safe operating condition (I.C. 13-2-20-2); and the Department of Natural Resources is required to conduct annual inspections of these structures (I.C. 13-2-20-4).

Conservancy districts may be established for purposes that include undertaking actions for the prevention and control of flooding (I.C. 19-3-2-1).

Soil and water conservation districts have been established in the state to promote the policy of conserving the state's soil and water resources and for the prevention of, among other things, damages due to flood water (I.C. 13-3-1-1).

Diversions Any person may divert flood waters of any water course for any useful purpose upon the approval of the Natural Resources Commission provided certain conditions are met. This is not limited to contiguous land owners (I.C. 13-2-1-6). Contiguous land owners have the right at all times to the use of water from public water courses in quantities necessary to satisfy domestic needs. They also have the right to impound water from such courses and use the increased flows resulting from releases from the impoundment. The action to impound must be approved by the Natural Resources Commission (I.C. 13-2-1-3).

A permit must be acquired from the Natural Resources Commission prior to withdrawing water from a navigable stream (I.C. 14-3-1-14), and cities and towns may regulate the withdrawal of water from courses within a distance of ten miles from their corporate limits, but not beyond the county in which the city hall is located (I.C. 18-1-1.5-9).

Agricultural Drainage Each county in Indiana has a county drainage board, of which the county surveyor is an ex-officio member (I.C. 19-4-1-3), which board has the primary responsibility for the construction, reconstruction, and maintenance of all legal drains except in areas where this responsibility has been relinquished to cities, towns, sanitary districts, conservancy districts, and any legal entity responsible for flood control and drainage (I.C. 19-4-1-1 through 19-4-10-5).

It is illegal to undertake any drainage activities that might cause the lowering of the water level in public fresh-water lakes (I.C. 13-2-17-1).

It is unlawful to conduct any activity in the floodway of any water course of the state that will adversely affect the efficiency or restrict the capacity of the floodway, constitute a hazard to the safety of life or property, or have detrimental effects upon fish, wildlife, and botanical resources. Therefore, any person wishing to undertake any construction activities on any floodway must first obtain approval from the Natural Resources Commission; however, approval is not required for reconstruction or maintenance projects on those streams or legal drains in rural areas where the total length of the specific stream or legal drain is ten miles or less (I.C. 13-2-22-13).

Cities have been granted the power to establish, maintain, and control water courses within a distance of ten miles from the corporate limits but not beyond the county line in which the city hall is located. These powers include the ability to dam, widen, straighten, dredge, change the channels of, or remove an obstruction in, any water course (I.C. 18-1-1.5-9).

Fifty-one percent of the frontage land owners bordering on any nonnavigable stream may petition their county commissioners requesting that a portion of the stream between two designated points be cleaned out or improved to provide adequate capacity (I.C. 17-2-29-1).

Conservancy districts can be established to undertake activities for improving drainage (I.C. 19-3-2-1), and soil and water conservation districts have been established in Indiana to promote wise and efficient use of the state's land and water resource (I.C. 13-3-1-2).

Stream Modification It is unlawful to erect any structure, obstruction, deposit, or excavation in the floodway of any water course of the state that will adversely affect the efficiency or unduly restrict the capacity of the floodway, constitute an unreasonable hazard to the safety of life or property, or have unreasonable detrimental effects upon fish, wildlife, and botanical resources. Any person wishing to undertake such activities in any floodway must first obtain approval from the Natural Resources Commission; however, approval is not required for reconstruction or maintenance projects on streams or legal drains in rural areas where the total length of the specific stream or legal drain is ten miles or less, or for bridges in rural areas where the drainage area of the bridge site is fifty square miles or less (I.C. 13-2-22-13).

Cities have been granted the power to establish, maintain, and control water courses within a distance of ten miles from the corporate limits but not beyond the county line in which the city hall is located. This power includes the ability to dam, widen, straighten, dredge, change the channels of, or remove an obstruction in, any water course (I.C. 18-1-1.5-9, I.C. 18-5-10-4).

Fifty percent of the frontage land owners bordering on any nonnavigable stream may petition their county commissioners requesting that a portion of the stream between two designated points be cleaned out or improved to provide adequate capacity (I.C. 17-2-29-1).

Flood Plain Management It is unlawful to conduct any activity in the floodway of any water course of the state which will adversely affect the efficiency or restrict the capacity of the floodway, constitute a hazard to the safety of life or property, or have detrimental effects upon fish, wildlife, and botanical resources. Therefore, any person wishing to undertake any construction activities on any floodway must first obtain approval from the Natural Resources Commission (I.C. 13-2-22-13). Also, the state has established minimum standards for the delineation and regulation of all flood hazard areas within the state and has provided the means by which local units of government, based on the minimum standards, can regulate the flood hazard areas within their jurisdiction (I.C. 13-2-22.5-1 *et seq.*).

Similarly, local units of government have been authorized to establish flood plain commissions which may regulate land uses within identified flood hazard areas (I.C. 18-7-4.5-1).

Soil Erosion With the establishment of soil and water conservation districts throughout the state it has become the policy of the state to promote the conservation of land and water resources (I.C. 13-3-1-1); and to further this policy the state provides funds for soil and water conservation districts as well as small watershed planning in cooperation with the United States Soil and Water Conservation Service (I.C. 13-4-3-2).

The state also regulates the reclamation of lands subject to surface mining for purposes that include the prevention of soil erosion (I.C. 13-4-6-1, I.C. 14-4-2-1).

Conservancy districts can be established for purposes that include preventing the loss of top soil from injurious water erosion (I.C. 19-3-2-3).

Water Research and Data Collection

The Natural Resources Commission is authorized to conduct investigations and measurements of water resources (I.C. 13-2-8-1). Also, the commission is authorized to investigate, compile, and disseminate information and make recommendations concerning the state's natural resources (I.C. 14-3-1-3), and make research data and reports available to public or private institutions or indicidual s (I.C. 14-3-1-4).

The State Board of Health and Natural Resources Commission are authorized to conduct research necessary for beneficial development, use, and management of the state's water resources (I.C. 13-2-7-2).

The United States may obtain land in the state for the development of fish hatcheries, wildlife or forest preserves, or for agricultural, recreational, or experimental uses (I.C. 4-21-8-1).

Water Quality

The Environmental Management Board has a general charge to preserve, protect, and enhance the quality of the state's environment and to develop programs that provide for the most beneficial use of the resources of the state (I.C. 13-7-1-1). In furtherance of this mandate, the EMB is given the specific duty, among others, to evolve standards and develop regulations to preserve, protect, and enhance the quality of the environment and assure accomplishment of the comprehensive, long-term program it is to develop (I.C. 13-7-3-1).

The Stream Pollution Control Board (SPCB), operating under the general overview of the Environmental Management Board, has been granted the jurisdiction to control and prevent pollution in the waters of the state (I.C. 13-1-3-4). This involves the determination of qualities or properties that indicate pollution and the development of regulations and orders to restrict the discharge of polluting substances into the surface and ground waters of the state (I.C. 13-1-3-7).

In addition to the authority provided by I.C. 13-1-3-7, the Stream Pollution Control Board, as well as the EMB, is empowered to prescribe, by regulation, standards or requirements:(1) to specify the maximum permissible short-term and long-term concentrations of various contaminants in the state's surface and ground water; and (2) for the filling or sealing of abandoned water wells, water holes, and drainage holes to protect ground water against contamination. (I.C. 13-7-7-5; also, I.C. 13-7-5-1).

The discharge (or threatened discharge) of any contaminant is prohibited, either alone or in combination with contaminants from other sources, into the environment in any form that violates (or would violate) regulations, standards — including water quality standards — or discharge requirements of the SPCB or the EMB (I.C. 13-7-4-1).

Any plans, specifications, and so forth, for the abatement or correction of any polluted condition must be approved by the SPCB (I.C. 13-1-3-10, I.C. 13-7-4-1).

The SPCB has been designated as the water pollution agency for the state for purposes of the Federal Water Pollution Act (I.C. 13-7-2-10).

Any person discharging or proposing to discharge or emit contaminants affecting environmental quality must furnish technical reports as the EMB or SPCB may specify (I.C. 13-7-16-7).

Finally, the EMB is to encourage, assist, and advise local governmental units in developing facilities or establishing standards for, among other things, water pollution control, including waste water treatment. If the EMB finds plans to meet minimum state standards have not been developed it may order the affected local governmental units to proceed to form regional water or sewage districts (I.C. 13-7-15-2).

In order to protect the state's ground water for the public's use, the state will provide the means whereby any test hole drilled will be plugged in such a manner as to prevent pollution, impairment, and waste of natural resources (I.C. 13-4-5-1). Similarly, injection wells must be plugged or repaired to prevent leakage of saltwater, oil, gas, or other deleterious substance into freshwater formations (I.C. 13-4-4-1). Also, the Natural Resources Commission has the power to regulate disposal of salt- or sulfur-bearing water and waste liquids produced in the operation of any oil and gas well (I.C. 13-4-7-12).

The proper reclamation of lands subject to mining of minerals is required to protect lakes and streams from pollution (I.C. 13-4-6-1).

Although its authority would appear to be largely superseded by I.C. 13-7, I.C. 13-1-3, and I.C. 16-1-26, the Natural Resources Commission is empowered (by I.C. 14-3-1-14) to protect the lakes, streams, and springs of the state against impurities or pollution by industrial, municipal, or other sewage waste. The Natural Resources Commission is charged with the responsibility of protecting and properly managing the fish and wildlife resources of the state (I.C. 14-2-1-1).

Cities have been authorized to establish, maintain, and control watercourses within a distance of ten miles from their corporate limits. These powers include the power to regulate, license, and prohibit the putting of substances into the water that might endanger public health, safety, or injure property (I.C. 18-1-1.5-9).

The Ohio River Valley Water Sanitation Commission, an interstate compact among Illinois, Indiana, Kentucky, Ohio, West Virginia, New York, and Virginia, develops water quality criteria for use by the signatory states in establishing water quality standards for the Ohio River and its tributary waters which form boundaries between two or more signatory states.

Ground Water Injection It is the policy of the state to conserve and protect the ground-water resource of the state and provide regulations for its most beneficial use and disposition (I.C. 13-2-2-2).

A permit must be acquired from the Natural Resources Commission in order to inject, pump, or otherwise induce potable water into underground formations that contain nonpotable water (I.C. 13-2-3-2).

In order to protect the public, any test hole drilled 200 feet or more in the state will be plugged in such a manner as to prevent pollution, impairment, and waste of natural resources (I.C. 13-4-5-8). Also, injection wells must be plugged or repaired to prevent leakage of saltwater, oil, gas, or other deleterious substances into freshwater formations (I.C. 13-4-4-1).

Independently of its authority under the Environment Management Act (I.C. 13-7), the SPCB is empowered under its enabling act to control and prevent pollution in waters (including underground waters) of the state (I.C. 13-1-3-4) and to require the sealing of mines, oil and gas wells, brine wells, or any other subterranean strata causing, contributing, or about to cause or contribute, to a polluted condition of the waters of this state (I.C. 13-1-3-5).

Waste Disposal In those instances where the SPCB lacks jurisdiction (under I.C. 13-1-3), authority has been transferred to the EMB to enforce I.C. 16-1-26-1 which provides that it is unlawful to deposit any substance into the waters of the state that is deleterious to public health; the prosecution of any industry or lawful occupation, agriculture, floriculture or horticulture, the livestock industry or use for domestic animals; or which lessens, impairs, or materially interferes with the use of the water by the state or any political subdivision of it; or which destroys or jeopardizes any beneficial animal, fish, or vegetable life in the waters (compare with I.C. 13-1-3-8). Also, any person who has suffered, or is threatened with damage, because of pollution of water by any person may bring a suit in a superior or circuit court of the appropriate county (I.C. 16-1-26-2).

The SPCB is mandated to enforce the phosphate detergent law (I.C. 13-1-5.5) which prohibits the disposal into state waters of any nondegradable detergent containing alkyl benzine sulfonate except for limited exceptions which may be granted pursuant to regulations prescribed by the SPCB.

No person shall construct and operate a confined feeding operation unless the SPCB gives its approval based upon a satisfactory water pollution control proposal for the operation (I.C. 13-1-5.7).

Although its authority would appear to be largely superseded by I.C. 13-7, I.C. 13-13, and I.C. 16-1-26-1, the Natural Resources Commission is empowered (by I.C. 14-3-1-14) to protect the lakes, streams, and springs of the state against impurities or pollution by industrial, municipal, or other sewage waste.

Cities have been authorized to establish, maintain, and control watercourses within a distance of ten miles from their corporate limits. This authorization includes the power to regulate, license, and prohibit the putting of substances into the water that might endanger public health, safety, or injure property (I.C. 18-1-1.5-9).

Each city and town is authorized to own, acquire, construct, equip, extend, operate, and maintain — within and without its corporate limits — a sewage treatment plant or plants (I.C. 19-2-5-2). The responsibility is usually charged either to the Board of Public Works and Safety, Board of Sanitation, Board of Trustees (of a town), Utility Service Board, or to any other agency of municipal government.

Conservancy districts can be established for purposes that include the collection, treatment, and disposal of sewage and other liquid waste (I.C. 19-3-2-1).

Any area in the state may be organized as a regional water and sewage district for purposes that include the collection, treatment, and disposal of sewage within and without the district. (I.C. 19-3-1.1).

The Ohio River Valley Water Sanitation Commission, an interstate compact, requires the treatment of sewage discharged or permitted to flow into the Ohio River and its tributary waters that form boundaries between two or more signatory states. It also establishes effluent standards for sewage and industrial waste discharged into tributaries wholly within a signatory state that flow into waters of an interstate stream (I.C. 13-5-5-1). Illinois, Indiana, Kentucky, and Ohio are among the signatory states.

Appendix Eight

FEDERAL WATER LAWS

Instream Uses

Navigation The Constitution of the United States provides Congress with the power to regulate commerce with foreign nations and among the several states, and with Indian tribes.

The secretary of the army is required to prescribe regulations necessary for the use, administration, and navigation of the navigable waters of the United States (33 USC 1).

The creation of any obstruction not authorized by Congress to the navigable capacity of any of the waters of the United States is prohibited (33 USC 403).

Similarly, any structure affecting the navigation of navigable waters in the U.S. must be approved by the secretary of the army (16 USC 797).

The secretary of transportation must approve the location and plans for bridges to be constructed over navigable waters of the United States (33 USC 525 *et. seq.*).

The secretary of the army is authorized to establish harbor lines when he determines it to be necessary for the preservation and protection of a harbor (33 USC 404).

A comprehensive program is authorized to provide for control and progressive eradication of noxious aquatic plant growth from the navigable and allied waters of the United States in the combined interest of navigation, flood control, drainage, agriculture, fish and wildlife conservation, public health and related purposes (33 USC 610).

The secretary of the army is authorized to receive funds from local interest for the prosecution of authorized river and harbor improvements (33 USC 561), and any improvements or other work done on any navigable river must be approved by the secretary of the army (33 USC 565).

Recreation A land and water conservation fund has been created to assist states in planning, acquisition, and development of needed land and water areas and facilities, and to assist in federal acquisition and development of recreational areas (16 USC 460L-4).

Uniform policies and procedures relating to benefits and costs of recreational and enhancement of fish and in connection with federal multipurpose water resource projects have been established through the federal Water Project Recreation Act (16 USC 460L-12 *et. seq.*).

The chief of engineers of the Army Corps of Engineers is authorized to construct, maintain, and operate public park and recreational facilities at water resource development projects (16 USC 460d).

Furthermore, the secretary of agriculture should cooperate with the states and their political subdivisions in the planning and development of works for the utilization and development of water (16 USC 1001).

The Wild and Scenic Rivers Act of 1968 is an effort by Congress to preserve certain selected rivers of the nation in their natural state (16 USC 1271).

Fish and Wildlife In the Fish and Wildlife Act, Congress established a comprehensive policy for fish, shellfish, and wildlife resources for the nation (16 USC 742a). Under this act the secretary of the interior has a broad policy-making role and is authorized to take required steps for the development, management, advancement, and protection of fish and wildlife resources through research, acquisition of refuge lands, development of existing facilities, and other means.

The Fish and Wildlife Coordination Act provides that whenever any federal license or permit impounds, diverts, or otherwise controls any waters, such agency shall consult the United States Fish and Wildlife Service and the head of the state agency having administration over the affected resource (16 USC 662a).

The Federal Water Project Recreation Act (16 USC 460L-12 *et. seq.*) establishes uniform policies and procedures for the evaluation of benefits and costs of federal multipurpose water resource projects.

The secretary of the interior has the authority to conserve fish and wildlife and project species of fish and wildlife that are threatened by extinction (16 USC 668 aa-dd).

The Watershed Protection Act authorizes certain fish and wildlife improvement activities at small watershed projects (16 USC 1001-1009).

Water Withdrawals

Water Supply Primary responsibilities for developing water supplies for domestic, municipal, industrial, and other purposes rests with the states and local interest, but the federal government may participate and cooperate with the states and local interests in developing water supplies (43 USC 390b[a]). Thus, water may be included in multiple purpose reservoirs (43 USC 390b[a]).

The secretary of the army is authorized to receive funds from states and political subdivisions and expend them in connection with funds appropriated by the United States for any authorized flood control work, and modify the plans of any reservoir project to provide additional storage capacity for domestic water supply or other conservation storage (33 USC 701h).

The secretary of the army is also authorized to make contracts with states, municipalities, private concerns, or individuals for domestic and industrial uses for surplus water that may be available at any reservoir under the control of the Department of the Army (33 USC 708).

The secretary of agriculture has broad powers to undertake activities directly or indirectly related to water supplies (16 USC 1001) through conducting investigations and surveys aimed at preserving, protecting, and improving the nation's land and water resources.

Production of Energy The Department of Energy is authorized to issue licenses for production of power on river sites by private companies or by state or municipal agencies (16 USC 791 *et. seq.*). If the proposed structure affects the navigability of any navigable stream it must first be approved by the corps of engineers.

The secretary of the army is authorized, upon his discretion, to provide in the permanent parts of any dam authorized by Congress for the improvement of navigation such foundations, sluices, and other works as may be considered desirable for the future development of its water power.

Furthermore, all examinations and surveys of projects relating to flood control must include data on the possible economic development and utilization of water power (33 USC 701).

Excess Water

Flood Control Authority to deal with federal investigations and improvements of rivers and other waterways for flood control and allied purposes is vested in the Department of the Army (33 USC 701 *et. seq.*).

In order to have any money expended on construction of local protection projects, assurances must be made by states and other nonfederal interests that they will provide land, easements, and rights-of-way; hold and save the United States free from damages due to construction works and maintain and operate the works (33 USC 701c). Construction of any water resources project shall not be commenced until each nonfederal interest has entered into a written agreement with the secretary of the army to furnish its required cooperation for the project (42 USC 1962d 5b).

In the Watershed Protection and Flood Prevention Act the secretary of agriculture is given certain authority with respect to watershed areas not exceeding 250,000 acres and not including any single structure that provides more than 12,500 acre-feet of floodwater detention capacity, and more than 25,000 acre-feet of total capacity (16 USC 1001 *et. seq.*).

The secretary of housing and urban development is authorized to establish and carry out a national flood insurance program. This insurance is to be made available throughout the nation through a cooperative effort of the federal government and the private insurance industry (42 USC 4001 *et. seq.*).

Water Quality The Rivers and Harbors Appropriation Act of 1899 makes it unlawful to discharge or cause to be discharged into the navigable waters of the United States any refuse matter of any kind or description other than that flowing in a liquid state from streets and sewers (33 USC 407). This prohibition extends to any tributary or bank of such tributary if the refuse is likely to be washed into the navigable water.

The Water Pollution Control Act provides that the administrator of the Environmental Protection Agency, in cooperation with others, shall develop or prepare comprehensive programs for preventing, reducing, or eliminating the pollution of navigable and ground waters and improving the sanitary condition of surface and underground waters (33 USC 1252 *et. seq.*). The act calls for the formulation of water quality standards, and the states are encouraged to establish quality criteria and enforcement plans.

Glossary

Glossary

Accretion: The gradual or imperceptible increase or extension of land by natural forces acting over a long period of time, as on a beach by the washing up of sand from the sea or on a flood plain by the accumulation of sediment deposited by a stream.

Advanced Waste Treatment: Wastewater treatment beyond the secondary or biological stage that includes removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids. Advanced waste treatment, known as tertiary treatment, is the "polishing stage" of wastewater treatment and produces a high quality effluent.

Agricultural Pollution: The liquid and solid waste from all types of farming including runoff from pesticides, fertilizers and feed lots; erosion and dust from plowing, animal manure and carcasses; and crop residues and debris. It has been estimated that agricultural pollution in the U.S. has amounted to more than two and one-half billion tons per year.

Algal Bloom: A proliferation of living algae on the surface of lakes, streams, or ponds. Algae blooms are stimulated by phosphate enrichment.

Alluvial: Pertaining to or composed of alluvium, or deposited by a stream or running water.

Alluvium: A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

Ammonia ($NH_3 - N$) and Organic Nitrogen: These are indicators of the freshness of sewage. Waters in which most of the nitrogen is in the form of organic and ammonia nitrogen are often considered to have been recently polluted. The presence of ammonia in municipal water sources is particularly significant because of its marked effect on the amount of chlorine needed to disinfect water properly. Ammonia is also capable of exerting a significant oxygen demand in surface waters. The toxic effect of ammonia on aquatic life increases with increasing pH and temperature.

Aquatic Plants: Plants that grow in water either floating on the surface, or growing up from the bottom.

Aquifer: A body of rock that contains sufficient saturated, permeable material to conduct ground water to wells and springs.

Bacteria: Single-celled microorganisms that lack chlorophyll. Some bacteria are capable of causing human, animal, or plant diseases; others are essential in pollution control because they break down organic matter in the air and in the water.

Basal Ice Load: Debris carried in the lower several meters of glacial ice that typically carries the bulk of the glacial debris.

Base: The bottom or that part of an engineering structure resting upon the subgrade or supporting soil or solid rock.

Base Flow: Sustained or fair-weathered flow of a stream, whether or not affected by the works of man.

BEA: Business And Economic Area.

Bedrock: A general term for the rock, usually solid, that underlies soils or other unconsolidated, superficial material.

Bedrock Aquifer: Saturated consolidated or bedrock formations which yield water in sufficient quantity to be of consequence as a source of supply.

Biochemical Oxygen Demand: A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. Large amounts of organic waste use up large amounts of dissolved oxygen, thus the greater the degree of pollution, the greater the BOD.

BOD: Biochemical Oxygen Demand, biological oxygen demand.

Coliform Bacteria: A group of organisms common to the intestinal tracts of man and of animals. The presence of coliform bacteria in water is an indicator of pollution and of potentially dangerous bacterial contamination.

Cold-Water Fishery: An environment having well oxygenated water (above six parts-per-million) and temperatures between 60 to 62°F. that will support salmonid populations, such as trout and salmon.

Combined Sewers: A sewerage system that carries both sanitary sewage and stormwater runoff. During dry weather, combined sewers carry all wastewater to the treatment plant. During a storm, only part of the flow is intercepted because of plant overloading; the remainder goes untreated to the receiving stream.

Cooling Lake: An artificial lake created to provide cooling water to, and receive discharge water from, an electric generating station.

Cooling Lake Method: Method of dispersing heat generated by electrical power generating stations. Heated water is discharged into a cooling lake where the water naturally cools and is in part recycled through the generating station as coolant water.

Cooling Tower: A structure where warm water from a power plant is cooled by the evaporation process.

Disinfection Facility: Effective killing by chemical or physical processes of all organisms capable of causing infectious disease. Chlorination is the disinfection method commonly employed in sewage treatment and drinking water treatment facilities.

Dissolved Oxygen: The oxygen dissolved in water or sewage. Adequately dissolved oxygen is necessary for the life of fish and other aquatic organisms and for the prevention of offensive odors. Low dissolved oxygen concentrations generally are due to discharge of excessive organic solids having high BOD, the result of inadequate waste treatment.

Dissolved Solids: The total amount of dissolved material, organic and inorganic, contained in water or wastes. Excessive dissolved solids make water unpalatable for drinking and unsuitable for industrial uses.

Drainage Basin: A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Drift Sheet: A widespread sheet-like body of glacial drift, deposited, continuously or discontinuously, during a single glaciation, or during a series of closely related glaciations.

Dry Holes: A drill hole in which no water is used for drilling, such as a hole driven upward through rock in a quarry.

Effluent: A discharge of pollutant into the environment, partially or completely treated, or in its natural state. Generally used in regard to discharges into waters.

EMB: Environmental Management Board.

End Moraine: A moraine that is being produced at the front of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.

EPA: U.S. Environmental Protection Agency.

Eutrophication: The normally slow, aging process by which a lake evolves into a bog or marsh and ultimately assumes a completely terrestrial state and disappears. During eutrophication the lake becomes so rich in nutritive compounds, especially nitrogen and phosphorus, that algae and other microscopic plant life become super-abundant, thereby "choking" the lake and causing it eventually to dry up. Eutrophication may be accelerated by many human activities.

Eutrophic Lakes: Shallow lakes, weed choked at the edges and very rich in nutrients. The water is characterized by large amounts of algae, low transparency, low dissolved oxygen, and high BOD.

Evaporation: The process by which water is changed from the liquid or the solid state into the vapor state. In hydrology, evaporation is vaporization that takes place at a temperature below the boiling point.

Evapotranspiration: Loss of water from a land area through transpiration of plants and evaporation from the soil.

Fallow: Cultivated land that is allowed to lie idle during the growing season.

Fecal Coliform Bacteria: A group of organisms common to the intestinal tracts of man and of animals. The presence of fecal coliform bacteria in water is an indicator of pollution and of potentially dangerous bacterial contamination.

Flood: The water of any river or stream which is above the bank and outside the channel.

Flood Frequency: A measure of severity of a flood, commonly expressed in years. Larger floods occur less often and have higher frequencies. Thus the 100 year flood is larger than the ten year flood. A ten year flood is the largest flood that is likely to occur in a ten year period, on the average.

Flood Plain: the low lying lands adjoining a river or stream that have been or may be covered with flood water.

Floodway: The channel of the river and those portions of the flood plain adjoining the channel that are required to carry flood water.

Flow Duration Curve: A cumulative frequency curve that shows the percentage of time that specified discharges are equalled or exceeded. For example, the 90% flow duration curve value is that flow at a specified site on a stream that can be expected to be equalled or exceeded 90% of the time.

GCD: gallons-per-capita-per-day.

Glacial Drift: A general term for drift transported by glaciers or icebergs and deposited directly on land or in the sea.

Glaciation: The formation, movement, and recession of glaciers or ice sheets.

Glacier: A large mass of ice formed, at least in part, on land by the compaction and recrystallization of snow, moving slowly downslope or outward in all directions due to the stress of its own weight, and surviving from year to year.

GPM: gallons-per-minute.

Ground Water: Water in the ground that is in the zone of saturation, from which wells, springs, and ground-water runoff are supplied.

Hard Water: Water containing dissolved minerals such as calcium, iron, and magnesium. The most noticeable characteristic of hard water is its inability to lather soap.

Hydroelectric: The production of electricity by waterpower.

Hydrograph: A graph showing stage, flow, velocity, or other property of water with respect to time.

Hydrograph Separation: A technique for separating a hydrograph into its components of base flow and direct runoff. Base flow is sustained or fair weather flow in a stream and is composed largely of ground-water runoff.

Hydrologic Cycle: The constant circulation of water from the sea, through the atmosphere, to the land and its eventual return to the atmosphere by way of evaporation from the sea and the land surfaces.

Internal Combustion: (for electric power) The generation of electric power from turbines driven by internal combustion engines such as diesel engines.

Inter-till: The material found between till sheets.

Lechates: A liquid solution or product that passes out or through the container or environment in which it was placed.

Legal Drain: A natural or artificial open channel or a tile drain, or a combination of the two, that has been established by the use of any drainage statute of Indiana.

Legal Tile Drain: A tiled channel for the carrying off of surplus water from the land, which channel was established pursuant to, or made subject to, any drainage statute of the State of Indiana.

Lense (water bearing): A geologic deposit bounded by converging surfaces (at least one of which is curved), thick in the middle and thinning out toward the edge, and containing water.

Loess: A widespread, homogeneous, commonly nonstratified, porous, friable, unconsolidated but slightly coherent, usually highly calcareous, fine-grained, blanket deposit of marl or loam, consisting predominantly of silt with subordinate grain sizes ranging from clay to fine sand.

MG: million gallons.

MGD: million-gallons-per-day.

MW: megawatts (1,000,000 watts)

Moraine: A mound, ridge, or other distinct accumulation of unsorted, unstratified glacial drift, predominantly till.

Mutual Drain: A tile or open drain running through the lands of two or more owners and established by their mutual consent and not under any drainage statute.

Nitrate: A mineral compound characterized by a fundamental anionic structure of NO_3.

Nitrate-Nitrogen ($NO_3 - N$): Nitrate-nitrogen is generally present in relatively small quantities in unpolluted surface water. Any significant increase in its concentration indicates that the water characteristics have been altered by industrial, domestic, and agricultural waste. Nitrate-nitrogen is the most highly oxidized form of ammonia; consequently it is the most stable state in the nitrogen cycle. Organic nitrogen is converted to ammonia nitrogen, which then is oxidized to nitrite and consequently to nitrate. When a stream is depleted of dissolved oxygen, it uses the nitrate as an alternated source of oxygen. High concentration of nitrate-nitrogen are reported to cause methemoglobinemia in infants (commonly called "blue babies"). A limit of ten mg/1 of nitrate-nitrogen is recommended for drinking water. Nitrates are necessary to complete the normal cycle of aquatic life, which is of particular significance in natural waters. If nitrate is present with phosphorus in excessive amounts, massive growths can be troublesome to municipal water operation and can also cause taste and odor problems. Others can cause unslightly conditions in streams and along shorelines.

Non-Point Source Pollution: A polluted material that has become soluble and has entered the receiving stream through natural drainage patterns. Agricultural pollution is usually considered as a non-point source of pollution.

Nutrients: Elements or compounds essential as raw materials for organism growth and development, for example, carbon, oxygen, nitrogen, and phosphorus.

OBERS: The projections of future economics activity made by the U.S. Department of Commerce and the U.S. Department of Agriculture.

Once-Through Cooling: A method of condensing steam from electric generating stations by withdrawing water from a lake or stream, passing it over condenser coils, and discharging that water back into the lake or stream.

Outwash Plain: A broad, outspread, flat or gently sloping, alluvial sheet of outwash deposited by meltwater streams flowing in front or beyond the terminal moraine of a glacier.

Partial Body Contact: Any contact with water excluding complete submergence.

PCB: Poly chlorinated biphenyl.

PDR: Planning and Development Region.

pH: A measure of the acidity or alkalinity of a substance. pH is represented on a scale of 0 to 14 with 7 representing a neutral state, 0 representing the most acid, and 14 the most alkaline.

Phosphorus: An element that, while essential to life, contributes to the eutrophication of lakes and other bodies of water.

Point Source Pollution: A polluted material that enters the receiving stream at a specific point, such as a conduit or pipe discharging a polluted material into a receiving stream.

Pollution: The presence of matter or of energy whose nature, location or quantity produces undesired environmental effects.

Potable Water: Water suitable for drinking or cooking.

PPM: parts-per-million.

Precipitation: As used in hydrology, precipitation is the discharge of water, in liquid or solid state, out of the atmosphere, generally upon a land or water surface.

Put and Take Trout Fishery: The management of a trout fishery where the fish are raised to harvestable size and stocked into the stream when the probability of the trout being caught is highest.

Raw Sewage: Untreated domestic or commercial wastewater.

Recharge: Replenishment of ground water contained in the aquifer primarily by infiltration of precipitation, with minor contribution by lakes and streams.

Riparian: Pertaining to the banks of a stream.

Riparian Owner: One who owns the property on a stream course.

Riprap: A layer, facing, or protective mound of stones randomly placed to prevent erosion, scour, or sloughing of a structure or embankment.

Sanitary Sewers: Sewers that carry only domestic or commercial sewage. Stormwater runoff is carried in a separate system.

Secondary Treatment: Wastewater treatment, beyond the primary stage, in which bacteria consume the organic part of the wastes. This biochemical action is accomplished by uses of trickling filters or the activated sludge process. Effective secondary treatment removes virtually all floating and settleable solids and approximately 85% of both BOD and suspended solids. Customarily, disinfection by chlorination is the final stage of the secondary treatment process.

Sewage: The total of organic waste and wastewater generated by residential and commercial establishments.

Sewer: Any pipe or conduit used to collect or carry away sewage or stormwater runoff from the generating source to treatment plants or receiving streams. A sewer that conveys household and commercial sewage is called a sanitary sewer. If it transports runoff from rain or snow, it is called a storm sewer. Often stormwater runoff and sewage are transported in the same system or combined sewers.

Shortfall: A deficiency, a failure to provide for a need.

SIC: Standard industrial classification code.

Siltation: Soil material that has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface.

SMSA: Standard Metroploitan Statistical Area.

Soil Association: A mapping unit used on reconnaissance or generalized soil maps in which two or more defined taxonomic units occurring together in a characteristic pattern are combined because the scale of the map or the purpose for which it is being made does not require delineation of the individual soils.

Soil Erosion: The detachment and movement of soil from the land surface by wind or water.

SPCB: Stream Pollution Control Board.

Storm Sewer: A conduit that collects and transports rain and snow runoff. In some sewerage systems, storm sewers are entirely separate from those carrying domestic and commercial wastewater.

Strip Mine Lakes: Primarily an impoundment created by the final cut of a surface coal mine operation.

Surface Runoff: The runoff that travels over the soil surface to the nearest surface stream.

Surface Water: All waters on the surface of the earth, including fresh and salt water, ice and snow.

Suspended Solids: Small particles of solid pollutants in sewage that can contribute to turbity and that resist separation by conventional means. The examination of suspended solids and the BOD test constitute the two main determinations for water quality performed at wastewater treatment facilities.

Thermal Pollution: Degradation of water quality by the introduction of a heated effluent. Primarily a result of the discharge of cooling waters from industrial processes, particularly from electrical power generation. Even small deviations from normal water temperatures can affect aquatic life. Thermal pollution usually can be controlled by cooling towers.