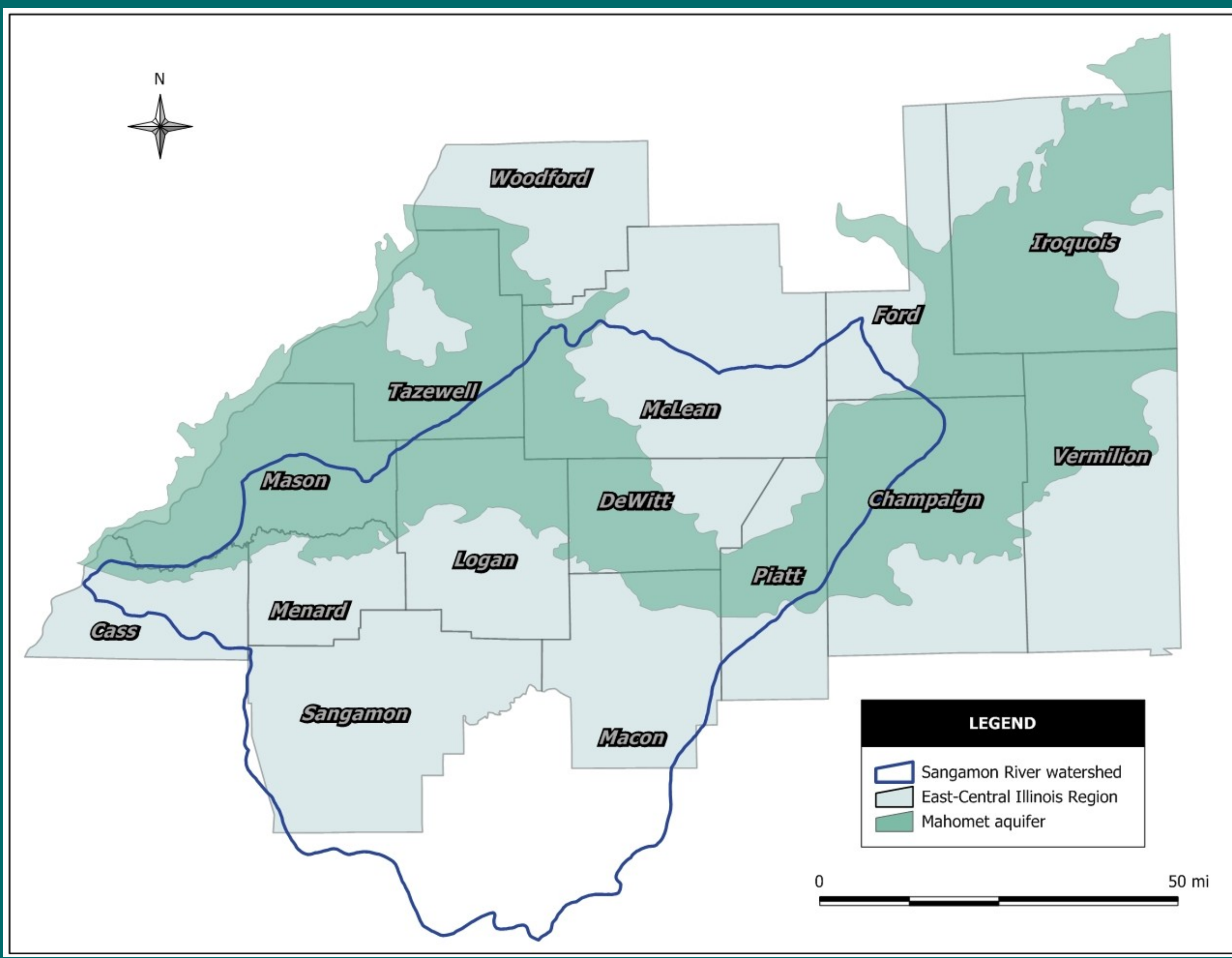
Water Demand Scenarios for the East-Central Illinois Planning Region: 2005-2050

FINAL REPORT

Prepared for:
East-Central Regional Water Supply Planning Committee



Prepared by:
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Bloomington, IN
August 29, 2008

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WATER DEMAND SCENARIOS FOR THE EAST-CENTRAL ILLINOIS PLANNING REGION: 2005-2050

FINAL PROJECT REPORT

Prepared for:

The East-Central Regional Water Supply Planning Committee

Prepared by:

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Contents

List of Figures

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List of Tables

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Key Terms

2005 Normal 2005 model generated value using normal (1971-2000) weather data.

2005 Reported 2005 value reported from the original data source; not a modeled value.

2005 Weather 2005 model generated value using actual weather data from 2005.

Adjusted R^2 modification of R^2 that adjusts for the number of explanatory terms in a model.

Consumptive use water abstracted which is no longer available for use because it has evaporated, transpired, been incorporated into products and crops, or consumed by man or livestock.

Elasticity the degree to which a change in an explanatory variable changes water demand.

Estimate an approximate calculation.

Model generated value derived from the model.

Model residuals the differences between the responses observed at each combination values of the explanatory variables and the corresponding prediction of the response computed using the regression function.

N number of observations

Non-consumptive use water abstracted from a source, used for some purpose, and returned to the source for use by others downstream.

Probability of t-statistics gives the probability of obtaining the given t-ratio by chance. This means lower probability indicates higher statistical significance. Generally the value of 0.05 or lower is taken to indicate statistical significance.

R^2 measures the fraction of the total variability in the response that is accounted for by the model.

Root Mean Square Error (MSE) the distance, on average, of a data point from the fitted line, measured along a vertical line.

Scenario a specific set of assumptions used to estimate future water withdrawals.

t ratio the ratio of the standard error of the estimate of the regression coefficient divided by the value of the coefficient (representing the ratio of signal to noise). Low t-ratios indicate low statistical significance of the estimated regression coefficient. Generally values greater than 2 indicate statistical significance.

Water demand the volume of water required by users to satisfy their needs. In a simplified way it is often considered equal to water withdrawal, although conceptually the two terms do not have the same meaning.

Water use the water from a groundwater or surface water source that is consumed or used. This water is not returned to the source.

Water withdrawals the amount of water removed from a groundwater or surface water source.

Abbreviations and Units

Ave. Average

BL Baseline Scenario

C&I Commercial and Industrial Water Sector

CWLP Springfield City Water Light and Power

DCEO Illinois Department of Commerce and Economic Opportunity

EIA Energy Information Administration

EPA United States Environmental Protection Agency

ET Actual Evapotranspiration

GPCD Gallons Per Capita Per Day

GPED Gallons Per Employee Per Day

IDES Illinois Department of Employment Security

IDNR Illinois Department of Natural Resources

ISGS Illinois State Geological Survey

ISWS Illinois State Water Survey

IREIM Illinois Region Econometric Input/Output Model

IR&AG Irrigation and Agriculture Water Sector

IWIP Illinois Water Inventory Program

kWh kiloWatt Hour

LRI Less Resource Intensive Scenario

MGD Million Gallons Per Day

MRI More Resource Intensive Scenario

MWh MegaWatt Hour

PET Potential Evapotranspiration

PG Power Generation Sector

Precip. Precipitation

PWS Public Water Supply Water Sector

SIC Standard Industrial Code

Temp. Temperature

USGS United States Geological Survey

WHPA Wittman Hydro Planning Associates

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Executive Summary

In January 2006, Governor Rod Blagojevich signed Executive Order 2006-01 calling for a comprehensive program of state and regional water-supply planning in the State of Illinois. The order charges the Illinois Department of Natural Resources (IDNR) with the responsibility of developing financial and technical support for two regional water supply planning committees in their development of water-supply plans for two priority regions in the state. The two areas, identified through work done by the Illinois State Water Survey (ISWS), were chosen as areas of potentially limited water-supply availability and substantial population and economic growth. The two pilot regions are eleven counties in Northeastern Illinois and fifteen counties in East-Central Illinois. As a first step in planning, each region is to estimate current and future water withdrawals. This report describes the water-demand study that estimates current and future withdrawals for the East-Central Illinois Region.

Regional water-supply planning in East-Central Illinois is focusing on the Mahomet Aquifer system and the Sangamon River watershed (Figure A). This study presents future water-demand scenarios for geographical areas which encompass groundwater withdrawal points and surface water intakes in the 15-county regional planning area of East-Central Illinois. The region under study includes the Illinois counties of Cass, Champaign, DeWitt, Ford, Iroquois, Logan, Macon, Mason, McLean, Menard, Piatt, Sangamon, Tazewell, Vermilion, and Woodford.

The Mahomet Aquifer Consortium (MAC) is facilitating the planning effort in the region and has formed a local planning committee with representatives of various stakeholder groups. In East-Central Illinois, the following groups are represented on the Regional Water Supply Planning Committee (RWSPC): Agriculture; County Government; Electric Generating Utilities; Environment; Industries; Municipal Government; the Public; Rural Water Districts; Small Business; Soil and Water Conservation; Water Authorities; and Water Utilities.

The four major water sectors are public water supply (PWS), self-supplied thermoelectric power generation (PG), self-supplied commercial and industrial (C&I), and self-supplied irrigation and agriculture (IR&AG). A chapter is provided for each sector that describes the method and

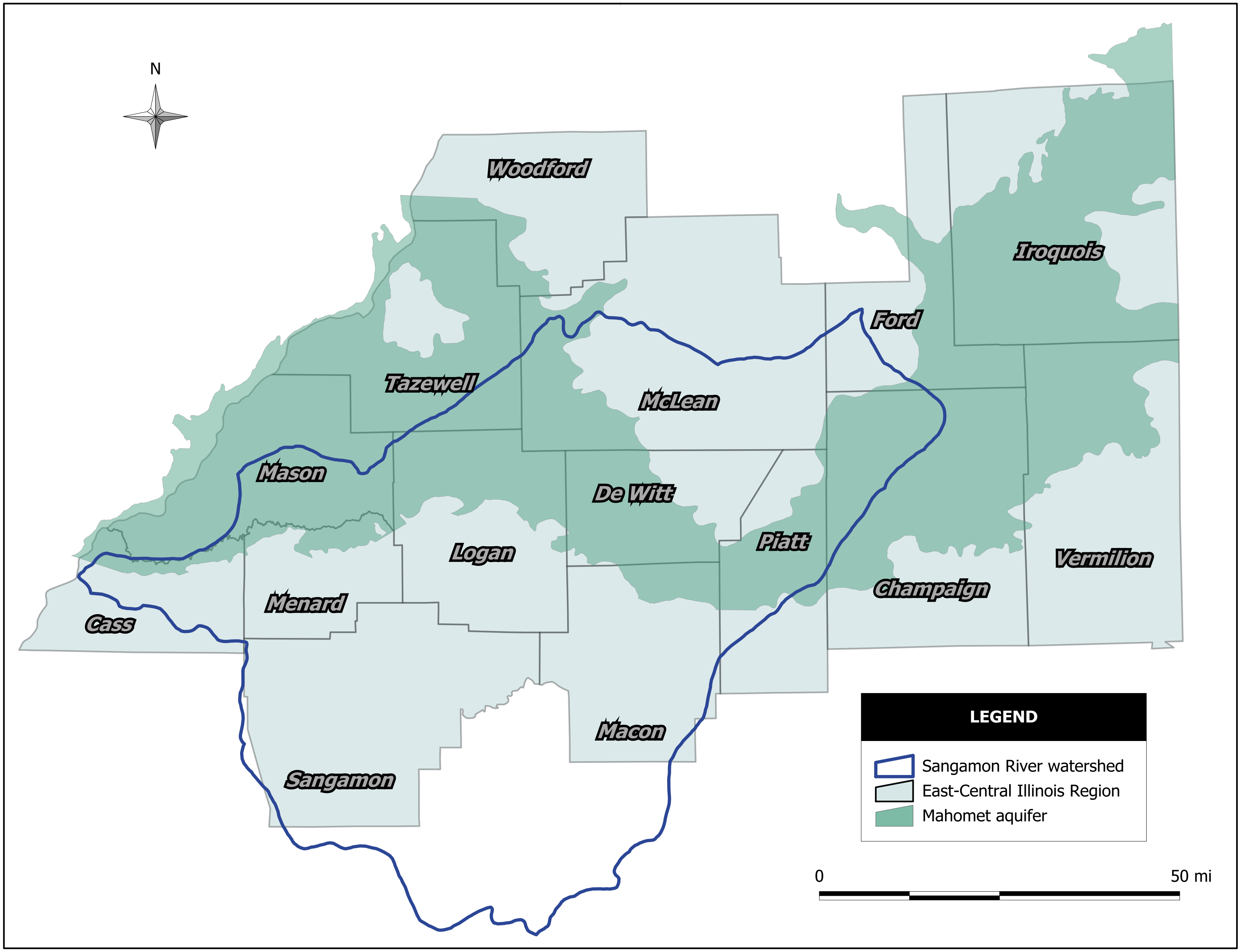

Figure A: The fifteen-county East-Central Water Supply Planning Region in Illinois.

estimates of water demand. In addition, a chapter is included that describes the potential impacts of climate change on water withdrawals for each water sector.

For each of the water sectors, we generated three water demand scenarios organized into separate geographical study areas within the region. The scenarios were defined by varying assumptions regarding the future values of demand drivers and explanatory variables. The three scenarios represent water withdrawals under baseline (BL Scenario) as well as under less and more resource intensive (LRI & MRI) demand conditions. The scenarios do not represent forecast or predictions, nor do they set upper and lower bounds of future water withdrawals. Different assumptions or conditions could result in withdrawals that are within or outside of this range. The purpose of the scenarios is to capture future water withdrawals under three different sets of future conditions.

The future water withdrawals generated from this work will be used by the ISWS, using groundwater and surface water modeling, to analyze the impacts of withdrawing water from specific withdrawal points to meet the demand scenarios. The data generated from this demand study will be delivered to the ISWS at the level of withdrawal points, meaning future water withdrawals will be determined for all existing wells and surface water intakes. Although withdrawal-point data are not included in this report, the data will be available upon request from the ISWS for the public water supply sector. The withdrawal-point data for the commercial and industrial and power generation sectors will not be available to the public due to confidentiality agreements.

Historical data

The project team at Wittman Hydro Planning Associates (WHPA) and Ben Dziegielewski at Southern Illinois University Carbondale (SIUC), in collaboration with the Illinois State Water Survey (ISWS) and Illinois State Geological Survey (ISGS) prepared data sets on historical withdrawals, which were subsequently used in developing water-use relationships for future scenarios. Data used to specify explanatory variables and their future values came from several sources.

Except for Lake Michigan, the State of Illinois does not require permits for the withdrawal of water, nor does it require reporting of the amounts of water withdrawn. Since data was not available from a mandatory State reporting source, data used came from several other sources. The principal source of data on historical water withdrawals is the Illinois Water Information Program (IWIP) of the Illinois State Water Survey (ISWS), a voluntary water withdrawal reporting program established in 1978. Additional data were obtained from the National Water Use Inventory Program (NWUIP) of the U.S. Geological Survey. A summary of the historical water withdrawals by sector is provided in Table A.

Table A: Reported historical water withdrawals in million gallons per day (MGD) for each water sector, 1985-2005.

Water Sector	1985	1990	1995	2000	2005
Public water supply	109.63	121.37	129.61	134.01	137.03
Self-supplied domestic	12.73	11.48	11.57	11.47	8.86
Power generation	–	1,568.8	1,095.5	1,067.7	1,315.35
Commercial & industrial	79.48	74.33	78.1	77.99	84.79
Irrigation & agriculture	37.78	51.39	96.89	103.48	236.82
TOTAL	239.62	1,827.37	1,411.67	1,394.65	1,782.85

We obtained other data from state and federal agencies, most often from routinely collected statistics available from libraries or in electronic format on agency websites. The techniques for developing future water demand varied by sector and included multiple regression and mass balance estimation. These techniques provide future water demand numbers as a function of demand drivers (i.e., population, employment, power generation, irrigated acreage for the respective demand sectors) and variables which influence average rates of water demand (i.e., weather conditions, price of water, income, employment mix).

Future water withdrawals

The techniques for developing estimates of future withdrawals were dictated by the type of water-withdrawal data and the corresponding data on independent or explanatory variables that were available for each water-demand sector. The two principal techniques which were used in this report are the unit-use coefficient approach and multiple regression. The unit-use coefficient method was used for the irrigation and agriculture sector, power generation, and domestic supply. Multiple regression was used for the PWS and C&I sectors. Table B shows the demand drivers and independent variables used for each of the water sectors.

Weather variables

As evidenced in Table B, weather is one of the most important determinants of water demand. Specific weather variables are used in the estimation of future withdrawals in PWS, C&I, and AG&IR sectors. Consequently, in order to estimate future water withdrawals, the weather variables (i.e., precipitation, temperature, and cooling degree days) must also be estimated. Weather data

Table B: Drivers of water demand and elasticities of explanatory variables used to estimate water withdrawals in East-Central Illinois.

Demand sector	Demand driver	Independent variables	Elasticity/ coefficient
Public supply	Population served	Air temperature	1.4222
		Precipitation	-0.1140
		Employment fraction	0.6381
		Price of water	-0.2226
		Median household income	0.3244
		Conservation trend	-0.0026
Power generation	Gross electric generation	2005 rate of water usage (gal/kWh)	0.93-591.1
Commercial & industrial	Employment	Cooling degree-days	0.5297
		Precipitation	-0.2766
		Conservation trend	-0.1262
		Health services empl. (%)	0.0618
		Retail empl. (%)	0.0740
		Manufacturing empl (%)	0.0098
		Percent self-supplied	0.0324
Irrigation & agriculture	Irrigated acres	Rainfall deficit (inches)	1.0000
	Livestock counts	Unit coefficients (gal/animal)	0.03-35.0
Domestic self-supplied	Population	Unit coefficient (gal/per capita)	82.0

Note: Elasticity values describe the degree to which a change in an explanatory variable changes water demand.

may be dealt with in a variety of ways when looking into the future. One approach is to "predict" future weather by using the climatic normals, as calculated by the National Center for Climatic Data (NCDC). Climatic normals are defined as the "statistical average over a time period usually consisting of three consecutive decades." The current climatic normals are defined as the average for the period 1971-2000. The averaging of the past weather data means that no inter-annual variation is taken into account in the water demand models (Figure B). In effect, this assumes that the average weather from the historical 30-year period can be used to estimate the future demand. On the one hand this approach firmly connects the forecast to the historical record. On the other hand, by representing the future as the average of the 30-years of record we lose the extremes that cause much of the variation in demand.

It was decided by the ISWS and technical committee of the RWSPC that the demand models would use climatic normal data as the future weather variables. The climatic normal method was chosen so that the general trend of water demand could be understood. By using normal weather data in the future, the annual variation, as seen the historic reported withdrawals, is not seen in the future estimates. Because normal climatic data were used in estimating future water withdrawals, for any given year in the future (or the past) the water demand estimates will not match the actual water withdrawn. This is particularly true of extreme years, such as 2005, where in some parts of the region the temperature and precipitation were considerably different from normal weather. What is revealed by this study is the *average* water withdrawals from 2010 to 2050.

Another implication of using normal weather data to estimate future water withdrawals, is that the future looks different than the past. In most of the future withdrawal graphs shown in this report there is a linear-type increase from 2010 to 2050 (Figure C). But, the historical data show variation from year to year; an increase in withdrawals one year and a decrease the next. The fluctuation in the historical data is due, in part, to the variation in weather patterns from year to year and study area to study area. A good example of this is 2005. Because 2005 was relatively hotter and drier than other years (particularly in some study areas), the water withdrawals for that year are higher than expected compared to normal historical growth. When 2005 reported data are compared to the model generated data which is calculated with normal (1971-2000) weather data, 2005 reported data are often higher than future withdrawal estimates. This is because of the anomalous weather pattern that year. What you see often in the graphs reported in this report is a decrease from reported 2005 values to the estimated 2010 withdrawals (Figure C). This is not a modeling error or under-prediction, this is due to the drought conditions evident in 2005. For this reason, this report often compares future withdrawal estimates to 2005 values generated by the model using normal (1971-2000) weather data. The following terms are used throughout the

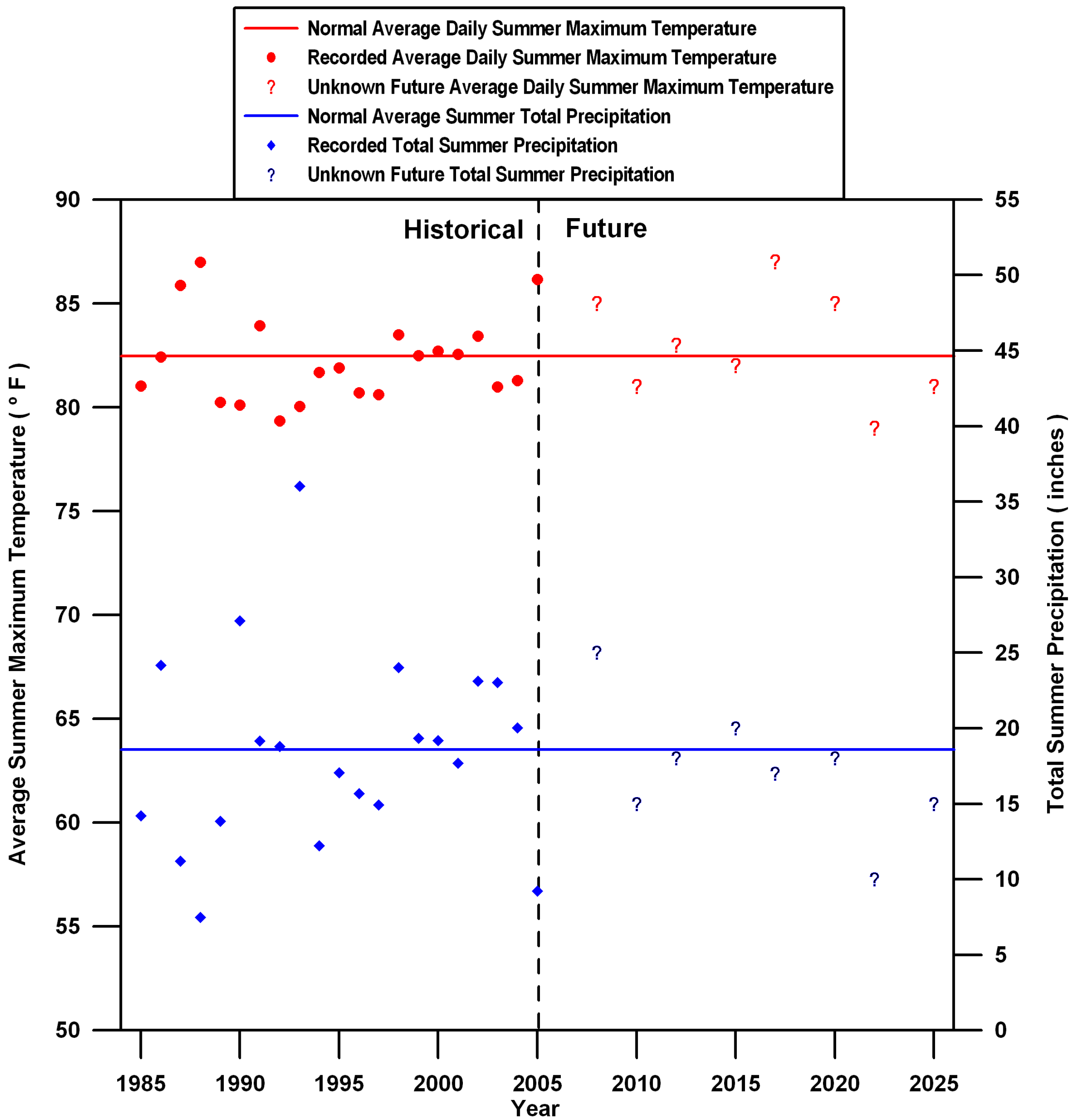

Figure B: Example of normal versus recorded weather data.

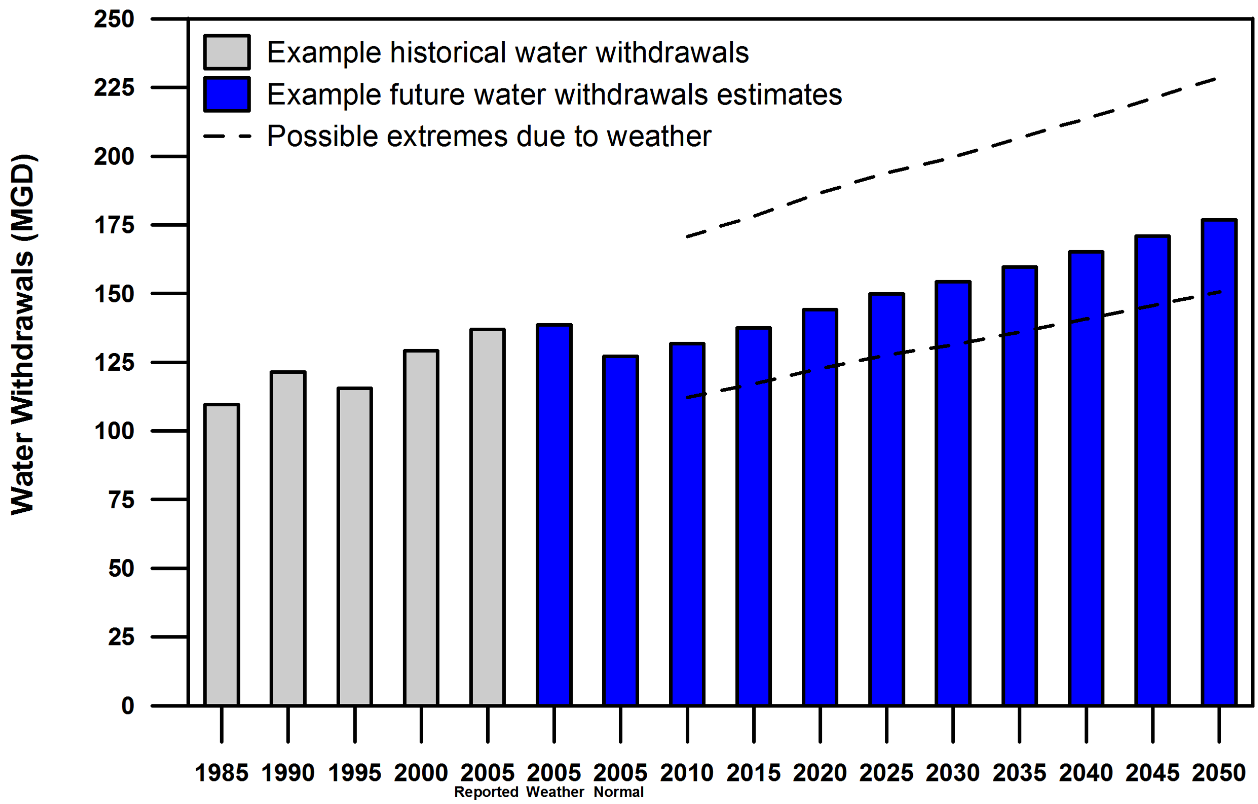

Figure C: Example of the effects of using climatic normal temperature and precipitation.

report.

2005 Normal 2005 model generated value using normal (1971-2000) weather data.

2005 Reported 2005 value reported from the original data source; not a modeled value.

2005 Weather 2005 model generated value using actual weather data from 2005.

As Figure C also shows with the dashed line, on any given year, the water withdrawals may be higher or lower than the estimated withdrawals due to natural variation in the weather in the future. This is important to remember when looking at graphs of future estimates throughout this report.

Public and self-supplied domestic water supply sector

The public and self-supplied domestic water supply sector includes the water withdrawals for domestic residential and community use and/or consumption. This sector includes the water withdrawals that are 1) treated and served to the public from a central location, such as a water utility, and 2) self-supplied domestic withdrawals which involves a homeowner with a private well that provides water to his/her own property.

For all other water sectors in this study, water withdrawal is examined only on a county level. For the public supply sector, additional study areas were selected for each county in order to more accurately estimate water withdrawals in these areas. A total of 26 municipalities were selected (Figure D). In addition, PWS water withdrawals were estimated in the 15-county rural areas which represent the balance of county areas outside the 26 selected municipalities.

Public water supply water withdrawals

The future public water supply (PWS) water withdrawals were estimated using multiple regression. The general purpose of multiple regression is to learn about the relationship between several independent variables (*e.g.* temperature, income, etc.) and a dependent variable (*e.g.* per capita water withdrawals). For the public water supply sector, a log-linear model was created to capture the relationship between per capita water demand and six independent variables. The six variables used were temperature, precipitation, marginal price, median household income, employment/population ratio, and conservation trend. The resulting equation was then used to estimate the future water withdrawals.

Water withdrawals were estimated for the three scenarios; BL, LRI, and MRI. The three future scenarios are designed to capture a range of future conditions of water demand for public supply water withdrawals which would result in lower and higher values of future water withdrawals by this sector based upon various specific assumptions (Table C).

The results for public water supply scenarios is shown in Figure E and Table D. Under the baseline scenario, the total public supply withdrawals are projected to increase from 127.2 MGD in 2005 (Normal) to 176.9 MGD in 2050 (Table D). This represents an increase of 49.6 MGD or 39.0 percent. Under the LRI scenario the withdrawals would increase to 153.5 MGD by 2050. This represents an increase of 14.0 MGD or 20.6 percent. Under the MRI scenario the withdrawals would increase to 185.4 MGD by 2050. This represents an increase of 58.1 MGD or 45.7 percent.

Self-supplied domestic water withdrawals

The self-supplied domestic water withdrawals were estimated using a unit-use coefficient method. For this calculation, the number of people in each county that supply their own water via private wells was multiplied by an average daily use (82 gallons per day per person). The self-supplied

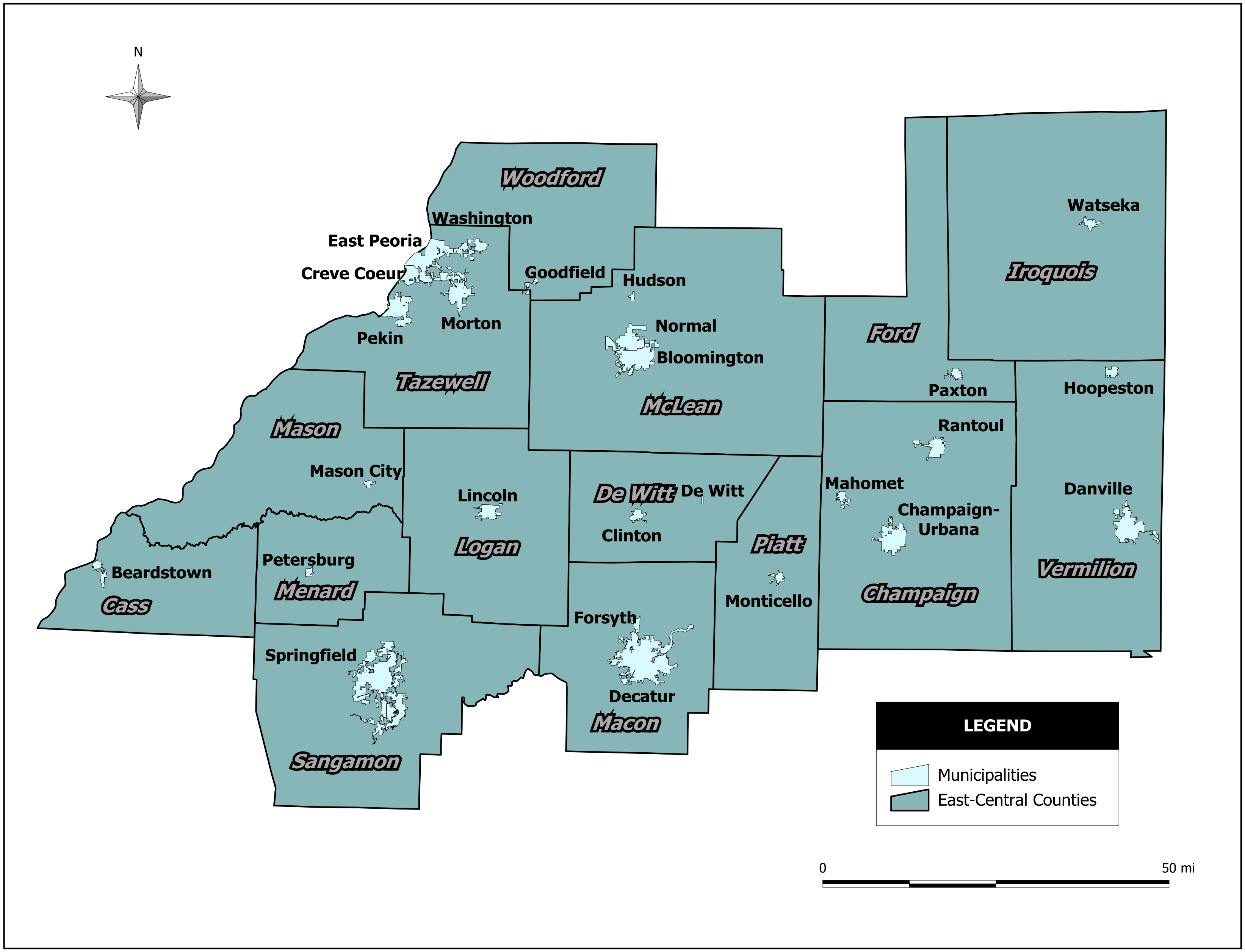

Figure D: Map of 26 public water supply study areas modeled in addition to the 15 counties within the East-Central Region.

Table C: Factors affecting future water demands in the public water supply sector in East-Central Illinois for each of scenarios.

Factor	Scenario 1- Baseline (BL)	Scenario 2- Less Resource Intensive (LRI)	Scenario 3 – More Resource Intensive (MRI)
Total population	DCEO projections	DCEO projections	DCEO projections
Median household income	Existing projections of 0.7 %/year growth	Existing projections of 0.5 %/year growth	Higher growth of 1.0%/years
Water conservation	Gradually reduced to 10% of the historical trend by 2050	Gradually reduced to 10% of the historical trend by 2050	Historical trend removed
Future water prices	Prices held at 2005 level in real terms	Conservation oriented future price increases (1.5%)	Prices held at 2005 level in real terms
Weather (air temperature and precipitation)	30-year normal (1971-2000)	30-year normal (1971-2000)	30-year normal (1971-2000)

Table D: Public water supply results for the baseline (BL), less resource intensive (LRI), and more resource intensive (MRI) scenarios.

Year	Population served	BL withdrawals (MGD)	LRI withdrawals (MGD)	MRI withdrawals (MGD)
2005 (Weather)	946,821	138.9	138.9	138.9
2005 (Normal)	946,821	127.2	127.2	127.2
2010	978,207	131.9	129.9	132.6
2015	1,012,168	137.6	133.5	139.1
2020	1,050,932	144.2	137.8	146.5
2025	1,081,997	149.9	141.0	153.1
2030	1,101,919	154.3	142.9	158.4
2035	1,129,372	159.7	145.6	164.9
2040	1,156,613	165.2	148.2	171.4
2045	1,184,582	171.0	150.8	178.2
2050	1,213,300	176.9	153.5	185.4
Difference from 2005 (Normal) to 2050				
Unit	266,479	49.6	26.3	58.1
Percent (%)	28.1	39.0	20.6	45.7

MGD = million gallons per day

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

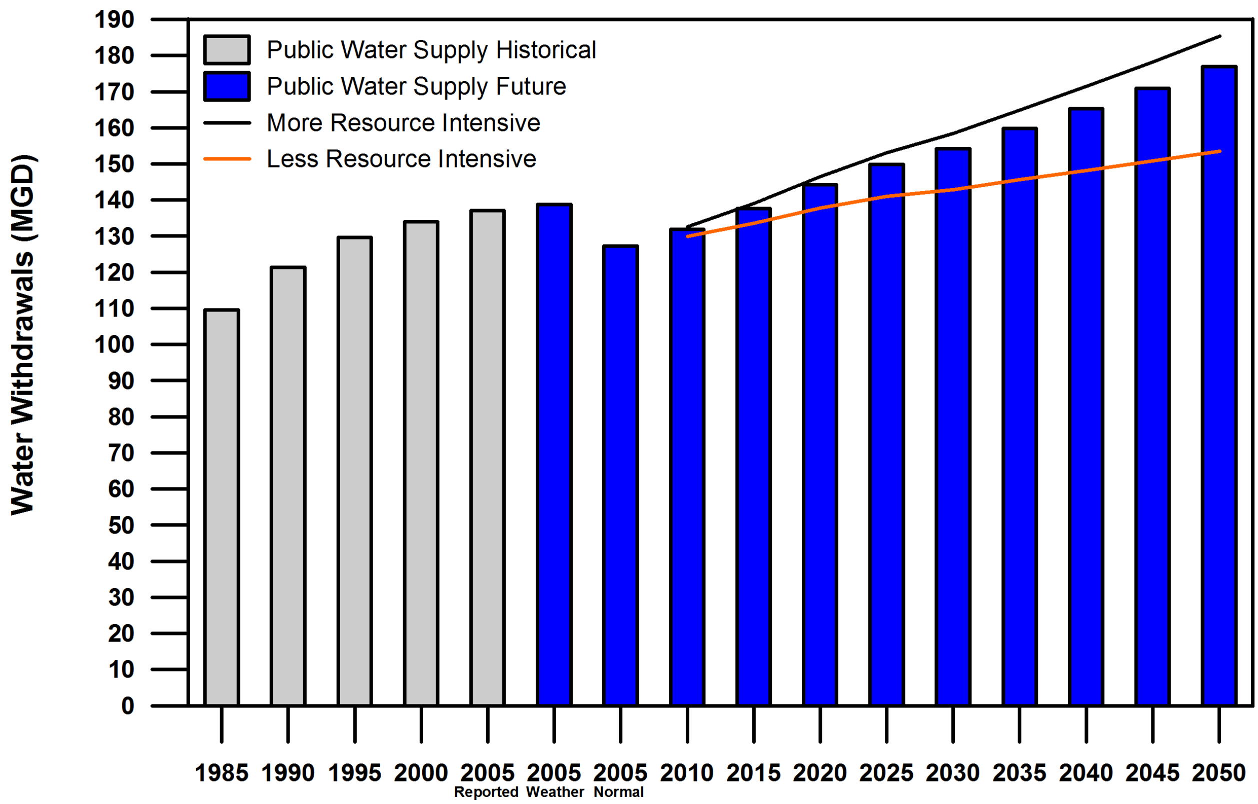

Figure E: Future water withdrawals for the public water supply sector.

Table E: Total withdrawals for the self-supplied domestic water sector, 2005-2050.

Year	Total self-supplied domestic population	Total self-supplied domestic withdrawals (MGD)
2005	108,076	8.9
2010	121,510	10.0
2015	125,363	10.3
2020	129,539	10.6
2025	132,847	10.9
2030	135,267	11.1
2035	137,249	11.3
2040	140,237	11.5
2045	143,290	11.7
2050	146,421	12.0
Difference from 2005 to 2050		
Unit	38,345	3.1
Percent (%)	35.5	35.5

Assumed water withdrawal rate of 82 gallons per person per day.

domestic population was calculated by subtracting the future total population served by a PWS system within a county from the future total county population. The total self-supplied domestic population is expected to increase by 38,345 people from 108,076 in 2005 to 146,421 in 2050 (Table E). The withdrawals are projected to increase from 8.9 MGD in 2005 to 12.0 MGD in 2050 (Figure F). This represents an increase of 3.1 MGD or 35.5 percent.

Power generation sector

Water withdrawn by power plants is classified by the United States Geological Survey (USGS) as thermoelectric generation water use. It represents the water applied in the production of heat-generated electric power. The heat sources may include fossil fuels such as coal, petroleum, natural gas, or nuclear fission. The main use of water at power plants is for cooling. Nearly 90 percent of electricity in the United States is produced with thermally-driven, water-cooled generation systems which require large amounts of water.

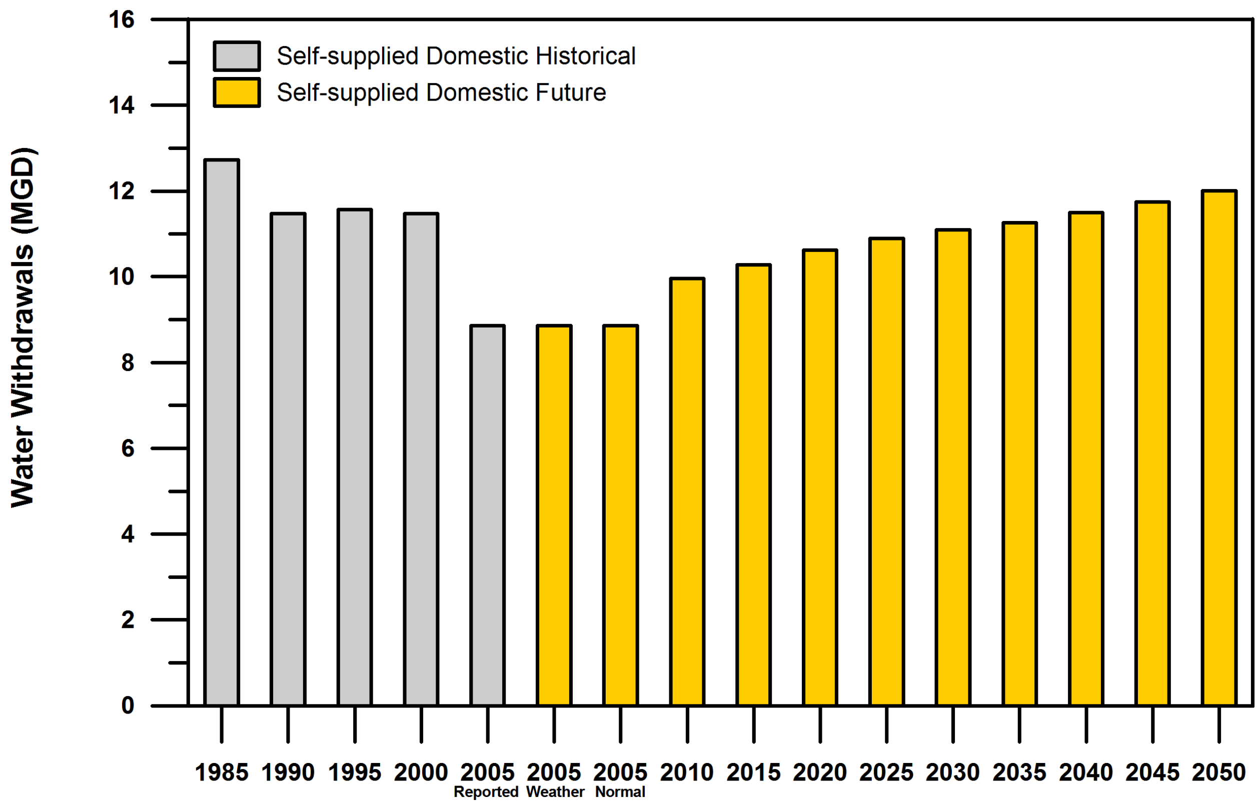

Figure F: Future water withdrawals for the self-supplied domestic sector.

The USGS National Water Use Information Program reported significant thermoelectric withdrawals from six power plants in five of the fifteen counties in East-Central Illinois. Although relative to the other water sectors, the volume of water withdrawals for power generation is large, it is important to note that much of the water is returned to the source and is available for re-use by others.

The plants in the region are separated into two groups: once-through open cycle and closed-loop make-up water intake plants. Once-through flow plants pump water directly to the condensers and almost immediately return it back to the river or lake. Closed-loop make-up water plants withdraw water to replace losses and blowdown in cooling towers and/or water losses from perched lakes or ponds. This division of plants provides for a better consistency in representing non-consumptive and consumptive water withdrawals for power production. Water withdrawn by once-through plants is considered non-consumptive use since nearly all water withdrawn is returned to the source. Because of evaporative losses in cooling towers, withdrawals by closed-loop make-up water plants represent a sum of both consumptive and non-consumptive use and are comparable with withdrawals by the industrial/commercial and agricultural sectors.

There is no accurate or predictable correlation between local demand for power and local generation, either now or in the future, due to the nature of the electric power market. Increasing future electric demand may not be met by the six plants currently within the study area. The demand may be met with power generated outside the study area, or with power generated inside the study area by alternate means, such as gas turbines, wind turbines, solar, etc. For this study, we were unable to correlate demand for electricity within the region to electricity production. Additionally, we were unable to correlate regional and national demand for electricity to production in the region due to the lack of data. So for the three scenarios, specific assumptions were made that related to how the existing and new plants would be run. For example, in the LRI scenario it was assumed that the oldest generating units would become prohibitively expensive to run and would, therefore, be put on standby. In the MRI scenario, a new closed-loop plant was added in Woodford County (Table F).

A straightforward unit-coefficient method was used in this study to derive future quantities of water withdrawals. This method represents cooling water demand as the product of total gross generation at the plant and the unit rate of water required in gallons per kilowatt-hour (gal/kWh). For each of the six power generation plants, the 2005 rate of water usage (gal/kWh) was applied to future years under the three scenarios along with the scenario assumptions. Additionally, one of the existing plants is expected to be replaced in 2010 with a new closed-loop plant.

Under the baseline scenario, between 2005 and 2050, total withdrawals would decline by 39.8

Table F: Factors affecting future water demands for power generation in East-Central Illinois for each of scenarios.

Factor	Scenario 1- Baseline (BL)	Scenario 2- Less Resource Intensive (LRI)	Scenario 3 – More Resource Intensive (MRI)
Power generation	No new power plants within study area	Older generating units put on standby	New power plant in study area with cooling towers

Note: The demand for electricity does not correlate to electricity production within the East Central Region.

MGD or 3.0 percent (Table G and Figure G).

In the LRI scenario, the older Havana (Units #1-5) and Vermilion (Units #1-2) units are put on stand by between 2020 and 2040 (Table G). Overall, between 2005 and 2050, total withdrawals would decline by 97.6 MGD or 7.4 percent.

In the MRI scenario, the assumed addition of one clean coal plant with closed-loop cooling would increase make-up water demand by 66.8 MGD in 2030 (Table G). The sum effect would be that the total withdrawals would decline by 26.9 MGD or 2.0 percent between 2005 and 2050.

It is important to note that while the thermoelectric power generation sector requires large quantities of water, the overall consumptive use of water is small. In once-through cooling systems, as much as 99 percent of water withdrawn can be returned back to the source. Closed-loop systems with cooling towers require smaller withdrawals (on average approximately 5 percent or less of the volumes withdrawn by once through cooling systems), however, between 30 to 70 percent of that smaller volume could be consumed due to evaporation.

Commercial & industrial sector

The commercial and industrial (C&I) sector represents water withdrawals that are self-supplied or purchased (*i.e.*, water delivered by a public water supply) to commercial, industrial, and other nonresidential establishments. The industrial sub-sector includes "water used for industrial purposes such as fabrication, processing, washing, and cooling, and includes such industries as steel, chemical and allied products, paper and allied products, mining, and petroleum refining." The commercial sub-sector includes water used for "motels, hotels, restaurants, office buildings, other commercial facilities, and institutions" (Avery, 1999).

Table G: Electric power generation and water withdrawals for the baseline (BL), less resource intensive (LRI), and more resource intensive (MRI) scenarios in East-Central Illinois.

Year	BL Scenario		LRI Scenario		MRI Scenario	
	generation (MWh/year)	withdrawals (MGD)	generation (MWh/year)	withdrawals (MGD)	generation (MWh/year)	withdrawals (MGD)
2005	25,624,970	1,315.4	25,624,970	1,315.4	25,624,970	1,315.4
2010	26,709,115	1,275.5	26,709,115	1,275.5	26,709,115	1,275.5
2015	26,709,115	1,275.5	26,709,115	1,275.5	26,709,115	1,275.5
2020	26,709,115	1,275.5	26,404,463	1,263.4	26,709,115	1,275.5
2025	26,709,115	1,275.5	26,397,671	1,252.4	26,709,115	1,275.5
2030	26,709,115	1,275.5	26,390,879	1,241.4	30,979,615	1,342.4
2035	26,709,115	1,275.5	25,978,997	1,228.8	30,979,615	1,342.4
2040	26,709,115	1,275.5	25,972,205	1,217.8	30,979,615	1,342.4
2045	26,709,115	1,275.5	25,972,205	1,217.8	30,979,615	1,342.4
2050	26,709,115	1,275.5	25,972,205	1,217.8	30,979,615	1,342.4
Difference from 2005 to 2050						
Unit	1,084,145	-39.8	347,235	-97.6	5,354,645	26.9
Percent %	4.2	-3.0	1.4	-7.4	20.9	2.0

MWh/year = mega watt hour per year; MGD = million gallons per day

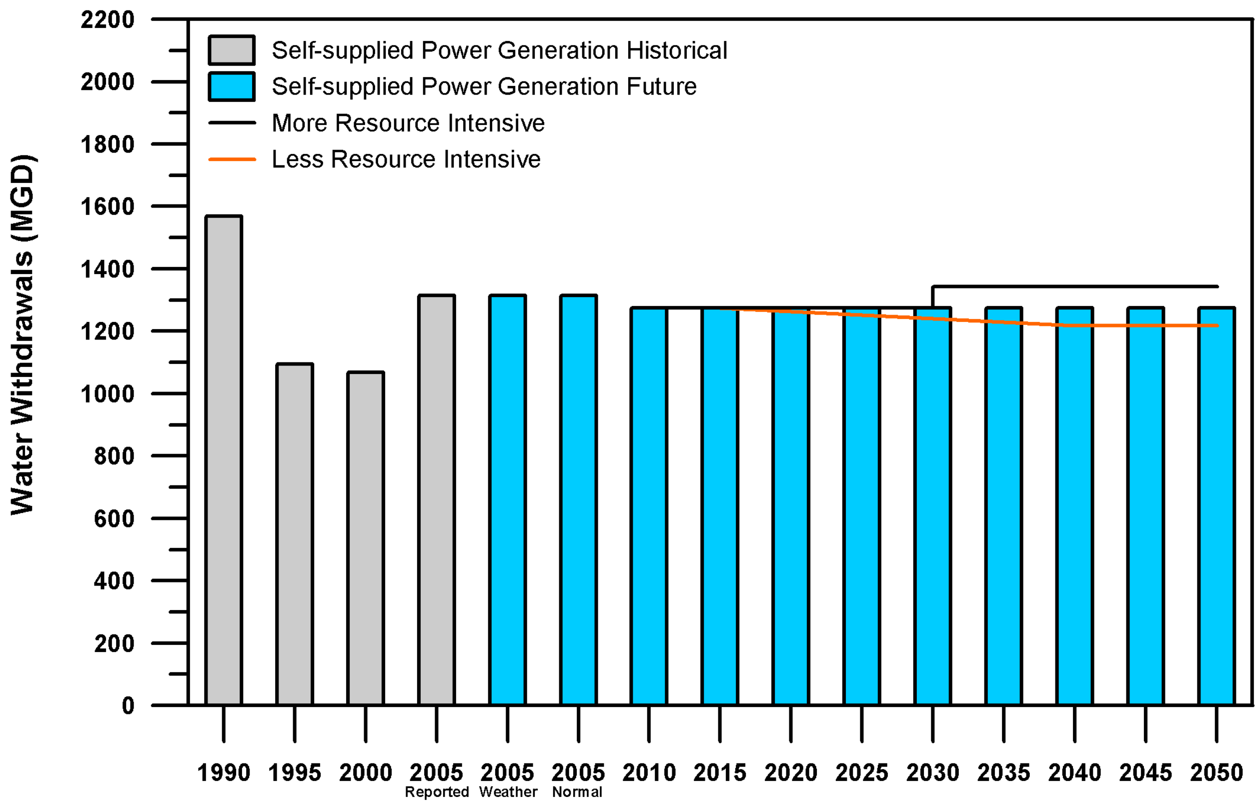

Figure G: Future water withdrawals for the power generation sector.

The future C&I water withdrawals were estimated using multiple regression. The general purpose of multiple regression is to learn about the relationship between several independent variables (*e.g.* temperature, cooling degree days, etc.) and a dependent variable (*e.g.* per capita water withdrawals). For the commercial and industrial sector, a log-linear model was created to capture the relationship between per employee water withdrawals and total county employment, annual cooling degree days, total precipitation during summer (May 1 through September 30), percent of employment in health services, percent of employment in retail trade, percent of employment in manufacturing, percent of self-supplied commercial and industrial water demand, and a conservation trend variable. The resulting equation was then used to estimate the future water withdrawals.

Because of the nationwide growth in ethanol production and the increase in the number of ethanol facilities, ethanol facilities were used to represent any new large industrial users of water for the East-Central Illinois region. While ethanol production is currently the anticipated new water demand, it is understood by the authors that ethanol may not be the only new industrial user and may not reach the anticipated growth rate. Therefore, in this study, demands created by future ethanol facilities are used to understand how a large new water demand may impact the region. For the purposes of this report, is was assumed that eight new ethanol facilities would be built within the region. The water use associated with these new large industrial users was assumed to be the rates of water use for ethanol production.

Water withdrawals were estimated for the three scenarios; BL, LRI, and MRI. The three future scenarios are designed to capture a range of future conditions of water demand for C&I withdrawals which would result in lower and higher values of future water withdrawals by this sector based upon various specific assumptions (Table H).

The estimated future water demands under each of the three scenarios for the entire 15-county study area are summarized in Table I and Figure H. Under the baseline scenario, self-supplied commercial and industrial (including mining) withdrawals are projected to increase from 63.7 MGD in 2005 to 137.5 MGD in 2050. This represents an increase of 73.8 MGD or 115.9 percent. The total self-supplied withdrawals in 2050 will be 21.3 MGD lower under the LRI scenario and 41.0 MGD higher under the MRI scenario as compared to the BL scenario results.

Irrigation & agriculture sector

The irrigation and agriculture (IR&AG) sector includes self-supplied withdrawals of water for irrigation of cropland and golf courses as well as water for livestock. The IR&AG sector represents a significant component of total water demand especially in the counties with large proportions of

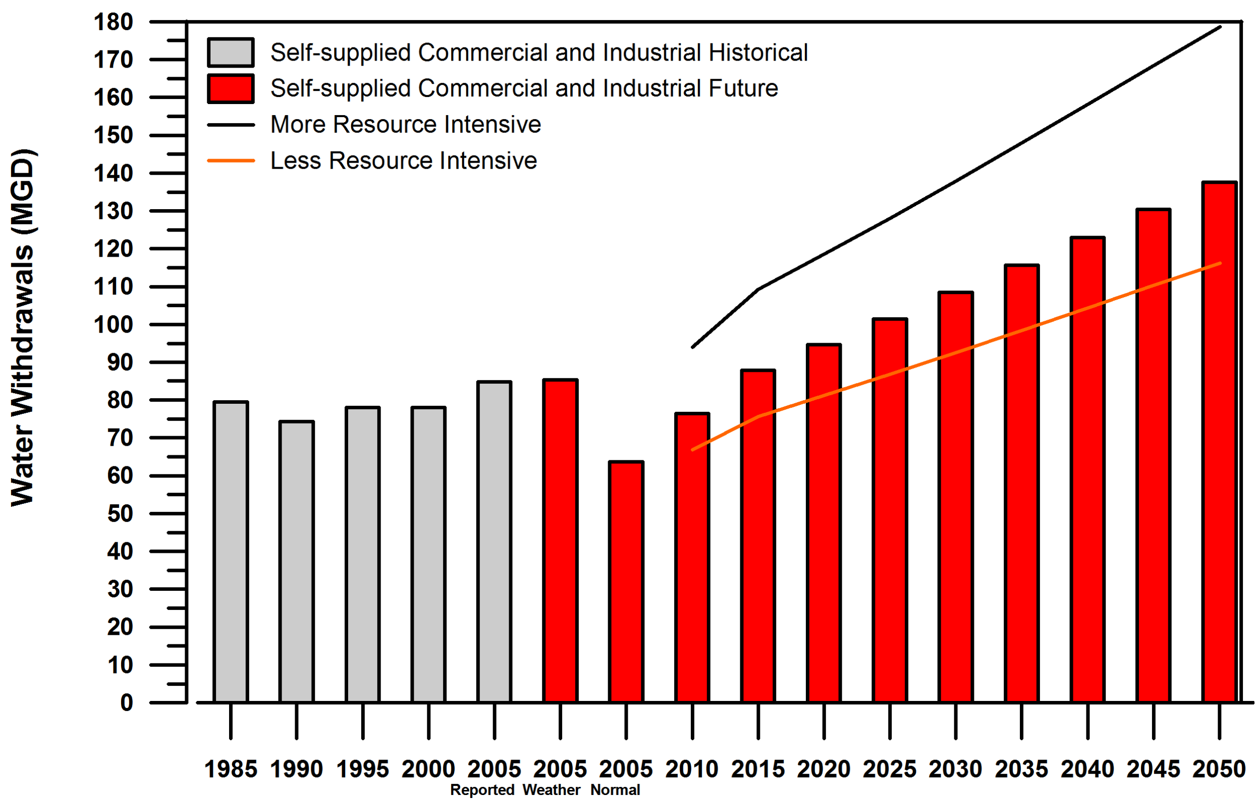

Figure H: Future water withdrawals for the commercial and industrial sector.

Table H: Factors affecting future the commercial and industrial water demands in East-Central Illinois for each of scenarios.

Factor	Scenario 1- Baseline (BL)	Scenario 2- Less Resource Intensive (LRI)	Scenario 3 – More Resource Intensive (MRI)
Employment population	IDES projections	IDES projections	IDES projections
New ethanol facilities	4 gallons of water per gallon EtOH produced	3 gallons of water per gallon EtOH produced	5 gallons of water per gallon EtOH produced
Mix of commercial/ industrial activities	IDES projections	IDES projections	IDES projections
Water conservation	Continuation of historical trend	30% higher than historical trend	50% lower than historical trend
Weather (cooling degree days and precipitation)	30-year normal (1971-2000)	30-year normal (1971-2000)	30-year normal (1971-2000)

land in irrigated cropland.

Water withdrawals for livestock use were estimated using a unit-use coefficient method. For this calculation, the type and number of animals in each county was multiplied by an average daily use. Estimates of future livestock numbers were generated based on baseline rates of growth projected by the U.S. Department of Agriculture Economic Research Service (USDA).

Water withdrawals for irrigation were calculated using the ISWS / USGS method of multiplying the number of irrigated acres times the annual rainfall deficit. The rainfall deficit is assumed to be the amount of water that is applied to cropland or golf courses to supplement precipitation in the growing season. For future years, the estimates of water irrigation are based on normal (average 1971-2000) rainfall deficit which depends on the distribution of weekly precipitation during the summer irrigation season (May through August). The rainfall deficit for each county was estimated for each irrigation season from 1985 to 2005 using the ISWS/USGS method.

Data on irrigated cropland are collected and reported by the U.S. Department of Agriculture. For future estimates of irrigated cropland, it was assumed that irrigated cropland for all counties (except Mason, Tazewell, and Cass counties) would increase at the region-wide historical rate of 1.05 percent per year. For Mason, Tazewell, and Cass counties the Imperial Valley Water Authority, local Farm Services Agencies, and Farm Bureau personnel provided estimates of the future amount

Table I: Results for commercial and industrial sector for the baseline (BL), less resource intensive (LRI), and more resource intensive (MRI) scenarios for East-Central Illinois, 2005-2050.

Year	Employment population	BL withdrawals (MGD)	LRI withdrawals (MGD)	MRI withdrawals (MGD)
2005 (Weather)	530,114	85.3	85.3	85.3
2005 (Normal)	530,114	63.7	63.7	63.7
2010	548,769	77.8	67.8	94.0
2015	567,424	87.9	75.7	109.2
2020	586,079	94.7	81.2	118.6
2025	604,734	101.4	86.7	128.0
2030	623,389	108.4	92.5	137.8
2035	642,044	115.7	98.4	147.9
2040	660,699	123.0	104.4	158.2
2045	679,354	130.4	110.4	168.4
2050	698,009	137.5	116.2	178.5
Difference from 2005 (Normal) to 2050				
Unit	167,895	73.8	52.5	114.8
Percent (%)	31.7	115.9	82.4	180.2

MGD = million gallons per day

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

Table J: Factors affecting future agriculture and irrigation water demands in East-Central Illinois for each of scenarios.

Factor	Scenario 1- Baseline (BL)	Scenario 2- Less Resource Intensive (LRI)	Scenario 3 – More Resource Intensive (MRI)
Irrigated land*	Regional irrigated cropland growth rate (1.05% per year)	75% of irrigated cropland growth rate (0.79% per year)	125% of irrigated cropland growth rate (1.31% per year)
Livestock	Baseline USDA growth rates	Baseline USDA growth rates	Baseline USDA growth rates
Weather (air temperature and precipitation)	30-year normal (1971-2000)	30-year normal (1971-2000)	30-year normal (1971-2000)

*Growth rates do not apply to Mason, Tazewell, and Cass counties; these growth rates are discussed in Chapter 5.

of irrigated acres.

Water withdrawals were estimated for the three scenarios; BL, LRI, and MRI. The three future scenarios are designed to capture a range of future conditions of water demand for IR&AG withdrawals which would result in lower and higher values of future water withdrawals by this sector based the specific assumptions summarized in Table J.

The estimated future irrigated acres and water withdrawals under each of the three scenarios for the entire 15-county study area are summarized in Table K and Figure I. Under the baseline scenario, irrigation and agriculture withdrawals are projected to increase from 139.4 MGD in 2005 to 186.5 MGD in 2050. This represents an increase of 47.0 MGD or 33.8 percent. Under the LRI scenario the withdrawals would increase to 177.2 MGD by 2050. This represents an increase of 37.8 MGD or 27.1 percent. Under the MRI scenario the withdrawals would increase to 195.8 MGD by 2050. This represents an increase of 56.4 MGD or 40.4 percent.

Impacts of climate change and drought

Climate change refers to significant changes in climate parameters, like precipitation, temperature, and wind, that would last for long periods of time, like a decade or longer. Climate change may result from any individual or a combination of natural factors (i.e., change in sun intensity or

Table K: Summary of irrigated acres and irrigation and agriculture water withdrawals for the baseline (BL), less resource intensive (LRI), and more resource intensive (MRI) scenarios in East-Central Illinois.

Year	BL Scenario		LRI Scenario		MRI Scenario	
	irrigated acres	withdrawals (MGD)	irrigated acres	withdrawals (MGD)	irrigated acres	withdrawals (MGD)
2005 (Weather)	–	236.8	–	236.8	–	236.8
2005 (Normal)	180,255	139.4	180,255	139.4	180,255	139.4
2010	210,274	162.4	200,459	155.0	220,094	169.7
2015	222,602	171.9	211,977	163.9	233,241	179.8
2020	234,834	181.3	223,418	172.7	246,276	189.9
2025	236,082	182.5	224,444	173.8	247,760	191.3
2030	237,207	183.6	225,378	174.7	249,089	192.5
2035	238,196	184.5	226,214	175.5	250,245	193.6
2040	239,042	185.3	226,946	176.2	251,214	194.5
2045	239,739	186.0	227,572	176.8	251,986	195.2
2050	240,284	186.5	228,091	177.2	252,558	195.8
Difference from 2005 to 2050						
Unit	60,029	47.1	47,836	37.8	72,303	56.4
Percent %	33.3	33.8	26.5	27.1	40.1	40.4

MGD = million gallons per day

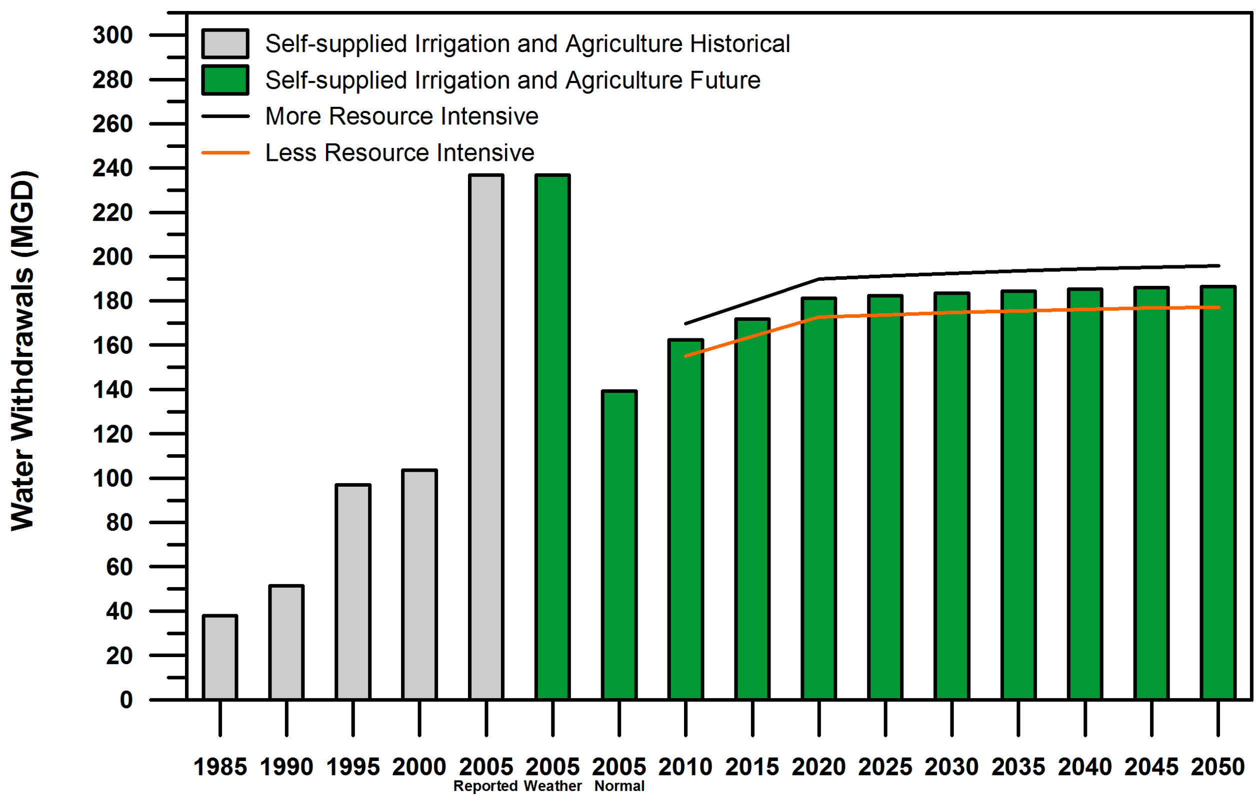

Figure I: Future water withdrawals for the irrigation and agriculture sector.

changes in Earth's orbit around the sun), natural processes (i.e., changes in ocean circulation, and volcanic eruptions), or human activities that impact atmosphere composition (i.e., burning of fossil fuels) or land surface (i.e., urbanization, deforestation, and desertification).

With the increase of greenhouse gases and rising global average temperature, many climate models have been developed throughout the world to model future changes in climate. The ISWS used the outputs from many of these existing global climate model runs to download climate scenarios specifically for Illinois to 2050. These include a possible average annual temperature departure from the 1971-2000 long-term normal of up to $+6^{\circ}F$ in Illinois. and a possible Illinois departure from 1971-2000 normal annual precipitation in a range from -5 inches to +5 inches per year.

Future water withdrawals will be affected by the anticipated changes in temperature and precipitation. The changes in annual temperature and precipitation also result in changes during the growing season. We assume the temperature increase of $6^{\circ}F$ will also apply to the summer growing season. We assume that the distribution of precipitation will range from +2.5 inches to -3.5 inches during the growing season. The effects of these changes will vary by water sector depending on the sensitivity of water demand to air temperature and precipitation. The specific assumptions about the changes in weather variables are discussed separately for each of the major water sectors in Chapter 6. The effect of climate change on water withdrawals for each water demand sector are summarized in Table L. The model suggests that if temperature increases, then water withdrawals will also increase. The effect is even greater when temperature increases and precipitation decreases. Conversely, if precipitation increases and temperature does not, water withdrawals may decrease.

Another type of climate impact on water demand is the effect of periodic droughts. In the future, in addition to possible changes in mean annual temperature and precipitation, it can be expected that periodic droughts will occur. While the severity and duration of future droughts is not known, their impact on water demand in the pubic supply sector can be determined by examining historical droughts. The most severe historical droughts in Illinois took place in the 1930s and 1950s. These were multi-year droughts which were associated with growing season precipitation deficits during the driest year of approximately 40 percent below normal.

For purposes of this analysis, it was assumed that during future droughts the normal (1971-2000) precipitation for the growing season would be reduced by 40 percent to represent a worst-case historical drought. Table M shows the results for average day water demand in each water sector under the conditions of a worst-case historical drought. The total water withdrawals for all sectors (except power generation) would increase by 106 MGD relative to the baseline scenario

Table L: Effects of possible climate change on water withdrawals (in MGD)

Weather scenario/ sector	2005 (Normal) withdrawals (MGD)	2030 withdrawals (MGD)	2050 withdrawals (MGD)	Change from BL in 2050
Baseline (BL) scenario				
Public-supply	127.2	154.3	176.9	–
Self-supplied C&I	63.7	108.1	137.5	–
Irrigation and agriculture	139.4	183.6	186.5	–
All sectors (w/o power)	330.3	446.0	500.9	–
$+6^{\circ}F$ temperature only				
Public-supply	127.2	163.2	195.6	18.7
Self-supplied C&I	63.7	119.5	175.7	38.2
Irrigation and agriculture	139.4	189.1	196.9	10.4
All sectors (w/o power)	330.3	483.2	579.6	78.7
$+2.5$” precipitation only				
Public-supply	127.2	152.1	174.4	-2.5
Self-supplied C&I	63.7	105.2	133.3	-4.2
Irrigation and agriculture	139.4	154.6	157.0	-29.5
All sectors (w/o power)	330.3	411.9	464.7	-36.2
-3.5” precipitation only				
Public-supply	127.2	157.8	181.0	4.1
Self-supplied C&I	63.7	102.6	144.8	7.3
Irrigation and agriculture	139.4	217.4	220.8	34.3
All sectors (w/o power)	330.3	489.2	546.6	45.7
$+6^{\circ}F$ temperature, $+2.5$” precipitation				
Public-supply	127.2	161.1	193.0	16.1
Self-supplied C&I	63.7	126.9	181.3	43.8
Irrigation and agriculture	139.4	160.5	167.9	-18.6
All sectors (w/o power)	330.3	448.5	542.2	41.3
$+6^{\circ}F$ temperature, -3.5” precipitation				
Public-supply	127.2	167.1	200.3	23.4
Self-supplied C&I	63.7	137.7	197.2	59.7
Irrigation and agriculture	139.4	223.1	231.4	44.9
All sectors (w/o power)	330.3	527.9	628.9	128.0

Table M: Effects of drought on water withdrawals (in MGD) in East-Central Illinois.

Weather scenario/ sector	2005 (Normal) withdrawals (MGD)	2030 withdrawals (MGD)	2050 withdrawals (MGD)	Change from BL in 2050
Baseline (BL) scenario				
Public-supply	127.2	154.3	176.9	–
Self-supplied C&I	63.7	108.1	137.5	–
Irrigation and agriculture	139.4	183.6	186.5	–
All sectors (w/o power)	330.3	446.0	500.9	–
Drought year (40 percent precipitation deficit)				
Public-supply	127.2	163.5	187.5	10.6
Self-supplied C&I	63.7	123.2	156.7	19.2
Irrigation and agriculture	139.4	259.0	263.0	76.5
All sectors (w/o power)	330.3	545.7	607.2	106.3

estimated with normal weather information. This means that on any given year, a drought could cause an increase of approximately 100 MGD.

Summary of results

The baseline scenario estimates the total water withdrawal to increase by 8.1% by the year 2050, from 1,654.6 MGD in 2005 to 1,788.4 MGD (Table N). Water withdrawals are expected to increase in all water demand sectors, except power generation (Table N). The power generation sector decreases water withdrawals in the baseline scenario because of the replacement of the Lakeside Plant with a new Dallman 4 Plant in Sangamon County which uses less water. Because power generation withdraws close to 80% of this total, it is useful to look at the changes in water withdrawals without including the power sector.

The water demand sectors, other than power generation, when totaled, increase by 173.6 MGD (51%) from 2005 to 2050 in the baseline scenario. This number is reduced to 119.7 MGD (35%) in the LRI scenario and increased to 232.5 MGD (69%) in the MRI scenario. These values underscore the importance of analyzing water demand and planning for the future. When the water demand increases are input into the groundwater and surface water supply models by the ISWS, the region will have a greater understanding of the demand placed on the regional water supply and the

Table N: Summary of water withdrawals in East-Central Illinois (in MGD).

Scenario/ Sector	2005 Normal (MGD)	2050 Modeled (MGD)	Change from 2005 (Normal) - 2050 (MGD)	Change from 2005 (Normal) - 2050 (%)
Baseline Scenario (BL)				
Public Supply	127.24	176.88	49.64	39.0
Self-supplied C&I	63.70	137.51	73.81	115.9
Self-supplied domestic	8.86	12.01	3.15	35.6
Irrigation and agriculture	139.40	186.46	47.06	33.8
Subtotal (w/o power)	339.20	512.86	173.66	51.2
Power generation	1,315.35	1,275.54	-39.81	-3.0
TOTAL	1,654.55	1,788.40	133.85	8.1
Less Resource Intensive Scenario (LRI)				
Public Supply	127.24	153.50	26.26	20.6
Self-supplied C&I	63.70	116.17	52.47	82.4
Self-supplied domestic	8.86	12.01	3.15	35.6
Irrigation and agriculture	139.40	177.21	37.81	27.1
Subtotal (w/o power)	339.20	458.89	119.69	35.3
Power generation	1,315.35	1,217.78	-97.57	-7.4
TOTAL	1,654.55	1,676.67	22.12	1.3
More Resource Intensive (MRI)				
Public Supply	127.24	185.36	58.12	45.7
Self-supplied C&I	63.70	178.52	114.82	180.2
Self-supplied domestic	8.86	12.01	3.15	35.6
Irrigation and agriculture	139.40	195.77	56.37	40.4
Subtotal (w/o power)	339.20	571.66	232.46	68.5
Power generation	1,315.35	1,342.37	27.02	2.1
TOTAL	1,654.55	1,914.03	259.48	15.7

C&I = Commercial and industrial water sector; w/o = without;

Note: All withdrawal values reported in million gallons per day (MGD) potential impacts to the resource and the region.

The total withdrawals for each county are shown in Table O. To compare the relative amounts withdrawn in each county in 2050, the percent of each demand sector are shown graphically in Figure J. DeWitt, Mason, Tazewell, and Sangamon counties all have withdrawals over 150 MGD. These large withdrawals are primarily due to the power generation plants within those counties. Ford, Iroquois, Logan, Menard, Piatt, and Woodford counties are all expected to have withdrawals less than 10 MGD.

Figure J shows that public water supply is the primary withdrawal sector in Champaign, McLean, Macon, and Vermilion counties, whereas irrigation and agriculture are the primary withdrawals in Cass, Mason, and Menard counties. Commercial and industrial water withdrawals are focused within Macon and Tazewell counties. Self-supplied domestic remains a very small portion of each county.

Uncertainty - data limitations, drought, and modeling

Like all modeling efforts, the process of modeling future water withdrawals and the withdrawals presented in this report have uncertainty associated with them. But, the importance of the regional water supply planning effort necessitates progress now, even with this uncertainty. Throughout this project, we have been confronted with three main types of uncertainty; data quality, drought, and modeling. These uncertainties are described below.

Data limitations

The water withdrawal data used in this regional water demand analysis were extracted from the Illinois Water Inventory Program (IWIP) of the ISWS. The IWIP database is a record of annual withdrawals for each of the reporting high capacity water users in the state. Every year, facilities are sent a questionnaire about the previous year's annual water withdrawals. Participation, while for some sectors is high (90% of participating facilities in 2005), is voluntary. Additionally, the water withdrawals for commercial, industrial, and power generation facilities are considered confidential and not available to the public. These characteristics of the database lead to problems with data quality:

- Under reporting - not all facilities report every year and/or some facilities never report.
- Not all water sectors are included - irrigation is not reported in the database.

Table O: Future withdrawals for each county, by demand sector, for the year 2050 (in MGD) for the baseline scenario.

County	Public water supply (MGD)	Domestic (MGD)	Power generation (MGD)	Commercial & industrial (MGD)	Irrigation & agriculture (MGD)	Total (MGD)
Cass	2.32	0.44	–	3.16	15.84	21.76
Champaign	33.62	2.56	–	9.74	6.15	52.07
DeWitt	1.83	0.4	810.44	0.03	0.94	813.64
Ford	2.25	0.25	–	6.54	0.92	9.96
Iroquois	3.3	0.96	–	1.48	3.25	8.99
Logan	3.99	0.71	–	2.82	2.08	9.59
Macon	31.33	0.21	–	26.59	0.41	58.54
Mason	0.95	0.55	105.00	7.48	108.26	222.24
McLean	24.07	1.55	–	2.07	2.15	29.85
Menard	1.04	0.02	–	0.00	3.09	4.16
Piatt	1.42	0.46	–	1.56	0.49	3.94
Sangamon	31.74	1.54	331.46	7.93	1.64	374.31
Tazewell	25.39	0.12	25.88	62.05	39.14	152.59
Vermilion	10.52	0.66	2.76	6.04	0.72	20.71
Woodford	3.08	1.58	–	0.02	1.39	6.06
Total	176.88	12.01	1,275.54	137.51	186.46	1,788.40

All data reported in million gallons per day (MGD).

All sectors, except public water supply, are self-supplied

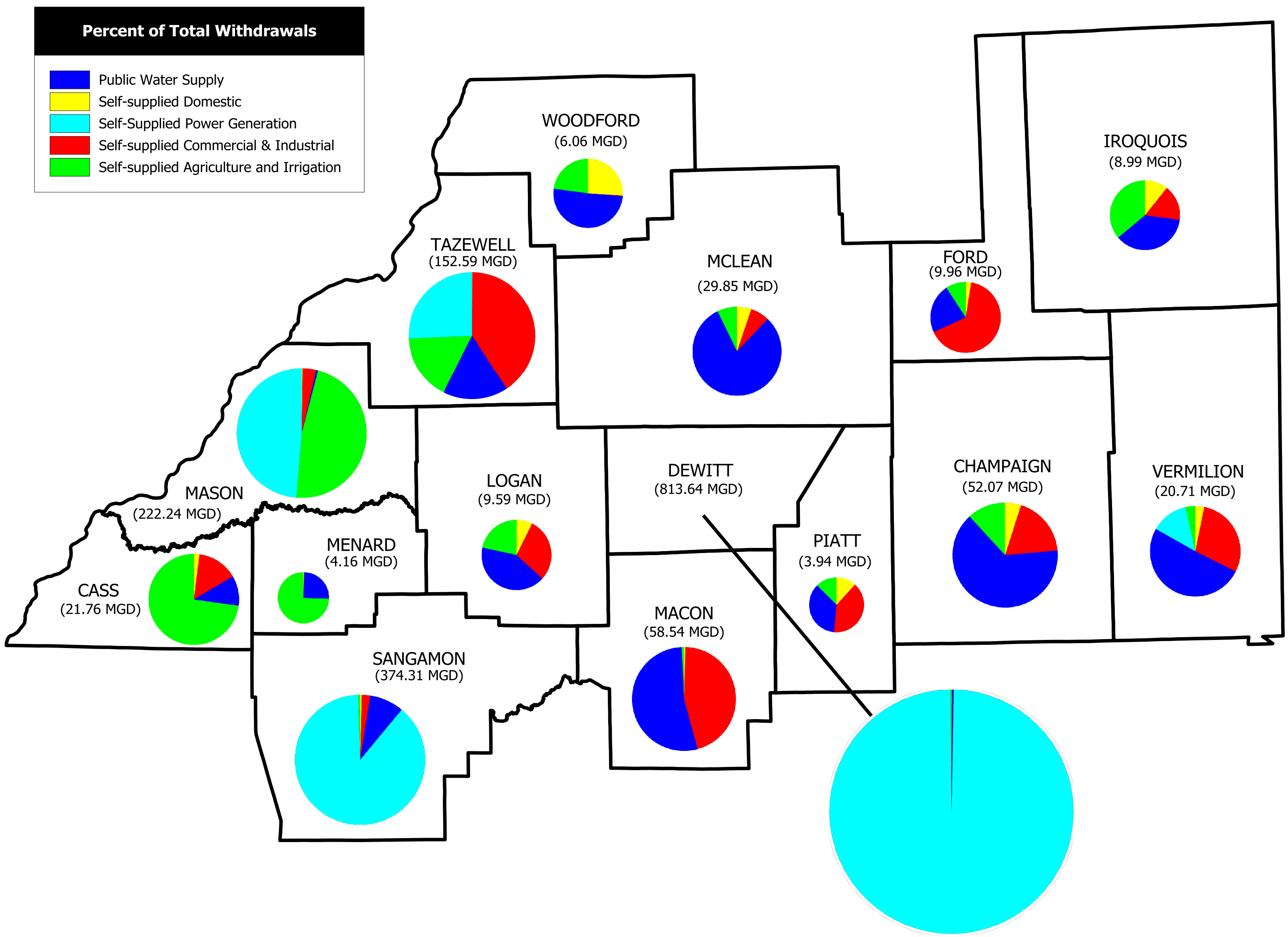

Figure J: County water withdrawals in East-Central Illinois in 2050 by demand sector for the baseline scenario.

- Facilities report annual withdrawals - this does not reflect the way water is actually withdrawn throughout the year; people and facilities use more water in the summer.

- Facilities do not all report the same way - some facilities report how much water was withdrawn from the source, others report how much water was sold to customers, some facilities report how much water was produced.

The future estimates that can be made with this data are limited by their temporal scale and the degree to which total withdrawals are represented in the record. For example, the annual values of water withdrawals limits our estimates to annual water withdrawals. We are not able to predict water withdrawals for any month or season. It is important that the reader recognize the fact that this limitation is a natural consequence of the way the data are currently being reported. Annual calendar year reporting makes it more difficult for a water withdrawal model to capture the true nature of the water demand relationships. Data regarding monthly withdrawals would improve the quality of the database.

The water withdrawal inventory only includes data that are reported voluntarily by the water user. This creates a bias in the database because voluntary reporting may inadvertently screen for a better representation of water users who are already required to maintain this information such as public water suppliers and power plants. Commercial water users can legally claim that their water withdrawals are proprietary information and even if it is reported, it may not be publicly available. Irrigation withdrawals, like commercial water users, are not required to be reported.

Implications The modeling analysis described in this report is based on the relationship between annual reported water withdrawals and a set of factors that are known to affect annual water withdrawals, such as regional population, income, price, precipitation, etc. However, inasmuch as the water demand model reflects an association between a set of fairly well-understood demographic and climatological factors with water withdrawals, there is substantial embedded uncertainty in all of our predictions because of the character of the water withdrawal data described above. In short, the model relates spatially distributed climate data and demographic information to relatively imprecise annual water withdrawal data. Improving water withdrawal data should improve future water withdrawal scenario results.

Consideration of drought

One of the confounding aspects of this project is that our work is being done to estimate future water withdrawal trends – but we are not considering future inter-annual variation in weather and the potential effects of drought (except in sensitivity analysis). As our team has presented the models and the analysis for technical review this has raised questions about the objectives of the work and the perceived need for a "worst case" analysis that considers future water shortages. Droughts and floods will occur over the next 5 decades but the timing, frequency and duration of these events cannot be predicted. Rather than focus attention on these extreme events the purpose of our demand modeling is to anticipate changes in water withdrawals that may happen because of fairly well-understood drivers of water demand; demographic changes (growth), price fluctuation, or the implementation of conservation practices. An illustration of the difference between the analysis of regional trends and the effects of a drought are shown in Figure K.

Another problem with the consideration of drought in the 15-county area is that drought response is normally handled by local infrastructure planning. Changes in local infrastructure may include additional wells, alternative water supplies and conservation planning. In some combination, these techniques can be coordinated to accommodate the spikes in demand for the relatively short duration of the dry spell. For example, in water systems that rely on surface water (these are inherently more vulnerable to drought conditions) some groundwater sources or alternative water supplies is one of the most common approaches to drought planning.

The 2005 water withdrawal data demonstrated how a short-duration drought could affect regional water withdrawals. This increase can be considered a "drought buffer" that needs to be added to the potentially increasing water withdrawals anticipated because of regional economic and demographic change.

Implications

1. Droughts are not being modeled in this project. Instead we have focused our attention on the general increases in water withdrawals that can be expected to occur in the next 50 years. The sensitivity analysis is used to understand the possible implications of drought.

2. Preparations for dry years have traditionally been done at the local level. Additional wells, alternative sources, wholesale agreements to share with neighboring water suppliers, and conservation are all appropriate measures for water systems to consider.

3. Long-term increases in water withdrawals are expected and these are being anticipated by the 15-county water demand model.

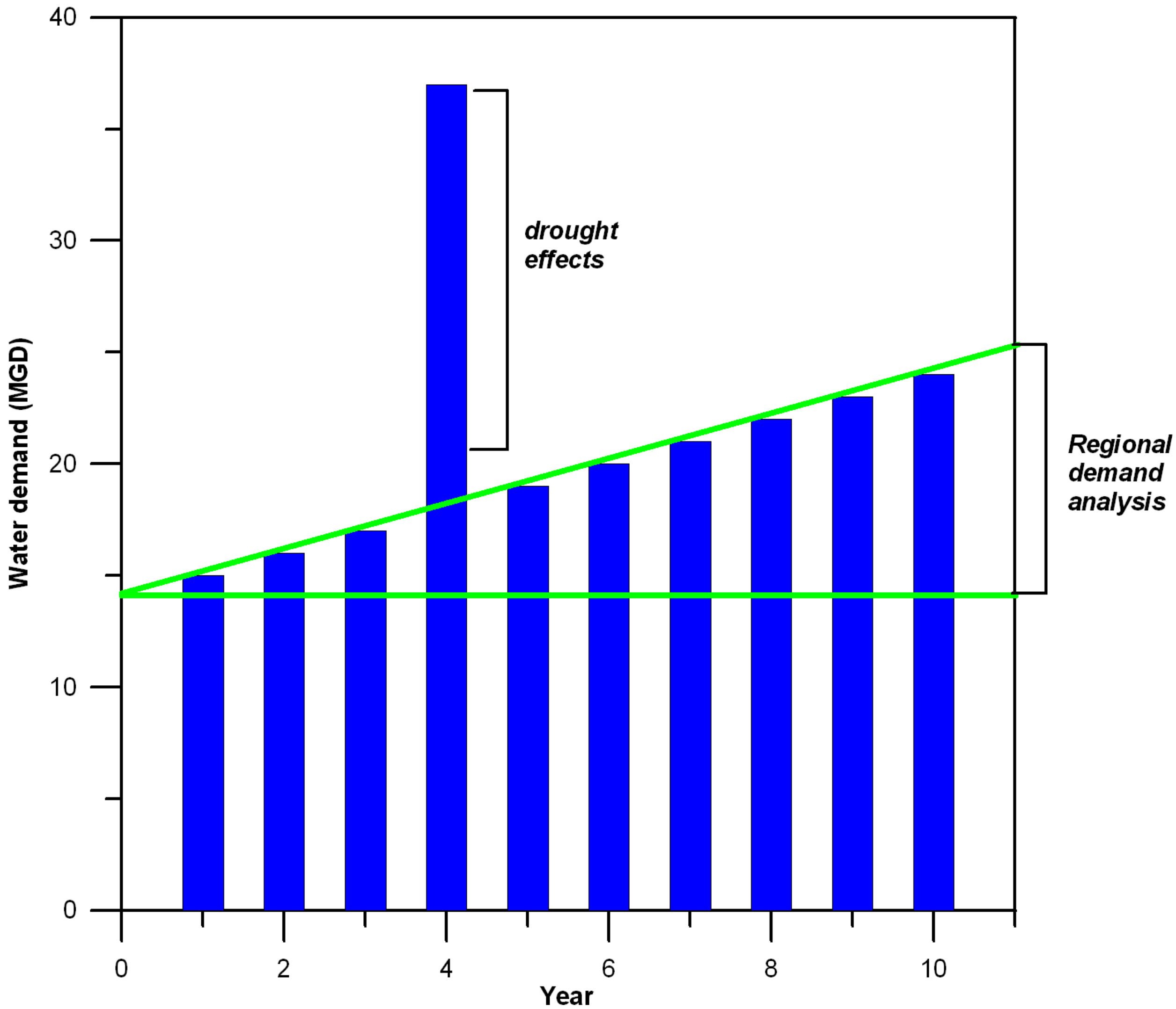

Figure K: Example of potential drought effects.

Uncertainty of future demands

It is important to recognize the uncertainty in determining future water demands in any study area and user sector. This uncertainty is always present and must be taken into consideration while making important planning decisions on future water conservation and supply requirements. Generally, the uncertainty associated with the analytically derived future values of water demand can come from a combination of the following distinct sources.

1. Random error: The random nature of the additive error process in a linear (or log-linear) regression model which is estimated based on historical data guarantees that future estimates will deviate from true values even if the model is specified correctly and its parameter values (i.e., regression coefficients) are known with certainty.

2. Error in model parameters: The process of estimating the regression coefficients introduces error because estimated parameter values are random variables which may deviate from the true values.

3. Specification error: Errors may be introduced because the model specification may not be an accurate representation of the "true" underlying relationship.

4. Scenario error: Future values for one or more model variables cannot be known with certainty. Uncertainty may be introduced when projections are made for the water demand drivers (such as population, employment or irrigated acreage) as well as the values of the determinants of water usage (such as income, price, precipitation and other independent variables). For example, 97% of the variability in public water supply withdrawals are explained by the population served. Therefore, variations in future water demand would result from different population change scenarios.

The approach used in this study is uniquely suited for dealing with the last source of error – the scenario error. By defining three alternative scenarios the range of uncertainty associated with future water demands in the study area can be examined and taken into consideration in planning decisions. A careful analysis of the data and model parameters was undertaken in other to minimize the remaining three sources of error.

Conclusion

This study examined the future water demand on a geographic region. However, it didn't address the ability of the water resources in that region to supply the estimated demand or the impact of the increased demand on the ecological or hydrological resources. Water demand estimates are important to understanding how different areas are using water and how fast and where the region is growing. What these estimates do not reveal is if the regional water sources, both surface water and groundwater, can supply and sustain the demand placed upon them. But, as these water withdrawals are utilized in the water supply modeling analysis performed by the ISWS, the RWSPC will be able to plan for the future and ensure that all water users within the region have a safe and secure water supply.

Chapter 1

Introduction

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In January 2006, Governor Rod Blagojevich signed Executive Order 2006-01 calling for a comprehensive program of state and regional water-supply planning in the State of Illinois. The order charges the Illinois Department of Natural Resources (IDNR) with the responsibility of developing financial and technical support for two regional water supply planning committees in their development of water-supply plans for two priority regions in the state. The two areas, identified through work done by the Illinois State Water Survey (ISWS), were chosen as areas of potentially limited water-supply availability and substantial population and economic growth. The two pilot regions are fifteen counties in East-Central Illinois and eleven counties in Northeastern Illinois (Figure 1.1). As a first step in planning, each region is to estimate current and future water withdrawals. This report describes the water-demand study that estimates current and future withdrawals for the East-Central Illinois Region.

Regional water-supply planning in East-Central Illinois is focusing on the Mahomet Aquifer system and the Sangamon River watershed (Figure 1.2). The planning region includes fifteen counties: Cass, Champaign, DeWitt, Ford, Iroquois, Logan, Macon, Mason, McLean, Menard, Piatt, Sangamon, Tazewell, Vermilion, and Woodford.

The Mahomet Aquifer Consortium (MAC) is facilitating the planning effort in the East-Central Illinois region and has formed a local planning committee with representatives from various stakeholder groups. In East-Central Illinois, the following groups are represented on the Regional Water Supply Planning Committee (RWSPC): Agriculture; County Government; Electric Generating Utilities; Environment; Industries; Municipal Government; the Public; Rural Water Districts; Small Business; Soil and Water Conservation; Water Authorities; and Water Utilities.

The RWSPC hired Wittman Hydro Planning Associates, Inc. (WHPA) to conduct the water demand study for the region. This report describes the data, methods, and models used to estimate future water withdrawals for the fifteen-county water supply planning region in East-Central Illinois up to the year 2050. The report provides a summary of the historical and future groundwater and surface water withdrawals for four different water-demand sectors: 1) public water supply and self-supplied domestic, 2) self-supplied thermoelectric power generation, 3) self-supplied commercial and industrial, and 4) self-supplied agriculture and irrigation. All sectors, except public water supply, are self-supplied, meaning the users in the sector do not buy the water they use but rather have a system (a well or surface water intake) that directly supplies the water from the source to the user. For simplicity, this report may not always use the descriptor “self-supplied”.

The future water withdrawals generated from this work will be used by the ISWS, using groundwater and surface water modeling, to analyze the impacts of withdrawing water from specific withdrawal points to meet the demand scenarios. The data generated from this demand study

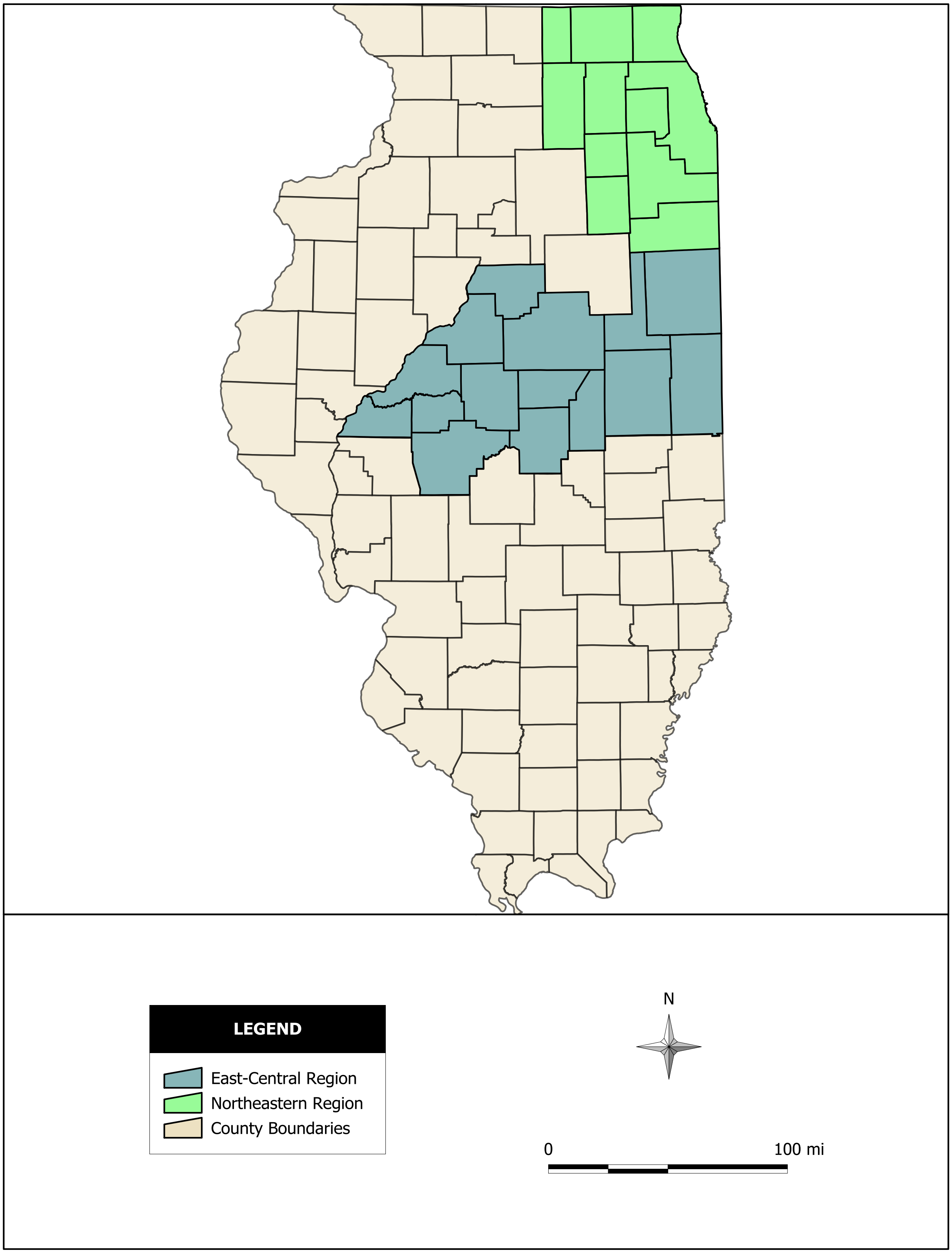

Figure 1.1: The two priority planning regions in Illinois identified through work by the Illinois State Water Survey.

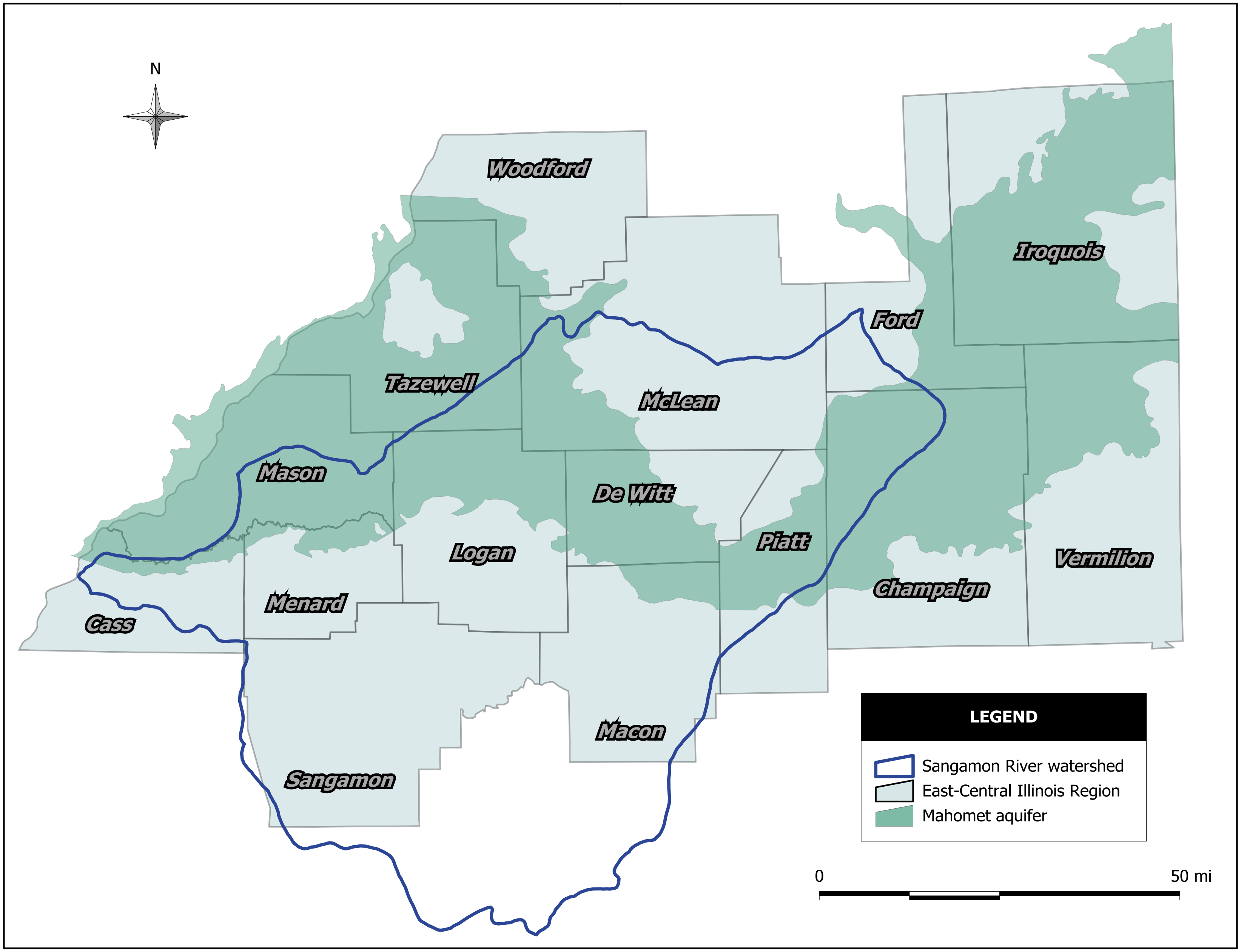

Figure 1.2: The 15-county East-Central Water Supply Planning Region in Illinois.

will be delivered to the ISWS at the level of withdrawal points, meaning future water withdrawals will be determined for all existing wells and surface water intakes. Although withdrawal-point data is not included in this report, the data will be available upon request from the ISWS for the public water supply sector. The withdrawal-point data for the commercial and industrial and power generation sectors will not be available to the public due to confidentiality agreements.

1.1 Purpose

The purpose of this study is to examine water demand on a regional basis and provide information to the East-Central RWSPC to begin the water-supply planning process. Future water withdrawals were estimated with a regional approach. We collected historical data on all water suppliers/users in the region, created regional models for each sector based upon the aggregated historical data, and used the models to estimate future withdrawals. Individual models for each city, industry, county were not created. For this reason, the regional model will be different than existing models for individual cities, counties, etc.

Additionally, future withdrawals were estimated for three specific scenarios. Each of these scenarios includes a set of assumptions that will differ from the assumptions in other existing models. For example, in the public water supply model baseline scenario, median household income was increased 0.7% per year. This income assumption has a direct effect on the estimate of future water withdrawals. Other models may use other reasonable assumptions to estimate future demand. Therefore, care should be used when comparing this regional model with other water demand models that were built for different purposes and at different scales.

The future withdrawals are estimated averages, which means that for any given year the authors do not expect to predict the precise amount of water withdrawn. The intent of this study is to understand the general water demand trends for the region. These estimates should be used for planning purposes only; they should be understood as the average estimates over the period of interest.

1.2 Objective

The objective of this study is to estimate current and future water withdrawals, both groundwater and surface water, for the 15-county East-Central Illinois planning region. The future withdrawals are estimated in five year increments to the year 2050. The future water withdrawals are developed for four water-demand sectors on a county level, for three scenarios.

1.3 Methodology

The methodology consists of the following five basic steps for each of the water-demand sectors. These steps are described below.

1. Collect historical water-withdrawals and water-demand variable data.

2. Conduct public outreach and obtain data specific to study areas.

3. Develop mathematical relationships between water withdrawals and water-demand variables.

4. Develop three future water-withdrawal scenarios.

5. Prepare water-withdrawal estimates.

1.4 Historical water-withdrawals and water-demand variable data

Historical data sets for the major water sectorsin the 15-county study area were collected to develop the statistical water-demand relationships used to estimate future water withdrawals.

1.4.1 Water-demand sectors

The four major sectors (or categories) of water withdrawals modeled in the study are:

1. public water supply (PWS) and self-supplied domestic (private domestic wells) sector. This sector also includes water supplied by a PWS to some commercial or industrial users.

2. self-supplied thermoelectric power generation (PG) sector.

3. self-supplied commercial and industrial (C&I) sector.

4. self-supplied irrigation and agricultural uses (IR&AG) sector.

1.4.2 Data years

The historical data sets assembled for each sector include the data years: 1985, 1990, 1995, 2000, and 2005. These years were chosen because many of the socio-economic data needed to establish statistical relationships between water-withdrawals and independent variables are only available in 5 or 10 year increments.

1.4.3 Study areas

Historical water withdrawals of all sectors, other than the PWS sector, are studied at the county level. For the PWS sector, the study areas include a total of 26 water service areas of the high-growth municipalities and 15 county rural areas which represent the balance of county areas outside of the 26 municipalities and water districts (Figure 1.3 and Table 1.1). The criteria used to select these areas are described in more detail in Chapter 2.

1.4.4 Water-withdrawal data

For each water-demand sector, water withdrawals between for 1985, 1990, 1995, 2000, and 2005 were collected from the ISWS, the United States Geological Survey (USGS), or estimated based upon these data sources. Water withdrawal data are expressed in million gallons per day (MGD). For some sectors the withdrawal data are converted into water demand per capita, per employee, per acre or per kilowatt-hour. More detail about the historical water-withdrawal data is provided in the discussions of each water-demand sector in Chapters 2-5 of this report.

1.4.5 Independent variable data

The historical data on water withdrawals in each sector were supplemented with corresponding data on independent variables for each study area and demand sector. Water withdrawals are associated with demand drivers like population or employment and independent variables such as price of water, income, air temperature, as well as other factors which influence the amount of water demand. The independent variable data include:

- resident population and population served;
- employment (ratio of employment to population, total employment, percent of employment in specific employment sectors);
- median household income;

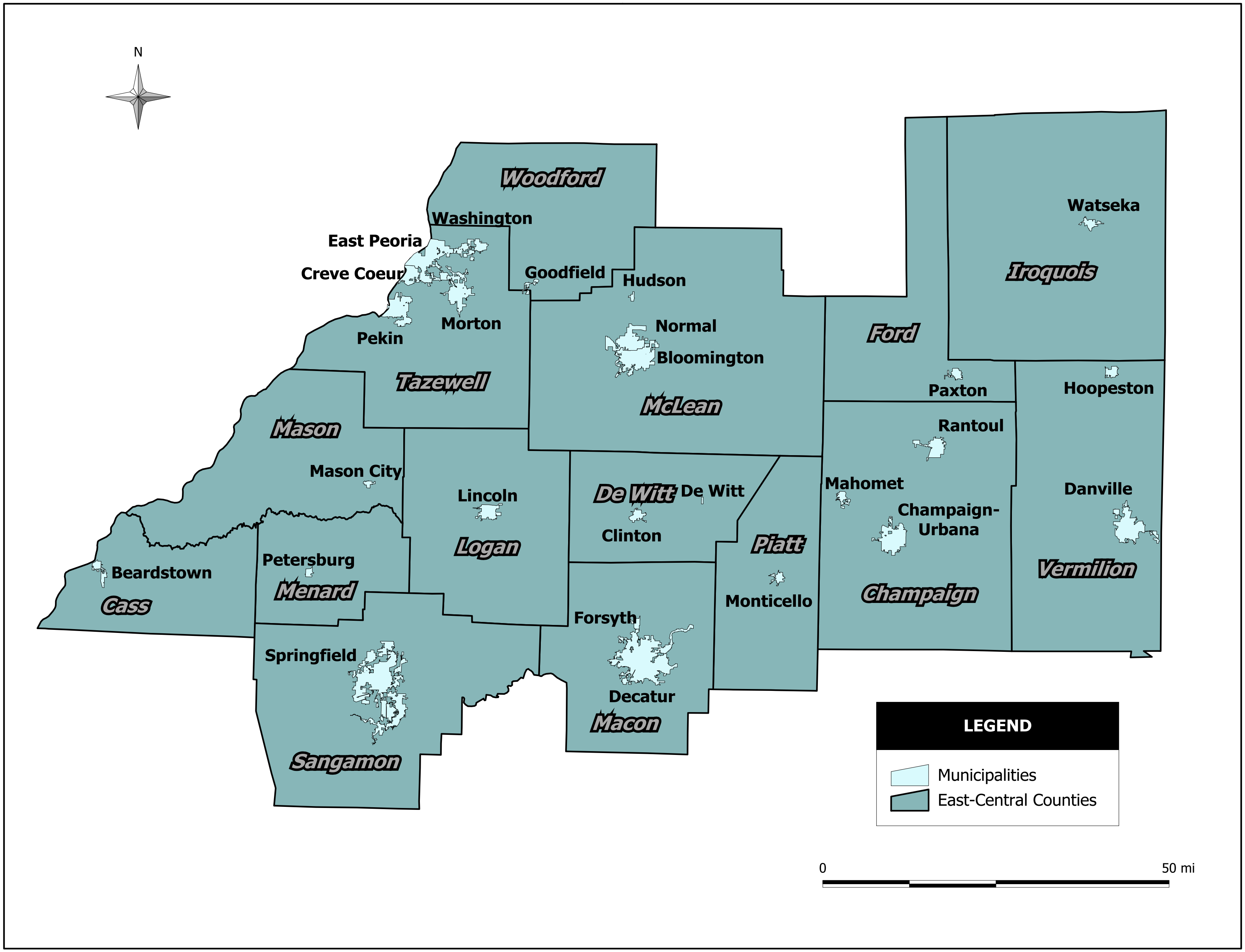

Figure 1.3: Map of 41 public water supply study areas in East-Central Illinois. The study areas include 26 municipalities and 15 county rural areas which represent all public water suppliers outside the 26 municipalities.

Table 1.1: The 26 municipal public water supply study areas and their population growth [Census, 2000]. *Note: These 26 study areas are in addition to the 15-county study areas representing the public water suppliers outside these high-growth areas.*

County	PWS Study Area	Percent Growth (1990-2000)	Population (2000)
Cass	Beardstown	9.4	5,766
Champaign	Rantoul	-25.3	12,857
Champaign	Mahomet	57.2	4,877
Champaign	Champaign/Urbana	6.3*	103,913
DeWitt	DeWitt	54.1	188
DeWitt	Clinton	0.6	7,485
Ford	Paxton	5.5	4,525
Iroquois	Watseka	4.5	5,670
Logan	Lincoln	-0.3	15,369
Macon	Decatur	-2.4	81,860
Macon	Forsyth	90.9	2,434
Mason	Mason City	10.1	2,558
McLean	Hudson	50.1	1,510
McLean	Normal	13.4	45,386
McLean	Bloomington	24.7	64,808
Menard	Petersburg	1.7	2,299
Piatt	Monticello	12.9	5,138
Sangamon	Springfield	5.9	111,454
Tazewell	Creve Coeur	-8.3	5,448
Tazewell	Morton	10.1	15,198
Tazewell	Washington	7.3	10,841
Tazewell	East Peoria	5.9	22,638
Tazewell	Pekin	5.0	33,857
Vermilion	Hoopeston	1.6	5,965
Vermilion	Danville	0.2	33,904
Woodford	Goodfield	51.1	686

*Percent growth for Champaign, Illinois; Population is 2000 U.S. Census data.

- marginal price of water;
- thermoelectric power generation (type of system and gross power generated);
- air temperature (annual average, growing season average, and average maximum during the growing season)
- precipitation (annual average and growing season total)
- cooling degree days
- irrigated acres
- rainfall deficit

1.5 Public outreach

After the historical data were collected, WHPA solicited input from the public and water users/purveyors from each sector. The purpose of this outreach portion of the project was to ensure that the data used in the scenario analysis reflect the experience of the public. To this end, the data and methodology were presented to the stakeholders in the region. Persons from each sector were invited to at least one meeting at which relevant data were presented. At the meetings, stakeholders had an opportunity to comment on and discuss the independent variables used to determine water withdrawals.

The stakeholders were asked to provide data on any known future changes within their sector and/or county. If specific data were obtained, WHPA incorporated the data into the future scenarios. For example, the City of Springfield will be replacing their Lakeside electrical generating plant with a new Dallman 4 electrical generating plant. This information is included in the power generation sector. Where stakeholders were unable to provide specific information, WHPA listened to their opinions and views and took them into consideration. However, these views and opinions were not included in the final withdrawal scenarios unless additional data were available to substantiate the views/opinions.

Invitations were sent to over 1,400 contacts within the 15-county region. The contact list included stakeholders from each county, including, but not limited to:

- city officials (*e.g.,* planners, managers, mayors, board members, city clerk)
- public water-suppliers

- commercial and industrial users
- thermoelectric power generators
- local engineers
- irrigators / farmers
- water authorities
- agricultural representatives
- media contacts (*e.g.,* reporters)
- state and federal agencies (*e.g.,* USDA, NRCS, EPA, ISGS, ISWS)[1]

Four multi-county meetings were scheduled in August, 2007 (Table 1.2). Each public meeting targeted specific counties in the water-supply region, but the information provided at each meeting was general enough that persons from other counties could attend. The agenda and meeting summaries from these meetings are provided in Appendix A.

In addition to the four multi-county meetings, WHPA met individually with the 26 PWS study areas. At these meetings, data for the municipality were discussed and revised accordingly. City planners, mayors, city-council members, water department/water company personnel, and other relevant groups were invited to the municipal meetings

1.6 Mathematical relationships between water-withdrawal and water-demand variables

The techniques for developing estimates of future withdrawals were dictated by the type of water-withdrawal data and the corresponding data on explanatory variables that were available for each water-demand sector. The two principal techniques used in this report are the unit-use coefficient approach and multiple regression. The unit-use coefficient method is used for irrigation and agriculture, power generation, and domestic supply sectors. Multiple regression is used for the public water supply and commercial and industrial sectors.

[1]USDA = United States Department of Agriculture; NRCS = Natural Resources Conservation Service; EPA = United States Environmental Protection Agency; ISGS = Illinois State Geological Survey; ISWS = Illinois State Water Survey

Table 1.2: Schedule and information for the four multi-county public outreach meetings held in August 2007.

Date	Time	Location	Targeted Counties
8/20/07	1:00 PM	Rantoul Public Library Community Room 106 West Flessner St. Rantoul, IL 61866	Champaign, Ford, Iroquois, and Vermilion counties
8/21/07	1:00 PM	Tremont United Methodist Church 112 W. Pearl St. Tremont, IL 61568	McLean, Tazewell, and Woodford counties
8/22/07	1:00 PM	St. Paul's Lutheran Church 121 N Pearl St. Havana, IL 62644	Cass, Mason, Menard, and Sangamon counties
8/23/07	1:00 PM	Vespasian Warner Public Library Revere Ware Room 310 N. Quincy St. Clinton, IL 61727	DeWitt, Logan, Macon, and Piatt counties

1.6.1 Unit-use coefficient method

The general approach to developing future water withdrawals can be described as:

$$Q_{\text{cit}} = N_{\text{cit}} \cdot q_{\text{cit}} \tag{1.1}$$

where:

Q_{cit} =water withdrawals in sector c of study area i in year t;

N_{cit} =number of users (demand drivers) such as population, employment, or acreage; and

q_{cit} =average rate of water demand in gallons per capita-day, gallon per employee-day, etc.

Unit-use approaches are based upon the assumption that q_{cit} will remain constant over time and future water demand will be proportional to the number of users N_{cit}. For example, in the self-supplied domestic sector the average water withdrawal rate is 82 gallons per person per day, so water withdrawals are directly proportional to the self-supplied domestic population in each county. Likewise, future withdrawals are calculated by multiplying estimates of future population by this unit-use coefficient (i.e., per capita rate of water withdrawals).

1.6.2 Multiple regression method

Modeling of water demand usually concerns the average rate of water withdrawal, q_{cit} , which is expected to change over time. Water-withdrawal relationships can be expressed in the form of equations, where this average rate of water withdrawal is expressed as a function of one or more independent (explanatory) variables. A multivariate context best relates to actual water-demand behaviors, and multiple regression analysis can be used to determine the relationship between water demand and each independent variable. The functional form (e.g., linear, multiplicative, exponential) and the selection of the independent variables depend on the category of water demand. For example, public water supply withdrawals can be estimated using the following linear model:

$$PS_{it} = a + \sum_j b_j X_{jit} + \varepsilon_{it} \tag{1.2}$$

where

PS_{it} = per capita public supply water withdrawals within geographical area i during year t;

X_{jit} = a set of independent variables (e.g., air temperature, precipitation, price of water, median household income and others), which are expected to explain public supply withdrawals; and

ε_{it} = random error.

The coefficients a and b_j can be estimated by fitting a multiple regression model to historical water-withdrawal data.

The models used in this study are specified as double-log (i.e., log-linear models). Additional variables serve to fit the model to the data and also isolate observations which are likely to be outliers:

$$lnPS_{it} = \alpha_o + \sum_j \beta_j lnX_{jit} + \sum_k \gamma_k lnR_{kit} + \sum_l \delta_l D_{lit} + \sum_m \rho_m S_{mit} + \varepsilon_{it} \tag{1.3}$$

where:

PS_{it} = per capita public supply water withdrawals within geographical area i during year t (in gallons per capita per day);

X_j = a set of independent variables;

R_k = ratio (percentage) variables such as ratio of employment to population;

D_l = indicator (or binary) variables designating specific public water supply systems which assume the value of one (1) for observations for the system and zero (0) otherwise;

S_m = indicator spike variables designating individual observations in the data;

ε_{it} = random error; and

α, β, γ, δ,and ρ are the parameters to be estimated.

A large number of econometric studies of water withdrawals have been conducted during the last 50 years. Haneman (1998) summarized the theoretical underpinnings of water-demand modeling and reviewed a number of determinants of water demand in major economic sectors. Useful summaries of econometric studies of water demand can be found in Boland et al. (1984). Dziegielewski et al. (2002a) reviewed a number of studies of aggregated sectoral and regional demand. A substantial body of work on model structure and estimation methods was also performed by the USGS (Helsel and Hirsch, 1992).

1.6.3 Model estimation and validation procedures

Several procedures were used to specify and select the water-demand models for this study: 1) models included variables that had been identified by previous research, 2) the variables had regression coefficients that were statistically significant, 3) the variables were within a reasonable range of *a priori* values and with expected signs, 4) the explanatory power of the model was reasonable, as measured by the coefficient of multiple determination (R^2), and 5) the absolute percent error of model residuals was not excessive. This modeling approach and estimation procedure were originally developed and tested in the study of geographically aggregated water withdrawal data conducted by Dziegielewski et al. (2002a, 2002b).

Additional information on analytical methods, models, and assumptions is included in the chapters and appendices which describe the analysis of water withdrawals and development of future water-withdrawal scenarios for each major sector.

1.7 Future water-withdrawal scenarios

For each of the water sectors, the water-demand drivers and/or variables were varied to simulate three different scenarios of water demand in the future: baseline, less resource intensive, and more resource intensive. The scenarios were defined by different sets of assumed conditions regarding the future values of demand drivers and independent variables. The general characteristics of each scenario are described below. A more detailed description of the scenarios and variables assumptions for each water sector are provided in the respective chapters.

The purpose of the scenarios is to capture future water withdrawals under three different sets of conditions. The three scenarios do not represent forecasts or predictions, nor do they set upper and lower bounds of future water demand. Different assumptions or conditions could result in withdrawals that are within or outside of the range represented by the three scenarios.

1.7.1 Scenario 1 - Baseline (BL)

The basic assumption of this scenario is that the recent trends in population growth and and other independent variable patterns will continue. With respect to population growth the baseline is represented by the official forecasts of population and employment in the 15-county planning area. The official forecast prepared by Illinois Department of Commerce and Economic Opportunity and Illinois Department of Economic Security includes the total number of residents and jobs for the region [DCEO, 2005 and IDES, 2007]. The population projections are based on technical analysis of demographic trends in the region.

The BL scenario does not rely on a simple extrapolation of recent historical trends in total or per capita (or per employee) water demand into the future. Instead, the future unit rates of water demand are determined by the water demand model as a function of the key independent variables. The "recent trends" assumption applies only to future changes in the independent variables. Accordingly, the BL scenario assumes that the independent variables such as income and price will follow the recent historical trends or their official or available forecasts. This scenario also assumes that recent trends in the efficiency of water usage (mostly brought about by the effects of plumbing codes and fixture standards, as well as actions of water users) will continue. The conservation trend on water use in the historical data is estimated as a part of the regression model.

1.7.2 Scenario 2 - Less resource intensive (LRI)

In the less resource intensive scenario, overall water demand is reduced compared to the BL scenario. Industrial withdrawals of water would decrease as some less water-intensive industrial activities continue to expand or locate in the study area. The efficiency assumptions include more water conservation (e.g., implementation of additional cost-effective water conservation measures by urban and industrial users). Other water demand parameters such as income and price are assumed to shift to levels which result in lower water demand (*i.e.*, lower income, higher prices for water). Irrigated acres are assumed to increase more slowly than in the BL scenario.

1.7.3 Scenario 3 - More resource intensive (MRI)

In the more resource intensive scenario, overall water demand is increased compared to the BL scenario. Industrial withdrawals of water would increase as some water-intensive industrial categories locate or expand in the study area. The price of water is assumed to remain unchanged in real terms, which implies that future price increases will only offset the general inflation. A higher rate of growth of median household income is also assumed. Additional discussion of sector-specific assumptions for each scenario is included in the chapters which describe estimates of water demand in each sector.

1.8 Water-withdrawal estimates

After the water-demand relationships are calculated via the unit-use coefficient or regression method, the future water-withdrawal estimates are prepared using the three scenarios described above for each sector. Water withdrawals are estimated in total million gallons per day for every five years until the year 2050. The data generated from this demand study will be delivered to the ISWS at the level of withdrawal points, meaning future water withdrawals will be determined for all existing wells and surface water intakes. Although withdrawal-point data is not included in this report, the data will be available upon request from the ISWS for the public water supply sector. The withdrawal-point data for the commercial and industrial and power generation sectors will not be available to the public due to confidentiality agreements.

1.9 Normal weather and impacts of using normal weather in future scenarios

Some of the most important determinants of water demand are related to weather. Consequently, in order to estimate future water withdrawals, the weather variables (i.e., precipitation, temperature, and cooling degree days) must also be estimated. Weather data may be dealt with in a variety of ways when looking into the future. One approach is to "predict" future weather by using the climatic normals, as calculated by the National Center for Climatic Data (NCDC). Climatic normals are defined as the "statistical average over a time period usually consisting of three consecutive decades" [Owenby et al., 2006]. The current climatic normals are defined for the period 1971-2000.

The averaging of the past weather data means that no inter-annual variation is taken into account in the water demand models. Figure 1.4 shows historical recorded data for temperature and precipitation compared to the climatic normals. The future data (shown as ?) shows that the future weather is not predictable and how it may vary in relation to the climatic normals used in this study. In effect, this assumes that the average weather from the 30-year historical period can be used to estimate the future demand. On the one hand, this approach firmly connects the forecast to the historical record. On the other hand, by representing the future as the average of the 30-years of record we lose the extremes that cause the variation in demand, as evidenced in the historical dataset.

It was decided by the ISWS and technical committee of the RWSPC that the demand models would use climatic normal data as the future weather variables. The climatic normal method was chosen so that the general trend of water demand could be understood. By using normal weather data in the future, the annual variation in the historic reported withdrawals due to weather, is not seen in the future estimates. Because normal climatic data were used in estimating future water withdrawals, for any given year in the future (or the past) the water demand estimates will not match the actual water withdrawn. What is revealed by this study is the *average* water withdrawals from 2010 to 2050.

Another implication of using normal weather data to estimate future water withdrawals, is that the future looks different than the past. In most of the future withdrawal graphs shown in this report there is a linear-type increase from 2010 to 2050 (Figure 1.5). But, the historical data show variation from year to year; an increase in withdrawals one year and a decrease the next. The fluctuation in the historical data is due, in part, to the variation in weather patterns from year to year and study area to study area. A good example of this is 2005. Because 2005 was relatively

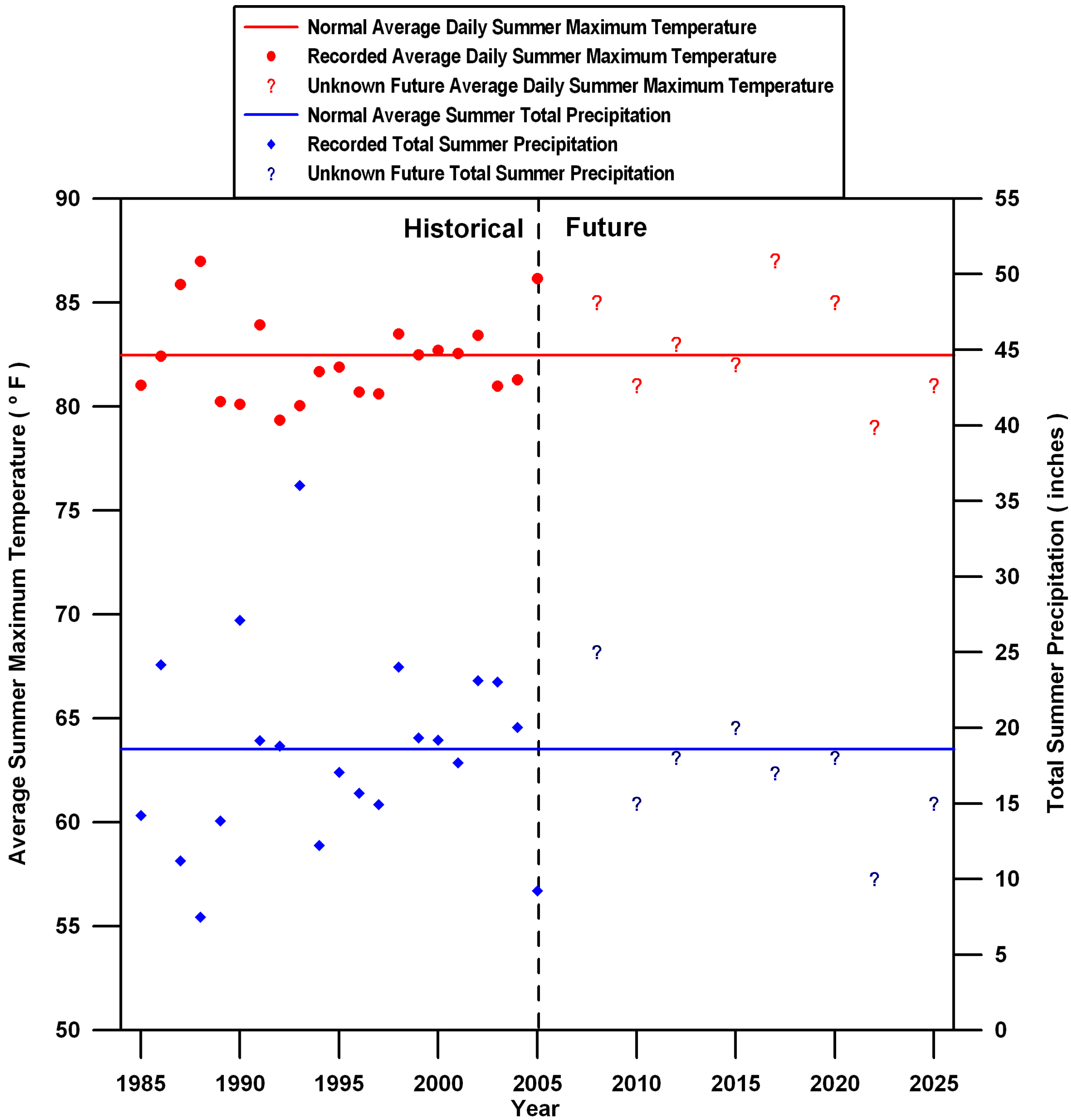

Figure 1.4: Example of inter-annual variation in temperature and precipitation compared to climatic normals.

hotter and drier than other years (particularly in some study areas), the water withdrawals for that year are higher than expected compared to normal historical growth. When 2005 reported data are compared to the model generated data which is calculated with normal (1971-2000) weather data, 2005 reported data are often higher than future withdrawal estimates. This is because of the anomalous weather pattern that year. What you see often in the graphs reported in this report is a decrease from reported 2005 values to the estimated 2010 withdrawals (Figure 1.5). This is not a modeling error or under-prediction, this is due to the drought conditions evident in 2005. For this reason, this report often compares future withdrawal estimates to 2005 values generated by the model using normal (1971-2000) weather data. The following terms are used throughout the report.

2005 Normal 2005 model generated value using normal (1971-2000) weather data.

2005 Reported 2005 value reported from the original data source; not a modeled value.

2005 Weather 2005 model generated value using actual weather data from 2005.

As Figure 1.5 also shows with the dashed line, on any given year, the water withdrawals may be higher or lower than the estimated withdrawals due to natural variation in the weather in the future. This is important to remember when looking at graphs of future estimates throughout this report.

1.10 Uncertainty - data quality, drought, and modeling

Like all modeling efforts, the process of modeling future water withdrawals and the withdrawals presented in this report have uncertainty associated with them. But, the importance of the regional water supply planning effort necessitates progress now, even with this uncertainty. Throughout this project, we have been confronted with three main types of uncertainty; data quality, drought, and modeling. These uncertainties are described below.

1.10.1 Data quality

The water withdrawal data used in this regional aquifer demand analysis were extracted from the Illinois Water Inventory Program (IWIP) of the ISWS. The IWIP database is a record of annual withdrawals for each of the reporting high capacity water users in the state. Every year, facilities are sent a questionnaire about the previous year's annual water withdrawals. Participation, while for some sectors is high (90% of participating facilities in 2005), is voluntary. Additionally, the

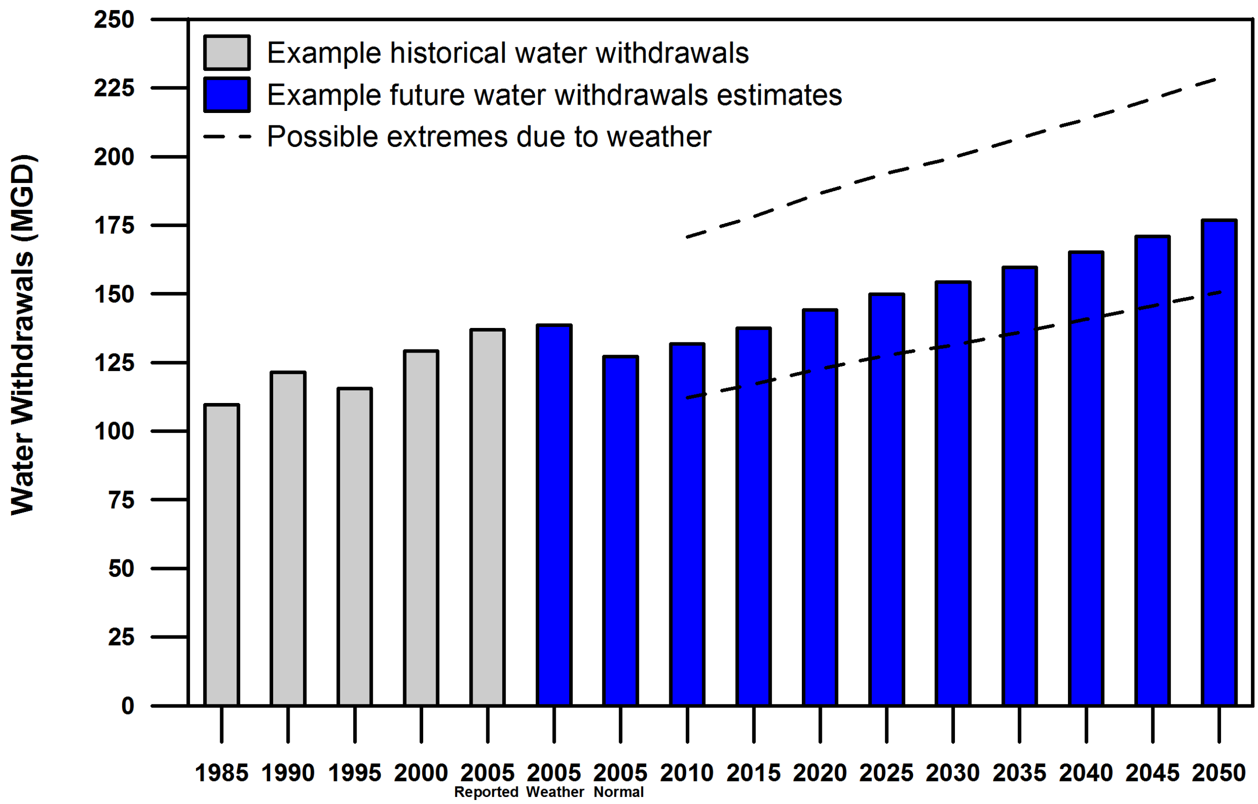

Figure 1.5: Example of the effects of using climatic normal temperature and precipitation.

water withdrawals for commercial, industrial, and power generation facilities are considered confidential and not available to the public. These characteristics of the database lead to problems with data quality:

- Under reporting - not all facilities report every year and/or some facilities never report.
- Not all water sectors are included - irrigation is not reported in the database.
- Facilities report annual withdrawals - this does not reflect the way water is actually withdrawn throughout the year; people and facilities use more water in the summer.
- Facilities do not all report the same way - some facilities report how much water was withdrawn from the source, others report how much water was sold to customers, some facilities report how much water was produced.

The future estimates that can be made with this data are limited by their temporal scale and the degree to which total withdrawals are represented in the record. For example, the annual values of water withdrawals limits our estimates to annual water withdrawals. We are not able to predict water withdrawals for any month or season. It is important that the reader recognize the fact that this limitation is a natural consequence of the way the data are currently being reported. Annual calendar year reporting makes it more difficult for a water withdrawal model to capture the true nature of the water demand relationships. Data regarding monthly withdrawals would increase the quality of the database.

The water withdrawal inventory only includes data that are reported voluntarily by the water user. This creates a bias in the database because voluntary reporting may inadvertently screen for a better representation of water users who are already required to maintain this information such as public water suppliers and power plants. Commercial water users can legally claim that their water withdrawals are proprietary information and even if it is reported, it may not be publicly available. Irrigation withdrawals, like commercial water users, are not required to be reported.

1.10.1.1 Implications of data quality

The modeling analysis described in this report is based on the relationship between annual reported water withdrawals and a set of factors that are known to affect annual water withdrawals, such as regional population, income, price, precipitation, etc. However, inasmuch as the water demand model reflects an association between a set of fairly well-understood demographic and climatological factors with water withdrawals, there is substantial embedded uncertainty in all of our predictions because of the character of the water withdrawal data described above. In short, the model relates spatially distributed climate data and demographic information to relatively imprecise annual water withdrawal data. There is no way to improve predictions of future water withdrawals without improving the existing water withdrawal data.

1.10.1.2 Data recommendations

There are three steps that need to be taken to improve our understanding of regional water withdrawals and how it may change in the future:

1. make water withdrawal reporting mandatory for all users;
2. have water users report monthly withdrawal;
3. institute a metering/verification program to better define the relationship between reported and actual water withdrawals.

These changes would allow the community to manage demand and determine whether the estimated future water withdrawals in this report reflect actual conditions in the field.

1.10.2 Consideration of drought

One of the confounding aspects of this project is that our work is being done to estimate future water withdrawal trends – but we are not considering future inter-annual variation in weather and the potential effects of drought (except in sensitivity analysis). As our team has presented the models and the analysis for technical review this has raised questions about the objectives of the work and the perceived need for a "worst case" analysis that considers future water shortages. Droughts and floods will occur over the next 5 decades but the timing, frequency and duration of these events cannot be predicted. Rather than focus attention on these extreme events the purpose of our demand modeling is to anticipate changes in water withdrawals that may happen because of fairly well-understood drivers of water demand; demographic changes (growth), price fluctuation, or the implementation of conservation practices. An illustration of the difference between the analysis of regional trends and the effects of a drought are shown in Figure 1.6.

Another problem with the consideration of drought in the 15-county area is that drought response is normally handled by local infrastructure planning. Changes in local infrastructure may include additional wells, alternative water supplies and conservation planning. In some combination, these techniques can be coordinated to accommodate the spikes in demand for the relatively

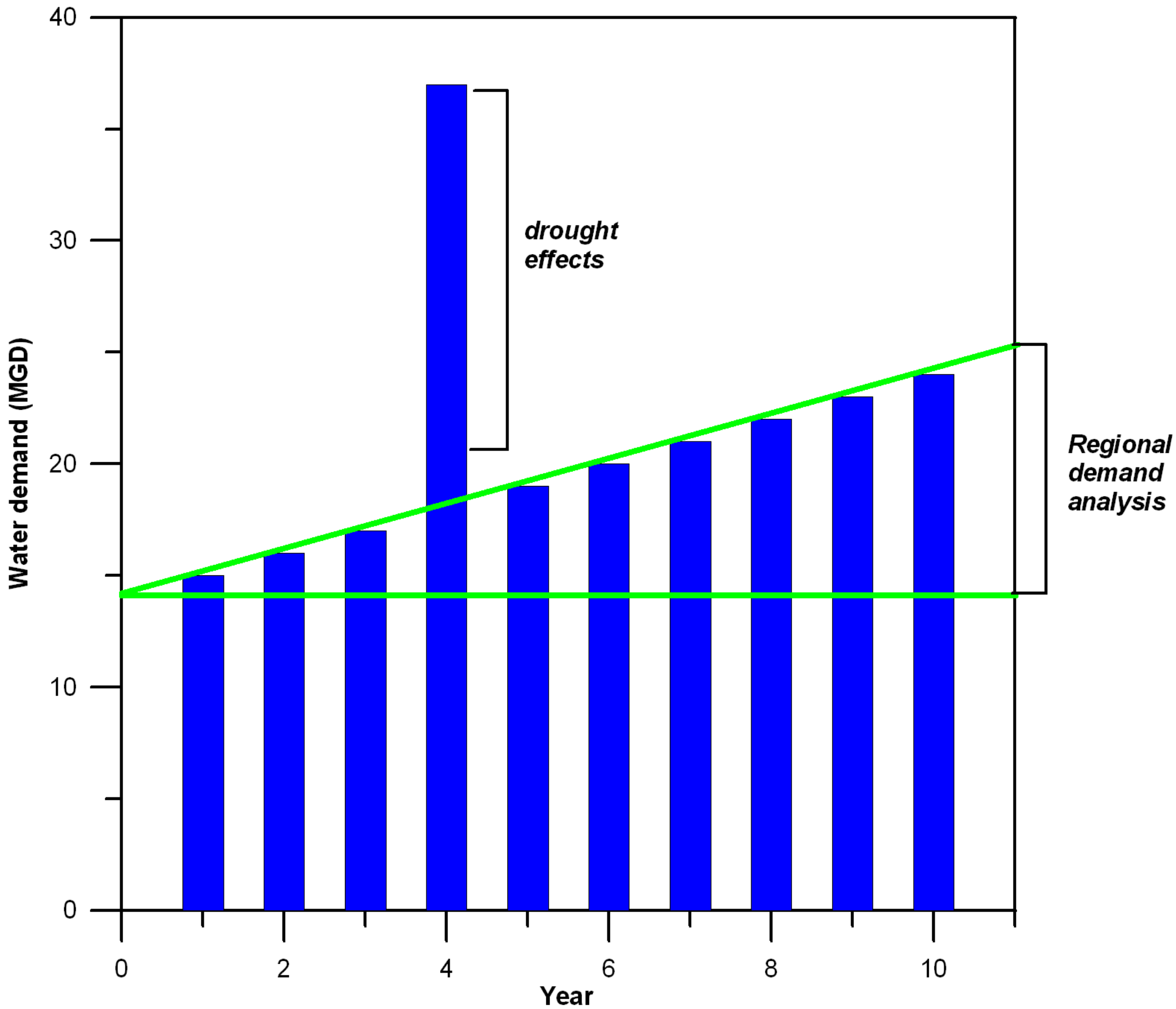

Figure 1.6: Example of potential drought effects.

short duration of the dry spell. For example, in water systems that rely on surface water (these are inherently more vulnerable to drought conditions) some groundwater sources or alternative water supplies is one of the most common approaches to drought planning.

The 2005 water withdrawal data demonstrated how a short-duration drought could affect regional water withdrawals. This increase can be considered a "drought buffer" that needs to be added to the potentially increasing water withdrawals anticipated because of regional economic and demographic change.

Implications

1. Droughts are not being modeled in this project. Instead we have focused our attention on the general increases in water withdrawals that can be expected to occur in the next 50 years. The sensitivity analysis is used to understand the possible implications of drought.

2. Preparations for dry years have traditionally been done at the local level. Additional wells, alternative sources, wholesale agreements to share with neighboring water suppliers, and conservation are all appropriate measures for water systems to consider.

3. Long-term increases in water withdrawals are expected and these are being anticipated by the 15-county water demand model.

1.10.3 Uncertainty of future demands

It is important to recognize the uncertainty in determining future water demands in any study area and user sector. This uncertainty is always present and must be taken into consideration while making important planning decisions on future water conservation and supply requirements. Generally, the uncertainty associated with the analytically derived future values of water demand can come from a combination of the following distinct sources.

1. Random error: The random nature of the additive error process in a linear (or log-linear) regression model which is estimated based on historical data guarantees that future estimates will deviate from true values even if the model is specified correctly and its parameter values (i.e., regression coefficients) are known with certainty.

2. Error in model parameters: The process of estimating the regression coefficients introduces error because estimated parameter values are random variables which may deviate from the true values.

3. Specification error: Errors may be introduced because the model specification may not be an accurate representation of the "true" underlying relationship.

4. Scenario error: Future values for one or more model variables cannot be known with certainty. Uncertainty may be introduced when projections are made for the water demand drivers (such as population, employment or irrigated acreage) as well as the values of the determinants of water usage (such as income, price, precipitation and other independent variables).

The approach used in this study is uniquely suited for dealing with the last source of error – the scenario error. By defining three alternative scenarios the range of uncertainty associated with future water demands in the study area can be examined and taken into consideration in planning decisions. A careful analysis of the data and model parameters was undertaken in other to minimize the remaining three sources of error.

1.11 Organization of this report

The report is organized into an executive summary and seven chapters. The executive summary combines the results for all sectors and briefly discusses some of the implications of this study for the further analysis of water withdrawals in East-Central Illinois. Chapter 1 introduces the data and analytical models for estimating future water demands. The four major water use sectors are described in the four subsequent chapters (Chapters 2, 3, 4, and 5). Each of these chapters begins with a brief review of the definition of the water demand sector, a summary of the historical data, and the procedure for deriving water-demand relationships for the sector. This is followed by a description of the assumptions used to develop water-demand scenarios for the sector and a summary of the scenario results. An appendix is included for each chapter to provide additional historical data, model explanations, and results for each sector. Chapter 6 describes the sensitivity analysis, which shows the impacts on water withdrawals under five climate change scenarios and drought. This is followed by Chapter 7, which provides a summary of the regional information and recommendations for future water demand studies. References for all the chapters appear at the end of the report.

The final task of this project included an allocation of future withdrawals within each geographical area to the existing withdrawal points, groundwater wells and surface water intakes. The results of this work are not included in this report. Instead, the electronic tables of withdrawals allocated to individual points of water withdrawal were provided directly to the Illinois State Water Survey for their use as inputs into hydrologic groundwater (and surface water) models.

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Chapter 2

Public Water Supply (PWS)

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2.1 Background

The public and self-supplied domestic water supply sector includes the water withdrawals for domestic residential and community use and/or consumption. This chapter includes the water withdrawals that are 1) treated and served to the public from a central location, such as a water utility, and 2) self-supplied domestic withdrawals which involves a homeowner with a private well that provides water to his/her own property. Public water supply (PWS) includes water delivered to residential homes, commercial and industrial facilities, institutions, and governmental users. PWS water is typically supplied by a publicly-owned or privately-owned utility and is regulated by the United States Environmental Protection Agency (EPA). The EPA defines a public water system as a system that serves at least 25 people or 15 service connections for at least 60 days per year [USEPA, 2004]. The water quality for public-water systems must be monitored regularly and must sustain contaminant concentrations below the maximum contaminant level (MCL). In Illinois the amount of water used by public systems is reported through a voluntary reporting system to the Illinois State Water Survey (ISWS) on an annual basis. This ISWS historical water-withdrawal database was the primary source of data used in this study. The following sections describe the process used to estimate future water withdrawals for PWS and domestic supply.

2.2 PWS multiple regression method

The general purpose of multiple regression is to learn more about the relationship between several independent variables (*e.g.* temperature, income, etc.) and a dependent variable (*e.g.* per capita water withdrawals). Multiple regression can establish that a set of independent variables explains a portion of the variance for a dependent variable at a significant level (through a significance test of R^2), and can establish the relative predictive importance of each of the independent variables. For the PWS sector, a log-linear model was created to capture the relationship between per capita water demand and temperature, precipitation, marginal price, median household income, employment/population ratio, and conservation trend. The statistical model explains the variability of per capita water demand as a function of these six variables which are described in Section 2.4.3. The resulting equation is then used to estimate future water withdrawals. The multiple regression method is described in greater detail in Chapter 1.

2.2.1 PWS study areas

For all other water sectors in this study, water withdrawal is examined only on a county level. For the public supply sector, additional study areas were selected for each county in order to more accurately estimate water withdrawals in these areas. Because water demand in large municipalities may differ from the rest of the county, it is important to study these areas individually. At least one municipality was selected from each county to be a study area. A municipality was selected if, in 2000, it had a population greater than 5,000 and/or had a growth rate greater than 50% from 1990 to 2000. For those counties that did not have a municipality that met these requirements, a study area was selected based upon the largest population in the county. A total of 26 municipalities were selected (Figure 2.1 and Table 2.1). In addition, PWS water withdrawals were estimated in the 15-county rural areas which represent the balance of a county area outside selected municipalities in each county. These areas are called county remainders throughout this report. Therefore, a total of 41 study areas are included in the study (15 county remainders and 26 municipalities).

2.3 Self-supplied domestic unit-use coefficient method

The self-supplied domestic water withdrawals were estimated using a unit-use coefficient method. For this calculation, the number of people in each county that supply their own water via private wells was multiplied by an average daily use (82 gallons per day per person). The average daily use of 82 gallons per day per person is based upon average per capita withdrawals for various residential communities in East-Central Illinois [Tim Bryant, personal communication, March 10, 2008]. The self-supplied domestic population was calculated by subtracting the publicly supplied portion of the population from the total county population. Population calculations were done for historical data years (1985-2005) and for the future based upon county population projections (2010-2050) [DCEO, 2005]. The self-supplied domestic historical population and population projections are provided in Section 2.6.1.2. Future water withdrawal estimates are shown in Section 2.8.4.

2.4 PWS historical data

In order to create a multiple regression model to analytically understand the relationship between water withdrawals and the selected water demand variables, historical data of water withdrawals and independent variables were collected for the years 1985, 1990, 1995, 2000, and 2005. Water withdrawals and the demand variables were analyzed during this historical period to establish the

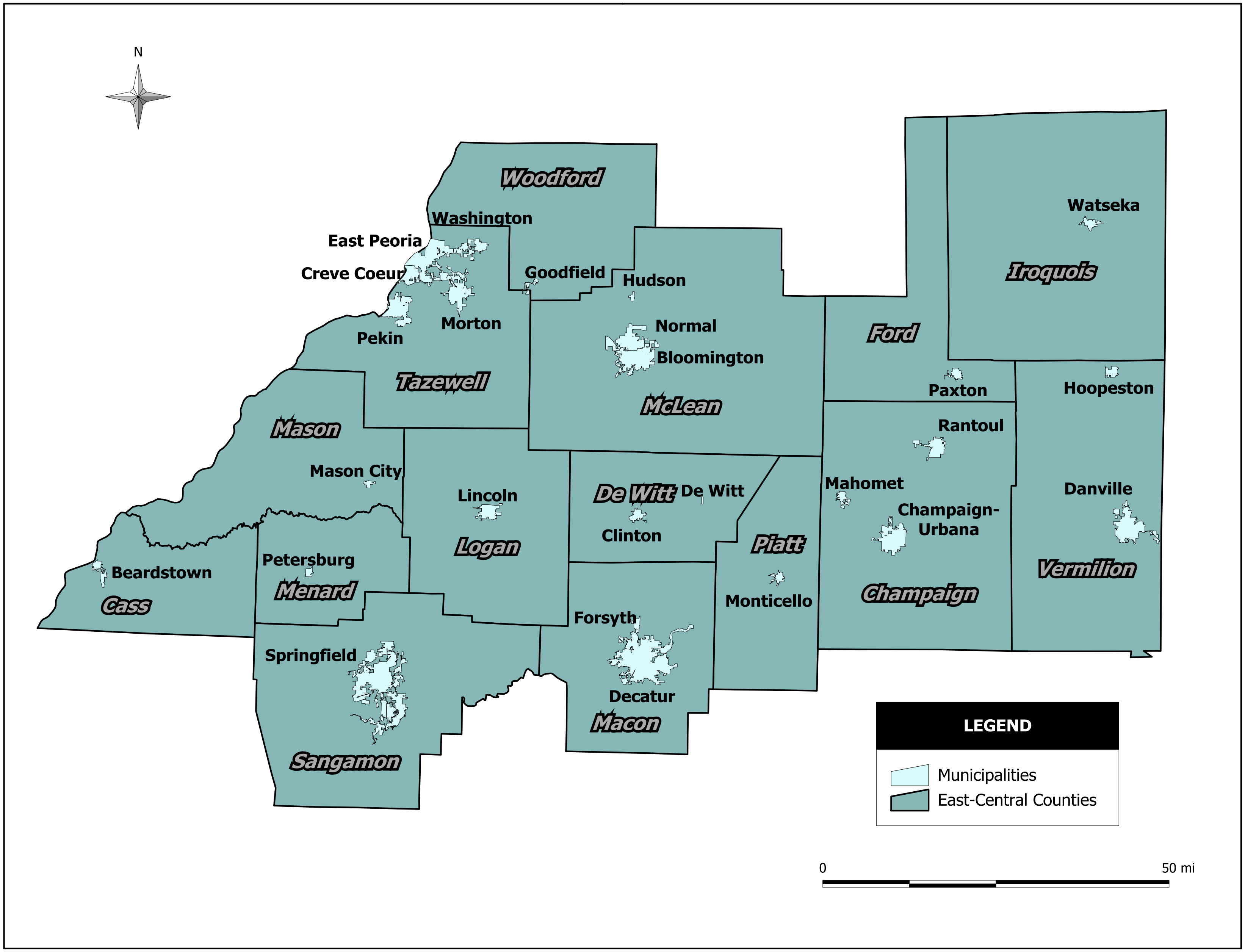


Figure 2.1: Map of 26 public water supply study areas modeled in addition to the 15 counties within the East-Central Region.

Table 2.1: The 26 public water supply study areas that were modeled in addition to the 15 counties within the East-Central Illinois Region [Census, 2000].

County	PWS Study Area	Percent Growth (1990-2000)	Population (2000)
Cass	Beardstown	9.4	5,766
Champaign	Rantoul	-25.3	12,857
Champaign	Mahomet	57.2	4,877
Champaign	Champaign/Urbana	6.3*	103,913
DeWitt	DeWitt	54.1	188
DeWitt	Clinton	0.6	7,485
Ford	Paxton	5.5	4,525
Iroquois	Watseka	4.5	5,670
Logan	Lincoln	-0.3	15,369
Macon	Decatur	-2.4	81,860
Macon	Forsyth	90.9	2,434
Mason	Mason City	10.1	2,558
McLean	Hudson	50.1	1,510
McLean	Normal	13.4	45,386
McLean	Bloomington	24.7	64,808
Menard	Petersburg	1.7	2,299
Piatt	Monticello	12.9	5,138
Sangamon	Springfield	5.9	111,454
Tazewell	Creve Coeur	-8.3	5,448
Tazewell	Morton	10.1	15,198
Tazewell	Washington	7.3	10,841
Tazewell	East Peoria	5.9	22,638
Tazewell	Pekin	5.0	33,857
Vermilion	Hoopeston	1.6	5,965
Vermilion	Danville	0.2	33,904
Woodford	Goodfield	51.1	686

*Percent growth for Champaign, Illinois; Population is 2000 U.S. Census data.

mathematical relationship between variables which drive the demand for water and water withdrawals. A description of the data and sources is provided in the following sections.

2.4.1 Historical water withdrawals

The data on PWS withdrawals were obtained from Mr. Timothy Bryant, Coordinator of the Illinois Water Inventory Program (IWIP) administered by the Illinois State Water Survey (ISWS). Under this program a questionnaire is sent to all of the nearly 1,800 public water systems in the state and includes questions about water sources, withdrawals, and water deliveries to domestic, commercial, and industrial users [ISWS, 2004]. Although participation by public water supplies is usually high (90% in 2005 statewide), it should be noted that in any given year the database is incomplete. If systems did not complete a survey for the target years, water withdrawals were estimated from data submitted in prior and/or subsequent years.

As discussed in Chapter 1, the data may also differ in what type of system data was reported to the ISWS. Some utilities may report the amount of water that is withdrawn directly from the source while others may report the amount of water that was sold to customers in a given year. Reporting the amount that is directly withdrawn from the source includes unaccounted for water (i.e., water for which no one pays, such as leaks and fire protection). Reporting only the amount of water sold, does not reflect the true amount being withdrawn from a water source. The amount of unaccounted for water differs from system to system and from year to year. In the United States, the average is 3.3-12.7%, although some systems may have a much higher percent unaccounted for water [van der Leeden, 1990].

And some utilities sell water on a wholesale basis to other utilties. Some utilities with such sales combine the wholesale amount and the amount used to supply their retail customers in their report, while others only include the amount for their retail customers. Additionally, when the wholesale supplier includes the wholesale amount in its report, and the wholesale purchasing utility also reports, there is double counting. Therefore, uncertainty is added to the historical withdrawals due to inaccurate reporting that can lead to over and under estimating the amounts of water withdrawals from public water supplies.

The water withdrawals from each reporting system were aggregated for each of the 26 public supply study areas and 15 county remainder areas. The historical water withdrawals for each study area is provided in Table 2.2.

As the data presented in Table 2.2 shows, most of the pubic water supply study areas increased their withdrawals from 1985 to 2005. The total public water supply withdrawals increased from 109.6 MGD in 1985 to 137.0 MGD in 2005. These increases are at least partly due to an increase in population in the region. However, the change may also be caused by increases in water demand due to weather or other factors like income.

The data for the each study area also show variability from year to year; water withdrawals may increase one year and decrease another. For example, if one year has a very hot, dry summer, water withdrawals may increase that particular year while the next year withdrawals decline due to a cooler summer. Or, perhaps there was a decrease in water withdrawals because there were job layoffs and household income declined for a few years. The variability in reasons or possible explanations for increases or decreases in water withdrawals shows the importance of using a multiple regression model. The model is designed to capture, or explain, the withdrawals using multiple independent variables that all impact water withdrawals.

All of the historical data was used as reported from the ISWS, with one exception. In 2001, the City of Decatur's public water supply system sold one of its water treatment plants to Archer Daniels Midland (ADM), a local industry. Prior to this year, Decatur sold water to ADM. The sale of the treatment plant in 2001 is evidenced in historical withdrawals as a drop in water withdrawals for Decatur (approximately 15 MGD in 2005). This decrease in withdrawals for 2005 creates a large decrease in per capita water withdrawals for Decatur as compared to other years. Conversely, in the Commercial and Industrial (C&I) Sector (Chapter 4), there is a large increase in the withdrawals in 2005. Because the model is designed to capture only changes in withdrawals that relate to the six independent variables, and not the change of large volumes of water from one sector to another, we removed this sectoral change from the historical data. The removal of the sector change was done by subtracting the amount of water that was sold to ADM in previous historical years (1985, 1990, 1995, and 2000) from Decatur's withdrawals. ADMs purchased amounts were removed from PWS and added to the withdrawals in the C&I Sector. This alteration better enables the model, which is based upon the historical data, to capture the other changes in water withdrawals. The modification in the historical withdrawals data is noted in the graphs and tables throughout the report.

Table 2.2: Historical water withdrawals (in MGD) for each public supply study area in East-Central Illinois.

Study Area	County	1985	1990	1995	2000	2005
Beardstown	Cass	1.51	1.44	1.04	1.26	1.30
Cass County Rem.	Cass	0.31	0.42	0.39	0.46	0.36

MGD = million gallons per day; Rem. = remainder.

Source: Illinois Water Inventory Program, Illinois State Water Survey, 2007.

* Water withdrawals for Decatur have ADM pumpage removed for all years. See text for explanation.

Table 2.2: Historical water withdrawals (in MGD) for each public supply study area in East-Central Illinois.

Study Area	County	1985	1990	1995	2000	2005
Champaign/Urbana	Champaign	16.66	17.29	18.87	20.46	23.24
Mahomet	Champaign	0.23	0.25	0.29	0.47	0.54
Rantoul	Champaign	1.38	1.13	1.29	1.55	1.67
Champaign County Rem.	Champaign	1.66	1.79	1.76	1.17	1.12
Clinton	DeWitt	1.01	1.00	1.09	0.87	0.87
DeWitt	DeWitt	0.01	0.02	0.02	0.02	0.01
DeWitt County Rem.	DeWitt	0.39	0.38	0.37	0.43	0.40
Paxton	Ford	0.55	0.49	0.61	0.70	0.56
Ford County Rem.	Ford	0.81	0.91	1.12	1.16	1.12
Watseka	Iroquois	1.47	1.60	1.62	1.65	1.61
Iroquois County Rem.	Iroquois	0.58	0.60	0.72	0.66	0.58
Lincoln	Logan	2.82	2.62	2.57	2.69	2.94
Logan County Rem.	Logan	0.68	0.64	0.73	0.66	0.66
Decatur*	Macon	16.77	20.33	23.46	25.59	23.64
Forsyth	Macon	0.12	0.16	0.29	0.31	0.41
Macon County Rem.	Macon	1.28	1.42	1.55	1.23	1.28
Mason City	Mason	0.27	0.33	0.32	0.27	0.27
Mason County Rem.	Mason	0.68	0.77	0.85	0.70	0.56
Bloomington	McLean	8.19	9.84	11.35	12.39	11.23
Hudson	McLean	0.07	0.08	0.09	0.11	0.14
Normal	McLean	3.43	3.94	3.79	4.22	4.29
McLean County Rem.	McLean	1.54	1.60	1.85	1.93	1.80
Petersburg	Menard	0.39	0.31	0.33	0.36	0.36
Menard County Rem.	Menard	0.26	0.27	0.36	0.44	0.39
Monticello	Piatt	0.73	0.62	0.68	0.67	0.72
Piatt County Rem.	Piatt	0.52	0.52	0.55	0.50	0.49
Springfield	Sangamon	17.78	20.75	21.45	20.84	22.94
Sangamon County Rem.	Sangamon	2.21	2.34	2.35	2.26	1.83

MGD = million gallons per day; Rem. = remainder.

Source: Illinois Water Inventory Program, Illinois State Water Survey, 2007.

* Water withdrawals for Decatur have ADM pumpage removed for all years. See text for explanation.

Table 2.2: Historical water withdrawals (in MGD) for each public supply study area in East-Central Illinois.

Study Area	County	1985	1990	1995	2000	2005
Creve Coeur	Tazewell	0.59	0.74	0.79	0.83	0.93
East Peoria	Tazewell	2.32	2.09	2.40	2.59	2.73
Morton	Tazewell	2.02	2.12	2.34	2.28	2.68
Pekin	Tazewell	4.41	4.57	5.30	6.39	7.42
Washington	Tazewell	1.12	0.82	1.08	0.94	1.16
Tazewell County Rem.	Tazewell	3.18	3.63	3.12	2.95	2.76
Danville	Vermilion	8.15	10.02	8.46	8.35	8.34
Hoopeston	Vermilion	0.80	0.66	0.79	0.45	0.56
Vermilion County Rem.	Vermilion	1.18	1.20	1.32	0.80	0.79
Goodfield	Woodford	0.04	0.04	0.04	0.06	0.09
Woodford County Rem.	Woodford	1.44	1.57	2.13	2.23	2.24
East-Central Illinois		109.63	121.37	129.61	134.01	137.03

MGD = million gallons per day; Rem. = remainder.

Source: Illinois Water Inventory Program, Illinois State Water Survey, 2007.

* Water withdrawals for Decatur have ADM pumpage removed for all years. See text for explanation.

2.4.2 Population served

The population served is the number of residents that a public water supplier serves. Population served is used to calculate the gallons per capita per day withdrawals (GPCD) in the historical dataset. The GPCD is calculated by dividing the total water withdrawals in a study area by the total population served in that study area. The historical population served data that was used is provided in Appendix B.

Population served is reported to the ISWS annually. Typically, the population served is the census population of a city. However, it is not unusual for population served to be larger than the census population if a public water supplier supplies subdivisions or communities outside corporate boundaries and sometimes even outside the county. Population served can also be smaller if a section of a municipality is served by another water supply system or if some residences rely on private wells. For example, the City of Decatur also serves Mount Zion, so the population served for Decatur is the city's population plus the population of Mount Zion.

Population served is an important driver of water withdrawals. In fact, 97% of variability in the total public water supply withdrawals can be explained by population. Therefore, population served was used to express the dependent variable as average public-supply water withdrawals (and purchases) per capita per day for each study area and data year. If the per capita rate of water withdrawals in each study area can be predicted with sufficient accuracy, then total public supply withdrawals can be estimated by multiplying the per capita use by population served, where the latter represents a driver of public-supply demands.

2.4.3 Independent variables

Water withdrawals are driven, or controlled, by certain influencing factors called independent or explanatory variables. A substantial data collection and processing effort was required to prepare appropriate variables for the development of water-demand relationships. The dependent variable was defined as gross water withdrawals per capita. Six independent variables were used to explain the variability of per capita water demand across study sites. These six variables were chosen based upon a previous study of Illinois water withdrawals [Dzielgielewski et al., 2005] in which over 20 variables were tested to determine if they significantly affected water demand. The variables used in this study include: marginal price of water, median household income, ratio of employment-to-population, summer season air temperature, summer season precipitation, and conservation trend. The data and source information for each of these variables are discussed in the following sections.

2.4.3.1 Marginal price of water

Studies across the United States (US) show that when the price of water increases, people use less water [JAWRA, 2008]. In fact, as many regions of the US are trying to reduce water demand and conserve water, price has become an important tool. So, price is an important water demand variable. In this study, marginal price is defined in this study as the cost difference in the total water bill between 5,000 gallons and 6,000 gallons of monthly usage. Using marginal price allows us to compare prices of different public water suppliers without the complication of other user-fees and billing frequency.

During the outreach portion of this project, each PWS system was asked to provide their historical marginal price data. These data were used preferentially, when they were available. Additional data on historical water prices were developed using data from a survey of water prices in Illinois systems conducted in 2003 (Dziegielewski et al., 2004). The historical marginal price data that was used is provided in Appendix B. All price data was converted to 2005 dollars.

2.4.3.2 Median household income

Median household income is positively related to water demand, meaning as median household income increases so does water demand. People who have more money tend to have larger houses with more bathrooms and larger properties with irrigation systems. People with less money have smaller houses and smaller yards. Additionally, people with less money are more conscious of where their money is being spent and may reduce use in order to reduce costs.

Data on median household income were obtained from the U.S. Census Bureau and the 2005 American Community Survey [United States Census Bureau, 2000]. Data for the inter-decadal years were calculated as an average of the census years prior to and after the year. All median household income data were converted to 2005 dollars. The historical median household income data that was used is provided in Appendix B.

2.4.3.3 Employment to population ratio

The employment to residential population ratio is positively correlated to water demand. Higher employment in an area means greater water withdrawals. Historical county and city data for employment were obtained from the U.S. Department of Labor, Bureau of Labor Statistics [2007]. The data show the total number of people employed, including governmental and institutional employment. The values for the county remainders were calculated by subtracting the PWS study areas from the total employment in that county. The historical employment to population ratio that was used for each study area is provided in Appendix B.

2.4.3.4 Summer temperature and summer precipitation

Temperature and precipitation are both important drivers of water demand. Temperature is positively correlated to water demand whereas, precipitation is negatively correlated to demand. When temperatures increase, people use more water. They use more to water their gardens and wash their cars. And often people take more showers when it is hotter. Conversely, when it rains people use less water to irrigate their lawn and gardens. The summer period is important to water withdrawals because that is the time when the greatest water demand occurs in the region; it is typically the hottest and driest time of year.

The correlation of weather to water withdrawals indicates that climate change will impact water demand in the region. Although, we do not account for it in our three scenarios, we do examine the possible effects of climate change and drought in Chapter 6. Please refer to this chapter for more discussion about climate change and the impacts to water withdrawals.

Data on weather variables were obtained from Dr. Jim Angel, State Climatologist, Illinois State Water Survey. Data from 29 stations in the 15-county region were organized and summarized. The weather station numbers and locations used for this study are listed in Table B.14 in Appendix B.

Total rainfall from May 1 through September 30 was summed and used as the summer precipitation variable. Maximum monthly temperature from May 1 through September 30 was averaged as the summer temperature variable.

The weather variables assigned to each county were the average of all the stations in that particular county. If there were no stations in a county or no data from the existing station, data from a surrogate station were used. Typically, the surrogate station used was the nearest station to the county in question. The surrogate stations were chosen with the advice of the State Climatologist. For the 26 PWS study areas, weather data were preferentially used from a station in that city; if such observations were unavailable, the average county data were used.

The historical maximum summer temperature and summer precipitation data used for each study area are shown in Table B.16 in Appendix B.

2.4.3.5 Conservation trend

An additional variable, conservation trend, was included to account for unspecified changes that are likely to influence water demand over time and that represent general trends in water conservation behavior. Such influences include the increase in water-use awareness programs, implementation of Federal laws mandating adoption of water conservation technologies, and a new emphasis on adoption of full-cost pricing of water. The conservation trend variable was specified as 0 for 1985, 5 for 1990, 10 for 1995, 15 for 2000, and 20 for the year 2005.

2.5 PWS water-withdrawal relationships

The historical data on per capita water withdrawals and the historical data for the six variables was used to generate a log-linear model. The model (specified as Equation 1.1 in Chapter 1) was applied to capture the relationship between per capita water demand and the explanatory variables. The statistical model explained per capita water demand as a function of the average of the monthly maximum daily air temperatures during summer - May 1 through September 30 (summer temperature), total precipitation during summer (summer precipitation), ratio of employment to resident population, marginal price of water, median household income, and the conservation trend variable.

Table 2.3: The structural portion of the log-linear model for per capita water withdrawals in the public supply sector.

Variables	Coefficients	t-Ratio	Probability >|t|
Intercept	-2.3058	-0.43	0.67
Max. summer temperature (ln)	1.4222	1.2	0.23
Summer precipitation (ln)	-0.1140	-1.67	0.10
Employment-population ratio (%)	0.6381	5.3	<.0001
Marginal price of water (ln)	-0.2226	-3.64	0.00
Median household income (ln)	0.3244	2.99	0.00
Conservation trend (ln)	-0.0026	-0.98	0.33
N = 205, R^2= 0.85, R^2Adj = 0.81, Root MSE = 0.15, Mean R.= 4.74			

The structural portion of the regression model for PWS is shown in Table 2.3. Figure 2.2 shows the sign and relative magnitude of the coefficients of each of the six variables. Together, these six coefficients, or elasticities, compose the equation that explain water withdrawals for PWS. The estimated elasticities of the explanatory variables in the structural model have the expected signs and magnitudes. The constant elasticity of the summer temperature variable indicates that, on average, a 1 percent increase in temperature increases per capita water demand by 1.4 percent. The negative constant elasticity of the summer precipitation variable indicates that, on average, a 1 percent increase in summer precipitation decreases per capita water demand by 0.11 percent. Similarly, a 1 percent increase in marginal price of water is associated with a 0.22 percent decrease in per capita water demand, and a 1 percent increase in median household income results in a 0.32 percent increase in per capita demand. The coefficient of employment-to-population ratio of 0.64 indicates that water withdrawals are higher in study areas with higher commercial/industrial employment relative to resident population per capita. The conservation trend with the estimated coefficient of -0.0026 indicates that in the historical data there was a declining trend in per capita water demand.

The last row of Table 2.3 shows the model statistics. The statistics (R^2= 0.85) indicate that the model explained 85 percent of time-series and cross-sectional variance in log-transformed per capita water use. Please refer to the list of key terms for explanations of the other statistical values shown. The binary and spike variables included in the model are discussed and shown in Appendix B.

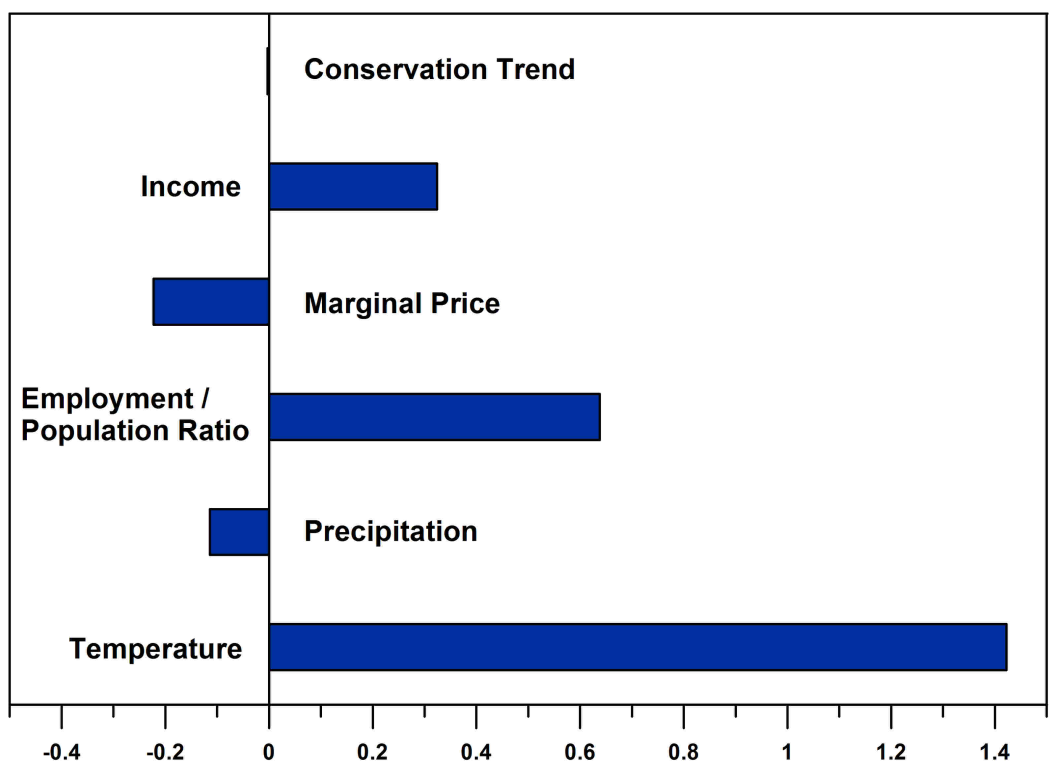


Figure 2.2: Structural model for public water supply sector in East-Central Illinois.

Table 2.4: Examples of estimated elasticities of four explanatory variables in public water supply water-demand models.

Study/Variable Definition	Elasticity	Notes
INCOME		
Griffin and Chang, 1990	0.480	Winter water use
Annual per capita income	0.300	Summer water use
Schneider et al., 1991	0.218	Generalized least-squares model (GLS)
Per capita income	0.458	GLS model with inclusion of cross-sectional dummy variables
	0.144	GLS with inclusion of time series dummy variables
	0.309	GLS with inclusion both cross-sectional and time series dummy variables
PRICE		
Berk et al., 1980	-0.090	Monthly water use
Marginal price		
Griffin and Chang, 1990	-0.160	Winter water use
Average water price	-0.380	Summer water use
Schneider and Whitlach, 1991	-0.066	Generalized least-squares model (GLS)
Marginal water cost	-0.057	GLS model with inclusion of cross-sectional dummy variables
	-0.114	GLS with inclusion of time series dummy variables
	-0.049	GLS with inclusion both cross-sectional and time series dummy variables
	-0.137	From partial adjustments, generalized least-squares model with time series dummy variables
PRECIPITATION		
Berk et al., 1980	-0.012	Pooled analysis of monthly data
Total monthly rainfall		
Schneider and Whitlach, 1991	-0.056	Generalized least-squares model (GLS)
Precipitation during	-0.068	GLS model with inclusion of cross-sectional dummy variables

Table 2.4: Examples of estimated elasticities of four explanatory variables in public water supply water-demand models.

Study/Variable Definition	Elasticity	Notes
summer (May-August)	-0.046	Partial adjustments, generalized least-squares model with time series dummy variables
TEMPERATURE		
Berk et al., 1980 Mean monthly temperature	1.370	Pooled cross-sectional time-series data

The estimated elasticities of the main variables in the structural model confirm the estimates obtained in other studies of municipal water demand. Table 2.4 shows the elasticities of income, price, precipitation and temperature which were reported in three previous studies.

Table 2.4 shows six estimates of per capita income elasticity. All reported elasticities are positive and range from 0.144 to 0.48. The data used in the two studies (Griffin et al., 1990 and Schneider, 1991) were pooled time-series and cross-sectional data – the same data configuration was used in the present study.

All eight price elasticity estimates (Table 2.4) are negative and range from -0.05 to -0.38. These elasticities indicate that municipal water demand is generally inelastic with respect to price. The highest (absolute) value of -0.38 is for summer season water use, which is expected to be more elastic than non-seasonal (or indoor use). There appears to be a relatively narrow range of estimated elasticities of municipal winter season and annual water demand (also captured by monthly models) with respect to price of –0.05 to –0.16.

Table 2.4 includes several estimates of the elasticity of municipal demand with respect to the weather variables. All four reported elasticities of precipitation are negative and range from -0.012 to -0.068. These values indicate relatively low responsiveness of municipal demand to changes in precipitation. The estimated elasticity of municipal demand with respect to air temperature in the study by Berk et al. [1980] is positive 1.37, demonstrating the expected relationship between water use and temperature.

The equations from the model were used to generate both the historical and future water withdrawals in each of the 41 study areas. Figure 2.3 shows the model-generated GPCD versus the historical reported GPCD for the years 1985-2005. The figure shows that the model approximates the reported GPCD well for most of the study areas. Of course, as in any dataset of this nature, there are outliers that are not captured by the model, but overall, the model is able to account for 85% of variance in per capita water demand.

Table 2.5 compares the 2005 model-generated and reported values of combined water withdrawals and purchases for each system and within county remainder areas. The differences between the model generated and reported values are relatively small, since in several cases where the differences for the 2005 data year were large, additional calibrations of model intercepts were performed. The total difference between the model and the reported values for the 15-county region is 1.87 MGD. The calibrated 2005 intercepts were retained in preparing estimates of future water withdrawals.

Table 2.5: Comparison of model-generated and reported water withdrawals in 2005 for public water supply sector.

Study Area	County	Model-generated withdrawals* (MGD)	Reported withdrawals (MGD)	Difference (MGD)
Beardstown	Cass	1.29	1.30	-0.01
Cass County Rem.	Cass	0.47	0.36	0.11
Champaign/Urbana	Champaign	23.24	23.24	0.00
Mahomet	Champaign	0.53	0.54	-0.01
Rantoul	Champaign	1.78	1.67	0.11
Champaign County Rem.	Champaign	1.08	1.12	-0.04
Clinton	DeWitt	0.95	0.87	0.08
DeWitt	DeWitt	0.02	0.01	0.01
DeWitt County Rem.	DeWitt	0.41	0.40	0.01
Paxton	Ford	0.55	0.56	-0.01
Ford County Rem.	Ford	1.25	1.12	0.13
Watseka	Iroquois	0.59	0.58	0.01
Iroquois County Rem.	Iroquois	1.86	1.61	0.25
Lincoln	Logan	2.80	2.94	-0.14
Logan County Rem.	Logan	0.82	0.66	0.16
Decatur	Macon	23.65	23.64	0.01
Forsyth	Macon	0.44	0.41	0.03
Macon County Rem.	Macon	1.28	1.28	0.00
Mason City	Mason	0.30	0.27	0.03
Mason County Rem.	Mason	0.60	0.56	0.04

MGD = million gallons per day; Rem. = remainder;

*Model-generated withdrawals are estimated using actual 2005 weather data.

Table 2.5: Comparison of model-generated and reported water withdrawals in 2005 for public water supply sector.

Study Area	County	Model-generated withdrawals* (MGD)	Reported withdrawals (MGD)	Difference (MGD)
Bloomington	McLean	11.36	11.23	0.13
Hudson	McLean	0.15	0.14	0.01
Normal	McLean	4.24	4.29	-0.05
McLean County Rem.	McLean	1.82	1.80	0.02
Petersburg	Menard	0.42	0.36	0.06
Menard County Rem.	Menard	0.38	0.39	-0.01
Monticello	Piatt	0.75	0.72	0.03
Piatt County Rem.	Piatt	0.48	0.49	-0.01
Springfield	Sangamon	22.90	22.94	-0.04
Sangamon County Rem.	Sangamon	2.04	1.83	0.21
Creve Coeur	Tazewell	0.93	0.93	0.00
East Peoria	Tazewell	2.80	2.73	0.07
Morton	Tazewell	3.18	2.68	0.50
Pekin	Tazewell	7.48	7.42	0.06
Washington	Tazewell	1.31	1.16	0.15
Tazewell County Rem.	Tazewell	2.73	2.76	-0.03
Danville	Vermilion	8.35	8.34	0.01
Hoopeston	Vermilion	0.64	0.56	0.08
Vermilion County Rem.	Vermilion	0.76	0.79	-0.03
Goodfield	Woodford	0.08	0.09	-0.01
Woodford County Rem.	Woodford	2.19	2.24	-0.05
East-Central Illinois		138.9	137.03	1.87

MGD = million gallons per day; Rem. = remainder;

*Model-generated withdrawals are estimated using actual 2005 weather data.

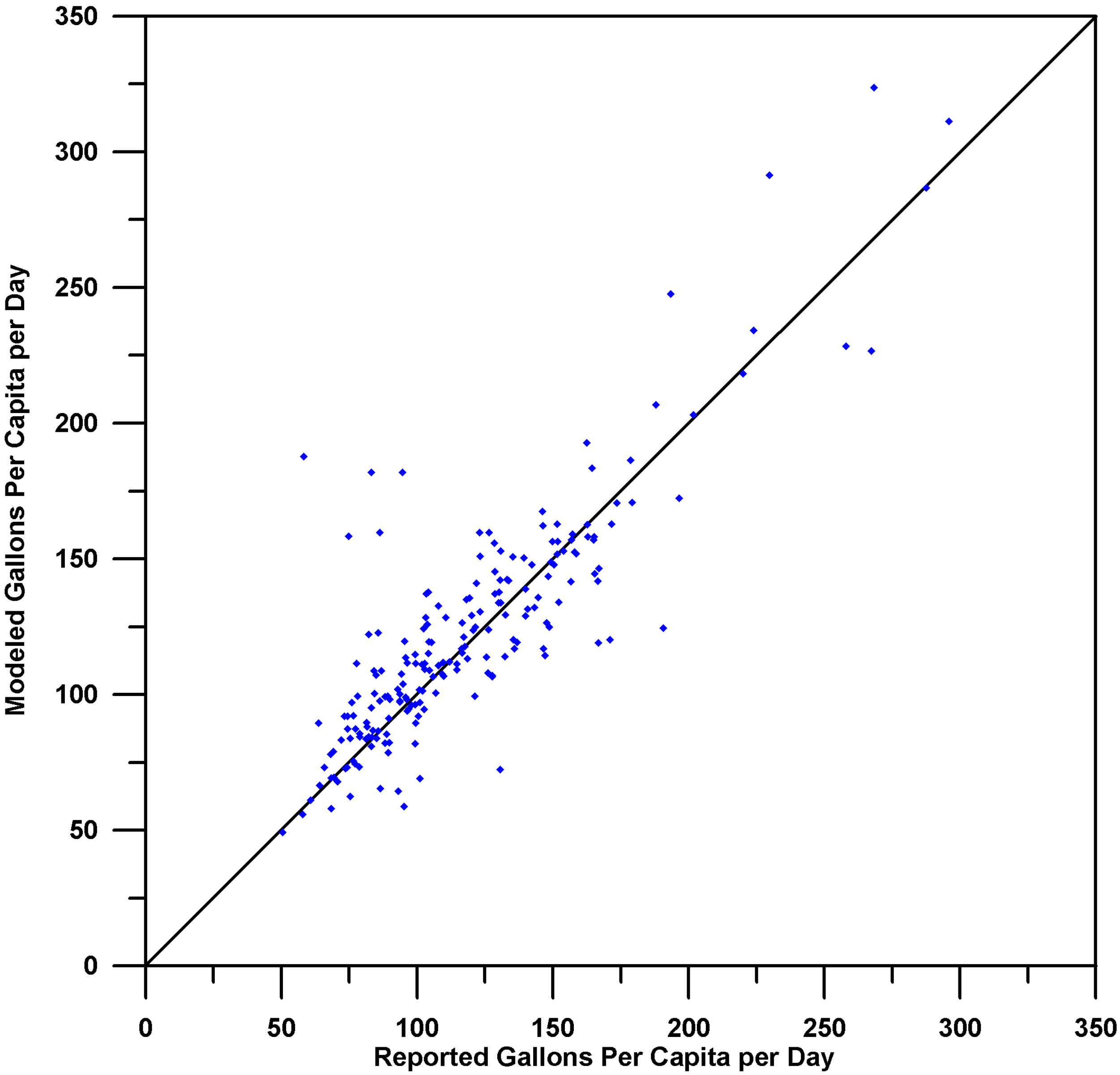


Figure 2.3: Comparison of the historical reported and the model-generated gallons per capita per day water withdrawals from 1985-2005.

2.6 Future data

The public water supply model established the relationship between water withdrawal and the water demand variables. Assuming that this relationship remains the same in the future, we can use the model along with future values of water demand variables to estimate water withdrawals. The following sections describes how the water-demand drivers and variables were projected to the year 2050.

2.6.1 Future population

The main driver of future demand in the PWS sector is population. Data on future resident population of the study area were obtained from the Illinois Department of Commerce and Economic Opportunity (DCEO) [2007]. These data are county-wide population projections to the year 2030. The 2030 to 2050 extension of population projections for the 15-county area was achieved by using the average annual growth rate from the county projection for the years 2020-2030. The method of extension of the projections was approved by John Chiang, Illinois State Demographer.

For the 15-county study area, the total resident population is expected to increase between 2000 and 2050 from 1,033,772 to 1,343,226 (Table 2.6). This represents an increase of 309,454 persons (or 29.9 percent). Graphs of the historical and future resident population for each county are shown in Figures 2.4 – 2.11. The population for each county was used to calculate the PWS population and the domestic supply population, which are described below.

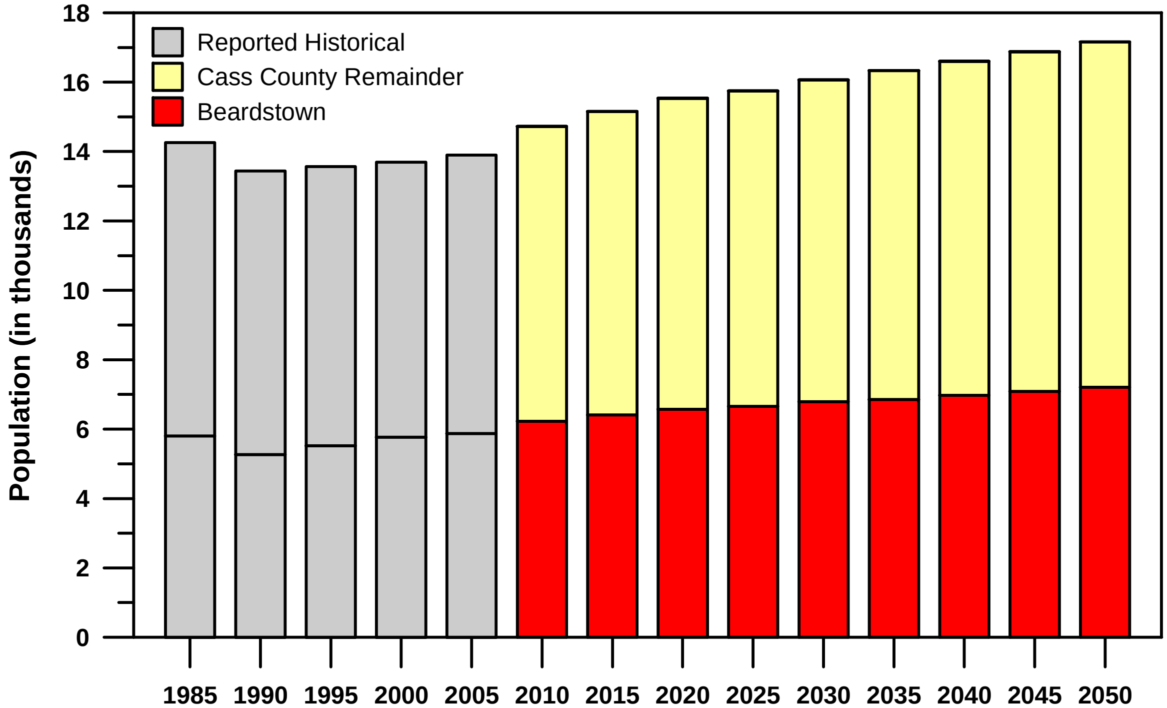
2.6.1.1 PWS population served

The future population served is used to calculate the future water withdrawals in million gallons per day (MGD) by multiplying population served by the model generated GPCD. Because there is no source for data on the future population served, we used future resident population to calculate an estimate of the future population served. In an effort to do this, the relationship between historical residential population and historical population served was analyzed. The general relationship between resident population and population served did not significantly change in the historical years for most of the study areas. However, because of changes in some study areas in 2005, for example Champaign/Urbana increased their population served in 2005 because they began serving additional communities outside their boundaries, the PWS population served was calculated using the 2005 percent of total population. It was assumed, for the purpose of this study, that the 2005 percent of the total population would remain constant into the future. The PWS population served

Table 2.6: Total population for each 15-County East-Central Illinois Region.

County	1990	2000	2030	2050	2000-2050 Change	Percent Change
Cass	13,437	13,695	16,064	17,158	3,463	25.3
Champaign	173,025	179,669	216,958	231,735	52,066	29.0
DeWitt	16,516	16,798	19,768	21,582	4,784	28.5
Ford	14,275	14,241	16,015	17,038	2,797	19.6
Iroquois	30,787	31,334	36,304	39,953	8,619	27.5
Logan	30,798	31,183	32,715	33,845	2,662	8.5
Macon	117,206	114,706	119,693	127,845	13,139	11.5
Mason	16,269	16,038	17,147	17,493	1,455	9.1
McLean	129,180	150,433	199,102	225,300	74,867	49.8
Menard	11,164	12,486	15,195	16,133	3,647	29.2
Piatt	15,548	16,365	18,034	18,620	2,255	13.8
Sangamon	178,386	188,951	222,367	247,655	58,704	31.1
Tazewell	123,692	128,485	165,373	189,378	60,893	47.4
Vermilion	88,257	83,919	80,137	85,937	2,018	2.4
Woodford	32,653	35,469	46,857	53,552	18,083	51.0
East-Central Region	991,193	1,033,772	1,221,729	1,343,226	309,454	29.9

Sources: 1990 and 2000 data from U.S. Census Bureau; 2030 county projections from Illinois Department of Commerce and Economic Opportunity. Note: County values do not include populations served outside of the county.



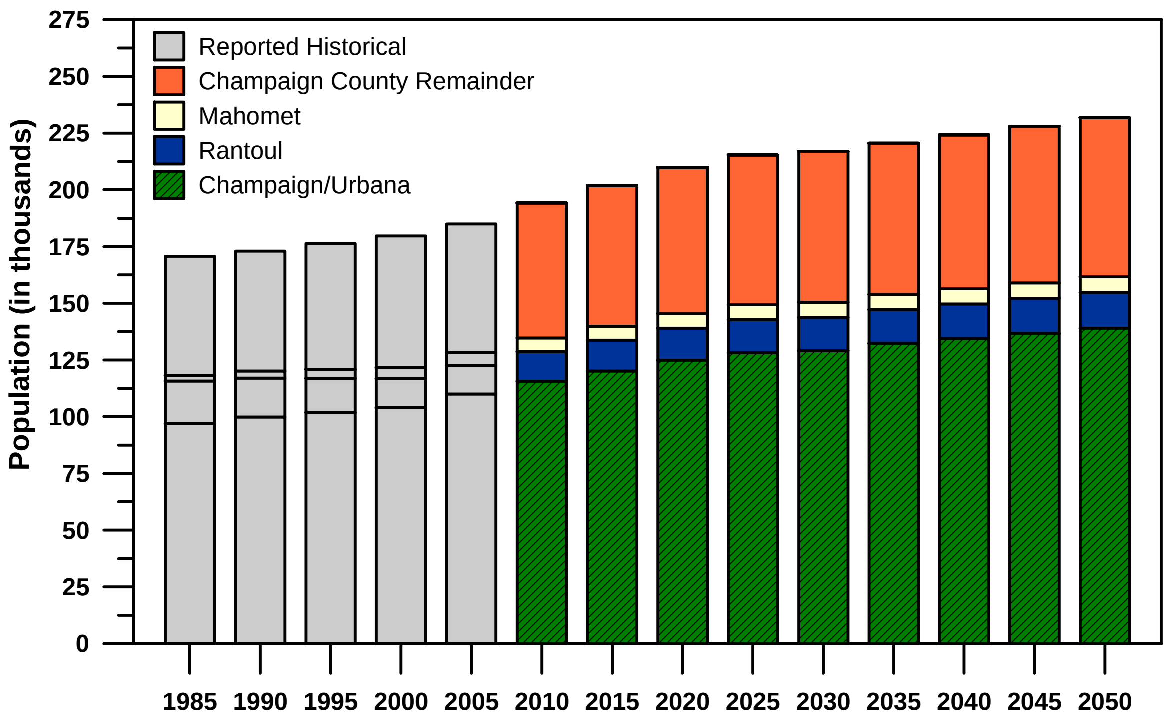


Figure 2.4: Historical and future resident population for the Cass and Champaign County study areas in East-Central Illinois.

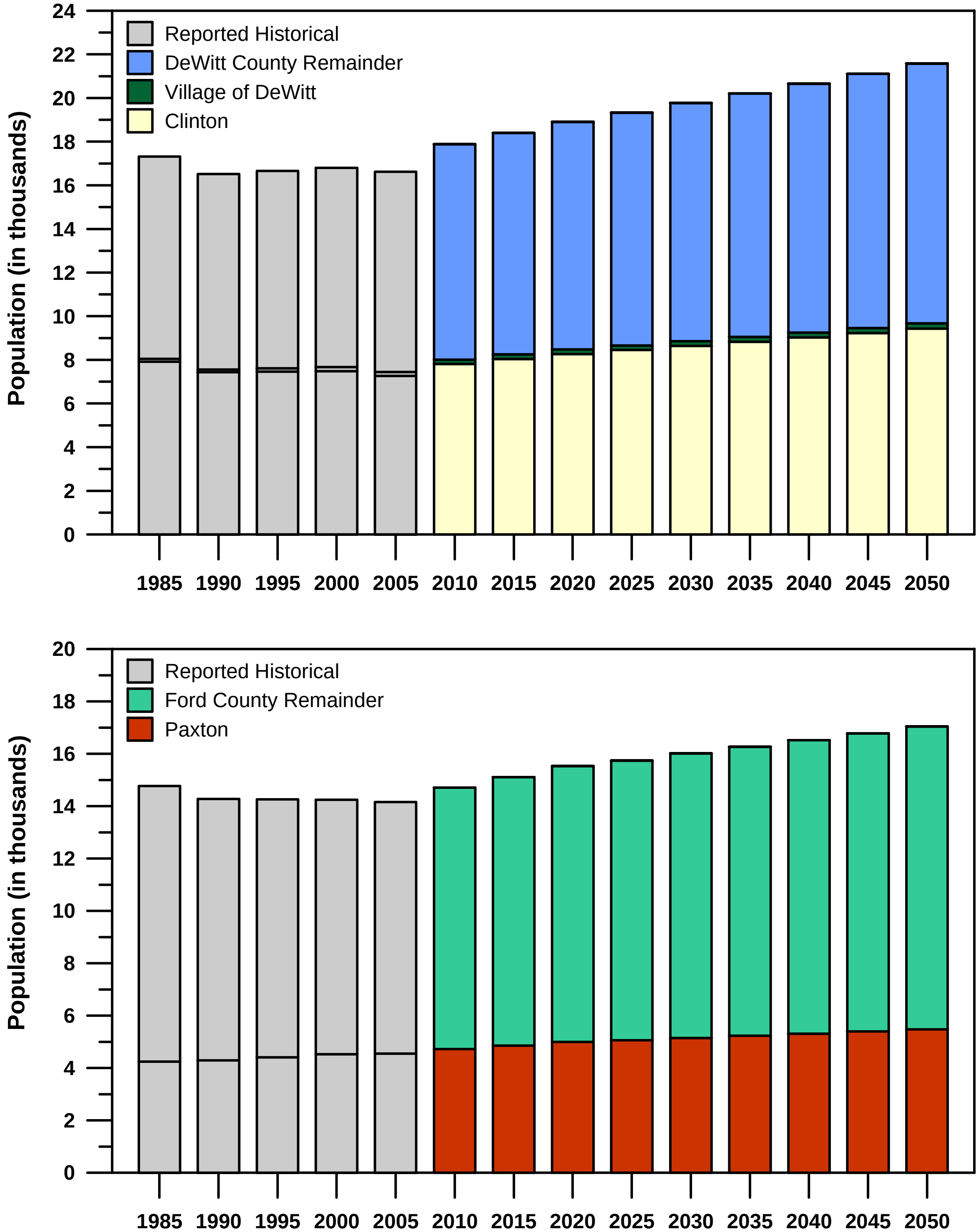


Figure 2.5: Historical and future resident population for the DeWitt and Ford County study areas in East-Central Illinois.

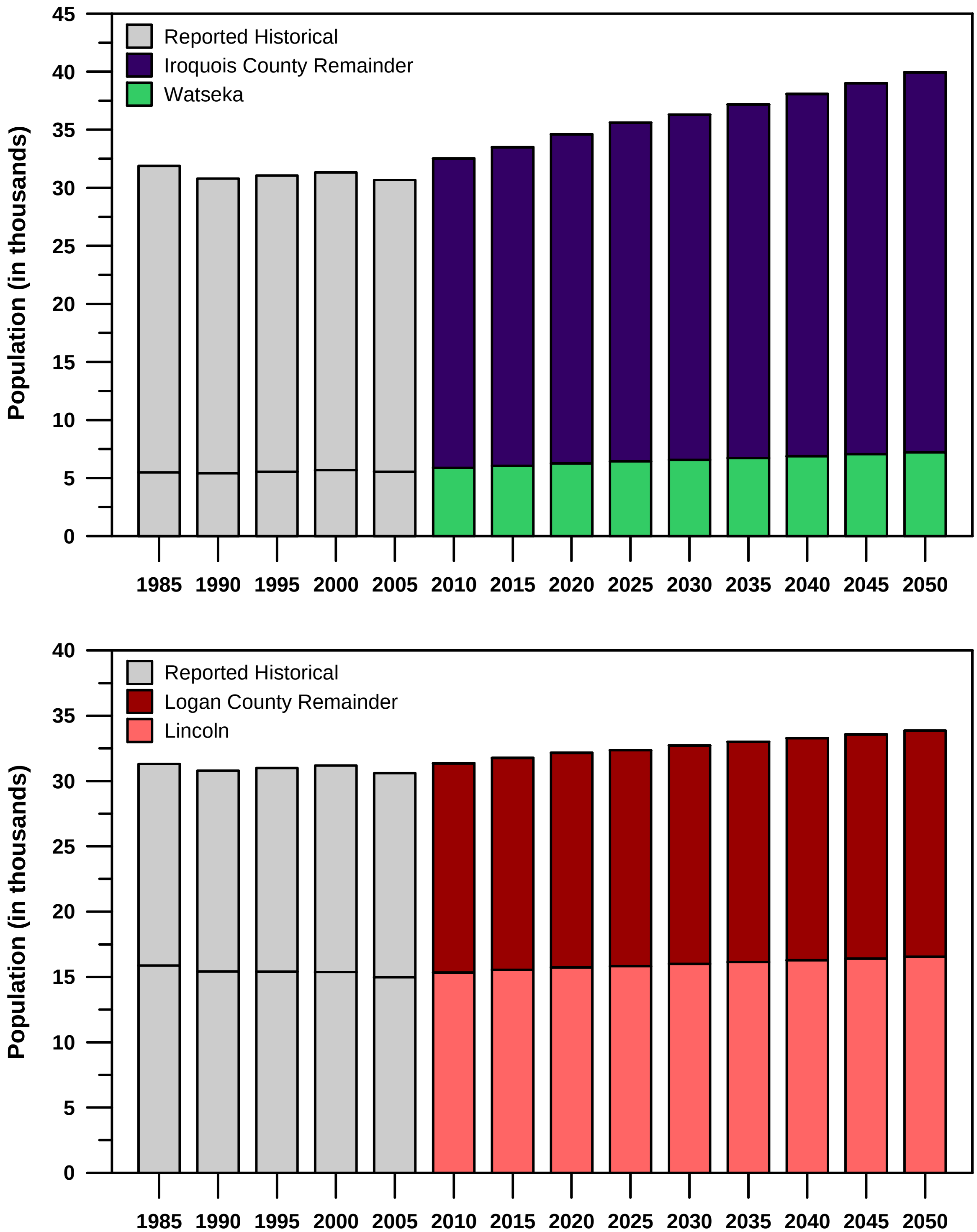


Figure 2.6: Historical and future resident population for the Iroquois and Logan County study areas in East-Central Illinois.

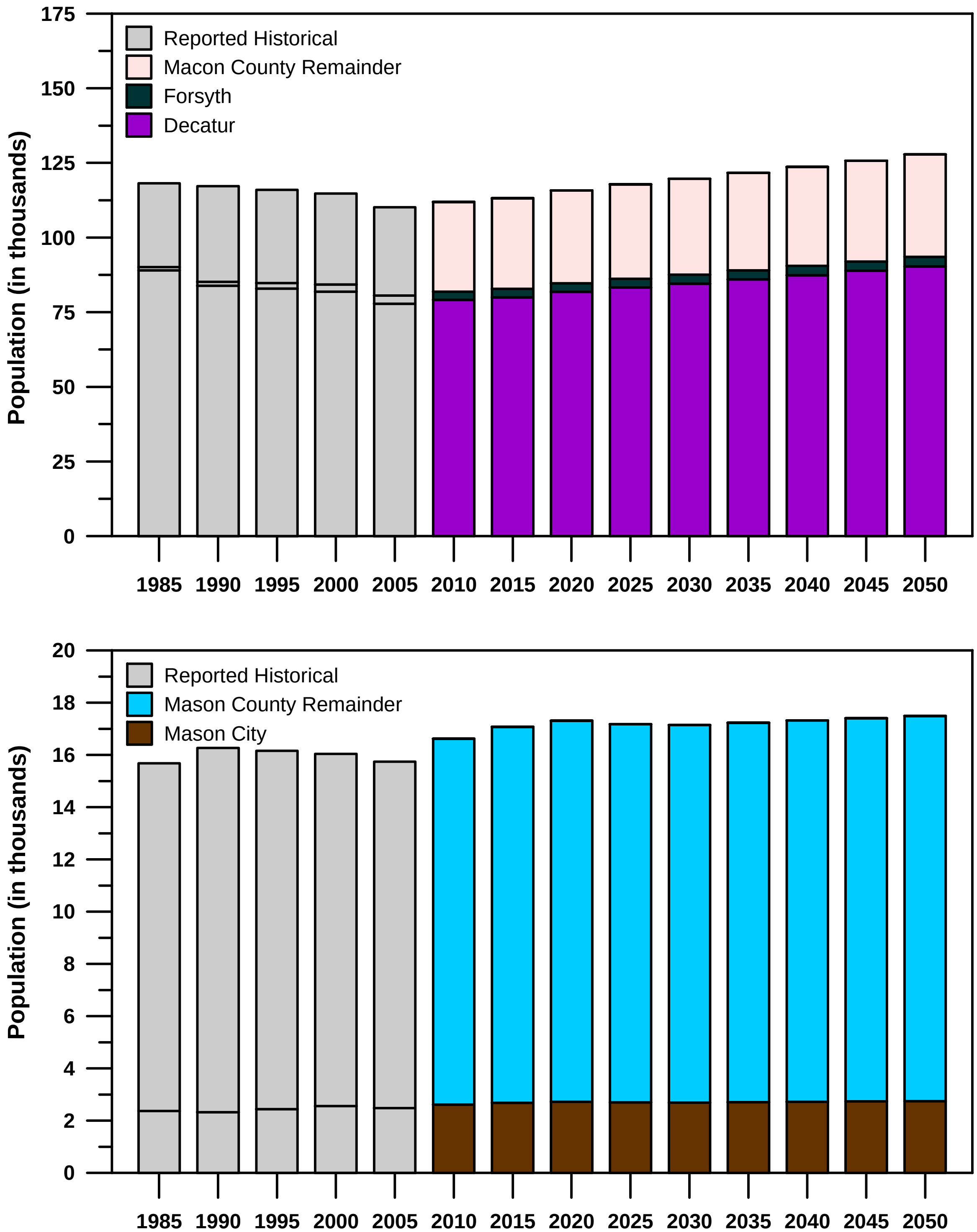


Figure 2.7: Historical and future resident population for the Macon and Mason County study areas in East-Central Illinois.

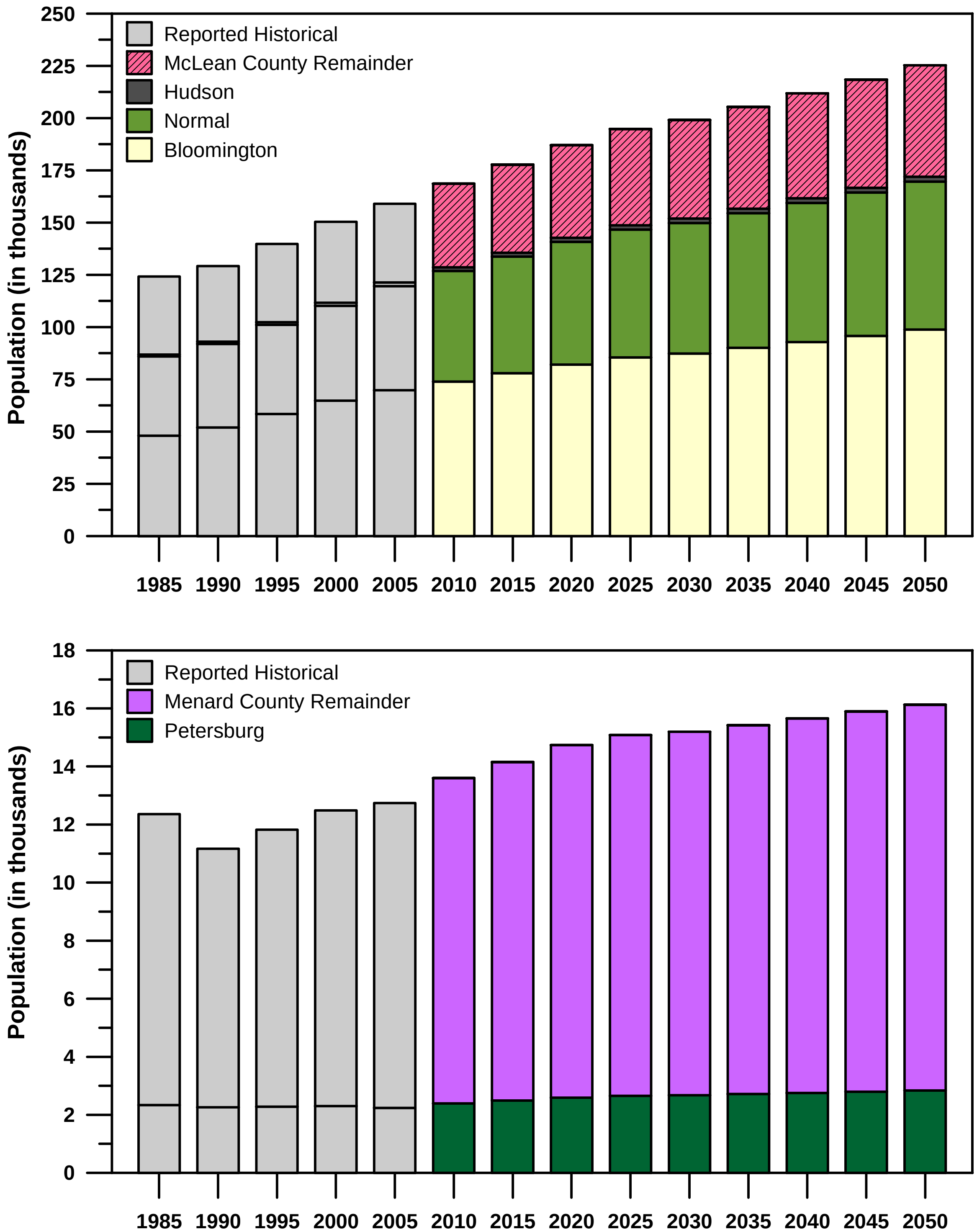


Figure 2.8: Historical and future resident population for the McLean and Menard County study areas in East-Central Illinois.

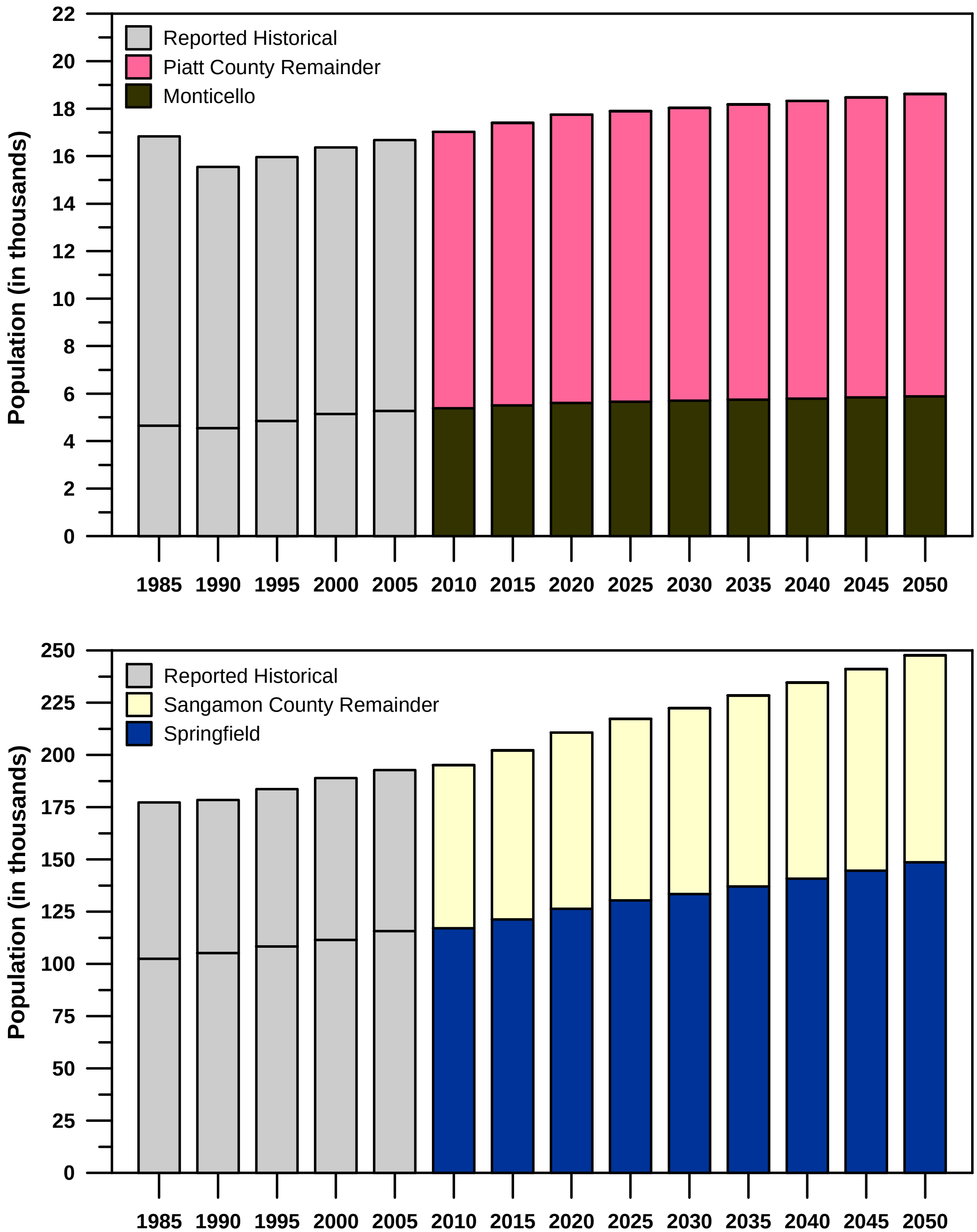


Figure 2.9: Historical and future resident population for the Piatt and Sangamon County study areas in East-Central Illinois.

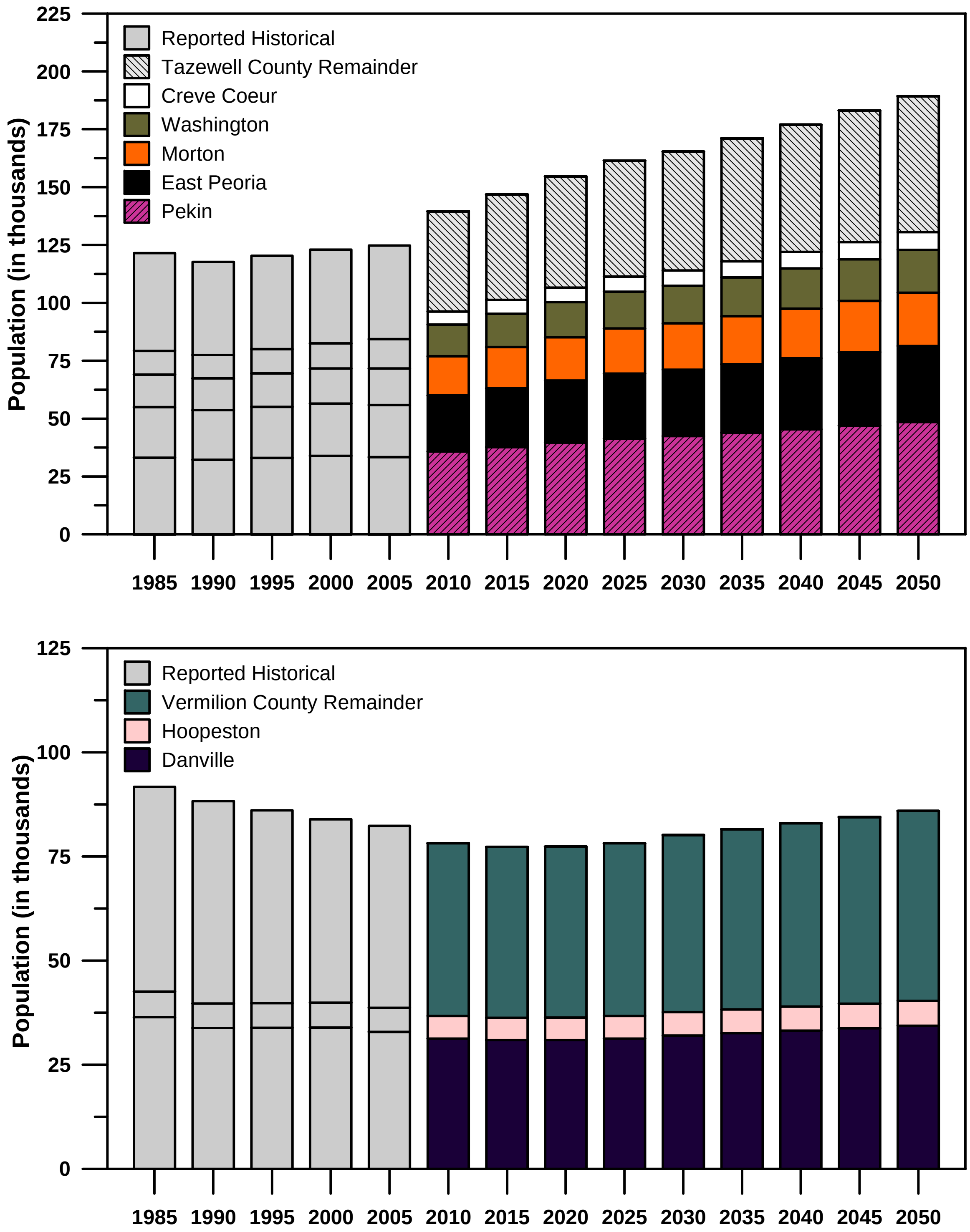


Figure 2.10: Historical and future resident population for the Tazewell and Vermilion County study areas in East-Central Illinois.

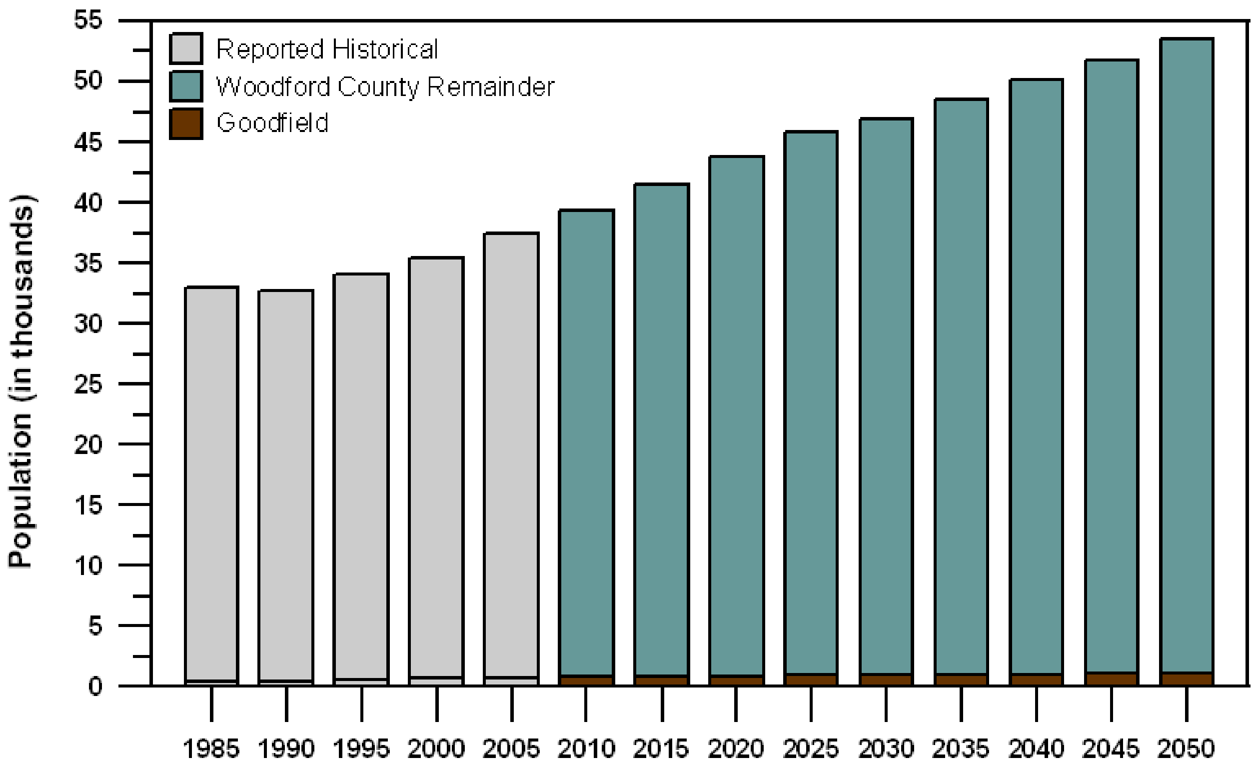


Figure 2.11: Historical and future resident population for the Woodford County study areas in East-Central Illinois.

Table 2.7: Total self-supplied domestic population, 2005-2050.

Year	Total self-supplied domestic population
2005	108,076
2010	121,510
2015	125,363
2020	129,539
2025	132,847
2030	135,267
2035	137,249
2040	140,237
2045	143,290
2050	146,421
Difference from 2005 to 2050	
Unit	38,345
Percent (%)	35.5

calculation was performed for every five years to 2050. The future population served values for each study area are provided in Appendix B.

2.6.1.2 Domestic population

The self-supplied domestic population was calculated by subtracting the future total population served by a PWS system within a county from the future total county population. The total self-supplied domestic population is expected to increase by 38,345 people from 108,076 in 2005 to 146,421 in 2050 (Table 2.7). The future self supplied domestic population values for each study area are provided in Appendix B.

2.6.2 Future explanatory variables

The future values of the six explanatory (or independent) variables (i.e., temperature, precipitation, employment/population ratio, price, income, and conservation) are used to determine the future rates of per capita water withdrawals in the public-supply sector in each study area. To estimate future water withdrawals, the future values of the independent variables must be determined. A description of the future estimates for the independent variables used is provided below.

2.6.2.1 Weather variables - temperature and precipitation

Some of the most important determinants of water demand are related to weather. Consequently, in order to estimate future water withdrawals, the weather variables (i.e., precipitation, temperature, and cooling degree days) must also be estimated. Weather data may be dealt with in a variety of ways when looking into the future. One approach is to "predict" future weather by using the climatic normals, as calculated by the National Center for Climatic Data (NCDC). Climatic normals are defined as the "statistical average over a time period usually consisting of three consecutive decades" [Owenby et al., 2006]. The current climatic normals are defined for the period 1971-2000. The averaging of the past weather data means that no inter-annual variation is taken into account in the water demand models (Figure 2.12). In effect, this assumes that the average weather from the 30-year period can be used to estimate the future demand. On the one hand, this approach firmly connects the forecast to the historical record. On the other hand, by representing the future as the average of the 30-years of record we lose the extremes that cause variation in demand.

A second method for estimating weather data in the future is to stochastically model the weather. Stochastic modeling would allow us to create a dataset of fictional weather data that is statistically the same as the historic data (i.e., the mean, mode, and median would be the same numbers in both the historical data and the future, fictional data). The statistical properties of the weather would vary the same in the future as it has in the past.

It was decided by the ISWS and technical committee of the East-Central Regional Water Supply Planning Committee (RWSPC) that the demand models would use climatic normal data as the future weather variables because it is understood that either method of estimating future weather variables will be inaccurate in the future for any given year. The climatic normal method was chosen so that the general trend of water demand could be understood. By using normal weather data in the future, the annual variation, as seen the historic reported withdrawals, is not seen in the future estimates. Because normal climatic data were used in estimating future water withdrawals, for any given year in the future (or the past) the water demand estimates will not match the actual water withdrawn. What is revealed by this study is the *average* demand in the future.

For the three scenarios, the future values of summer temperature and summer precipitation were assumed to represent normal weather. This means that the values used for each future year represent average values for the 30-year period from 1971 to 2000 specific to the study area. The normal maximum temperature values and total summer precipitation values are shown in Table B.15 in Appendix B. Higher or lower summer temperatures will result in higher or lower per capita

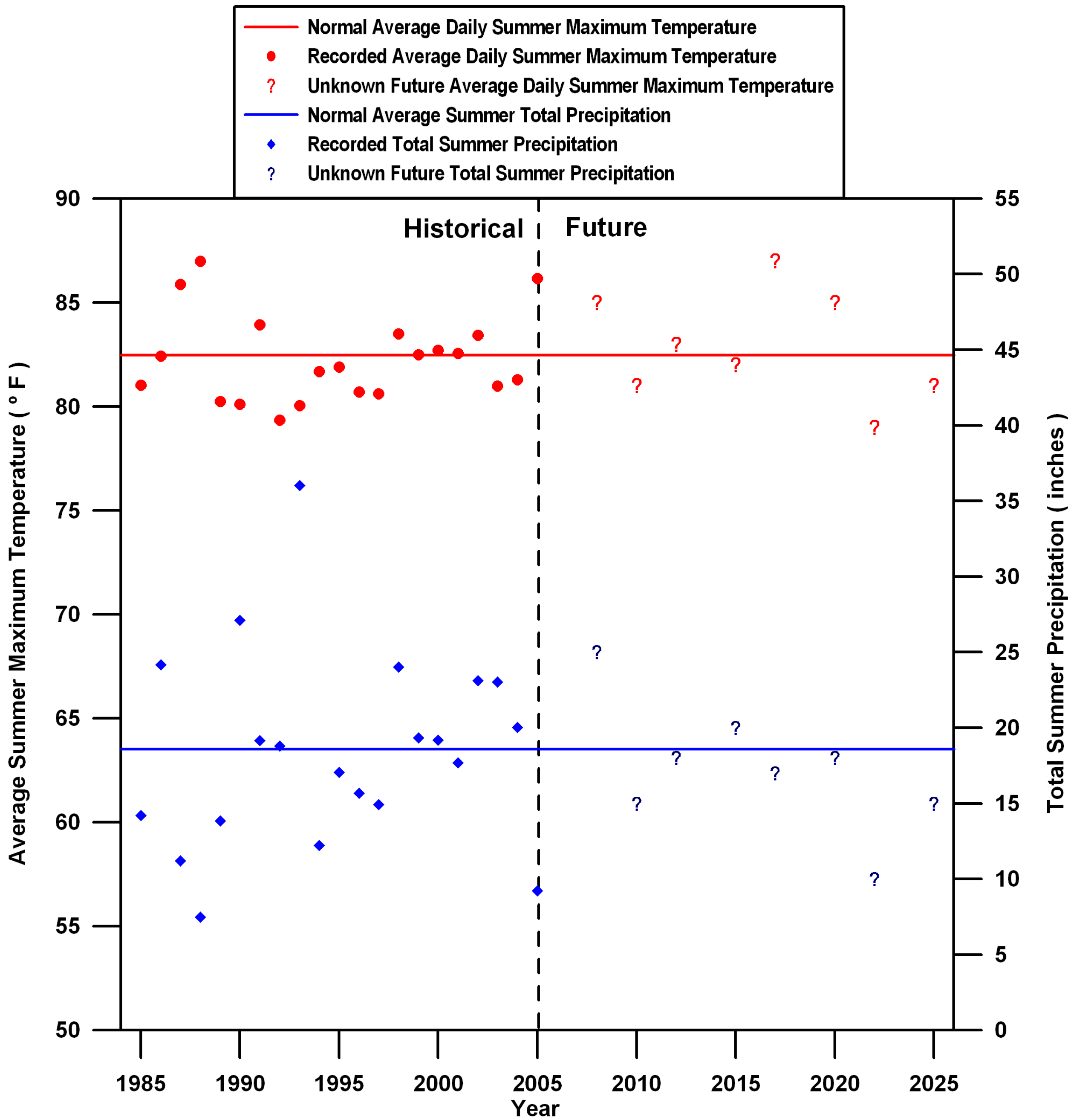


Figure 2.12: Example of inter-annual variation in temperature and precipitation compared to climatic normals.

water demand as determined by elasticity of 1.42. Similarly, higher or lower summer precipitation will result in lower or higher per capita water demand as determined by elasticity of -0.1140. The potential effects of climate change are provided in the sensitivity analysis (Chapter 6).

2.6.2.2 Employment-to-population ratios

The future ratios of employment to population were held constant at the 2005 ratio for each public supply study area. The 2005 ratio is shown in Table B.16 of Appendix B.

2.6.2.3 Marginal price of water

Future changes in retail water prices will result in changes of per capita water demand as determined by the estimated price elasticity of -0.2226. This means that, on average, a 1% increase in price will result in a 0.22 percent decrease in water withdrawals. The marginal price of water in the historical data was calculated as the incremental water bill per 1,000 gallons at the level of consumption between 5,000 gallons and 6,000 gallons per month.

Future values of marginal price will depend on the adoption of pricing strategies by retail water suppliers, as well as the frequency of rate adjustments. Water rate structures often remain unchanged for several years thus resulting in a decline of real price with respect to inflation. However, there is an expectation in the water supply industry that in the future the retail prices for water will increase faster than inflation because water quality issues will require more investment in treatment processes, increasing cost of energy, and other increasing water-system costs, especially infrastructure replacement costs.

Recent trends in water prices were determined from a survey of water rates in Illinois [Dziegielewski et al., 2004]. The data for 219 water systems in Illinois showed only a 3 percent increase in median value of total water bill at the consumption level of 5,000 gallons per month between 1990 and 2003 (increasing from $18.18 in 1990 to $18.70 in constant 2003 dollars). During the same period, the median value of the marginal price of water increased from $2.59 to $2.90, which represents an increase of 12 percent (in constant 2003 dollars) or 0.9 percent per year. The modest increase in price is a result of a number of systems which kept the nominal prices of water unchanged. Real water price declined (due to inflation) in 112 systems and increased in 107 systems. The average increase in the 107 systems in terms of total bill was 25 percent and 39.6 percent in average marginal price (or 2.6 percent per year).

Other published sources also report increases in the price of municipal water. The NUS Consulting [2007] reported that average price of water in 51 systems located throughout the United States increased by 6 percent for the period of July 1, 2006 to July 1, 2007. Earth Policy Institute

[2007] reported an increase in the United States of 27 percent during the last 5 years. Based on the changes in inflation during the five year period (CPI 2000 = 172.2, CPI 2005 = 195.3), the increase in real price would be approximately 12 percent (or 2.3 percent per year).

For the purpose of this study, it is assumed that changes in future water rates will span the range (depending on the scenario) from remaining constant in real terms, to increasing marginal price by 1.5 percent per year with revenue-neutral rates as compared to the 0.9 percent increasing trend. The 1.5 percent increase in marginal price represents a 67 percent (2/3) increase at the rate of 0.9 percent per year. The 1.5 percent increase would represent pricing strategy, which provides increased incentive to conserve water without affecting the total revenue that would be collected (relative to the historical trend of 0.9 percent per year increase).

2.6.2.4 Median household income

Future changes in median household income will result in changes of per capita water demand as determined by the estimated income elasticity of 0.3244. This means that, on average, a 1% increase in price will result in a 0.32 percent decrease in water withdrawals. In the historical data for 1990, 1995, 2000 and 2005, the average trend in median household income (expressed in constant 2005 dollars) was an increase of 1.5 percent per five-year increment. Future income is likely to grow, following economic growth in the study area. However, official projections of future income growth at the county or study area levels were not available.

One projection of income growth for the State of Illinois was obtained from the Illinois Region Econometric Input/Output Model (IREIM) developed by Hewings [1999]. These projections indicate that, for the State of Illinois, the average annual growth in personal income between 1997 and 2022 is projected to increase at the rate of 1.5 percent per year. The growth of median household income is generally less than the expected growth in total personal income.

The assumed annual growth rate of median household income for the baseline scenario is 0.7 percent. This assumption is based on analysis of the data from the U.S. Census Bureau, Bureau of Labor Statistics performed by Dr. Parry Frank [Parry Frank, personal communication, 2008]. The assumed values for less resource intensive and more resource intensive scenarios are 0.5 and 1.0 percent per year, respectively.

2.7 Scenarios

The three future scenarios are designed to capture a range of future conditions of water demand for public supply water withdrawals which would result in lower and higher values of future water withdrawals by this sector. The scenarios include baseline (BL), less resource intensive (LRI) outcome, and more resource intensive (MRI) outcome. These scenarios do not represent forecasts or predictions, nor set upper or lower bounds of future water withdrawals. Different assumptions or conditions could result in withdrawals that are within or outside of this range. The scenarios chosen describe three possible future outcomes of the virtually infinite number of possible futures. The specific assumptions used in the formulation of each scenario are described below.

2.7.1 Scenario 1 - Baseline (BL)

The intent of the BL scenario is to define future conditions as a moderate scenario based upon specific assumptions. The specific assumptions of this scenario are:

1. Population growth in the study areas will follow population projections as described in Section 2.6.1.
2. Employment to population ratio will remain at the 2005 value for each PWS study area.
3. Marginal prices of water after 2005 will remain constant at the 2005 values (in constant 2005 dollars) thus implying that future increases in water prices will offset general inflation while no actual increase in price will occur.
4. Annual growth of median household income (in constant 2005 dollars) during the 2005-2050 period will be 0.7 percent.
5. The future effect of the conservation trend was gradually phased out so that by 2050 it represented approximately 10% of the the effect which was estimated in the historical data.
6. Summer temperature and precipitation will represent normal values derived from the historical data for the 30-year period from 1971 to 2000.

In addition to these assumptions, all planned water supply developments are included in the scenarios. In the public meetings with utilities, two major public supply changes were identified that are expected to occur by 2010. The first is the construction of a centralized water-supply system in Cass County for Virgina, Ashland, Chandlerville, Cass County Rural Water District (RWD), and the Arenzville RWD. The new system in Cass County affects the county system in two ways, 1) it increases the population served in the county and decreases the domestic population and 2) changes the source water for Ashland from surface water to groundwater. These two expected changes are reflected in this baseline scenario as well as the other two scenarios.

The second public supply change is in Sangamon County. There the Village of Chatham, which is currently served by surface water from Springfield, has decided to construct a wellfield to supply the village. This change moves a portion of the population served by Springfield into the population served in the Sangamon County Remainder. The population shift was changed for 2010 in the baseline scenario as well as the LRI and MRI scenarios. The percent of surface water for Springfield will remain unchanged. The percent of groundwater for the Sangamon County Remainder will increase.

2.7.2 Scenario 2 - Less resource intensive (LRI)

The intent of the LRI scenario is to define future conditions which would lead to less water withdrawals by the PWS sector. The specific assumptions for the LRI scenario are:

1. Population growth in the study areas will follow population projections as described in Section 2.6.1.

2. Employment to population ratio will remain at the 2005 value for each PWS study area.

3. Marginal price of water will increase at the rate of 1.5 percent per year (in constant 2005 dollars) in order to provide water conservation incentives.

4. The future effect of the conservation trend was gradually phased out so that by 2050 it represented approximately 10% of the the effect which was estimated in the historical data.

5. Annual growth of median household income during the 2005-2050 period will be 0.5 percent (in constant 2005 dollars).

6. Summer temperature and precipitation will represent normal values derived from historical data for the 30-year period from 1971 to 2000.

2.7.3 Scenario 3 - More resource intensive (MRI)

The intent of the MRI scenario is to define future conditions which would lead to more water withdrawals by the PWS sector. The specific assumptions for the MRI scenario are:

1. Population growth in the study areas will follow population projections as described in Section 2.6.1.

2. Employment to population ratio will remain at the 2005 value for each PWS study area.

3. Marginal price of water will remain constant at the 2005 values (in constant 2005 dollars) thus implying that future increases in water prices will offset general inflation while no actual increase in price will occur.
4. Annual growth of median household income during the 2005-2050 period will be 1.0 percent (in constant 2005 dollars).
5. Effect of conservation trend was removed.
6. Summer temperature and precipitation will represent normal values derived from historical data for the 30-year period from 1971 to 2000.

2.8 Results

The results for the public water supply and the self-supplied domestic water sector are provided in the following sections and in tables provided in Appendix B.

2.8.1 PWS results

The results of the three scenarios for the 15-county study area are shown in Figure 2.13and Tables 2.8-2.10. Under the baseline scenario, the total public supply withdrawals are projected to increase from 127.2 MGD in 2005 (Normal) to 176.9 MGD in 2050. This represents an increase of 49.6 MGD or 39.0 percent. Under the LRI scenario the withdrawals would increase to 153.5 MGD by 2050. This represents an increase of 26.3 MGD or 20.6 percent. Under the MRI scenario the withdrawals would increase to 185.4 MGD by 2050. This represents an increase of 58.1 MGD or 45.7 percent.

Results for the baseline scenario by individual study area are provided in Figures 2.14–2.21. Tabular results for each scenario for each PWS study area are provided in Appendix B. The figures confirm that the counties with the largest cities, withdraw the most water for public water supply. For example, Champaign County contains Champaign/Urbana and is estimated to withdraw 33.6 MGD in 2050. McLean County which contains both Bloomington and Normal is estimated to withdraw 24.0 MGD in 2050. The other counties that use large amounts of public supply water are Macon, Sangamon, Tazewell, and Vermilion counties (Figures 2.14–2.21). The remaining counties use less than 4 MGD each.

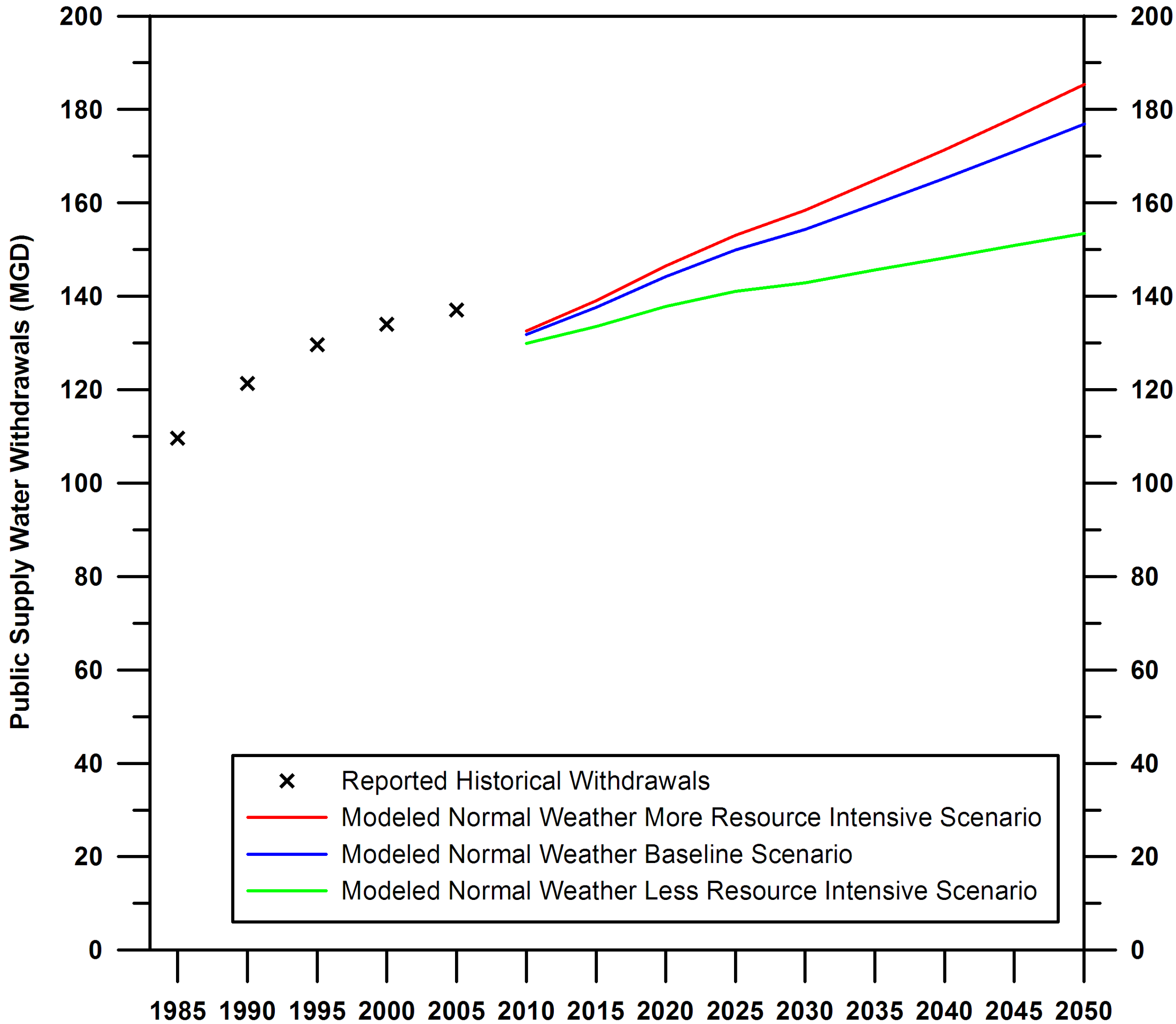


Figure 2.13: Historical and future public water supply withdrawals for the baseline scenario, the less resource intensive scenario, and the more resource intensive scenario for East-Central Illinois.

Table 2.8: Public water supply results for the baseline (BL) scenario.

Year	Population served	Per capita (GPCD)	Total withdrawals (MGD)
2005 (Weather)	946,821	146.5	138.9
2005 (Normal)	946,821	134.4	127.2
2010	978,207	134.8	131.9
2015	1,012,168	135.9	137.6
2020	1,050,932	137.2	144.2
2025	1,081,997	138.5	149.9
2030	1,101,919	140.0	154.3
2035	1,129,372	141.4	159.7
2040	1,156,613	142.9	165.2
2045	1,184,582	144.3	171.0
2050	1,213,300	145.8	176.9
Difference from 2005 (Normal) to 2050			
Unit	266,479	11.4	49.6
Percent (%)	28.1	8.5	39.0

GPCD = gallons per capita per day; MGD = million gallons per day

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

Table 2.9: Public water supply results for the less resource intensive (LRI) scenario.

Year	Population served	Per capita (GPCD)	Total withdrawals (MGD)
2005 (Weather)	946,821	146.5	138.9
2005 (Normal)	946,821	134.4	127.2
2010	978,207	132.8	129.9
2015	1,012,168	131.9	133.5
2020	1,050,932	131.1	137.8
2025	1,081,997	130.3	141.0
2030	1,101,919	129.7	142.9
2035	1,129,372	128.9	145.6
2040	1,156,613	128.1	148.2
2045	1,184,582	127.3	150.8
2050	1,213,300	126.5	153.5
Difference from 2005 (Normal) to 2050			
Unit	266,479	-7.9	26.3
Percent (%)	28.1	-5.9	20.6

GPCD = gallons per capita per day; MGD = million gallons per day

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

Table 2.10: Public water supply results for the more resource intensive (MRI) scenario.

Year	Population served	Per capita (GPCD)	Total withdrawals (MGD)
2005 (Weather)	946,821	146.5	138.9
2005 (Normal)	946,821	134.4	127.2
2010	978,207	135.6	132.6
2015	1,012,168	137.4	139.1
2020	1,050,932	139.4	146.5
2025	1,081,997	141.5	153.1
2030	1,101,919	143.7	158.4
2035	1,129,372	146.0	164.9
2040	1,156,613	148.2	171.4
2045	1,184,582	150.5	178.2
2050	1,213,300	152.8	185.4
Difference from 2005 (Normal) to 2050			
Unit	266,479	18.4	58.1
Percent (%)	28.1	13.7	45.7

GPCD = gallons per capita per day; MGD = million gallons per day

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

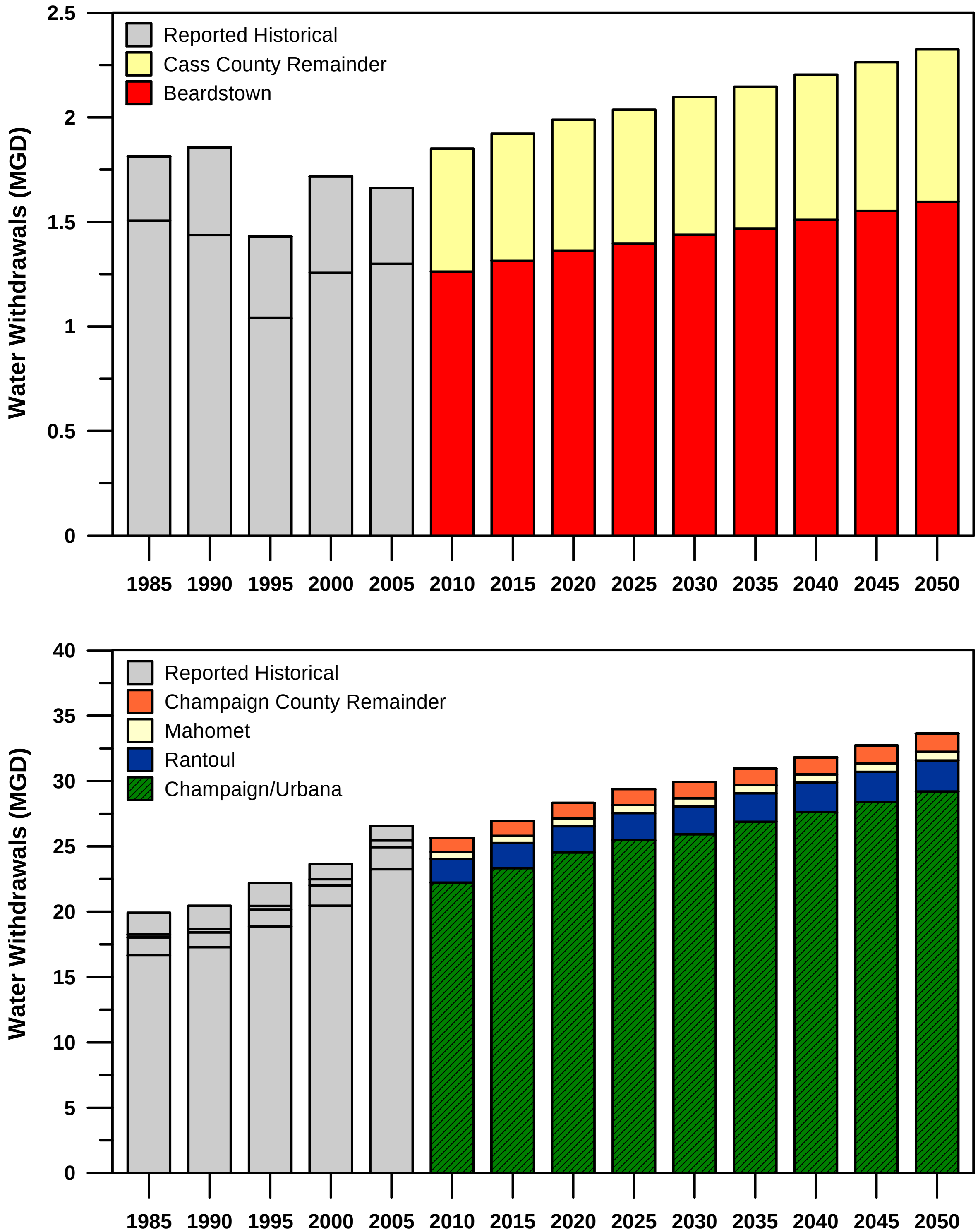


Figure 2.14: Public water supply historical and future water withdrawals for the Cass and Champaign County study areas.

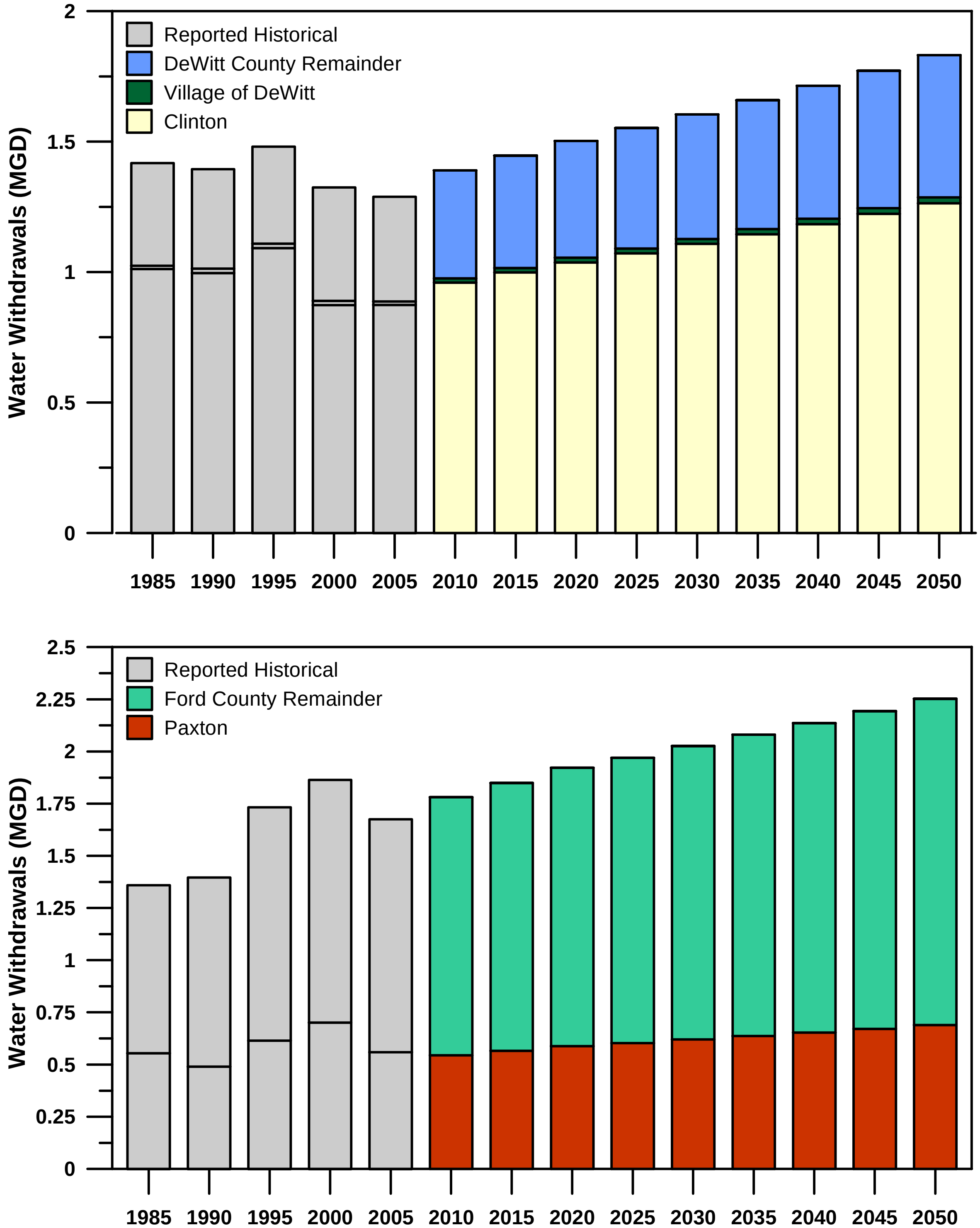


Figure 2.15: Public water supply historical and future water withdrawals for the DeWitt and Ford County study areas.

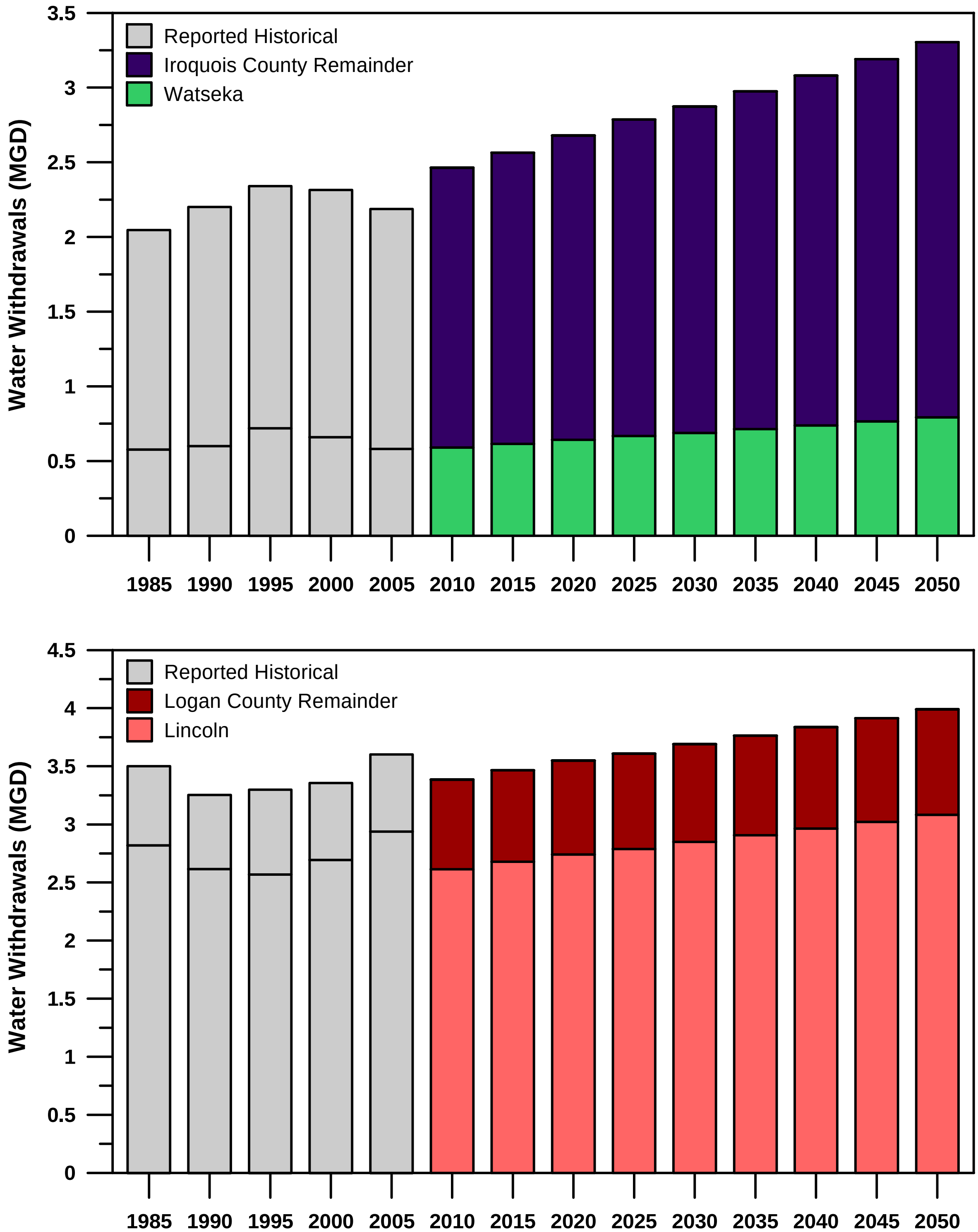


Figure 2.16: Public water supply historical and future water withdrawals for the Iroquois and Logan County study areas.

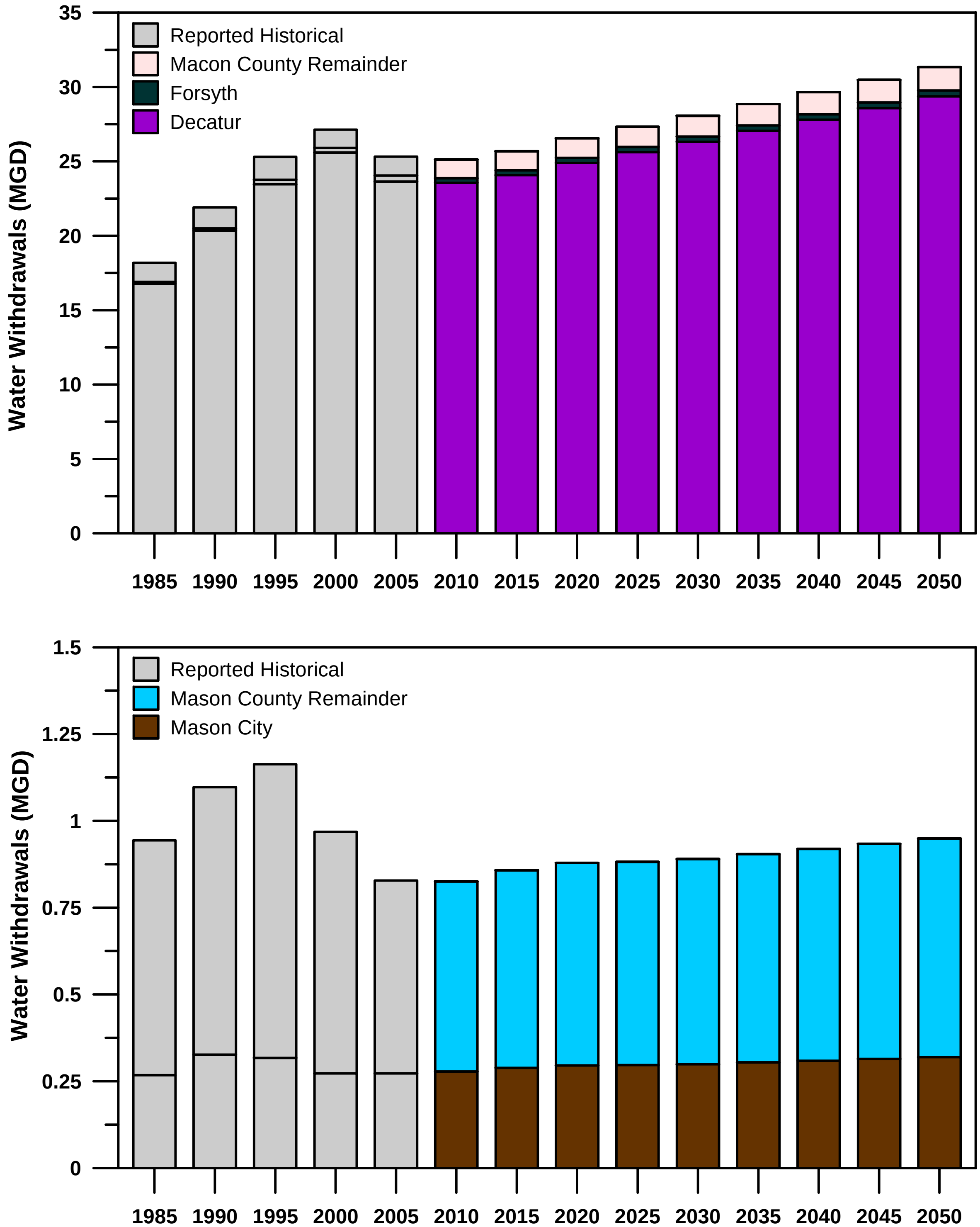
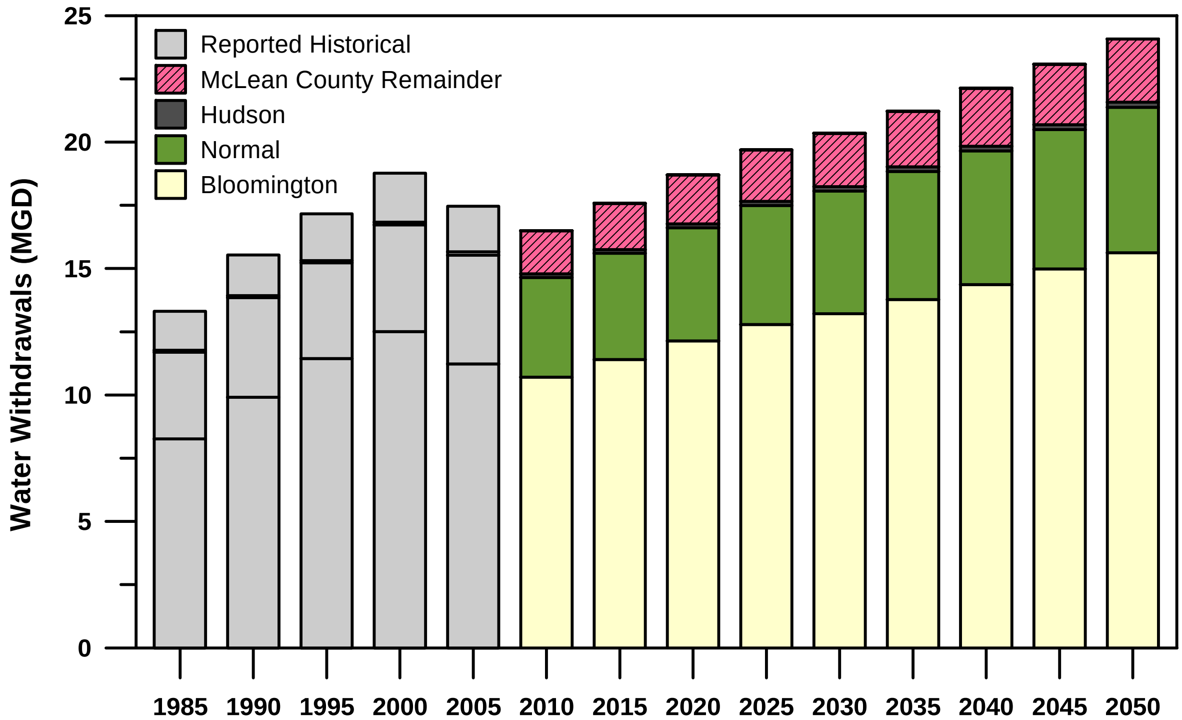


Figure 2.17: Public water supply historical and future water withdrawals for the Macon and Mason County study areas.



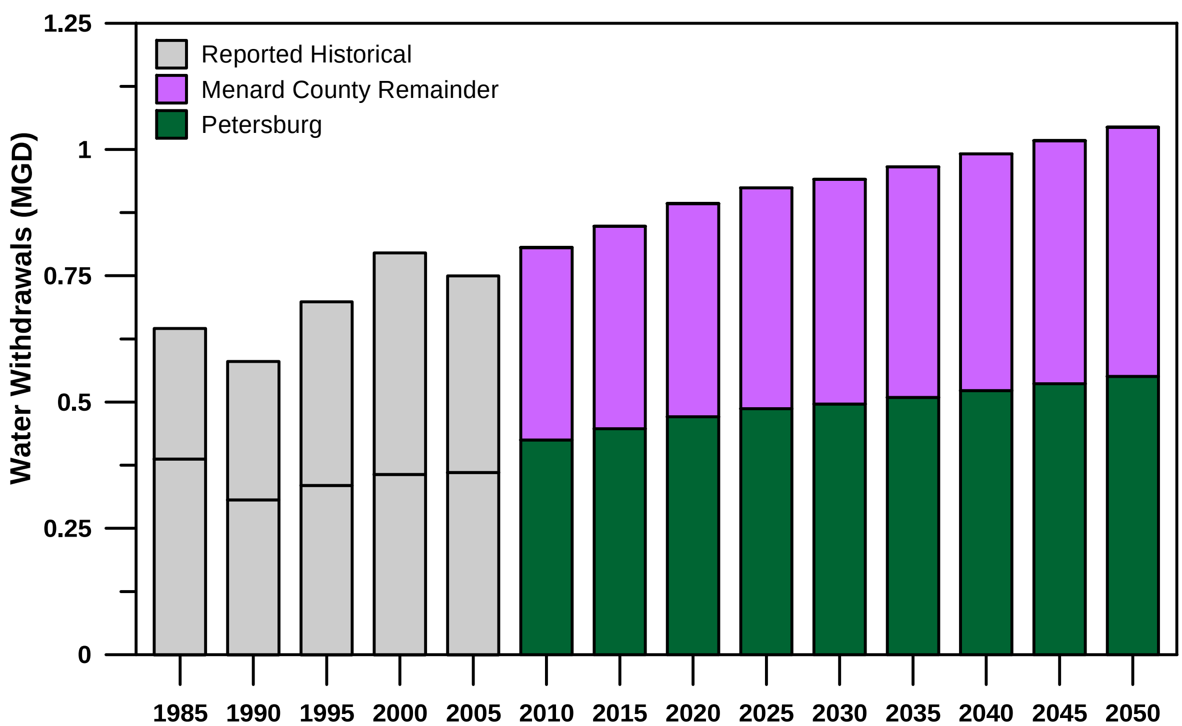


Figure 2.18: Public water supply historical and future water withdrawals for the McLean and Menard County study areas.

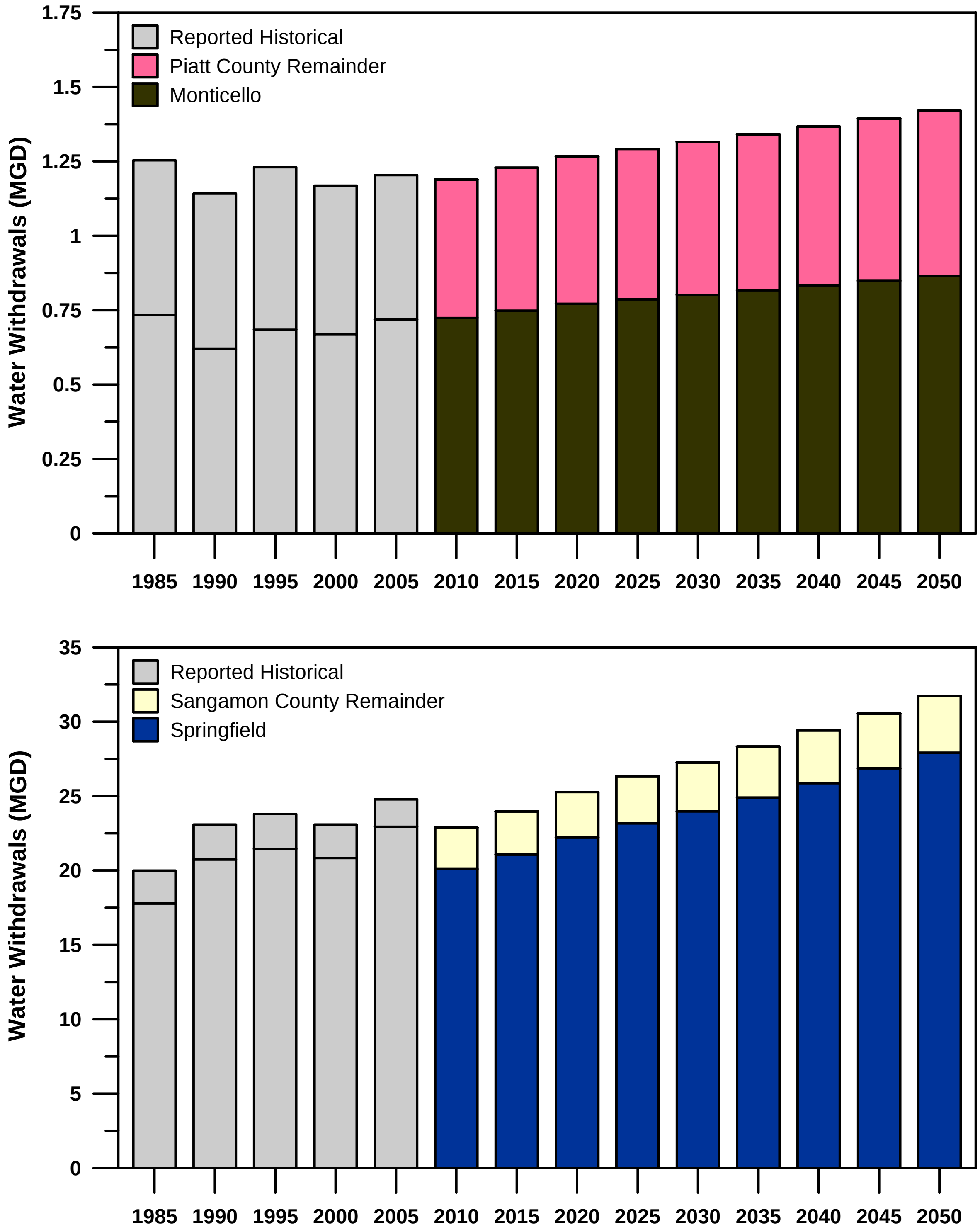


Figure 2.19: Public water supply historical and future water withdrawals for the Piatt and Sangamon County study areas.

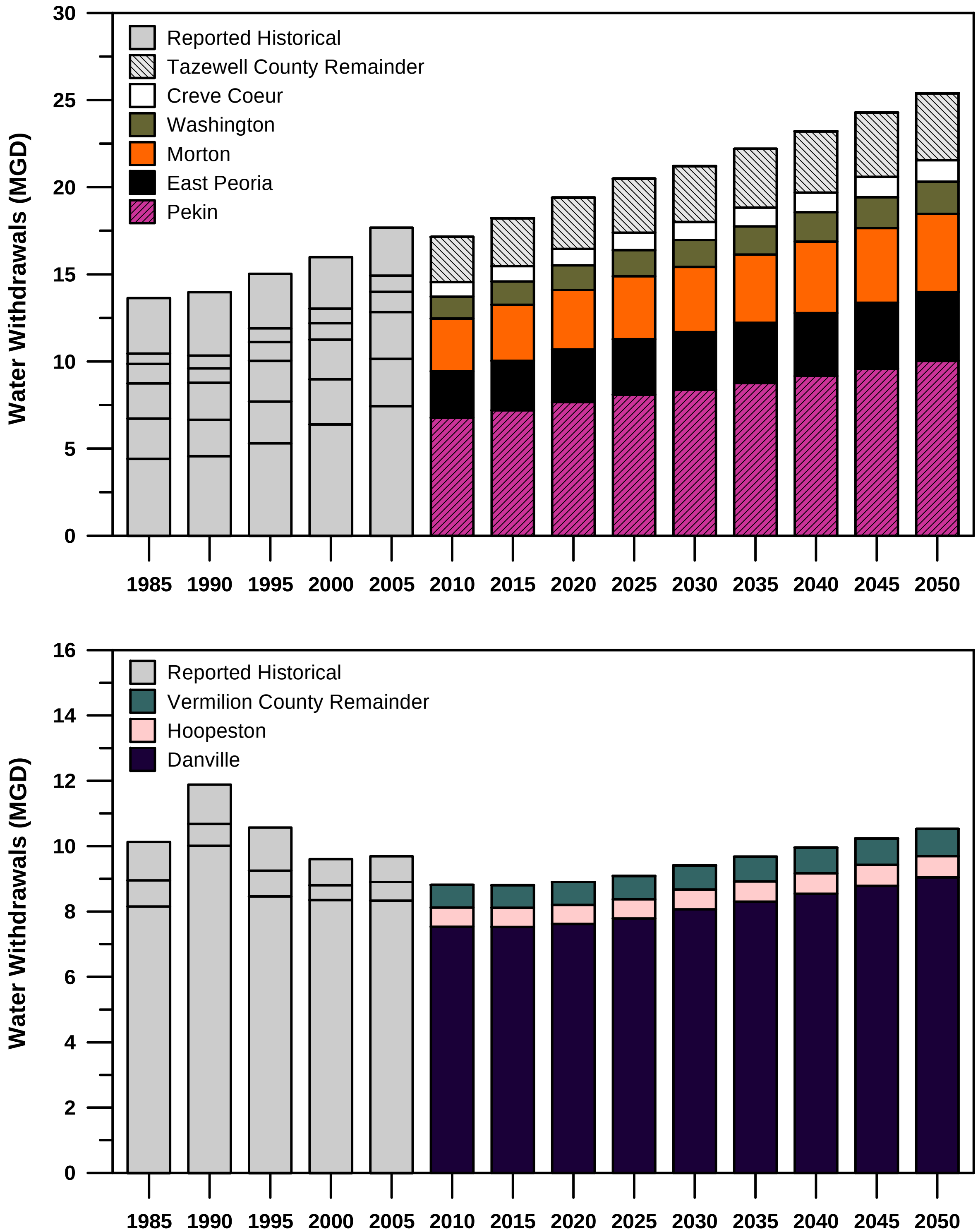


Figure 2.20: Public water supply historical and future water withdrawals for the Tazewell and Vermilion County study areas.

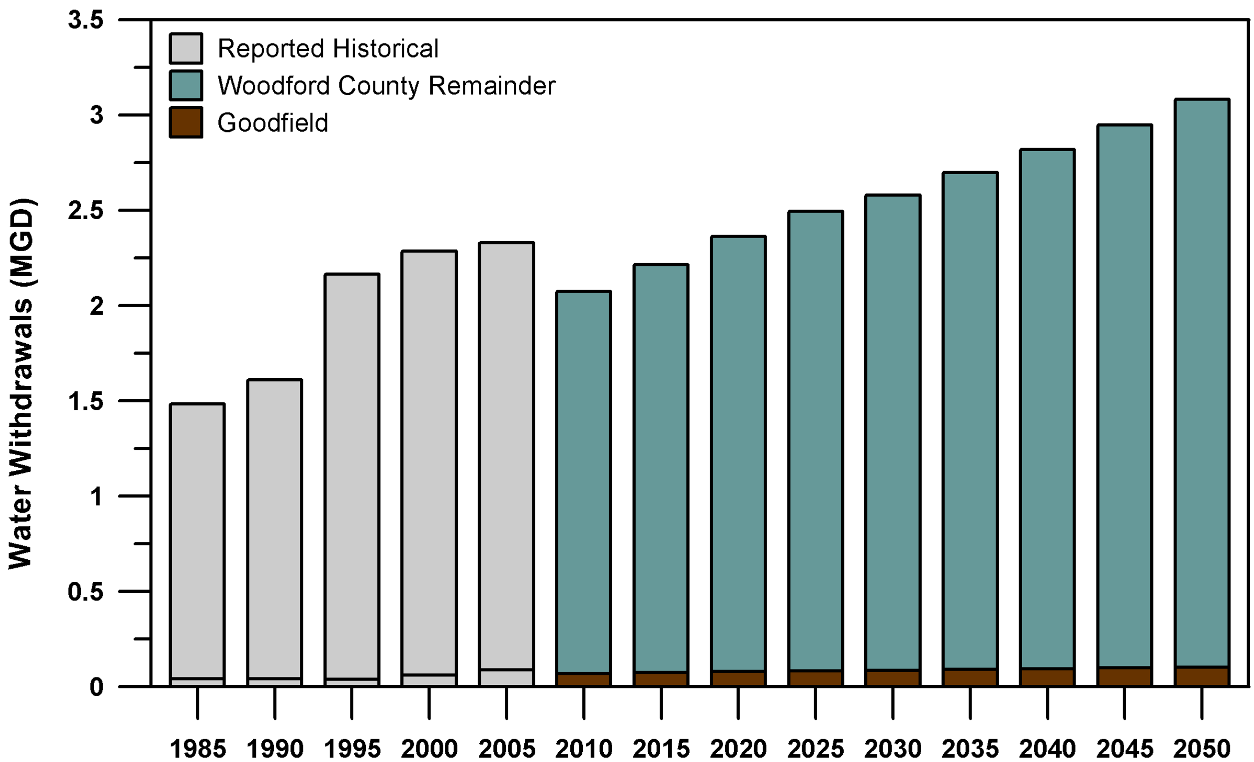


Figure 2.21: Public water supply historical and future water withdrawals for the Woodford County study areas.

2.8.2 Groundwater and surface water withdrawals

The data generated from this demand study will be delivered to the ISWS as digital data at the level of withdrawal points, meaning future water withdrawals will be determined for all existing wells and surface water intakes. Using groundwater and surface water modeling, the ISWS will evaluate water availability in the East-Central Region and determine if the water supply is sufficient for the future water withdrawals. Although withdrawal-point data is not included in this report, the data will be available upon request from the ISWS for the public water supply sector.

The allocation of the future public water supply between groundwater and surface water withdrawals is generally assumed to remain at the 2005 level for each study area, with the exceptions of the Cass County Remainder and Sangamon County Remainder. These two study areas will be affected by the additions of the new proposed groundwater supplies, Cass County Rural Water District and the new Chatham PWS. For these areas, the percent groundwater will be higher than the 2005 percentage. Table 2.11 shows the future percentages of surface water and groundwater for each county.

Table 2.11: Future percent groundwater and surface water for each public supply study area in East-Central Illinois.

Study Area	County	Future Percent	
		Groundwater	Surface water
Beardstown	Cass	100	0
Cass County Rem.	Cass	100	0
Champaign/Urbana	Champaign	100	0
Mahomet	Champaign	100	0
Rantoul	Champaign	100	0
Champaign County Rem.	Champaign	100	0
Clinton	DeWitt	100	0
DeWitt	DeWitt	100	0
DeWitt County Rem.	DeWitt	100	0
Paxton	Ford	100	0
Ford County Rem.	Ford	100	0
Watseka	Iroquois	100	0

Rem. = remainder.

Source: Calculated from Illinois Water Inventory Program, Illinois State Water Survey, 2007.

Table 2.11: Future percent groundwater and surface water for each public supply study area in East-Central Illinois.

Study Area	County	Future Percent	
		Groundwater	Surface water
Iroquois County Rem.	Iroquois	100	0
Lincoln	Logan	100	0
Logan County Rem.	Logan	100	0
Decatur	Macon	6.9	93.1
Forsyth	Macon	100	0
Macon County Rem.	Macon	100	0
Mason City	Mason	100	0
Mason County Rem.	Mason	100	0
Bloomington	McLean	0	100
Hudson	McLean	0	100
Normal	McLean	100	0
McLean County Rem.	McLean	100	0
Petersburg	Menard	100	0
Menard County Rem.	Menard	100	0
Monticello	Piatt	100	0
Piatt County Rem.	Piatt	100	0
Springfield	Sangamon	0	100
Sangamon County Rem.	Sangamon	96.4	3.6
Creve Coeur	Tazewell	100	0
East Peoria	Tazewell	100	0
Morton	Tazewell	100	0
Pekin	Tazewell	100	0
Washington	Tazewell	100	0
Tazewell County Rem.	Tazewell	100	0
Danville	Vermilion	0	100
Hoopeston	Vermilion	100	0
Vermilion County Rem.	Vermilion	85.5	14.5

Rem. = remainder.

Source: Calculated from Illinois Water Inventory Program, Illinois State Water Survey, 2007.

Table 2.11: Future percent groundwater and surface water for each public supply study area in East-Central Illinois.

Study Area	County	Future Percent	
		Groundwater	Surface water
Goodfield	Woodford	100	0
Woodford County Rem.	Woodford	100	0

Rem. = remainder.

Source: Calculated from Illinois Water Inventory Program, Illinois State Water Survey, 2007.

2.8.3 Peaking data for public water supply

The data used to estimate future water withdrawals was the annual average withdrawal rate (as MGD) for each public supply facility. However, water withdrawals are not equal on every day of the year. In fact, some systems have days where water demand is 3-4 times the annual average rate. This is because people use more water at certain times of the year, week, and day. Typically, people use more water on hotter days to water lawns and gardens, wash cars, cool-off, etc. When temperatures are cooler people tend to use less water.

Knowledge about peak withdrawals is important for water-system management and water-supply considerations. A public supplier must ensure the system can meet the peak day withdrawals. This means treatment capacity, storage capacity, and volume must be large enough to accommodate peak demand.

Each public supply system reports their peak day of water withdrawals to the ISWS water inventory program. These data were collected for East-Central Illinois. From these data, regional peaking factors of 2.29 and 1.65 were calculated for groundwater and surface water systems, respectively. This means that on average in the region, public water supply systems using groundwater have a peak day that is 2.29 times their reported average annual withdrawal rate. Public water supply systems using surface water have a peak day that is 1.65 times their reported average annual withdrawal rate. These peaking factors will be used by the ISWS in their study of the water supply resource.

Table 2.12: Total withdrawals for the self-supplied domestic water sector, 2005-2050.

Year	Total self-supplied domestic population	Total self-supplied domestic withdrawals (MGD)
2005	108,076	8.9
2010	121,510	10.0
2015	125,363	10.3
2020	129,539	10.6
2025	132,847	10.9
2030	135,267	11.1
2035	137,249	11.3
2040	140,237	11.5
2045	143,290	11.7
2050	146,421	12.0
Difference from 2005 to 2050		
Unit	38,345	3.1
Percent (%)	35.5	35.5

Assumed water withdrawal rate of 82 gallons per person per day.

2.8.4 Self-supplied domestic results

The future domestic supply withdrawals, based upon the self-supplied domestic population in each county, is provided in Table 2.12. The withdrawals are projected to increase from 8.9 MGD in 2005 to 12.0 MGD in 2050. This represents an increase of 3.1 MGD or 35.5 percent. The future demands of self-supplied domestic are expected to continue to be minimal with respect to total withdrawals for all sectors.

Chapter 3

Self-supplied Power Generation (PG)

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3.1 Background

Water withdrawn by power plants is classified by the United States Geological Survey (USGS) as thermoelectric generation water use. It represents the water applied in the production of heat-generated electric power. The heat sources may include fossil fuels such as coal, petroleum, natural gas, or nuclear fission. The main use of water at power plants is for cooling. Nearly 90 percent of electricity in the United States is produced with thermally-driven, water-cooled generation systems which require large amounts of water.

The three major types of thermoelectric plants include: conventional steam, nuclear steam, and internal combustion plants. In internal combustion plants, the prime mover is an internal combustion diesel or gas-fired engine. Since no steam or condensation cooling is involved, almost no water is used by internal combustion power generation.

In conventional steam and nuclear steam power plants, the prime mover is a steam turbine. Water is heated in a boiler until it turns into steam. The steam is then used to turn the turbine-generator, which produces electricity. The shaft power is produced when a nozzle directs jets of high-pressure steam against the blades of the turbine's rotor. The rotor is attached to a shaft that is coupled to an electrical generator. After leaving the turbine the steam is condensed and then, in the form of condensate, is returned back to the boiler to be converted to steam again.

Water is used primarily for cooling and condensing steam after it leaves the turbine. In a conventional power-only steam turbine installation, designers increase efficiency by maximizing the pressure drop across the turbines. In this type of generation, the use of cooling water is essential because the collapse of steam volume in the condenser creates a vacuum (or backpressure) which affects the rotation of the turbine. The conventional low-pressure steam turbine generators can operate over a modest backpressure range from 1.0 to 4.0 inches of mercury absolute (Hga) and the optimal efficiency range from 2.0 to 3.5 inches Hga (Micheletti and Burns, 2002). Because the backpressure depends on the removal of "waste" heat by cooling water, the cooling system is an integral part of the power generation process.

3.1.1 Types of cooling

The "waste" heat removed in the condenser is transferred to the surrounding environment by "wet" or "dry" cooling process. In "wet" systems, which dominate in thermoelectric generation, this is done through a combination of evaporation and sensible heating of water or air (sensible heat is heat energy transferred between the surface and air when there is a difference in temperature between them). In "dry" systems the heat is transferred to the atmosphere through sensible heating. The wet systems fall into two broad categories: once-through cooling systems and closed-loop (or recirculating) systems.

In once-through cooling systems water is withdrawn from a natural water body (such as a river or lake) and is pumped through a heat exchanger (a condenser) to cool down and condense the steam. After leaving the condenser, the cooling water, with a somewhat higher temperature, is discharged into the receiving water body. Thus, in once-through cooling systems the heat is transferred into a surface water body to which the heated cooling water is discharged. The once-through method has several advantages. It is the least costly to construct; it requires less water treatment; and it evaporates less water than evaporative cooling towers. A drawback of the once-through systems is that a large amount of surface water needs to be pumped through the condensers. A variation of a once-through system is a recirculating system with an evaporation lake, pond, or canal. In such a system the heated water is discharged into a pond or lake where its temperature is lowered by mixing with the lake water and further cooled by forced evaporation due to the overall increase of water temperature in the lake.

In wet closed-loop cooling systems, although water *consumption* is higher than in once-through cooling systems, the total volume of water *withdrawals* is reduced by nearly 95 percent as compared to the water withdrawals required for once-through cooling (Harte, 1978). The conventional type of wet cooling system uses towers that are designed to remove heat by pumping hot water to the top of the tower and then allowing it to fall down while contacting the air which comes in from the bottom and/or sides of the tower. As the air passes through the water, it exchanges some of the heat and some of the water is evaporated. Generally, in cooling towers, as much as 50 to 70 percent of water is evaporated or consumed in the process. The cooled water is collected at the bottom of the tower and is then pumped back to the condenser for reuse. Cooling towers have increasingly been used because they require much lower water withdrawals than once-through cooling systems. However, the total consumptive use of water in closed-loop systems is substantially higher than in once-through systems.

3.1.2 Theoretical cooling water requirements

In once-through cooling systems, theoretical water requirements are a function of the amount of "waste" heat that has to be removed in the process of condensing steam. According to Backus and Brown (1975) the amount of water for one megawatt (MW) of electric generation capacity can be calculated as:

$$L = \frac{6,823\,(1-e)}{Te} \tag{3.1}$$

where

L = amount of water flow in gallons per minute per MW of generating capacity;

T = temperature rise of the cooling water in °F; and

e = thermodynamic efficiency of the power plant, expressed as decimal fraction.

For example, in a coal-fired plant with thermal efficiency of 40 percent and the condenser temperature rise of 20 °F, the water flow rate obtained from Equation 3.1 would be 512 gallons per minute (gpm) per MW. For a typical 650 MW plant, operating at 90 percent of capacity, the theoretical flow rate (L) would be nearly 300,000 gpm or 431.3 million gallons per day. The daily volume of cooling water is equivalent to approximately 31 gallons per 1 kilowatt hour (kWh) of generation.

According to Croley et al., (1975), in recirculating systems with cooling towers, theoretical make-up water requirements are determined using the following relationship:

$$W = E - \frac{1}{\frac{c}{c_o} - 1} \tag{3.2}$$

where

$\frac{c}{c_o}$ = the concentration ratio and

E = evaporative water loss which for a typical mean water temperature of 80 °F can be calculated as:

$$E = (1.91145 \cdot 10^{-6}) \cdot aQ \tag{3.3}$$

where

a = the fraction of heat dissipated as latent heat of evaporation (for evaporative towers a = 75% to 85%); and

Q = rate of heat rejection by the plant in Btu/hr, which can be calculated as:

$$Q = 3,414,426 \cdot P \cdot \frac{1-e}{e} \tag{3.4}$$

where

P = the rated capacity of the plant in MW; and

e = thermodynamic efficiency of plant expressed as a fraction.

3.1.3 Theoretical vs. actual water use

While the theoretical (or minimum) water requirements for energy generation are similar for plants of the same type, the actual unit amounts of water withdrawn per kilowatt-hour of gross generation vary from plant to plant even when the same type of cooling is used and at the same level of thermal efficiency. Significant differences in unit water use per kilowatt-hour of electricity generation among different types of cooling systems were reported in previous studies (Harte and El-Gasseir, 1978; Gleick, 1993; Baum et al., 2003).

Some of the reasons for this variability are easily explained. For example, in load-following plants using once-through cooling systems, intake pumps are left on when the level of generation declines. This is often caused by the lack of control technologies to regulate flow to match the fluctuating load on generators. There is limited ability to close or open control valves on pipes between the pumps and the condenser, or regulate the operation of pumps.

Better measurement and control of flows is available on closed-loop systems with cooling towers. The make-up water is usually metered and its flow rate could be regulated automatically depending on the quality of the recirculating water. However, the level of control varies among plants and the amounts of intake water per kilowatt-hour of generation also vary. Without advanced technologies for water measurement and control, it is difficult to optimize system operations to minimize water intake as well as operational costs associated with maintaining the high efficiency of heat transfer in the condenser.

It is important to note that while the thermoelectric power generation sector usually requires large quantities of water, the overall consumptive use of water is small. In once-through cooling systems, as much as 99 percent of water withdrawn can be returned back to the source. Closed-loop systems with cooling towers require smaller withdrawals (on average approximately 5 percent or less of the volumes withdrawn by once through cooling systems), however, between 30 to 70 percent of that smaller volume could be consumed due to evaporation.

As shown in the formulas presented in the previous section, the amount of water required for the cooling process depends on the amount of "waste" heat being removed, which depends on the amount of energy being generated. The amount of energy being generated at the power plant is measured as gross generation. The amount of energy leaving the power plant is referred to as net generation. Gross generation is the electrical output directly produced by a given generator or a set of generators. Net generation, as defined by the Energy Information Administration (EIA) is "the amount of electric energy generated, measured at the generator terminals, less the total electric energy consumed at the generating station." Power plants use part of the generated electricity to run auxiliary equipment such as water pumps, electric motors, and pollution control equipment.

Table 3.1: Average withdrawal rates and evaporative loss rates of cooling water based on Energy Information Administration data.

Description	Withdrawals per unit (gallons/kWh)	Evaporative loss (gallons/kWh)
Once-through systems	44.0	0.2
Recirculating system with ponds	24.0	0.7
Closed-loop w/ cooling towers	1.0	0.7

Source: Dziegielewski and Kiefer, 2006. The values represent weighted (by net generation) average water demand rates.

Generally the energy consumed by generating stations ranges from 3 to 6 percent of plant's gross output (although in some plants with extensive pollution control equipment it can reach 12 percent) (EPA, 1999).

Table 3.1 shows average rates of water withdrawals and evaporative losses in cooling systems of fossil fuel plants obtained from national data (Dziegielewski et al., 2006). These estimates were derived from the data on water pumpage and discharges in thermoelectric power plants (based on Form EIA-767).

The estimates in Table 3.1 were obtained by dividing total reported water withdrawals by the net generation in kilowatt-hours. The estimates show average amounts of water per kilowatt-hour (kWh) of net generation in different types of cooling systems. The resultant values represent weighted (by the net generation) average rates of water withdrawals. Because the estimates are based on net generation they are slightly higher (by 3 to 6 percent) than the rates of water withdrawals which would be obtained by dividing water withdrawals by gross generation.

The average rates for once-through cooling and closed-loop cooling systems in fossil-fuel plants shown in Table 3.1 are consistent with the theoretically derived values which were calculated for typical plants in the previous section (i.e., 31 gallons/kWh in once-through systems and 0.63 gallons/kWh in systems with cooling towers).

3.2 Generation and water withdrawals in East-Central Illinois

The USGS National Water Use Information Program reported significant thermoelectric withdrawals from six plants in five of the fifteen counties in East-Central Illinois (Figure 3.1). Table

Table 3.2: Thermoelectric water withdrawals in East-Central Illinois (1990-2005).

County	Water withdrawals (MGD)			
	1990	1995	2000	2005
DeWitt	493.2	709.4	628.3	934.6
Mason	102.8	61.2	84.2	109.4
Sangamon	204.6	307.1	314.3	371.2
Tazewell	765.4	16.3*	38.7*	25.9*
Vermilion	2.8	1.5	2.2	2.7
Total	1,568.8	1,095.5	1,067.7	1,443.8

Source: USGS water reports, various years. Values represent average annual withdrawals in MGD (million gallons per day).
* Values revised by industry to reflect withdrawal from source.
All withdrawals are from surface water sources.

3.2 shows the estimated withdrawals for these five counties during the past four data compilation years: 1990, 1995, 2000 and 2005. Although, relative to the other water sectors, the volume of water withdrawals for power generation is large, it is important to note that much of the water is returned to the source and is available for re-use by others. All of the reported withdrawals for cooling water are from surface water bodies, not groundwater resources. Some of the power plants also have groundwater wells at their facilities, but these are not typically used for cooling water purposes.

The USGS data in Table 3.2 show a significant decline in reported withdrawals between 1990 and 1995 in Tazewell County. This was primarily due to the change in how the withdrawals were reported for the closed-cycle plant located in this county. In 1990, the total amount of water flowing through the condensers was reported. Beginning in 1995, only the amount of make-up water added to the cooling pond from the source water was reported. This more accurately represents the withdrawals and consumptive use for this plant.

The other historical variation in water withdrawals is due to the fluctuation of energy production and the rate of usage (gal/kWh) from year to year.

3.2.1 Electric generation

According to the inventory of electric generators maintained by the EIA, there are 31 generation facilities in the 15-county area of East-Central Illinois (Appendix C). This number includes six

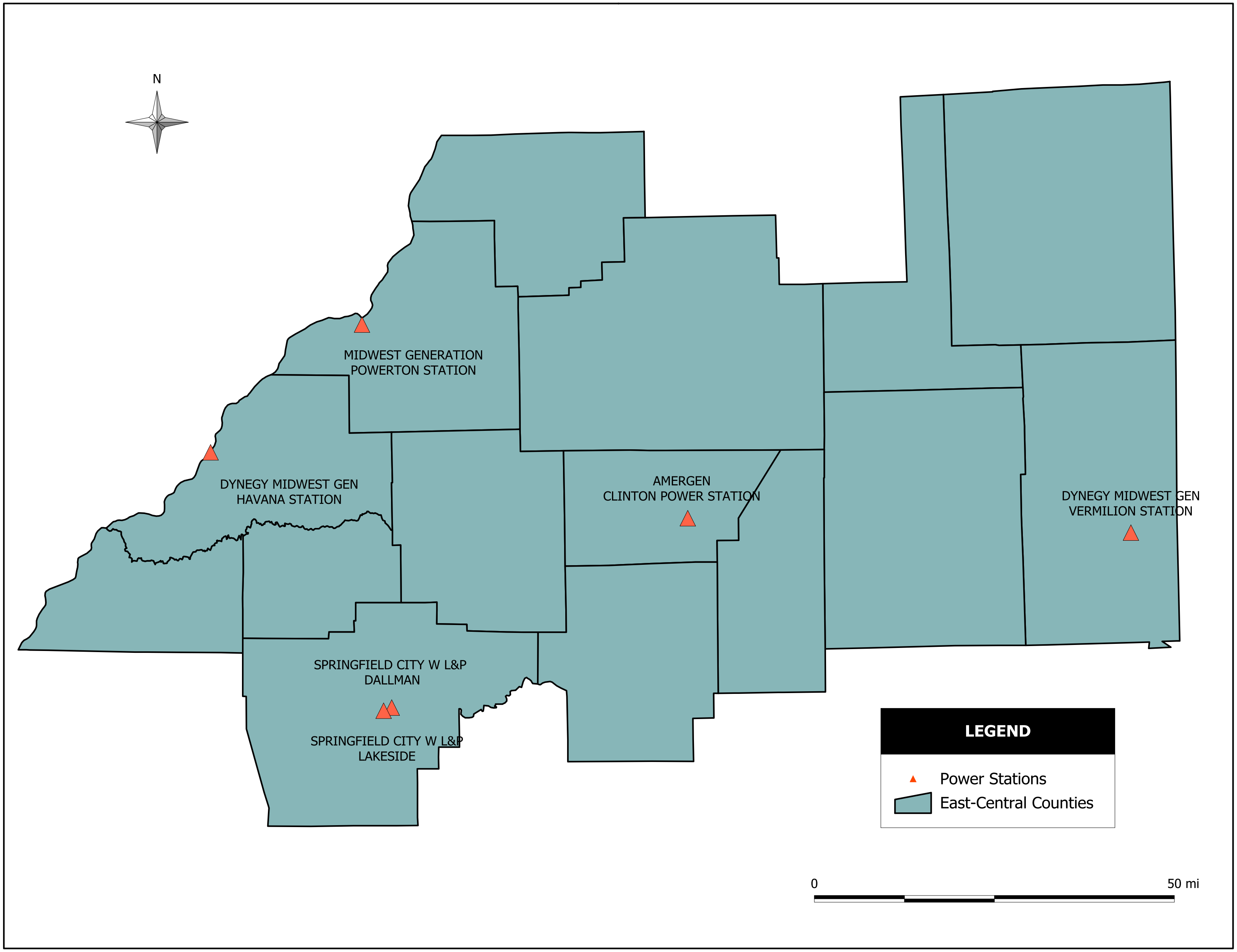


Figure 3.1: Location of six significant thermoelectric power generating plants within the 15-county East-Central Region.

large plants and 25 smaller plants. Total nameplate capacity of the 31 plants is 6,000 MW. Because the smaller plants are not self-supplied, but have water supplied to them by municipalities or other utilities, their water withdrawals are not analyzed in this section of the report but are accounted for within the Public Water Supply Chapter.

The six large power generation plants within the study area have total generation capacity of approximately 4,000 MW. The capacity and generation data for the six large plants in the 15-county study area are listed in Table 3.3. The capacity utilization (also referred to as operational efficiency) is the ratio of the average load on a generating unit to its capacity rating during a specified period of time. In 2005, the capacity utilization ranged from 39 to 96 percent among the individual plants. Average capacity utilization for all six plants was approximately 70 percent.

3.2.2 Reported plant-level withdrawals

Table 3.4 compares gross electricity generation and water withdrawals for the six large power plants. In 2005, the reported water withdrawals totaled 1,315.4 MGD. The 2005 values reported in Table 3.4 differ from the values reported by the USGS in Table 3.2. The values in Table 3.4 reflect the revisions of the plant-level data for 2005 performed for this study. The revisions were made in collaboration with industry representatives and ISWS. The values shown in Table 3.4 are the values used for future estimation of water withdrawals.

The plants in Table 3.4 are separated into two groups: once-through open cycle and closed-loop make-up water intake plants. Once-through flow plants pump water directly to the condensers and almost immediately return it back to the river or lake. Closed-loop make-up water plants withdraw water to replace losses and blowdown in cooling towers and/or water losses from perched lakes or ponds. This separation of plants provides for a better consistency in representing non-consumptive and consumptive water withdrawals for power production. Water withdrawn by once-through plants represents non-consumptive use since nearly all water withdrawn is returned to the source. Withdrawals by closed-loop make-up water plants represent a sum of both consumptive and non-consumptive use and are comparable with withdrawals by the industrial/commercial and agricultural sectors.

The 2005 withdrawals for the once-through flow plants totaled 1,236.71 MGD. Almost all of these withdrawals represent non-consumptive use because the water withdrawn is returned to the source after passing through the condensers.

Total 2005 withdrawals by the three closed-loop make-up water plants were 78.64 MGD. A large but undetermined portion of this volume represents consumptive use. The consumptive use portion represents water being evaporated during the cooling process.

Table 3.3: Capacities and generation in large power plants located in East-Central Illinois.

Plant name/ (Owner)/ Water source	County	Gross capacity (MWe)	2005 Gross generation (MWh/year)	2005 Net generation (MWh/year)	Net/gross generation (%)	Capacity utilization (%)
1. Clinton Plant (Amergen) Clinton Lake	DeWitt	1,030	9,014,690	8,692,074	96.4	96.3
2a. Havana Plant (Dynegy Midwest) Illinois River	Mason	675	3,228,853	2,934,856	90.9	54.6
3. Dallman Plant (City of Springfield) Sangamon River	Sangamon	352	2,328,492	2,084,105	89.5	75.5
4. Lakeside Plant (City of Springfield) Sangamon River	Sangamon	66	229,452	208,452	90.8	39.7
5. Vermilion Plant (Dynegy Midwest) Station Reservoir	Vermilion	177	702,950	633,258	90.1	45.3
6. Powerton Plant (Midwest Generation) Illinois River to Pond	Tazewell	1,697	10,120,133	9,468,947	93.6	68.1
Total/Average		3,977	25,624,570	24,0021,692	93.7	73.2

Comments: Plant capacity and gross and net generation data were obtained from the Energy Information Administration.

Table 3.4: Generation and water withdrawals of large power plants located in East-Central Illinois.

Plant name/ (Owner)/ Water source	County	2005 Gross generation (MWh/year)	2005 Water withdrawals (MGD)	Estimate 2005 rate of usage (gal/kWh)
ONCE-THROUGH PLANTS				
1. Clinton Plant (Amergen) Clinton Lake	DeWitt	9,014,690	810.44	32.8
2a. Havana Plant #1-5 (Dynegy Midwest) Illinois River	Mason	33,960	55.00	591.1
3. Dallman Plant (City of Springfield) Sangamon River	Sangamon	2,328,492	328.10	51.4
4. Lakeside Plant (City of Springfield) Sangamon River	Sangamon	229,855	43.17	68.6
	Total/average	11,606,997	1,236.71	38.9
CLOSED-LOOP PLANTS				
2b. Havana Plant #6 (Dynegy Midwest) Illinois River	Mason	3,194,890	50.00	5.71
5. Vermilion Plant (Dynegy Midwest) Station Reservoir	Vermilion	702,950	2.76	1.43
6. Powerton Plant (Midwest Generation) Illinois River to Pond	Tazewell	10,120,133	25.88	0.93
	Total/average	14,017,973	78.64	2.18
ALL PLANTS TOTALS		25,624,970	1,315.35	–

Sources: Water withdrawals are based on self-supplied water quantities reported to the Illinois State Water Survey. Gross generation data were obtained from Energy Information Administration.

As shown in Table 3.4, the ratios of annual withdrawals to gross electricity generation ranged from 32.8 to 591.1 gallons/kWh for once-through cooling plants. For closed-loop systems, the ratios ranged from 0.93 to 5.7 gallons/kWh.

The estimates of future water demands for electric power generation in the 15-county study are based on the generation ability and cooling water needs of the six large plants shown in Table 3.4. The method of future estimation and the assumptions used are discussed in more detail in Section 3.4.

3.3 Water-withdrawal relationships

A straightforward unit-coefficient method was used in this study to derive future quantities of water withdrawals. This method represents cooling water demand as a product of total gross generation at the plant and the unit rate of water required in gallons per kilowatt-hour. The specific coefficients and relationship for the two main types of cooling systems are discussed below.

3.3.1 Once-through cooling systems

Previous studies of water demand in plants with once-through cooling systems show that total water withdrawals depend primarily on the level of generation in kWh per year and also vary depending on the operational efficiency (i.e., the percent of capacity utilization), thermal efficiency of the plant, the design temperature rise in the condenser at 100 percent capacity, fuel type, and other system design and operational conditions (Dziegielewski et al., 2006, Xiaoying and Dziegielewski, 2007). However, for the purpose of this study, the usefulness of the published water-use relationships is somewhat limited because the water-use equations are derived from the data reported on the EIA-767 Steam Electric Plant Operation and Design Report which include only net electric generation. More precise estimation methods for cooling water withdrawals can be derived using gross generation. The relationship between gross generation and water withdrawals is described below.

The data in Table 3.4 include water withdrawals and gross generation in four plants with once-through open-loop systems in the study area. Figure 3.2 shows a plot of the reported water withdrawals versus gross generation for seven once-through open loop plants in Northeastern Illinois together with the four plants in East-Central Illinois. The seven Northeastern plants were included in order to examine a general relationship between water withdrawals and gross generation.

The regression line which is fitted to the 11 data points shows a correlation of 0.993 (and R^2 of 0.986). The R^2 coefficient indicates that 98.6 percent of variance in total withdrawals among the

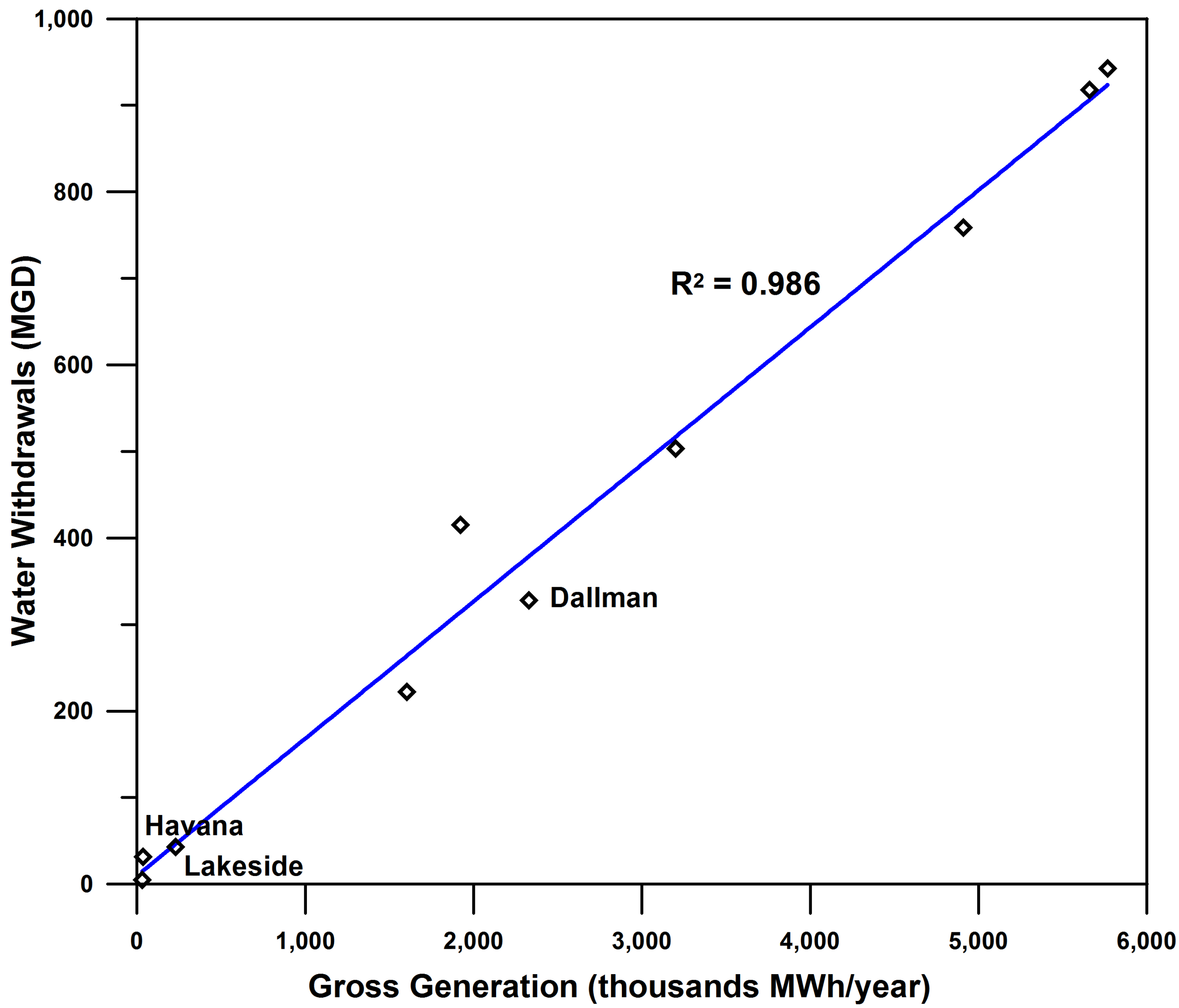


Figure 3.2: Relationship between total water withdrawals and gross generation for eleven once-through plants in East-Central and Northeastern Illinois

11 plants is explained by the values of gross generation. The relationship between the amount of generation and water withdrawals is also confirmed by previous studies of water withdrawals for power generation (e.g., Dziegielewski et al., 2002; Dziegielewski and Bik, 2006).

The slope of the regression line on Figure 3.2 is 57.8 gallons/kWh. This value represents the average incremental unit withdrawal per 1 kWh of gross generation. In deriving future estimates of water withdrawal for the four once-through plants, the actual unit withdrawals shown on Table 3.4 were used.

3.3.2 Closed-loop cooling systems

In the group of closed-loop make-up water plants, three plants (Havana #6, Vermilion and Powerton), use closed-loop cooling systems. The estimates of water withdrawals in these closed-loop plants are 5.71, 1.43, and 0.93 gallons/kWh, respectively. These unit-values were used in determining future water withdrawals.

3.4 Future demand for electricity

It is reasonable to expect that the future demand for electricity within the 15-county study area will change because of population growth and the concomitant increase in economic activity. The current use of electricity within the study area is difficult to determine precisely. There is no accurate or predictable correlation between local demand for power and local generation, both now and in the future, due to the nature of the electric power market. Increasing future electric demand may not be met by the six plants currently within the study area. The demand may be met with power generated outside the study area, or with power generated inside the study area by alternate means, such as gas turbines, wind turbines, solar, etc. As such, there is no way to predict or estimate where additional sources of power to serve the 15-county area will come from in the next five, let alone the next 42 years (2050). New and developing technologies will likely play a large part in how electric demand will be handled, but there are no current plans from which to develop any plausible scenarios regarding future water demand by the industry. All told, these unknowns make the development of likely future water demand scenarios involving the electric power industry difficult to specify or even generally conceptualize. Regardless of the difficulty in determining future power demand in East-Central Illinois and the sources for that power, it is necessary for the purpose of water-supply planning to account for current withdrawals and to estimate future withdrawals for the power generation sector. In this report, using the data available, we provide three possible scenarios for future power generation water withdrawals. The assumptions for these scenarios are provided in the following sections.

For the purposes of this report, an approximate level of electricity usage per capita can be derived by comparing the current aggregate sales of electricity with population served. Table 3.5 compares the available estimates of per capita energy consumption for Illinois and the U.S. The data is derived by dividing total sales of electricity by estimated population served.

Using the data in Table 3.5, the estimate of 10.77 MWh per capita per year was chosen as the best approximation of electricity use in the 15-county study area. This estimate is lower than the nation-wide rates reported by the EIA (12.33 MWh/capita/year for the U.S.) yet higher than the per capita reported by the Illinois Commerce Commission (ICC).

According to the EIA, at the national level, total electricity sales to all sectors (i.e., residential, commercial, and industrial) are expected to increase from 3,660 billion kWh in 2005 to 5,168 billion kWh in 2030 (AEO2007 reference case, EIA, 2007). During the same time period the projected U.S. population is expected to increase from 296.94 million in 2005 to 364.94 million in 2030. This implies that at the national level, per capita use of electricity is expected to increase from the current level of 12.33 MWh/capita/year to 14.16 MWh/capita/year in 2030. This represents the annual growth in electricity consumption of 0.56% per year. For developing future scenarios both the constant rate and increasing annual growth rate of 0.56% were assumed in deriving estimates of future demand for electricity within the 15-county study area. The estimates of the future demand for electricity during the 2005-2050 period are shown in Table 3.6.

The baseline estimates in Table 3.6 indicate that total demand for electricity would be expected to increase from 11,284,548 MWh/year in 2005 to 14,466,542 MWh in 2050. Assuming increasing per capita demand, by 2050, total demand for electricity would increase by 7,314,968 MWh or by 65 percent above the 2005 level.

According to EIA (2007), the growth in demand for electricity at the national level "is expected to be potentially offset by efficiency gains in both residential and commercial sectors." The assumption related to energy conservation is incorporated in the "less resource intensive" scenario.

3.5 Scenarios

The three future scenarios are designed to capture future conditions of water withdrawals for electric power generation under three different sets of conditions. The scenarios include a baseline scenario, a less resource intensive outcome, and a more resource intensive outcome. The assump-

Table 3.5: Estimation of per capita generation and consumption of electricity.

Source and data year	Electrical use (MWh/capita/year)	Comments
Illinois Commerce Commission (ICC), 2006	10.14	State-wide electricity sales and number of customers served
Energy Information Administration (EIA), 2005	10.77	Illinois average
Energy Information Administration (EIA), 2005	12.33	U.S. average

Table 3.6: Population-based estimates of future demand for electricity in East-Central Illinois.

Year	Resident population in 15-County Area	Estimated electricity demand[a] (MWh/year)	Electricity demand with growth[b] (MWh/year)
2005	1,047,776	11,284,548	11,284,548
2010	1,085,502	11,690,857	12,021,887
2015	1,123,080	12,095,572	12,790,250
2020	1,165,718	12,554,783	13,651,745
2025	1,199,724	12,921,027	14,447,821
2030	1,221,729	13,158,021	15,129,417
2035	1,250,916	13,472,361	15,929,482
2040	1,280,879	13,795,067	16,772,897
2045	1,311,641	14,126,378	17,662,063
2050	1,343,226	14,466,542	18,599,516

[a]The estimated electricity demand is obtained by multiplying the 15-county resident population by per capita use of electricity of 10.77 MWh per year.

[b]Demand with growth includes the annual growth factor in demand of 0.56%.

Note: Due to the nature of the market, local electricity demand is not related to local energy production.

tions used in the formulation of each scenario are described below.

As discussed in Section 3.4, due to the nature of the power generation market, there is no accurate or predictable correlation between local demand and local energy production. Therefore, in all scenarios, it is assumed that the plants will remain at their 2005 rates of usage (with the stated exceptions).

3.5.1 Scenario 1 - Baseline (BL)

Under the baseline scenario (BL), future generation of electricity in the 15-county study area will continue in the existing six power plants with the exception that the electric generator units which are scheduled to be retired will be retired. One new plant, Dallman 4, with a capacity of 200 MW will be completed by 2010 in Springfield, Illinois and will replace the Lakeside Plant to be retired, which has a capacity of only 76 MW. The new Dallman 4 Plant will use pulverized coal and a cooling system with cooling towers instead of once-through cooling.

Based on power industry comments regarding the formulation of scenarios presented in the reviews of the draft report, the BL scenario makes the assumption that all currently operating plants will remain in service using the existing cooling methods. Their annual gross generation will be maintained at the 2005 levels as shown in Table 3.4.

New demands for electricity within the study area are assumed to be met by higher utilization of the locally generated power in the five existing plants plus Dallman 4 as well as importing electricity from outside of the study area. For example, the Springfield City Water Light and Power (CWLP) has already entered into two 10-year contracts with FPL Energy for the purchase of 120 megawatts (MW) of wind power, which will be produced at FPL's Hancock and Osceola Wind Farms located in Northern Iowa. With the capacity factor for wind turbine plants in the range of 20 to 40 percent, the total amount of energy at the midpoint capacity of 30 percent would be 315,360 MWh per year.

For the purpose of the BL scenario it is assumed that no new thermoelectric plants will be built to meet the future increases in demand for electricity.

The specific assumptions for the Baseline Scenario are:

1. Future demand for electricity in the study area will grow in proportion to population growth at the rate of 10.77 MWh/capita/year plus an annual increase in per capita use of 0.56 percent.

2. Two generating units in the Lakeside Plant will be retired as scheduled and replaced by the newly constructed Dallman 4 Plant.

3. New demand for electricity will be met by obtaining more power from the existing five plants plus the new Dallman 4 Plant and also importing some power from outside the 15-county study area.

3.5.2 Scenario 2 - Less resource intensive (LRI)

The intent of this scenario is to define future conditions which would lead to less water withdrawals by power generation sector. Such an outcome would result if some of the existing plants would convert from once-through open-cycle cooling systems to closed-loop water plants with cooling towers (although this would result in higher overall water *consumption*). However, a review of the current supply sources to determine which of the two once-through plants might implement retrofits with cooling towers showed that neither plant is a realistic candidate for such a conversion. Therefore, we assumed, for this scenario, that in the future some of the older generator units may be used less because of the high cost of their operation.

We chose the oldest of all of the generators and assumed that in the future they would be put on standby. The oldest generators in the region are Units #1 through #5 at the Havana Plant built between 1947 and 1950 and Units #1 and #2 at the Vermilion Plant built in 1955 and 1956. These units are assumed to fall into the high operating cost category. Therefore, water withdrawals by these 7 generating units were assumed to decline as the units would possibly be placed on standby in the future. It should be noted here that none of the companies have current plans to change their operations of existing units; these reductions are assumed for the sole purpose of formulating the LRI scenario. The generators were chosen specifically due to their age, not any other reason.

The specific assumptions for the Less Resource Intensive (LRI) scenario are:

1. Future increases in per capita consumption of electricity are offset by conservation and demand for electricity will follow population growth at the rate of 10.77 MWh/capita/year.

2. The future increase in electricity consumption not provided by local plants will be met by importing electricity from outside the 15-county area.

3. Two generating units in the Lakeside Plant will be retired as scheduled and replaced by the newly constructed Dallman 4 Plant.

4. The generation in the existing five plants will maintain production at the current levels of capacity utilization with the exception of the five older units at Havana Plant and two older units at Vermilion Plant. The one new plant, Dallman 4, will be run at a capacity utilization of 75%.

5. The five older units at the Havana Plant (Units #1 to #5) were assumed to be gradually put on standby between 2020 and 2040.

6. The two older units at Vermilion Plant were assumed to by placed on standby by 2020 (Unit #1) and by 2035 (Unit #2).

3.5.3 Scenario 3 - More resource intensive (MRI)

The intent of the MRI scenario is to define future conditions which would lead to more water withdrawals by the power generation sector. Higher water demand in terms of water withdrawals will result if new power plants are built in the 15-county study area.

According to the comments of the power industry representatives, there are no current plans for constructing new power plants, other than Dallman 4, in the study area. Also, the opinion of power industry representatives is that if any new conventional power plants are built anywhere in the country they would be required to use closed-loop cooling systems in accordance with the USEPA Phase I 316(b) rule.

For the purpose of this scenario, an assumption is made that one clean coal power plant with gross capacity of 650 MW would be constructed within the 15-county study area during the later years of the planning horizon. The new plant could be built in Woodford County on the Illinois River or in another county with a large cooling/storage pond that would receive make-up water from the Sangamon River, Salt Creek, or lower Mackinaw River. For this scenario, we assumed the new plant will be built in Woodford County on the Illinois River and will use river water only as make-up water for closed-loop cooling system with cooling towers.

The specific assumptions for the More Resource Intensive (MRI) scenario are:

1. Future demand for electricity will grow in proportion to population growth at the rate of 10.77 MWH/capita/year plus an annual increase in per capita use of 0.56 percent.

2. Two generating units in the Lakeside Plant will be retired as scheduled and replaced by the newly constructed Dallman 4 Plant.

3. The generation in existing five plants will continue at the current levels of capacity utilization. The one new plant, Dallman 4, will be run at a capacity utilization of 75%.

4. New demand for electricity will be met by constructing one new clean coal power plant with a closed-loop cooling system in Woodford County with gross capacity of 650 MW.

3.6 Results

Figure 3.3 summarizes the total historical and estimated future water withdrawals for each of the scenarios. The historical fluctuation in water withdrawals is due to differences in energy production and rates of water usage from year to year. Future withdrawals were estimated using the 2005 rate of usage (gal/kWh) along with the previously discussed assumptions. The overall change in the Baseline Scenario, -3.0%, is due to the replacement of the Lakeside Plant with the Dallman 4 Plant in Sangamon County. This change also occurs in the LRI and MRI Scenarios. The LRI Scenario, additionally decreases due to the older generation units being put on standby (total of -7.4% change). The MRI Scenario, increases by 2.0% with the addition of a new plant in Woodford County.

It is important to note that while the thermoelectric power generation sector requires large quantities of water, the overall consumptive use of water is small. In once-through cooling systems, as much as 99 percent of water withdrawn can be returned back to the source. Closed-loop systems with cooling towers require smaller withdrawals (on average approximately 5 percent or less of the volumes withdrawn by once through cooling systems), however, between 30 to 70 percent of that smaller volume could be consumed due to evaporation.

The results for each of the three scenarios on water withdrawals are also summarized in Tables 3.7-3.9. Under the baseline scenario, the future water withdrawals for power generation would decline by 39.8 MGD in 2010 when the Lakeside Plant is retired and the new Dallman 4 Plant comes on line (Table 3.7). After 2010, total withdrawals would remain unchanged as the level of generation in the existing plants and utilization of existing capacity remain unchanged. Because the Lakeside Plant with once-through cooling system would be replaced with the Dallman 4 Plant with a cooling tower, total once-through withdrawals would decline by 43.2 MGD and closed-loop make-up water withdrawals would increase by 3.4 MGD (for a net change of 39.8 MGD). Overall, between 2005 and 2050, under the BL scenario, total withdrawals would decline by 39.8 MGD or 3.0 percent.

In the LRI scenario, following the decline in 2010 when the Lakeside Plant is retired and the new Dallman 4 Plant comes online, the level of once-through water withdrawals would additionally decline by 57.7 MGD after the older Havana (Units #1-5) and Vermilion (Units #1-2) units are put on stand by (Table 3.8). Between 2020 and 2040, the total water withdrawals are reduced approximately 11-13 MGD per 5-year increment due to the units put on stand by. Overall, between 2005 and 2050, under the LRI scenario, total withdrawals would decline by 97.6 MGD or 7.4 percent.

In the MRI scenario, the assumed addition of one clean coal plant with closed-loop cooling

Table 3.7: Electric power generation and water withdrawals for Baseline (BL) Scenario in East-Central Illinois.

Year	Once-through plants		Closed-loop water plants		All plants	
	Generation (MWh/year)	Withdrawals (MGD)	Generation (MWh/year)	Withdrawals (MGD)	Generation (MWh/year)	Withdrawals (MGD)
2005	11,606,997	1,236.7	14,017,973	78.6	25,624,970	1,315.4
2010	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2015	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2020	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2025	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2030	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2035	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2040	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2045	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2050	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
Difference from 2005 to 2050						
Unit	-229,855	-43.2	1,314,000	3.4	1,084,145	-39.8
Percent %	-2.0	-3.5	9.4	4.3	4.2	-3.0

MWh/year = mega watt hour per year; MGD = million gallons per day

would increase make-up water demand by 66.8 MGD in 2030 (Table 3.9). Once-through flow withdrawals would decline by 43.2 MGD after the retirement of Lakeside Plant by 2010 and would remain unchanged after 2010. The sum effect would be that the total withdrawals would increase by 26.9 MGD or 2.0 percent between 2005 and 2050.

Table 3.10 shows the future withdrawals for power generation for the five counties with power plants plus new generation (in the MRI scenario) in Woodford County. Figures 3.4-3.6 show the historical and future withdrawals for the power plants for the baseline scenario.

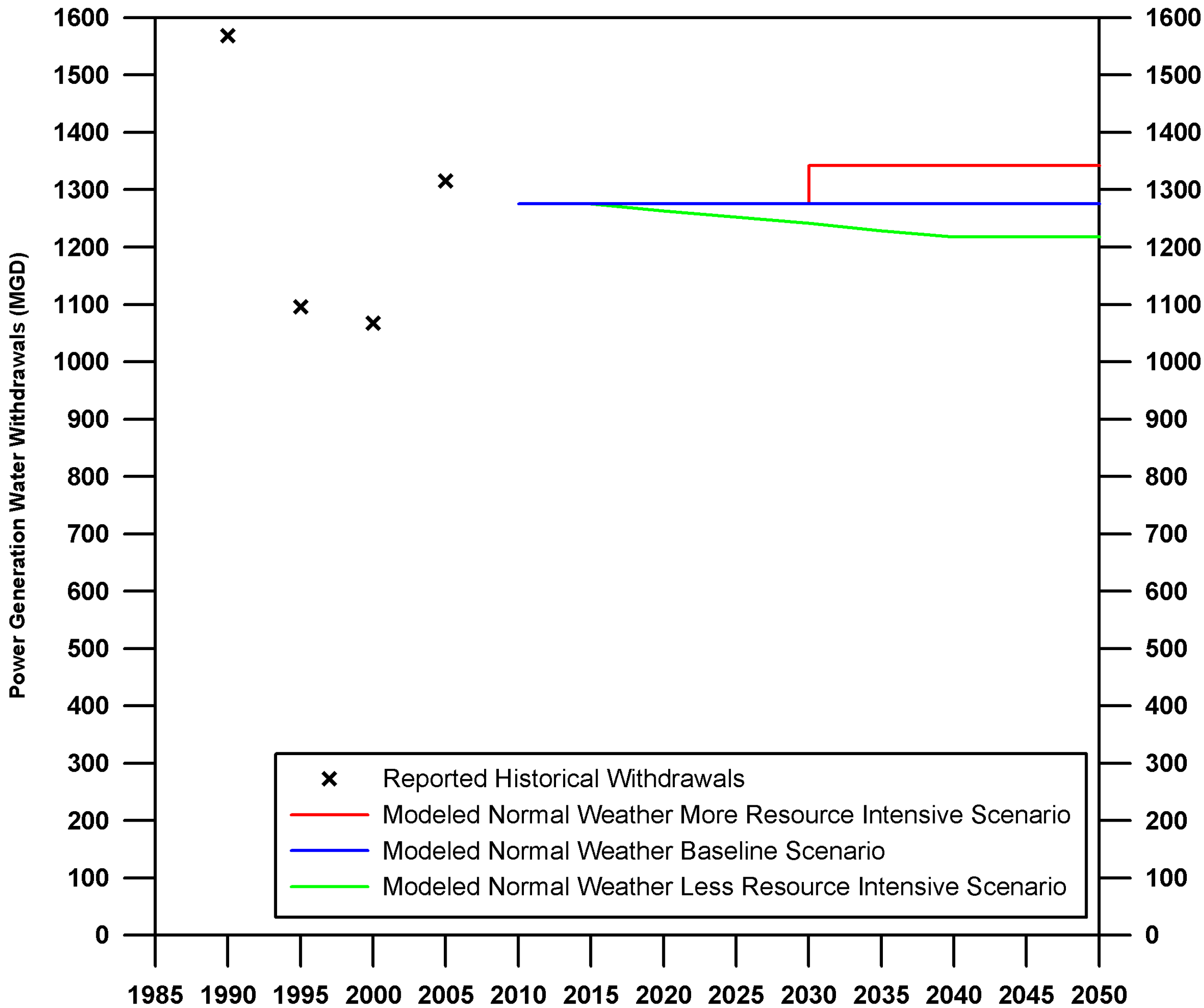


Figure 3.3: Historical and future thermoelectric water withdrawals for the baseline scenario, the less resource intensive scenario, and the more resource intensive scenario for East-Central Illinois.

Note: Future withdrawals were estimated using the 2005 rate of usage (gal/kWh). The historical fluctuation in water withdrawals is due to differences in energy production and rate of usage from year to year. Large discrepancy in withdrawals between 1990 and other years, in part, due to change in reporting from Tazewell County Plant in 1995. See Section 3.2 for further explanation.

Table 3.8: Electric power generation and water withdrawals for less resource intensive (LRI) scenario in East-Central Illinois.

Year	Once-through plants		Closed-loop water plants		All plants	
	Generation (MWh/year)	Withdrawals (MGD)	Generation (MWh/year)	Withdrawals (MGD)	Generation (MWh/year)	Withdrawals (MGD)
2005	11,606,997	1,236.8	14,017,973	78.6	25,624,970	1,315.4
2010	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2015	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2020	11,370,350	1,182.5	15,034,113	80.8	26,404,463	1,263.4
2025	11,363,558	1,171.5	15,034,113	80.8	26,397,671	1,252.4
2030	11,356,766	1,160.5	15,034,113	80.8	26,390,879	1,241.4
2035	11,349,974	1,149.5	14,629,023	79.2	25,978,997	1,228.8
2040	11,343,182	1,138.5	14,629,023	79.2	25,972,205	1,217.8
2045	11,343,182	1,138.5	14,629,023	79.2	25,972,205	1,217.8
2050	11,343,182	1,138.5	14,629,023	79.2	25,972,205	1,217.8
Difference from 2005 to 2050						
Unit	-263,815	-98.2	611,050	0.6	347,235	-97.6
Percent %	-2.3	-7.9	4.4	0.8	1.4	-7.4

MWh/year = mega watt hour per year; MGD = million gallons per day

Table 3.9: Electric power generation and water withdrawals for more resource intensive (MRI) scenario in East-Central Illinois.

Year	Once-through plants		Closed-loop water plants		All plants	
	Generation (MWh/year)	Withdrawals (MGD)	Generation (MWh/year)	Withdrawals (MGD)	Generation (MWh/year)	Withdrawals (MGD)
2005	11,606,997	1,236.8	14,017,973	78.6	25,624,970	1,315.4
2010	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2015	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2020	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2025	11,377,142	1,193.5	15,331,973	82.0	26,709,115	1,275.5
2030	11,377,142	1,193.5	19,602,473	148.8	30,979,615	1,342.4
2035	11,377,142	1,193.5	19,602,473	148.8	30,979,615	1,342.4
2040	11,377,142	1,193.5	19,602,473	148.8	30,979,615	1,342.4
2045	11,377,142	1,193.5	19,602,473	148.8	30,979,615	1,342.4
2050	11,377,142	1,193.5	19,602,473	148.8	30,979,615	1,342.4
Difference from 2005 to 2050						
Unit	-229,855	-43.2	5,584,500	70.2	5,354,645	26.9
Percent %	-2.0	-3.5	39.8	89.3	20.9	2.0

MWh/year = mega watt hour per year; MGD = million gallons per day

Table 3.10: Electric power generation and water withdrawals in East Central Illinois.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
BL - Baseline Scenario										
DeWitt	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4
Mason	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Sangamon	371.3	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5
Tazewell	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
Vermilion	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Woodford	-	-	-	-	-	-	-	-	-	-
Total study area	1,315.4	1,275.5	1,275.5	1,275.5	1,275.5	1,275.5	1,275.5	1,275.5	1,275.5	1,275.5
LRI - Less Resource Intensive Scenario										
DeWitt	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4
Mason	105.0	105.0	105.0	94.0	83.0	72.0	61.0	50.0	50.0	50.0
Sangamon	371.3	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5
Tazewell	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
Vermilion	2.8	2.8	2.8	1.6	1.6	1.6	0.0	0.0	0.0	0.0
Woodford	-	-	-	-	-	-	-	-	-	-
Total study area	1,315.4	1,275.5	1,275.5	1,263.4	1,252.4	1,241.4	1,228.8	1,217.8	1,217.8	1,217.8
MRI - More Resource Intensive Scenario										
DeWitt	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4
Mason	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Sangamon	371.3	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5
Tazewell	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
Vermilion	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Woodford	-	-	-	-	-	73.5	73.5	73.5	73.5	73.5
Total study area	1,315.4	1,275.5	1,275.5	1,275.5	1,275.5	1,342.4	1,342.4	1,342.4	1,342.4	1,342.4

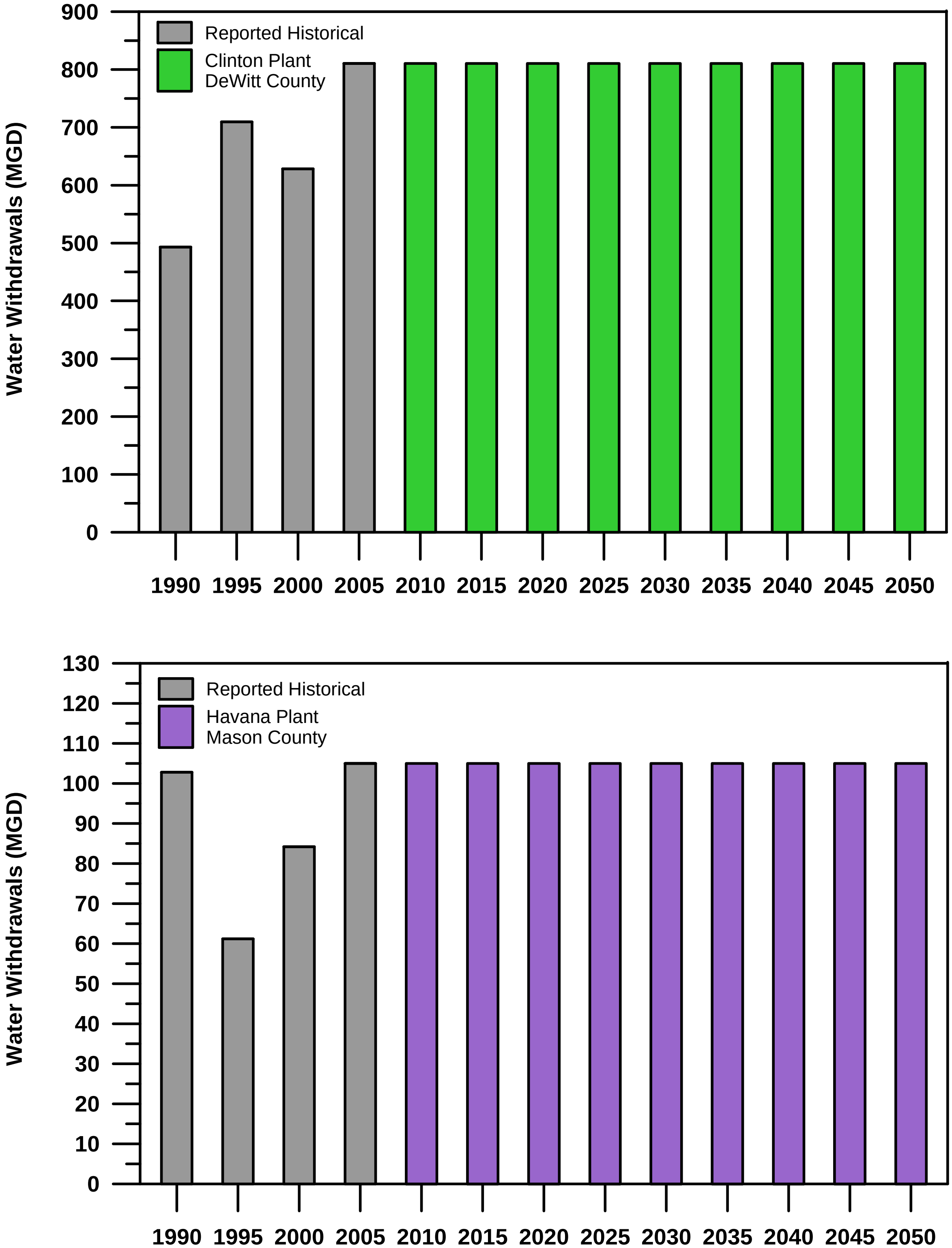


Figure 3.4: Historical and future power generation water withdrawals from the baseline scenario for the Clinton and Havana plants.

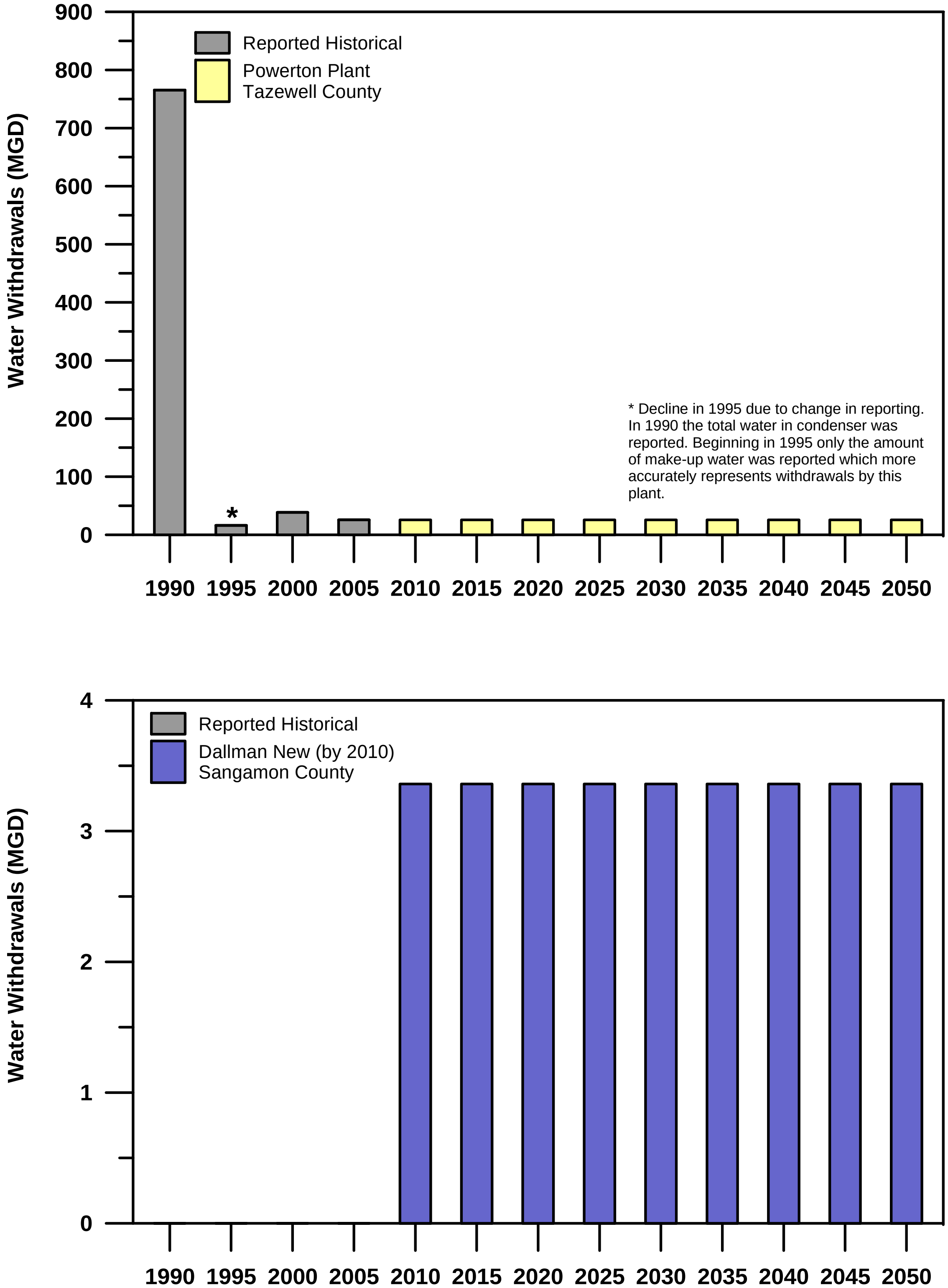
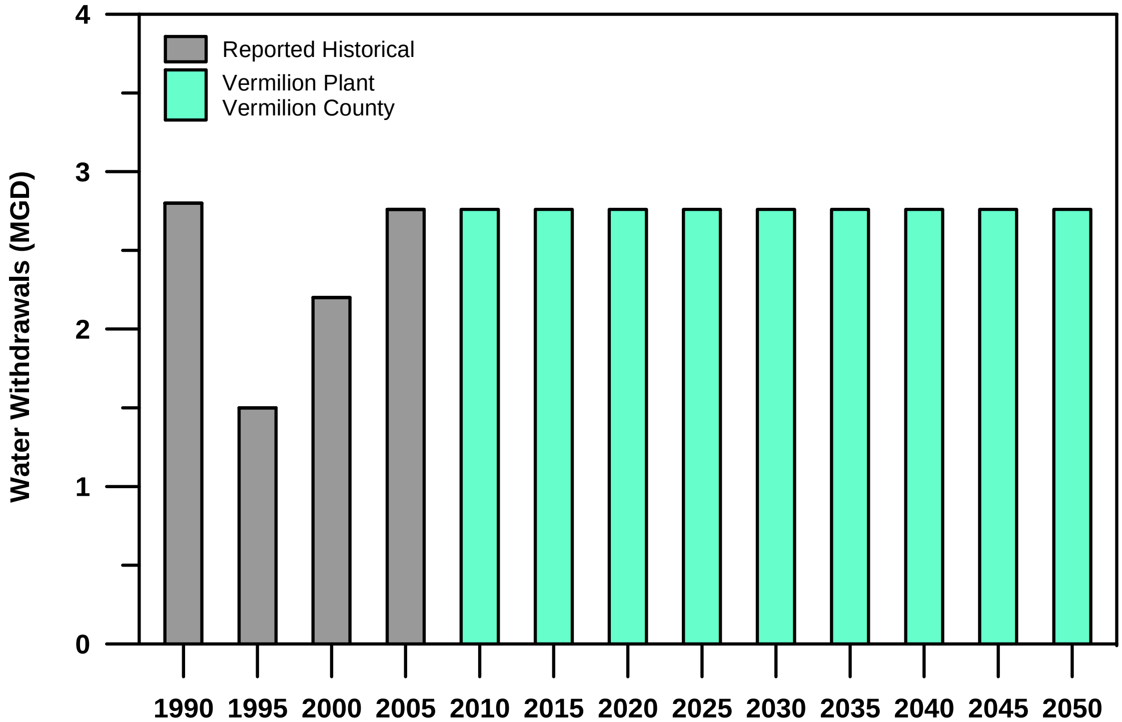


Figure 3.5: Historical and future power generation water withdrawals from the baseline scenario for the Powerton and Dallman (new) plants.



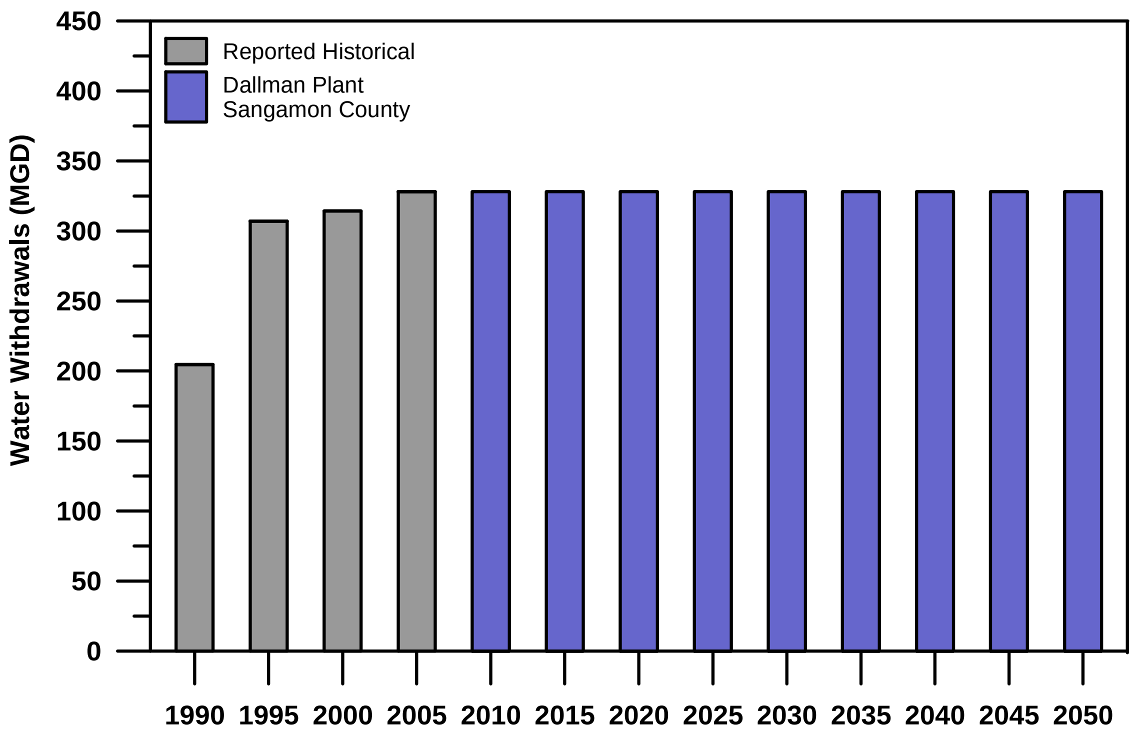


Figure 3.6: Historical and future power generation water withdrawals from the baseline scenario for the Vermilion and Dallman (existing) plants.

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Chapter 4

Self-supplied Commercial and Industrial (C&I)

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4.1 Background

The commercial and industrial (C&I) sector represents water withdrawals that are self-supplied or purchased (*i.e.*, water delivered by a public supply system) to commercial, industrial, and other nonresidential establishments. The industrial sub-sector includes "water used for industrial purposes such as fabrication, processing, washing, and cooling, and includes such industries as steel, chemical and allied products, paper and allied products, mining, and petroleum refining"[Avery, 1999]. The commercial sub-sector includes water used for "motels, hotels, restaurants, office buildings, other commercial facilities, and institutions" [Avery, 1999].

This chapter focuses on *self-supplied* water withdrawals by industrial and commercial (or institutional) establishments within the 15-county study area in East-Central Illinois. However, for analytical purposes both self-supplied and publicly delivered supplies are considered in order to correlate future water demand in this sector with the projections of the main driver variable – total employment in each of the 15 counties.

4.2 Multiple regression method

The general purpose of multiple regression is to learn more about the relationship between several independent variables (e.g. cooling degree days, precipitation, etc.) and a dependent variable (e.g. per employee water withdrawals). Multiple regression can establish that a set of independent variables explains a proportion of the variance in a dependent variable at a significant level (through a significance test of R^2), and can establish the relative predictive importance of each of the independent variables. The relative importance is shown via the sign and magnitude of the resulting coefficients or elasticities. The general multiple regression method is described in greater detail in Chapter 1.

4.2.1 Commercial and industrial water-demand relationships

Water withdrawals and purchases for C&I purposes are most often explained in economic terms, where water is treated as a factor of production. Ideally, econometric models of C&I water demand could be developed based on outputs, the price of water, and other inputs. Unfortunately, such data are rarely collected at the county level or are not publicly available because of their proprietary nature. An alternative approach that has been commonly used is to use unit-use demand coefficients to estimate water demand based upon the size and type of products or services produced by the firm. Because the size of the firm is frequently represented by its number of employees, total water demand estimates for the C&I sector are frequently calculated in terms of the quantity of water per employee for a specified type of business enterprise.

The type of firm can be determined by its SIC code, a system that is now converted into the North American Industry Classification System (NAICS). Several SIC/NAICS codes, especially those in the manufacturing sector, are commonly associated with high-levels of water demand. The ready availability of data on the number of employees by SIC/NAICS codes at the county level has led to the widespread use of sectoral employment as the primary independent variable in C&I water demand studies [Davis et al., 1987].

The variability of self-supplied C&I water demand for different SIC/NAICS codes tends to be very high and therefore is difficult to model at the aggregate level of water-demand data. Table 4.1 compares the reported self-supplied C&I withdrawals for the 15 counties in the study area. The last column in Table 4.1 shows the water demand per employee which were obtained by dividing the self-supplied withdrawals by the reported total employment in self-supplied firms. Often times, the C&I facilities do not provide the number of employees in their firm when they report their water withdrawals which is part of the variability seen in the water demand per employee. The per employee water demand ranges from 35 gallons per employee per day (GPED) in Iroquois County to 504,691 GPED in Ford County. Because it would difficult to develop water-demand models which explain such great variability, the combined total self-supplied and purchased C&I water withdrawals were used as the dependent variable in deriving water-demand relationships.

Table 4.2 shows the data on per employee water demand at the county level for total self-supplied and total C&I water demand in 2005. The per-employee rates of total water demand (self-supplied and purchased) show much less variability (from 7 gallons per employee per day (GPED) to 792 GPED) than per-employee rates of self-supplied withdrawals in the subset of self-supplied firms as shown in Table 4.1. For this reason the total self-supplied and purchased C&I water demand is modeled.

A log-linear model similar to the public-supply model was applied to capture the relationship between average water demand per employee (for combined self-supplied and delivered water) and independent variables. The independent variables included two weather variables, annual cooling degree days and total precipitation from May 1 through September 30, and three variables representing the structure of employment within each county. The employment structure was captured as the percentage of employment in the 2-digit SIC/NAICS categories health services, retail trade, and manufacturing. Also, a variable was included in the data to provide a measure of the allocation of publicly supplied and self-supplied C&I water demand in each county. The percent of self-supplied C&I withdrawals variable was calculated as the quantity of self-supplied

Table 4.1: County-level estimates of self-supplied commercial and industrial water demand in 2005.

County	Self-supplied withdrawals (MGD)	Employment in self-supplied establishments	Water demand per employee (GPED)
Cass	1.83	2,300	796
Champaign	5.54	2,117	2,617
DeWitt	$2E^{-5}$	23	0.9
Ford	3.03	6	504,691
Iroquois	0.02	704	35
Logan	1.00	no data	–
Macon	15.73	842	18,677
Mason	5.58	75	74,428
McLean	0.01	17	391
Menard	0.00	30	0
Piatt	1.09	45	24,241
Sangamon	5.06	19	266,503
Tazewell	43.20	5,192	8,321
Vermilion	2.70	380	7,095
Woodford	0.00	10	0
Total/Ave.	84.79	1,760	7,210 (Ave.)

Source: Illinois Water Inventory Program, Illinois State Water Survey, 2007.

MGD = million gallons per day. GPED = gallons per employee per day.

Table 4.2: County-level self-supplied and purchased commercial and industrial water withdrawals in 2005.

County	Total county employment	Self-supplied withdrawals (MGD)	Public-supply deliveries to C&I (MGD)	Total C&I withdrawals (MGD)	Water demand per employee (GPED)
Cass	7,324	1.83	0.10	1.93	263
Champaign	98,084	5.54	5.65	11.19	114
DeWitt	8,023	0.00	0.27	0.27	34
Ford	6,994	3.03	0.44	3.47	496
Iroquois	15,923	0.02	0.34	0.36	23
Logan	12,718	1.00	0.34	1.34	106
Macon	50,203	15.73	4.85	20.58	410
Mason	7,175	5.58	0.10	5.68	792
McLean	84,570	0.01	1.36	1.36	16
Menard	6,751	0.00	0.05	0.05	7
Piatt	8,858	1.09	0.15	1.24	140
Sangamon	101,526	5.06	7.99	13.05	129
Tazewell	66,606	43.20	7.24	50.44	757
Vermilion	35,850	2.70	3.38	6.07	169
Woodford	19,509	0.00	0.26	0.26	13
Total/Ave.	530,114	84.79	32.50	117.29	231(Ave.)

MGD = million gallons per day; GPED = gallons per employee per day; Ave. = average

Sources: Illinois Water Inventory Program, Illinois State Water Survey, 2007; US Geological Survey 2005 provisional data; and County Business Patterns and Illinois Department of Employment Security, 2007.

C&I withdrawals divided by the sum of self-supplied and delivered C&I water. The conservation trend variable was included to account for unspecified changes that are likely to influence water withdrawals over time, and that represent general trends in efficiency in production processes and technologies.

4.3 Historical data

Water withdrawals and independent variables for each county in the region were analyzed for the historical period to establish the mathematical relationship between independent variables and withdrawals. Data were gathered for the historical years 1985, 1990, 1995, 2000, and 2005. A description of the data and the sources from which data were obtained is provided in the following sections. Individual counties are the geographical areas of analysis for this sector.

4.3.1 Historical water withdrawals

Total C&I water withdrawals are comprised of two datasets 1) self-supplied C&I facilities that own their water supply system and 2) C&I facilities that purchase water from public suppliers. Data on self-supplied C&I withdrawals for both surface water and groundwater sources were obtained directly from the Illinois Water Inventory Program (IWIP) of the Illinois State Water Survey (ISWS). Data on water delivered to C&I establishments by public suppliers were obtained from U.S. Geological Survey (USGS).

Self-supplied C&I facilities voluntarily report annual water withdrawals to the ISWS (Table 4.3). For the entire 15-county study area in East-Central Illinois, total self-supplied commercial and industrial withdrawals (including mining) range between 74 – 85 MGD from 1985 to 2005. All of the historical data was used as reported from the ISWS, with one exception. In 2001, the City of Decatur's public water supply system sold one of its water treatment plants to Archer Daniels Midland (ADM), a local industry. Prior to 2001, Decatur sold water to ADM. The sale of the treatment plant in 2001 was evidenced in the IWIP historical withdrawals as an increase in water withdrawals for Macon County of approximately 15 MGD in 2005. This increase in withdrawals for 2005 creates an "artificial" increase in per employee water withdrawals for Macon County as compared to other years. Conversely, in the Public Water Supply (PWS) Sector (Chapter 2), there is a large decrease in the withdrawals in 2005. Because the model is designed to capture only changes in withdrawals that relate to the eight independent variables, not the change of large volumes of water from one sector to another, we removed this change from the historical data. This was done by adding ADM's withdrawals to Macon County in the amount of water that was sold to ADM in 1985, 1990, 1995, and 2000. The historical withdrawals (1985, 1990, 1995, and 2000) were removed from PWS and added to the withdrawals in the C&I Sector. Including ADM withdrawals in C&I for all historical years better enables the model, which is based upon the historical data, to capture the other changes in water withdrawals. The modification in the historical withdrawals data is noted in the graphs and tables throughout the report.

The data in Table 4.3 shows some variability of the reported withdrawals across the data years at the county level. The variability of the reported withdrawals can be partially attributed to the voluntary method in which the self-supplied withdrawals are inventoried. Although participation by known facilities is common, it should be noted that in any given year the database *may* be underestimating total withdrawals because of non-reporting by known facilities and lack of participation by unidentified facilities. For example, In Sangamon County the increase between 1995 and 2000 is due to one large facility reporting withdrawals only in 2000 and 2005 and no previous years. The non-reporting facility may either be an existing business that did not report in the past or a new business. The variability in Tazewell County is a result of the facilities reporting differing amounts of withdrawals in any given year and the addition of facilities throughout the time period. The reduction in withdrawals for Champaign County in 1995 as compared to 1990 withdrawals are a result of one large facility closing. In Macon County the gradual decline in water withdrawals is due in part to one large facility reducing total withdrawals over the years. The variability in other counties may also be due to the addition or subtraction of facilities, changes due to weather, some facilities no reporting or variability in production from year to year.

4.3.2 Total county employment

County-level total employment data were obtained from the Illinois Department of Employment Security (IDES) (2007) for 1985, 1990, 1995, 2000, and 2005. The IDES reports the number of people employed on a monthly basis and reports the average number of people employed annually. Since employment is generally not seasonal, the annual average number of people employed for each county are used.

Total county employment is used to convert total water withdrawals into gallons per employee per day (GPED). The model uses GPED as the dependent variable, or the left-hand side of the equation. GPED is calculated by dividing total water withdrawals by total county employment.

Table 4.3: Historical self-supplied commercial and industrial water withdrawals as reported to Illinois State Water Survey.

County	1985 MGD	1990 MGD	1995 MGD	2000 MGD	2005 MGD
Cass	0.77	1.99	1.59	2.00	1.83
Champaign	8.97	10.87	7.60	5.33	5.54
DeWitt	0.00	0.01	0.00	0.00	0.00
Ford	0.05	0.02	0.79	2.66	3.03
Iroquois	0.10	0.05	0.05	0.10	0.02
Logan	0.07	0.21	0.06	0.13	1.00
Macon *	19.52	20.81	19.30	17.17	15.73
Mason	8.98	7.56	4.83	4.87	5.58
McLean	0.65	0.04	0.06	0.01	0.01
Menard	0.00	0.00	0.00	0.00	0.00
Piatt	1.18	0.80	0.81	0.90	1.09
Sangamon	1.58	1.92	1.26	5.06	5.06
Tazewell	34.37	27.06	39.08	37.41	43.20
Vermilion	3.23	2.99	2.65	2.37	2.70
Woodford	0.00	0.01	0.01	0.00	0.00
Total	79.48	74.33	78.1	77.99	84.79

*Water withdrawals for Macon County has ADM pumpage added for 1985-2000; see Section 4.3.1 for explanation. MGD = million gallons per day.

Source: Illinois Water Inventory Program, Illinois State Water Survey, 2007.

4.3.3 Independent variables

Water withdrawals are driven, or controlled, by certain influencing factors called independent variables. A substantial data collection and processing effort was required to prepare appropriate independent variables for the development of water-withdrawal relationships. The dependent variable was defined as gross water withdrawals (self-supplied withdrawals plus water purchased from public water suppliers). Seven independent variables were used to explain the variability of water withdrawals across study areas. These six variables were chosen based upon a previous study of Illinois water withdrawals [Dzielgielewski et al., 2005] in which approximately 20 variables were tested to determine if they significantly affected water demand. A discussion of the data and source information for each of the variables listed below is found in the sections following this section:

- total annual cooling degree days;
- total precipitation from May 1 through September 30;
- percent of employment in health services;
- percent of employment in retail trade;
- percent of employment in manufacturing;
- percent of self-supplied C&I water withdrawals; and
- a conservation trend.

4.3.3.1 Weather variables - cooling degree days and precipitation

Cooling degree days and precipitation are both important drivers of water demand. Cooling degree days are calculated by subtracting 65 from a day's average temperature so that on any day where the average temperature is above $65°F$ the day is said to have as least one cooling degree day. For example, if the average temperature for the day is $80°F$ and we subtract $65°F$ from $80°F$, the day has 15 cooling degree days. Cooling degree days are positively correlated to water demand, meaning that an increase in cooling degree days results in an increase in water withdrawals.

The total summer precipitation (May 1 through September 30) is also used as an independent variable in the model. So for each county, the total summer precipitation was collected and analyzed in the model. Precipitation is negatively correlated to water withdrawals, meaning an increase in precipitation results in a decrease in water demand.

The correlation of weather to water withdrawals indicates that climate change will impact water withdrawals in the region. Although, we do not account for it in our three scenarios, we do examine the possible effects of climate change and drought in Chapter 6. Please refer to this chapter for more discussion about climate change and the impacts to water withdrawals.

The data for the weather variables, total annual cooling degree days and total summer (May 1 through September 30) precipitation, were obtained from Dr. Jim Angel, State Climatologist, ISWS. Data from 29 stations in the 15-county region were organized and summarized. The station number and location of the weather stations used for this study are listed in Appendix D.

The weather variables assigned to each county were the average of all the stations in that particular county. If there were no stations in a county or no data from the existing station, data from a surrogate station were used. Typically, the surrogate station used was the nearest station to the county where no data existed. The surrogate stations were chosen with the advice of the State Climatologist.

4.3.3.2 Percent health services employment, percent retail trade employment, and percent manufacturing employment

The employment structure within in a county is related to water withdrawals. For example, if a county has a high percent of people employed in the manufacturing sector, it also has high water withdrawals. Employment data for 2-digit Standard Industrial Classification (SIC) codes were obtained from County Business Patterns [United States Census Bureau, 2005] and different employment sectors were tested to see if they were significant. Three variables representing employment structure within each county are used in the model. Employment structure is captured as the percentage fraction of employment in 2-digit SIC categories for health services, retail trade, and manufacturing. The percentages are calculated from the total employment of the county.

4.3.3.3 Percent self-supplied commercial and industrial withdrawals

County-level estimates of self-supplied C&I water withdrawals from both surface and groundwater sources were obtained from ISWS for 1985, 1990, 1995, 2000 and 2005. Data on self-supplied C&I water withdrawals were added to the public deliveries to C&I establishments in order to obtain total water withdrawals and purchases by the C&I sector. The percent of self-supplied C&I withdrawals variable was calculated as the quantity of self-supplied C&I withdrawals divided by the sum of the publicly supplied and self-supplied C&I water.

4.3.3.4 Conservation trend

An additional variable was included to account for unspecified changes that are likely to influence water withdrawals over time and that represent general trends in water conservation behavior. Water demand per employee can be expected to change over time and the conservation trend variable is intended to capture water demand changes due to gains in efficiency in production processes and technologies. The conservation trend variable was specified as zero for 1985, 5 for 1990, 10 for 1995, 15 for 2000, and 20 for the year 2005.

4.4 Commercial and industrial multiple regression model

The final regression model for the C&I sector is shown in Table 4.4 and Figure 4.1. Based upon previous water demand research and modeling efforts, the estimated elasticities (or coefficients) of the independent variables in the structural model have the expected signs and magnitudes. For example, it is expected that the summer precipitation coefficient will be negative which indicates that as precipitation increases, water demand decreases. The expected signs and magnitude of the independent variables were used as one indicator of model validity.

Besides the structural coefficients, two types of binary variables were tested during model development. County binaries were added to the model to account for county specific characteristics that were not accounted for by other variables in the model. Outlier binary variables were added to the model to account for county/year observations that are far outside the expected range of variables. A detailed description of the model development procedure and a complete set of estimated coefficients including binary county intercepts and binary spike variables is included in Appendix D.

The estimated coefficients represent constant elasticities of the independent variable with respect to per employee water demand. For example, the constant elasticity of annual cooling degree days indicates that, on average, a one (1.0) percent increase in the number of cooling degree days increases per employee water demand by 0.53 percent. The negative constant elasticity of summer precipitation variable indicates that, on average, a one (1.0) percent increase in summer precipitation decreases per employee water demand by 0.28 percent. Figure 4.1 is used to graphically indicate the relative impact each variable will have on the modeled per employee water demand compared to other variables in the model.

The last row of Table 4.4 shows the model statistics. These statistics indicate that the model explained 94 percent of time-series and cross-sectional variance in log-transformed per employee water demand. Please refer to the list of key terms for explanation of the other statistical values

Table 4.4: Structural portion of the regression model for commercial and industrial water demand in East-Central Illinois.

Variables	Estimated regression coefficient	t-Ratio	Probability >|t|
Intercept	-1.1465	-0.34	0.73
Annual cooling degree days (ln)	0.5297	1.20	0.24
Summer precipitation (ln)	-0.2766	-1.13	0.26
Health services employment (%)	0.0618	3.25	0.00
Retail employment (%)	0.0740	4.34	<.0001
Manufacturing employment (%)	0.0098	1.30	0.2
Self-supplied C&I demand (%)	0.0324	18.58	<.0001
Conservation trend (ln)	-0.1262	-1.70	0.09
N = 75, R^2= 0.94, R^2Adj = 0.92, Root MSE = 0.41, Mean of Response= 4.6			

shown.

The regression models were used to generate both historical and future GPED withdrawals in each of the 15 counties. Figure 4.2 shows the model versus reported historical water withdrawals. The figure shows that, as expected, there is scatter around the line which indicates that the model predicts GPED accurately for most data points. The model predicted the GPED withdrawals best when the the GPED withdrawals were below 400 GPED as shown by most of these points falling on or near the line. Most of the withdrawals fall below 400 GPED.

Table 4.5 compares the model-generated 2005 values versus the 2005 reported values. As a region, the model versus the reported difference in 2005 withdrawals was -0.55 MGD. The differences between the model generated and reported values are relatively small, since in some cases where the differences for the 2005 data year were large additional calibrations of model intercepts were performed. The calibrated 2005 intercepts were retained in preparing estimates of future water withdrawals.

4.5 Future data

The model described in Section 4.4 established the relationship between water withdrawals and water demand variables. Assuming that this relationship remains the same in the future, the model is used with the future water demand variables to estimate water withdrawals in the future. The

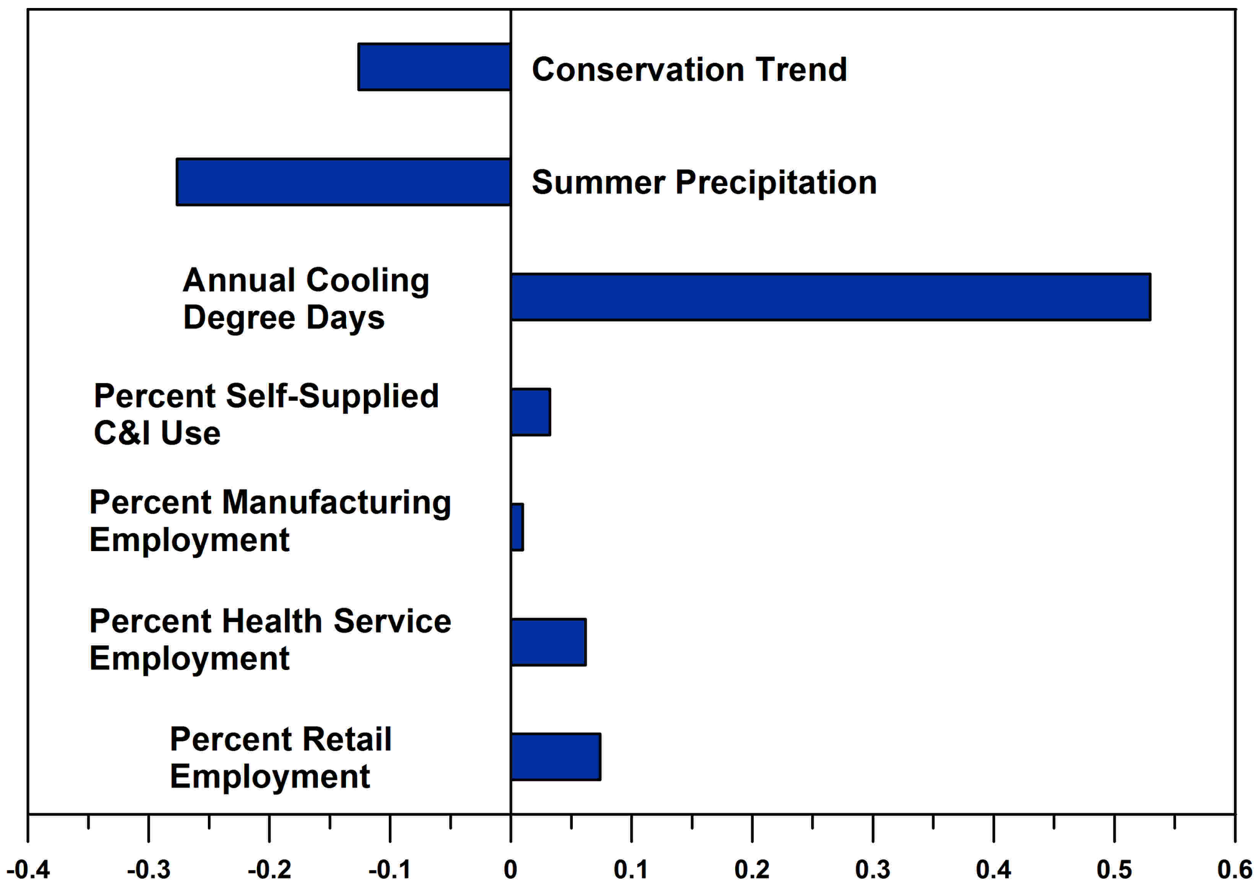


Figure 4.1: Structural model for commercial and industrial sector in East-Central Illinois.

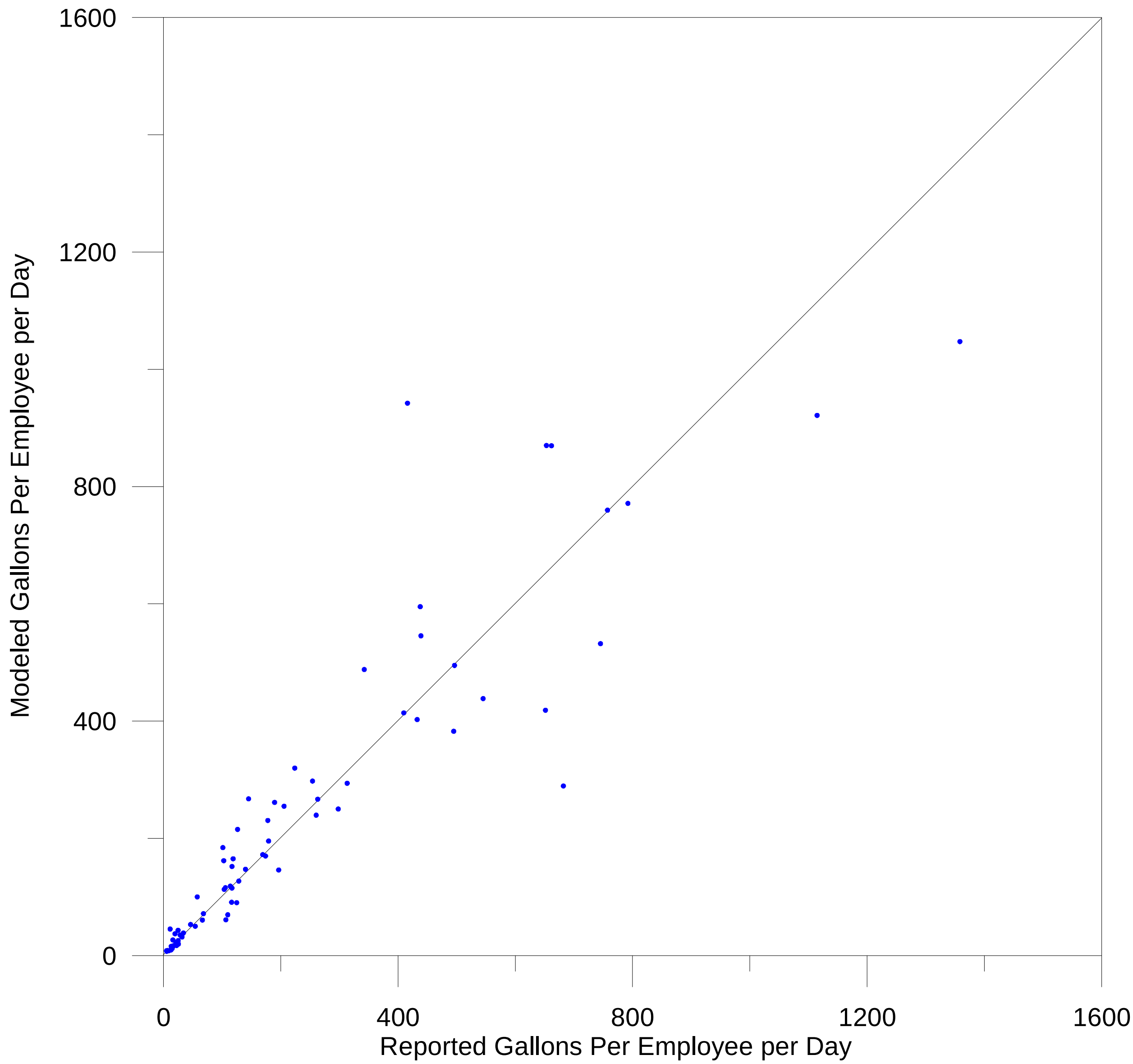


Figure 4.2: Reported versus modeled gallons per employee per day.

Table 4.5: Comparison of model-generated and reported water withdrawals in 2005 for self-supplied commercial and industrial sector.

County	Model-generated withdrawals* (MGD)	Reported withdrawals (MGD)	Difference (MGD)
Cass	1.87	1.83	-0.04
Champaign	5.74	5.54	-0.20
DeWitt	0.00	0.00	0.00
Ford	3.02	3.03	0.01
Iroquois	0.02	0.02	0.00
Logan	1.10	1.00	-0.10
Macon	15.89	15.73	-0.16
Mason	5.44	5.58	0.14
McLean	0.01	0.01	0.00
Menard	0.00	0.00	0.00
Piatt	1.15	1.09	-0.06
Sangamon	5.01	5.06	0.05
Tazewell	43.35	43.20	-0.15
Vermilion	2.74	2.70	-0.04
Woodford	0.00	0.00	0.00
East-Central Illinois	85.33	84.79	-0.55

*Model-generated withdrawals are estimated using actual 2005 weather data.

MGD = million gallons per day.

Source: Illinois Water Inventory Program, Illinois State Water Survey, 2007.

following sections describe how employment and the water demand variables are estimated to the year 2050.

4.5.1 Future employment population

The main driver of future water demand in the C&I sector is the future level of production of goods and services as measured by total employment. The future output of goods and services will also depend on labor productivity; the total future employment should be adjusted for productivity. The long-term growth in labor productivity in Illinois between 1977 and 2000 was 1.3 percent per year as reported by the U.S. Bureau of Labor Services of the U.S. Department of Labor [USBLS, 2000]. However, no information was available on the projections of future growth in productivity and, for the purpose of this study, a long-term rate in productivity increase was assumed to be 1.0 percent per year. The assumption of 1.0 percent per year makes the estimates of future self-supplied C&I withdrawals conservative. Higher future increases in productivity would translate into higher physical output per employee and result in higher withdrawals.

Future employment projections were obtained from IDES out to the year 2014. This study assumes that future employment trends will continue as projected by IDES to the year 2050 (2007). Table 4.6 and Figures 4.3 – 4.10 shows the historical and future total employment for each of the 15 counties in the study area. Between 2005 and 2050, total employment is projected to increase by 167,895 employees or by 32 percent. The employment population is used to generate water withdrawals in the future by multiplying the model derived GPED amounts by the employment to obtain MGD for the county.

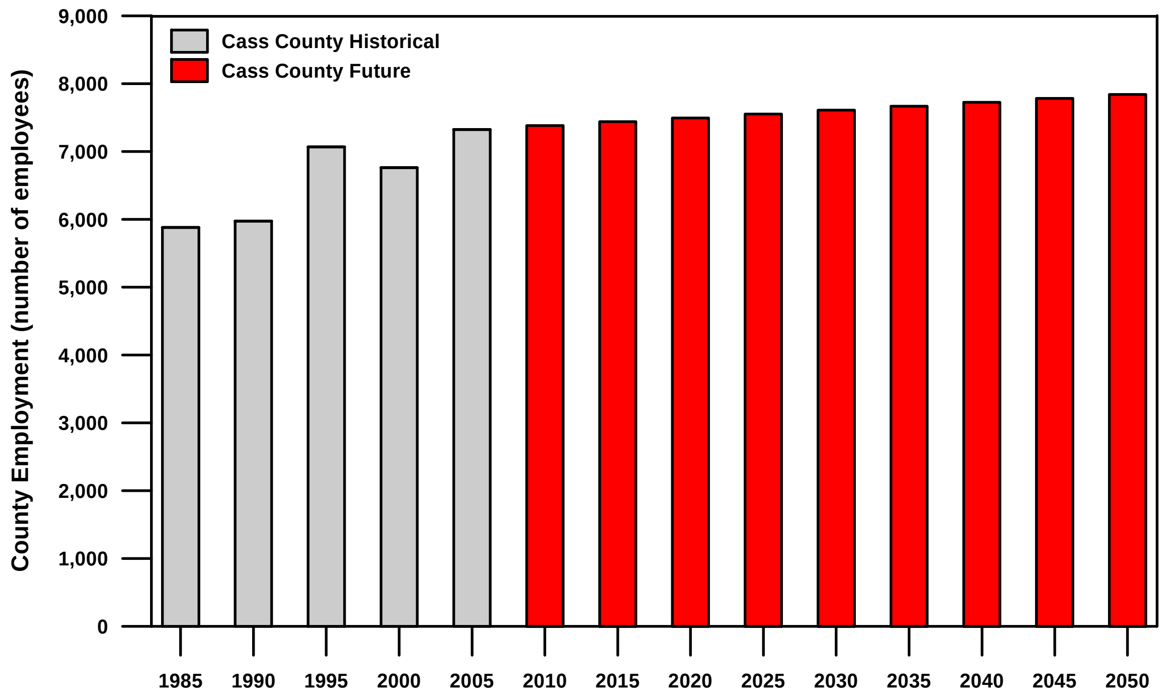
Table 4.6: 2005 total employment, 2050 total employment projections, and number of employees added per year.

County	2005 employment[1]	2050 employment	Employees added per year[2]
Cass	7,324	7,842	11.5
Champaign	98,084	134,921	818.6
DeWitt	8,023	9,063	23.1
Ford	6,994	7,485	10.9
Iroquois	15,923	17,705	39.6
Logan	12,718	14,230	33.6
Macon	50,203	67,375	381.6
Mason	7,175	8,453	28.4
McLean	84,570	121,781	826.9
Menard	6,751	7,296	12.1
Piatt	8,858	9,511	14.5
Sangamon	101,526	137,148	791.6
Tazewell	66,606	89,489	508.5
Vermilion	35,850	39,981	91.8
Woodford	19,509	25,733	138.3
Total	530,114	698,009	3,731

[1]Source: County Business Patterns and Illinois Department of Employment Security, 2007; [2]Source: Illinois Department of Employment Security, 2007

4.5.2 Future values of independent variables

The future values of the seven independent variables (i.e., annual cooling degree days, May through September precipitation, percent health services employment, percent retail trade employment, percent manufacturing employment, percent self-supplied C&I demand, and conservation trend) will determine the future rates of per employee water demand in the C&I sector in each study area. In preparing future C&I withdrawals, future values of the independent variables have to be projected. A description of the projections is provided below.



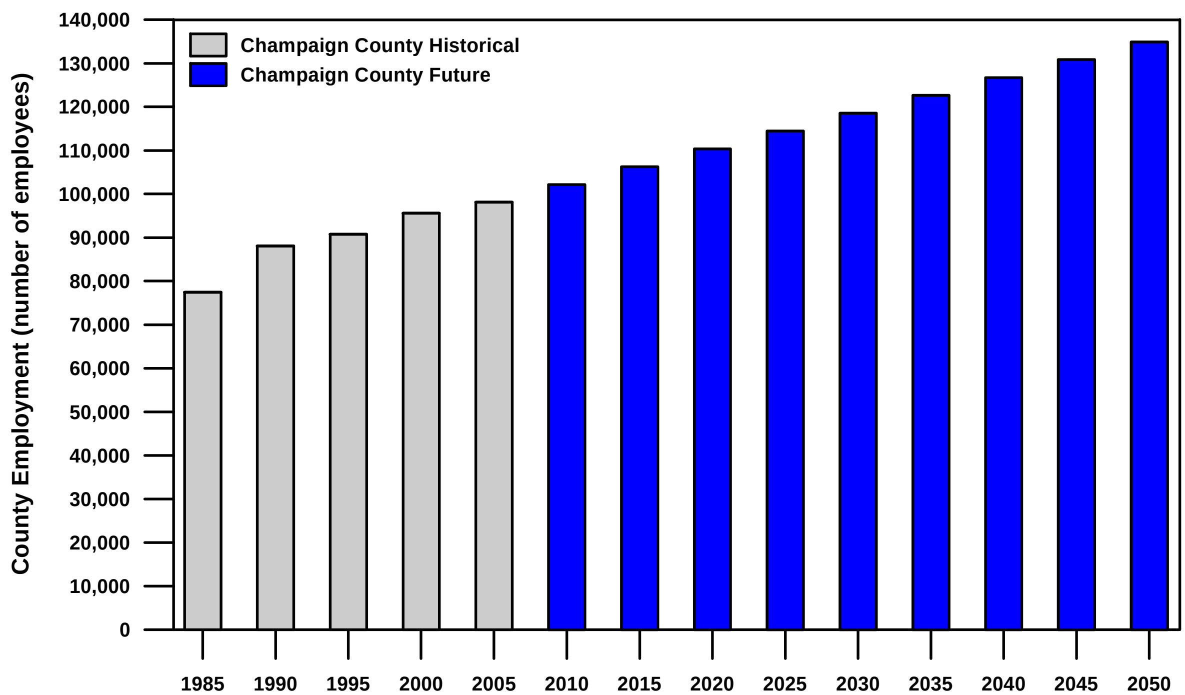


Figure 4.3: Historical and future employment populations for Cass and Champaign counties in East-Central Illinois.

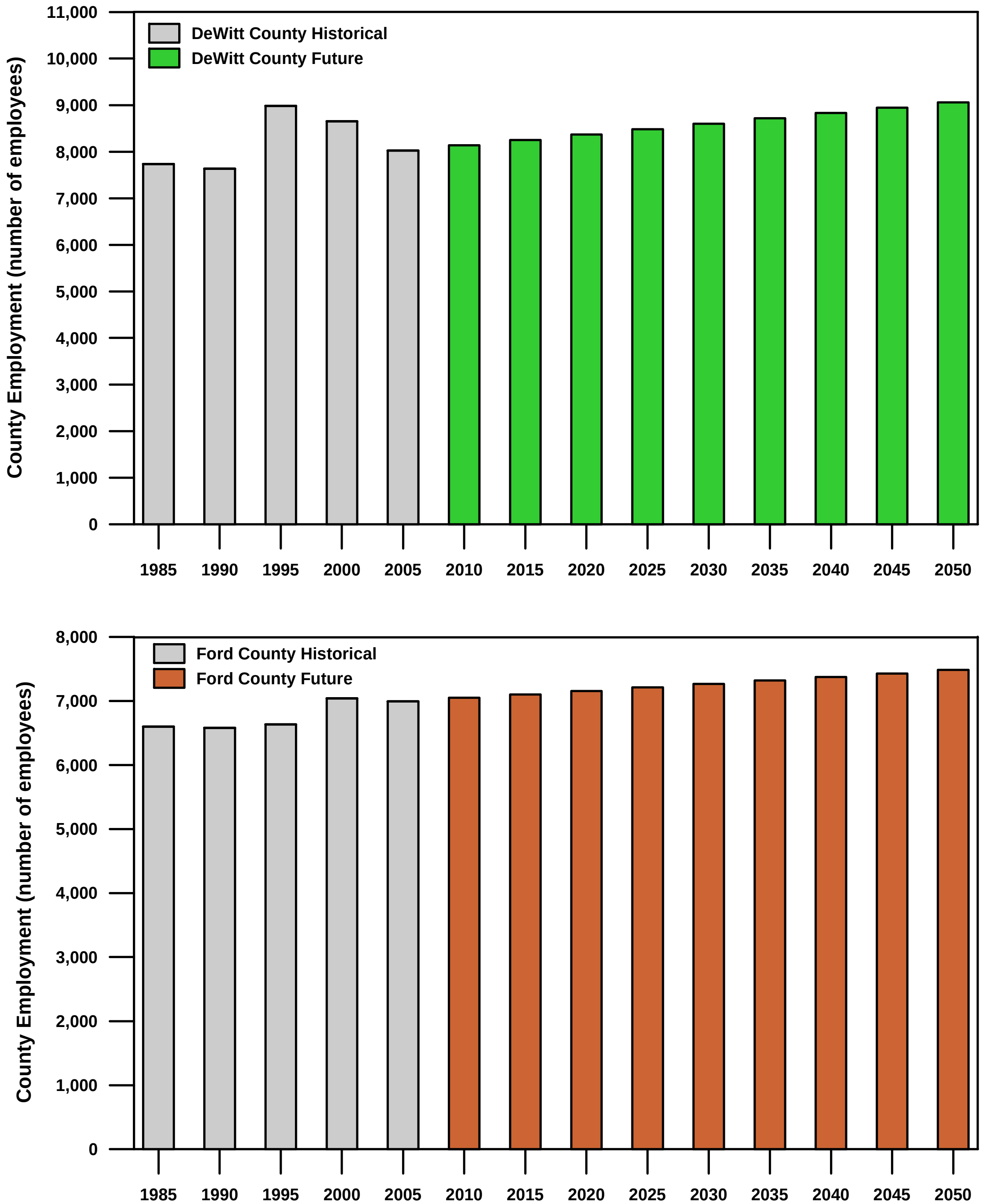


Figure 4.4: Historical and future employment populations for DeWitt and Ford counties in East-Central Illinois.

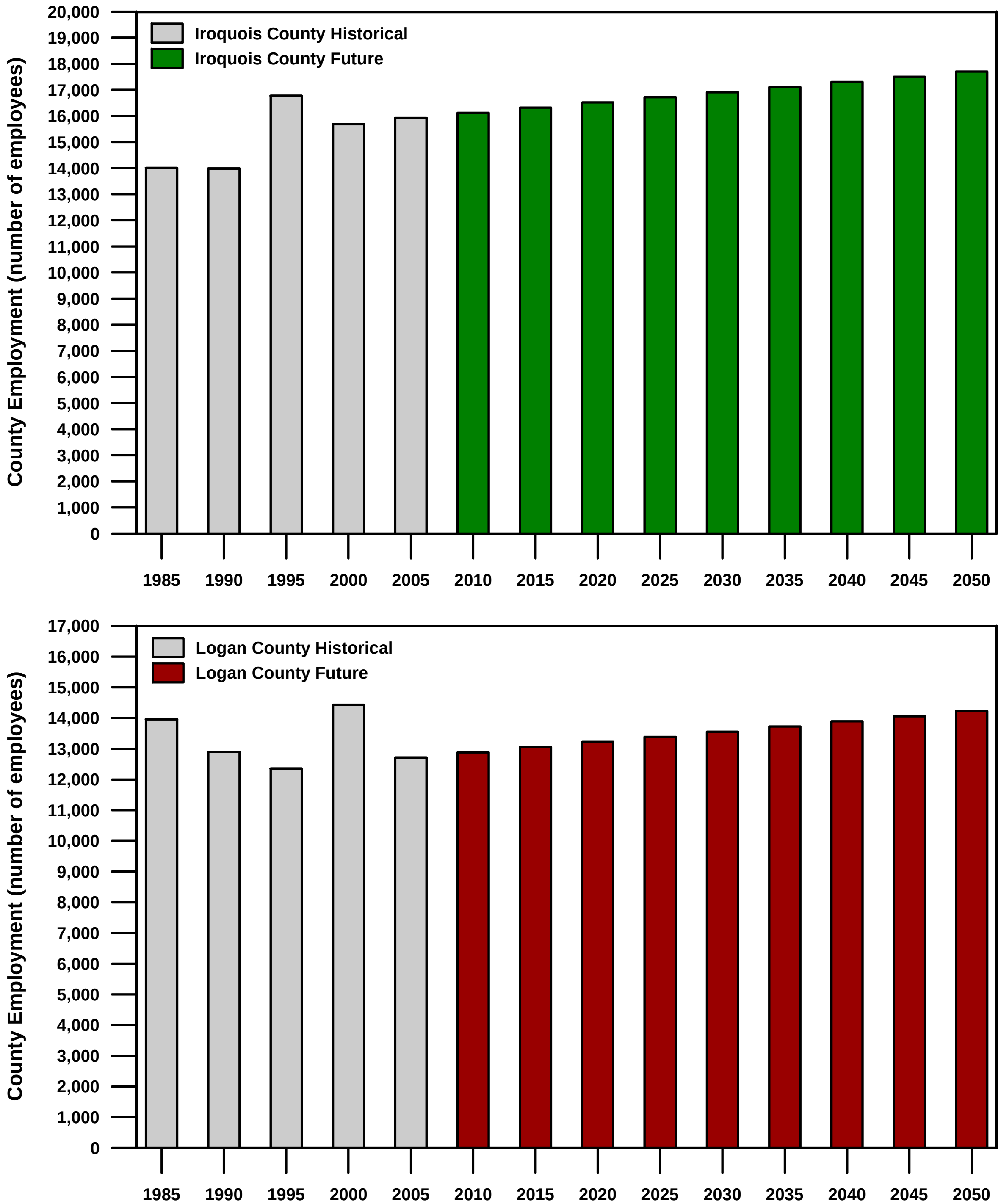


Figure 4.5: Historical and future employment populations for Iroquois and Logan counties in East-Central Illinois.

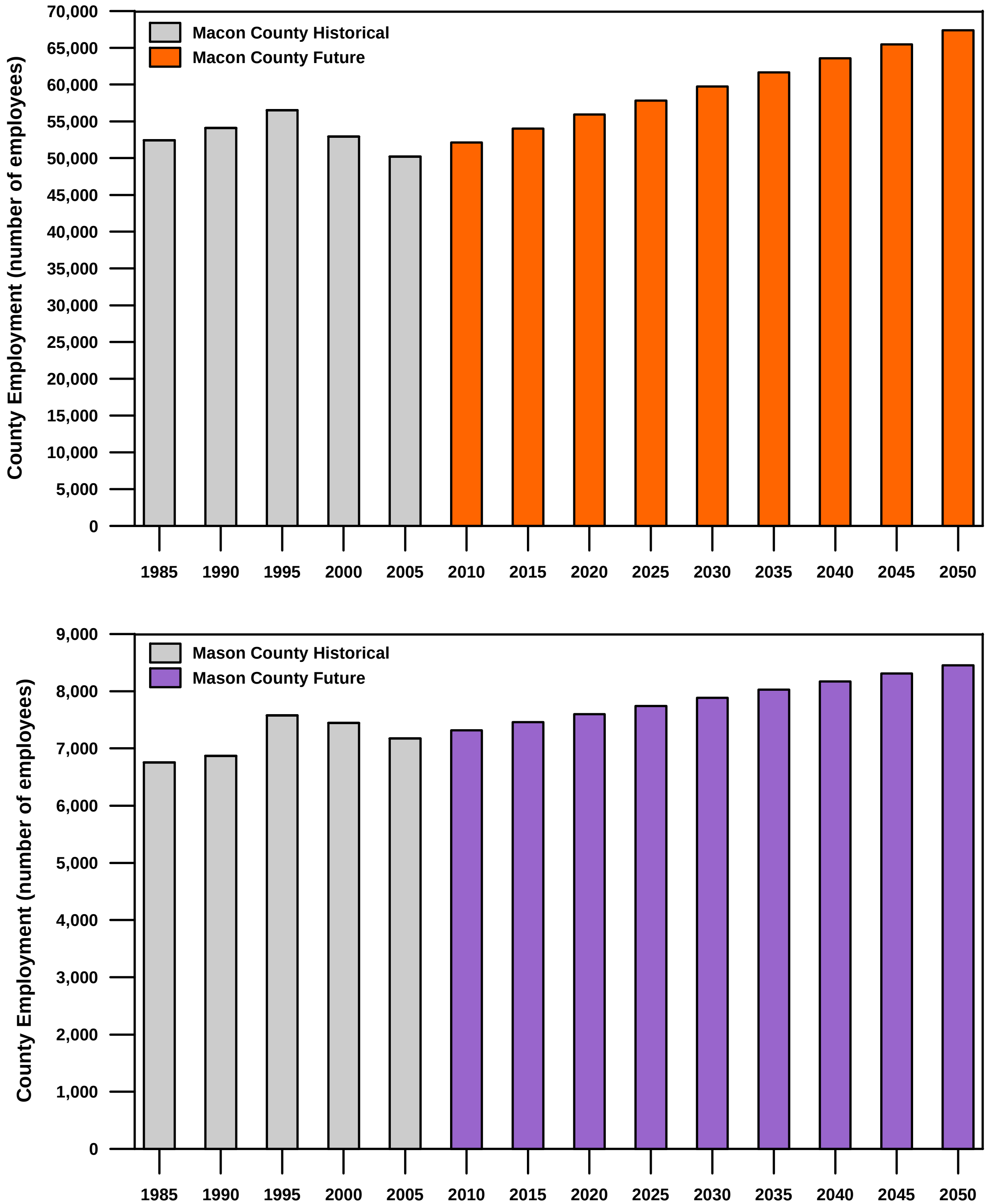


Figure 4.6: Historical and future employment populations for Macon and Mason counties in East-Central Illinois.

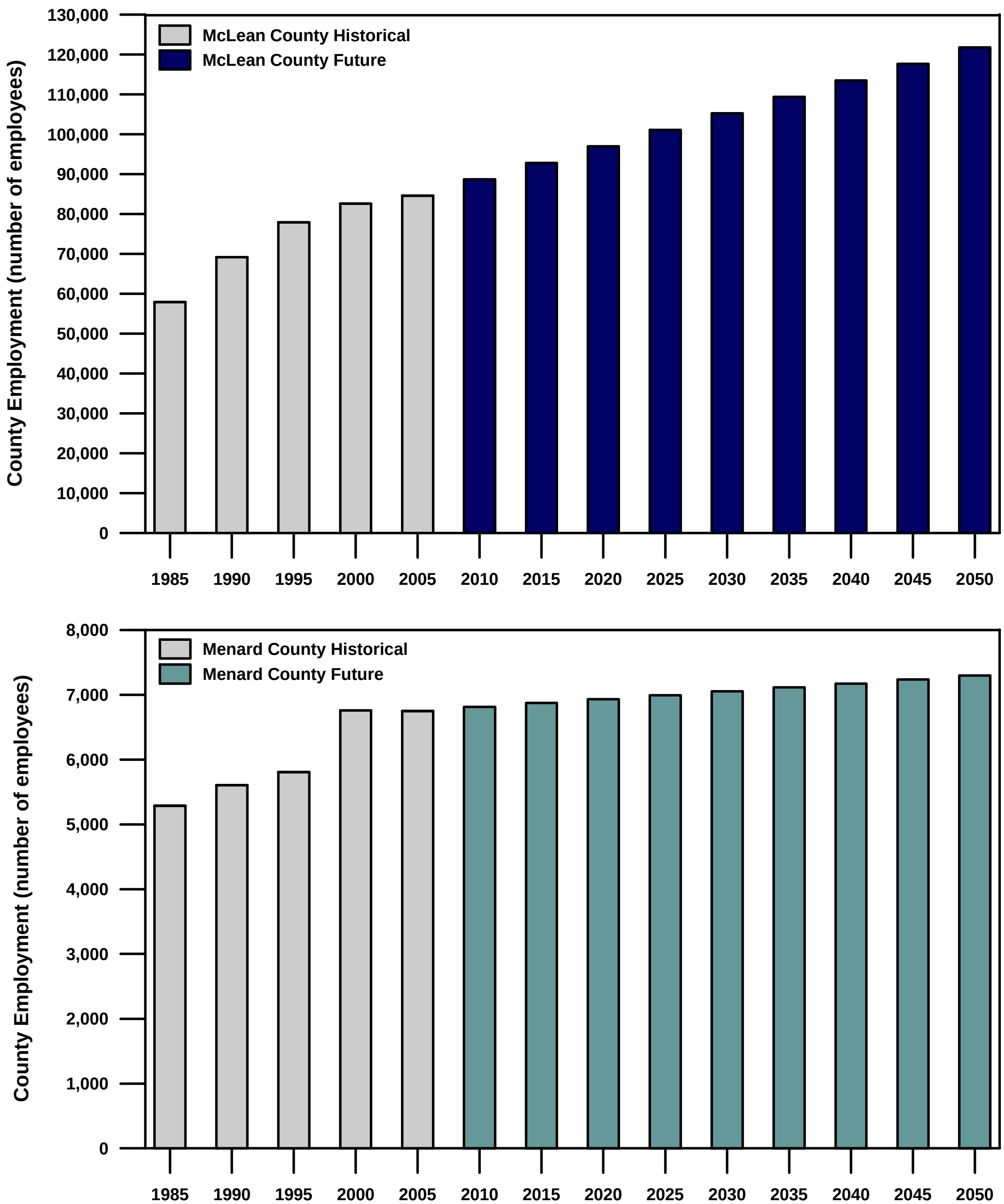


Figure 4.7: Historical and future employment populations for McLean and Menard counties in East-Central Illinois.

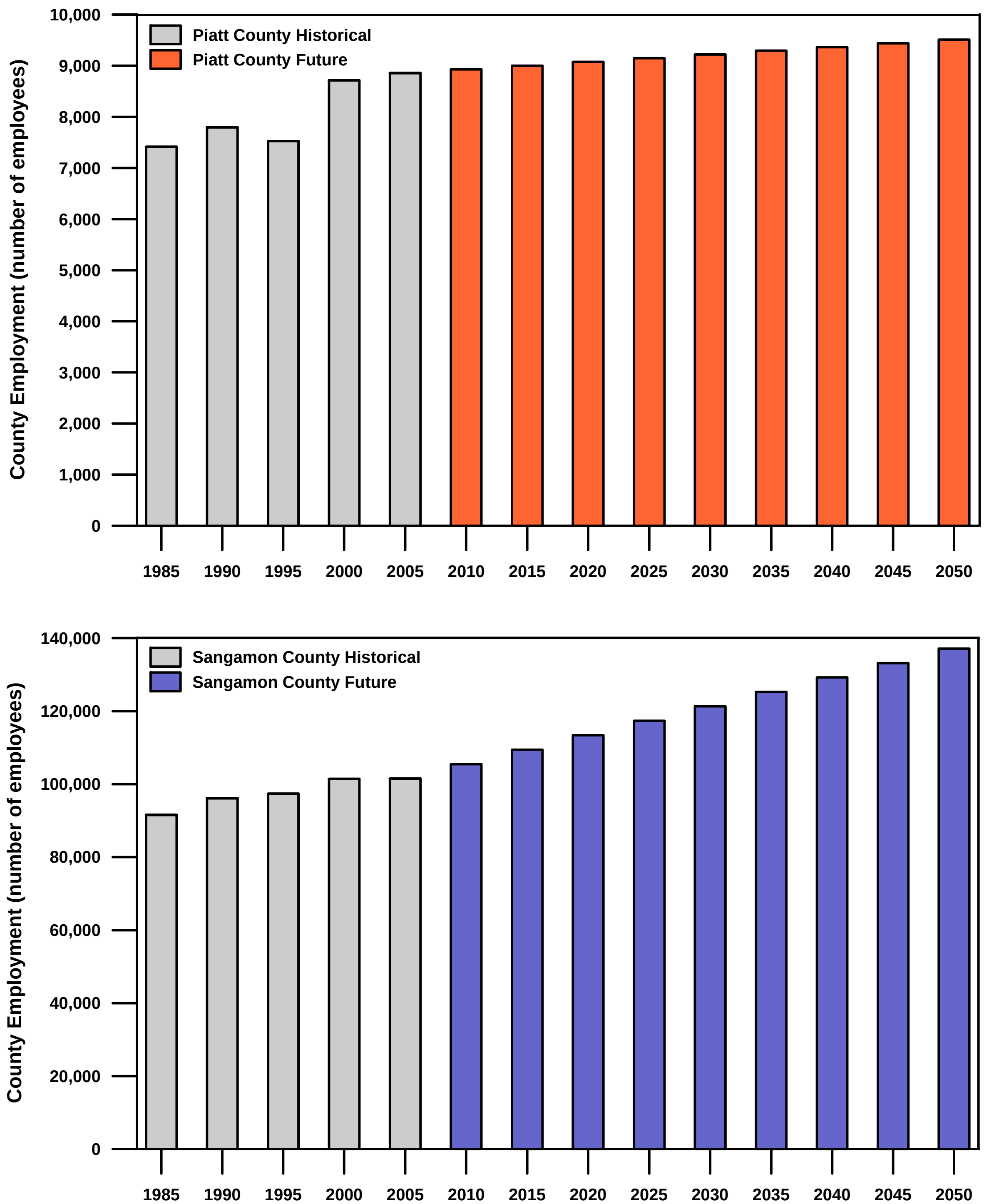


Figure 4.8: Historical and future employment populations for Piatt and Sangamon counties in East-Central Illinois.

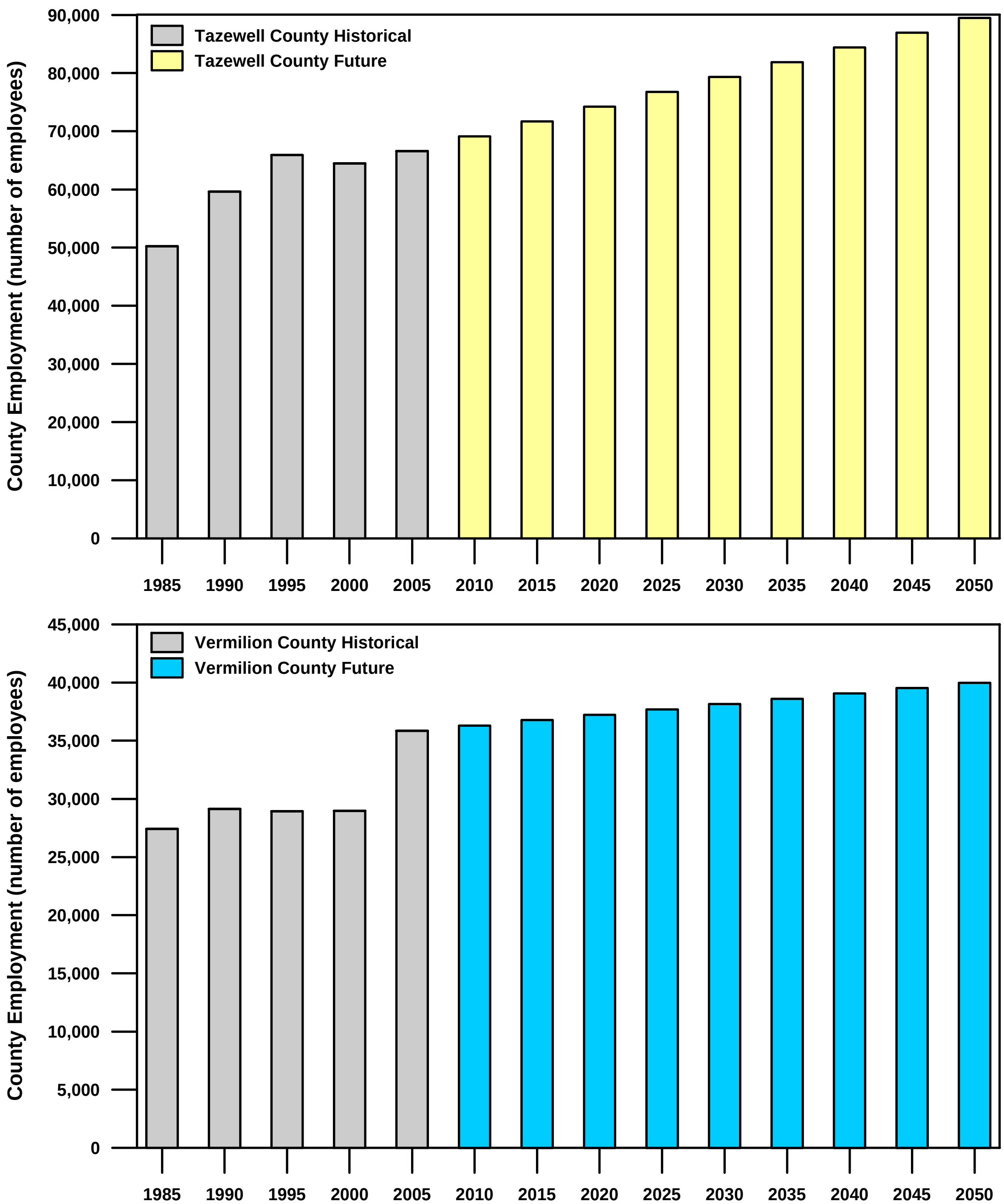


Figure 4.9: Historical and future employment populations for Tazewell and Vermilion counties in East-Central Illinois.

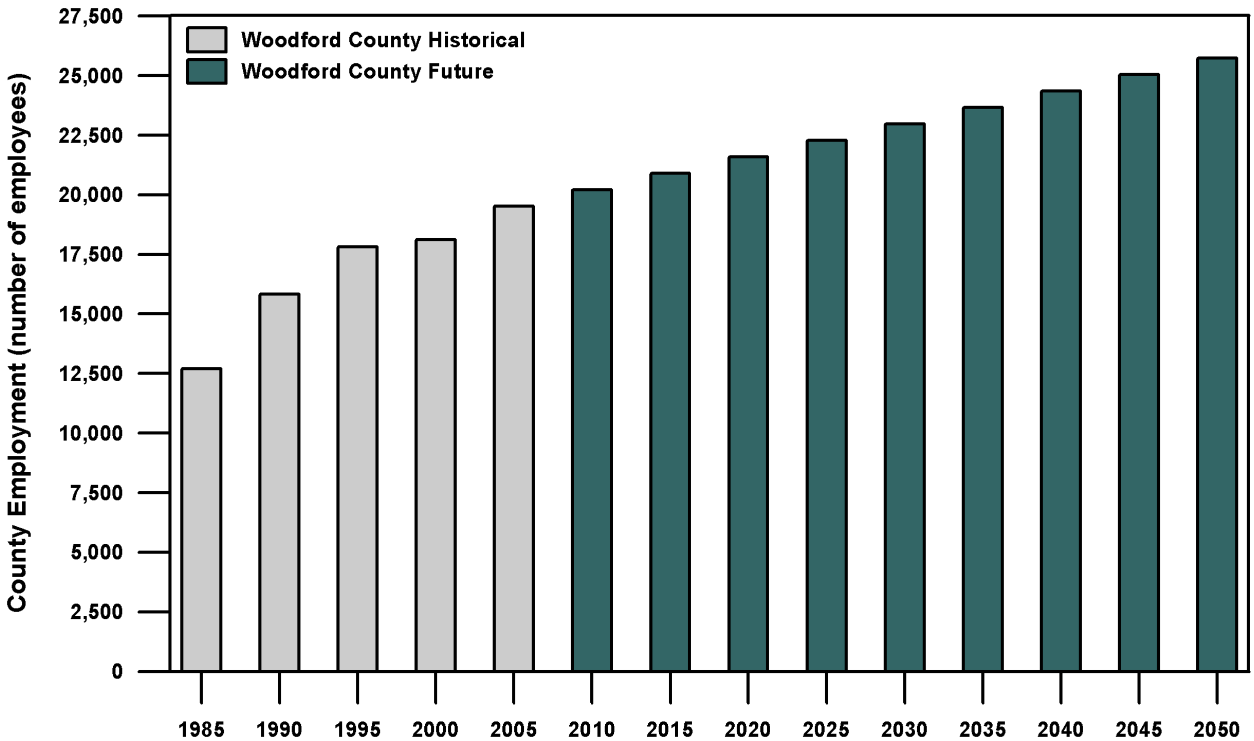


Figure 4.10: Historical and future employment populations for Woodford County in East-Central Illinois.

4.5.2.1 Weather variables - cooling degree days and precipitation

Some of the most important determinants of water demand are related to weather. Consequently, in order to estimate future water withdrawals, the weather variables (i.e., annual cooling degree days and summer precipitation) must also be estimated. Weather data may be dealt with in a variety of ways when looking into the future. One approach is to use the climatic normals, as calculated by the National Center for Climatic Data (NCDC), as future weather. Climatic normals are defined as the "statistical average over a time period usually consisting of three consecutive decades" [Owenby et al., 2006]. The current climatic normals are defined for the period 1971-2000. The averaging of the past weather data means that no inter-annual variation is taken into account in the water demand models. In effect, this assumes that the normal weather from the historical 30-year period will be similar to the future weather and can be used to estimate the future demand. On the one hand, this approach firmly connects the forecast to the historical record. On the other hand, by representing the future as the average of the 30-years of record we lose the extremes that cause much of the variation in demand (Figure 4.11).

A second method for estimating weather data in the future is to use stochastic models. Stochastic modeling would allow us to create a dataset of fictional weather data that is statistically the same as the historic data (i.e., the mean, mode, and median would be the same numbers in both the historical data and the future, fictional data). The statistical properties of the weather would vary the same in the future as it has in the past. But, again, this approach does not accurately predict water withdrawals for a given year due to the fictional weather.

It was decided by the ISWS and technical committee of the RWSPC that the demand models would use climatic normal data as the future weather variables because, although, it is understood that either method of estimating future weather variables may be inaccurate for any given year in the future, the climatic normal method was chosen so that the general trend of water demand could be understood. By using normal weather data in the future, the annual variation, as seen the historic reported withdrawals, is not seen in the future estimates but the overall average withdrawals may be estimated. Because normal climatic data were used in estimating future water withdrawals, for any given year in the future (or the past) the water demand estimates will not match the actual water withdrawn.

For these reasons, the future values of weather variables (i.e., annual cooling degree-days and summer precipitation) are assumed to be normal values, or the average values from 1971-2000. The cooling degree days and rainfall data is 1971-2000 normal data from each of the 29 stations within the 15-county region. The normal data vary for each county based upon the weather stations within the county. This means that the values used for each future year represent average values

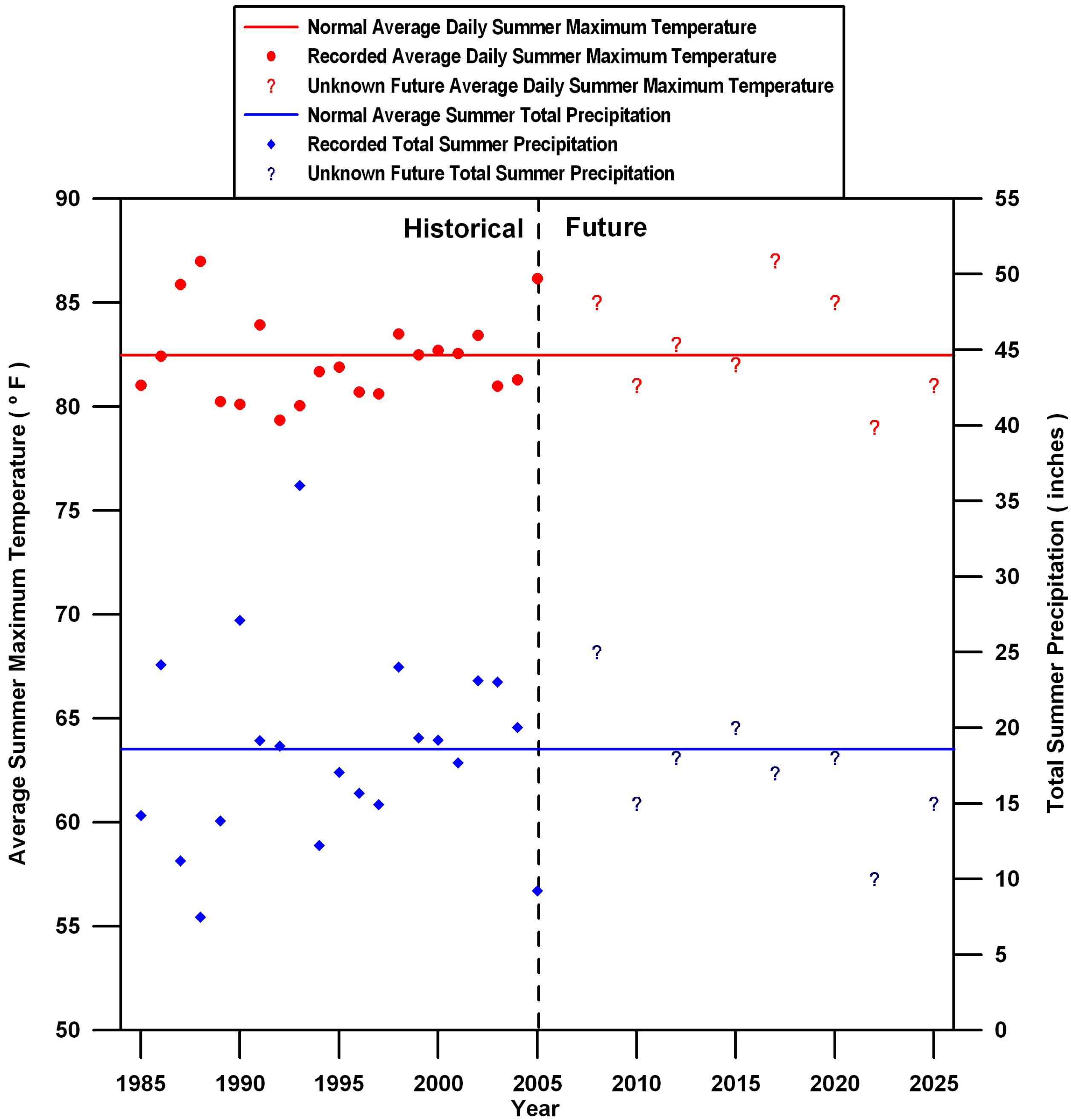


Figure 4.11: Example of inter-annual variation in temperature and precipitation compared to climatic normals.

from each of the weather stations for the 30-year period from 1971 to 2000. Higher or lower annual cooling degree days will result in higher or lower per employee water demand. Similarly, higher or lower total summer precipitation will result in lower or higher per employee water demand.

4.5.2.2 Percent health services, retail trade, and manufacturing employment

Future growth rates for employment in the three SIC/NAICS categories health services, retail trade, and manufacturing were obtained from IDES. The most recent projections are from 2004 - 2014. This study assumes that shares of each SIC/NAICS category will continues as projected by IDES to the year 2020. From 2025 through 2050 the growth rates in each category were linearly decreased by 25 percent. The growth rates were decreased due to uncertainty of extrapolating trends from 2014 out to 2050. Table 4.7 shows the IDES projected growth rates for the three employment categories.

4.5.2.3 Percent self-supplied commercial and industrial demand

Since the percentage fraction of self-supplied C&I water is used as one of the independent variables, the future values of the self-supplied share of water had to be determined. The historical fractions of the self-supplied C&I withdrawals are shown in Table 4.8.

The future values were assumed after examination of the historical shares of self-supplied withdrawals by comparing the historical averages for the entire data period 1985-2005 and the most recent period 1995-2005. The future shares of self-supplied withdrawals were set as rounded percentage (to the nearest 5 percent) of total C&I demand (i.e., the sum of both self-supplied and delivered by public systems). These assumed percentage fractions were also used in calculating self-supplied withdrawals from the future estimates of total C&I water demand.

4.5.2.4 Conservation trend

The conservation trend variable was included in the future to account for unspecified changes that are likely to influence water withdrawals over time, and that represent general trends in water conservation behavior. The conservation trend variable is intended to capture water demand changes due to gains in efficiency in production processes and technologies. The conservation trend variable was specified as 25 for 2010, 30 for 2015, 35 for 2020 and so on, ending with 65 for the year 2050.

Table 4.7: Projected 2004-2014 annual compound growth rates for health services, retail trade, and manufacturing employment.

County	Health services growth rate (%)	Retail trade growth rate (%)	Manufacturing growth rate (%)
Cass	1.85	0.22	-0.61
Champaign	1.41	0.29	-0.57
DeWitt	1.30	0.52	-0.10
Ford	1.26	0.04	-1.26
Iroquois	1.29	0.18	-1.01
Logan	1.59	0.10	-1.81
Macon	1.11	0.67	-0.19
Mason	1.88	0.20	-1.51
McLean	2.32	0.49	-2.28
Menard	1.81	0.18	-1.59
Piatt	1.21	0.00	-0.93
Sangamon	1.29	0.33	-0.97
Tazewell	2.19	0.52	-0.09
Vermilion	1.13	0.24	-0.78
Woodford	1.71	0.66	-0.50

Source: Illinois Department of Employment Security, Economic Information and Analysis Division, 2007. Note: in the model the growth rates were decreased by 25 percent from 2025 to 2050 due to the uncertainty of extrapolating the projections to 2050.

Table 4.8: Historical and assumed percent of self-supplied commercial and industrial withdrawals.

County	1985	1990	1995	2000	2005	Assumed 2010-2050
Cass	75.6	97.2	88.7	94.3	95.9	95.0
Champaign	56.3	65.1	57.6	48.0	49.5	50.0
DeWitt	2.5	5.4	0.1	0.1	0.0	5.0
Ford	11.2	6.4	66.8	86.0	87.2	90.0
Iroquois	28.8	32.3	20.7	24.5	6.9	25.0
Logan	3.8	13.6	4.4	8.6	74.7	75.0
Macon	89.5	70.6	78.0	74.9	76.4	80.0
Mason	97.9	98.8	97.6	98.9	98.2	95.0
McLean	16.4	1.9	3.8	0.3	0.5	15.0
Menard	0.0	0.0	0.0	0.0	0.0	5.0
Piatt	89.4	85.8	85.1	88.0	88.1	90.0
Sangamon	29.9	18.8	11.8	48.5	38.8	40.0
Tazewell	91.8	91.7	91.0	85.1	85.7	85.0
Vermilion	39.5	39.4	40.9	41.6	44.4	45.0
Woodford	1.6	2.7	2.9	1.0	0.0	5.0

Source: historical percent self-supplied calculated using data from Illinois Water Inventory Program, Illinois State Water Survey, 2007. 2010-2050 value assumed, using historical data as guidance.

4.6 Scenarios

The three scenarios define future conditions which would result in different levels of self-supplied C&I water demand. The specific assumptions used in each scenario are described below.

4.6.1 Water intensive facilities

C&I water withdrawals are anticipated to increase as new water intensive industries move into the East-Central Illinois region. In order to understand how estimated future demands will or will not be met by the existing supply, the future withdrawals need to be assigned to a specific withdrawal points. To account for new industries within the region at specific withdrawal points, ethanol facilities are used to represent new industrial users of water for the East-Central Illinois region. While ethanol production is currently the anticipated new water demand, it is understood by the authors that ethanol may not be the only new industrial user and may not reach the anticipated growth rate. In the 1990s peaking electric plants were the anticipated new water intensive industry. However, the electric peaking plants did not reach the anticipated maximum density. Ethanol production plants are the new electric peaking plants in that they are expected to be a booming industry yet their future is uncertain. Therefore, in this study, demands created by future ethanol facilities are used to understand how a new water demand may impact the region.

Water intensive facilities, such as ethanol production plants, are expected to increase total withdrawals throughout the East-Central Illinois region in the future. Ethanol use in automobiles in the United States increased from 1,630 million gallons in 2000 to 3,904 million gallons in 2005 [EIA, 2007]. Much of the ethanol used is produced in the Midwest. Already Illinois is ranked number three, behind Iowa and Nebraska, in ethanol facility capacity [Nebraska, 2007]. Based on 2006 survey results, ethanol plants use 2.65 - 6.10 gallons of fresh water to produce a gallon of ethanol [Wu, 2008]. The average of dry and wet mills were 3.45 and 3.92, respectively[Wu, 2008]. The ISWS and technical committee of the RWSPC assumed that 4.0 gallons of water per gallon of ethanol (gal/gal ethanol) produced for the baseline scenario, 3.0 gal/gal ethanol for the less resource intensive, and 5.0 gal/gal ethanol for more resource intensive. Because of the rapid growth and water withdrawals of these facilities and/or other similar industries, these withdrawals need to be accounted for in future scenarios.

There are currently three (3) ethanol facilities within the region. An additional 16 ethanol facilities have obtained air permits from the Illinois EPA. Since water withdrawal permits are not required in the State of Illinois, except for Lake Michigan, the air permits were used to determine the number of potential ethanol facilities and expansions of existing facilities within the region. In

Table 4.9: Existing and proposed water intensive industries (represented by ethanol production plants) included in the East-Central Illinois regional water demands.

County	City	Status	Permitted production (MGY)	Year included in study
Champaign	Champaign	proposed	125	2010
Cass	Beardstown	proposed	60	2015
Ford	Gibson City	proposed	118	2010
Iroquois	Gilman	proposed	118	2010
Logan	Hartsburg	proposed	110	2015
Macon	Decatur	existing	290	historical
Mason	Havana	proposed	115	2015
McLean	Chenoa	proposed	110	2015
Tazewell	Pekin	2 existing	190	historical
		2 expansions	165	2010
Vermilion	Danville	proposed	118	2010

MGY = million gallons per year of ethanol. Source: Illinois EPA Bureau of Air, 2007.

many instances the proposed facilities were located in the same town or very near one another, so only one ethanol plant was added per county if there were no existing facilities within the county. For each of the scenarios it was assumed that water withdrawals for a total of eight (8) new facilities would be added with four (4) new facilities by 2010 and four (4) additional facilities by 2015. Two (2) existing facilities are expected to expand their ethanol producing capacities (Figure 4.12 and Table 4.9). In 2010 estimated water withdrawals were included for the expansions in Tazewell County and new facilities in Champaign, Ford, Iroquois, and Vermilion counties; in 2015 water withdrawals were included for new facilities in Cass, Mason, McLean, and Logan counties.

4.6.2 Scenario 1 - Baseline (BL)

The baseline (BL) scenario defines future conditions in terms of recent trends in demand drivers and independent variables. The main demand driver is total county employment. The assumptions pertaining to the values of independent variables and other parameters are described below.

1. Total county employment will follow the 2004-2014 projection trends, which were obtained from IDES, until 2050.

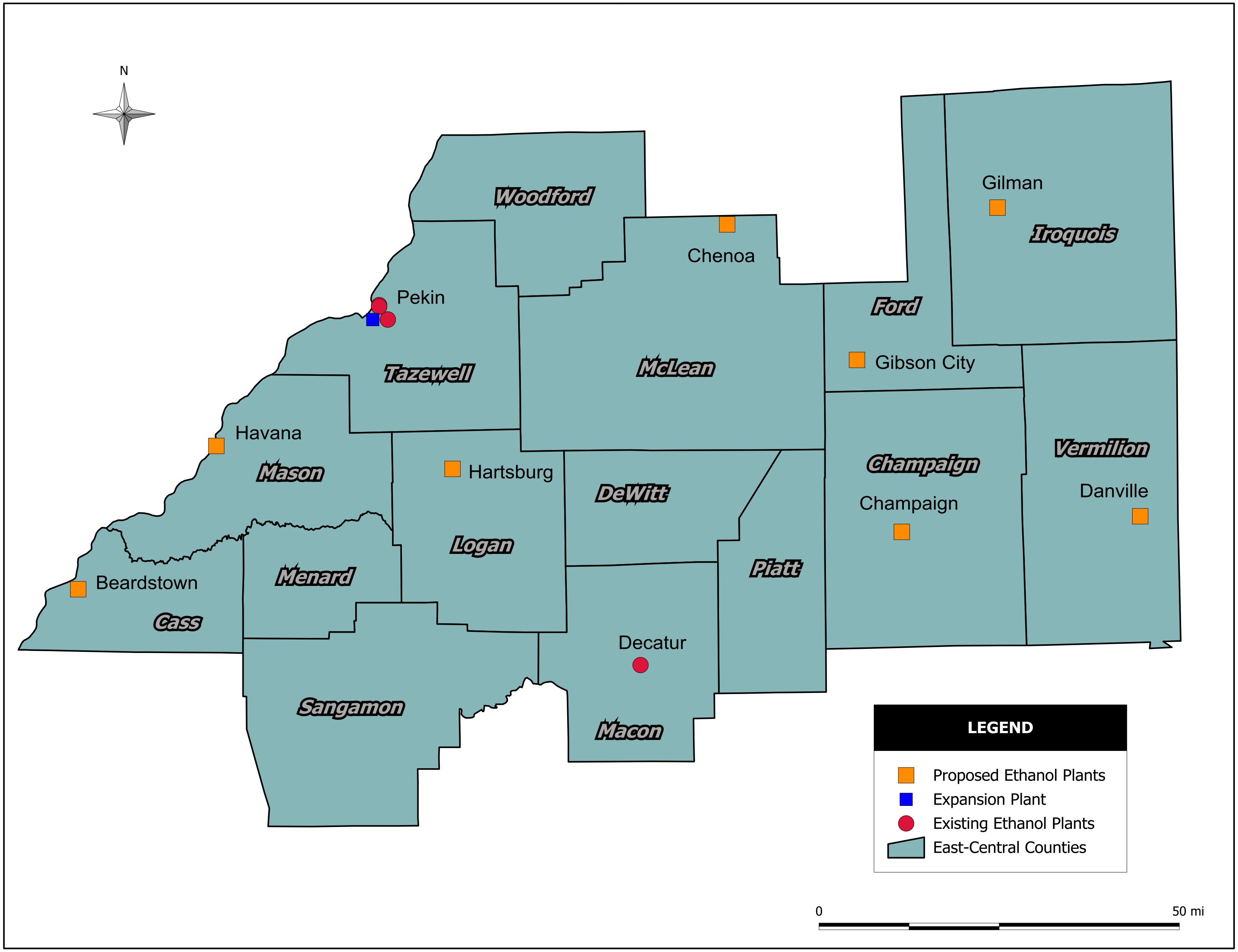


Figure 4.12: Existing and proposed water intensive industries in the East-Central Illinois region. *Note: Water intensive industries are represented by ethanol production facilities due to the need to tie water withdrawals to specific locations. Ethanol facilities were chosen as a surrogate because they are currently the most well-known and understood growing industry for this region.*

2. Fractions of employment in health services, retail trade, and manufacturing will follow growth rates, as projected by IDES, until 2020 (Table 4.7). From 2025 to 2050 the growth rates for each sector will linearly decline by 25 percent.
3. Self-supplied C&I water demand for each county will be the percentage levels shown in the last column of Table 4.8.
4. Future conservation will follow the estimated historical trend of annual reduction of approximately 0.2 MGD per year (when all other variables would be held constant).
5. Annual cooling degree-days and total May 1 to September 30 precipitation will remain at normal weather values.
6. New industrial facilities (represented by ethanol production plants) will use 4.0 gallons of water for each gallon produced.
7. Productivity will increase by 1.0 percent per year.

4.6.3 Scenario 2 - Less resource intensive (LRI)

The less resource intensive (LRI) scenario defines conditions which would result in lower self-supplied C&I water withdrawals. The specific assumptions pertaining to the values of independent variables and other parameters are described below.

1. Total county employment will follow the 2004-2014 projection trends, which were obtained from IDES, until 2050.
2. Fractions of employment in health services, retail trade, and manufacturing will follow growth rates, as projected by IDES, until 2020 (Table 4.7). From 2025 to 2050 the growth rates for each sector will linearly decline by 25 percent.
3. Self-supplied C&I water demand for each county will remain at the percentage levels shown in the last column in Table 4.8.
4. Future conservation will increase by 30 percent compared to the estimated historical trend.
5. Annual cooling degree-days and total May 1 to September 30 precipitation will remain at normal weather values.

6. New industrial facilities (represented by ethanol production plants) will use 3.0 gallons of water for each gallon produced.

7. Productivity will increase by 1.0 percent per year.

4.6.4 Scenario 3 - More resource intensive (MRI)

The more resource intensive (MRI) scenario defines conditions which would result in higher self-supplied C&I water withdrawals. The specific assumptions pertaining to the values of independent variables and other parameters are described below.

1. Total county employment will follow the 2004-2014 projection trends, which were obtained from IDES, until 2050.

2. Fractions of employment in health services, retail trade, and manufacturing will follow growth rates, as projected by IDES, until 2020 (Table 4.7). From 2025 to 2050 the growth rates for each sector will linearly decline by 25 percent.

3. Self-supplied water demand for each county will remain at the percentage levels shown in the last column in Table 4.8.

4. Future conservation will decrease by 50 percent compared to the estimated historical trend.

5. Annual cooling degree-days and total May 1 to September 30 precipitation will remain at normal weather values.

6. New industrial facilities (represented by ethanol production plants) will use 5.0 gallons of water for each gallon produced.

7. Productivity will increase by 1.0 percent per year.

4.7 Results

The estimated future water demands under each of the three scenarios for the entire 15-county study area are summarized in Tables 4.10, 4.11, and 4.12. Under the baseline scenario, self-supplied commercial and industrial (including mining) withdrawals are estimated to increase from 63.7 MGD in 2005 to 137.5 MGD in 2050. This represents an increase of 73.8 MGD or 116 percent. The total self-supplied withdrawals in 2050 will be 21.3 MGD (29%) lower under the

LRI scenario and 41.0 MGD (56%) higher under the MRI scenario as compared to the BL scenario results. Figure 4.13 shows the self-supplied withdrawal results for all three scenarios.

Figures 4.14–4.21 show the county results for the baseline scenario. Thirteen of the fifteen counties will withdrawal 10 MGD or less for self-supplied commercial and industrial uses by the year 2050. Macon and Tazewell counties will have the largest withdrawals for self-supplied C&I, withdrawing 27 and 62 MGD, respectively. Counties where new water intensive industries may locate will see an increase in water demand of approximately 1 MGD due to these new facilities. For Tazewell county, this increase is minimal compared to the overall expected growth in C&I water demands. For Iroquois and McLean counties almost all of their demand for estimated future self-supplied C&I withdrawals are created from new water intensive industries. However, currently, these two counties have virtually zero demand for self-supplied C&I. The regional summary (Chapter 7) will compare the self-supplied C&I withdrawals to other sectors.

4.7.1 Groundwater and surface water withdrawals

The data generated from this demand study will be delivered to the ISWS as digital data at the level of withdrawal points, meaning future water withdrawals will be determined for all existing wells and surface water intakes. The allocation of the future self-supplied C&I demands between groundwater and surface water withdrawals is generally assumed to remain at the 2005 level for each study area. The exception to the generalization is for those counties where additional industrial users were assumed to locate or expand: Cass, Champaign, Ford, Iroquois, Logan, Mason, McLean, Tazewell, and Vermilion counties. It is assumed that the new industrial facilities will use 100 percent groundwater and therefore, the percent groundwater used will increase and the percent surface water will decrease in those nine counties. Table 4.13 shows the estimated percentages of surface water and groundwater for each county. The withdrawal-point data for the commercial and industrial sector will not be available to the public due to confidentiality agreements and the proprietary nature of the data.

Table 4.10: Baseline scenario results for commercial and industrial sector for East-Central Illinois, 2005-2050.

Year	Per employee withdrawals (GPED)	Self-supplied C&I withdrawals (MGD)
2005 (Weather)	224.5	85.3
2005 (Normal)	170.4	63.7
2010	195.5	77.8
2015	208.9	87.9
2020	218.5	94.7
2025	227.3	101.4
2030	236.3	108.4
2035	245.2	115.7
2040	253.8	123.0
2045	261.7	130.4
2050	269.0	137.5
Difference from 2005 (Normal) to 2050		
Unit	98.6	73.8
Percent (%)	57.9	115.9

GPED = gallons per employee per day; MGD = million gallons per day.

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

Table 4.11: Less resource intensive scenario results for commercial and industrial sector for East-Central Illinois, 2005-2050.

Year	Per employee withdrawals (GPED)	Self-supplied C&I withdrawals (MGD)
2005 (Weather)	224.5	85.3
2005 (Normal)	170.4	63.7
2010	171.1	67.8
2015	181.1	75.7
2020	188.6	81.2
2025	195.5	86.7
2030	202.5	92.5
2035	209.5	98.4
2040	216.2	104.4
2045	222.4	110.4
2050	228.0	116.2
Difference from 2005 (Normal) to 2050		
Unit	57.6	52.5
Percent (%)	33.8	82.4

GPED = gallons per employee per day; MGD = million gallons per day.

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

Table 4.12: More resource intensive scenario results for commercial and industrial sector for East-Central Illinois, 2005-2050.

Year	Per employee withdrawals (GPED)	Self-supplied C&I withdrawals (MGD)
2005 (Weather)	224.5	85.3
2005 (Normal)	170.4	63.7
2010	240.4	94.0
2015	259.5	109.2
2020	273.8	118.6
2025	287.1	128.0
2030	300.5	137.8
2035	313.7	147.9
2040	326.5	158.2
2045	338.6	168.4
2050	349.6	178.5
Difference from 2005 (Normal) to 2050		
Unit	179.2	114.8
Percent (%)	105.2	180.2

GPED = gallons per employee per day; MGD = million gallons per day

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

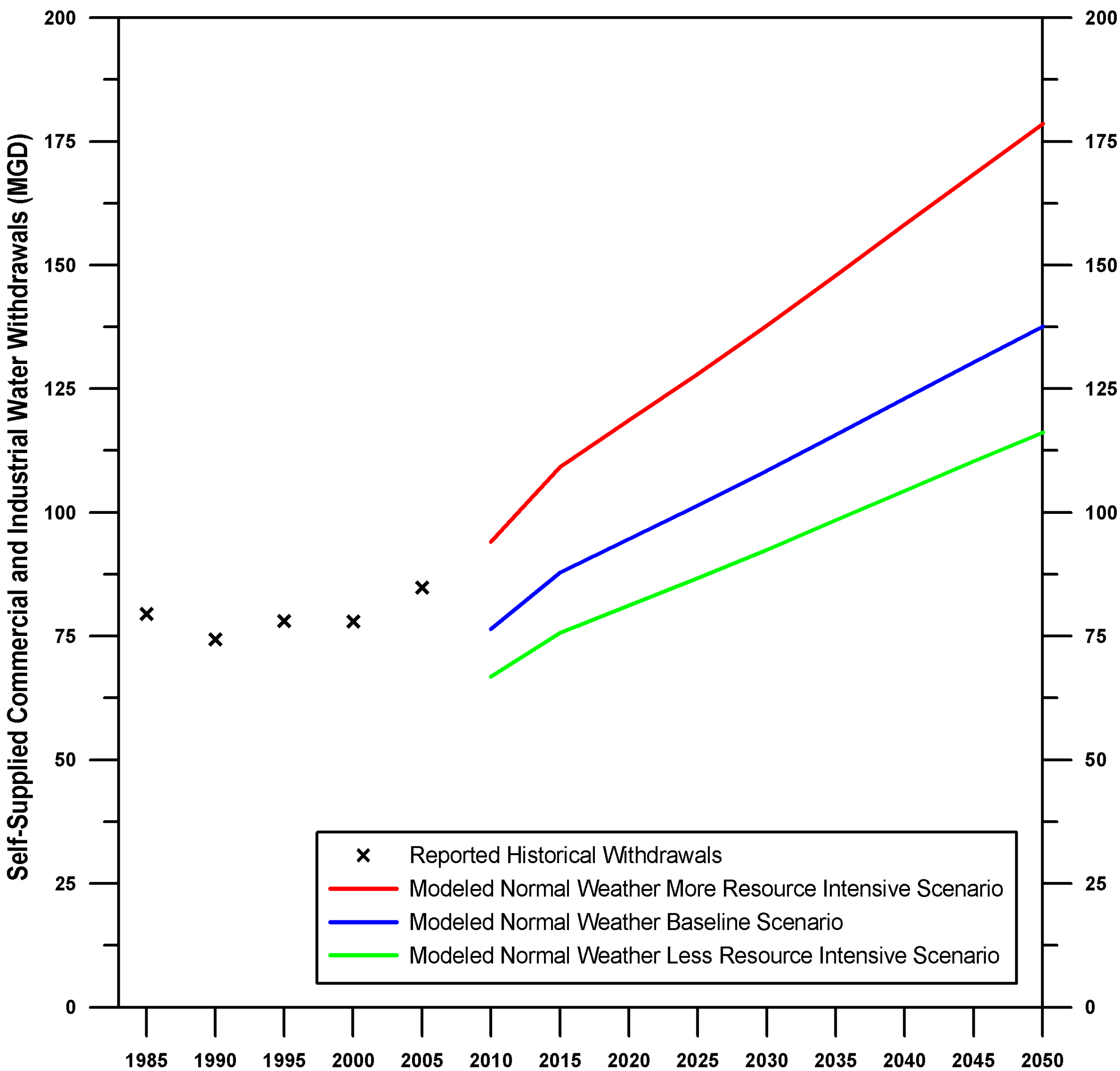


Figure 4.13: Historical and future self-supplied commercial and industrial withdrawals for the baseline scenario, the less resource intensive scenario, and the more resource intensive scenario for East-Central Illinois.

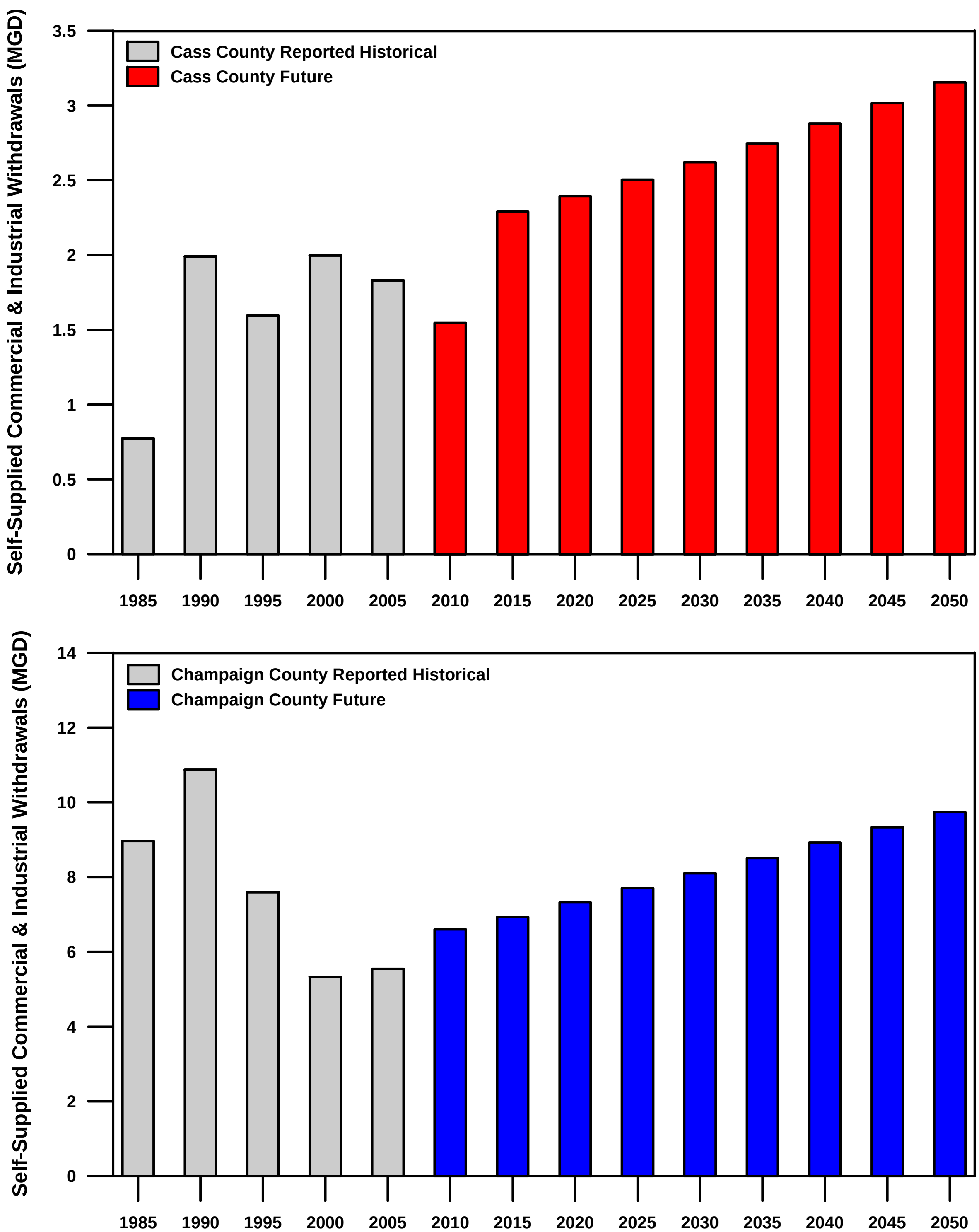


Figure 4.14: Self-supplied commercial and industrial historical and future water withdrawals for Cass and Champaign counties in East-Central Illinois. Note: New water intensive industry added in Champaign County in 2010 and in Cass County in 2015.

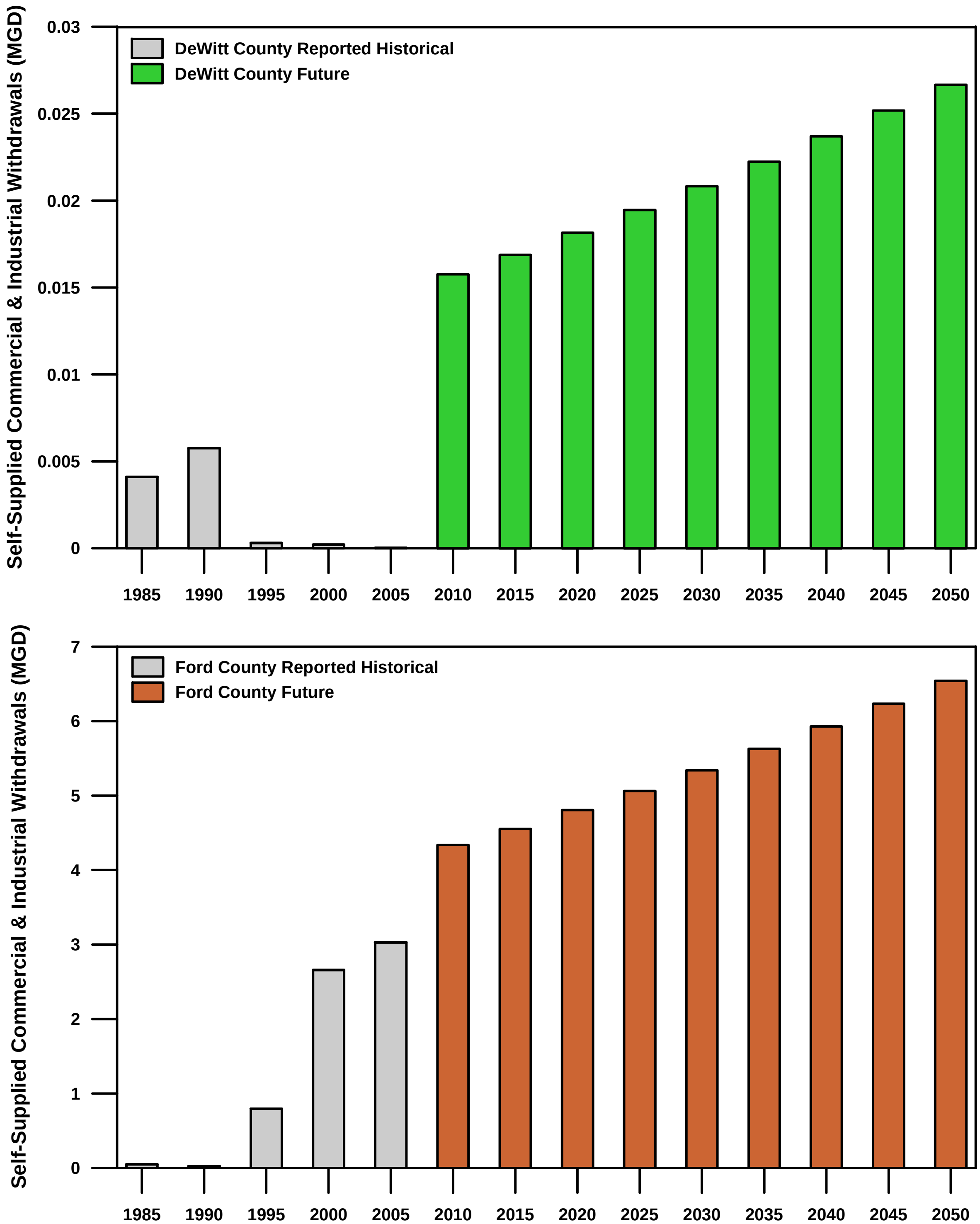


Figure 4.15: Self-supplied commercial and industrial historical and future water withdrawals for DeWitt and Ford counties in East-Central Illinois. Note: New water intensive industry added in Ford County in 2010.

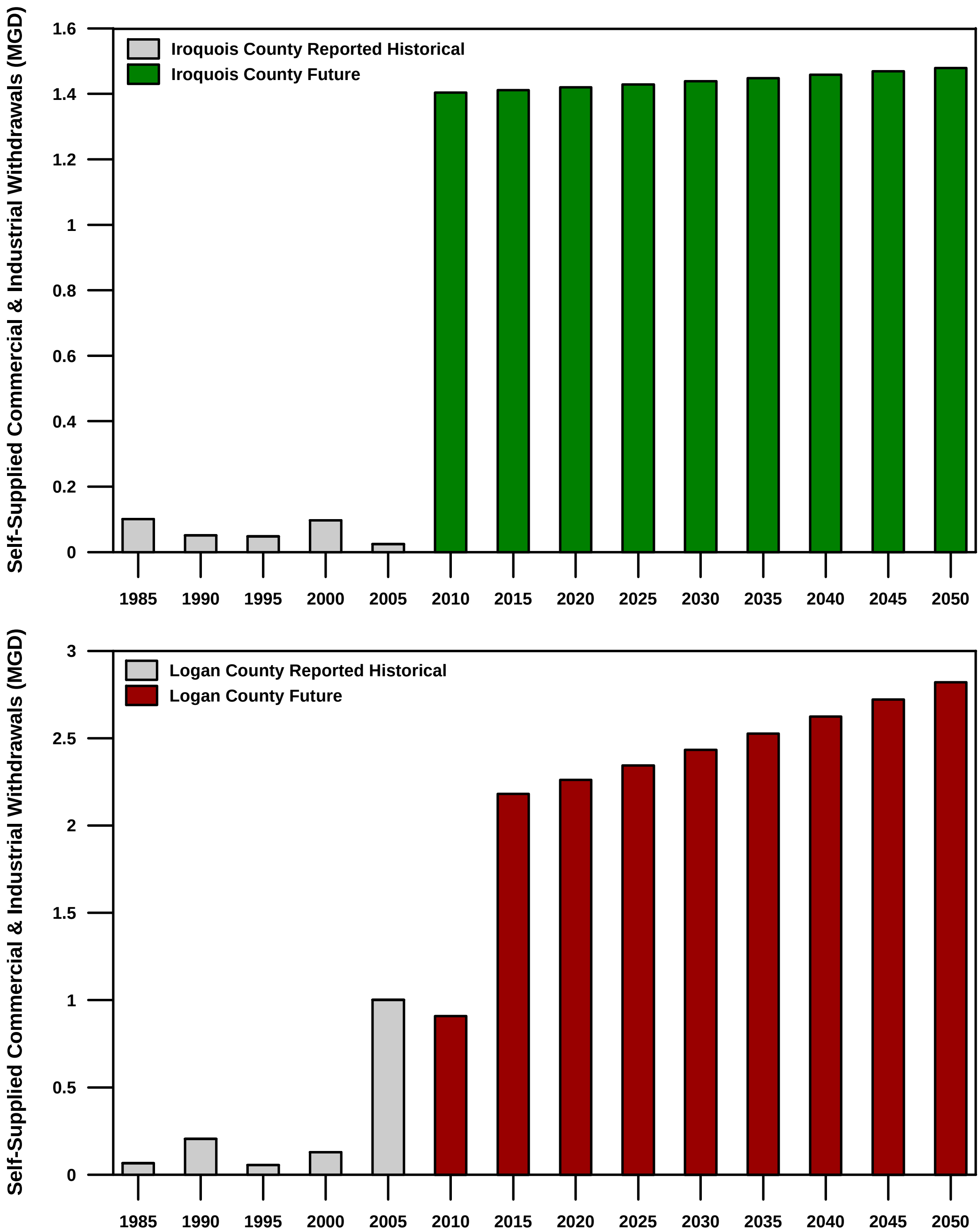


Figure 4.16: Self-supplied commercial and industrial historical and future water withdrawals for Iroquois and Logan counties in East-Central Illinois. Note: New water intensive industry added in Iroquois County in 2010 and in Logan County in 2015.

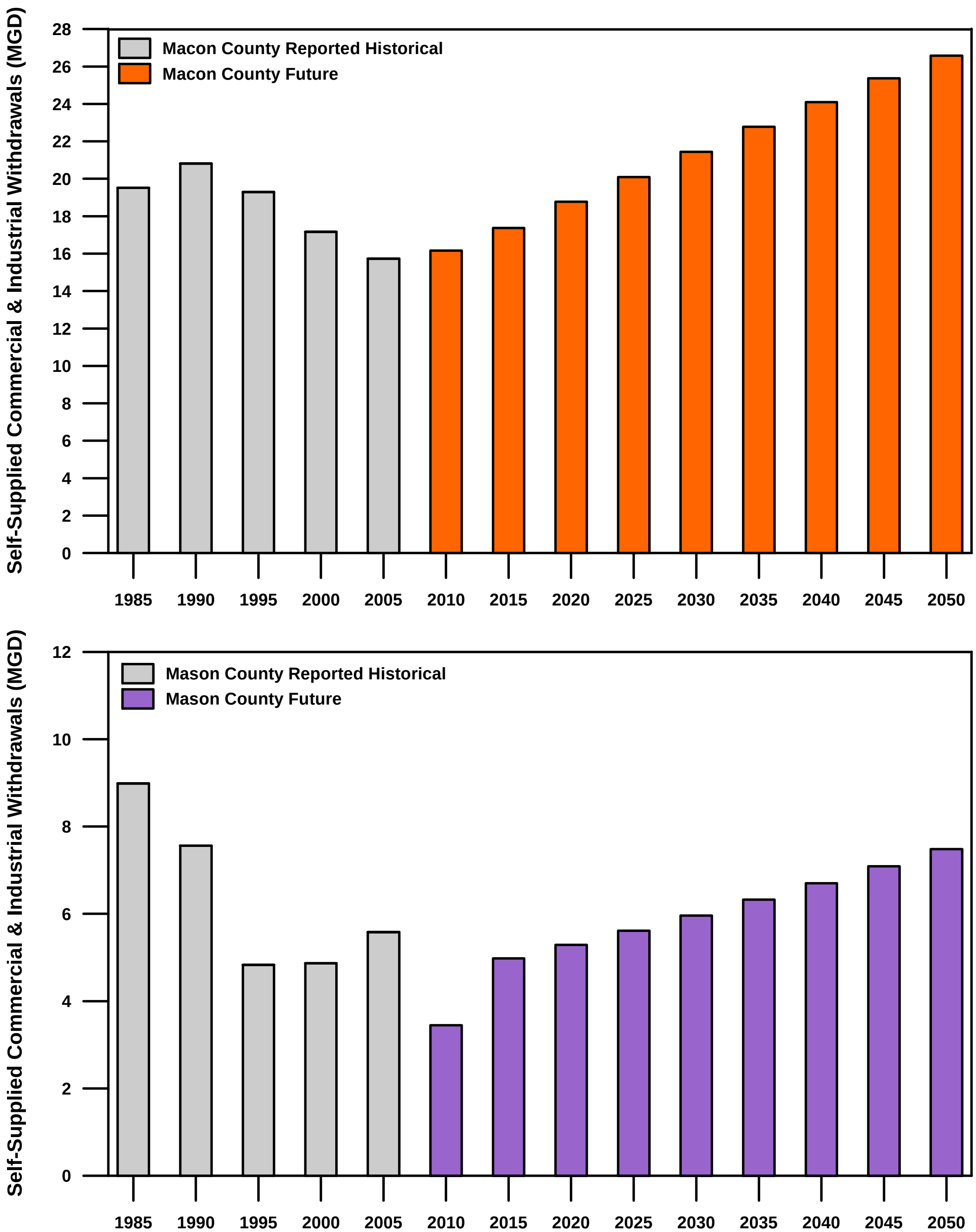


Figure 4.17: Self-supplied commercial and industrial historical and future water withdrawals for Macon and Mason counties in East-Central Illinois. *Note: 1985-2000 water withdrawals for Macon County has ADM withdrawals added; see Section 4.3.1 for explanation.* Note: New water intensive industry added in Mason County in 2015.

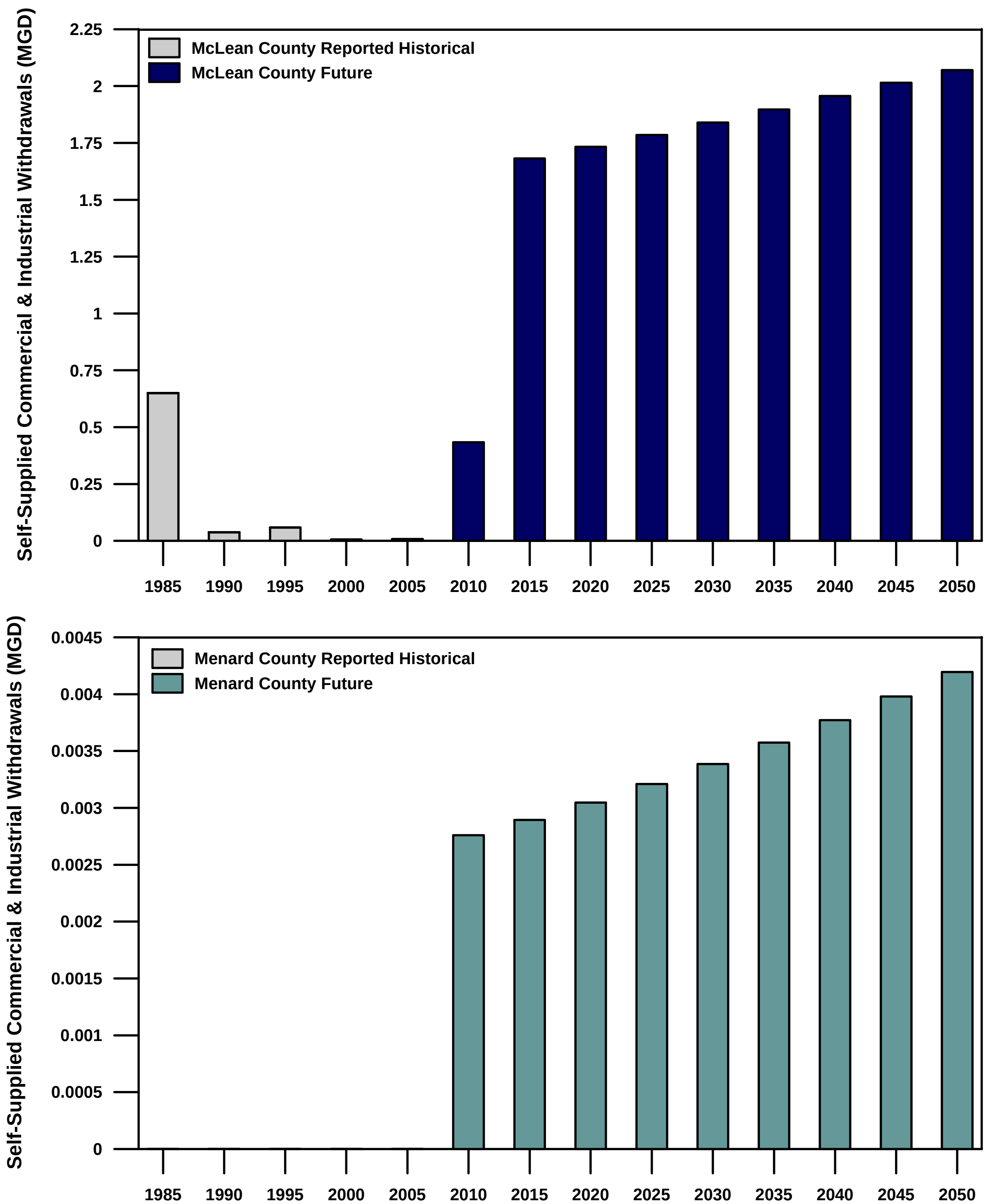


Figure 4.18: Self-supplied commercial and industrial historical and future water withdrawals for McLean and Menard counties in East-Central Illinois. Note: New water intensive industry added in McLean County in 2015.

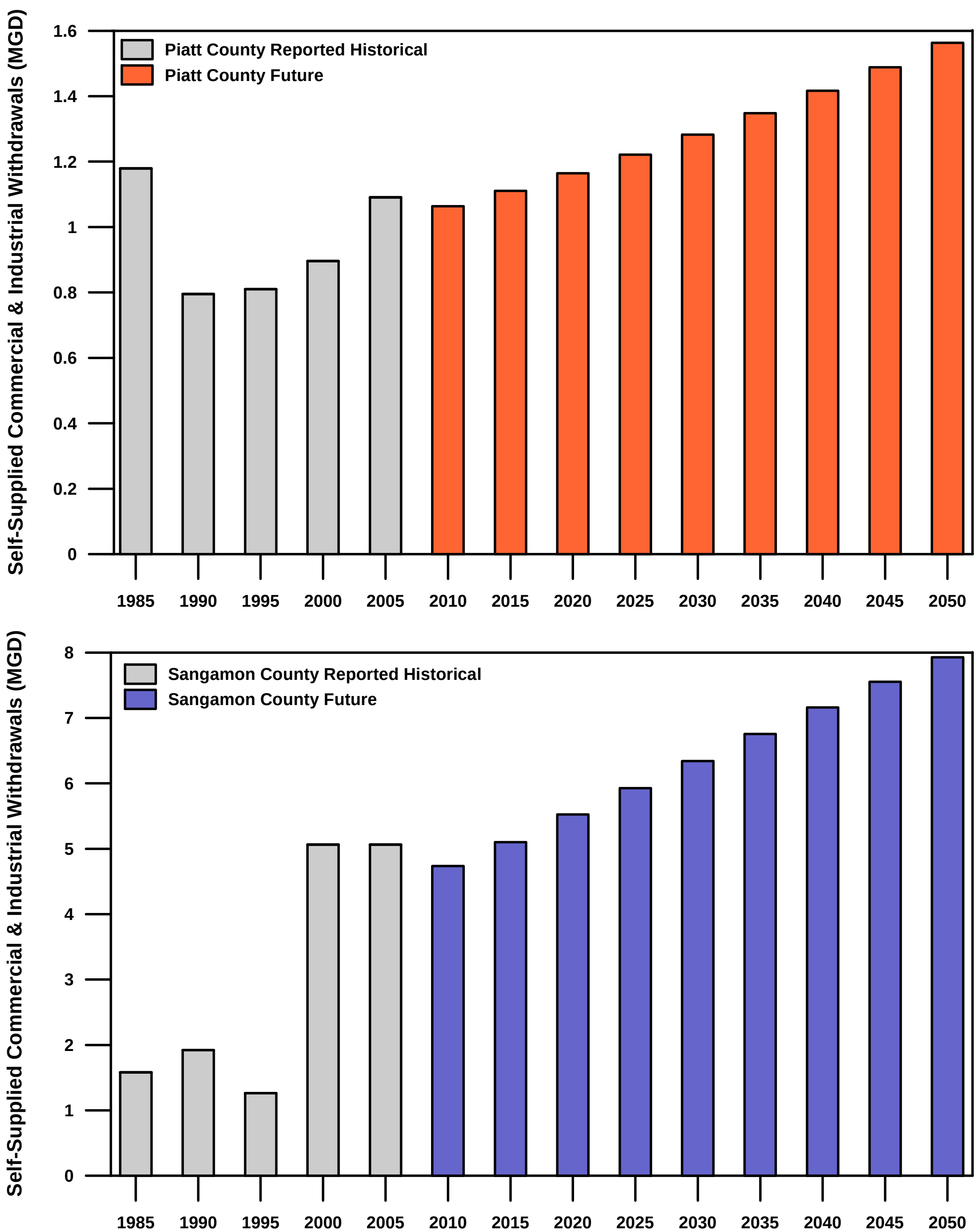


Figure 4.19: Self-supplied commercial and industrial historical and future water withdrawals for Piatt and Sangamon counties in East-Central Illinois.

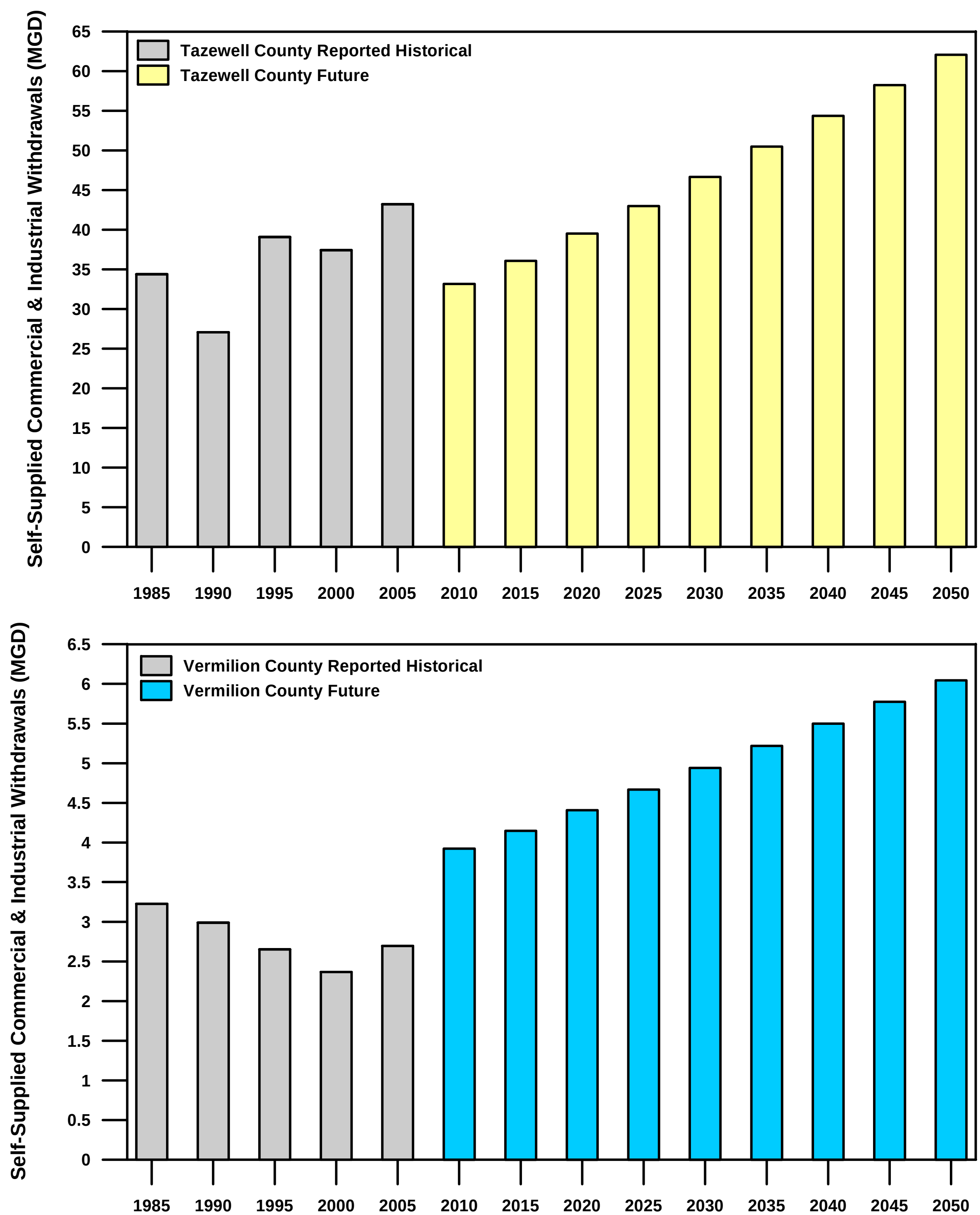


Figure 4.20: Self-supplied commercial and industrial historical and future water withdrawals for Tazewell and Vermilion counties in East-Central Illinois. Note: Expansion of water intensive industry added in Tazewell County in 2010 and new water intensive industry added in Vermilion County in 2010.

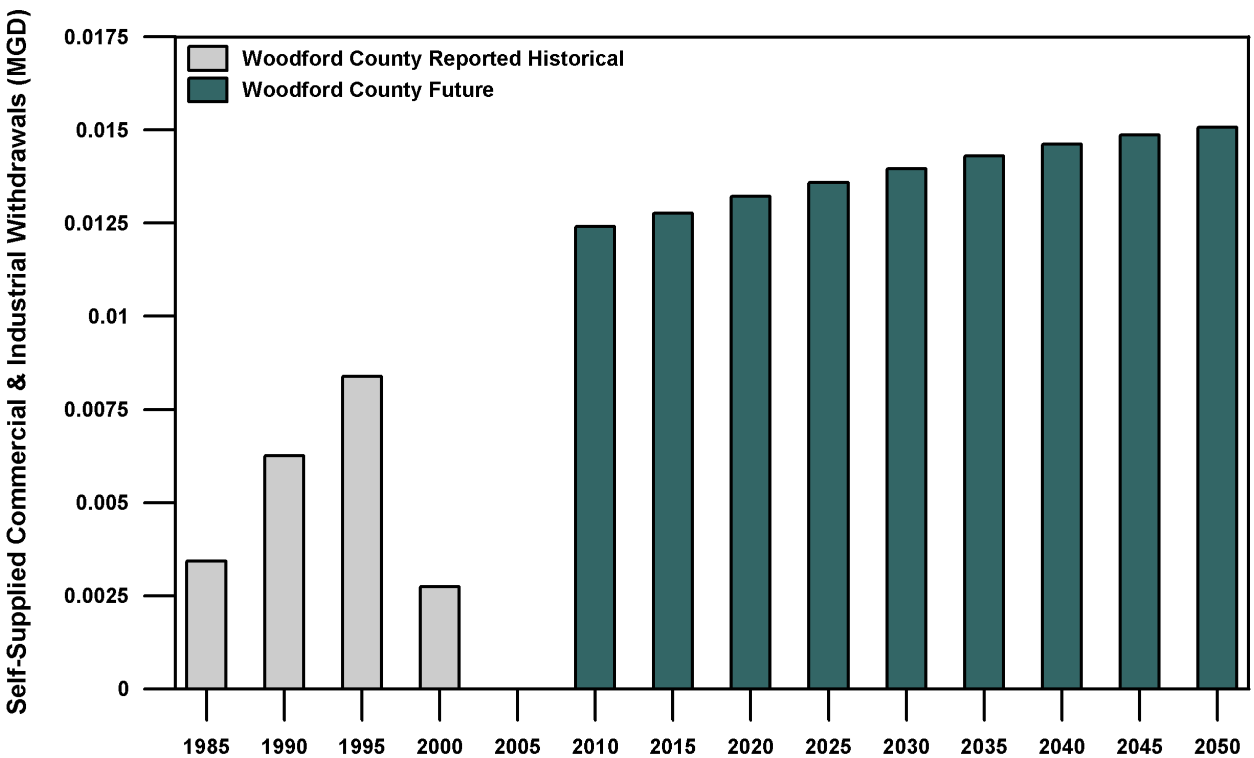


Figure 4.21: Self-supplied commercial and industrial historical and future water withdrawals for Woodford County in East-Central Illinois.

Table 4.13: Percent of total withdrawals that are groundwater and surface water.

County	Groundwater (%)	Surface Water (%)
Cass	100.0	0.0
Champaign	58.7	41.3
DeWitt	100.0	0.0
Ford	19.8	80.2
Iroquois	100.0	0.0
Logan	51.7	48.3
Macon	7.8	92.2
Mason	100.0	0.0
McLean	100.0	0.0
Menard	100.0	0.0
Piatt	100.0	0.0
Sangamon	79.8	20.2
Tazewell	38.3	61.7
Vermilion	100.0	0.0
Woodford	100.0	0.0

Source: Illinois Water Inventory Program, Illinois. State Water Survey, 2007.

Chapter 5

Self-supplied Irrigation and Agriculture (IR&AG)

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5.1 Background

Throughout the world, irrigation (water for agriculture, or growing crops) is one of the most important uses of water. Almost 60 percent of all the world's freshwater withdrawals go towards irrigation uses [USGS, 2005]. In the United States alone, withdrawals were an estimated 137,000 million gallons per day (MGD) in 2000. The majority of these withdrawals (86%) and irrigated acres (75%) were in the 17 contiguous Western States [USGS, 2005]. Irrigated acreage in these states were located in areas where average annual precipitation typically is less than 20 inches. In 2000, the state of Illinois was estimated to use less than 200 MGD for irrigation. In the East-Central Illinois Region, irrigation is important primarily in the western portion of the region where relatively sandy soils make irrigation economically beneficial.

The irrigation and agriculture (IR&AG) sector includes self-supplied water withdrawals for cropland and golf course irrigation as well as water for livestock. In the U. S. Geological Survey (USGS) inventories of water demand, the designation of irrigation water demand includes "all water artificially applied to farm and horticultural crops as well as self-supplied water withdrawal to irrigate public and private golf courses" [Solley et al., 1998]. The USGS inventories of agricultural livestock water withdrawals include water for animals, feedlots, dairies, fish farms, and other on-farm needs [Avery, 1999]. In East-Central Illinois livestock water withdrawals are small relative to irrigation withdrawals, usually less than 3% of the total withdrawals in this sector.

Irrigation represents a significant component of total water demand for this sector, especially in the counties with large proportions of land in irrigated cropland. Table 5.1 shows that in 2002 in the East-Central Illinois 15-county region 82.1 percent of the total land is cropland while only 2.4 percent of the total land is irrigated. In 2002, Mason County had the highest total (91,811 acres) and percentage (26.6%) of irrigated cropland in the East-Central Illinois study region [USDA, 2002]. While all 15 counties have over 65 percent of land that is cropland, only 3 counties have over 1 percent of irrigated land (Table 5.1). These three counties are Mason, Tazewell, and Cass counties. These counties are all located in the western part of the region along the Illinois River where the soils are relatively sandy and do not retain water like soils in the eastern part of the region.

This chapter first discusses the methodology and water withdrawals for livestock and then explains the methodology and water withdrawals for cropland irrigation and golf course irrigation. The final sections present the assumptions for both livestock and irrigation withdrawals for the three scenarios and results for each of the scenarios.

Table 5.1: Total land area, cropland, and irrigated cropland in East-Central Illinois counties in 2002.

County	Land area[a] (acres)	Harvested Cropland[b] (acres)	Harvested Cropland (%)	Irrigated cropland (acres)	Irrigated cropland (%)
Cass	240,576	166,247	69.1	12,250[b]	5.1
Champaign	637,958	559,248	87.7	5,049[b]	0.8
DeWitt	254,451	192,809	75.8	840[c]	0.4
Ford	310,976	276,567	88.9	688[b]	0.2
Iroquois	714,515	648,406	90.7	2,627[b]	0.4
Logan	395,610	342,890	86.7	1,591[b]	0.4
Macon	371,532	302,838	81.5	15[b]	0.0
Mason	344,922	259,687	75.3	91,811[b]	26.6
McLean	757,459	659,423	87.1	920[b]	0.1
Menard	201,120	139,523	69.4	2,098[b]	1.0
Piatt	281,613	251,066	89.2	451[b]	0.2
Sangamon	555,635	436,471	78.6	781[b]	0.1
Tazewell	415,270	301,970	72.7	30,748[b]	7.4
Vermilion	575,411	428,904	74.5	273[c]	0.1
Woodford	337,888	283,467	83.9	738[b]	0.2
Total	6,394,936	5,249,516	82.1	150,880	2.4

Sources: [a]http://quickfacts.census.gov/; [b]US Census of Agriculture (2002); [c]US Geological Survey (2005).

Table 5.2: Estimated amount of unit water demand by animal type per day.

Animal type	Estimated water demand (gallons per day per animal)
Dairy cattle	35.00
Beef cattle	12.00
Horses	12.00
Hogs	4.00
Sheep	2.00
Chickens	0.60

Source: Avery, 1999.

5.2 Livestock

The USGS inventories of agricultural livestock water withdrawals include water for animals, feedlots, dairies, fish farms, and other on-farm needs. The categories of livestock water withdrawals include water used to care for all cattle, sheep, goats, hogs, and poultry, including such animal specialties as horses [Avery, 1999].

Water withdrawals for livestock use were estimated using the USGS unit-use coefficient method. For this calculation, livestock water demand in each county is estimated by multiplying the total county population of each type of farm animal by an estimate of the amount of water consumed per animal. The USGS estimated daily demand of water by each animal type is shown in Table 5.2. These five animal types account for the majority of water use by livestock in the study area. The table shows that dairy cattle consume the most water of the five species listed; over twice the amount for beef cattle. This means that if a county has a large population of dairy cattle, the water withdrawals may be larger than a county with twice the number of beef cattle, horses, or hogs.

5.2.1 Livestock historical withdrawals

The historical number of livestock are reported by the U.S. Department of Agriculture in the Census of Agriculture (Ag Census). The Ag Census collects information on the number of livestock for each census year (1982, 1987, 1992, 1997, and 2002). Table 5.3 shows the reported number of livestock for beef cattle, dairy cows, hogs, horses, and sheep for 2002. Livestock data for all historical year is shown in Appendix E. In the East-Central Illinois study area only one fish hatchery exists and because the withdrawals in a hatchery are more akin to commercial & industrial use, the hatchery was included in the commercial and industrial sector of this study. Table 5.3 shows that hogs are the largest livestock population in the region; over six times the number of beef cattle, the next largest population. Dairy cows, the largest water user, has the smallest population in the region with 5,313. McLean County has the largest number of livestock in the region. The county has the largest population of sheep, dairy cow, and hogs. McLean County also has the third largest population of beef cattle. It should be noted that the USGS uses the Ag Census data (years 1982, 1987, 1992, 1997, and 2002) but calculates the water withdrawals for the year 1985, 1990, 1995, 2000, and 2005. This method assumes that the data change little between the census data and the published data.

The population of livestock shown in Table 5.3 were multiplied by the water use for each animal shown in Table 5.2. The resulting total historical withdrawals are shown in Table 5.4. The historical withdrawals for livestock are a minor withdrawal within the irrigation and agriculture sector; ranging from 4.20 - 6.14 MGD. Table 5.4 also shows that within the region, livestock withdrawals have decreased over the past 25 years approximately 2 MGD. This decrease may be due to the conversion of pasture to urban lands or croplands.

5.2.2 Future livestock water withdrawals

The process described in Section 5.2 was used to estimate the future water withdrawals for the region. The future livestock populations were generated based on the baseline rates of growth as projected by the U.S. Department of Agriculture Economic Research Service (USDA). The growth rates for livestock are national growth rates due to a lack of information specific to the region or even Illinois. Table 5.5 shows the livestock populations in 2050. Since growth rate data were limited, the growth rates for each animal type were decreased linearly by half from projected growth rates for the period 2010 to 2050. The projections for each animal for each future model year are provided in Appendix E. The estimated future water withdrawals for livestock based upon these numbers are provided in the results section of this chapter, Section 5.5 and in more detail in Appendix E.

5.3 Irrigation

Water withdrawals for irrigation were calculated using the Illinois State Water Survey (ISWS)/ USGS method of multiplying the number of irrigated acres times the annual rainfall deficit.

The demand for irrigation water is determined using the following formula:

Table 5.3: Estimated numbers of livestock in the East-Central Illinois study area in 2002.

County	Number of beef cattle	Number of dairy cows	Number of hogs	Number of horses	Number of sheep	Number of chickens
Cass	9,409	D	82,080	176	214	D
Champaign	5,062	D	21,158	522	371	3,772
DeWitt	3,591	D	22,107	228	111	536
Ford	5,675	12	29,874	93	296	D
Iroquois	18,682	1,007	32,137	514	908	D
Logan	6,037	D	80,755	188	458	237
Macon	3,584	D	6,397	346	189	214
Mason	6,225	D	13,521	216	357	106
McLean	10,282	2,840	92,321	759	2,179	503
Menard	5,400	109	30,859	206	115	285
Piatt	2,181	113	8,072	286	230	177
Sangamon	10,705	252	50,810	1,536	401	1,463
Tazewell	8,809	608	74,762	656	578	478
Vermilion	8,236	167	19,056	504	358	504
Woodford	6,958	205	82,337	358	1,387	D
Total	110,836	5,313	646,246	6,588	8,152	8,275

D = data withheld due to data disclosure limitations.

Source: U.S. Department of Agriculture Census (2002).

Table 5.4: USGS estimated water withdrawals (MGD) for livestock 1985-2005.

County	Withdrawals for livestock (MGD)				
	1985	1990	1995	2000	2005[a]
Cass	0.53	0.52	0.54	0.56	0.44
Champaign	0.28	0.27	0.21	0.16	0.15
DeWitt	0.12	0.10	0.07	0.06	0.13
Ford	0.25	0.26	0.25	0.22	0.19
Iroquois	0.63	0.56	0.57	0.47	0.40
Logan	0.44	0.47	0.48	0.44	0.40
Macon	0.16	0.14	0.14	0.09	0.07
Mason	0.25	0.19	0.27	0.23	0.13
McLean	0.67	0.64	0.55	0.60	0.61
Menard	0.38	0.34	0.33	0.22	0.19
Piatt	0.19	0.14	0.11	0.10	0.07
Sangamon	0.58	0.52	0.48	0.45	0.36
Tazewell	0.64	0.69	0.58	0.61	0.44
Vermilion	0.40	0.37	0.28	0.19	0.19
Woodford	0.62	0.59	0.58	0.46	0.43
Total	6.14	5.79	5.45	4.88	4.20

Source: U.S. Geological Survey, [a]2005 data are provisional.

MGD = million gallons per day.

Table 5.5: Estimated numbers of livestock in the East-Central Illinois study area in 2050.

County	Number of beef cattle	Number of dairy cows	Number of hogs	Number of horses	Number of sheep	Number of chickens
Cass	12,764	0	106,956	214	176	0
Champaign	6,867	0	27,570	522	371	3,772
DeWitt	4,871	0	28,807	228	111	536
Ford	7,699	18	38,928	93	296	0
Iroquois	25,344	1,541	41,877	514	908	0
Logan	8,190	0	105,229	188	458	237
Macon	4,862	0	8,336	346	189	214
Mason	8,445	0	17,619	216	357	106
McLean	13,948	4,346	120,300	759	2,179	503
Menard	7,326	167	40,211	206	115	285
Piatt	2,959	173	10,518	286	230	177
Sangamon	14,522	386	66,209	1,536	401	1,463
Tazewell	11,950	930	97,420	656	578	478
Vermilion	11,173	256	24,831	504	358	504
Woodford	9,439	314	107,291	358	1,387	0
Total	150,358	8,131	842,101	6,626	8,114	8,275

Source: U.S. Department of Agriculture Economic Research Service

$$Q_t = \frac{325,851}{12 \cdot 365} A_t \cdot d_t$$

Where:

Q_t= annual seasonal volume of irrigation water withdrawals in million gallons per day (MGD) in year t

A_t= irrigated land area in acres in year t

d_t= depth of water application in inches in year t,

the conversion factors represent: 325,851 gallons/acre-foot, 12 inches/foot, and 365 days/year.

The rainfall deficit is assumed to be the amount of water that is applied to cropland or golf courses to supplement precipitation in the growing season. The rainfall deficit is calculated according the ISWS/USGS method which is based on weekly precipitation records for the irrigation season from May 1 through August 31. The growing season for 2005 golf-course irrigation estimates was the second week in April to the end of September; for other historical years it was May 1 through August 31. Rainfall deficit is calculated by accumulating weekly deficits or surpluses over the consecutive weeks of the growing season for each county as follows:

1. If more than 1.25 inches of rain falls during the first week of the growing season, one-half the amount of rain exceeding 1.25 inches is added to the rain amount during the following week.

2. If less than 1.25 inches of rain falls during the first week, the difference between the actual rainfall and 1.25 inches is the rainfall deficit that is assumed to be the quantity of water, in inches, applied for irrigation that week.

3. For each subsequent week during the growing season, one-half of the cumulative rainfall during the previous week in excess of 1.25 inches is added to the rainfall amount for the week.

4. If the cumulative rainfall amount for a week is less than 1.25 inches, then the difference is the rainfall deficit that is assumed to be the quantity of water, in inches, applied for irrigation that week.

5. The rainfall deficits for each week are then summed to determine the total irrigation water demand for the growing season.

The rainfall deficit calculation can be expressed mathematically as follows:

If the total rainfall in the first week, r_1, is less than 1.25 inches, then

$$d_1 = r_1 - 1.25 \tag{5.1}$$

Where:

d_1= rainfall deficit in week 1.

If the total rainfall in the first week, r_1, is greater than 1.25 inches, then

$$d_1 = 0 \tag{5.2}$$

$$r_2^e = r_2 + ((r_1 - 1.25))/2 \tag{5.3}$$

$$d_2 = r_2^e - 1.25 \tag{5.4}$$

Where:

r_2^e = effective rainfall in week 2.

In week 2, again, the precipitation deficit will be 0 if r_2^e is greater than 1.25 inches, and the surplus will carry to the next week. The total seasonal rainfall deficit for 16 weeks (i.e., 4 months) is calculated as:

$$d_t = \sum_{i=1}^{16} d_i \tag{5.5}$$

Table 5.6 shows the historical values of calculated growing season rainfall deficit. The growing season in 2005 was generally drier than any of the other historical data years. Therefore, the 2005 rainfall deficits (calculated for the growing season) are generally higher than 1985-2000 historical data years.

5.3.1 Historical irrigation withdrawals

The amount of water applied for irrigation is a function of the number of acres of cropland and golf courses which are irrigated during the growing season. The data on irrigated cropland are collected and reported by the U.S. Department of Agriculture every five (5) years (1982, 1987, 1992, 1997, and 2002). Table 5.7 shows data from the four most recent censuses.

For Cass, Champaign, Mason, Menard, and Tazewell counties the Illinois Farm Service Agency

Table 5.6: Rainfall deficits in East-Central Illinois for 1985-2005 growing seasons.

County	Rainfall deficits (inches)				
	1985	1990	1995	2000	2005
Cass	9.29	4.43	10.04	8.63	15.31
Champaign	6.76	4.87	10.16	10.24	11.77
DeWitt	6.90	8.54	10.13	8.88	12.52
Ford	9.61	5.97	8.03	10.69	11.68
Iroquois	18.21	6.99	8.89	9.91	11.06
Logan	8.02	10.27	8.58	8.85	14.28
Macon	9.42	11.81	8.47	8.47	11.67
Mason	10.83	3.98	8.50	8.21	15.99
McLean	7.18	5.30	7.97	8.89	14.93
Menard	8.60	4.18	10.25	10.43	16.21
Piatt	7.54	5.14	9.35	8.88	11.68
Sangamon	8.60	4.18	10.25	10.43	13.60
Tazewell	8.46	2.53	10.66	12.23	14.50
Vermilion	8.60	5.28	9.26	9.34	10.90
Woodford	9.75	5.70	7.27	11.13	15.96

Source: 2005 data are provisional (USGS, 2007). All other values calculated from Illinois State Climatologist Office data.

Note: See Section 5.3.1
for discussion regarding difference between historical dates
of irrigated acres and historical dates of rainfall deficit.

collects data on irrigated cropland annually. However historical data was only available for 2007 from the Illinois Farm Service Agency. Therefore, in this report where tables or text are comparing all counties, the 2002 data are reported. For future estimates of irrigated acres, the 2007 data are used as the base year for the future estimates, if the data are available. If 2007 data are used, it is noted in the tables.

Table 5.7 shows inter-annual variation of irrigated cropland within a county. This variation may be attributed to one or a combination of the following factors.

- **Reporting.** The way farmers report irrigated acres may differ between different census years and individual farmers. Farmers within a county may report actual irrigated acres (the total number of acres actually irrigated) or potential irrigated acres (meaning the farmer reports the acreage as irrigated if he/she has the ability to irrigate, not if the acres actually were irrigated).

- **Precipitation.** In years of higher precipitation, when an irrigation system is not used, the farmer may not report the acres as irrigated, thus showing a decline in irrigated acres for that year. In some counties, such as Champaign County, there are growing seasons were irrigation is not needed because there is adequate precipitation throughout the growing season. The soils in the eastern portion of the study area are less sandy than soils on the western portion of the study area, which means the eastern farmers need less precipitation/irrigation water because the soils hold water (making it available for plant uptake) longer than soils in the western portion of the study area.

- **Irrigation system changes.** Between U.S. Agriculture Census reporting years, there may be some farmers who abandon an irrigation system(s) and other farmers who install an irrigation system(s). These changes in systems, and therefore acreage, may also account for some of the variability seen in the historical irrigated acres.

The historical data shown in Table 5.7 shows that Mason County has the largest number of irrigated acres (125,961 in 2007), this is over three times the acreage of the next largest irrigating county, Tazewell County (40,207 in 2007). Cass County has 17,774 acres, but the remaining counties all have less than 10,000 acres. Eight counties have less than 1,000 irrigated acres. This indicates that the irrigation water withdrawals in the East-Central Region will be focused in three counties, Mason, Tazewell, and Cass counties.

The 1982-2002 acreage shown in Table 5.7 was used in the USGS estimates of irrigation withdrawals. The USGS reported irrigation withdrawals every five years on the basis of rainfall deficits

Table 5.7: Irrigated cropland (in acres) in East-Central Illinois counties, 1987-2007.

County	Irrigated cropland (acres)				
	1987	1992	1997	2002	2007
Cass	2,424	7,787	8,746	12,250	17,774[b]
Champaign	1,957	8,175	6,092	5,049	6,542[b]
DeWitt	590[a]	630[a]	803	840[a]	–
Ford	300	1,515	693	688	–
Iroquois	1,221	1,175	4,424	2,627	–
Logan	270[a]	1,273	988	1,591	–
Macon	25	D	D	15	–
Mason	59,962	75,855	84,802	91,811	125,961[b]
McLean	958	D	961	920	–
Menard	340	936	927	2,098	2,933[b]
Piatt	111	220	255	451	–
Sangamon	229	335	394	781	–
Tazewell	16,390	22,625	30,487	30,748	40,207[b]
Vermilion	380	210	52	273[a]	–
Woodford	371	500[a]	319	738	–

D = data withheld due to data disclosure limitations. – = data not available.

Source: [a]U.S. Geological Survey; [b]Illinois Farm Service Agency;

all other data from U.S. Department of Agriculture Census.

and number of irrigated acres of cropland, as reported in the Ag Census. The USGS uses precipitation data from 1985, 1990, 1995, 2000, and 2005 and the reported irrigated acres from the Ag Census which is from 1982, 1987, 1992, 1997, and 2002. Therefore in this report, the historical water withdrawals are reported for 1985, 1990, 1995, 2000, and 2005 while the irrigated acres are reported for 1982, 1987, 1992, 1997, and 2002. The underlying assumption in this method is that the irrigated acres do not vary significantly in the three years between the Ag Census, where acreage is reported, and the USGS withdrawals estimation.

During 1985-2000, the USGS reported estimates included golf-course irrigation. For 2005, golf-course irrigation is reported separately from agricultural irrigation by the USGS. For 1982-2000 golf-course irrigation, irrigated acres were estimated by the USGS on the basis of length of the course and average width of a course.

Table 5.8 shows the reported irrigation withdrawals for 1985-2005. These historical data were obtained from published USGS reports with the exception of the withdrawals for Mason and Tazewell counties. The withdrawals for 1990, 1995, 2000, and 2005 for Mason and Tazewell counties were estimated from data obtained from the Imperial Valley Water Authority. The Imperial Valley Water Authority collects information on the number of irrigation systems and the amount of electricity used by all irrigation systems in the water authority. The estimated gallons used are based on the number of accounts, the kilowatt hours (KWh) used by irrigators using power from Menard Electric Coop, and the total number of systems listed on the irrigation plat map supplied by Central Illinois Irrigated Growers Association.

The data in Table 5.8 show what we expected, that Mason, Tazewell, and Cass counties had the largest withdrawals. Mason County, alone, withdrew over 68% of the total withdrawals in every historical data year. The only other counties that have over 2 MGD are Champaign, Iroquois, and Menard counties.

Table 5.8 also shows that the 2005 reported water withdrawals are generally higher than other historical years. This is, in part, due to the drier growing season than other historical years. In fact, the irrigation and agricultural withdrawal estimates for the drought scenario (Chapter 6) closely approximate the 2005 historical withdrawals.

5.3.2 Future irrigated acres

The number of future irrigated acres includes both cropland and golf course acres that are irrigated. The estimates of irrigated cropland and golf course acres are discussed below.

Table 5.8: Irrigation water withdrawals (MGD) in East-Central Illinois for 1985-2005.

County	Water withdrawals for agriculture irrigation (MGD)				
	1985	1990	1995	2000	2005[a]
Cass	0.37	1.29	5.28	4.56	16.40
Champaign	0.13	0.81	5.32	4.50	4.93
DeWitt	0.00	0.13	0.38	0.52	0.79
Ford	0.04	0.09	0.62	0.48	0.71
Iroquois	0.46	0.19	0.73	2.45	2.20
Logan	0.00	0.06	0.64	0.65	1.72
Macon	0.00	0.02	0.26	0.18	0.30
Mason	24.64	34.62[b]	62.09[b]	67.61[b]	159.64[b]
McLean	0.16	0.06	0.26	0.75	1.51
Menard	0.00	0.11	0.52	0.52	2.61
Piatt	0.00	0.13	0.15	0.12	0.41
Sangamon	0.06	0.07	0.49	0.39	1.29
Tazewell	5.54	7.91[b]	14.19[b]	15.45[b]	36.82[b]
Vermilion	0.00	0.00	0.25	0.18	0.24
Woodford	0.25	0.11	0.26	0.24	1.03
Total	31.65	45.60	91.44	98.60	230.6

MGD = million gallons per day. Sources: U.S. Geological Survey; [a] 2005 is provisional data. [b]Mason and Tazewell counties 1990, 1995, 2000 and 2005 data are from Imperial Valley Water Authority. See text for discussion regarding difference between historical dates of withdrawals and historical dates of irrigated acres.

5.3.2.1 Irrigated cropland

In the future, the number of irrigated cropland acres can change to a greater or smaller proportion of the available cropland. Currently, 82.1 percent of total land in the 15-county study area is used as cropland and only 2.9 percent of total cropland is irrigated (representing approximately 2.4 percent of total land area; see Table 5.1).

For future estimates of irrigated cropland, it was assumed that irrigated cropland for all counties (except Mason, Tazewell, and Cass counties) would increase at the historical region-wide rate of 1.05 percent per year. The regional growth rate was calculated from historical data trends for all but three counties; Mason, Tazewell, and Cass counties. The region-wide growth rate was linearly decreased by 0.5 percent from 2010 to 2050 resulting in the total acreage seen in Table 5.9.

For Mason, Tazewell, and Cass counties the Imperial Valley Water Authority, Illinois Farm Services Agency, and Illinois Farm Bureau personnel provided estimates of the future amount of total irrigated acres. By 2050, Mason County was assumed to have an increase of 22,000 irrigated acres; Tazewell County an increase of 8,000 irrigated acres; and Cass County an increase of 3,000 irrigated acres. For these 3 counties it was assumed that 90 percent of the growth in irrigated acres would occur by 2020 and that the irrigated acres would reach the assumed maximum acreage by 2050.

5.3.2.2 Golf courses

For golf course irrigation, the future level of water withdrawals will increase as new golf courses are built. The existing golf course inventories show that there are approximately 72 golf courses in the 15 county study area (as compared to the approximately 750 golf courses in the State of Illinois). Data on “year built” of these golf courses indicate that, since 1950, approximately eight (8) golf courses were build per decade in the study area (Table 5.10). Assuming the average size of irrigated golf course area is 30 acres, the future irrigated golf course area is estimated by assuming the number of golf-courses which will be built per decade in each county. Table 5.11 shows the number of irrigated golf course acres that will be added to IR&AG sector every five years from 2010-2050.

5.3.3 Weather variables - Rainfall deficit

Some of the most important determinants of water demand are related to weather. Consequently, in order to estimate future water withdrawals, the weather variable (i.e., rainfall deficit) must also be estimated. Weather data may be dealt with in a variety of ways when looking into the future.

Table 5.9: Estimates of irrigated cropland for 2002, 2007, 2020, and 2050.

County	Irrigated cropland (acres)				Increase in acreage
	2002	2007[a]	2020	2050	
Cass	12,250	17,774	20,474	20,774	3,000[b,c]
Champaign	5,049	6,542	7,368	8,194	1,652[b]
DeWitt	840	–	991	1,080	240
Ford	688	–	811	885	197
Iroquois	2,627	–	3,097	3,378	751
Logan	1,591	–	1,876	2,046	455
Macon	15	–	18	19	4
Mason	91,811	125,961	145,761	147,961	22,000[b,c]
McLean	920	–	1,085	1,183	263
Menard	2,098	2,933	3,303	3,674	741[b]
Piatt	451	–	532	580	129
Sangamon	781	–	921	1,004	223
Tazewell	30,748	40,207	47,407	48,207	8,000[b,c]
Vermilion	273	–	322	351	78
Woodford	738	–	870	949	211

Source: U.S. Department of Agriculture; [a]data are from the Illinois Farm Service Agency. [b]increase in acreage is calculated from the base 2007 data. [c]total increase in acreage are based on Imperial Valley Water Authority, Illinois Farm Services Agency, and/or Farm Bureau local data.

Table 5.10: Golf courses built in each decade from 1900-2007 in East-Central Illinois.

County	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s	Total
Cass	0	0	1	0	0	0	0	0	0	0	0	1
Champaign	1	0	1	0	0	3	2	1	0	1	0	9
DeWitt	0	0	1	0	0	0	0	0	0	0	0	1
Ford	0	0	0	0	0	0	0	0	0	1	0	1
Iroquois	0	0	0	0	0	0	0	0	0	0	0	0
Logan	0	1	0	0	0	0	0	0	0	0	0	1
McLean	0	2	3	0	0	0	1	2	2	2	1	13
Macon	1	2	2	0	0	1	2	1	0	0	1	10
Mason	0	0	0	0	0	0	2	0	0	2	0	4
Menard	0	0	0	0	0	0	1	0	0	0	0	1
Piatt	0	0	1	0	0	0	0	0	0	0	0	1
Sangamon	2	0	2	1	0	1	0	1	0	4	0	11
Tazewell	0	0	1	0	0	1	5	3	0	0	1	11
Vermilion	0	0	2	0	1	1	1	0	0	3	0	8
Woodford	0	0	0	0	0	0	0	0	0	0	0	0
Total	4	5	14	1	1	7	14	8	2	13	3	72

Sources: http://www.golfguideweb.com/illinois/illinois.html and http://www.golflink.com/golf-courses/.

Table 5.11: Assumed increase in golf course acres irrigated every five years in East-Central Illinois.

County	2005 (acres)	2050 (acres)	Increase in irrigated golf course acres every 5 years
Cass	19	19	0
Champaign	367	533	18
DeWitt	37	37	0
Ford	40	64	3
Iroquois	77	77	0
Logan	59	59	0
Macon	267	386	13
Mason	37	132	11
McLean	369	558	21
Menard	59	80	2
Piatt	19	19	0
Sangamon	403	545	16
Tazewell	326	563	26
Vermilion	220	339	13
Woodford	139	139	0
Total	2,438	3,550	124

One approach is to use the climatic normals, as calculated by the National Center for Climatic Data (NCDC), as future weather. Climatic normals are defined as the “statistical average over a time period usually consisting of three consecutive decades”[Owenby et al., 2006]. The current climatic normals are defined for the period 1971-2000.

It was decided by the ISWS and technical committee of the East-Central Regional Water Supply Planning Committee (RWSPC) that the demand models would use climatic normal data as the future weather variables. A consequence of this averaging of the past weather data means that no inter-annual variation is taken into account in the water demand models. Figure 5.1 shows historical recorded data for temperature and precipitation compared to climatic normals; the future data (shown as ?) shows that the future weather is not predictable and how it may vary in relation to the climatic normals used in this study. In effect, this assumes that the average weather from the 30-year period can be used to estimate the future demand. On the one hand, this approach firmly connects the forecast to the historical record. On the other hand, by representing the future as the average of the 30-years of record we lose the extremes that cause some of the variation in demand.

The climatic normal method was chosen so that the general trend of water demand could be understood. By using normal weather data in the future, the annual variation in the historic reported withdrawals due to weather, is not seen in the future estimates. Because normal climatic data were used in estimating future water withdrawals, for any given year in the future (or the past) the water demand estimates will not match the actual water withdrawn. What is revealed by this study is the *average* water withdrawals from 2010 to 2050.

For irrigation, the amount of water withdrawn in any given year depends directly on precipitation during the growing season (May 1 to August 31). For the reasons explained above, the estimates of irrigation withdrawals for future years are based on the normal rainfall deficit. The normal rainfall deficit depends on the distribution of weekly precipitation during the summer irrigation season of approximately 16 weeks. The rainfall deficit for each county is estimated for each irrigation season from 1985 to 2005 using the ISWS/USGS method as described in Section 5.3. It is assumed that these years approximated the climatic normal (1971-2000). Table 5.12 shows the estimates of rainfall deficit for each county in the 15-county study region used to generate future withdrawals from 2010 to 2050.

5.4 Scenarios

The future water demand for agriculture and irrigation can change depending on the future changes in independent variables (*i.e.* irrigated acres, livestock population, and precipitation deficit). The

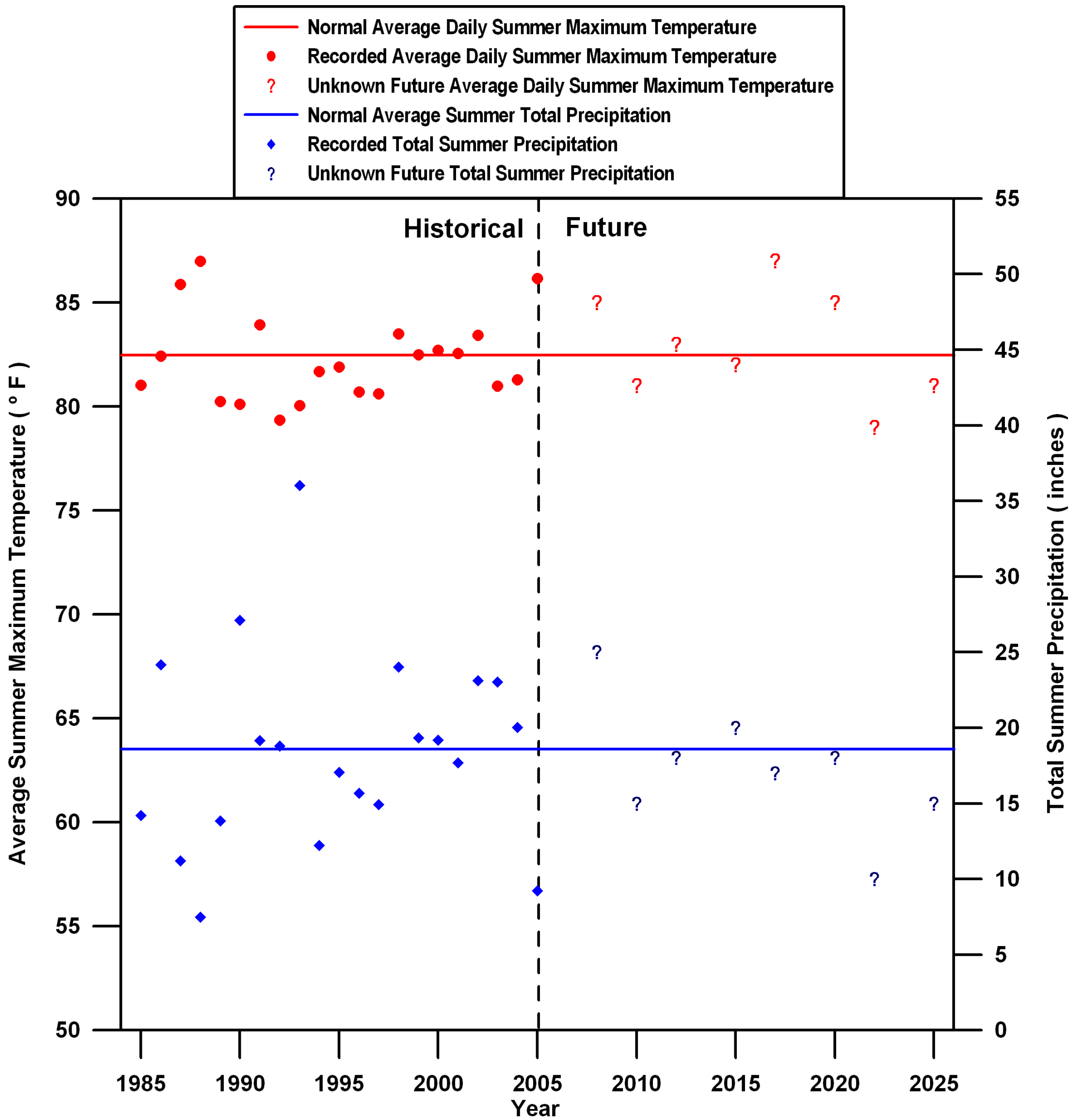

Figure 5.1: Example of inter-annual variation in temperature and precipitation compared to climatic normals.

Table 5.12: Annual rainfall deficit as calculated from climatic normals.

County	Normal rainfall deficit (inches)
Cass	9.86
Champaign	9.17
DeWitt	9.21
Ford	9.45
Iroquois	10.55
Logan	9.92
Macon	10.34
Mason	9.81
McLean	10.34
Menard	10.15
Piatt	9.1
Sangamon	10.15
Tazewell	10.63
Vermilion	9.17
Woodford	10.2

Table 5.13: Summary of irrigated acres for the baseline (BL), less resource intensive (LRI), and more resource intensive (MRI) scenarios in East-Central Illinois.

Year	BL Scenario irrigated acres	LRI Scenario irrigated acres	MRI Scenario irrigated acres
2005	180,255	180,255	180,255
2010	210,274	200,459	220,094
2015	222,602	211,977	233,241
2020	234,834	223,418	246,276
2025	236,082	224,444	247,760
2030	237,207	225,378	249,089
2035	238,196	226,214	250,245
2040	239,042	226,946	251,214
2045	239,739	227,572	251,986
2050	240,284	228,091	252,558
Difference from 2005 to 2050			
Unit (acres)	60,029	47,836	72,303
Percent %	33.3	26.5	40.1

number of irrigated acres has a large impact on the total amount of withdrawals estimated for each scenario. Table 5.13 shows the irrigated acres associated with each of the baseline, less resource intensive, and more resource intensive scenarios. All three scenarios use normal precipitation deficit as the weather variable. The following sections describe the other assumptions used for each of the scenarios.

5.4.1 Scenario 1 - Baseline (BL)

The baseline scenario assumes:

1. Irrigated cropland acres increases at the regional rate of 1.05 percent per year for all counties except Cass, Mason, and Tazewell counties.

2. Irrigated cropland acres in Cass, Mason, and Tazewell counties increases by 1.1, 1.3, and 0.97 percent per year, respectively, up to 2020. From 2020 to 2050 the growth rate in irrigated cropland for Cass, Mason, and Tazewell counties increase by 0.05, 0.07, and 0.05

percent per year, respectively.

3. The number of golf course irrigated acres increase at the rates shown in Table 5.11.

4. Statewide rate of growth in livestock occurs as described in Section 5.2.2.

5.4.2 Scenario 2 - Less resource intensive (LRI)

The less resource intensive scenario assumes:

1. Irrigated cropland acres increases at 75 percent of the regional rate or 0.79 percent per year for all counties except Cass, Mason, and Tazewell counties.

2. The irrigated cropland acres for Cass, Mason, and Tazewell counties is decreased by 5 percent of the baseline scenario acreage for every study year (2010, 2020,..., 2050).

3. Irrigated golf course acres increases by 75 percent as compared to the rates shown in Table 5.11.

4. Statewide rate of growth in livestock occurs as described in Section 5.2.2.

5.4.3 Scenario 3 - More resource intensive (MRI)

The more resource intensive scenario assumes:

1. Irrigated cropland acres increases at 125 percent of the regional rate or 1.31 percent per year for all counties except Cass, Mason, and Tazewell counties.

2. The irrigated cropland acres for Cass, Mason, and Tazewell counties is increased by 5 percent of the baseline scenario acreage for every study year (2010, 2020,..., 2050).

3. The growth rate of the irrigated cropland acreage increases by 25 percent, increasing acreage of golf course irrigation by 25 percent as compared to the rates shown in Table 5.11.

4. Statewide rate of growth in livestock occurs as described in Section 5.2.2.

5.5 Results

The results of the assumptions for each of the three scenarios are summarized in Tables 5.14, 5.15, and 5.16. Figure 5.2 shows the total withdrawals for all three scenarios for the 15-county region.

The baseline scenario estimates show that for average weather in 2050 the water demands will reach approximately 190 MGD. Most of these withdrawals (over 95%) are due to the irrigated cropland in the region. Golf course and livestock withdrawals account for less than 5% of the total withdrawals.

In the LRI scenario, the total withdrawals in 2005 are lower than the baseline scenario, 177.2 MGD. The MRI scenario increases the water withdrawals to approximately 196 MGD. It is important to note that on any given year, if a drought were to occur the water withdrawals will be much higher than the reported amounts in these summary tables (see Chapter 6 for a discussion about the effects of drought).

The results for each county for the baseline scenario are provided Figures 5.3–5.10. Twelve of the fifteen counties are estimated to withdraw 6 MGD or less by the year 2050 in the baseline scenario. The three largest withdrawals will come from Cass (16 MGD), Tazewell (39 MGD), and Mason (108 MGD) counties. All three of these counties are in the western portion of the study area where soils are sandy (these soils hold less water). Additionally, these three counties currently have the highest percentage of irrigated cropland.

The regional summary (Chapter 7) will compare the irrigation and agriculture withdrawals to other sectors.

5.5.1 Groundwater versus surface water withdrawals

The data generated from this demand study will be delivered to the ISWS as digital data. For those withdrawals where the exact location of the withdrawals point is known within the irrigation and agriculture sector, the future withdrawal estimates will be allocated to that withdrawal point. Generally, the only known points of withdrawal are for golf courses; the cropland irrigation and livestock withdrawal points are generally unknown. For those demands where exact location points are unknown, the ISWS will determine the locations.

The allocation of the future self-supplied IR&AG demands between groundwater and surface water withdrawals is generally assumed to remain at the 2005 level for each study area. Table5.17 shows the estimated percentages of surface water and groundwater for each county. The vast majority of the water withdrawals for irrigation and agricultural purposes are from groundwater.

Table 5.14: Total withdrawals for the baseline scenario for the irrigation and agriculture.

Year	Cropland (MGD)	Golf course (MGD)	Livestock (MGD)	Total withdrawals (MGD)
2005 (Weather)	226.5	2.4	4.2	233.1
2005 (Normal)	133.4	1.8	4.2	139.4
2010	156.0	1.9	4.5	162.4
2015	165.2	2.0	4.7	171.9
2020	174.3	2.1	4.9	181.3
2025	175.2	2.2	5.1	182.5
2030	176.0	2.3	5.3	183.6
2035	176.7	2.4	5.4	184.5
2040	177.3	2.5	5.5	185.3
2045	177.9	2.5	5.6	186.0
2050	178.3	2.6	5.6	186.5
Difference from 2005 (Normal) to 2050				
MGD	44.8	0.8	1.4	47.0
Percent (%)	33.6	45.6	32.3	33.7

MGD = million gallons per day.

2005 (Weather) = 2005 withdrawals using actual rainfall deficit.

2005 (Normal) = 2005 withdrawals using normal rainfall deficit.

Note: See Section 5.3.3 for discussion of effects of using normal rainfall deficit.

Table 5.15: Total withdrawals for the less resource intensive scenario for the irrigation and agriculture.

Year	Cropland (MGD)	Golf course (MGD)	Livestock (MGD)	Total withdrawal (MGD)
2005 (Weather)	226.5	2.4	4.2	233.1
2005 (Normal)	133.4	1.8	4.2	139.4
2010	148.7	1.9	4.5	155.0
2015	157.3	2.0	4.7	163.9
2020	165.8	2.0	4.9	172.7
2025	166.5	2.1	5.1	173.8
2030	167.2	2.2	5.3	174.7
2035	167.8	2.2	5.4	175.5
2040	168.4	2.3	5.5	176.2
2045	168.8	2.4	5.6	176.8
2050	169.2	2.4	5.6	177.2
Difference from 2005 (Normal) to 2050				
MGD	35.8	0.6	1.4	37.8
Percent (%)	26.8	34.3	32.3	27.1

MGD = million gallons per day.

2005 (Weather) = 2005 withdrawals using actual rainfall deficit.

2005 (Normal) = 2005 withdrawals using normal rainfall deficit.

Note: See Section 5.3.3 for discussion of effects
of using normal rainfall deficit.

Table 5.16: Total withdrawals for the more resource intensive scenario for the irrigation and agriculture.

Year	Cropland (MGD)	Golf course (MGD)	Livestock (MGD)	Total withdrawals (MGD)
2005 (Weather)	226.5	2.4	4.2	233.1
2005 (Normal)	133.4	1.8	4.2	139.4
2010	163.3	1.9	4.5	169.7
2015	173.1	2.0	4.7	179.8
2020	182.8	2.2	4.9	189.9
2025	183.8	2.3	5.1	191.3
2030	184.8	2.4	5.3	192.5
2035	185.7	2.5	5.4	193.6
2040	186.4	2.6	5.5	194.5
2045	186.9	2.7	5.6	195.2
2050	187.4	2.9	5.6	195.8
Difference from 2005 (Normal) to 2050				
MGD	54.0	1.0	1.4	56.4
Percent (%)	40.4	57.1	32.3	40.4

MGD = million gallons per day.

2005 (Weather) = 2005 withdrawals using actual rainfall deficit.

2005 (Normal) = 2005 withdrawals using normal rainfall deficit.

Note: See Section 5.3.3 for discussion of effects
of using normal rainfall deficit.

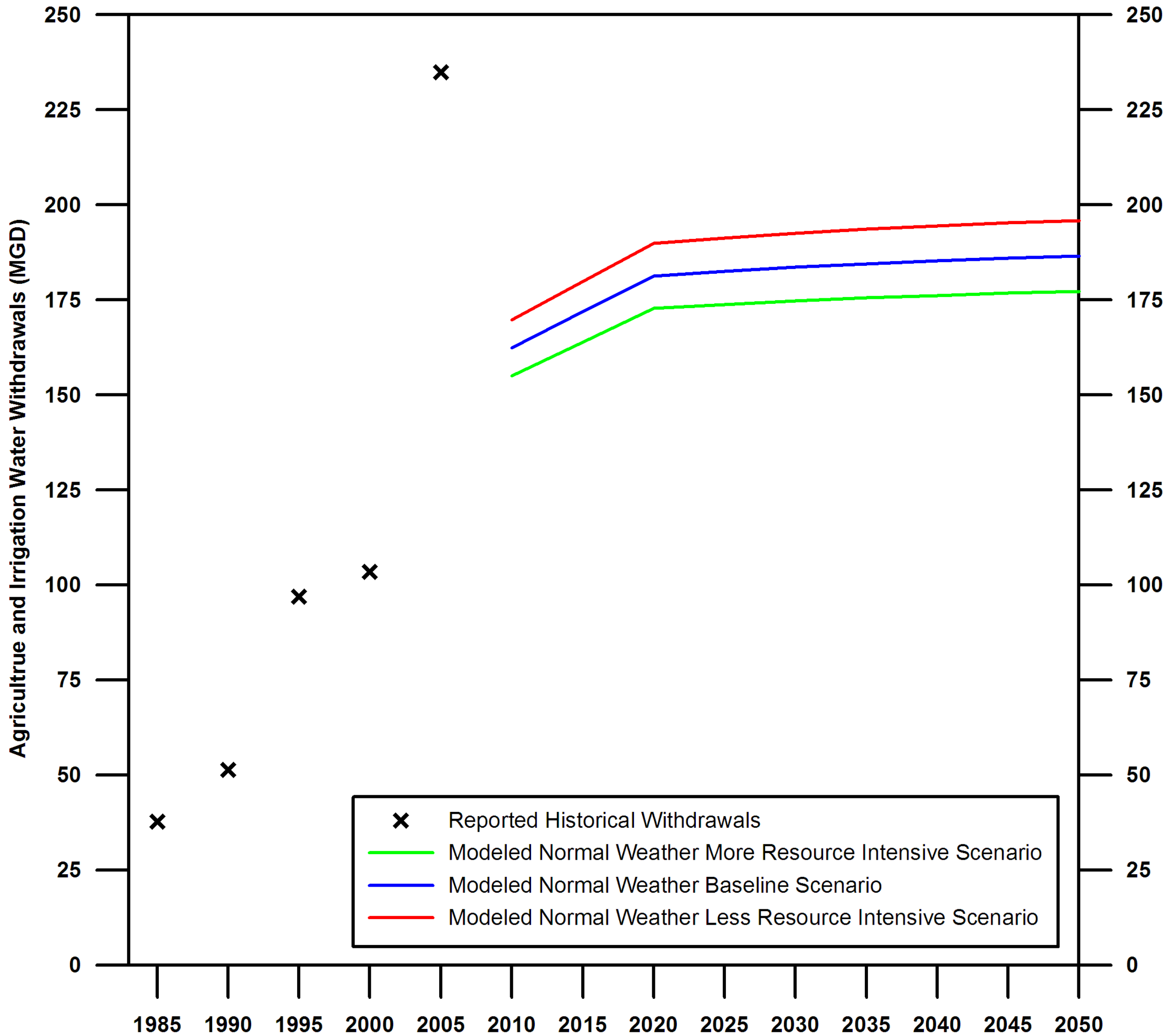

Figure 5.2: Historical and future irrigation and agriculture withdrawals for the baseline scenario, the less resource intensive scenario, and the more resource intensive scenario for East-Central Illinois.

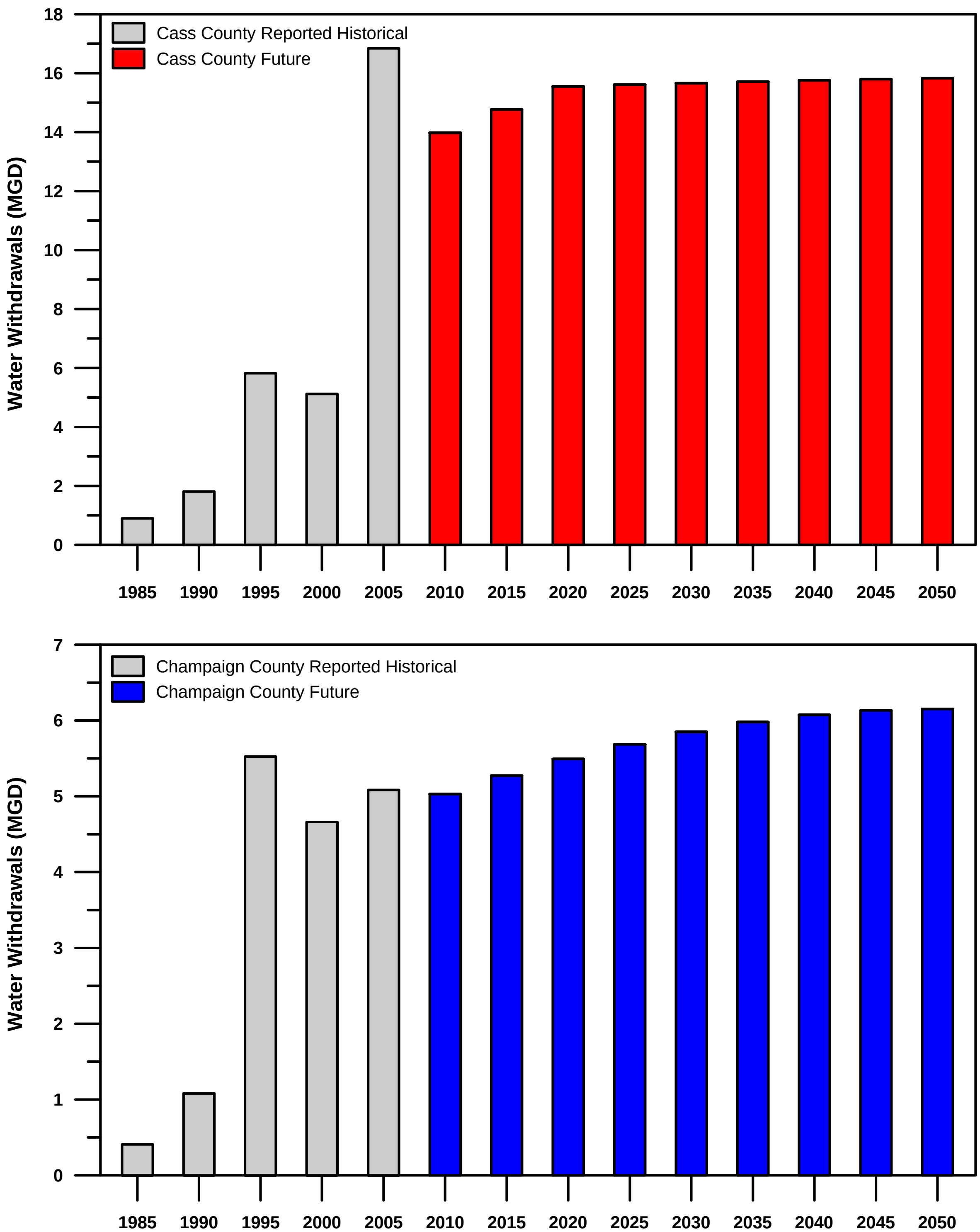

Figure 5.3: Irrigation and agriculture historical and future water withdrawals for Cass and Champaign counties in East-Central Illinois.

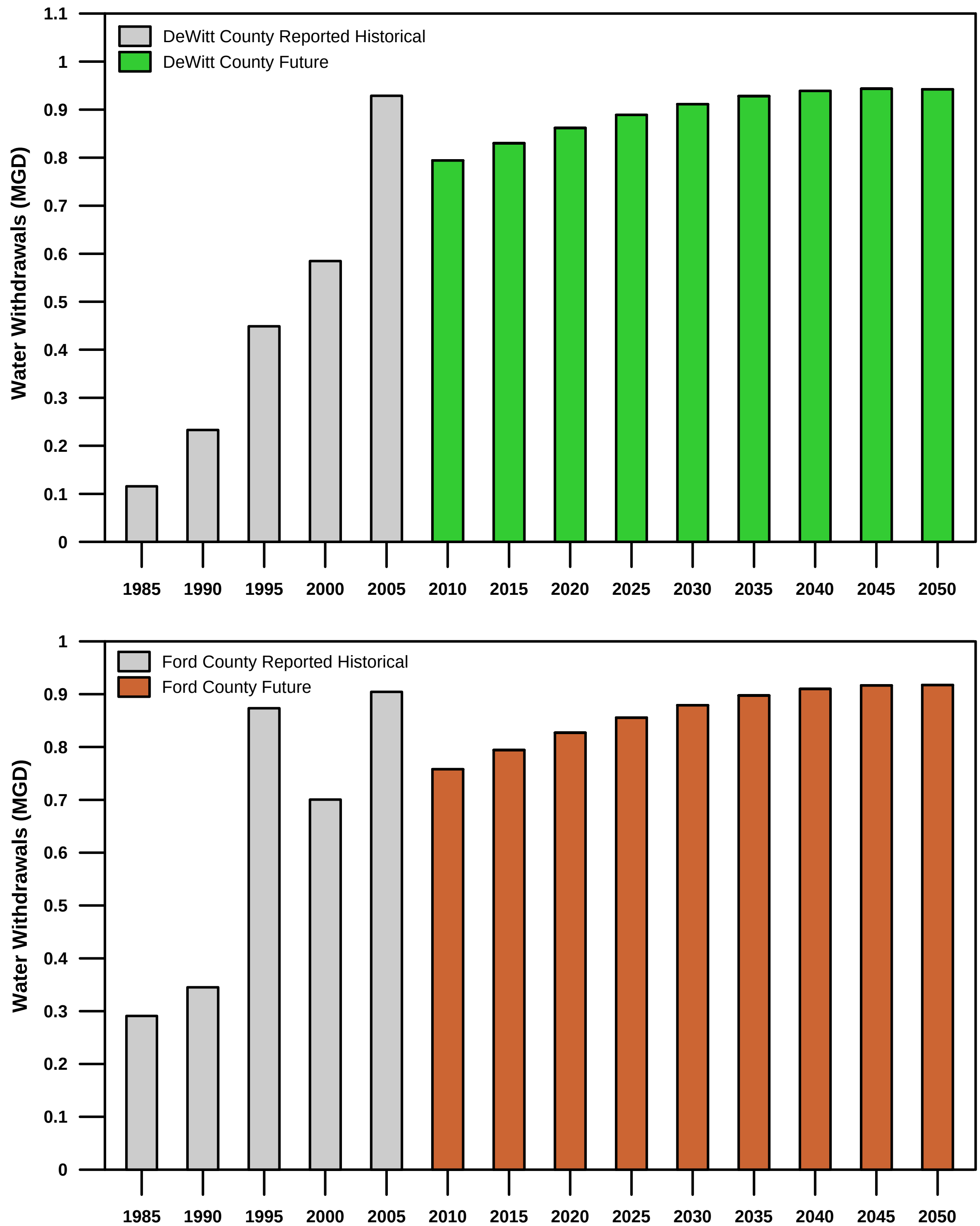

Figure 5.4: Irrigation and agriculture historical and future water withdrawals for DeWitt and Ford counties in East-Central Illinois.

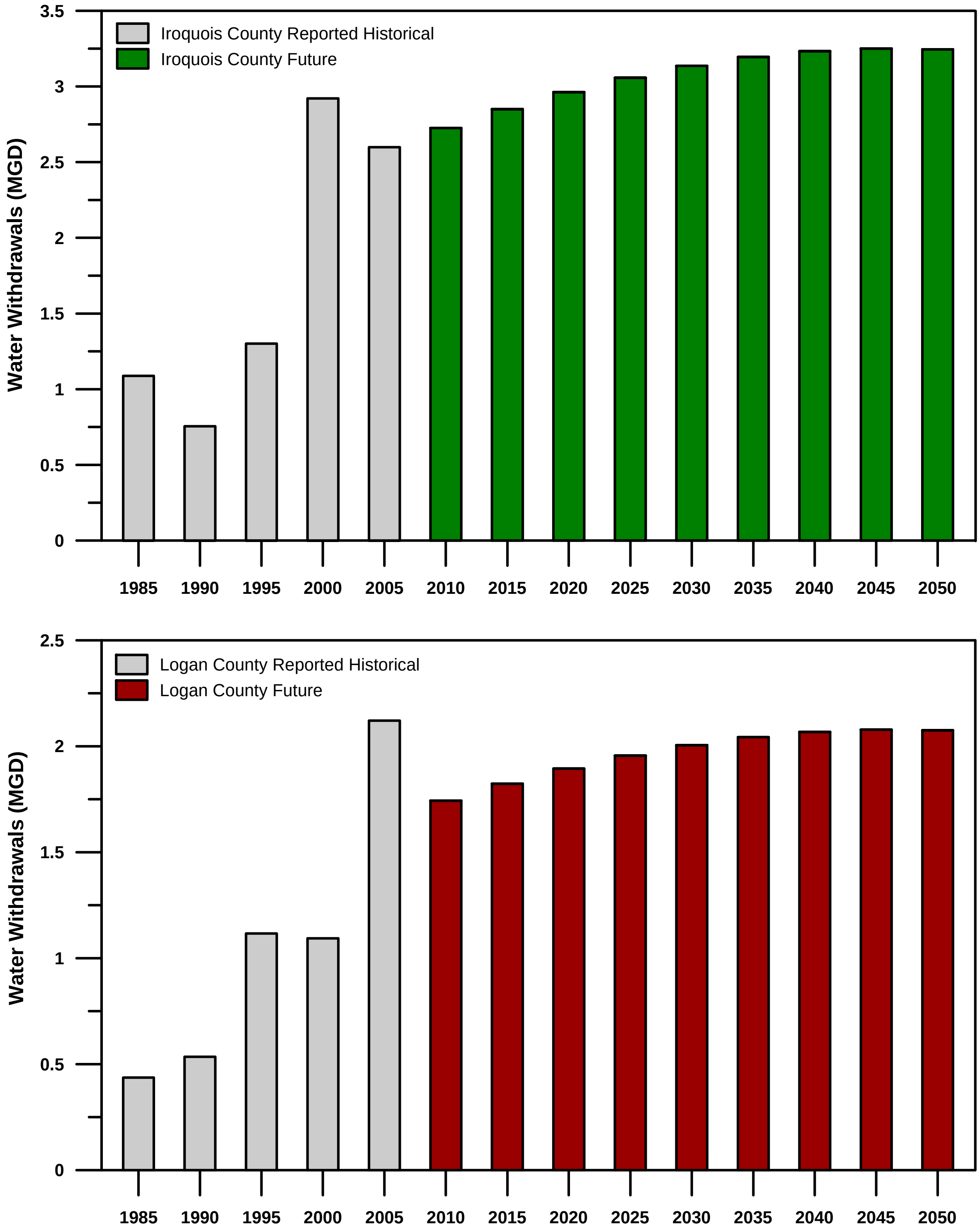

Figure 5.5: Irrigation and agriculture historical and future water withdrawals for Iroquois and Logan counties in East-Central Illinois.

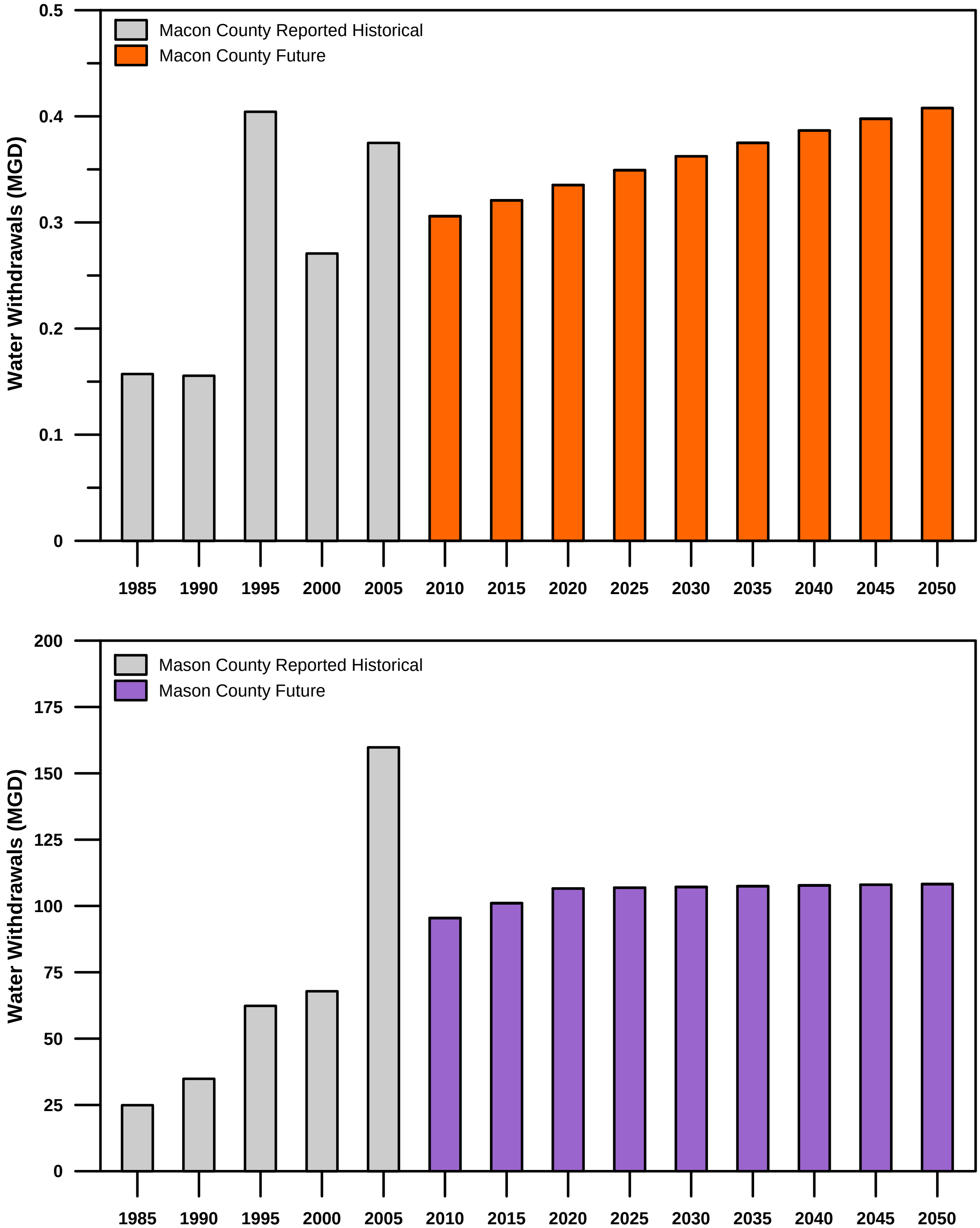

Figure 5.6: Irrigation and agriculture historical and future water withdrawals for Macon and Mason County study areas in East-Central Illinois.

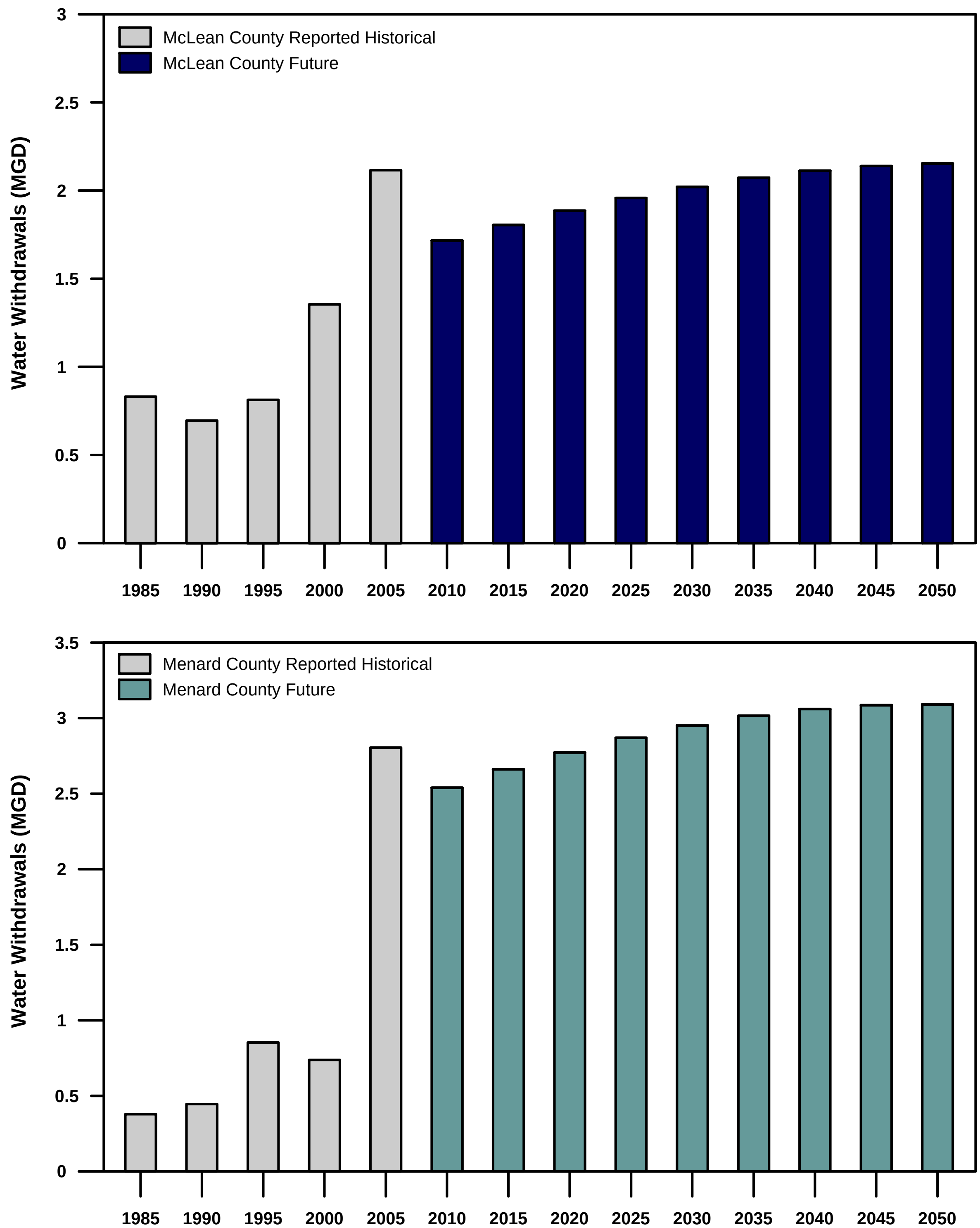

Figure 5.7: Irrigation and agriculture historical and future water withdrawals for McLean and Menard counties in East-Central Illinois.

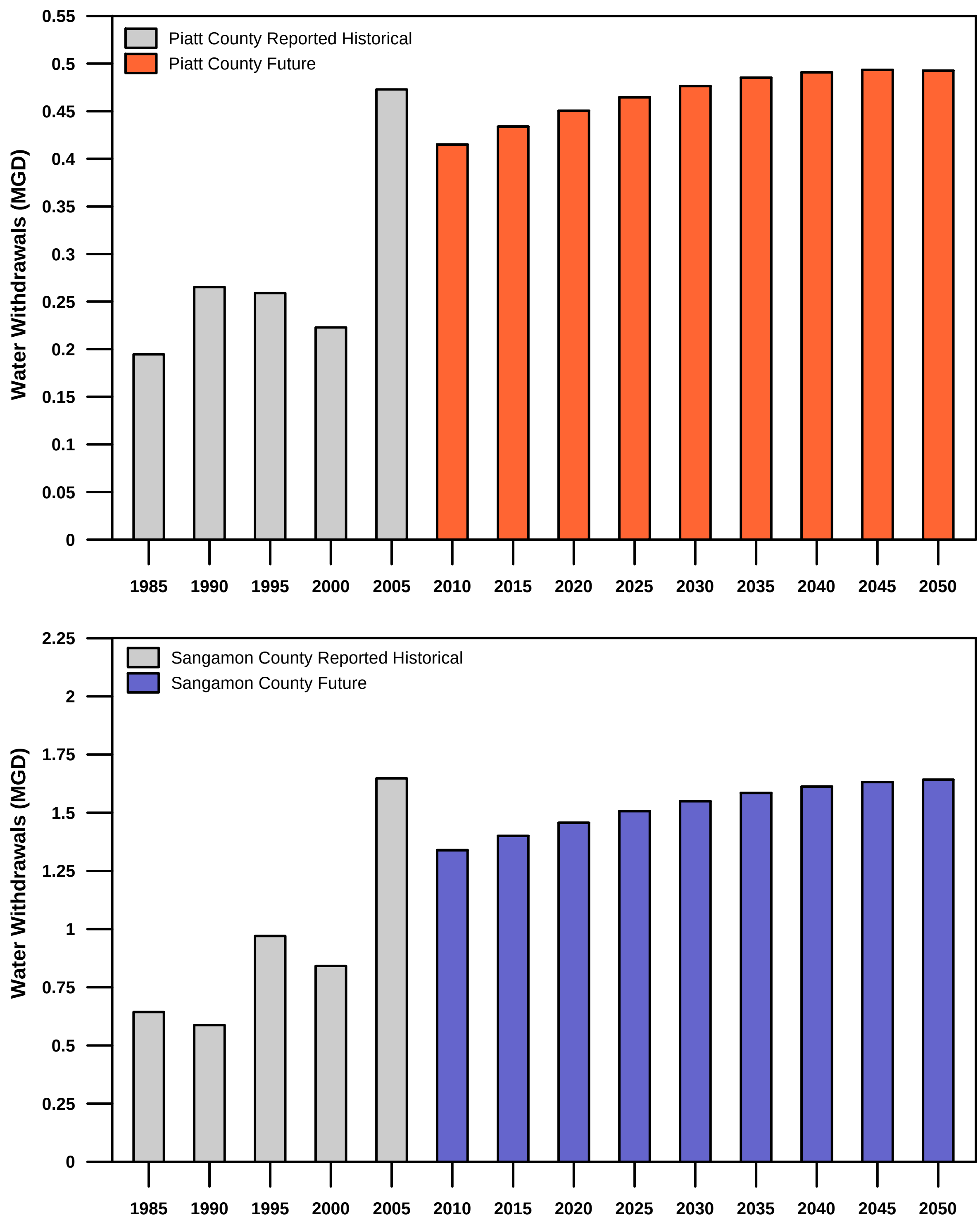

Figure 5.8: Irrigation and agriculture historical and future water withdrawals for Piatt and Sangamon counties in East-Central Illinois.

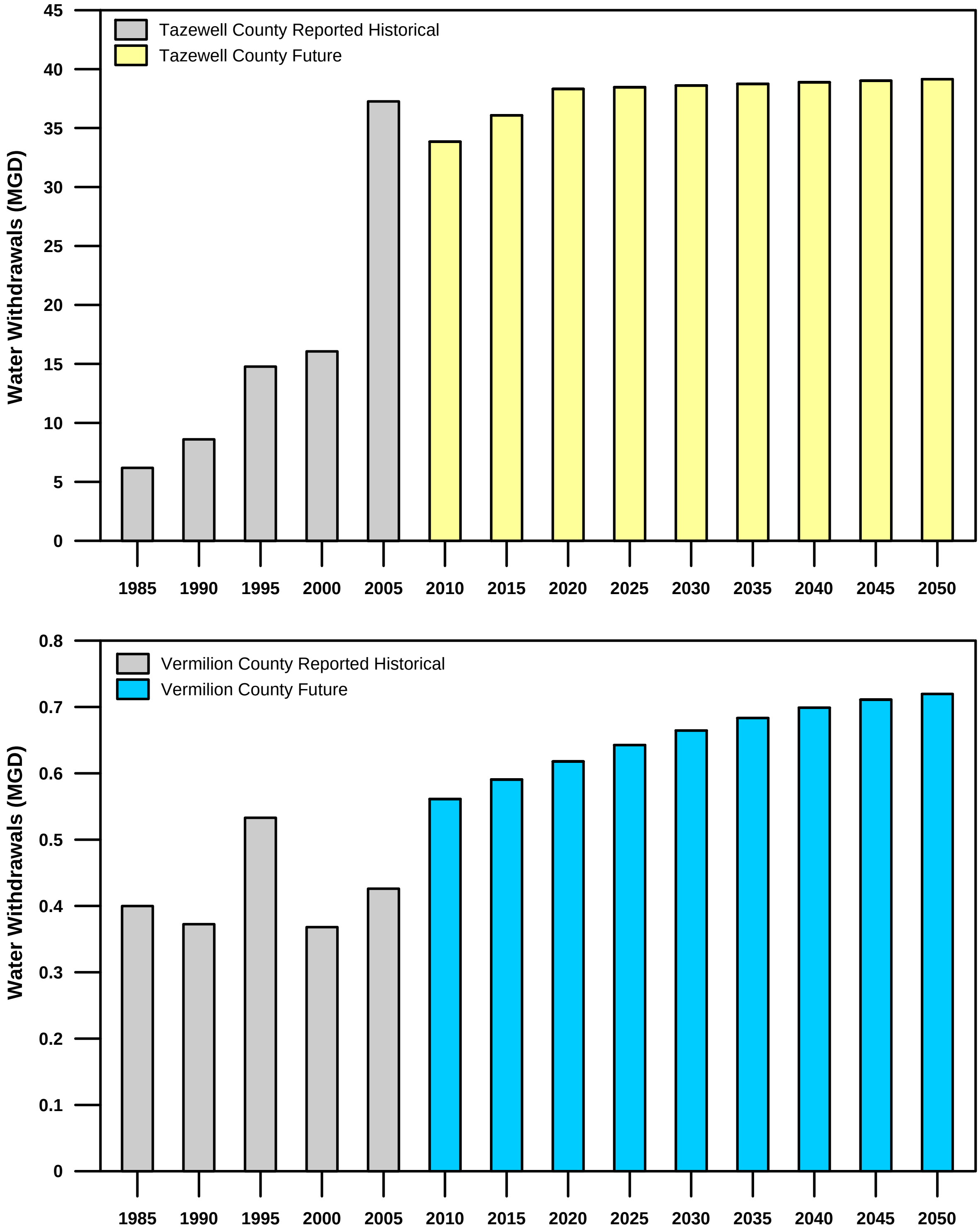

Figure 5.9: Irrigation and agriculture historical and future water withdrawals for Tazewell and Vermilion counties in East-Central Illinois.

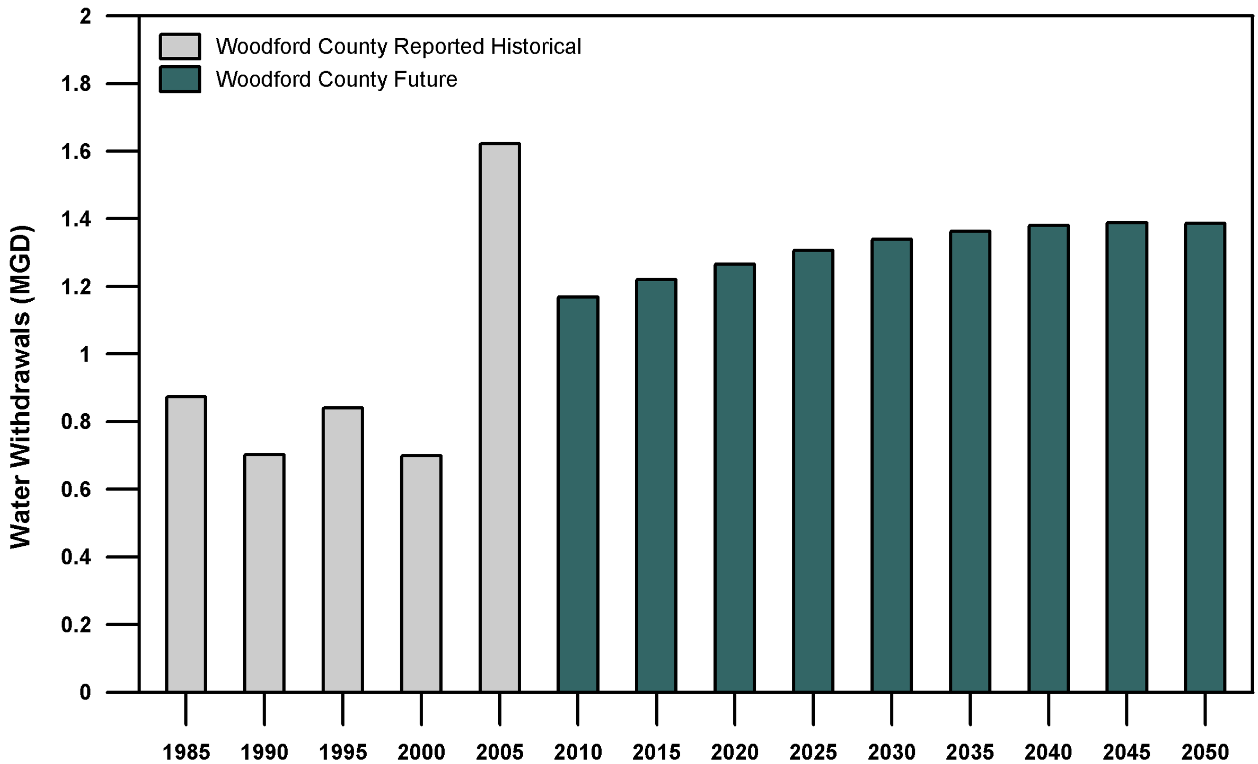

Figure 5.10: Irrigation and agriculture historical and future water withdrawals for Woodford County in East-Central Illinois.

Table 5.17: Source of water withdrawals for cropland irrigation.

County	Water Withdrawals	
	Groundwater (%)	Surface water (%)
Cass	95.6	4.4
Champaign	100	0.0
DeWitt	100	0.0
Ford	100	0.0
Iroquois	100	0.0
Logan	100	0.0
Macon	100	0.0
Mason	99.8	0.2
McLean	100	0.0
Menard	100	0.0
Piatt	100	0.0
Sangamon	94.6	5.4
Tazewell	100	0.0
Vermilion	0.0	100
Woodford	100	0.0
Total	99.5	0.5

Source: USGS provisional data (2005).

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Chapter 6

Sensitivity to Climate Change and Drought

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6.1 Background

As we have seen in the other chapters of this study, weather can have a large impact on water withdrawals. The scenarios of future water withdrawals presented assume normal weather conditions. Specifically, the values of air temperature and precipitation, which are used as explanatory variables in the water-demand models, represent long-term averages based on the 30-year record from 1971 to 2000. Using normal weather conditions to estimate future water withdrawals assumes that the weather patterns of the past will be the same in the future. Recent studies on global climate change have shown that this assumption may not be realistic at some point in the future. For this reason, the weather variables within the water withdrawal models were adjusted to analyze the potential effects of climate change on the future water withdrawals. The effects of these changes will vary by water sector depending on the sensitivity of water demand to air temperature and precipitation. The specific assumptions about the changes in weather variables are discussed separately for each of the major water sectors.

6.1.1 Climate change and global warming

Climate change refers to significant changes in climate parameters, like precipitation, temperature, and wind, that would last for long periods of time, like a decade or longer. Climate change may result from any individual or a combination of natural factors (i.e., change in sun intensity or changes in Earth's orbit around the sun), natural processes (i.e., changes in ocean circulation, and volcanic eruptions), or human activities that impact atmosphere composition (i.e., burning of fossil fuels) or land surface (i.e., urbanization, deforestation, and desertification). Global warming and climate change are terms often used interchangeably although climate change has been gaining preference because it refers to other climatic changes than just temperature increase. Global warming refers to increase of average atmospheric temperatures that can impact global climate patterns. Causes of global warming can be natural or human, like the increased emissions of greenhouse gases. Because the period of analysis for water demand scenarios extends until the year 2050 the average weather conditions are expected to change in response to climate change and global warming.

6.1.2 Climate change models in Illinois

With the increase of greenhouse gases and the rising of global average temperatures and changes in precipitation, many climate models have been developed by researchers throughout the world to model future changes in climate. Climate models indicate by 2050, a possible average annual temperature departure from the 1971-2000 long-term normal of up to $+6^\circ F$ in Illinois. Climate models also indicate a possible Illinois departure from 1971-2000 normal annual precipitation in a range from -5 inches to +5 inches per year. The future estimates of the climate models are shown in Figures 6.1 and 6.2. The future scenarios shown in Figures 6.1 and 6.2 were derived from 21 models on the latest set of global climate model simulations produced for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4). Simulations were produced for three different scenarios about how emissions may change in the future, moderately high scenario (denoted as “A2”), an intermediate scenario (denoted as “A1B”), and a low scenario (denoted as “B1”) [ISWS, 2007]. Some models simulate the emissions sdenarios with different starting conditions in the atmosphere and oceans. In total there were more than 120 model simulations. The model simulations are smoothed to show trends and reduce year-to-year variability.

Because there are so many models with large ranges of simulated climate conditions, scientists treat results for each model as being equal, after eliminating the extremes by selecting the 5th and 95th percentile limits of all model runs. This accounts for 90 percent of all model scenarios. Within the 5th and 95th percentile limits, the model results cover all scenarios in between.

Future water withdrawals will be affected by the anticipated changes in temperature and precipitation. In order to analyze the impacts these potential weather changes could have on water withdrawals in East-Central Illinois, we applied the temperature increase predicted from the global climate models to our water withdrawal models. We also simulated the possible increase and decrease in precipitation to our water withdrawal models.

Figure 6.1 shows an approximate linear increase in temperature departure between 2005 and 2050. Therefore, for this sensitivity analysis, the normal temperature in the model is increased linearly to an additional $6^\circ F$ in 2050. The annual temperature increase of $6^\circ F$ was applied to the summer growing season.

The annual range in potential changes in precipitation is ±5 inches. The winter, fall, and spring precipitation ranges are within -1.5 to +2.5 inches and the growing season range is +2.5 to -3.5 inches. Figure 6.2 indicates that the precipitation change takes place early during the 2005-2050 period. Therefore, for the sensitivity analysis it is assumed that changes in precipitation will reach the +2.5 inches and -3.5 inches by 2015.

So, for each sector we analyzed the impacts of five different weather scenarios.

- an increase of $6^\circ F$ applied to the summer growing season (applied as a linear increase, reaching $6^\circ F$ by 2050)
- a decrease of 3.5 inches during the growing season (assumed to decrease by 3.5 inches by 2015)

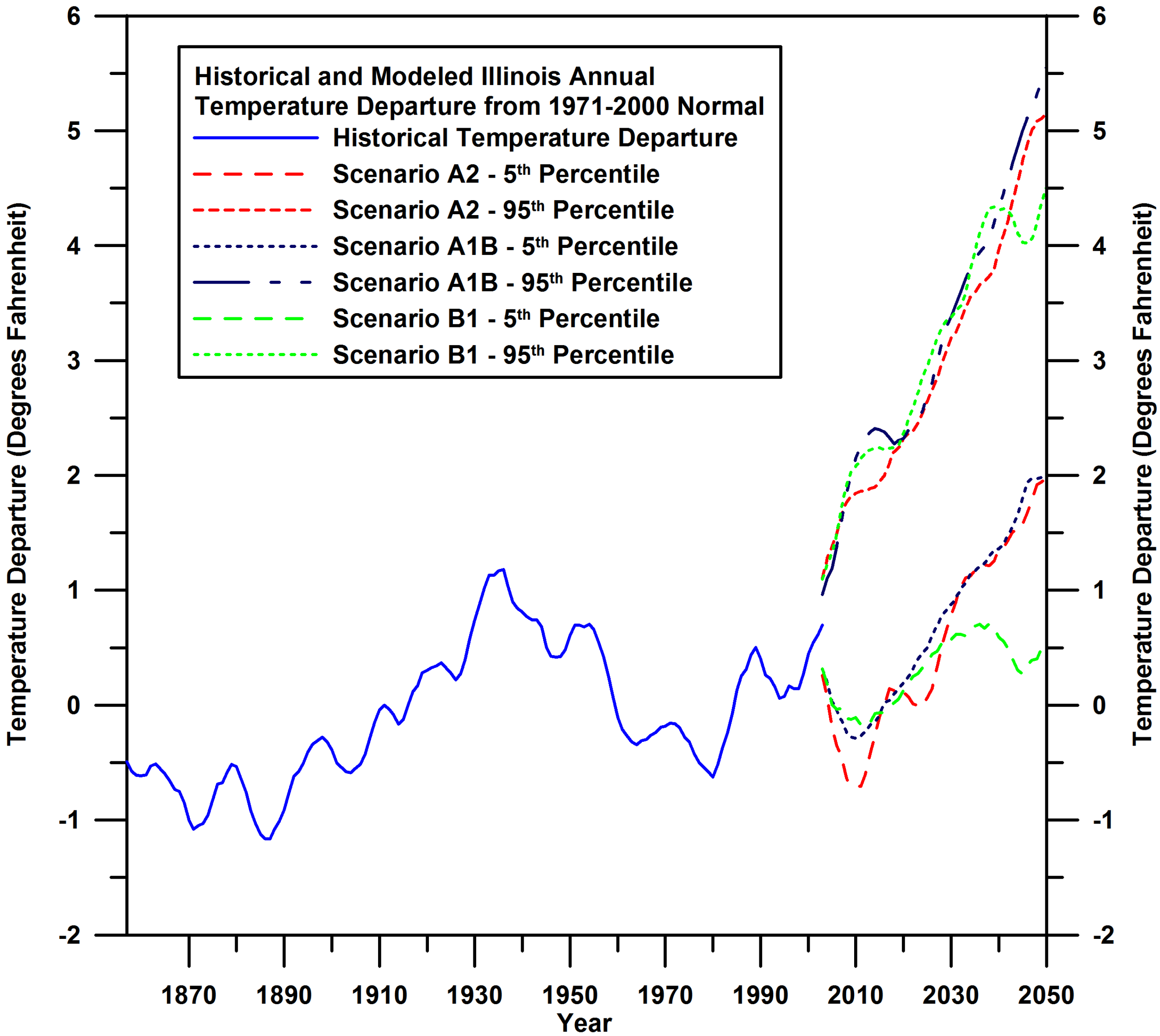

Figure 6.1: Global climate model scenarios on potential departures from normal annual temperature: 2005-2050 (ISWS, 2007).

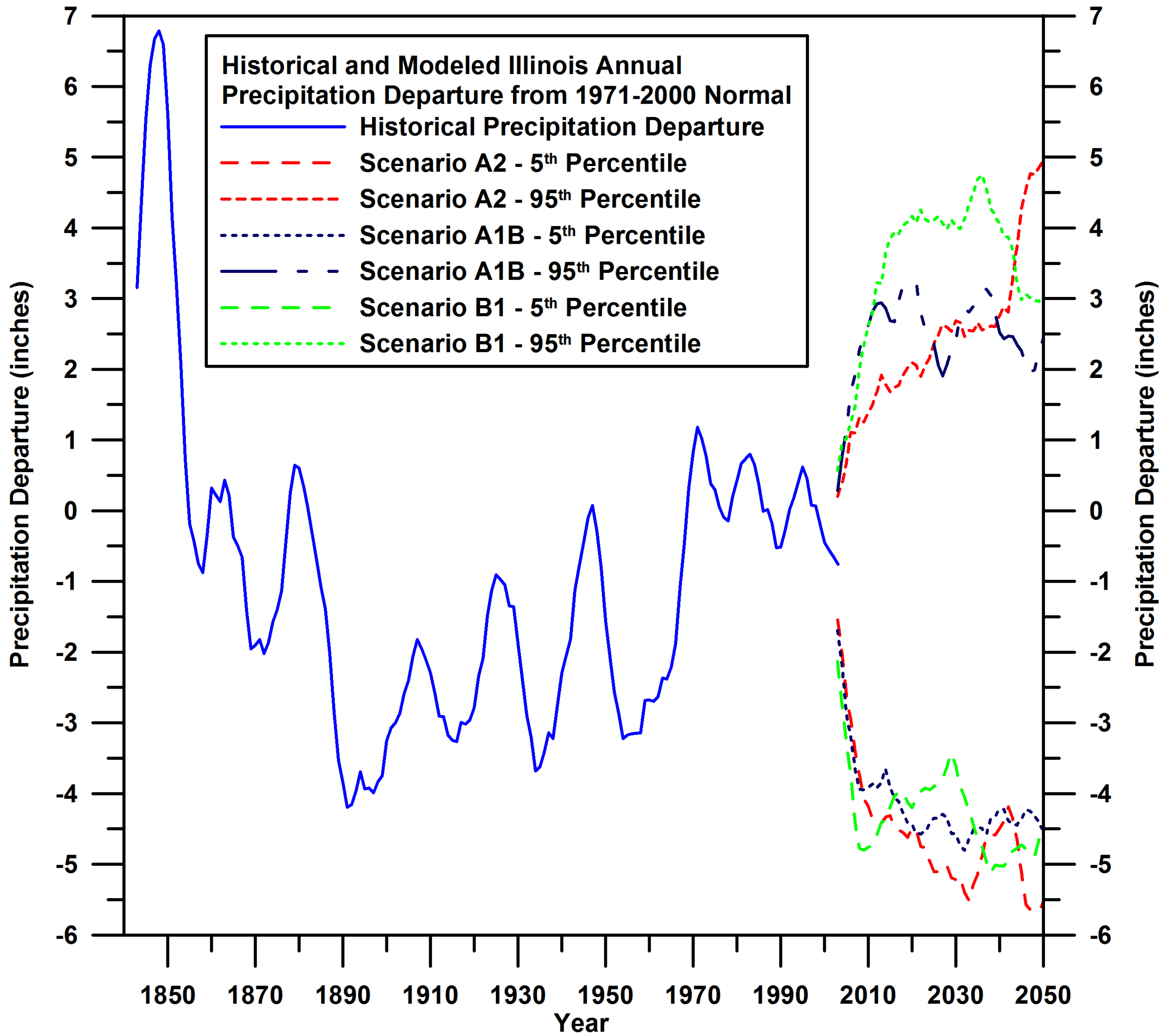

Figure 6.2: Global climate model scenarios on potential departures from normal annual precipitation: 2005-2050 (ISWS, 2007).

- an increase of 2.5 inches during the growing season (assumed to increase by 2.5 inches by 2015)
- an increase of $6^\circ F$ and a decrease of 3.5 inches during the growing season
- an increase of $6^\circ F$ and an increase of 2.5 inches during the growing season

These changes were applied to the baseline scenario in each sector. The normal weather (1971-2000) was used as the base values for the temperature and precipitation departures. The results for the climate change and drought sensitivity analysis are provided in the following sections.

6.1.3 Drought

Another type of climate impact on water demand is the effect of periodic droughts. In the future, in addition to possible changes in mean annual temperature and precipitation, it can be expected that periodic droughts will occur. While the severity and duration of future droughts is not known, their impact on water demand can be determined by examining historical droughts. The most severe historical drought in Illinois took place in the 1930s and 1950s. These were multi-year droughts which were associated with growing season precipitation deficits during the driest year of approximately 40 percent below normal. For purposes of the drought analysis, it was assumed that during future droughts, the 1971-2000 precipitation for the growing season would be reduced by 40 percent to represent a historical drought. For each sector, except power generation, the precipitation was decreased by 40 percent in the baseline scenario in order to anticipate the possible effects of future droughts. The results of this analysis is provided in the following sections.

6.2 Public water supply sector

The sensitivity of public water supply (PWS) withdrawals to weather conditions are captured by two variables: average maximum daily temperatures and total precipitation during the 5-month growing season from May 1 to September 30. The estimated constant elasticity of the temperature variable is +1.42 indicating that per capita water demand would be expected to increase by 1.42 percent in response to a 1.0 percent increase in temperature. The estimated constant elasticity of growing season precipitation is -0.11 indicating that average annual per capita water demand would be expected to decrease by 0.11 percent in response to a 1.0 percent increase in precipitation.

Table 6.1: Impact of a $6^{\circ}F$ temperature increase on public water supply withdrawals.

Year	BL scenario withdrawals (MGD)*	$+6^{\circ}F$, $+0''$ withdrawals (MGD)	Change from baseline	
			(MGD)	(%)
2005 (Weather)	138.9	-	-	-
2005 (Normal)	127.2	-	-	-
2010	131.9	133.4	1.5	1.2
2015	137.6	140.8	3.2	2.3
2020	144.2	149.2	5.0	3.5
2025	149.9	156.9	7.0	4.7
2030	154.3	163.2	9.0	5.8
2035	159.7	170.9	11.2	7.0
2040	165.2	178.8	13.6	8.2
2045	171.0	187.0	16.1	9.4
2050	176.9	195.6	18.8	10.6

BL = baseline scenario; MGD = million gallons per day.

($+6^{\circ}F$, $+0''$) means $6^{\circ}F$ increase in temperature and no changes in precipitation.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal) and 2005 (Weather).

6.2.1 Impacts of climate change

The five different climate change scenarios were applied to the baseline scenario of the public water supply model. The water withdrawal impacts of the combinations of temperature and precipitation changes during the growing season are shown in Tables 6.1 to 6.5.

Table 6.1 shows the effects of a gradual temperature increase on total water withdrawals in the PWS sector. By 2050, the $6^{\circ}F$ increase in air temperature would increase total PWS withdrawals by 18.8 MGD or 10.6 percent relative to normal weather demand in the baseline scenario.

Tables 6.2 and 6.3 show the impact of changes in growing season precipitation without the temperature increase. The 2.5 inches increase in precipitation by 2050 would decrease withdrawals by 2.4 MGD or 1.4 percent decrease relative to the baseline scenario. The 3.5 inches decrease in precipitation would increase withdrawals by 4.1 MGD or 2.3 percent.

Table 6.2: Impact of 2.5 *inches* increase in growing season precipitation on public water supply withdrawals.

Year	BL scenario withdrawals (MGD)*	$+0^oF$, $+2.5''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	138.9	-	-	-
2005 (Normal)	127.2	-	-	-
2010	131.9	130.9	-0.9	-0.7
2015	137.6	135.7	-1.9	-1.4
2020	144.2	142.2	-2.0	-1.4
2025	149.9	147.8	-2.1	-1.4
2030	154.3	152.1	-2.1	-1.4
2035	159.7	157.5	-2.2	-1.4
2040	165.2	163.0	-2.3	-1.4
2045	171.0	168.6	-2.4	-1.4
2050	176.9	174.4	-2.4	-1.4

BL = baseline scenario; MGD = million gallons per day.

($+0°F$, $+2.5''$) means no increase in temperature and 2.5 inches increase in precipitation.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal) and 2005 (Weather).

Table 6.3: Impact of 3.5 *inches* decrease in growing season precipitation on public water supply withdrawals.

Year	BL scenario withdrawals (MGD)*	$+0^oF$, $-3.5''$ Withdrawals (MGD)	Change from baseline	
			(MGD)	(%)
2005 (Weather)	138.9	-	-	-
2005 (Normal)	127.2	-	-	-
2010	131.9	133.3	1.4	1.1
2015	137.6	140.8	3.2	2.3
2020	144.2	147.5	3.3	2.3
2025	149.9	153.3	3.5	2.3
2030	154.3	157.8	3.6	2.3
2035	159.7	163.4	3.7	2.3
2040	165.2	169.1	3.8	2.3
2045	171.0	174.9	3.9	2.3
2050	176.9	181.0	4.1	2.3

BL = baseline scenario; MGD = million gallons per day.

($+0°F$, $-3.5''$) means no temperature increase and 3.5 *inches* decrease in precipitation.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal) and 2005 (Weather).

Table 6.4: Impact of combined $6^{\circ}F$ temperature increase and $2.5\,inches$ precipitation increase on public water supply withdrawals.

Year	BL scenario withdrawals (MGD)*	$+6^{\circ}F$, $+2.5''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	138.9	-	-	-
2005 (Normal)	127.2	-	-	-
2010	131.9	132.5	0.6	0.4
2015	137.6	138.9	1.3	0.9
2020	144.2	147.2	3.0	2.1
2025	149.9	154.8	4.9	3.3
2030	154.3	161.1	6.8	4.4
2035	159.7	168.7	8.9	5.6
2040	165.2	176.4	11.2	6.8
2045	171.0	184.6	13.6	8.0
2050	176.9	193.0	16.2	9.1

BL = baseline scenario; MGD = million gallons per day.

($+6^{\circ}F$, $+2.5''$) means $6^{\circ}F$ increase in temperature and $2.5 inches$ increase in precipitation.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See instructions for more detail information about 2005 (Normal) and 2005 (Weather).

Table 6.5: Impact of combined $6^\circ F$ temperature increase and $3.5\,inches$ precipitation decrease on public water supply withdrawals.

Year	BL scenario withdrawals (MGD)*	$+6^\circ F$, $-3.5''$ withdrawals (MGD)	Change from baseline	
			(MGD)	(%)
2005 (Weather)	138.9	-	-	-
2005 (Normal)	127.2	-	-	-
2010	131.9	134.9	3.0	2.3
2015	137.6	144.1	6.5	4.7
2020	144.2	152.7	8.5	5.9
2025	149.9	160.6	10.7	7.1
2030	154.3	167.1	12.8	8.3
2035	159.7	175.0	15.3	9.5
2040	165.2	183.0	17.8	10.8
2045	171.0	191.5	20.5	12.0
2050	176.9	200.3	23.4	13.2

BL = baseline scenario; MGD = million gallons per day.

($+6^\circ F$, $-3.5''$) means $6^\circ F$ increase in temperature and 3.5 inches decrease in precipitation.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See instructions for more detail information about 2005 (Normal) and 2005 (Weather).

Tables 6.4 and 6.5 show the combined impact of changes in growing season temperature and precipitation. The temperature change combined with the 2.5 inches increase in precipitation would increase withdrawals by 16.2 MGD, or 9.1 percent by 2050. The 3.5 inches decrease in precipitation combined with the temperature change results on 23.4 MGD increase in withdrawals, or 13.2 percent.

Figure 6.3 shows the results of the potential effects of climate change on the public water supply sector. The figure shows that all scenarios of climate change, except the increase in precipitation, will increase the water withdrawals in the region. The scenario with the largest impact is the combination of the increase in temperature and the decrease in precipitation, resulting in 13.2 percent increase in withdrawals.

6.2.2 Impacts of drought

For purposes of this analysis, it was assumed that during future droughts the 1971-2000 precipitation for the growing season would be reduced by 40 percent. Table 6.6 shows the result for average day water demand in the public supply sector under the conditions of a drought.

The results in Table 6.6 indicate that during a drought year total public supply withdrawals would increase by 6 percent. This percentage increase would be equivalent to an additional 7.9 MGD by 2010, and 10.6 MGD by 2050.

6.3 Power generation sector

Higher air temperatures will have an impact on the quantity of water withdrawn for thermoelectric cooling. In once-through cooling systems, warmer intake water may lead to increased rates of withdrawals in order meet thermal effluent limits. Also, the performance of cooling towers will be affected by higher air temperatures. However, the actual impacts on water withdrawals cannot be easily quantified and are not included in the sensitivity analysis conducted here.

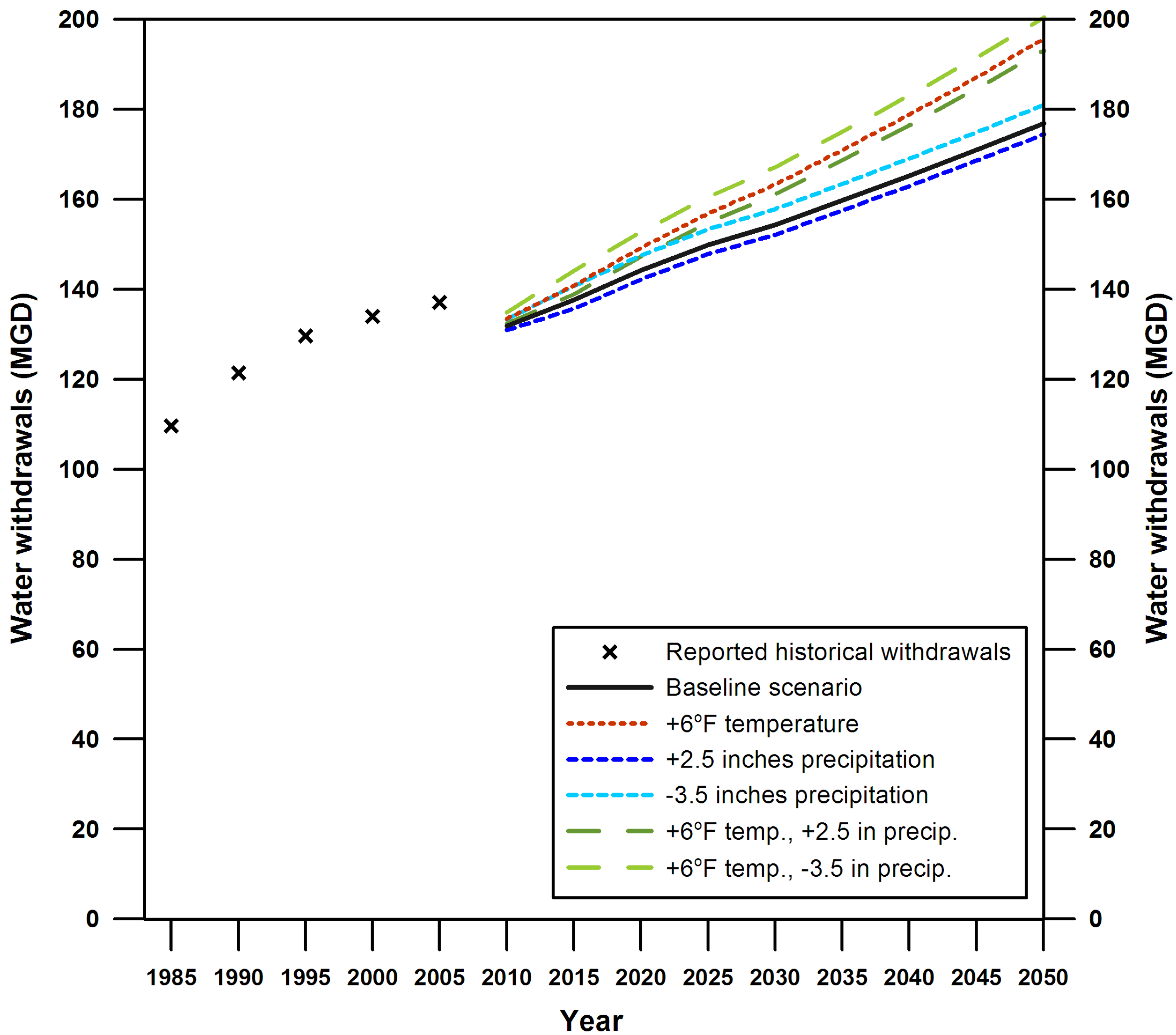

Figure 6.3: Sensitivity analysis results for public water supply sector.

Table 6.6: Impact of drought-induced precipitation deficit on total public supply withdrawals (compared to baseline scenario).

Year	BL scenario withdrawals (MGD)*	Drought scenario withdrawals (MGD)	Change from baseline	
			(MGD)	(%)
2005 (Normal)	127.2	134.9	7.6	6.0
2010	131.9	139.8	7.9	6.0
2015	137.6	145.8	8.2	6.0
2020	144.2	152.8	8.6	6.0
2025	149.9	158.9	9.0	6.0
2030	154.3	163.5	9.2	6.0
2035	159.7	169.3	9.6	6.0
2040	165.2	175.2	9.9	6.0
2045	171.0	181.2	10.2	6.0
2050	176.9	187.5	10.6	6.0

BL = baseline scenario; MGD = million gallons per day.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal).

6.4 Commercial and industrial sector

The sensitivity of commercial and industrial (C&I) water withdrawals to weather conditions are captured by two variables: total cooling degree days and total precipitation during the 5-month growing season from May 1 to September 30. The estimated constant elasticity of the cooling degree days variable is 0.529 indicating that per employee water demand would be expected to increase by 0.53 percent in response to a 1.0 percent increase in cooling degree days. The estimated constant elasticity of growing season precipitation is -0.2766 indicating that average annual per employee water demand would be expected to decrease by 0.28 percent in response to a 1.0 percent increase in precipitation. The same size but opposite effect would result from a 1.0 percent increase in precipitation.

6.4.1 Impacts of climate change

A $6^{\circ}F$ increase in annual average temperature by 2050 will translate into higher values for cooling degree days. Using the historical daily temperatures from 1985-2000 for each of the 29 weather stations, the temperature was increased linearly to $6^{\circ}F$ and the new number of cooling degree days was calculated for each year. The average number of cooling degree days from 1985-2005 was calculated and used in the sensitivity analysis. The average cooling degree days value was used to estimate the impact of temperature increase on C&I water withdrawals.

Table 6.7 shows the effects of cooling degree days increase on total water withdrawals in the C&I sector. By 2050, the impact of the increase in cooling degree days would increase total C&I withdrawals by 49.6 MGD, or 36.1 percent relatively to normal weather demand. Tables 6.8 and 6.9 show the effects on the increase and decrease of precipitation without an increase in cooling degree days on C&I withdrawals. An increase of $2.5\,inches$ in precipitation by 2050 would decrease withdrawals by 4.2 MGD or 3.1 percent. A decrease of $3.5\,inches$ in precipitation would increase withdrawal by 7.3 MGD or 5.3 percent by 2050.

Tables 6.10 and 6.11 give a summary of impacts of changes of combined cooling degree days and precipitation on self-supplied C&I water demand as compared to the baseline scenario under normal weather conditions. The results show that by 2050 the self-supplied C&I withdrawals would increase by 47.3 MGD or 31.8 percent if the increase in temperature is associated with a $2.5\,inches$ increase in precipitation. If the temperature increase is associated with a $3.5\,inches$ decrease in precipitation, total withdrawals would increase by 59.7 MGD or 43.4 percent.

Figure 6.4 shows the results of the potential effects of climate change on the C&I sector. The figure illustrates the increase in cooling degree days with the precipitation decrease is the most

Table 6.7: Estimated effects of 6°F temperature increase, represented by an increase in annual cooling degree days, on commercial and industrial (C&I) water withdrawals.

Year	BL scenario withdrawals (MGD)*	$+CDD$, $+0''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	85.3	–	–	–
2005 (Normal)	63.7	–	–	–
2010	76.5	81.3	4.8	6.3
2015	87.9	96.2	8.3	9.4
2020	94.7	107.1	12.5	13.2
2025	101.4	118.6	17.2	17.0
2030	108.4	130.9	22.5	20.7
2035	115.7	144.1	28.4	24.5
2040	123.0	158.0	34.9	28.4
2045	130.4	172.3	42.0	32.2
2050	137.5	187.1	49.6	36.1

BL = baseline scenario; MGD = million gallons per day.

(+CDD, 0”) means cooling degree days increase and no precipitation change.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See instructions for more information about 2005 (Normal) and 2005 (Weather).

influential factor in the increase of C&I withdrawals. With exception of precipitation increase, all other climate change scenarios increase withdrawals. The change in slope for all scenarios is due to the effects of the assumed increase of 2.5 *inches* and decrease of 3.5 *inches* in precipitation by 2015.

6.4.2 Impacts of drought

Water withdrawals in the self-supplied commercial and industrial sector will also be affected by periodic droughts in the future. For the purpose of this analysis, it was assumed that during future droughts, the 1971-2000 precipitation for the growing season would be reduced by 40 percent.

Table 6.12 shows the results for the average-day water demand in the commercial and industrial

Table 6.8: Estimated effects of 2.5 *inches* precipitation increase on commercial and industrial (C&I) water withdrawals.

Year	BL scenario withdrawals (MGD)*	$0\,CDD, +2.5''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	85.3	–	–	–
2005 (Normal)	63.7	–	–	–
2010	76.5	75.3	-1.2	-1.5
2015	87.9	85.4	-2.5	-2.8
2020	94.7	91.9	-2.7	-2.9
2025	101.4	98.4	-3.0	-2.9
2030	108.4	105.2	-3.2	-2.9
2035	115.7	112.2	-3.4	-3.0
2040	123.0	119.3	-3.7	-3.0
2045	130.4	126.4	-4.0	-3.0
2050	137.5	133.3	-4.2	-3.1

BL = baseline scenario; MGD = million gallons per day.

(0 CDD, +2.5”) means no cooling degree days change and 2.5 *inches* precipitation increase.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See instructions for more information about 2005 (Normal) and 2005 (Weather).

Table 6.9: Estimated effects of 3.5 *inches* precipitation decrease on commercial and industrial (C&I) water withdrawals.

Year	BL scenario withdrawals (MGD)*	$0\,CDD, -3.5''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	85.3	–	–	–
2005 (Normal)	63.7	–	–	–
2010	76.5	78.4	1.9	2.5
2015	87.9	92.3	4.4	5.0
2020	94.7	99.5	4.8	5.1
2025	101.4	106.6	5.2	5.1
2030	108.4	114.0	5.6	5.2
2035	115.7	121.7	6.0	5.2
2040	123.0	129.5	6.4	5.2
2045	130.4	137.2	6.9	5.3
2050	137.5	144.8	7.3	5.3

BL = baseline scenario; MGD = million gallons per day.

(0 CDD, -3.5”) means no cooling degree days change and 3.5 *inches* precipitation decrease.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See instructions for more information about 2005 (Normal) and 2005 (Weather).

Table 6.10: Impact of combined increase in temperature and 2.5 *inches* increase in precipitation on self-supplied commercial and industrial withdrawals.

Year	BL scenario withdrawals (MGD)*	$+CDD, +2.5''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	85.3	–	–	–
2005 (Normal)	63.7	–	–	–
2010	76.5	80.0	3.5	4.6
2015	87.9	93.3	5.5	6.2
2020	94.7	103.9	9.3	9.8
2025	101.4	115.0	13.6	13.4
2030	108.4	126.9	18.5	17.0
2035	115.7	139.6	24.0	20.7
2040	123.0	153.1	30.1	24.4
2045	130.4	167.0	36.6	28.1
2050	137.5	181.3	43.7	31.8

Baseline withdrawals represent normal weather (1971-2000).

(+CDD, +2.5”) means cooling degree days increase and 2.5 *inches* precipitation increase.

MGD = million gallons per day.

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See instructions for more information about 2005 (Normal) and 2005 (Weather).

Table 6.11: Impact of combined increase in temperature and 3.5 *inches* decrease in precipitation on self-supplied commercial and industrial withdrawals.

Year	BL scenario withdrawals (MGD)*	$+CDD, -3.5''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	85.3	–	–	–
2005 (Normal)	63.7	–	–	–
2010	76.5	83.3	6.8	8.9
2015	87.9	101.0	13.2	15.0
2020	94.7	112.6	17.9	19.0
2025	101.4	124.7	23.3	23.0
2030	108.4	137.7	29.3	27.0
2035	115.7	151.7	36.0	31.1
2040	123.0	166.4	43.3	35.2
2045	130.4	181.6	51.2	39.3
2050	137.5	197.2	59.7	43.4

BL = baseline scenario; MGD = million gallons per day.

(+CDD, -3.5”) means cooling degree days increase and 3.5 *inches*of precipitation decrease.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See instructions for more information about 2005 (Normal) and 2005 (Weather).

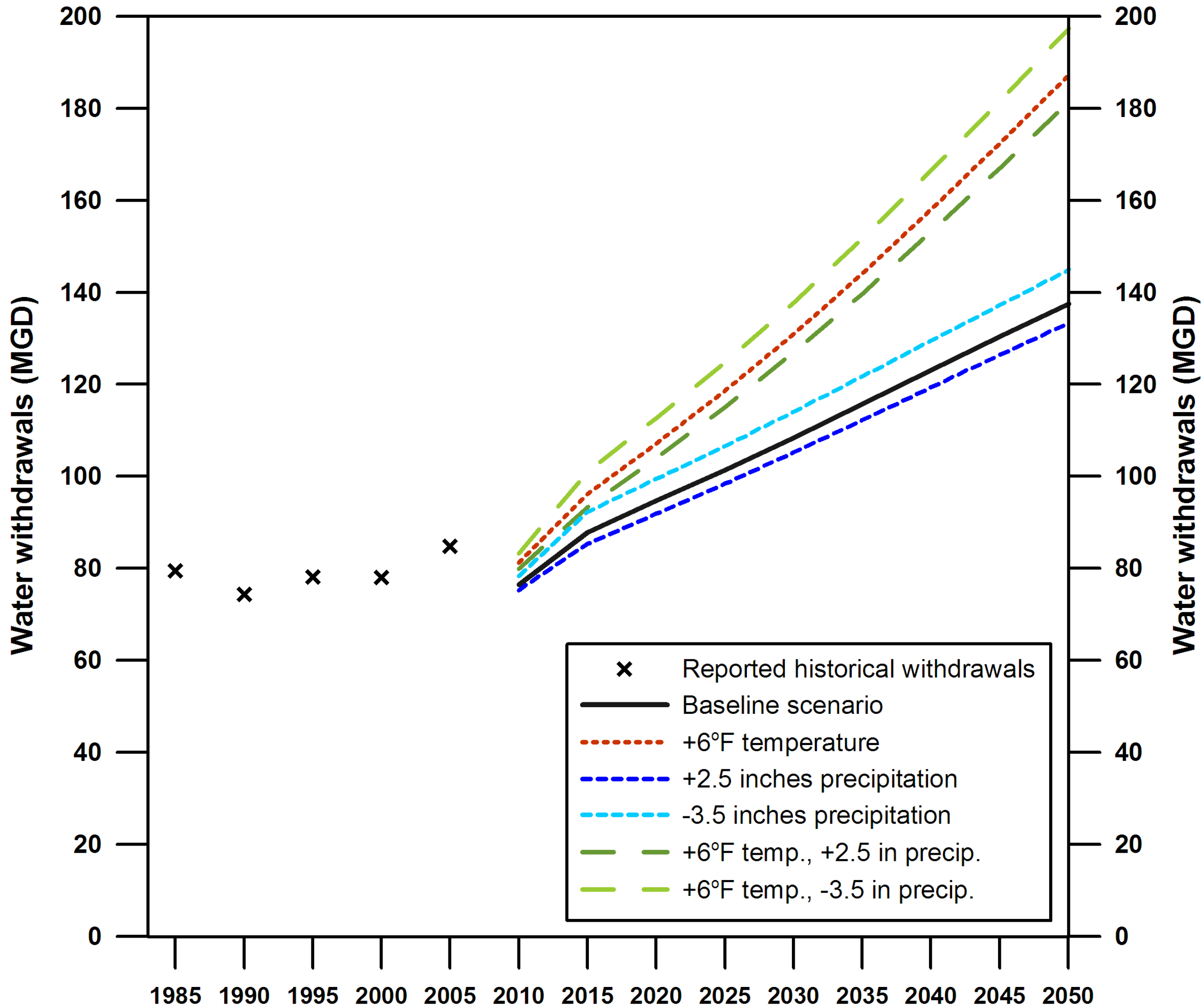

Figure 6.4: Sensitivity analysis results for commercial and industrial sector.

Table 6.12: Impact of drought-induced precipitation on commercial and industrial (C&I) water withdrawals.

Year	BL scenario withdrawals (MGD)*	Total withdrawals during drought (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Normal)	63.7	73.4	9.7	15.2
2010	76.5	87.2	10.7	14.0
2015	87.9	99.5	11.6	13.2
2020	94.7	107.3	12.6	13.3
2025	101.4	115.0	13.7	13.5
2030	108.4	123.2	14.7	13.6
2035	115.7	131.5	15.8	13.7
2040	123.0	140.0	16.9	13.8
2045	130.4	148.4	18.1	13.8
2050	137.5	156.7	19.1	13.9

BL = baseline scenario, MGD = million gallons per day.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal).

during the drought. The results in Table 6.12 indicate that during a drought year, self-supplied C&I withdrawals would increase by 13.9 percent. This percentage increase would be equivalent to additional 10.7 MGD by 2010, and 19.1 MGD by 2050.

6.5 Irrigation and agriculture sector

For the purpose of the sensitivity analysis with respect to climate change, future estimates of water demand for irrigation and agriculture (IR&AG) were further analyzed for the effects of decreased or increased precipitation and the effect of increased temperature on evapotranspiration. The effect of the change in normal precipitation was translated into change in the precipitation deficit. The change was calculated using the equation:

$$d_t = 20.760 - 0.585.P_n$$

Where:

d_t = precipitation deficit during irrigation season (May 1 - August 31),

P_n = normal precipitation during the irrigation season increased by $2.5\,inches$ or decreased by $3.5\,inches$.

The correction for the departure of average irrigation season temperature is based on the analysis of potential evapotranspiration and monthly temperature by Dr. Ken Kunkel and his staff at ISWS. It is approximated using the adjustment of $0.1\,inches/degree\,Fahrenheit$:

$$d_t^c = d_t + 0.1.(T_a - T_n)$$

Where:

d_t^c= the corrected total application depth during the irrigation season,

T_a= is average monthly air temperature for May 1 – August 31,

T_n= average of normal monthly temperatures during the 4-month irrigation season.

In arriving at this relationship, Dr. Kunkel analyzed the soil moisture model data in order to examine the year-to-year variability in the ratio ET/PET (actual to potential evapotranspiration) for each month of the irrigation season. In July and August, there are years when the model-estimated ratio is 1.0 thus indicating that the use of PET as actual ET is appropriate. In June, the highest ET/PET values were in the range of 0.90 to 0.95. In May, the highest ET/PET values were near or slightly above 0.70. The average value for May was 0.50. Assuming that a stretch of 1-2 weeks of dry weather in May would concern a farmer enough to irrigate, the higher value of 0.70 would be appropriate for May. Because development of a weighted coefficient for ET/PET ratio would require monthly data (while seasonally aggregated data are used in this study), no downward adjustment for actual ET was introduced (thus assuming a value of 1.0 for all months of the irrigation season). This assumption contributes to slightly overestimated effects of temperature on irrigation water demand.

6.5.1 Impacts of climate change

The water withdrawal impacts of the combinations of temperature and precipitation changes for the IR&AG are shown in Tables 6.13 to 6.17.

Table 6.13 shows the effects of gradual temperature increase on total water withdrawals. By 2050, a $6^{\circ}F$ increase in air temperature would increase total IR&AG withdrawals by 10.5 MGD or 5.6 percent relative to normal weather demand.

Tables 6.14 and 6.15 show the impact of changes in precipitation deficit without the temperature increase. The 2.5 inches increase in precipitation translates into a decrease of 29.4 MGD or 15.8 percent on water withdrawals by 2050. The 3.5 inches decrease in precipitation would increase withdrawals by 34.3 MGD or 18.4 percent.

By 2050, a $6^{\circ}F$ increase in air temperature combined with $2.5\,inches$ increase in precipitation would decrease total agricultural withdrawals by 18.6 MGD or 10.0 percent relative to normal weather (Tables 6.16). When a $6^{\circ}F$ increase in air temperature is combined with $3.5\,inches$ decrease in precipitation, the 2050 withdrawals increase by 44.9 MGD or by 24.1 percent relative to normal weather baseline withdrawals (Table 6.17).

Figure 6.5 shows the results of potential effects of climate change on the IR&AG sector. The figure shows that temperature increase, without a change in precipitation, increases withdrawals slightly but decrease in precipitation has a large effect on total water withdrawals for this sector. Both the increase in precipitation and the combined increase in precipitation and temperature decrease the water withdrawals. The changes in slopes of the climate change scenarios, as well as the baseline scenario are due to the dependence of results on the precipitation deficit factor and the irrigated acreage increase.

6.5.2 Impacts of drought

Water withdrawals by the IR&AG sector will also be affected by periodic droughts in the future. Irrigation demands are very sensitive to the decreasing precipitation during the summer growing season. The assumption that during future droughts, the normal precipitation for the growing season would be reduced by 40 percent would substantially increase the amount of water applied

Table 6.13: Impact of a $6^\circ F$ temperature increase of on irrigation and agriculture (IR&AG) withdrawals.

Year	BL scenario withdrawals (MGD)*	$+6^oF$, $+0''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	233.1	–	–	–
2005 (Normal)	139.4	–	–	–
2010	162.4	163.1	0.8	0.5
2015	171.9	173.7	1.8	1.1
2020	181.3	184.4	3.1	1.7
2025	182.5	186.8	4.3	2.4
2030	183.6	189.1	5.5	3.0
2035	184.5	191.3	6.8	3.7
2040	185.3	193.3	8.0	4.3
2045	186.0	195.2	9.2	5.0
2050	186.5	196.9	10.5	5.6

BL = baseline scenario; MGD = million gallons per day.

(+6^{o}F, +0") means 6^{o}F temperature increase and no precipitation change.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal) and 2005 (Weather).

Table 6.14: Impact of 2.5 *inches* precipitation increase on irrigation and agriculture (IR&AG) withdrawals.

Year	BL scenario withdrawals (MGD)*	$+0^oF$, $+2.5''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	233.1	–	–	–
2005 (Normal)	139.4	–	–	–
2010	162.4	148.4	-14.0	-8.6
2015	171.9	144.8	-27.1	-15.8
2020	181.3	152.7	-28.6	-15.8
2025	182.5	153.7	-28.8	-15.8
2030	183.6	154.6	-29.0	-15.8
2035	184.5	155.4	-29.1	-15.8
2040	185.3	156.1	-29.2	-15.8
2045	186.0	156.6	-29.3	-15.8
2050	186.5	157.0	-29.4	-15.8

BL = baseline scenario; MGD = million gallons per day.

(+0^{o}F, +2.5”) means no temperature increase and 2.5 inches precipitation increase.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal) and 2005 (Weather).

Table 6.15: Impact of 3.5 *inches* precipitation decrease on irrigation and agriculture (IR&AG) withdrawals.

Year	BL scenario withdrawals (MGD)*	$+0^oF$, $-3.5''$ withdrawals (MGD)	Change from baseline	
			(MGD)	(%)
2005 (Weather)	233.1	–	–	–
2005 (Normal)	139.4	–	–	–
2010	162.4	176.2	13.8	8.5
2015	171.9	203.6	31.8	18.5
2020	181.3	214.8	33.5	18.5
2025	182.5	216.2	33.7	18.5
2030	183.6	217.4	33.8	18.4
2035	184.5	218.5	34.0	18.4
2040	185.3	219.4	34.1	18.4
2045	186.0	220.2	34.2	18.4
2050	186.5	220.8	34.3	18.4

BL = baseline scenario; MGD = million gallons per day.

(+0^{o}F, -3.5”) means no temperature increase and 3.5 inches precipitation decrease.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal) and 2005 (Weather).

Table 6.16: Effects of $6^\circ F$ temperature increase and 2.5 *inches* precipitation increase on irrigation and agriculture withdrawals.

Year	BL scenario withdrawals (MGD)*	$+6^oF$, $+2.5''$ withdrawals (MGD)	Change from baseline (MGD)	Change from baseline (%)
2005 (Weather)	233.1	–	–	–
2005 (Normal)	139.4	–	–	–
2010	162.4	149.4	-13.0	-8.0
2015	171.9	146.9	-24.9	-14.5
2020	181.3	156.2	-25.1	-13.9
2025	182.5	158.4	-24.1	-13.2
2030	183.6	160.5	-23.1	-12.6
2035	184.5	162.5	-22.0	-11.9
2040	185.3	164.4	-20.9	-11.3
2045	186.0	166.2	-19.8	-10.6
2050	186.5	167.9	-18.6	-10.0

BL = baseline scenario; MGD = million gallons per day.

($+6^o$F, +2.5”) means 6^oF temperature increase and 2.5 inches precipitation increase.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal) and 2005 (Weather).

Table 6.17: Effects of $6^{\circ}F$ temperature increase and 3.5 *inches* precipitation decrease on irrigation and agriculture withdrawals.

Year	BL scenario withdrawals (MGD)*	$+6^{o}F$, $-3.5''$ withdrawals (MGD)	Change from baseline	
			(MGD)	(%)
2005 (Weather)	233.1	–	–	–
2005 (Normal)	139.4	–	–	–
2010	162.4	177.1	14.7	9.1
2015	171.9	205.6	33.8	19.6
2020	181.3	218.1	36.8	20.3
2025	182.5	220.6	38.2	20.9
2030	183.6	223.1	39.5	21.5
2035	184.5	225.4	40.9	22.2
2040	185.3	227.6	42.2	22.8
2045	186.0	229.5	43.6	23.4
2050	186.5	231.4	44.9	24.1

BL = baseline scenario; MGD = million gallons per day.

(+6^{o}F, -3.5”) means 6^{o}F temperature increase and 3.5 inches precipitation decrease.

*Baseline withdrawals represent normal weather (1971-2000).

2005 (Weather) = modeled 2005 withdrawals using actual weather data.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

see introduction for more detailed information about 2005 (Normal) and 2005 (Weather).

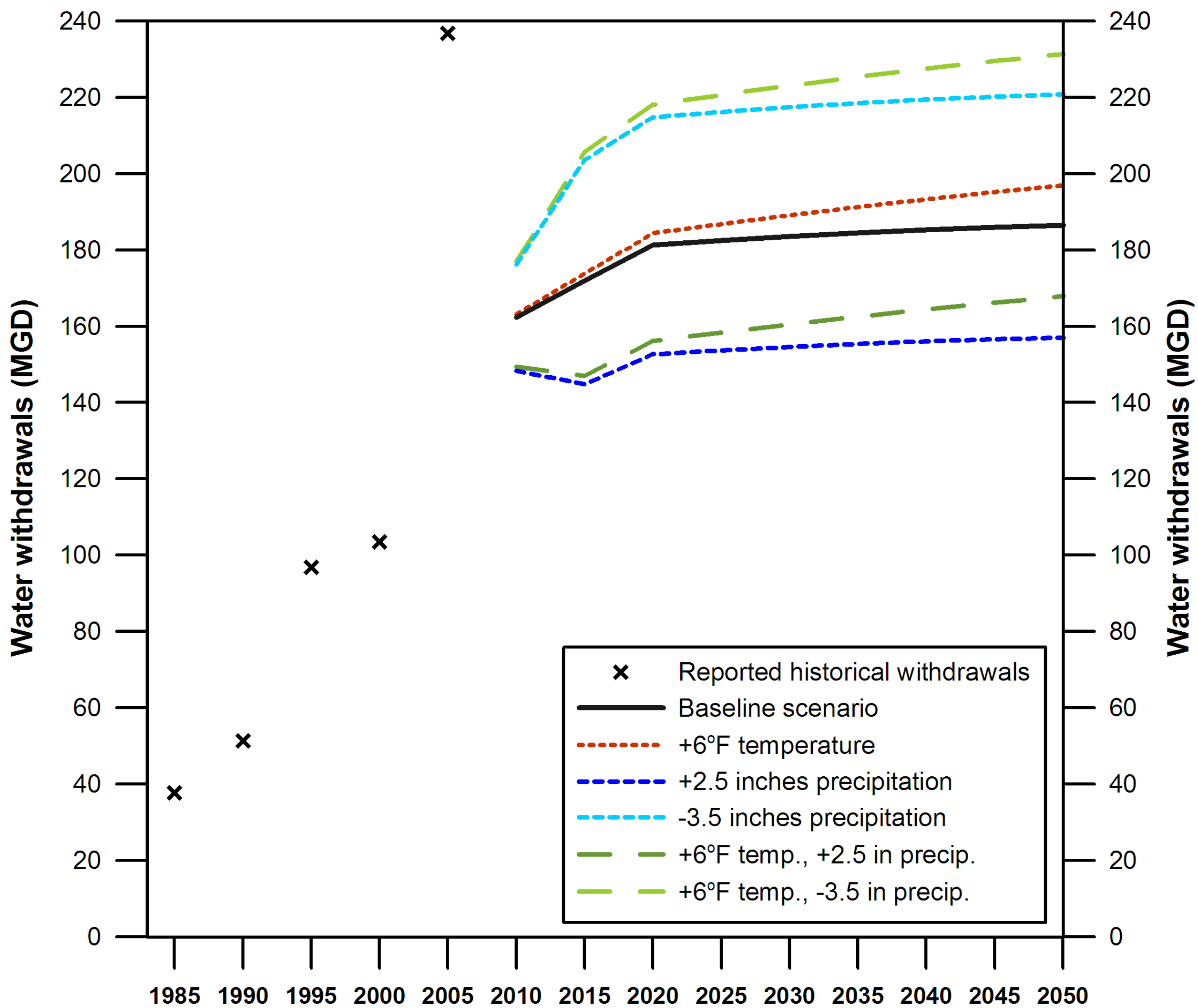

Figure 6.5: Sensitivity analysis results for irrigation and agriculture sector.

Table 6.18: Impact of drought-induced precipitation deficit on irrigation and agriculture withdrawals (compared to baseline scenario).

Year	Total normal weather withdrawals (MGD)	Total withdrawals during drought (MGD)	Change from normal weather (MGD)	Change from normal weather (%)
2005 (Normal)	139.4	233.5	94.1	67.5
2010	162.4	229.2	66.9	41.2
2015	171.9	242.6	70.8	41.2
2020	181.3	255.9	74.6	41.2
2025	182.5	257.6	75.1	41.1
2030	183.6	259.0	75.4	41.1
2035	184.5	260.3	75.8	41.1
2040	185.3	261.4	76.1	41.1
2045	186.0	262.3	76.3	41.1
2050	186.5	263.0	76.6	41.1

Total normal weather withdrawals represent baseline scenario.

MGD = million gallons per day.

2005 (Normal) = modeled 2005 withdrawals using normal weather data.

See introduction for more detailed information about 2005 (Normal).

for crop and turf irrigation.

Table 6.18 shows the results for average-day water demand in the IR&AG sector during a drought. The results in Table 6.18 indicate that during a drought year, self-supplied IR&AG withdrawals would increase approximately 41 percent. This percentage increase would be equivalent to additional 66.9 MGD by 2010 and 76.6 MGD by 2050.

6.6 Summary of climate change and drought impacts

To test the model sensitivity to climate change and drought, precipitation and temperature changes were analyzed for three sectors; PWS, C&I, and IR&AG. The five scenario analyzed were: 1) linear increase of temperature up to $6\,^{\circ}F$ by 2050, 2) increase of $2.5\,inches$ in total annual precipitation (+1.25 inches in 2010 and +2.5 inches by 2015), 3) 3.5 inches decrease in precipitation (-1.75 inches in 2010 and -3.5 inches by 2015), 4) combination of increase in temperature and precipitation, and 5) increase in temperature and decrease in precipitation by the respective values described above.

Table 6.19 shows the summary of climate change scenarios per sector. The change from the baseline scenario (normal conditions) is shown in the last column. For all three analyzed sectors, the combination of temperature increase and precipitation decrease has the largest impact on total water withdrawals, increasing withdrawals by 128 MGD by 2050. This makes sense given the established relationship to temperature and precipitation for each of the sectors; as temperature increases withdrawals will increase, as precipitation decreases water withdrawals will increase. This scenario had the largest impact on the C&I sector (+59.7 MGD), followed by IR&AG (44.9 MGD), and PWS (23.4 MGD).

The scenarios with just the change in precipitation affected the IR&AG sector the most. The precipitation decrease scenario increased withdrawals in IR&AG by 34.3 MGD. The precipitation increase scenario decreased withdrawals in IR&AG by 29.5 MGD.

The temperature increase scenario has the largest impact on C&I (+49.6 MGD), followed by PWS (+18.7 MGD) and IR&AG (+10.4 MGD) for a total increase of 78.7 MGD for all sectors (excluding power generation) by 2050.

Table 6.20 shows the effects of drought on withdrawals for all sectors. Drought conditions could increase the total withdrawals for the region 106.3 MGD, from 500.9 MGD to 607.2 MGD in 2050. IR&AG would be the most affected sector with water withdrawals increasing 76.5 MGD from baseline conditions. This makes sense from what we learned in the climate change scenarios; IR&AG is more effected by precipitation that the other sectors. Overall, this drought scenario shows that, without a change in temperature, a precipitation drought can cause an increase of approximately 100 MGD on any given year. This is important to remember when looking at the graphs and tables of future water withdrawal estimates.

Table 6.19: Effects of possible climate change on water withdrawals (in MGD) in East-Central Illinois.

Weather scenario/ Sector	2005 (Normal) withdrawals (MGD)	2030 withdrawals (MGD)	2050 withdrawals (MGD)	Change from BL in 2050
Baseline (BL) scenario				
Public-supply	127.2	154.3	176.9	–
Self-supplied C&I	63.7	108.4	137.5	–
Irrigation and agriculture	139.4	183.6	186.5	–
All sectors (w/o power)	330.3	446.0	500.9	–
$+6^{\circ}F$ temperature only				
Public-supply	127.2	163.2	195.6	18.7
Self-supplied C&I	63.7	130.9	187.1	49.6
Irrigation and agriculture	139.4	189.1	196.9	10.4
All sectors (w/o power)	330.3	483.2	579.6	78.7
$+2.5$” precipitation only				
Public-supply	127.2	152.1	174.4	-2.5
Self-supplied C&I	63.7	105.2	133.3	-4.2
Irrigation and agriculture	139.4	154.6	157.0	-29.5
All sectors (w/o power)	330.3	411.9	464.7	-36.2
-3.5” precipitation only				
Public-supply	127.2	157.8	181.0	4.1
Self-supplied C&I	63.7	114.0	144.8	7.3
Irrigation and agriculture	139.4	217.4	220.8	34.3
All sectors (w/o power)	330.3	489.2	546.6	45.7
$+6^{\circ}F$ temperature, $+2.5$” precipitation				
Public-supply	127.2	161.1	193.0	16.1
Self-supplied C&I	63.7	126.9	181.3	43.8
Irrigation and agriculture	139.4	160.5	167.9	-18.6
All sectors (w/o power)	330.3	448.5	542.2	41.3
$+6^{\circ}F$ temperature, -3.5” precipitation				
Public-supply	127.2	167.1	200.3	23.4
Self-supplied C&I	63.7	137.7	197.2	59.7
Irrigation and agriculture	139.4	223.1	231.4	44.9
All sectors (w/o power)	330.3	527.9	628.9	128.0

Table 6.20: Effects of drought on water withdrawals (in MGD) in East-Central Illinois.

Weather scenario/ Sector	2005 (Normal) withdrawals (MGD)	2030 withdrawals (MGD)	2050 withdrawals (MGD)	Change from BL (MGD)
Baseline (BL) scenario				
Public-supply	127.2	154.3	176.9	–
Self-supplied C&I	63.7	108.1	137.5	–
Irrigation and agriculture	139.4	183.6	186.5	–
All sectors (w/o power)	330.3	446.0	500.9	–
Drought year (40 percent precipitation deficit)				
Public-supply	127.2	163.5	187.5	10.6
Self-supplied C&I	63.7	123.2	156.7	19.2
Irrigation and agriculture	139.4	259.0	263.0	76.5
All sectors (w/o power)	330.3	545.7	607.2	106.3

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Chapter 7

Summary and Conclusions

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This study provides a summary of the historical and future water withdrawals for four different water-demand sectors: 1) public water supply and self-supplied domestic, 2) self-supplied thermoelectric power generation 3) self-supplied commercial and industrial, and 4) self-supplied agriculture and irrigation. The purpose of this study is to examine water demand on a regional basis and provide water demand information to the East-Central RWSPC to begin the water-supply planning process.

Future water withdrawals were estimated with a regional approach. We collected historical data on all water suppliers/users in the region, created regional models for each sector based upon the aggregated historical data, and used the models to estimate future withdrawals. The future water withdrawals generated from this study will be distributed to existing points of withdrawal for use by the ISWS in groundwater and surface water models to analyze whether the water supplies can meet the water demands from now until 2050.

7.1 Regional results

The baseline scenario estimates the total water withdrawal to increase by 8.0% by the year 2050, from 1,654.6 MGD in 2005 to 1,788.4 MGD (Table 7.1 and Figure 7.1). In all water demand sectors, except power generation, water withdrawals are expected to increase (Table 7.1). The power generation sector decreases water withdrawals in the baseline scenario because of the replacement of the Lakeside Plant with a new Dallman 4 Plant in Sangamon County which uses less water. Because power generation withdraws close to 80% of this total, it is useful to look at the changes in water withdrawals without including the power sector.

The water demand sectors, other than power generation, when totaled, increase by 173.6 MGD (51%) from 2005 to 2050 in the baseline scenario. This number is reduced to 119.7 MGD (35%) in the LRI scenario and increased to 232.5 MGD (69%) in the MRI scenario. These values underscore the importance of analyzing water demand and planning for the future. By including demand these increases in groundwater and surface water supply models, as the ISWS is going to do, the region will have a greater understanding of the demand placed on the regional water supply and the potential impacts to the resource and the region.

The percent of the total withdrawals is shown for each sector in 2005 and 2050 in Figure 7.2. Power generation withdraws the most of all the water sectors, 71% of the total in 2050. In 2050, both IR&AG and PWS will withdraw approximately 10% of the total water in the region. The withdrawals for C&I will increase from approximately 4% in 2005 to 8% of the total in 2050. Domestic water withdrawals will remain less than 1% of the total water withdrawals in the region.

Table 7.1: Summary of water withdrawals in East-Central Illinois (in MGD).

Scenario/ Sector	2005 Normal (MGD)	2050 Modeled (MGD)	Change from 2005 (Normal) - 2050 (MGD)	Change from 2005 (Normal) - 2050 (%)
Baseline Scenario (BL)				
Public Supply	127.24	176.88	49.64	39.0
Self-supplied C&I	63.70	137.51	73.81	115.9
Self-supplied domestic	8.86	12.01	3.15	35.6
Irrigation and agriculture	139.40	186.46	47.06	33.8
Subtotal (w/o power)	339.20	512.86	173.66	51.2
Power generation	1,315.35	1,275.54	-39.81	-3.0
TOTAL	1,654.55	1,788.40	133.85	8.1
Less Resource Intensive Scenario (LRI)				
Public Supply	127.24	153.50	26.26	20.6
Self-supplied C&I	63.70	116.17	52.47	82.4
Self-supplied domestic	8.86	12.01	3.15	35.6
Irrigation and agriculture	139.40	177.21	37.81	27.1
Subtotal (w/o power)	339.20	458.89	119.69	35.3
Power generation	1,315.35	1,217.78	-97.57	-7.4
TOTAL	1,654.55	1,676.67	22.12	1.3
More Resource Intensive (MRI)				
Public Supply	127.24	185.36	58.12	45.7
Self-supplied C&I	63.70	178.52	114.82	180.2
Self-supplied domestic	8.86	12.01	3.15	35.6
Irrigation and agriculture	139.40	195.77	56.37	40.4
Subtotal (w/o power)	339.20	571.66	232.46	68.5
Power generation	1,315.35	1,342.37	27.02	2.1
TOTAL	1,654.55	1,914.03	259.48	15.7

C&I = Commercial and industrial water sector; w/o = without;

Note: All withdrawal values reported in million gallons per day (MGD)

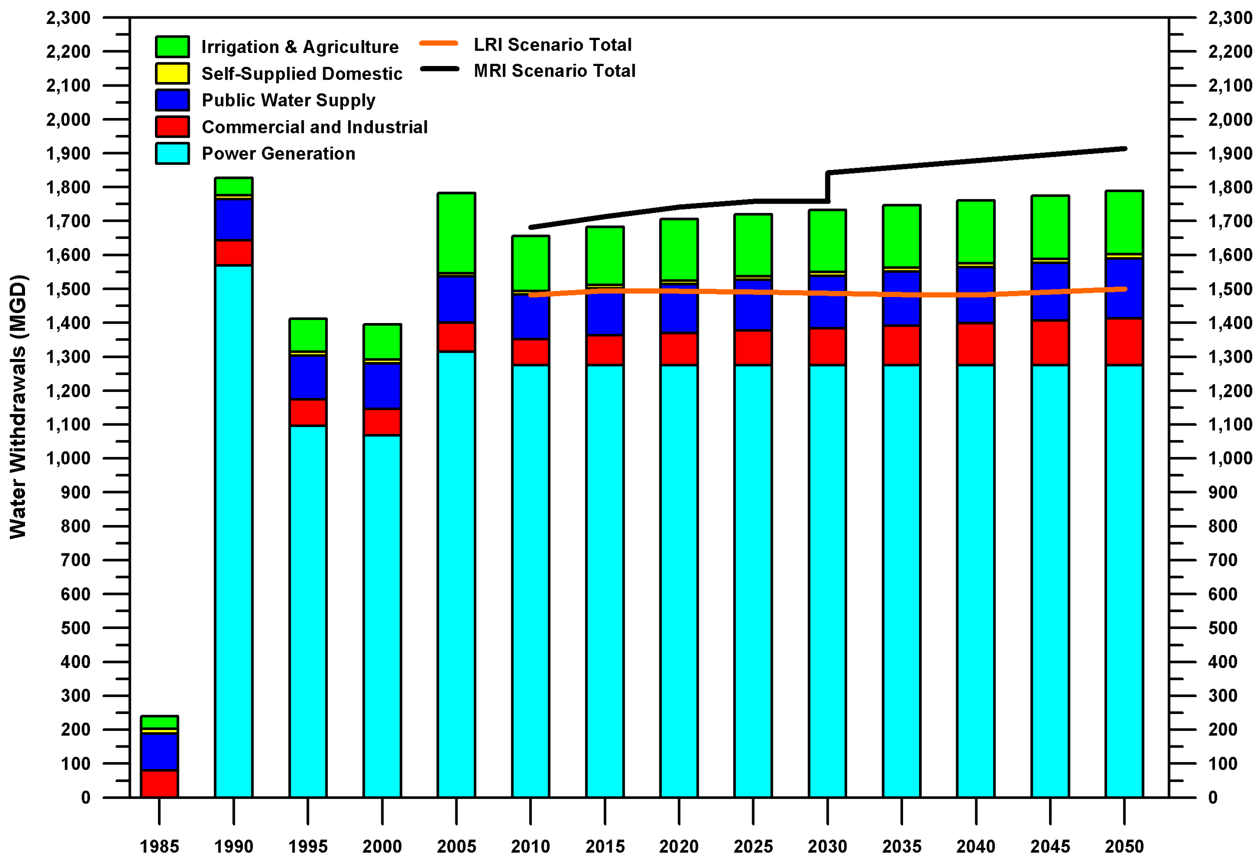
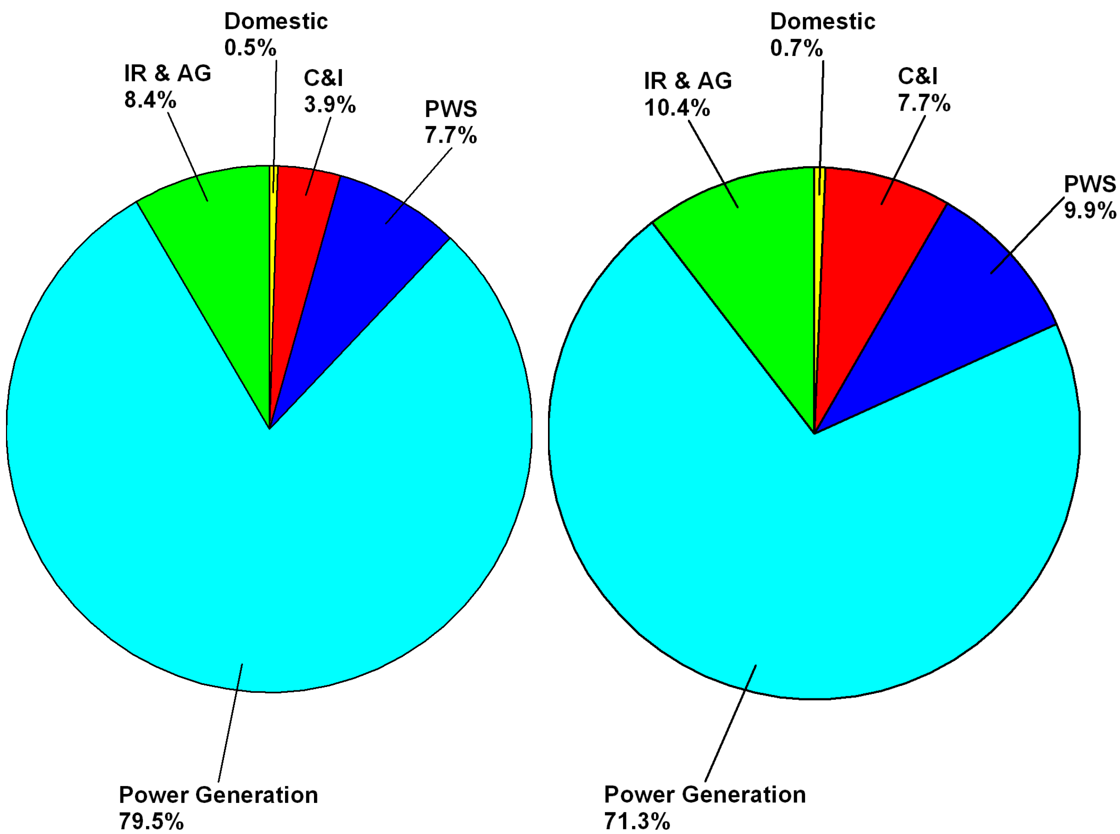


Figure 7.1: Historical and future water withdrawals in East-Central Illinois from 1985 to 2050.



(a) 2005 (Normal) (b) 2050

Figure 7.2: Percent of total water withdrawals by demand sector in East-Central Illinois in 2005 (Normal) and 2050 for the baseline scenario.

The following summarizes the baseline scenario for each sector in the demand analysis.

Public water supply - The public supply sector accounts for approximately 9.9% of the 2050 withdrawals in East-Central Illinois. Not including the power generation withdrawals, public supply accounts for 34.5% of the 2050 withdrawals. The baseline scenario estimates an 39% increase, from 127.2 MGD to 176.9 MGD by 2050.

Self-supplied domestic - The smallest water-demand sector, domestic supply accounts for approximately 0.7% of the 2050 withdrawals in East-Central Illinois. Not including the power generation withdrawals, domestic supply accounts for 2.3% of the 2050 withdrawals. The baseline scenario estimates an 35.6% increase from 8.9 MGD to 12.0 MGD in 2050.

Self-supplied power generation - Power generation is the largest water demand in the region accounting for 71.3% of total withdrawals. However, the water withdrawals are expected to decline in the baseline and LRI scenarios and increase only 2.1% in the MRI scenario. The baseline scenario estimates a 3.0% decrease, from 1,315.4 MGD to 1,275.5 MGD, by 2050.

Self-supplied commercial and industrial - The commercial and industrial sector accounts for approximately 7.7% of the 2050 withdrawals in East-Central Illinois. Not including the power generation withdrawals, C&I accounts for 26.8% of the 2050 withdrawals. The baseline scenario estimates a 115.9% increase, from 63.7 MGD to 137.5 MGD, by 2050. This sector is estimated to have the largest increase in demand. This increase is due, in part (approximately 10 MGD), because of proposed water intensive industries, included as ethanol plants, in the scenarios.

Self-supplied irrigation and agriculture - Irrigation and agriculture accounts for approximately 10.4% of the 2050 withdrawals in East-Central Illinois. Not including the power generation withdrawals, IR&AG accounts for 36.4% of the 2050 withdrawals. The baseline scenario estimates a 33.8% increase, from 139.4 MGD to 186.5 MGD, by 2050.

7.2 County results

The total withdrawals for each county are shown in Table 7.2. To compare the relative amounts withdrawn in each county in 2050, the percent of each demand sector are shown graphically in Figure 7.3. DeWitt, Mason, Tazewell, and Sangamon counties all have withdrawals over 150 MGD. These large withdrawals are primarily due to the power generation plants within those counties. Ford, Iroquois, Logan, Menard, Piatt, and Woodford counties are all expected to have withdrawals less than 10 MGD.

Figure 7.3 shows that public water supply is the primary withdrawal sector in Champaign, McLean, Macon, and Vermilion counties, whereas irrigation and agriculture are the primary withdrawals in Cass, Mason, and Menard counties. Commercial and industrial water withdrawals are focused within Macon and Tazewell counties. Self-supplied domestic remains a very small portion of each county.

Because the power generation withdrawals are relatively large compared to the other sectors and there are plants in only five of the fifteen counties, it is insightful to look at withdrawals without power generation. When you exclude power generation, Mason and Tazewell counties have the largest total withdrawals (Figure 7.4), but for different reasons. In Mason County the withdrawals are primarily for irrgation and agriculture. In Tazewell County, the withdrawals are mostly commercial and industrial, but also have significant withdrawals for public water supply and irrigation and agriculture. The next tier of counties, in the 40-60 MGD range, are Champaign, Macon, and Sangamon. These withdrawals are in large part public water supply and commercial and industrial water sectors. The remaining counties are all expected to have withdrawals less than 30 MGD by 2050.

Tables and figures showing the individual county results, by water sector for every year of interest are provided in Appendix G.

Table 7.2: Future withdrawals for each county, by demand sector, for the year 2050 (in MGD) for the baseline scenario.

County	Public water supply (MGD)	Domestic (MGD)	Power generation (MGD)	Commercial & industrial (MGD)	Irrigation & agriculture (MGD)	Total (MGD)
Cass	2.32	0.44	–	3.16	15.84	21.76
Champaign	33.62	2.56	–	9.74	6.15	52.07
DeWitt	1.83	0.4	810.44	0.03	0.94	813.64
Ford	2.25	0.25	–	6.54	0.92	9.96
Iroquois	3.3	0.96	–	1.48	3.25	8.99
Logan	3.99	0.71	–	2.82	2.08	9.59
Macon	31.33	0.21	–	26.59	0.41	58.54
Mason	0.95	0.55	105.00	7.48	108.26	222.24
McLean	24.07	1.55	–	2.07	2.15	29.85
Menard	1.04	0.02	–	0.00	3.09	4.16
Piatt	1.42	0.46	–	1.56	0.49	3.94
Sangamon	31.74	1.54	331.46	7.93	1.64	374.31
Tazewell	25.39	0.12	25.88	62.05	39.14	152.59
Vermilion	10.52	0.66	2.76	6.04	0.72	20.71
Woodford	3.08	1.58	–	0.02	1.39	6.06
Total	176.88	12.01	1,275.54	137.51	186.46	1,788.40

All data reported in million gallons per day (MGD).

All sectors, except public water supply, are self-supplied

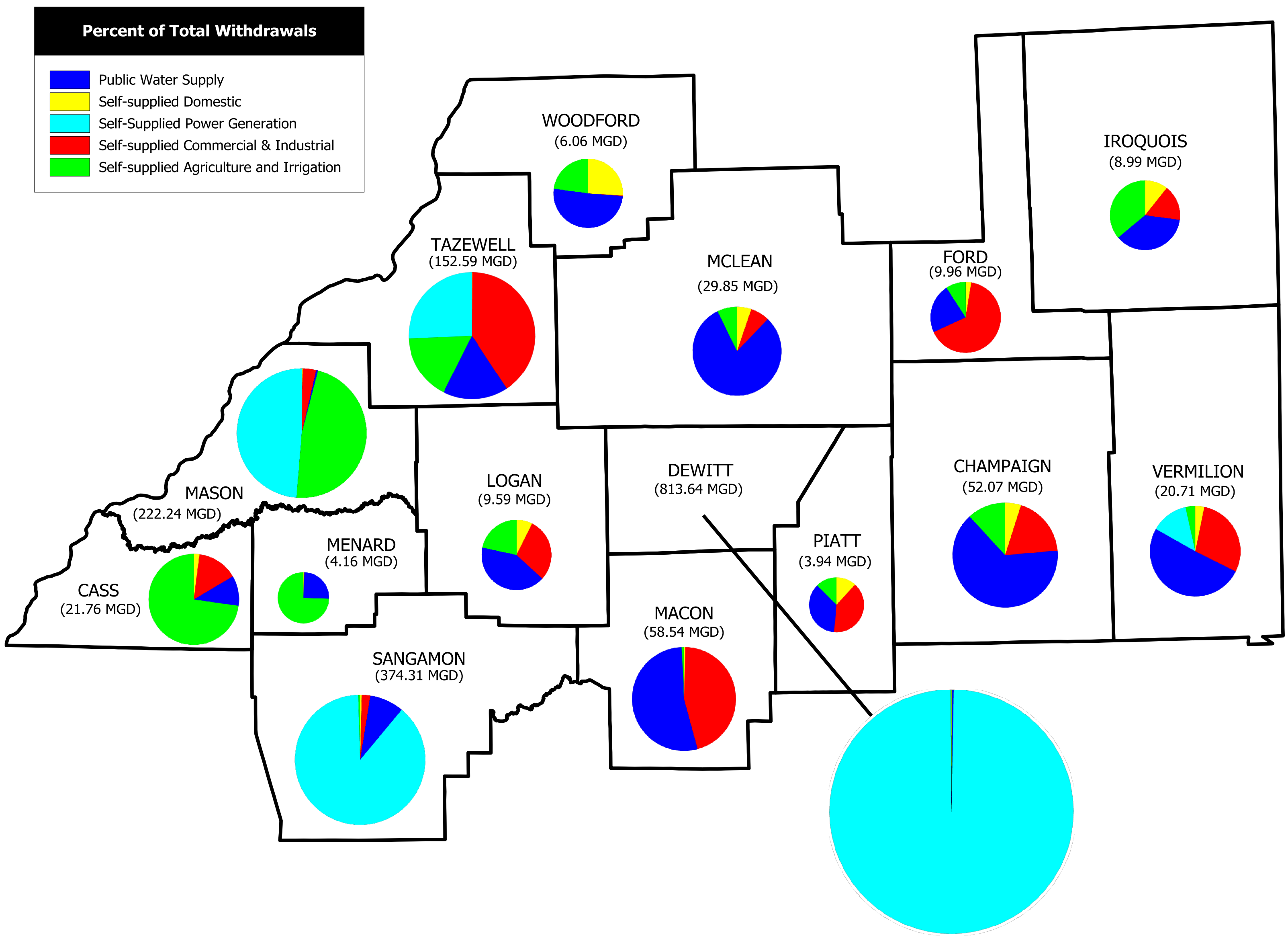


Figure 7.3: County water withdrawals in East-Central Illinois in 2050 by demand sector for the baseline scenario.

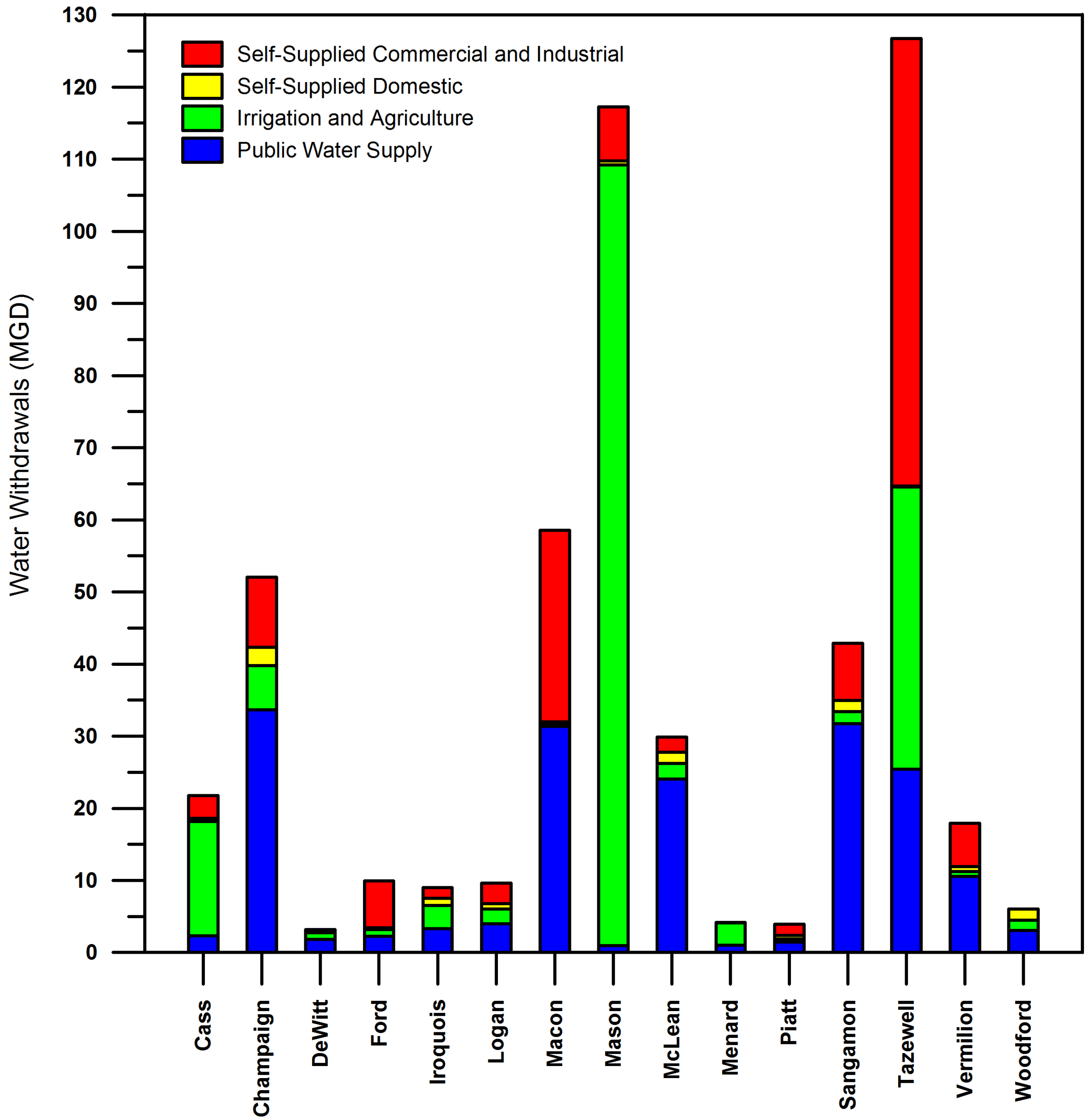


Figure 7.4: Future withdrawals for each county, by demand sector, for the year 2050 (in MGD) for the baseline scenario. *Power generation sector not included.*

7.3 Data issues

The goal of this study is to estimate the water withdrawals by water demand sector for the 15-county region in East-Central Illinois to the year 2050. This goal has been achieved with the best information available and the future withdrawal estimates are provided to the RWSPC with confidence. However, the process has not been without difficulty and we would like to inform the RWSPC about the data issues we confronted. The following are our recommendations to the RWSPC on how to improve the data so as to better enable water demands to be estimated in the future.

- **All water demand sectors should report water withdrawals -** Currently, three of the four water demand sectors report to the IWIP program of the ISWS; public water supply, commercial and industrial, and power generation. Because irrigation has significant withdrawals in the region, approximately 10% of the total, it is important that these withdrawals are accurately reported and accounted for in the water withdrawals database.

- **Reporting should be mandatory -** Reporting to the IWIP program of the ISWS is currently voluntary. In order to achieve accurate accounting of all water withdrawals, the reporting should be made mandatory.

- **All water withdrawals should be made public -** Under the current system, commercial & industrial and power generation withdrawals are not available to the public due to confidentiality agreements with the ISWS (although some data is available through other public records, such as the EIA). As a public resource, the public should be able to see how water in the region is being used.

- **Water withdrawals should be accurately reported as withdrawals, not total water produced or used -** It is evident in the data that water users are not all reporting the same way. Some water users report how much water was sold to customers. Some report how much water was produced. Some report how much water was used in the cooling process. Some report how much water was withdrawn from the source. These differences provide an inaccurate accounting system of water withdrawals.

- **Monthly withdrawals should be reported -** Currently, withdrawals are reported on an annual basis as an annual average. However, water is not used uniformly throughout the year; there is monthly variation. In some cases, the monthly withdrawals can be 2-3 times the average. And with seasonal uses, like irrigation, withdrawals only occur a few months out of the year. By collecting monthly withdrawal data, the model will be better able to capture the relationship between the variables and water withdrawals. Monthly reporting provides more data and a more accurate portrayal of withdrawals. Reported water withdrawals should still be reported only annually, but should include monthly withdrawal data.

- **Population served should be accurately reported annually** The population served data supplied to the ISWS is inconsistent and often inaccurate. A lot of time and energy was spent trying to rectify this important dataset. Much of the problem was that not all PWSs were reporting the same way. For example, some reported census data one year and number of connections the next year leading to an inaccurate dataset.

- **Resident population estimates should be projected for the entire water supply planning period** - The county level resident population projections used in this study were provided by the Illinois Department of Commerce and Economic Opportunity (DCEO). These population projections were done for the years 2000 - 2030. Because the water demand study estimates withdrawals to the year 2050, we had to extend the state's projections. The RWSPC should request that when the state updates their population projections, they utilize the same projection years as the water supply planning process.

- **Employment populations should be projected for the entire water supply planning period -** The county level employment population projections used in this study were provided by the Illinois Department of Employment Security (IDES). These population projections were done for the years 2004 - 2014. Because the water demand study estimates withdrawals to the year 2050, we had to extend the state's projections. The RWSPC should request that when the state updates their employment projections, they utilize the same projection years as the water supply planning process.

- **Public water suppliers should report price annually -** Price, in this case marginal price, is an important demand variable for the public water supply sector. To better enable future studies, marginal price should be reported annually with the water withdrawals from each public water supply.

- **Significant changes (large increases or decreases in annual average) in water withdrawals should be explained -** Sometimes water suppliers or users, have large changes in water withdrawals from year to year. In some cases, the supplier may stop supplying water altogether. For example, in 2001 the City of Decatur sold one of its treatment plants to a local industrial user. In the water dataset, this was evidenced by a large decrease, 15 MGD, in 2005. Significant changes, like this one, that effect the amount of water withdrawn should be noted in the annual reporting.

As water supply planning in Illinois matures, the hope is to streamline the process of data collection and analysis such that appropriate decisions can be made about water supply planning in each region and in the state. The recommendations outlined above will better enable the RWSPC to understand water demand and withdrawals in the future.

This study examined the future water demand on a geographic region. However, it didn't address the ability of the water resources in that region to supply the estimated demand or the impact of the increased demand on the ecological or hydrological resources. Water demand estimates are important to understanding how different areas are using water and how fast and where the region is growing. What these estimates do not reveal is if the regional water sources, both surface water and groundwater, can supply and sustain the demand placed upon them. But, as these water withdrawals are utilized in the water supply modeling analysis performed by the ISWS, the RWSPC will be able to plan for the future and ensure that all water users within the region have a safe and secure water supply.

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Appendix A

Public Outreach

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EAST CENTRAL ILLINOIS REGIONAL WATER SUPPLY PLANNING COMMITTEE

P.O. Box 7318, Champaign, Illinois 61826-7318

Water-Demand Study
Meeting Agenda

- Welcome and introduction of water-demand study team

- Water-demand study background and methodology

  A power point presentation will be given that:
  1. provides background information about water-supply planning in Illinois
  2. shows the boundaries of the East Central Region
  3. discusses the goal of the water-demand study
  4. describes the study methodology and demand scenarios

- Historical data

  Graphs of county historical water-use and variable data will be presented by water-use sector.

- Divide into groups by water-use sector

  Participants will be asked to break into groups by water-use sector to share knowledge about historical and current trends in water-use. Meeting packets will be distributed that include graphs and a table of historical water-use and variables for each sector. A questionnaire, also included in the information packet, will be used to lead the group discussion and should be completed by participants as best as possible.

Please make sure you sign-in.

If you have questions regarding this meeting, please contact WHPA using the contact information on bottom of this page.

Wittman Hydro Planning Associates, Inc.
320 West Eighth Street, Suite 201, Bloomington, Indiana 47404
phone: (812) 333-9399 **fax: (812) 333-3080** *www.wittmanhydro.com*

Water-Demand Study Meeting for Cass, Mason, Menard, and Sanagmon Counties

The following is a synopsis of the water supply planning meeting held on August 22, 2007 in Havana, Illinois targeting Cass, Mason, Menard, and Sangamon counties.

Meeting Location: Havana, Illinois

Meeting Date: August 22, 2007

Targeted Areas: Cass, Mason, Menard, and Sangamon Counties

Main Concerns:
1. Water availability
2. Water quality
3. Economic impacts
4. Water conservation
5. Future regulations

Meeting Attendees

Group Represented	Number of Attendees
Public	44
East Central Illinois Regional Water Supply Planning Committee	2
Mahomet Aquifer Consortium Board	3
Illinois State Water Survey	2
Illinois State Geological Survey	1
Wittman Hydro Planning Associates (Water-Demand Study Team)	2
Total	**54**

Meeting Summary
Susan Licher of Wittman Hydro Planning Associates, Inc. (WHPA) gave a presentation on the scope and time line for the water supply planning project. This project involves a fifteen county region in East Central Illinois and was initiated in response to Governor Blagojevich's Executive Order 2006-1. Susan Licher's presentation focused on the background of the water supply planning initiative, the methods associated with assessing water-demand, and the historical data being used in the water-demand study.

After the presentation, the attendees were asked to state with whom they were affiliated and what specific concerns or comments they had regarding the study. The following paragraphs are a general synopsis of the stakeholders concerns.

Steve Waterworth of the Central Illinois Economic Development Corporation had a concern about how this study might influence the growth within the state of Illinois. If citizens and corporations in less water-rich areas have a report saying that water resources in East Central Illinois are abundant, they might move here in order to feel secure about the water supply. This influx may have a negative impact on the water supply.

Susan Licher responded by saying that the possible increase in demand by commercial and industrial uses will be part of the supply and demand study. The studies will look at where commercial and industrial activities may locate and determine where there might be conflict due to water availability.

Dr. Derek Winstanley of the Illinois State Water Survey followed this comment by saying that without reasonable planning there is conflict and that one objective of this study is to reduce conflict.

Wendy Martin from the Mason County Democrat said she wanted to know how the two separate studies - supply and demand - would complement one another and how we would avoid inconsistencies between the studies

Susan Licher responded by saying that the water demand study results will be given to the State Water Survey and they will be incorporating the demand results into the supply modeling.

Richard Nichols, the executive director of the Illinois Soil and Water Conservation District, is interested in what the study will accomplish. Specifically, he was interested in how conservation would be utilized. He also stated that the Soil and Water Conservation Districts can help with groundwater recharge and conservation initiatives. Richard also talked about how climate change could impact water availability in the area. Industries could also come in and have substantial water uptake and impact water availability.

Cecil Gilson, a retired citizen concerned about water, remarked that municipalities want to tap into the aquifer. He asked if this was being considered in this study and asked if there would be large withdrawals as a result of this.

Susan Licher responded by saying that part of the future scenarios will look at the cumulative effects of all water users on the resource. Currently water is being withdrawn without looking at how water demands impact other users. This study will look at ways each of the users impact the water. One person's actions affect others and we must consider the cumulative impacts on all users and areas.

Aleda Riviere, a citizen from Forest City said that she applauds Richard Nichols for his comment regarding water conservation. Mason County has laws against gray water recycling and she wants to see this study used to save the water resources.

In response to Aleda Riviere's comment, Susan Licher stated that water conservation is important for the future and it is important to talk to committee members and voice your opinion. The Regional Water Supply Planning Committee is the public's voice and are the ones who will make the final recommendations regarding planning and management of the resource.

Andy Wiesenhofer, of Reynolds Well Drilling and member the Board of Directors of the Illinois Association of Groundwater Professionals, said that he came because he is information gathering. He is concerned about groundwater because he has been in the water business for thirty years. He also wants to see what the government is planning in regards to the water sources in Illinois.

A gentleman asked how the 12 member Regional Water Supply Planning Committee (RWSPC) obtained their positions on the committee.

Susan Licher said that it was formed by the Mahomet Aquifer Consortium. Invitations were sent out to people to invite them to sit on the board and be a part of the planning effort.

A gentleman asked if the Regional Water Supply Planning Committee was a closed board.

Morris Bell, a member of the RWSPC from Mason County, said that it is not a closed board and that meetings are held once a month and those meetings are open to the public. The committee has a responsibility after the studies are over to make recommendations for water management and planning.

A gentleman from St. Paul's Lutheran Church said that he was there to gather information. He is interested in private water use and particularly interested on what impact commercial and industrial users will have on private use.

Susan Licher stated that the study is regional in its focus, so it will not cover specific wells. In general, however, activities that affect the aquifer and areas of potential conflict will be considered. Susan Licher asked Dr. Derek Winstanley how he would deal with changes in heads on the supply side.

Dr. Derek Winstanley stated that the Water Survey will deal with head changes but not on a well-by-well basis.

A gentleman asked, “So there are no plans to put meters on every well?”

Dr. Derek Winstanley replied that the Survey would incorporate the water demand results into the supply models and see how water demands would change water levels on a regional basis but not on a well-by-well basis.

A gentleman asked Dr. Derek Winstanley where he could find the results of the completed studies.

Dr. Derek Winstanley said that the results from both studies will be published and available to the public. He then reiterated that people are welcome to come to the meetings being held over the course of the studies and obtain updated information as the studies continue.

A gentleman asked if the meeting details will be posted on the website and Dr. Derek Winstanley said that they would be available on the websites provided at the end of the presentation.

A gentleman asked how the RWSPC was selected and Dr. Derek. Winstanley said that the meeting to select the board members was put in local newspapers eight to nine months ago. About one hundred people turned up and those present made their own nominations for who they wanted as representatives. It was a self-selected process and not a state-led process. He said that they have looked at other states in determining how to run this process. Texas has been involved in water supply planning process for fifty years. In 1985, they decided that their previous top-down, government led approach did not work and finally started a bottom-up approach. For this reason, Illinois is implementing a bottom-up approach and developing recommendations through a grassroots effort.

Joan Esarey, a Havana citizen, said that she wondered if projections for supply included water quality parameters or water quality changes. She mentioned a concern about arsenic in groundwater, for example.

Dr. Derek Winstanley said that this is a three year study that is only dealing with two (2) priority areas and utilizing the available resources. He envisions that in the long term there will be a statewide process that will involve water quality, but right now there is not appropriate resources, time, and understanding to include water quality. Dr. Winstanley said that currently there is not a consensus about how naturally occurring arsenic gets into water resources. Water quality is a big issue in Northern Illinois, with naturally occurring radionucleides in the bedrock but again this is not being included at this time due to limited resources.

Ron Armbrust of Manito said that he is interested in the planning process because his livelihood, farming, is dependent on water. His biggest concern is water control or restrictions. He said that the aquifer is unconfined in this area and in Champaign situations are different. Ron Armbrust wanted to make sure this difference was considered. He also asked in what sector the local fish hatchery fell.

Susan Licher responded by saying that she thought that the hatchery was included in the irrigation and sector because the water use at the hatchery is different from most commercial and industrial users. Susan said she would look at the data to find out for sure where the Hatchery's use was included.

Ron Armbrust followed by saying that the Hatchery pumps all year long and does not have the seasonal changes like agriculture and irrigation, so he felt that the hatchery's water use was more closely related to commercial and industrial. Susan Licher stated she would take that into consideration and look more closely at the Hatchery's use.

As a follow up to Mr. Armbrust's comment on how different areas of the aquifer are structurally different, Dr. Derek Winstanley agreed and said that it was certainly wrong to generalize about the whole aquifer. In this area, for instance, there are large pumping rates and we know it is sustainable. This idea cannot be transposed to the eastern part of the aquifer, however.

Jim Nelson of the Soil and Water Conservation District asked if the water demand in one area affected the other side of the aquifer very much, since the areas were so different.

Dr. Derek Winstanley said that for some areas the water use on one side does not impact water availability on the other side. However, there is a very slow westward movement. Unlike the rapid water movement in a river, groundwater movement is only a few feet or tens of feet per year. Over a long period, though, there will be an affect.

Aleda Riviere expressed her concern that water is wasted by farmers. She has seen some irrigation water spraying onto roads rather than the intended fields. She asked if phone numbers could be posted at the end of the irrigation systems so that people could let the farmers know what was occurring.

Ron Armburst stated that the farmers had been informed that their irrigation systems were not reaching the intended areas.

Mel Pleines, chairman of the Mahomet Aquifer Consortium, said that when people have local concerns it is important that they let people in the committee know. They need citizens to let them know about issues so they can serve them appropriately.

Dr. Derek Winstanley said that planning is important and there is already a lot of planning within communities and industries. Dr. Winstanley related the idea of planning to individuals planning for retirement and that if you do not plan, you will not have enough resources for the future. The same ideas can be applied to water resources and without planning the State may not have enough resources for the future. It is better to begin planning now, rather then not have enough water in the future.

Susan Licher asked if there were more questions and seeing no more hands said that she would like people to take the packet(s) related to specific interests and fill out and return the questionnaires at the back of the packets by September 1. She thanked everyone for coming, reiterated that everyone needs to use the Regional Water Supply Planning Committee as their voice throughout this water supply planning process and the meeting was adjourned.

ADDENDUM
The local fish hatchery water demand has been placed in the Livestock sector. Aquaculture is considered in the U.S. Census of Agriculture as livestock production. Due to this fact, it was placed in Livestock rather than Commercial and Industrial water demand sector.

Water Demand Study Meeting for Champaign, Ford, Iroquois, and Vermilion Counties

The following is a brief synopsis of the August 20, 2007 water supply planning meeting held in Rantoul, Illinois targeting Champaign, Ford, Iroquois, and Vermilion counties.

Meeting Location: Rantoul, Illinois

Meeting Date: August 20, 2007

Targeted Areas: Champaign, Ford, Iroquois, and Vermilion counties

Main Concerns:
1. Water availability
2. Ethanol production

Meeting Attendees

Group Represented	Number of Attendees
Public	27
East Central Illinois Regional Water Supply Planning Committee	4
Mahomet Aquifer Consortium Board	2
Illinois State Water Survey	3
Illinois State Geological Survey	1
Wittman Hydro Planning Associates (Water Demand Study Team)	4
Total	**40**

Meeting Summary
Susan Licher of Wittman Hydro Planning Associates, Inc. (WHPA) gave a presentation on the scope and time line for the water supply planning project. This project involves a fifteen county region in East-Central Illinois and was initiated in response to Governor Blagojevich's Executive Order 2006-1. WHPA, in cooperation with Dr. Ben Dziegielewski from Southern Illinois University, was hired to conduct the demand study. Susan Licher's presentation focused on the background of the water supply planning initiative, the methods associated with assessing water demand, and the historical data being used in the water demand study.

After the presentation was completed, Susan invited attendees to ask questions.

One gentleman voiced a concern about the well that had been drilled for an incoming ethanol plant that is located a short distance from his well. He wanted to know if pumping would significantly affect the water-level in his well.

Jack Wittman of WHPA said that one plant would likely not have much of an effect on his supply. If many plants are introduced to the area, on the other hand, the impact could be significant. This is why regional demands are being examined. Jack suggested that the gentleman contact the State Water Survey. The survey can test the water level within the aquifer before and after the plant comes on-line to see if the plant caused a significant drop in the water level. During this discussion, it was noted that the water supply planning effort is regional in scale and will assess heads in the aquifer and areas of possible conflict and/or abundance.

Someone asked how much water it took to produce one gallon of ethanol. George Roadcap and Ed Mehnert, representatives of the Illinois State Water and Geological Survey, said that they thought it took about six to seven gallons to produce one gallon of ethanol. Jack Wittman said that he thought the numbers were closer to ten gallons of water per gallon of ethanol. The State Survey representatives added that ethanol plants use about 2 million gallons of water per day and release about 300,000 gallons of water per day into surface water sources. The baseline water demand scenarios will include the demand for all permitted ethanol plants and the "increased use" scenario will include potential future plants.

Bradley Uken commented that the aquifer changes as you go from east to west. The aquifer in the eastern portion of the study area is a confined aquifer while the western portion is unconfined. Therefore, the differences in how the aquifer recharges is different. Bradley stressed that due to these differences the best available data must be used in each portion of the aquifer. The eastern portion of the aquifer has less data available especially in regards to irrigation and cooperation from all parties will be required in order to properly assess the demands and supplies.

Susan Licher stated at the end of the discussion that the recommendations that will be made by the East Central Illinois Regional Water Supply Planning Committee must fall within existing regulations, laws, and property rights.

At the end of the meeting, the group was divided into sub-groups based upon water-use sector and questions and concerns were addressed within those groups. Each participant was provided with a packet of information regarding water-demand within their specific sector and a questionnaire that they were asked to fill out and return to WHPA.

ADDENDUM

After the meeting, WHPA, reviewed existing information on the amount of water needed to produce one gallon of ethanol. An article published by the Institute for Agriculture and Trade Policy (Kenney and Muller, 2006) states that a review of the existing data indicate that most plants consume from 3.5 to 6.0 gallons of water per gallon of ethanol produced. The Renewable Fuels Association estimates that 3 gallons of water are used per gallon of ethanol produced. Below are some links to websites that have additional information regarding ethanol.

http://www.ethanolrfa.org/

http://www.epa.state.il.us/air/permits/ethanol-plants.html

http://www.agobservatory.org/library.cfm?refid=89449

Water-Demand Study Meeting for DeWitt, Logan, Macon, and Piatt Counties

The following is a brief synopsis of the August 23, 2007 water supply planning meeting held in Clinton, Illinois targeting DeWitt, Logan, Macon, and Piatt counties.

Meeting Location: Clinton, Illinois

Meeting Date: August 23, 2007

Targeted Areas: DeWitt, Logan, Macon, and Piatt counties

Main Concerns:
1. Water availability
2. Implications for future regulations
3. Water quality
4. Study methods

Meeting Attendees

Group Represented	**Number of Attendees**
Public	26
East Central Illinois Regional Water Supply Planning Committee	3
Mahomet Aquifer Consortium Board	2
Illinois State Water Survey	2
Illinois State Geological Survey	1
Wittman Hydro Planning Associates (Water-Demand Study Team)	2
Total	**36**

Meeting Summary
Susan Licher of Wittman Hydro Planning Associates, Inc. (WHPA) gave a presentation on the scope and time line for the water supply planning project. This project involves a fifteen county region in East-Central Illinois and was initiated in response to Governor Blagojevich's Executive Order 2006-1. WHPA, in cooperation with Dr. Ben Dziegielewski from Southern Illinois University, was hired to conduct the demand study. Susan Licher's presentation focused on the background of the water supply planning initiative, the methods associated with assessing water-demand, and the historical data being used in the water-demand study.

After Susan Licher's presentation, she asked for volunteers to introduce themselves, explain why they were at the meeting, and to voice any questions or concerns they had regarding the study.

Robert Lieb from Piatt County stated that there are five or six wells located in the Mahomet aquifer that are being used to export water to areas outside of the Mahomet Aquifer. He asked if water-demands beyond the 15-county areas were being considered if they received their water from the Mahomet aquifer.

Susan Licher responded by stating that the water-demands will be considered for any well located within the Mahomet Aquifer even if the water was being exported outside the study boundaries. The study looks at the water-demand on the aquifers and surface waters within the 15-county region even if the users are outside of that 15-county boundary.

Dave Joswiak, the city manager of Farmer City, said that he was there to gather information and to figure out the impacts of water use on Farmer City. While there has not been a lot of growth in Farmer City in the last few years, he is concerned about the city being restricted in water-use and that this could affect their growth. In particular, he is concerned about the impacts of ethanol plants on water availability.

Susan Licher followed by saying that WHPA will try to get at that with the different scenarios, in terms of how ethanol plants will impact the aquifer. Also, part of the study is looking at the cumulative effects of individual users and individual industries.

Ed Glatfelter of the Illinois State Water Survey added that the study is to be done within existing rules and regulations. The study itself will be within those bounds. However, there may be changes in regulations later on as an indirect result of the studies taking place in relation to planning.

Matt Ringenburg of the Logan County Health Department said his main concern regarded domestic well users. He asked what type of recommendations would be made - regulatory, educational, or other?

Susan Licher responded by saying that there will likely be a variety of types of recommendations including educational, conservation, and regulatory but these would be just recommendations. It is the expectation that the local entities will take the recommendations and begin implementing. There will be different approaches in different areas, because this is a bottom-up process. What recommendations are appropriate for some areas may not be appropriate for others.

Shane Balding of S&J Well Drilling wanted to know if the study dealt with water quality issues related to abandoned wells. He wanted to know if the study dealt with water contamination from abandoned wells that had been capped. He was also concerned about geothermal intrusion.

Ed Glatfelter said that well abandonment will not be addressed in the study. Geothermal intrusion by smaller private or commercial users will not be considered in this study either because it is a water quality issue.

Charles Jolly from the Reynolds Drilling Coop asked how a firm from Indiana (WHPA) was selected and the amount of the contract awarded.

Susan Licher responded by saying that a request for proposal was sent out and WHPA sent a proposal. After all of the proposals were reviewed and companies were interviewed, WHPA was selected for the project. In terms of the exact price for the study, Susan Licher was unsure, but she said that she could retrieve that information.

Mel Pleines of the Mahomet Aquifer Consortium said that WHPA's proposal will be on the committee's website in the near future.

Stephen Parker of the DeWitt Soil and Water Conservation District asked if there had been comparisons done between the regression models used in other water-demand studies and the actual water-demand. He also asked that if yearly averages and seasonal averages are being extrapolated how well will this work if we do not have seasonal data.

Derek Winstanely talked about how the study done by Ben Dziegielewski was only completed two years ago, so there has been no comparisons available at this time. He also mentioned that some studies have been great at predicting actual usages while others have over estimated water-demands. It is important to recognize that no one can predict the future but depending on the information, the output can be very good.

Susan Licher said that she has only been with WHPA for a year, so she does not know how well some of the water-demand studies completed by WHPA had predicted future water-demands.

Stephen Parker asked how well these Texas regression models worked.

Derek Winstanley said that he wanted to clarify that Texas is just being used as an example. The actual water conditions in Illinois are quite different from those in Texas. Texas's approach to general water supply planning is being used but the water-demand modeling is different and specific to Illinois.

Stephen Parker asked how the data could be broken down seasonally.

Susan Licher said that part of the process of data collection is to talk to the public water supplies and to determine the peak season and peak daily demand. Peak season water demand is reported to the State Water Survey, but peak daily demand is not.

Stephen Parker asked how will the study be completed in time if not all the data are in. Will the data be in in time?

Susan Licher responded by saying that the historical data go back to 1985 and the study will analyze water-demand on a five-year increment. So the data is available for making those relationships.

John Stolfa, a resident of Piatt County, asked about the current water use regulations that users must adhere to.

Ed Glatfelter said that generally there are not a lot of regulations in regard to water use but there are regulations for water quality. As to a person's right to utilize water, there really are few laws to regulate usage. It is primarily common law that governs water usage. He said that this is one reason he feels it is important to have a planning process. It is legal to overuse the resource right now and there are no legal standings for someone to who is impacted by other users.

Shane Balding said that he thought that in Decatur there were laws to deal with this issue because Decatur had replaced or lowered several wells which had been impacted by their water-use.

Ed Glatfelter said that is a situation in which a company was trying to be a good neighbor and help people who had been impacted. However, they are not required by the law to help in any way.

Ed Mehnert of the Illinois State Geological Survey suggested looking at the Mahomet Aquifer Consortium website to read about Illinois water law.

Mel Pleines said that the main focus in this study was to determine what people expect to use in the future, factoring in growth, etc. The State is trying to find out how much water there is in the aquifer and from there it will be determined if the aquifer can supply the demand. If not, then steps will have to be made to reduce future conflicts.

Dave Joswiak asked if the study is only looking at the Mahomet Aquifer.

Susan Licher responded by saying that other aquifers, such as the Glasford Aquifer, are being considered. The study will include the entire strata from ground level all the way to the base of the Mahomet Aquifer.

Ed Mehnert added that the study incorporates both groundwater as well as surface water so it is a comprehensive planning process.

One gentleman asked if this was strictly a county based study or if we would be looking at HUCs or Hydraulic Units on the surface water side.

Susan Licher said that the water-demand study will be based both on county and city boundaries as discussed in the study area portion of the presentation. For the demand side, the data are generally at the county or city level.

Derek Winstanley said that the supply study is looking at the whole watershed in the statistical hydrological analyses.

The same gentleman asked if these studies are looking at the counties themselves.

Derek Winstanley responded by saying that the water supply study is based upon watershed boundaries.

Then, the gentleman asked if the models generated and the results were going to be accessible to other groups using models.

Derek Winstanley said that absolutely all the data models will be accessible and that they are going to go through external peer reviews.

Dave Joswiak asked where the risk of water contamination will be factored in.

Susan Licher responded by saying that this study deals more with water quantity than quality.

Ed Glatfelter said that the first three (3) years of the study will deal strictly with quantity. Where water quality makes some water unusable, that will be taken into account. In future iterations water quality will be taken into account.

One gentleman asked if the shallow unconsolidated glacial deposits that are not in the main Mahomet Aquifer would be considered in the study.

Susan Licher said that the whole strata in the fifteen county region will be considered not just the Mahomet Aquifer.

A gentleman asked if drainage systems that intersect the groundwater would be considered in the study.

Derek Winstanley said that the State Water Survey will look at recharge and total water budgets to the extent that it can and will draw connections.

The same gentleman asked if there were records for where there are farm fed drainage systems.

Derek Winstanley said that it varies. The data for tile drainage is emerging “slowly but surely” and that as the data becomes available there will be an effort to incorporate this information into the models. Right now there is not enough data to include the farm tile drainage networks.

There were no further comments so the meeting was concluded.

Water-Demand Study Meeting for McLean, Tazewell, and Woodford Counties

The following is a synopsis of the August 21, 2007 water supply planning meeting held in Tremont, Illinois targeting McLean, Tazewell, and Woodford counties.

Meeting Location: Tremont, Illinois

Meeting Date: August 21, 2007

Targeted Areas: McLean, Tazewell, and Woodford counties

Main Concerns:
1. Water availability
2. Water quality
3. Future regulations
4. Regional planning

Meeting Attendees

Group Represented	Number of Attendees
Public	42
East Central Illinois Regional Water Supply Planning Committee	3
Mahomet Aquifer Consortium Board	1
Illinois State Water Survey	1
Wittman Hydro Planning Associates (Water-Demand Study Team)	2
Total	**49**

Meeting Summary
Susan Licher of Wittman Hydro Planning Associates, Inc. (WHPA) gave a presentation on the scope and time line for the water supply planning project. This project involves a fifteen county region in East Central Illinois and was initiated in response to Governor Blagojevich's Executive Order 2006-1. Susan Licher's presentation focused on the background of the water supply planning initiative, the methods associated with assessing water-demand, and the historical data being used in the water-demand study.

After the presentation, the attendees were asked to state with whom they were affiliated and what specific concerns or comments they had regarding the study. The following paragraphs are a general synopsis of the stakeholders concerns.

Traci Barkley from the Prairie Rivers Network was concerned about surface-water base flows, public water supply protection, and habitat protection. Traci Barkley stated that people must realize that surface water and groundwater systems are interconnected and are not completely separate systems. She also expressed concerns regarding the inclusion of climate change through sensitivity analysis rather than in the three future scenarios, because climate does have an impact on the explanatory variables that will be used in the water demand models.

Susan Licher responded by saying that we are assessing climatic relationships between historical climate data and water. In order to understand the future scenarios in the study, sensitivity analysis was chosen by the group because of the uncertainty in the climatic models. The sensitivity analysis will allow us to asses the impacts of climate separately from the other variables that will be included in the three future scenarios.

Dave Dingledine, a water well contractor with M.E. Bent Company and the director of the Illinois Association of Groundwater Professionals, stated that he wanted to make sure that this group had the proper focus and that water restrictions were not implemented where water was plentiful. He wants to be a direct partner in water supply planning and the studies that are currently being conducted.

James Adams, McLean Mayor, and Dick McMann, a McLean Trustee, stated their concerns about growth in northern McLean County and its potential to significantly deplete the water supply in the Village of McLean.

Larry Littell with Spin Lake Public Water stated his concern about well-drilling by Bloomington and the potential of that well to significantly deplete the water supply.

Jennifer Sicks, McLean County Regional Planning Commission, stated that McLean County is currently working on a local demand study and she is interested in seeing how the regional water demand study data and information match up and work with their local study. In response to the two previous comments she said that she wants to see everyone in the county and region discussing how a new well field might impact them. She wants to see people involved in these processes and is interested in regional water supply planning in general.

At that point, Tom Korn with the Allin Township Water Authority introduced himself and stated that he came to the meeting to learn about and be involved in the whole process of water supply planning.

Glen Thompson of Tremont, who is originally from eastern Colorado, wants to see a fair and equitable system for water distribution here in Illinois. Being from the West he understands the importance of water supply planning and he is concerned about the long-term availability of water in Illinois without water supply planning.

Susan Licher stated that one reason Illinois began looking at water supply planning is that there are so many states that currently have water supply planning and Illinois is at a disadvantage without water supply planning. In areas where water shortages are common, water supply planning is critical. While Illinois is not in that situation currently, water supply planning can begin the process of looking at those areas where quantity may become an issue in the future.

Tom Edwards with the Sierra Club and River Rescue stated that he wanted conservation to be in the discussion. He was also concerned that water quality was not being directly included in these studies because there are many different sources of groundwater contamination.

As a response, Ed Glatfelter of the Illinois State Water Survey said that the supply study will deal with water quality only on a "macro level." Highly saline water in parts of the aquifer are not considered available water sources, for instance.

Traci Barkley followed by saying that water quantity will affect the water quality because water is used to dilute wastewater. In order to reduce the concentration of contaminants in surface waters there must be a sufficient supply of clean water to be used in the dilution process. She is concerned about both quality and quantity and does not want to see valuable groundwater being wasted for dilution.

Joyce Blumenshine of the Sierra Club followed that by saying that water quality is of concern now because groundwater and surface water are being polluted.

Although this is a concern, Ed Glatfelter stated that this is just the first iteration of a much longer process. He said that this study is largely modeled on work done in Texas. Every five (5) years Texas must start the whole water demand/supply process over. The first iteration of the study will not take a detailed look at water quality but the State hopes to incorporate it in the future.

One gentleman asked how the results of the study would be used and what role the planning committee plays in the outcome.

Ed Glatfelter answered by saying that once the study is completed, the Water Supply Planning Committee's role will be strictly advisory. The recommendations made by the committee must fall under existing laws and property rights. He hopes that the recommendations will be picked up by those organizations that have control of water use in their jurisdictions and that some or all of the recommendations will be implemented locally.

One gentleman requested a synopsis of the statements made today. Bob Duvall, Patrick Engineering, also requested copies of today's sign-in sheets.

Mel Pleines of the Mackinaw Valley Water Authority and Chairman of the Mahomet Aquifer Consortium stated that the goal of the study was to estimate the amount of water-demand the aquifer can support, what areas area available for growth, and those areas where conflict may occur in the future.

Wayne Deppert, a livestock and crop farmer and a representative of the Imperial Valley Water Authority, introduced himself and stated that his concern is water availability for his crops, livestock, and domestic use.

Traci Barkley asked how people can stay involved in the whole process.

Brent O'Neill, chairman of the Regional Water Supply Planning Committee, replied that on September 20, 2007 there will be a committee meeting at the Park Inn in Urbana. Registration will start around 9:30 a.m. and the meeting will run from approximately 10:00 a.m. until 2:00 p.m.. Lunch will be provided.

One gentleman asked about nitrates and other contaminants that are leaching into groundwater due to agricultural practices.

Morris Bell of the RWSPC believes there are no contaminants in the wells due to agriculture fertilization. He explained that farmers apply what is needed and what is applied is taken up by crops and not leached into the groundwater. He feels that people perceive the contamination to be much worse than it actually is.

In response, Tom Korn stated that, although farmers may apply only what is needed, there are spills sometimes. He mentioned an incident in which a a spill was cleaned up by the EPA 1.5 years after the spill occurred.

Susan Licher asked if there were more questions or concerns. She then invited all attendees to pick up information and questionnaire packets and the meeting was concluded.

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Appendix B

Public Water Supply Sector

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B.1 Public water supply model development

The development of the water use equation for preparing future water withdrawals represented a significant challenge because of the aggregate nature of the data and the limited number of observations on historical water withdrawals. The total number of available cross-sectional and time series observations was 205 (i.e., 41 study areas times 5 time periods). The procedure for estimating the predictive water-use equations consisted of three steps: (1) derivation of a "structural model", (2) compensating for fixed effects of study sites, and (3) examination of outliers on the estimated model coefficients. Each of these steps is described and illustrated with tables and figures below.

B.1.1 Structural model

A preliminary analysis of the data revealed that population served by public water supply systems in the study area explains 97 percent of the variability in total public-supply withdrawals. Therefore, population served was used to express the dependent variable as average public-supply water withdrawals (and purchases) per capita per day for each study area and data year. If the per capita rate of water withdrawals in each study area can be predicted with sufficient accuracy, then total public supply withdrawals can be estimated by multiplying the per capita use by population served, where the latter represents a driver of public-supply demands. One advantage of modeling the per capita use is that by expressing total withdrawals in per capita terms, the dependent variable is "normalized" across study sites and the heterogeneity associated with total withdrawals among the supply systems is reduced.

The first step was to identify the relevant explanatory variables, which would explain the variability of per capita withdrawals across study sites and time periods. These variables were selected based on information from previous studies of water demand. Several combinations of explanatory variables were examined prior to selecting the best "structural" model which explained the variability of historical water quantities in the data in terms of known determinants of water demand. The criteria for developing a good forecasting model are somewhat different from criteria in typical econometric applications where researcher wishes to know which variables are significant. A useful forecasting model requires not only an appropriate model specification but also accurate estimates of the regression coefficient (or elasticity) for each of the explanatory variables.

Table B.1 shows the estimated log-liner regression equation of the structural model. The equation includes six relevant explanatory variables. The expected signs (positive or negative) and magnitudes of the regression coefficients in the structural model are based on economic theory

Table B.1: Structural log-linear model of per capita water demand in public water supply sector (ln GPCD).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Structural Model			
Intercept	2.3339	0.30	0.7624
Max. summer temperature (ln)	0.8730	0.51	0.6085
Summer precipitation (ln)	0.0458	0.39	0.6936
Employment-population ratio	0.3057	1.71	0.0897
Marginal price of water (ln)	-0.3218	-4.55	<.0001
Median household income (ln)	-0.3457	-2.93	0.0038
Conservation trend	0.0015	0.33	0.7401
N = 205, R^2= 0.22, Mean Y = 4.74, Root MSE = 0.31			

and on the underlying physical relationships as well as on the results of the previous studies of aggregate water demand in public water systems. The expected signs are positive for temperature and income and negative for precipitation and price of water. Expectations about the sign of the other two other variables are: positive for employment-to-population ratio and negative for time/conservation trend. However, the prior knowledge about the magnitude of the coefficients of these two variables is limited.

The results in Table B.1 show that three of the six regression coefficients are not statistically significant. Median household income, employment-population ratio, and marginal price of water variables have statistically significant coefficients at 10 percent level of significance. Also, the coefficients of the summer precipitation and the conservation trend variables are positive, which is contrary to the expected sign.

The low significance of the three variables is likely a result of the small data sets (n = 205) and possible data errors in some of the observations on the dependent and independent variables. Under such conditions it is a challenge to derive a water-demand equation which meets the requirements of a good model for deriving future water demand. This is the main reason why alternative model specifications must be considered and each data point needs to be examined in some detail.

B.1.2 Model with Year 2005 binary

One concern regarding the data was that the year 2005 was a drought year (with a moderate drought in terms of precipitation deficits) and that its inclusion in the data could bias the estimated regres-

Table B.2: Re-estimated log-linear model of per capita water demand with Year 2005 binary (ln GPCD).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Structural Model			
Intercept	-3.9862	-0.75	0.4550
Max. summer temperature (ln)	1.7903	1.53	0.1289
Summer precipitation (ln)	-0.1047	-1.56	0.1206
Employment-population ratio	0.6562	5.54	<.0001
Marginal price of water (ln)	-0.2050	-3.39	0.0009
Median household income (ln)	0.3282	3.07	0.0025
Conservation trend	-0.0028	-1.07	0.2861
Year 2005 binary	-0.0756	-1.58	0.1170
N = 205, R^2= 0.23, Mean Y = 4.74, Root MSE = 0.30			

sion coefficients of the structural variables. In order to determine if this was the case a time period binary variable which designates the year 2005 was added to the extended model (from Table B.1) and the model was re-estimated. The resultant regression equation is shown in Table B.2 below.

The results in Table B.2 show that the coefficient of the binary time period variable (Year 2005 binary) is not significant at the 10 percent level of significance. The addition of the 2005 binary increased the coefficients of temperature and changed the sign of the precipitation variable. Also the level of significance of the temperature and precipitation variables have increased although the coefficients of the temperature, precipitation, and conservation trend variables are not significant at the 10 percent level. Because of the lack of statistical significance of the four regression coefficients the next step in model building was undertaken.

B.1.3 Model with fixed effects of study areas

The next step in model development was to extend the model from Table B.2 by including the binary variables designating individual study areas. A regression of the key structural variables along with the study area binary variables to compete for a significant share of the remaining model variance was estimated. This was accomplished by using a stepwise regression procedure through which binary variables are added to the structural model to account for each study area. The binary study area variables with statistically significant regression coefficients were kept in the model. This extended, fully-specified model is presented in Table B.4 below. In addition to the six structural model variables and the Year 2005 binary, it includes 26 binary variables which designate the study areas. All but 2 of the 26 system bianary variables have regression coefficients which are statistically significant. These statistically significant coefficients can be considered as representing site specific “intercept adjusters” because they increase or decrease the main intercept of the regression equation.

The structural part of the model in Table B.4 includes statistically significant regression coefficients for three of the six variables and the Year 2005 binary. Because of the lack of statistical significance of the three regression coefficients the next step in model building was undertaken.

B.1.4 Effects of outliers on model coefficients

The model shown in Table B.4 was examined for the effects of possible outliers on the magnitudes and statistical significance of the estimated coefficients. A special procedure was used to examine the effects of outliers on the estimated model without removing any suspected observation from the data or changing the observations in the original data by using a statistical “smoothing” procedure, or other methods. Accordingly, each of the 205 observations in the data set was assigned a binary indicator variable (i.e. a spike dummy) which assumes the value of 1 for a given data point and a value of zero elsewhere. For example a binary variable designated as Springfield-2005 assumes the value of 1 for the 2005 data point for Springfield system and zero for all other observations. Similarly, Bloomington-1995 is binary variable which assumes the value of 1 for 1995 in Bloomington and zero elsewhere.

These binary variables are referred to as “outlier variables” and their estimated coefficients would reveal “outlier effects”. The advantage of this procedure is that all observations can be assessed with respect to the prediction surface of any model being estimated. It is important to note that the term “outlier” as used in this analysis or any other analysis is not necessarily a data error. It is only an observation that is far away from the regression surface or the prediction surface in a multivariate model. This distance depends on the model and different outliers are identified for different models. In this sense, these data points can be could be called "model outliers" as opposed to "data outliers."

Using the above procedure, the effects of outliers on the coefficients of the model in Table B.4 are analyzed and are presented in Table B.5 and are graphed in Figures B.1 - B.6. For some variables these effects appear to be minor. Significant shifts on the regression coefficients were obtained for four variables: maximum summer temperature, summer precipitation, median household income, and conservation trend.

Table B.3: Re-estimated log-linear model of per capita water demand with study area binaries (ln GPCD).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Structural model			
Intercept	-1.1056	-0.19	0.8534
Max. summer temperature (ln)	1.1247	0.86	0.3934
Summer precipitation (ln)	-0.0515	-0.69	0.4925
Employment-population ratio	0.6289	4.81	<.0001
Marginal price of water (ln)	-0.2257	-3.33	0.0011
Median household income (ln)	0.3003	2.53	0.0123
Conservation trend	-0.0004	-0.14	0.8857
Year 2005 binary	-0.0945	-1.76	0.0796
System intercepts			
Cass County Rem.	0.2356	2.94	0.0037
Champaign-Urbana	0.1700	2.13	0.0343
Mahomet	-0.4324	-4.79	<.0001
Champaign County Rem.	-0.6201	-7.70	<.0001
Ford County Rem.	0.1229	1.51	0.1342
Lincoln	0.3184	3.79	0.0002
Decatur	0.8335	10.07	<.0001
Forsyth	-0.3232	-2.79	0.0058
Macon County Rem.	-0.3962	-4.72	<.0001
Petersburg	-0.2800	-3.31	0.0011
Menard County Rem.	-0.7185	-8.73	<.0001
Monticello	0.1553	1.87	0.0633
Piatt County Rem.	-0.2889	-3.49	0.0006
East Peoria	-0.1853	-2.25	0.0260
Pekin	0.2514	3.10	0.0023
Tazewell County Rem.	-0.4970	-6.16	<.0001
Danville	0.3797	4.53	<.0001
Vermilion County Rem.	0.4102	5.18	<.0001
N = 205, R^2= 0.80, Mean Y = 4.74, Root MSE = 0.17			

Rem. = remainder of the county served by a PWS not listed as a study area.

Table B.4: Re-estimated log-linear model of per capita water demand with study area binaries (ln GPCD). (continued)

Variables	Estimated coefficient	t Ratio	Probability >ltl
System intercepts			
Goodfield	-0.3738	-4.33	<.0001
Woodford County Rem.	-0.3677	-4.37	<.0001
Beardstown	0.3202	2.66	0.0086
Hudson	-0.2744	-2.52	0.0125
Normal	-0.2334	-2.86	0.0047
Iroquois County Rem.	-0.1702	-2.11	0.0362
McLean County Rem.	-0.1325	-1.61	0.1091
Sangamon County Rem.	-0.3240	-3.89	0.0001
N = 205, R^2= 0.80, Mean Y = 4.74, Root MSE = 0.17			

Rem. = remainder of the county served by a PWS not listed as a study area.

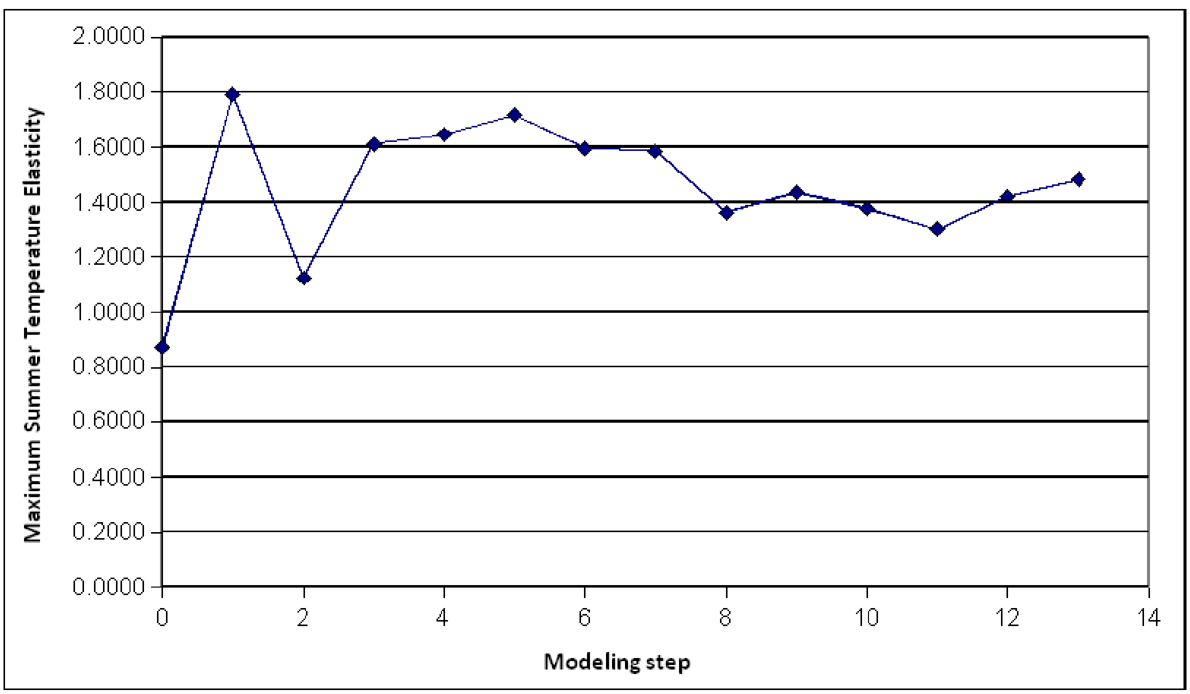

Figure B.1: Effects of binary site variables and spike dummies on estimated elasticity of temperature.

Table B.5: Effects of adding binary study area and spike dummies on estimated regression coefficients of the structural model.

Step	Model specification/ Outliers	Maximum Summer Temperature (ln)	Summer Precipitation (ln)	Employment to Population ratio	Marginal Prince (ln)	Median Household Income (ln)	Conservation Trend	Year 2005
0	Structural model only	0.8730	0.0458	0.3057	-0.3218	-0.3457	0.0015	–
1	Structural + Year 2005	1.7903	-0.1047	0.6562	-0.2050	0.3282	-0.0028	-0.0756
2	Study area binaries	1.1247	-0.0515	0.6289	-0.2257	0.3003	-0.0004	-0.0945
Spike variables								
3	Mason Co. Rem. 2005	1.6133	-0.0664	0.6579	-0.2276	0.2784	-0.0010	-0.1021
4	Bloomington 2000	1.6455	-0.0695	0.6368	-0.2424	0.2561	-0.0013	-0.0980
5	Decatur 1985	1.7150	-0.0747	0.6397	-0.2397	0.2721	-0.0021	-0.0960
6	Washington 2005	1.5967	-0.0874	0.6089	-0.2465	0.3180	-0.0023	-0.0857
7	Sangamon Co. Rem. 2005	1.5859	-0.0872	0.6049	-0.2446	0.3164	-0.0022	-0.0765
8	Sangamon Co. Rem. 2000	1.3628	-0.0956	0.5962	-0.2442	0.3123	-0.0013	-0.0820
9	DeWitt Co. Rem. 2005	1.4369	-0.0865	0.6060	-0.2403	0.3232	-0.0014	-0.0715
10	Mason City 1990	1.3758	-0.0996	0.6491	-0.2277	0.3308	-0.0015	-0.0726
11	Ford Co. Rem. 1985	1.3005	-0.1169	0.6493	-0.2211	0.3248	-0.0019	-0.0732
12	Piatt Co. Rem. 2000	***1.4222***	***-0.1140***	***0.6381***	***-0.2226***	***0.3244***	***-0.0026***	***-0.0645***
13	Dewitt 2005	1.4810	-0.0993	0.6008	-0.2204	0.3593	-0.0027	-0.0468

Rem. = remainder. Note: Coefficients of the selected model are shown in ***italics***.

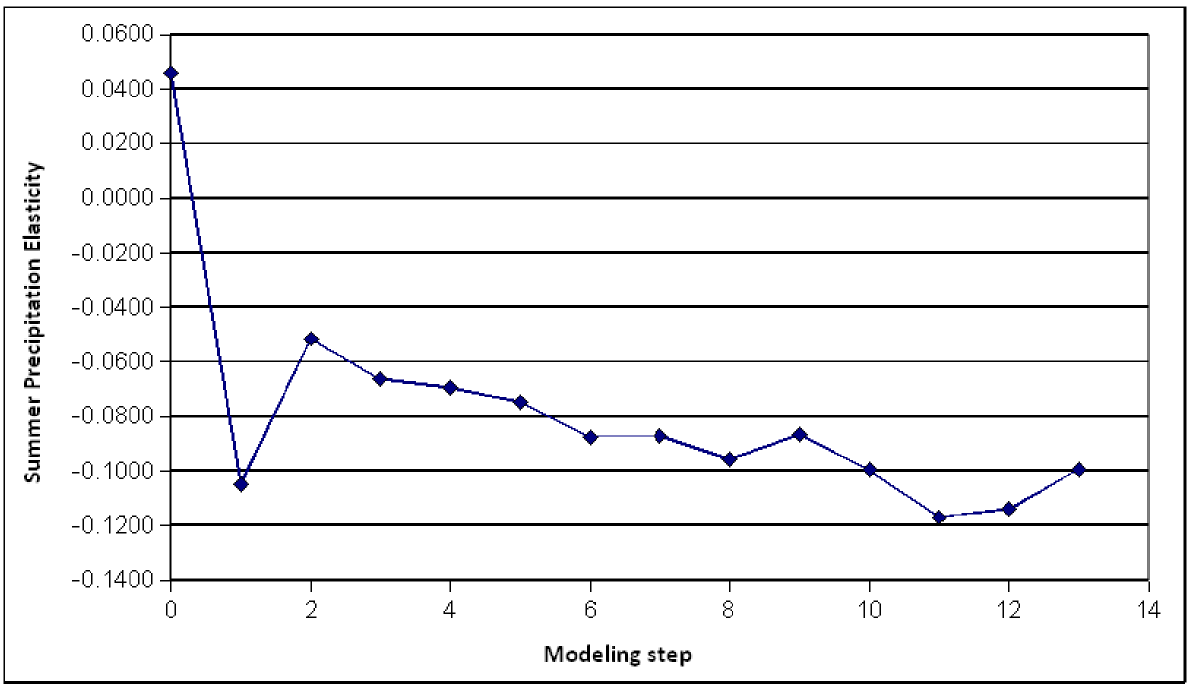

Figure B.2: Effects of binary site variables and spike dummies on estimated elasticity of precipitation.

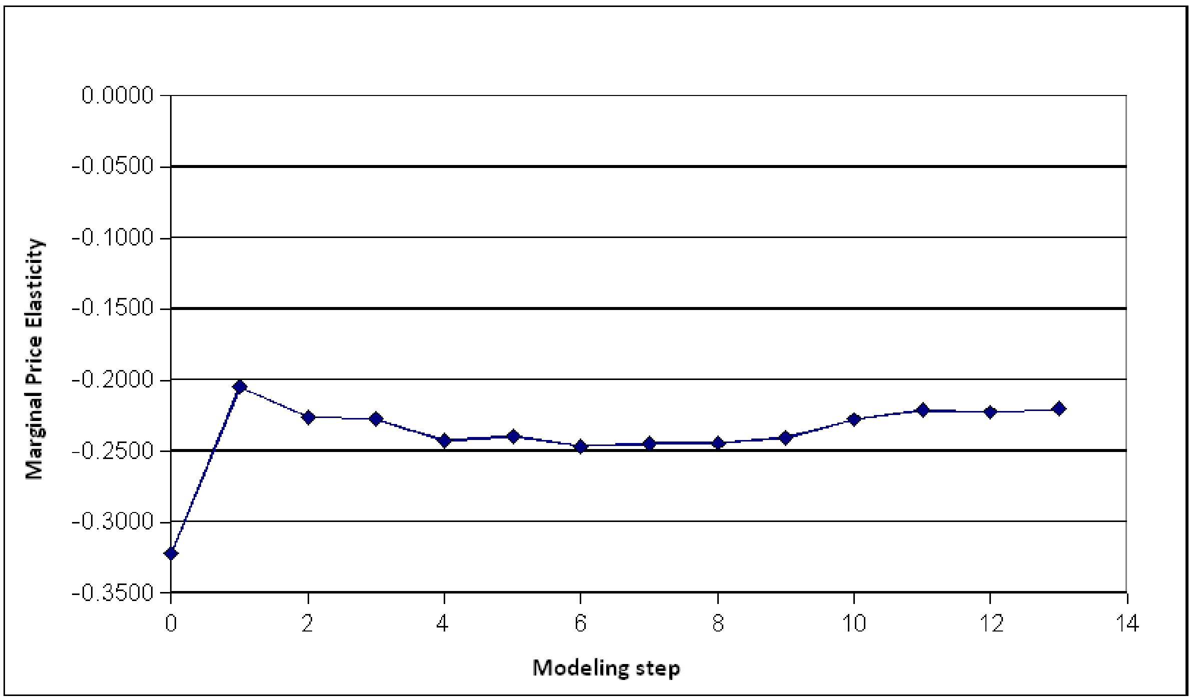

Figure B.3: Effects of binary site variables and spike dummies on estimated elasticity of marginal price.

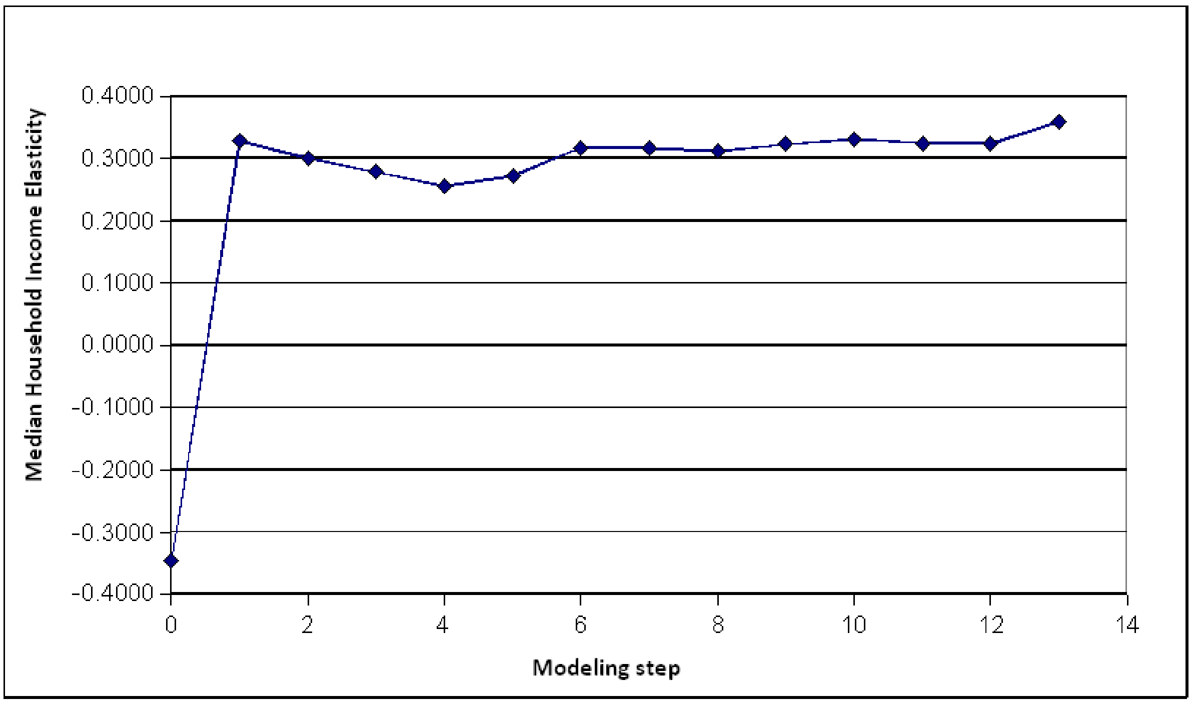

Figure B.4: Effects of binary site variables and spike dummies on estimated elasticity of median household income.

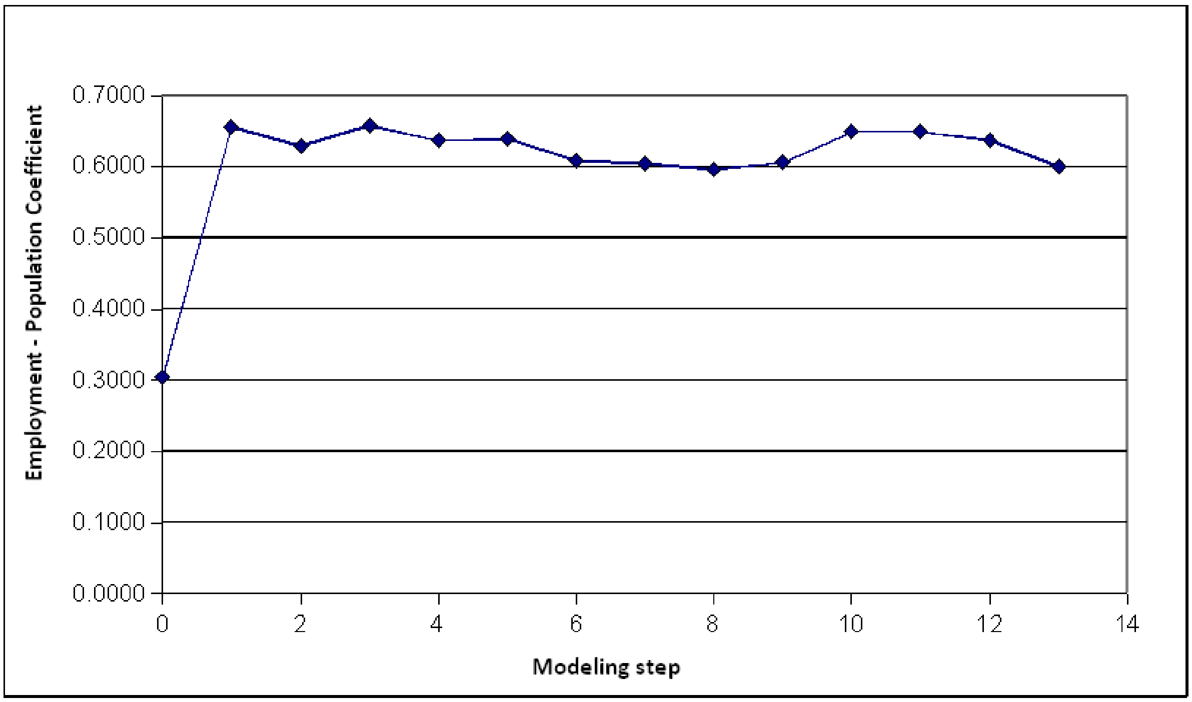

Figure B.5: Effects of binary site variables and spike dummies on estimated coefficient of population to employment ratio.

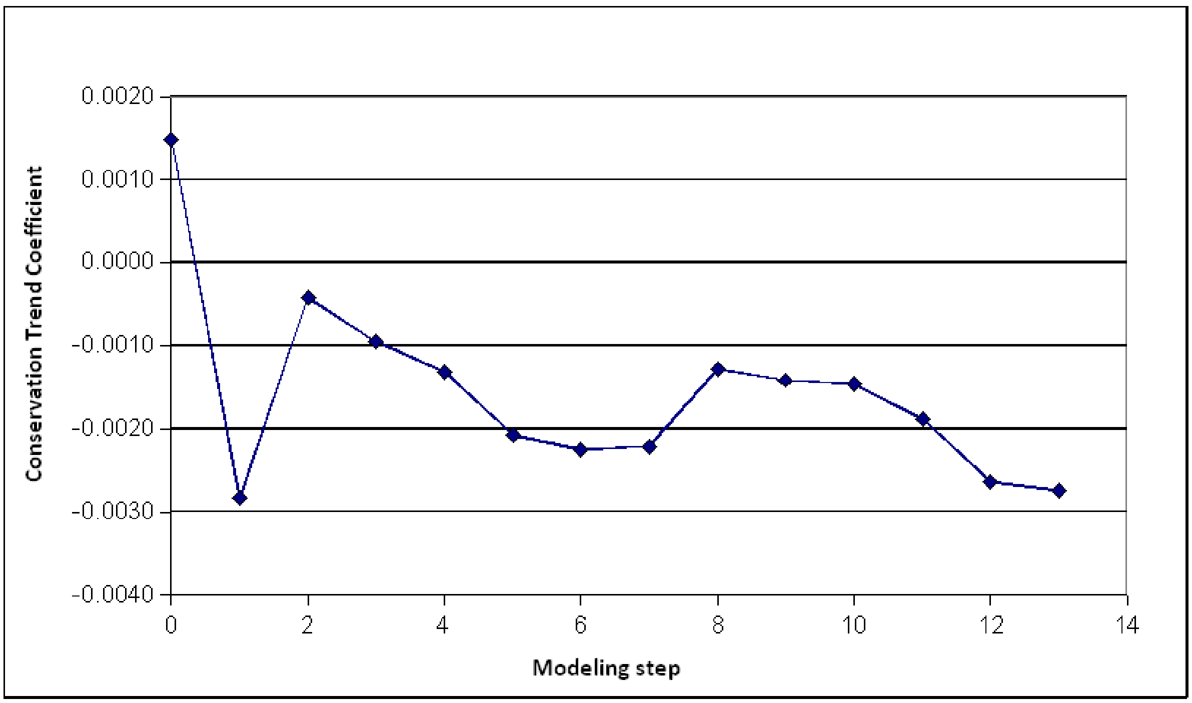

Figure B.6: Effects of binary site variables and spike dummies on estimated coefficient of conservation trend variable.

B.1.5 Final regression model

After examining the effects of model outliers on the estimated regression coefficients of the structural model, 10 binary outlier variables were added to the model from Table B.5, thus removing their effects on the estimated model. The re-estimated regression equation with the 10 outlier variables is shown in Table B.6 below.

Table B.6: Final log-linear model of per capita water demand in public water supply sector (ln GPCD).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Structural model			
Intercept	-2.3058	-0.43	0.6683
Max. summer temperature (ln)	1.4222	1.20	0.2313
Summer precipitation (ln)	-0.1140	-1.67	0.0964
Employment-population ratio	0.6381	5.30	<.0001
Marginal price of water (ln)	-0.2226	-3.64	0.0004
Median household income (ln)	0.3244	2.99	0.0033
Conservation trend	-0.0026	-0.98	0.3284
Year 2005 binary	-0.0645	-1.33	0.1863

Table B.6: Final log-linear model of per capita water demand in public water supply sector (ln GPCD).

Variables	Estimated coefficient	t Ratio	Probability >|t|
System intercepts			
Cass County Rem.	0.2323	3.26	0.0014
Champaign-Urbana	0.1707	2.41	0.0172
Mahomet	-0.4449	-5.48	<.0001
Champaign County Rem.	-0.6218	-8.66	<.0001
Ford County Rem.	0.1819	2.26	0.0255
Lincoln	0.3132	4.18	<.0001
Decatur	0.9007	11.03	<.0001
Forsyth	-0.3502	-3.36	0.0010
Macon County Rem.	-0.4081	-5.45	<.0001
Petersburg	-0.2865	-3.80	0.0002
Menard County Rem.	-0.7343	-9.97	<.0001
Monticello	0.1510	2.03	0.0439
Piatt County Rem.	-0.3826	-4.72	<.0001
East Peoria	-0.1987	-2.70	0.0077
Pekin	0.2430	3.36	0.0010
Tazewell County Rem.	-0.5103	-7.08	<.0001
Danville	0.3806	5.10	<.0001
Vermilion County Rem.	0.4085	5.80	<.0001
Goodfield	-0.3969	-5.11	<.0001
Woodford County Rem.	-0.3894	-5.16	<.0001
Beardstown	0.3222	2.99	0.0033
Hudson	-0.2936	-2.99	0.0032
Normal	-0.2422	-3.33	0.0011
Iroquois County Rem.	-0.1714	-2.39	0.0180
McLean County Rem.	-0.1474	-2.00	0.0470
Sangamon County Rem.	-0.1542	-1.65	0.1001

Table B.6: Final log-linear model of per capita water demand in public water supply sector (ln GPCD).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Spike Binaries			
Mason Co. Rem. 2005	-0.5772	-3.71	0.0003
Bloomington 2000	0.3475	2.25	0.0258
Decatur 1985	-0.3755	-2.21	0.0285
Washington 2005	-0.3597	-2.28	0.0240
Sangamon Co. Rem. 2005	-0.4765	-2.72	0.0073
Sangamon Co. Rem. 2000	-0.4344	-2.49	0.0139
DeWitt Co. Rem. 2005	-0.3094	-2.02	0.0451
Mason City 1990	0.2892	1.85	0.0663
Ford Co. Rem. 1985	-0.3195	-1.87	0.0633
Piatt Co. Rem. 2000	0.4436	2.62	0.0095

N = 205, R^2= 0.848, Mean Y = 4.737, Root MSE = 0.149; MAPE = 14.0%
Model specification tests (statistic and significance): Ramsey power 2 = 0.1595 (0.6901), Ramsey power 3 = 0.0793 (0.9238), Ramsey power 4 = 0.0636 (0.9790)
Heteroscedasticity tests (statistic and significance):
White's test = 158.0 (0.6982), Breusch-Pagan test =36.55 (0.7456)

The results in Table B.6 show that the significance of the regression coefficients has increased to approximately 10 percent level for the weather variables. Model diagnostics tests shown at the bottom of the table indicate that the model is free from model specification errors (all three Ramsey tests have statistics which are not statistically significant).

The two heteroscedasticity tests of the model in Table B.6 relate to the classical assumptions of the regression model that the model error variance is constant, or homogeneous, across all observations. If this assumption is violated, the errors are said to be heteroscedastic. Heteroscedasticity (i.e., non-constant error problem) often arises in the analysis of cross-sectional data. The White test (158.0) is highly insignificant thus accepting the null hypothesis of no heteroscedasticity. Also, the Breusch-Pagan test (36.55) shows an insignificant value indicating the absence of the heteroscedasticity problem.

Finally, the graph of residuals versus predicted values of the dependent variable (Figure B.7 below) does not indicate a problem of non-constant error.

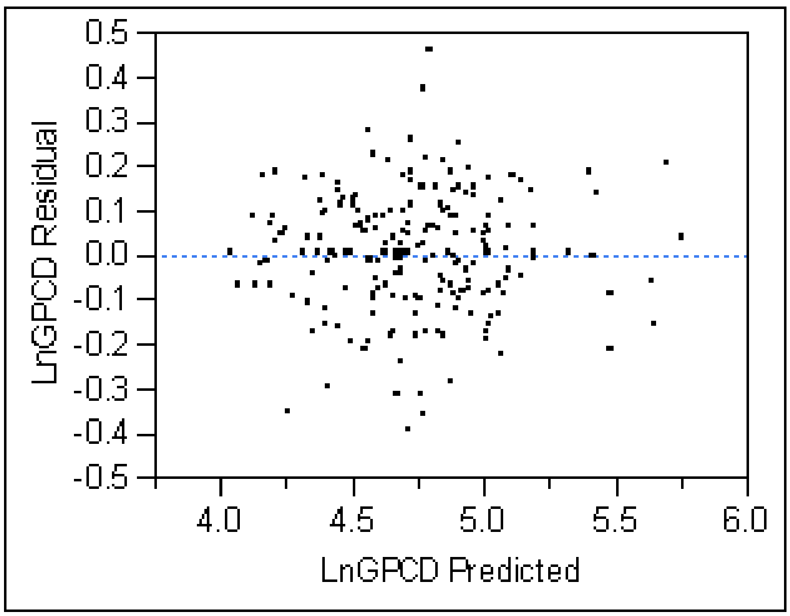

Figure B.7: Residuals plot for the model in Table B.6.

B.1.6 In-sample prediction error

The accuracy of the predictive models shown in Table B.6 was evaluated by the mean absolute percentage error (MAPE) by using the regression equation to estimate the historical values of water use in the data. This procedure is known as "in-sample" predictions.

In a linear model, designating $\hat{Y}_{it}$ to be the predicted value of the dependent variable Y_{it}, the absolute percentage error (APE) is given by:

$$APE_{it} = \left| \frac{\hat{Y}_{it} - Y_{it}}{Y_{it}} \right| x\,100 \tag{B.1}$$

In a log-linear model of the form shown in Table B.6, the APE in the log scale is given by:

$$APE_{it} = \left| \frac{ln\hat{Y}_{it} - lnY_{it}}{lnY_{it}} \right| x\,100 \tag{B.2}$$

Assuming that the errors are normally distributed in a log-linear model it can be shown that the expected value of the dependent variable in the raw (linear) scale is:

$$E\left(Y \mid explanatory\,variables\right) = e^{\sigma_{\varepsilon}^{2}/2}\left(e^{\ln \mathrm{Y}}\right) \tag{B.3}$$

Thus, in log-linear models, the predicted raw scale value denoted as $\widetilde{Y}$ is given by:

$$\widetilde{Y} = e^{\hat{\sigma}_{\varepsilon}^{2}/2}\left(e^{\ln \hat{\mathrm{Y}}}\right) \tag{B.4}$$

where:

$\hat{\sigma}_{\varepsilon}^{2}$= the mean square error of the log-linear model; and

$ln\hat{Y}_{it}$ = the predicted value obtained from the log-linear model.

APE in the raw scale is obtained as:

$$APE_{it} = \left| \frac{\widetilde{Y_{it}} - Y_{it}}{Y_{it}} \right| x\,100 \tag{B.5}$$

Finally, the mean absolute percentage error (MAPE) is defined as the average over all observations (*i.e.*, over i and t) of APE_{it}. *i.e.*,

$$MAPE = \frac{\sum_{i}\sum_{t} APE_{it}}{n} \tag{B.6}$$

where:

$n = mT$, *i.e.*, number of cross-sectional observations times the number of time periods in the data.

The regression model from Table B.6 has the MAPE value for in-sample predictions of 14.0 percent. The actual and predicted values of per capita water use in the data are shown in Tables B.7 - B.13 below.

Table B.7: Actual and predicted values of per capita water demand in historical data.

Study Area	Year	Actual GPCD	Predicted GPCD	Difference	Absolute Error (%)
Beardstown	1985	258.0	228.3	-29.6	11.5
(Cass County)	1990	267.2	226.8	-40.4	15.1
	1995	193.4	247.7	54.3	28.1
	2000	223.8	234.3	10.5	4.7
	2005	220.0	218.3	-1.7	0.8
Cass County Rem.	1985	104.0	137.7	33.7	32.4
(Cass County)	1990	143.1	132.0	-11.1	7.7
	1995	130.2	137.8	7.6	5.8
	2000	156.7	141.6	-15.1	9.6
	2005	122.9	159.8	36.9	30.1
Champaign/Urbana	1985	165.3	144.6	-20.7	12.5
(Champaign County)	1990	166.4	141.9	-24.5	14.7
	1995	162.8	158.2	-4.6	2.8
	2000	165.1	158.2	-6.9	4.2
	2005	162.7	162.6	0.0	0.0
Mahomet	1985	89.6	82.2	-7.4	8.3
(Champaign County)	1990	81.4	89.6	8.2	10.1
	1995	75.8	97.1	21.3	28.2
	2000	96.8	94.9	-1.9	2.0
	2005	97.9	96.2	-1.7	1.7
Rantoul	1985	106.8	100.6	-6.2	5.8
(Champaign County)	1990	94.7	104.0	9.3	9.8
	1995	117.1	121.2	4.1	3.5
	2000	119.2	135.6	16.4	13.8
	2005	128.5	137.3	8.8	6.9
Champaign County Rem.	1985	75.2	62.5	-12.7	16.9
(Champaign County)	1990	86.4	65.4	-21.0	24.3
	1995	101.0	69.1	-31.9	31.6
	2000	78.5	73.3	-5.2	6.6
	2005	77.0	74.5	-2.5	3.2

Table B.8: Actual and predicted values of per capita water demand in historical data.

Study Area	Year	Actual GPCD	Predicted GPCD	Difference	Absolute Error (%)
Clinton	1985	118.0	135.1	17.0	14.4
(DeWitt County)	1990	120.0	129.2	9.2	7.6
	1995	133.1	142.5	9.3	7.0
	2000	133.6	142.0	8.5	6.3
	2005	116.5	126.5	10.0	8.5
Village of DeWitt	1985	93.5	100.3	6.8	7.3
(DeWitt County)	1990	121.3	99.4	-21.9	18.1
	1995	107.8	110.8	3.0	2.7
	2000	86.7	108.8	22.0	25.4
	2005	74.4	92.0	17.6	23.7
DeWitt County Rem.	1985	89.9	98.3	8.4	9.3
(DeWitt County)	1990	89.1	99.5	10.3	11.6
	1995	82.0	122.1	40.1	48.9
	2000	95.4	119.7	24.2	25.4
	2005	89.4	91.2	1.8	2.0
Paxton	1985	125.4	113.8	-11.5	9.2
(Ford County)	1990	109.6	111.8	2.3	2.1
	1995	135.4	120.1	-15.2	11.2
	2000	148.5	124.9	-23.5	15.9
	2005	116.6	115.4	-1.1	1.0
Ford County Rem.	1985	118.4	113.1	-5.3	4.4
(Ford County)	1990	130.7	152.9	22.2	16.9
	1995	171.5	162.9	-8.6	5.0
	2000	173.6	170.6	-3.0	1.7
	2005	164.3	183.5	19.2	11.7
Watseka	1985	99.4	111.4	12.0	12.1
(Iroquois County)	1990	105.2	119.2	13.9	13.2
	1995	126.3	124.0	-2.4	1.9
	2000	116.4	116.9	0.5	0.4
	2005	105.8	106.6	0.8	0.8

Table B.9: Actual and predicted values of per capita water demand in historical data.

Study Area	Year	Actual GPCD	Predicted GPCD	Difference	Absolute Error (%)
Iroquois County Rem.	1985	93.5	97.7	4.2	4.5
(Iroquois County)	1990	101.0	97.0	-3.9	3.9
	1995	101.7	111.0	9.3	9.1
	2000	102.7	111.6	8.9	8.6
	2005	99.1	114.7	15.7	15.8
Lincoln	1985	151.5	162.9	11.4	7.5
(Logan County)	1990	158.5	151.9	-6.6	4.2
	1995	128.4	155.8	27.4	21.3
	2000	149.7	156.5	6.8	4.6
	2005	179.2	170.8	-8.3	4.7
Logan County Rem.	1985	102.0	101.4	-0.6	0.6
(Logan County)	1990	96.0	98.4	2.4	2.5
	1995	111.9	112.0	0.1	0.1
	2000	102.3	124.3	22.0	21.5
	2005	103.2	128.4	25.1	24.3
Decatur	1985	187.9	206.9	18.9	10.1
(Macon County)	1990	229.8	291.5	61.7	26.8
	1995	268.2	323.7	55.5	20.7
	2000	295.9	311.2	15.3	5.2
	2005	287.5	286.8	-0.7	0.2
Forsyth	1985	103.8	125.9	22.1	21.3
(Macon County)	1990	121.4	124.9	3.5	2.9
	1995	146.4	116.8	-29.6	20.2
	2000	121.8	141.1	19.3	15.9
	2005	139.3	150.4	11.1	8.0
Macon County Rem.	1985	76.4	92.2	15.8	20.7
(Macon County)	1990	77.3	87.3	9.9	12.8
	1995	86.2	97.7	11.5	13.4
	2000	63.7	89.4	25.8	40.5
	2005	60.8	61.0	0.2	0.4

Table B.10: Actual and predicted values of per capita water demand in historical data.

Study Area	Year	Actual GPCD	Predicted GPCD	Difference	Absolute Error (%)
Mason City	1985	104.4	109.0	4.5	4.3
(Mason County)	1990	130.0	133.8	3.8	2.9
	1995	127.7	107.0	-20.7	16.2
	2000	109.8	106.8	-3.0	2.7
	2005	104.1	115.2	11.2	10.8
Mason County Rem.	1985	107.8	132.6	24.7	23.0
(Mason County)	1990	117.5	117.7	0.1	0.1
	1995	130.6	106.6	-24.1	18.4
	2000	103.3	137.3	34.0	32.9
	2005	78.8	84.5	5.6	7.2
Bloomington	1985	152.2	134.0	-18.2	12.0
(McLean County)	1990	170.9	120.3	-50.6	29.6
	1995	190.6	124.6	-66.1	34.7
	2000	178.6	186.3	7.7	4.3
	2005	157.2	159.1	1.9	1.2
Hudson	1985	65.7	73.2	7.5	11.5
(McLean County)	1990	64.0	66.5	2.5	3.8
	1995	69.3	69.4	0.2	0.3
	2000	73.6	72.7	-0.9	1.2
	2005	78.8	85.6	6.8	8.6
Normal	1985	95.7	99.1	3.4	3.6
(McLean County)	1990	100.3	91.9	-8.4	8.4
	1995	93.6	97.2	3.7	3.9
	2000	99.2	96.3	-3.0	3.0
	2005	85.0	83.9	-1.1	1.3
McLean County Rem.	1985	84.9	107.1	22.2	26.2
(McLean County)	1990	84.3	100.4	16.1	19.1
	1995	96.2	111.6	15.4	16.0
	2000	95.7	113.6	17.9	18.8
	2005	85.6	86.5	0.9	1.1

Table B.11: Actual and predicted values of per capita water demand in historical data.

Study Area	Year	Actual GPCD	Predicted GPCD	Difference	Absolute Error (%)
Petersburg	1985	83.2	84.2	1.0	1.2
(Menard County)	1990	68.1	77.9	9.8	14.4
	1995	83.7	86.8	3.1	3.7
	2000	89.2	78.6	-10.6	11.9
	2005	74.3	87.5	13.2	17.7
Menard County Rem.	1985	95.0	58.7	-36.3	38.2
(Menard County)	1990	68.3	58.0	-10.3	15.1
	1995	70.6	68.0	-2.6	3.7
	2000	68.2	69.4	1.2	1.8
	2005	50.4	49.3	-1.2	2.3
Monticello	1985	158.0	152.5	-5.4	3.4
(Piatt County)	1990	135.2	150.8	15.6	11.5
	1995	150.4	147.9	-2.6	1.7
	2000	128.5	145.4	16.9	13.1
	2005	142.2	147.9	5.8	4.1
Piatt County Rem.	1985	81.2	83.6	2.4	3.0
(Piatt County)	1990	81.5	88.1	6.6	8.0
	1995	83.0	95.1	12.1	14.5
	2000	74.8	158.3	83.5	111.7
	2005	74.0	73.1	-0.9	1.2
Sangamon County Rem.	1985	166.8	119.0	-47.8	28.6
(Sangamon County)	1990	147.1	114.4	-32.7	22.2
	1995	123.2	130.5	7.2	5.9
	2000	99.2	81.9	-17.3	17.4
	2005	75.3	83.8	8.4	11.2
Springfield	1985	130.8	133.8	3.0	2.3
(Sangamon County)	1990	147.7	126.5	-21.2	14.3
	1995	148.2	143.6	-4.6	3.1
	2000	139.8	138.8	-1.0	0.7
	2005	149.1	148.9	-0.2	0.1

Table B.12: Actual and predicted values of per capita water demand in historical data.

Study Area	Year	Actual GPCD	Predicted GPCD	Difference	Absolute Error (%)
Creve Coeur	1985	84.1	108.9	24.8	29.5
(Tazewell County)	1990	109.2	107.5	-1.7	1.6
	1995	132.5	129.4	-3.1	2.4
	2000	140.7	131.5	-9.2	6.5
	2005	156.8	157.1	0.2	0.2
East Peoria	1985	100.8	101.8	1.0	1.0
(Tazewell County)	1990	92.7	102.0	9.3	10.0
	1995	104.2	119.5	15.3	14.7
	2000	114.6	109.1	-5.5	4.8
	2005	120.6	123.8	3.2	2.7
Morton	1985	139.8	129.0	-10.8	7.7
(Tazewell County)	1990	144.5	135.7	-8.8	6.1
	1995	164.9	157.1	-7.8	4.7
	2000	146.1	167.6	21.5	14.8
	2005	162.5	192.7	30.2	18.6
Pekin	1985	123.1	151.0	27.9	22.6
(Tazewell County)	1990	130.5	142.2	11.6	8.9
	1995	146.3	162.4	16.1	11.0
	2000	196.5	172.4	-24.1	12.2
	2005	201.7	203.1	1.4	0.7
Tazewell County Rem.	1985	93.0	64.4	-28.6	30.8
(Tazewell County)	1990	104.8	72.4	-32.3	30.9
	1995	88.6	85.4	-3.2	3.6
	2000	82.1	84.3	2.2	2.7
	2005	76.5	75.4	-1.0	1.4
Washington	1985	132.2	114.0	-18.2	13.8
(Tazewell County)	1990	102.7	109.3	6.6	6.4
	1995	110.4	128.4	18.1	16.4
	2000	85.6	122.7	37.1	43.4
	2005	88.1	99.2	11.2	12.7

Table B.13: Actual and predicted values of per capita water demand in historical data.

Study Area	Year	Actual GPCD	Predicted GPCD	Difference	Absolute Error (%)
Danville	1985	126.4	159.8	33.4	26.4
(Vermilion County)	1990	166.9	146.6	-20.3	12.2
	1995	153.9	152.8	-1.1	0.7
	2000	151.8	156.5	4.6	3.1
	2005	151.6	151.9	0.3	0.2
Hoopeston	1985	136.8	119.2	-17.5	12.8
(Vermilion County)	1990	114.5	111.3	-3.2	2.8
	1995	135.8	116.8	-19.0	14.0
	2000	77.7	111.5	33.9	43.6
	2005	94.2	107.6	13.5	14.3
Vermilion County Rem.	1985	83.1	182.0	98.8	118.9
(Vermilion County)	1990	86.2	159.8	73.5	85.3
	1995	94.6	182.0	87.4	92.4
	2000	58.2	187.7	129.5	222.6
	2005	57.8	55.8	-2.0	3.5
Goodfield	1985	83.0	80.9	-2.0	2.5
(Woodford County)	1990	88.1	82.1	-6.0	6.8
	1995	73.2	91.9	18.7	25.6
	2000	78.0	99.5	21.5	27.5
	2005	126.1	108.0	-18.1	14.3
Woodford County Rem.	1985	69.1	79.0	9.9	14.4
(Woodford County)	1990	71.9	83.2	11.3	15.7
	1995	99.4	89.5	-9.9	9.9
	2000	102.5	94.6	-7.9	7.7
	2005	96.3	93.9	-2.3	2.4

B.2 Public supply data tables

Table B.15: Normal maximum summer temperature and summer precipitation values used in each study area in East-Central Illinois.

Study Area	County	Normal maximum temperature ($^{\circ}F$)	Normal precipitation (in)
Beardstown	Cass	82.48	17.90
Cass County Rem.	Cass	82.48	17.90
Champaign/Urbana	Champaign	80.44	21.27
Mahomet	Champaign	81.29	20.53
Rantoul	Champaign	82.14	19.78
Champaign County Rem.	Champaign	81.29	20.53
Clinton	DeWitt	81.00	19.37
DeWitt	DeWitt	81.00	19.37
DeWitt County Rem.	DeWitt	81.00	19.37
Paxton	Ford	79.76	18.06
Ford County Rem.	Ford	80.33	18.33
Watseka	Iroquois	79.48	19.94
Iroquois County Rem.	Iroquois	79.48	19.94
Lincoln	Logan	81.00	19.87
Logan County Rem.	Logan	81.00	19.50
Decatur	Macon	82.82	20.03
Forsyth	Macon	82.82	20.03
Macon County Rem.	Macon	82.82	20.03
Mason City	Mason	82.42	18.59
Mason County Rem.	Mason	82.48	18.59
Bloomington	McLean	80.65	18.53
Hudson	McLean	80.65	18.53
Normal	McLean	80.36	19.13
McLean County Rem.	McLean	80.65	18.53

in = inches. Rem. = remainder. Source: Illinois State Climatologist, Illinois State Water Survey.

Normal weather data is average from 1971-2000.

Summer is May 1 through September 30.

Table B.15: Normal maximum summer temperature and summer precipitation values used in each study area in East-Central Illinois.

Study Area	County	Normal maximum temperature ($^{\circ}F$)	Normal precipitation (in)
Petersburg	Menard	82.48	19.64
Menard County Rem.	Menard	82.48	19.64
Monticello	Piatt	81.29	19.89
Piatt County Rem.	Piatt	81.29	19.89
Springfield	Sangamon	81.44	17.60
Sangamon County Rem.	Sangamon	81.44	17.60
Creve Coeur	Tazewell	80.65	18.77
East Peoria	Tazewell	80.65	18.77
Morton	Tazewell	80.65	18.77
Pekin	Tazewell	80.65	18.77
Washington	Tazewell	81.01	19.49
Tazewell County Rem.	Tazewell	80.65	18.77
Danville	Vermilion	81.48	20.53
Hoopeston	Vermilion	80.54	18.82
Vermilion County Rem.	Vermilion	81.01	19.49
Goodfield	Woodford	80.65	18.42
Woodford County Rem.	Woodford	80.65	18.42

in = inches. Rem. = remainder. Source: Illinois State Climatologist, Illinois State Water Survey.

Normal weather data is average from 1971-2000.

Summer is May 1 through September 30.

Table B.14: Weather stations in East-Central Illinois.

County	Station name / location	Station no.
Cass	Virginia	118870
Cass	Beardstown	110492
Champaign	Urbana	118740
Champaign	Rantoul	117150
DeWitt	Clinton 1 SSW	111743
Ford	Gibson City 1 E	113413
Ford	Paxton	116663
Ford	Piper City	116819
Iroquois	Watseka 2 NW	119021
Logan	Lincoln	115079
Logan	Mount Pulaski	115927
Macon	Decatur	112193
Mason	Havana 4 NNE	113940
Mason	Mason City 1 W	115413
McLean	Normal	116200
McLean	Bloomington Waterworks	110761
McLean	Chenoa	111475
Menard	Petersburg 2 SW	116765
Menard	Petersburg 3 SSW	116760
Piatt	Monticello No 2.	115792
Sangamon	Springfield WSO AP	118179
Tazewell	Mackinaw 1 N	115272
Vermilion	Danville	112140
Vermilion	Danville Sewage Plant	112145
Vermilion	Hoopeston	114198
Vermilion	Sidell 5 NW	117952
Peoria	Peoria GTR Peoria Regional AP	116711
Woodford	Minonk	115712
Morgan	Jacksonville 2E	114442

Source: Illinois State Climatologist, Illinois State Water Survey, 2007.

Table B.16: Historical values of dependent and independent variables for public water supply.

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Beardstown*	1985	1.51	258.0	79.76	17.72	0.552	$0.00	$34,860	5,837
(Cass County)	1990	1.44	267.2	80.32	26.79	0.617	$0.00	$34,167	5,380
	1995	1.04	193.4	80.52	20.17	0.715	$0.00	$33,253	5,380
	2000	1.26	223.8	81.78	23.48	0.628	$0.00	$32,910	5,614
	2005	1.30	220.0	84.80	11.49	0.693	$0.00	$30,500	5,908
Cass County Rem.	1985	0.31	104.0	79.76	17.72	0.396	$3.37	$36,157	2,951
(Cass County)	1990	0.42	143.1	80.32	26.79	0.406	$3.37	$35,427	2,934
	1995	0.39	130.2	80.52	20.17	0.388	$3.37	$37,725	2,994
	2000	0.46	156.7	81.78	23.48	0.396	$3.37	$39,852	2,946
	2005	0.36	122.9	84.80	11.49	0.406	$3.37	$37,819	2,960
Champaign/Urbana	1985	16.66	165.3	79.66	19.02	0.480	$2.16	$35,515	100,777
(Champaign County)	1990	17.29	166.4	79.24	24.57	0.516	$2.18	$35,701	103,902
	1995	18.87	162.8	80.98	19.89	0.526	$1.95	$39,468	115,888
	2000	20.46	165.1	80.18	20.98	0.539	$2.13	$42,721	123,953
	2005	23.24	162.7	83.30	15.61	0.522	$2.59	$39,604	142,873
Mahomet	1985	0.23	89.6	80.20	19.71	0.457	$2.99	$50,319	2,548
(Champaign County)	1990	0.25	81.4	79.29	24.04	0.511	$2.25	$58,568	3,115
	1995	0.29	75.8	81.82	18.60	0.486	$2.17	$61,925	3,837
	2000	0.47	96.8	81.16	18.27	0.446	$2.22	$65,104	4,904
	2005	0.54	97.9	83.86	17.59	0.469	$2.56	$59,600	5,520
Rantoul*	1985	1.38	106.8	80.20	20.39	0.224	$2.99	$36,913	12,898
(Champaign County)	1990	1.13	94.7	79.29	23.51	0.316	$3.00	$39,267	11,900
	1995	1.29	117.1	81.82	17.30	0.358	$2.56	$40,431	11,000
	2000	1.55	119.2	81.16	15.55	0.500	$2.42	$41,731	13,000
	2005	1.67	128.5	83.86	19.56	0.587	$2.85	$38,200	13,000

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem. = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.17: Historical values of dependent and independent variables for public water supply.

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Champaign County Rem.	1985	1.66	75.2	80.20	19.71	0.500	$2.99	$34,164	22,135
(Champaign County)	1990	1.79	86.4	79.29	24.04	0.579	$2.25	$33,470	20,669
	1995	1.76	101.0	81.82	18.60	0.539	$2.17	$33,726	17,411
	2000	1.17	78.5	81.16	18.27	0.533	$2.22	$42,721	14,855
	2005	1.12	77.0	83.86	17.59	0.540	$2.56	$40,756	14,480
Clinton*	1985	1.01	118.0	80.84	19.07	0.614	$2.34	$36,552	8,573
(DeWitt County)	1990	1.00	120.0	79.58	23.81	0.599	$2.02	$35,995	8,300
	1995	1.09	133.1	81.90	18.68	0.613	$2.04	$38,632	8,200
	2000	0.87	133.6	81.14	18.55	0.570	$1.80	$41,024	6,537
	2005	0.87	116.5	83.62	15.17	0.464	$3.18	$38,100	7,500
Village of DeWitt	1985	0.01	93.5	80.84	19.07	0.324	$5.80	$42,035	130
(DeWitt County)	1990	0.02	121.3	79.58	23.81	0.324	$4.80	$43,081	140
	1995	0.02	107.8	81.90	18.68	0.324	$4.10	$44,846	155
	2000	0.02	86.7	81.14	18.55	0.324	$4.52	$46,645	190
	2005	0.01	74.4	83.62	15.17	0.324	$3.07	$48,051	180
DeWitt County Rem.	1985	0.39	89.9	80.84	19.07	0.310	$5.80	$40,626	4,377
(DeWitt County)	1990	0.38	89.1	79.58	23.81	0.354	$4.80	$40,752	4,275
	1995	0.37	82.0	81.90	18.68	0.488	$4.10	$43,854	4,543
	2000	0.43	95.4	81.14	18.55	0.474	$4.52	$46,652	4,553
	2005	0.40	89.4	83.62	15.17	0.506	$3.07	$44,506	4,487
Paxton	1985	0.55	125.4	79.75	14.75	0.344	$2.18	$34,345	4,422
(Ford County)	1990	0.49	109.6	78.97	21.06	0.347	$1.80	$35,619	4,473
	1995	0.61	135.4	81.42	22.78	0.354	$1.69	$38,510	4,539
	2000	0.70	148.5	79.74	17.69	0.358	$1.64	$42,748	4,725
	2005	0.56	116.6	82.80	16.21	0.379	$1.42	$39,700	4,800

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem. = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.18: Historical values of dependent and independent variables for public water supply. (continued)

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Ford County Rem.	1985	0.81	118.4	79.75	14.75	0.488	$2.18	$38,781	6,800
(Ford County)	1990	0.91	130.7	78.97	21.06	0.510	$1.80	$38,662	6,934
	1995	1.12	171.5	81.42	22.78	0.515	$1.69	$40,921	6,519
	2000	1.16	173.6	79.74	17.69	0.558	$1.64	$43,052	6,700
	2005	1.12	164.3	82.80	16.21	0.549	$1.42	$42,629	6,788
Watseka	1985	0.58	99.4	79.38	18.53	0.486	$3.26	$32,922	5,802
(Iroquois County)	1990	0.60	105.2	78.1	19.61	0.602	$2.70	$32,487	5,700
	1995	0.72	126.3	80.84	18.77	0.809	$6.38	$33,391	5,700
	2000	0.66	116.4	79.64	19.28	0.632	$4.40	$34,421	5,670
	2005	0.58	105.8	81.8	16.55	0.537	$0.85	$31,900	5,500
Iroquois County Rem.	1985	1.47	93.5	79.38	18.53	0.430	$2.72	$37,899	15,715
(Iroquois County)	1990	1.60	101.0	78.10	19.61	0.423	$2.25	$38,113	15,853
	1995	1.62	101.7	80.84	18.77	0.481	$1.92	$40,685	15,927
	2000	1.65	102.7	79.64	19.28	0.472	$1.70	$43,050	16,113
	2005	1.61	99.1	81.80	16.55	0.515	$2.20	$40,971	16,203
Lincoln*	1985	2.82	151.5	80.84	18.69	0.631	$5.51	$37,669	18,604
(Logan County)	1990	2.62	158.5	79.58	26.52	0.574	$4.71	$38,103	16,500
	1995	2.57	128.4	81.90	22.81	0.486	$4.15	$38,352	20,000
	2000	2.69	149.7	81.14	19.49	0.461	$3.87	$38,939	18,000
	2005	2.94	179.2	83.62	11.84	0.462	$3.61	$36,100	16,400
Logan County Rem.	1985	0.68	102.0	80.84	18.94	0.256	$4.08	$40,532	6,695
(Logan County)	1990	0.64	96.0	79.58	26.52	0.264	$3.54	$41,250	6,639
	1995	0.73	111.9	81.90	22.20	0.312	$3.02	$42,871	6,533
	2000	0.66	102.3	81.14	20.03	0.465	$3.08	$44,541	6,451
	2005	0.66	103.2	83.62	11.84	0.371	$2.71	$40,475	6,421

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem. = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.19: Historical values of dependent and independent variables for public water supply. (continued)

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Decatur*	1985	16.77	187.9	81.76	17.70	0.417	$2.61	$38,787	89507
(Macon County)	1990	20.33	229.8	80.56	24.08	0.443	$2.34	$38,137	88730
	1995	23.46	268.2	83.30	16.22	0.461	$2.23	$37,518	87718
	2000	25.59	295.9	82.36	19.32	0.441	$2.07	$37,441	86705
	2005	23.64	287.5	84.68	17.03	0.434	$1.83	$32,233	82449
Forsyth*	1985	0.12	103.8	81.76	17.70	0.819	$2.99	$60,642	1,194
(Macon County)	1990	0.16	121.4	80.56	24.08	0.764	$2.47	$72,270	1,302
	1995	0.29	146.4	83.30	16.22	0.459	$2.11	$75,103	2,010
	2000	0.31	121.8	82.36	19.32	0.852	$2.68	$78,024	2,575
	2005	0.41	139.3	84.68	17.03	0.884	$2.37	$71,300	2,910
Macon County Rem.	1985	1.28	76.4	81.76	17.70	0.546	$2.43	$42,850	16,784
(Macon County)	1990	1.42	77.3	80.56	24.08	0.529	$2.20	$42,853	18,299
	1995	1.55	86.2	83.30	16.22	0.559	$2.12	$42,576	17,959
	2000	1.23	63.7	82.36	19.32	0.485	$2.21	$42,810	19,248
	2005	1.28	60.8	84.68	17.03	0.472	$2.03	$39,047	20,989
Mason City	1985	0.27	104.4	81.03	14.11	0.157	$1.81	$37,432	2,561
(Mason County)	1990	0.33	130.0	80.11	26.62	0.172	$1.80	$35,409	2,510
	1995	0.32	127.7	81.90	21.28	0.182	$1.92	$37,956	2,483
	2000	0.27	109.8	82.70	17.54	0.193	$3.05	$40,273	2,481
	2005	0.27	104.1	86.16	8.79	0.186	$3.46	$37,400	2,620
Mason County Rem.	1985	0.68	107.8	81.03	14.11	0.480	$1.81	$35,557	6,274
(Mason County)	1990	0.77	117.5	80.11	26.62	0.464	$1.80	$33,729	6,557
	1995	0.85	130.6	81.90	21.28	0.520	$2.56	$37,560	6,476
	2000	0.70	103.3	82.70	17.54	0.516	$2.21	$40,771	6,733
	2005	0.56	78.8	86.16	8.79	0.506	$2.50	$38,420	7,043

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem. = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.20: Historical values of dependent and independent variables for public water supply. (continued)

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Bloomington	1985	8.26	152.2	80.68	19.76	0.484	$2.08	$44,506	54,300
(McLean County)	1990	9.91	170.9	79.87	23.78	0.551	$3.97	$43,986	58,000
	1995	11.44	190.6	80.82	23.73	0.563	$4.46	$48,594	60,000
	2000	12.50	178.6	80.49	19.99	0.571	$4.17	$52,577	70,000
	2005	11.23	157.2	84.44	10.65	0.548	$4.10	$51,273	72,330
Hudson*	1985	0.07	65.7	80.68	18.43	0.144	$5.44	$53,875	1,135
(McLean County)	1990	0.08	64.0	79.87	23.11	0.172	$9.59	$61,287	1,190
	1995	0.09	69.3	80.82	21.86	0.117	$8.20	$66,328	1,300
	2000	0.11	73.6	80.49	19.63	0.108	$7.24	$70,823	1,525
	2005	0.14	78.8	84.44	10.27	0.120	$6.40	$68,700	1,745
Normal*	1985	3.43	95.7	80.68	20.49	0.463	$3.27	$46,804	35,837
(McLean County)	1990	3.94	100.3	79.87	24.58	0.540	$4.90	$47,016	39,315
	1995	3.79	93.6	80.82	22.74	0.562	$3.97	$45,970	40,500
	2000	4.22	99.2	80.49	21.08	0.537	$3.90	$45,660	42,500
	2005	4.29	85.0	84.44	11.05	0.519	$3.84	$44,300	50,519
McLean County Rem.	1985	1.54	84.9	80.68	18.43	0.457	$3.27	$45,236	18,091
(McLean County)	1990	1.60	84.3	79.87	23.11	0.519	$4.90	$47,001	19,012
	1995	1.85	96.2	80.82	21.86	0.559	$3.97	$50,220	19,213
	2000	1.93	95.7	80.49	19.63	0.543	$3.90	$53,171	20,220
	2005	1.80	85.6	84.44	10.27	0.536	$3.84	$51,176	21,055
Petersburg	1985	0.39	83.2	80.06	17.53	0.452	$2.81	$31,425	4,657
(Menard County)	1990	0.31	68.1	79.74	28.13	0.463	$3.22	$31,651	4,500
	1995	0.33	83.7	82.32	15.85	0.466	$3.92	$34,827	4,000
	2000	0.36	89.2	80.82	18.22	0.416	$5.54	$39,225	4,000
	2005	0.36	74.3	84.14	13.09	0.472	$5.50	$36,400	4,850

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem. = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.21: Historical values of dependent and independent variables for public water supply. (continued)

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Menard County Rem.	1985	0.26	95.0	80.06	17.53	0.422	$3.20	$46,500	2,720
(Menard County)	1990	0.27	68.3	79.74	28.13	0.512	$3.35	$47,066	4,005
	1995	0.36	70.6	82.32	15.85	0.497	$2.86	$51,939	5,153
	2000	0.44	68.2	80.82	18.22	0.570	$2.96	$55,729	6,435
	2005	0.39	50.4	84.14	13.09	0.542	$4.27	$54,737	7,724
Monticello*	1985	0.73	158.0	79.66	19.02	0.450	$2.30	$48,756	4,640
(Piatt County)	1990	0.62	135.2	79.24	24.57	0.437	$1.90	$50,185	4,579
	1995	0.68	150.4	80.98	19.89	0.357	$2.26	$50,769	4,550
	2000	0.67	128.5	80.18	20.98	0.344	$2.16	$51,738	5,204
	2005	0.72	142.2	83.30	15.61	0.298	$2.40	$48,000	5,050
Piatt County Rem.	1985	0.52	81.2	79.66	19.02	0.437	$2.84	$45,000	6,417
(Piatt County)	1990	0.52	81.5	79.24	24.57	0.528	$2.35	$45,690	6,409
	1995	0.55	83.0	80.98	19.89	0.522	$2.27	$48,815	6,579
	2000	0.50	74.8	80.18	20.98	0.619	$2.17	$51,735	6,675
	2005	0.49	74.0	83.30	15.61	0.639	$1.34	$50,621	6,563
Springfield*	1985	17.78	130.8	80.06	17.53	0.514	$1.98	$40,474	135,912
(Sangamon County)	1990	20.75	147.7	79.74	28.13	0.531	$2.18	$41,950	140,477
	1995	21.45	148.2	82.32	15.85	0.523	$1.99	$43,169	144,742
	2000	20.84	139.8	80.82	18.22	0.531	$2.07	$44,539	149,007
	2005	22.94	149.1	84.14	13.09	0.519	$1.85	$43,054	153,872
Sangamon County Rem.	1985	2.21	166.8	80.06	17.53	0.520	$1.89	$43,897	13,248
(Sangamon County)	1990	2.34	147.1	79.74	28.13	0.550	$1.96	$45,478	15,892
	1995	2.35	123.2	82.32	15.85	0.540	$1.73	$46,965	19,032
	2000	2.26	99.2	80.82	18.22	0.546	$1.76	$48,575	22,745
	2005	1.83	75.3	84.14	13.09	0.538	$1.85	$46,022	24,321

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem. = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.22: Historical values of dependent and independent variables for public water supply. (continued)

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Creve Coeur	1985	0.59	84.1	79.10	18.81	0.393	$3.72	$40,292	7,070
(Tazewell County)	1990	0.74	109.2	77.38	29.70	0.482	$2.92	$37,549	6,800
	1995	0.79	132.5	80.54	18.01	0.523	$2.38	$39,206	5,934
	2000	0.83	140.7	80.14	13.30	0.502	$2.53	$40,864	5,900
	2005	0.93	156.8	83.90	9.73	0.512	$2.63	$39,200	5,900
East Peoria	1985	2.32	100.8	79.10	18.81	0.546	$3.72	$44,700	22,976
(Tazewell County)	1990	2.09	92.7	77.38	29.70	0.648	$2.92	$42,532	22,500
	1995	2.40	104.2	80.54	18.01	0.641	$2.38	$44,796	23,000
	2000	2.59	114.6	80.14	13.30	0.572	$4.02	$46,971	22,638
	2005	2.73	120.6	83.90	9.73	0.597	$3.50	$45,000	22,638
Morton*	1985	2.02	139.8	79.10	18.81	0.381	$2.81	$60,123	14,430
(Tazewell County)	1990	2.12	144.5	77.38	29.70	0.555	$2.32	$59,621	14,700
	1995	2.34	164.9	80.54	18.01	0.624	$2.51	$60,002	14,200
	2000	2.28	146.1	80.14	13.30	0.669	$2.44	$60,914	15,600
	2005	2.68	162.5	83.90	9.73	0.773	$2.65	$58,400	16,500
Pekin*	1985	4.41	123.1	79.10	18.81	0.378	$1.99	$39,410	35,806
(Tazewell County)	1990	4.57	130.5	77.38	29.70	0.446	$2.02	$37,758	35,000
	1995	5.30	146.3	80.54	18.01	0.469	$2.26	$40,470	36,250
	2000	6.39	196.5	80.14	13.30	0.470	$2.06	$42,938	32,500
	2005	7.42	201.7	83.90	9.73	0.479	$1.77	$41,100	36,800
Washington	1985	1.12	132.2	79.10	18.81	0.342	$3.72	$51,311	8,456
(Tazewell County)	1990	0.82	102.7	77.38	29.70	0.347	$2.92	$51,573	8,000
	1995	1.08	110.4	80.54	18.01	0.334	$2.38	$55,498	9,743
	2000	0.94	85.6	80.14	13.30	0.328	$4.02	$59,038	11,000
	2005	1.16	88.1	83.90	9.73	0.311	$2.63	$56,600	13,177

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.23: Historical values of dependent and independent variables for public water supply. (continued)

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Tazewell County Rem.	1985	3.18	93.0	79.10	18.81	0.286	$3.72	$47,415	34,226
(Tazewell County)	1990	3.63	104.8	77.38	29.70	0.487	$2.92	$48,136	34,658
	1995	3.12	88.6	80.54	18.01	0.573	$2.38	$47,483	35,281
	2000	2.95	82.1	80.14	13.30	0.526	$2.53	$47,746	35,880
	2005	2.76	76.5	83.90	9.73	0.508	$2.63	$45,647	36,145
Danville*	1985	8.15	126.4	81.26	16.87	0.400	$3.69	$34,196	64,470
(Vermilion County)	1990	10.02	166.9	79.16	23.64	0.402	$3.69	$33,438	60,000
	1995	8.46	153.9	81.00	22.20	0.402	$3.69	$33,792	55,000
	2000	8.35	151.8	81.36	19.56	0.388	$3.55	$34,411	55,000
	2005	8.34	151.6	83.46	16.06	0.387	$2.86	$31,000	55,000
Hoopeston*	1985	0.80	136.8	79.84	18.01	0.393	$1.63	$33,767	5,881
(Vermilion County)	1990	0.66	114.5	78.70	22.81	0.492	$2.70	$33,365	5,800
	1995	0.79	135.8	81.42	17.59	0.388	$2.31	$34,732	5,800
	2000	0.45	77.7	80.32	21.02	0.330	$2.04	$36,125	5,800
	2005	0.56	94.2	83.18	20.32	0.254	$2.12	$32,500	5,987
Vermilion County Rem.	1985	1.18	83.1	80.55	17.44	0.376	$1.81	$36,283	14,134
(Vermilion County)	1990	1.20	86.2	78.93	23.12	0.425	$3.22	$35,725	13,968
	1995	1.32	94.6	81.21	18.58	0.469	$2.75	$37,102	13,964
	2000	0.80	58.2	80.84	19.44	0.487	$2.43	$38,527	13,731
	2005	0.79	57.8	83.32	17.04	0.496	$3.42	$36,233	13,633

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem. = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.24: Historical values of dependent and independent variables for public water supply. (continued)

Study Area	Year	MGD	GPCD	Temp.	Precip.	E/P ratio	Price	Income	Pop. served
Goodfield	1985	0.04	83.0	79.60	15.91	0.391	$3.57	$49,452	515
(Woodford County)	1990	0.04	88.1	79.00	22.19	0.492	$3.57	$49,948	490
	1995	0.04	73.2	81.20	24.30	0.532	$3.52	$59,839	523
	2000	0.06	78.0	80.72	15.88	0.521	$3.41	$67,925	796
	2005	0.09	126.1	83.90	8.27	0.532	$4.02	$63,000	700
Woodford County Rem.	1985	1.44	69.1	79.60	15.91	0.385	$4.31	$50,410	20,869
(Woodford County)	1990	1.57	71.9	79.00	22.19	0.485	$3.57	$51,532	21,811
	1995	2.13	99.4	81.20	24.30	0.523	$3.52	$54,864	21,396
	2000	2.23	102.5	80.72	15.88	0.511	$3.41	$57,918	21,712
	2005	2.24	96.3	83.90	8.27	0.521	$4.02	$57,442	23,281
Average	1985	109.63	130.5	80.18	18.03	0.427	$3.02	$42,781	840,369
(MGD & Pop served is Total)	1990	121.37	142.7	79.21	25.11	0.473	$3.00	$43,141	851,217
	1995	129.61	148.8	81.44	19.48	0.482	$2.88	$45,121	871,432
	2000	134.01	148.8	80.84	18.27	0.486	$2.93	$47,321	900,820
	2005	137.02	144.9	83.91	13.44	0.486	$2.81	$44,578	946,821

MGD = million gallons per day; GPCD = gallons per capita per day; temp. = May - September average temperature

precip. = precipitation; E/P ratio = employment to population ratio; Rem. = remainder; Pop. = population

All price and income data have been converted to 2005 dollars.

* price data was obtained from representatives of the public water supply system at public outreach meetings.

Table B.25: Future withdrawals (in MGD) for public water supply baseline (BL) scenario for each study area.

Study Area	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-50 % Change
Beardstown	1.29	1.18	1.26	1.31	1.36	1.40	1.44	1.47	1.51	1.55	1.60	35.38
Cass County Rem.	0.47	0.43	0.59	0.61	0.63	0.64	0.66	0.68	0.69	0.71	0.73	68.63
Champaign/Urbana	23.24	21.34	22.22	23.34	24.54	25.47	25.93	26.88	27.63	28.40	29.19	36.77
Mahomet	0.53	0.50	0.53	0.56	0.59	0.61	0.62	0.62	0.63	0.65	0.67	34.30
Rantoul	1.78	1.71	1.82	1.91	2.01	2.09	2.12	2.18	2.24	2.31	2.37	38.32
Champaign County Rem.	1.08	1.01	1.08	1.13	1.19	1.23	1.26	1.28	1.31	1.35	1.39	36.53
Clinton	0.95	0.88	0.96	1.00	1.04	1.07	1.11	1.14	1.18	1.22	1.26	43.38
De Witt	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	43.72
DeWitt County Rem.	0.41	0.38	0.41	0.43	0.45	0.46	0.48	0.49	0.51	0.53	0.55	43.35
Paxton	0.55	0.52	0.54	0.57	0.59	0.60	0.62	0.64	0.65	0.67	0.69	32.85
Ford County Rem.	1.25	1.18	1.24	1.28	1.33	1.37	1.41	1.44	1.48	1.52	1.56	32.84
Watseka	0.59	0.55	0.59	0.61	0.64	0.67	0.69	0.71	0.74	0.76	0.79	43.74
Iroquois County Rem.	1.86	1.75	1.87	1.95	2.04	2.12	2.18	2.26	2.34	2.43	2.51	43.76
Lincoln	2.80	2.52	2.61	2.68	2.74	2.79	2.85	2.91	2.96	3.02	3.08	22.08
Logan County Rem.	0.82	0.74	0.77	0.79	0.81	0.82	0.84	0.86	0.87	0.89	0.91	22.08
Decatur	23.65	22.49	23.55	24.08	24.90	25.62	26.31	27.04	27.80	28.57	29.37	30.60
Forsyth	0.44	0.42	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	-3.74
Macon County Rem.	1.28	1.22	1.25	1.28	1.32	1.36	1.40	1.44	1.48	1.52	1.56	28.10
Mason City	0.30	0.26	0.28	0.29	0.30	0.30	0.30	0.30	0.31	0.31	0.32	22.67
Mason County Rem.	0.60	0.51	0.55	0.57	0.58	0.59	0.59	0.60	0.61	0.62	0.63	22.67

Rem. = remainder; MGD = million gallons per day.

2005 Weather = model generated results using actual 2005 weather data. 2005 Normal = model generated results using normal (1971-2000) weather data.

Table B.26: Future withdrawals (in MGD) for public water supply baseline (BL) scenario for each study area. (continued)

Study Area	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-50 % Change
Bloomington	11.36	9.99	10.71	11.41	12.14	12.79	13.21	13.78	14.37	14.98	15.63	56.38
Hudson	0.15	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.21	56.93
Normal	4.24	3.67	3.94	4.19	4.46	4.70	4.86	5.06	5.28	5.51	5.74	56.41
McLean County Rem.	1.82	1.60	1.71	1.82	1.94	2.04	2.11	2.20	2.29	2.39	2.49	56.39
Petersburg	0.42	0.39	0.42	0.45	0.47	0.49	0.50	0.51	0.52	0.54	0.55	39.84
Menard County Rem.	0.38	0.35	0.38	0.40	0.42	0.44	0.44	0.46	0.47	0.48	0.49	39.80
Monticello	0.75	0.70	0.72	0.75	0.77	0.79	0.80	0.82	0.83	0.85	0.86	23.20
Piatt County Rem.	0.48	0.45	0.46	0.48	0.50	0.51	0.51	0.52	0.53	0.54	0.56	23.23
Springfield	22.90	21.14	20.10	21.07	22.22	23.17	23.97	24.90	25.87	26.87	27.91	32.02
Sangamon County Rem.	2.04	1.88	2.78	2.91	3.05	3.18	3.29	3.42	3.55	3.69	3.83	103.71
Creve Coeur	0.93	0.81	0.83	0.89	0.94	1.00	1.03	1.08	1.13	1.18	1.24	52.10
East Peoria	2.80	2.46	2.67	2.84	3.02	3.19	3.30	3.45	3.61	3.78	3.95	60.84
Morton	3.18	2.79	3.03	3.22	3.42	3.62	3.75	3.92	4.10	4.29	4.48	60.75
Pekin	7.48	6.56	6.77	7.20	7.66	8.09	8.38	8.76	9.17	9.59	10.03	52.93
Tazewell County Rem.	2.73	2.39	2.60	2.76	2.94	3.10	3.21	3.36	3.52	3.68	3.85	60.81
Washington	1.31	1.15	1.25	1.33	1.41	1.49	1.54	1.61	1.69	1.77	1.85	60.73
Danville	8.35	7.85	7.53	7.53	7.62	7.78	8.07	8.30	8.54	8.79	9.04	15.20
Hoopeston	0.64	0.62	0.59	0.58	0.58	0.59	0.61	0.62	0.63	0.64	0.65	5.17
Vermilion County Rem.	0.76	0.72	0.69	0.69	0.70	0.71	0.74	0.76	0.78	0.81	0.83	15.19
Goodfield	0.08	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.10	57.93
Woodford County Rem.	2.19	1.89	2.01	2.14	2.28	2.41	2.49	2.61	2.73	2.85	2.98	57.85
Total	138.88	127.24	131.88	137.60	144.19	149.88	154.26	159.74	165.25	170.96	176.88	39.02

Rem. = remainder; MGD = million gallons per day.

2005 Weather = model generated results using actual 2005 weather data. 2005 Normal = model generated results using normal (1971-2000) weather data.

Table B.27: Future withdrawals (in MGD) for public water supply less resource intensive (LRI) for each study area.

System Name	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-2050 % Change
Beardstown	1.29	1.32	1.26	1.30	1.35	1.38	1.42	1.44	1.48	1.51	1.55	17.67
Cass County Rem.	0.47	0.34	0.58	0.59	0.60	0.60	0.61	0.61	0.62	0.62	0.63	81.94
Champaign/Urbana	23.24	21.76	21.88	22.63	23.42	23.92	23.97	24.44	24.70	24.97	25.24	15.96
Mahomet	0.53	0.50	0.52	0.54	0.56	0.57	0.57	0.56	0.57	0.57	0.58	16.77
Rantoul	1.78	1.56	1.79	1.85	1.92	1.96	1.96	1.98	2.00	2.02	2.04	30.81
Champaign County Rem.	1.08	0.85	1.06	1.10	1.14	1.16	1.16	1.16	1.17	1.19	1.20	40.59
Clinton	0.95	0.80	0.94	0.97	0.99	1.00	1.02	1.04	1.05	1.07	1.09	36.07
De Witt	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	49.79
DeWitt County Rem.	0.41	0.38	0.41	0.42	0.43	0.43	0.44	0.45	0.45	0.46	0.47	23.10
Paxton	0.55	0.44	0.54	0.55	0.56	0.57	0.58	0.59	0.59	0.60	0.61	38.94
Ford County Rem.	1.25	1.13	1.22	1.25	1.28	1.29	1.31	1.33	1.34	1.36	1.38	22.09
Watseka	0.59	0.57	0.58	0.60	0.62	0.64	0.65	0.66	0.68	0.69	0.71	25.50
Iroquois County Rem.	1.86	1.70	1.85	1.89	1.95	1.99	2.02	2.06	2.10	2.14	2.18	28.66
Lincoln	2.80	2.47	2.57	2.59	2.61	2.61	2.62	2.63	2.63	2.64	2.64	7.22
Logan County Rem.	0.82	0.68	0.76	0.77	0.77	0.77	0.78	0.78	0.78	0.78	0.78	14.93
Decatur	23.65	23.22	23.23	23.40	23.85	24.17	24.45	24.75	25.05	25.35	25.64	10.41
Forsyth	0.44	0.37	0.32	0.32	0.32	0.33	0.33	0.34	0.34	0.34	0.35	-5.42
Macon County Rem.	1.28	1.36	1.23	1.24	1.27	1.28	1.30	1.31	1.33	1.34	1.36	-0.51
Mason City	0.30	0.23	0.27	0.28	0.28	0.28	0.28	0.28	0.27	0.27	0.27	18.10
Mason County Rem.	0.60	0.44	0.54	0.55	0.56	0.55	0.55	0.55	0.55	0.55	0.55	24.33

Rem. = remainder; MGD = million gallons per day.

2005 Weather = model generated results using actual 2005 weather data. 2005 Normal = model generated results using normal (1971-2000) weather data.

Table B.28: Future withdrawals (in MGD) for public water supply less resource intensive (LRI) scenario for each study area. (continued)

Study Area	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-2050 % Change
Bloomington	11.36	10.21	10.53	11.03	11.55	11.95	12.13	12.44	12.74	13.05	13.37	30.98
Hudson	0.15	0.14	0.14	0.14	0.15	0.16	0.16	0.16	0.17	0.17	0.17	28.00
Normal	4.24	3.55	3.87	4.06	4.25	4.40	4.46	4.58	4.69	4.80	4.92	38.59
McLean County Rem.	1.82	1.84	1.68	1.76	1.84	1.91	1.94	1.99	2.04	2.09	2.14	16.06
Petersburg	0.42	0.35	0.42	0.43	0.45	0.45	0.45	0.46	0.46	0.47	0.47	34.77
Menard County Rem.	0.38	0.45	0.37	0.39	0.40	0.41	0.41	0.41	0.42	0.42	0.42	-5.19
Monticello	0.75	0.65	0.71	0.73	0.74	0.74	0.74	0.74	0.75	0.75	0.75	14.56
Piatt County Rem.	0.48	0.55	0.46	0.47	0.48	0.48	0.48	0.48	0.49	0.49	0.49	-10.55
Springfield	22.90	21.53	19.82	20.47	21.28	21.86	22.28	22.79	23.30	23.83	24.35	13.12
Sangamon County Rem.	2.04	1.71	2.74	2.83	2.92	3.00	3.06	3.13	3.20	3.27	3.34	95.54
Creve Coeur	0.93	0.69	0.82	0.86	0.90	0.94	0.95	0.98	1.01	1.04	1.07	53.98
East Peoria	2.80	2.29	2.63	2.75	2.87	2.99	3.04	3.13	3.21	3.30	3.39	48.18
Morton	3.18	2.67	2.98	3.12	3.27	3.40	3.46	3.56	3.66	3.77	3.87	45.34
Pekin	7.48	6.26	6.68	7.00	7.34	7.64	7.79	8.03	8.27	8.51	8.76	40.00
Tazewell County Rem.	2.73	2.94	2.56	2.68	2.80	2.91	2.97	3.05	3.14	3.23	3.32	13.11
Washington	1.31	1.04	1.23	1.29	1.35	1.40	1.43	1.47	1.51	1.55	1.60	53.96
Danville	8.35	7.97	7.42	7.30	7.27	7.30	7.44	7.53	7.62	7.71	7.80	-2.09
Hoopeston	0.64	0.61	0.59	0.58	0.58	0.58	0.59	0.60	0.61	0.61	0.62	1.94
Vermilion County Rem.	0.76	1.34	0.68	0.67	0.66	0.67	0.68	0.69	0.70	0.70	0.71	-46.86
Goodfield	0.08	0.08	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	12.81
Woodford County Rem.	2.19	2.00	1.97	2.07	2.17	2.25	2.29	2.35	2.42	2.48	2.55	27.37
Total	138.88	128.98	129.94	133.54	137.81	141.04	142.88	145.61	148.21	150.84	153.50	19.01

Rem. = remainder; MGD = million gallons per day.

2005 Weather = model generated results using actual 2005 weather data. 2005 Normal = model generated results using normal (1971-2000) weather data.

Table B.29: Future withdrawals (in MGD) for public water supply more resource intensive (MRI) scenario for each study area.

Study Area	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-50 % Change
Beardstown	1.29	1.32	1.27	1.33	1.38	1.42	1.48	1.52	1.57	1.62	1.67	26.89
Cass Co. Rem.	0.47	0.34	0.59	0.62	0.64	0.65	0.68	0.70	0.72	0.74	0.76	121.83
Champaign/Urbana	23.24	21.76	22.34	23.59	24.93	26.01	26.62	27.73	28.65	29.60	30.58	40.51
Mahomet	0.53	0.50	0.53	0.56	0.59	0.62	0.63	0.64	0.66	0.68	0.70	41.45
Rantoul	1.78	1.56	1.83	1.93	2.04	2.13	2.18	2.25	2.33	2.40	2.48	58.88
Champaign Co. Rem.	1.08	0.85	1.08	1.14	1.21	1.26	1.29	1.32	1.36	1.40	1.45	70.31
Clinton	0.95	0.80	0.96	1.01	1.05	1.09	1.14	1.18	1.23	1.27	1.32	65.68
DeWitt	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	82.25
DeWitt Co. Rem.	0.41	0.38	0.42	0.44	0.45	0.47	0.49	0.51	0.53	0.55	0.57	49.78
Paxton	0.55	0.44	0.55	0.57	0.60	0.62	0.64	0.66	0.68	0.70	0.72	65.41
Ford Co. Rem.	1.25	1.13	1.24	1.30	1.35	1.40	1.44	1.49	1.54	1.59	1.64	45.36
Watseka	0.59	0.57	0.59	0.62	0.65	0.68	0.71	0.74	0.77	0.80	0.83	46.75
Iroquois Co. Rem.	1.86	1.70	1.88	1.97	2.07	2.16	2.24	2.33	2.43	2.53	2.63	55.23
Lincoln	2.80	2.47	2.63	2.71	2.78	2.85	2.93	3.00	3.07	3.15	3.23	30.91
Logan Co. Rem.	0.82	0.68	0.77	0.80	0.82	0.84	0.86	0.88	0.91	0.93	0.95	39.41
Decatur	23.65	23.22	23.68	24.34	25.30	26.16	27.01	27.90	28.83	29.78	30.77	32.50
Forsyth	0.44	0.37	0.32	0.33	0.35	0.36	0.37	0.38	0.39	0.41	0.42	14.34
Macon Co. Rem.	1.28	1.36	1.26	1.29	1.34	1.39	1.43	1.48	1.53	1.58	1.63	19.77
Mason City	0.30	0.23	0.28	0.29	0.30	0.30	0.31	0.31	0.32	0.33	0.33	44.07
Mason Co. Rem.	0.60	0.44	0.55	0.58	0.59	0.60	0.61	0.62	0.63	0.65	0.66	50.52

Rem. = remainder; MGD = million gallons per day.

2005 Weather = model generated results using actual 2005 weather data. 2005 Normal = model generated results using normal (1971-2000) weather data.

Table B.30: Future withdrawals (in MGD) for public water supply more resource intensive (MRI) scenario for each study area. (continued)

Study Area	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-50 % Change
Bloomington	11.36	10.21	10.77	11.53	12.34	13.06	13.56	14.21	14.90	15.62	16.37	60.32
Hudson	0.15	0.14	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.21	57.82
Normal	4.24	3.55	3.96	4.24	4.54	4.80	4.99	5.23	5.48	5.74	6.02	69.43
McLean Co. Rem.	1.82	1.84	1.72	1.84	1.97	2.08	2.16	2.27	2.38	2.49	2.61	41.88
Petersburg	0.42	0.35	0.43	0.45	0.48	0.50	0.51	0.53	0.54	0.56	0.58	65.79
Menard Co. Rem.	0.38	0.45	0.38	0.41	0.43	0.45	0.46	0.47	0.49	0.50	0.52	16.14
Monticello	0.75	0.65	0.73	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.91	38.54
Piatt Co. Rem.	0.48	0.55	0.47	0.49	0.50	0.52	0.53	0.54	0.55	0.57	0.58	6.29
Springfield	22.90	21.53	20.21	21.29	22.57	23.67	24.61	25.69	26.82	28.00	29.24	35.79
Sangamon Co. Rem.	2.04	1.71	2.80	2.94	3.10	3.24	3.38	3.53	3.68	3.84	4.01	134.75
Creve Coeur	0.93	0.69	0.84	0.90	0.96	1.02	1.06	1.11	1.17	1.23	1.30	86.65
East Peoria	2.80	2.29	2.68	2.87	3.07	3.26	3.39	3.56	3.75	3.94	4.14	80.81
Morton	3.18	2.67	3.04	3.25	3.48	3.69	3.84	4.04	4.25	4.47	4.70	76.21
Pekin	7.48	6.26	6.81	7.28	7.78	8.26	8.60	9.04	9.50	9.99	10.50	67.85
Tazewell Co. Rem.	2.73	2.94	2.61	2.79	2.98	3.17	3.30	3.47	3.65	3.83	4.03	37.12
Washington	1.31	1.04	1.25	1.34	1.43	1.52	1.58	1.67	1.75	1.84	1.94	86.63
Danville	8.35	7.97	7.57	7.61	7.74	7.95	8.28	8.56	8.86	9.16	9.47	18.92
Hoopeston	0.64	0.61	0.60	0.60	0.61	0.63	0.66	0.68	0.70	0.72	0.75	22.86
Vermilion Co. Rem.	0.76	1.34	0.69	0.70	0.71	0.73	0.76	0.78	0.81	0.84	0.87	-35.19
Goodfield	0.08	0.08	0.07	0.07	0.08	0.09	0.09	0.09	0.10	0.10	0.11	38.04
Woodford Co. Rem.	2.19	2.00	2.02	2.16	2.32	2.46	2.56	2.69	2.83	2.97	3.12	55.85
Total	138.88	128.98	132.60	139.09	146.52	153.10	158.38	164.86	171.42	178.24	185.36	43.71

Rem. = remainder; MGD = million gallons per day.

2005 Weather = model generated results using actual 2005 weather data. 2005 Normal = model generated results using normal (1971-2000) weather data.

Table B.31: Estimated future population served for each public water supply study area.

Study Area	County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Beardstown	Cass	6,258	6,442	6,605	6,695	6,829	6,896	7,011	7,127	7,246
Cass County Rem.	Cass	3,985	4,078	4,159	4,204	4,271	4,345	4,403	4,462	4,522
Champaign/Urbana	Champaign	147,156	152,866	158,975	163,211	164,373	168,488	171,286	174,131	177,023
Mahomet	Champaign	5,799	6,023	6,264	6,431	6,477	6,392	6,498	6,606	6,716
Rantoul	Champaign	13,656	14,186	14,753	15,146	15,254	15,505	15,762	16,024	16,290
Champaign County Rem.	Champaign	15,211	15,801	16,432	16,870	16,990	17,046	17,329	17,617	17,909
Clinton	DeWitt	8,073	8,308	8,537	8,725	8,923	9,121	9,323	9,530	9,742
De Witt	DeWitt	194	200	205	210	215	219	224	229	234
DeWitt County Rem.	DeWitt	4,829	4,969	5,107	5,219	5,337	5,456	5,577	5,701	5,827
Paxton	Ford	4,986	5,123	5,266	5,338	5,430	5,515	5,601	5,688	5,777
Ford County Rem.	Ford	7,051	7,244	7,446	7,548	7,679	7,799	7,920	8,044	8,169
Watseka	Iroquois	5,831	6,003	6,204	6,383	6,508	6,666	6,827	6,993	7,162
Iroquois County Rem.	Iroquois	17,179	17,687	18,280	18,808	19,176	19,640	20,116	20,604	21,103
Lincoln	Logan	16,802	17,023	17,237	17,340	17,532	17,681	17,832	17,984	18,138
Logan County Rem.	Logan	6,578	6,665	6,749	6,789	6,864	6,923	6,982	7,041	7,101
Decatur	Macon	85,425	86,379	88,355	89,911	91,328	92,845	94,387	95,955	97,549
Forsyth	Macon	2,961	2,994	3,062	3,116	3,165	3,218	3,271	3,326	3,381
Macon County Rem.	Macon	21,330	21,568	22,061	22,450	22,804	23,183	23,568	23,959	24,357
Mason City	Mason	2,765	2,843	2,881	2,859	2,854	2,868	2,883	2,897	2,912
Mason County Rem.	Mason	7,434	7,642	7,746	7,686	7,672	7,711	7,749	7,788	7,827
Bloomington	McLean	76,689	80,823	85,092	88,617	90,558	93,400	96,331	99,355	102,473
Hudson	McLean	1,857	1,957	2,060	2,145	2,192	2,261	2,332	2,405	2,481
Normal	McLean	53,572	56,459	59,442	61,904	63,259	65,245	67,293	69,405	71,583
McLean County Rem.	McLean	22,324	23,528	24,770	25,796	26,361	27,189	28,042	28,922	29,830

Rem. = remainder

Table B.32: Estimated future population served for each public water supply study area.

Study Area	County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Petersburg	Menard	5,179	5,390	5,614	5,745	5,787	5,874	5,963	6,053	6,144
Menard County Rem.	Menard	8,245	8,582	8,937	9,146	9,213	9,352	9,493	9,637	9,782
Monticello	Piatt	5,153	5,266	5,373	5,418	5,459	5,503	5,547	5,592	5,636
Piatt County Rem.	Piatt	6,698	6,845	6,984	7,042	7,096	7,153	7,211	7,268	7,327
Springfield	Sangamon	144,736	150,057	156,544	161,479	165,237	169,746	174,379	179,139	184,028
Sangamon County Rem.	Sangamon	35,613	36,801	38,184	39,331	40,301	41,401	42,531	43,692	44,885
Creve Coeur	Tazewell	5,994	6,304	6,636	6,931	7,099	7,344	7,597	7,859	8,130
East Peoria	Tazewell	24,319	25,579	26,923	28,123	28,805	29,798	30,825	31,888	32,987
Morton	Tazewell	17,715	18,633	19,612	20,486	20,983	21,706	22,454	23,228	24,029
Pekin	Tazewell	37,587	39,535	41,613	43,467	44,522	46,056	47,644	49,286	50,984
Washington	Tazewell	14,145	14,878	15,660	16,358	16,755	17,332	17,929	18,547	19,187
Tazewell County Rem.	Tazewell	38,820	40,831	42,977	44,892	45,981	47,566	49,205	50,901	52,656
Danville	Vermilion	52,221	51,629	51,675	52,222	53,528	54,471	55,431	56,408	57,402
Hoopeston	Vermilion	5,687	5,623	5,628	5,687	5,829	5,932	6,037	6,143	6,251
Vermilion County Rem.	Vermilion	12,943	12,796	12,807	12,943	13,266	13,500	13,738	13,980	14,227
Goodfield	Woodford	736	777	820	856	876	906	937	969	1,002
Woodford County Rem.	Woodford	24,471	25,832	27,258	28,466	29,130	30,119	31,142	32,199	33,292

Rem. = remainder

Self-supplied domestic data tables

Table B.33: Estimated future water withdrawals (in MGD) for the self-supplied domestic sector for the baseline scenario.

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	0.37	0.38	0.39	0.40	0.41	0.42	0.43	0.43	0.44
Champaign	2.27	2.33	2.39	2.44	2.47	2.44	2.48	2.52	2.56
DeWitt	0.31	0.32	0.33	0.35	0.36	0.37	0.38	0.39	0.4
Ford	0.22	0.22	0.23	0.23	0.24	0.24	0.25	0.25	0.25
Iroquois	0.78	0.8	0.83	0.85	0.87	0.89	0.91	0.94	0.96
Logan	0.65	0.66	0.67	0.67	0.68	0.69	0.69	0.7	0.71
Macon	0.18	0.19	0.19	0.19	0.2	0.2	0.2	0.21	0.21
Mason	0.53	0.54	0.55	0.54	0.54	0.55	0.55	0.55	0.55
McLean	1.16	1.22	1.29	1.34	1.37	1.42	1.46	1.51	1.55
Menard	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Piatt	0.42	0.43	0.44	0.45	0.45	0.45	0.46	0.46	0.46
Sangamon	1.21	1.25	1.31	1.35	1.38	1.42	1.46	1.50	1.54
Tazewell	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12
Vermilion	0.60	0.59	0.59	0.60	0.62	0.63	0.64	0.65	0.66
Woodford	1.16	1.23	1.29	1.35	1.38	1.43	1.48	1.53	1.58
Total	9.96	10.28	10.62	10.89	11.09	11.25	11.50	11.75	12.01

MGD = million gallons per day

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Appendix C

Power Generation Sector

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Table C.1: Power generator status from ISWS data.

Utility	Plant Name	County	Mega Watts
1. Rantoul, Village of	Rantoul	Champaign	29.9
2. University of Illinois	U. of I. Abbott Power Plant	Champaign	88.0
3. Breese, City of	Breese	Clinton	13.9
4. Carlyle, City of	Carlyle	Clinton	12.5
5. AmerGen Energy Co LLC	Clinton Power Station	De Witt	990.0
6. Farmer City, City of	Farmer City	De Witt	6.9
7. Ameren Energy Generating Co	Gibson City	Ford	270.0
8. A E Staley Manufacturing Co	A E Staley Decatur Plant Cogen	Macon	62.0
9. Archer Daniels Midland Co	Archer Daniels Midland Decatur	Macon	230.0
10. DTE Biomass	KMS Macon Power	Macon	1.6
11. PPG Industries Inc Works 14	PPG Industries Works 14	Macon	5.9
12. Dynegy Midwest Gen. Inc	Havana	Mason	718.0
13. Ameren IP	State Farm	McLean	5.1
14. Corn Belt Energy Corporation	Parkside	McLean	6.0
15. Corn Belt Energy Corporation	Gillum	McLean	4.0
16. Corn Belt Energy Corporation	BNWRD	McLean	2.0
17. Aquila Services Inc	Goose Creek Energy Center	Piatt	684.0
18. Resource Technology Corp	Biodyne Springfield	Sangamon	3.0
19. Springfield, City of	Dallman	Sangamon	387.7
20. Springfield, City of	Lakeside	Sangamon	80.4

Table C.2: Power generator status from ISWS data (cont.).

Utility	Plant Name	County	Mega Watts
21. Springfield, City of	Reynolds	Sangamon	17.5
22. Springfield, City of	Interstate	Sangamon	138.6
23. Springfield, City of	Factory	Sangamon	26.6
24. Bio-Energy Partners	Tazewell Gas Recovery	Tazewell	2.4
25. Central Illinois Light Co	Indian Trails Cogen 1	Tazewell	21.0
26. Midwest Gen. EME LLC	Powerton	Tazewell	1,785.6
27. Pekin Paperboard Co LP	Pekin Paperboard	Tazewell	1.5
28. Bunge Milling Inc	Bunge Milling Cogen	Vermilion	20.0
29. Dynegy Midwest Gen. Inc	Vermilion	Vermilion	198.8
30. Dynegy Midwest Gen. Inc	Tilton	Vermilion	188.0
31. Illinois Electrical Gen. Partnership	Brickyard Energy Partners LLC	Vermilion	3.3
Total generating capacity			6,004.2

Appendix D

Commercial and Industrial Sector

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D.1 General regression method

Modeling of water demand usually concerns the average rate of water withdrawal, q_{cit} , which is expected to change over time. Water-withdrawal relationships can be expressed in the form of equations, where this average rate of water withdrawal is expressed as a function of one or more independent (explanatory) variables. A multivariate context best relates to actual water-demand behaviors, and multiple regression analysis can be used to determine the relationship between water demand and each independent variable. The functional form (e.g., linear, multiplicative, exponential) and the selection of the independent variables depend on the category of water demand. For example, public water supply withdrawals can be estimated using the following linear model:

$$PS_{it} = a + \sum_{j} b_j X_{jit} + \varepsilon_{it} \tag{D.1}$$

where

PS_{it} = per capita public supply water withdrawals within geographical area i during year t;

X_{jit} = a set of independent variables (e.g., air temperature, precipitation, price of water, median household income and others), which are expected to explain public supply withdrawals; and

ε_{it} = random error.

The coefficients a and b_j can be estimated by fitting a multiple regression model to historical water-withdrawal data.

The models used in this study are specified as double-log (i.e., log-linear models). Additional variables serve to fit the model to the data and also isolate observations which are likely to be outliers:

$$lnPS_{it} = \alpha_o + \sum_{j} \beta_j lnX_{jit} + \sum_{k} \gamma_k lnR_{kit} + \sum_{l} \delta_l D_{lit} + \sum_{m} \rho_m S_{mit} + \varepsilon_{it} \tag{D.2}$$

where:

PS_{it} = per capita public supply water withdrawals within geographical area i during year t (in gallons per capita per day);

X_j = a set of independent variables;

R_k = ratio (percentage) variables such as ratio of employment to population;

D_l = indicator (or binary) variables designating specific public water supply systems which assume the value of one (1) for observations for the system and zero (0) otherwise;

S_m = indicator spike variables designating individual observations in the data;

ε_{it} = random error; and

α, β, γ, δ,and ρ are the parameters to be estimated.

A large number of econometric studies of water withdrawals have been conducted during the last 50 years. Haneman (1998) summarized the theoretical underpinnings of water-demand modeling and reviewed a number of determinants of water demand in major economic sectors. Useful summaries of econometric studies of water demand can be found in Boland et al. (1984). Dziegielewski et al. (2002a) reviewed a number of studies of aggregated sectoral and regional demand. A substantial body of work on model structure and estimation methods was also performed by the USGS (Helsel and Hirsch, 1992).

Model estimation and validation procedures Several procedures were used to specify and select the water-demand models for this study: (1) models included variables that had been identified by previous research, (2) the variables had regression coefficients that were statistically significant, (3) the variables were within a reasonable range of *a priori* values and with expected signs, (4) the explanatory power of the model was reasonable, as measured by the coefficient of multiple determination (R^2), and (5) the absolute percent error of model residuals was not excessive. This modeling approach and estimation procedure were originally developed and tested in the study of geographically aggregated water withdrawal data conducted by Dziegielewski et al. (2002a, 2002b).

The procedure for estimating the predictive water-demand equations consisted of three elements: (1) development of a "structural" model, (2) compensating for fixed effects of study areas and outliers, and (3) final model calibration.

The first step was to identify the best "driver" variables and the "key" significant independent variables. These variables were selected based on information from previous studies of water withdrawals. Several combinations of predictor variables were examined prior to selecting the best "structural" model, which explained the variability of historical water withdrawal in the data in terms of known determinants of water demand.

In the second step, the "structural" model was examined for the effects of study areas and influences of data outliers on the signs and magnitudes of the estimated coefficients. This was accomplished by using an interactive stepwise regression procedure through which one binary variable is added to the structural model to account for each outlier, and its effect on the regression coefficients is examined. The statistically significant binary variables were kept in the model, thus accounting for their influence on the structural model.

In the third step, the "structural" model, supplemented with the binary site and outlier variables to account for the effects of study areas and data outliers, was extended to include additional binary variables, designating individual geographical areas and observations for the most recent data year (*i.e.*, 2005) for model calibration purposes. This was accomplished by estimating a model of residuals used as dependent variables on the full set of binary variables which identified individual public water supply systems (or study areas) through a stepwise regression procedure. The purpose of this step was to use the information contained in the residuals to enhance the predictions from the model without affecting the coefficients of the structural model. In the final step, the structural model of water withdrawals was re-estimated with all statistically significant binary variables and coefficients with low statistical significance were left in the residuals model.

Finally, the accuracy of predictive models was evaluated by the mean absolute percentage error (MAPE). In the linear model of the form shown in Equation 1.2, designated to be the predicted value of the dependent variable Y_{it}, the absolute percentage error (APE) is given by:

$$APE_{it} = \left| \frac{\hat{Y}_{it} - Y_{it}}{Y_{it}} \right| x\,100 \qquad \text{(D.3)}$$

In a log-linear model of the form shown in Equation 1.3, the APE in the log scale is given by:

$$APE_{it} = \left| \frac{ln\hat{Y}_{it} - lnY_{it}}{lnY_{it}} \right| x\,100 \qquad \text{(D.4)}$$

Assuming that the errors are normally distributed in a log-linear model it can be shown that the expected value of the dependent variable in the raw (linear) scale is:

$$E\,(Y \mid explanatory\,variables) = e^{\sigma_{\varepsilon}^{2}/2}(e^{\ln\,Y}) \qquad \text{(D.5)}$$

Thus, in log-linear models, the predicted raw scale value denoted as $\widetilde{Y}$ is given by:

$$\widetilde{Y} = e^{\hat{\sigma}_{\varepsilon}^{2}/2}(e^{\ln\hat{}\,Y}) \qquad \text{(D.6)}$$

where:
$\hat{\sigma}_{\varepsilon}^{2}$= the mean square error of the log-linear model; and
$ln\hat{Y}_{it}$ = the predicted value obtained from the log-linear model.
APE in the raw scale is obtained as:

$$APE_{it} = \left| \frac{\widetilde{Y_{it}} - Y_{it}}{Y_{it}} \right| x\,100 \qquad \text{(D.7)}$$

Finally, the mean absolute percentage error (MAPE) is defined as the average over all observations (*i.e.*, over i and t) of APE_{it}. *i.e.*,

$$MAPE = \frac{\sum_i \sum_t APE_{it}}{n} \tag{D.8}$$

where:

$n = mT$, *i.e.*, number of cross-sectional observations times the number of time periods in the data.

D.2 Commercial and industrial model development procedures

The development of the water use equation for preparing future water withdrawals represented a significant challenge because of the aggregate nature of the data and the limited number of observations on historical water withdrawals. The total number of available cross-sectional and time series observations was 75 (i.e., 15 study areas representing counties times 5 time periods). The procedure for estimating the predictive water-use equation was similar to the procedure used in the public-supply sector (as described in Chapter 2 Appendix). It consisted of three steps: (1) derivation of a "structural model", (2) compensating for fixed effects of study sites (individual counties), and (3) examination of the influence of outliers on the estimated model coefficients. Each of these steps is described and illustrated with tables and figures below.

D.2.1 Structural model

Total county employment was used to express the dependent variable as average industrial and commercial water withdrawals (and purchases) per employee per day for each county (i.e., study area) and data year. If the per employee rate of water withdrawals in each study area could be predicted with sufficient accuracy, then total withdrawals (and purchases) would be obtained by multiplying the per employee use by total county employment, where the latter represents a driver of industrial and commercial demands. An important advantage of modeling the per employee use is that by expressing total withdrawals in per employee terms, the dependent variable is "normalized" across study sites and the heterogeneity associated with total withdrawals is reduced.

The first step was to identify the relevant explanatory variables, which would explain the variability of per employee withdrawals across the 15 counties and the 5 time periods. These variables were selected based on information from previous studies of water use. Several combinations of explanatory variables were examined prior to selecting the best "structural" model which explained

Table D.1: Structural log-linear model of per employee water demand in *Commerical* and Industrial sector (ln GPED).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Structural model			
Intercept	-1.4240	-0.31	0.7540
Annual cooling degree days (ln)	0.5644	0.94	0.3512
Summer precipitation (ln)	-0.0932	-0.27	0.7861
Health services employment (%)	0.0773	2.96	0.0042
Retail employment (%)	0.0528	2.16	0.0343
Manufacturing Employment (%)	0.0022	0.21	0.8322
Percent self-supplied C&I demand (%)	0.0328	16.14	<.0001
Conservation trend (ln)	-0.1726	-1.68	0.0970
N = 75, R^2= 0.837, Mean Y = 4.599, Root MSE = 0.613			

the variability of historical water quantities in the data in terms of known determinants of industrial and commercial water demand.

Table D.1 shows the estimated log-liner regression equation of the structural model. The equation includes six relevant explanatory variables. The expected signs (positive or negative) and magnitudes of the regression coefficients in the structural model are based on economic theory and on the underlying physical relationships as well as on the results of the previous studies of aggregate water demand. The expected signs are positive for temperature and negative for precipitation and conservation trend variable. A priori expectations about the signs of the other three variables (percent of county employment in health services, percent of employment in retail trade and percent of employment in manufacturing) were not available.

The results in Table D.1 show that only four of the eight regression coefficients are statistically significant at approximately 10 percent level. The low significance of the two weather variables and one of the manufacturing share of employment are likely a result of the small data sets (n = 75) and possible data errors in some of the observations on the dependent and independent variables. To address this problem, alternative model specification had to be considered and each data point needed to be examined in some detail.

D.2.2 Model with fixed effects of study areas

The next step in model development was to extend the structural model from Table D.1 by including the binary variables designating individual study sites. A regression of the key structural variables along with the study site binary variables to compete for a significant share of the remaining model variance was estimated. This was accomplished by using a stepwise regression procedure through which binary variables are added to the structural model to account for each study site. The binary study site variables with statistically significant regression coefficients were kept in the model.

This extended, more fully-specified model is presented in Table D.2 below. In addition to the seven structural model variables, it includes four binary variables which designate individual counties. Of the 11 variables in the model seven have regression coefficients which are statistically significant. The coefficients of the county binaries can be considered as representing site specific "intercept adjusters" because they increase or decrease the main intercept of the regression equation.

The structural part of the model in Table D.2 still shows a lack of statistical significance of regression coefficients for four of the seven variables. However, the coefficients of cooling degree-days and precipitation, although not statistically significant have the expected sign.

One concern regarding the data was that the year 2005 was a drought year (with a moderate drought in terms of precipitation deficits) and that its inclusion in the data could bias the estimated regression coefficients of the structural variables. In order to determine if this was the case, a time period binary variable which designates the year 2005 was added to the extended model (from Table D.2). However its regression coefficient was found to be highly insignificant. Because of the lack of statistical significance of the four regression coefficients the next step in model building was undertaken.

D.2.3 Effects of outliers on model coefficients

The model shown in Table D.2 was examined for the effects of possible outliers on the magnitudes and statistical significance of the estimated coefficients. The procedure which was used to examine the effects of outliers on the estimated model without removing any suspected observation from the data is described in Chapter 2 Appendix.

Using the above procedure, the effects of outliers on the coefficients of the model in Table 4.4 are analyzed and are presented in Table D.3 and are graphed in Figures D.1 - D.7. For some variables these effects appear to be minor. Significant shifts on the regression coefficients were

Table D.2: Re-estimated log-linear model of per employee water demand with study site binaries (ln GEPD).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Structural model			
Intercept	-0.0168	0.00	0.9966
Annual cooling degree days (ln)	0.3406	0.65	0.5149
Summer precipitation (ln)	-0.2061	-0.73	0.4695
Health services employment (%)	0.0676	2.98	0.0041
Retail employment (%)	0.0699	3.44	0.0010
Manufacturing Employment (%)	0.0115	1.27	0.2088
Percent self-supplied C&I demand (%)	0.0308	15.16	<0.0001
Conservation trend (ln)	-0.1149	-1.34	0.1850
County intercepts			
DeWitt	0.4840	1.90	0.0625
Ford	0.5145	2.07	0.0427
Mason	1.2191	4.34	<0.0001
Logan	0.8532	3.47	0.0009
N = 55, R^2= 0.922, Mean Y = 4.616, Root MSE = 0.211			

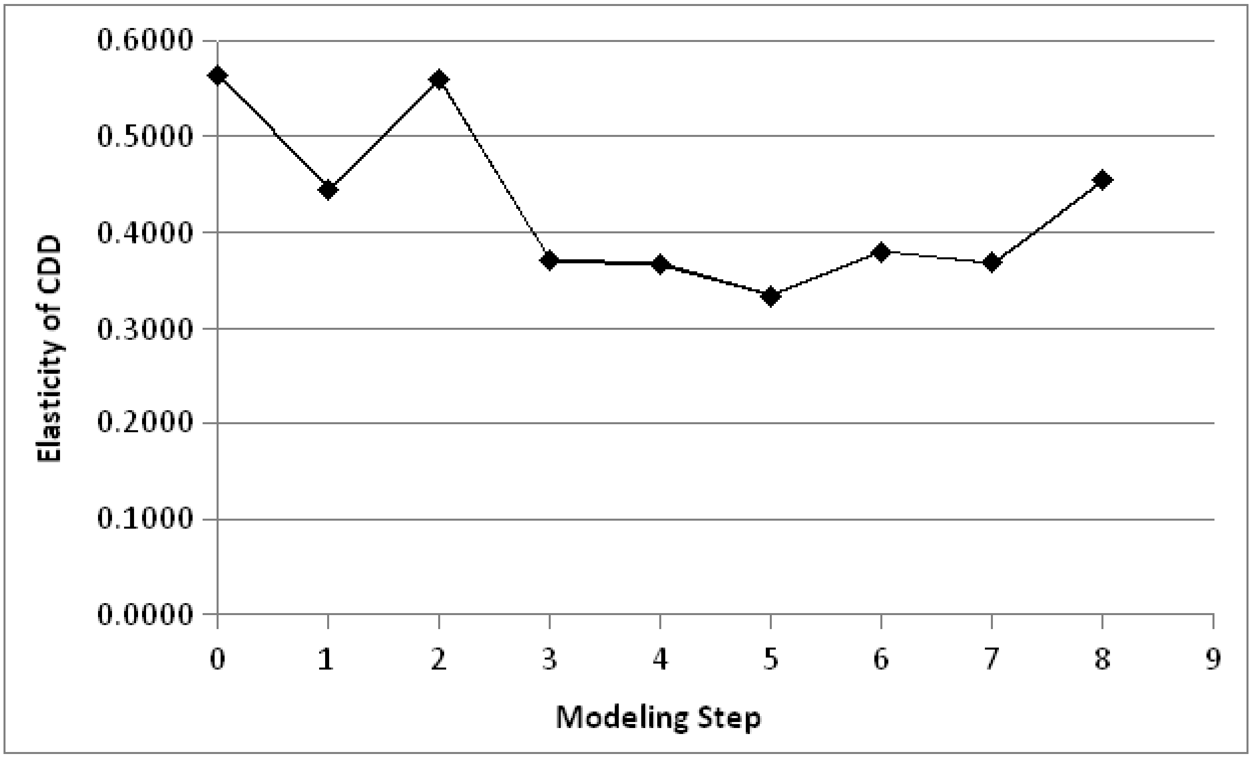

Figure D.1: Effects of binary site variables and spike dummies on estimated elasticity of cooling degree days.

obtained for the two weather variables: cooling degree-days and precipitation.

D.2.4 Final regression models

After examining the effects of model outliers on the estimated regression coefficients of the structural model, the model with four binary variables designating individual counties and two binary outlier variables was selected (Modeling Step 6) as a suitable model. The re-estimated regression equation with the nine outlier variables is shown in Table D.4 below.

The results in Table D.4 show that the significance of the regression coefficients has increased to the 10 percent level for most variables with the exception of annual cooling degree-days and precipitation. Also the magnitudes of all six regression coefficients are within the expected levels. However, because the prediction errors of the model in Table D.4 are high for some observations (MAPE =41%), an alternative model from Step 10 was selected for the scenario analysis. The final model is shown in Table D.5 below.

Model diagnostics tests shown at the bottom of the table indicate that the model is free from

Table D.3: Effects of adding binary study area and spike dummies on estimated regression coefficients of the structural commercial and industrial model.

Step	Model specification/ Outliers	CDD	Precipitation	Health Services Employment (%)	Retail Trade Employment (%)	Manufacturing Employment (%)	Self-supplied (%)	Conservation Trend
0	Structural model only	0.5644	-0.0932	0.0022	0.0528	0.0773	0.0328	-0.1726
1	Fixed - Logan Co.	0.4257	-0.2177	0.0601	0.0638	0.0011	0.0336	-0.1363
2	Fixed - DeWitt Co.	0.4257	-0.2177	0.0601	0.0638	0.0011	0.0336	-0.1363
3	Fixed - Ford Co.	0.6282	-0.1984	0.0632	0.0643	-0.0003	0.0348	-0.1613
4	Fixed - Mason Co.	0.3406	-0.2061	0.0676	0.0699	0.0115	0.0308	-0.1149
Spike variables								
5	DeWitt 1990	0.3082	-0.1574	0.0677	0.0702	0.0127	0.0307	-0.1108
6	Logan 2000	*0.4033*	*-0.1632*	*0.0678*	*0.0715*	*0.0126*	*0.0309*	*-0.1279*
7	Iroquois 1995	0.4521	-0.1319	0.0687	0.0686	0.0135	0.0305	-0.1300
8	Logan 2005	0.3203	-0.3481	0.0650	0.0719	0.0107	0.0321	-0.0981
9	DeWitt 1985	0.3906	-0.3287	0.0669	0.0698	0.0105	0.0322	-0.1285
10	Ford 1995	0.5297	-0.2766	0.0618	0.0740	0.0098	0.0324	-0.1262

Note: Coefficients of the selected model are shown in *italics*.

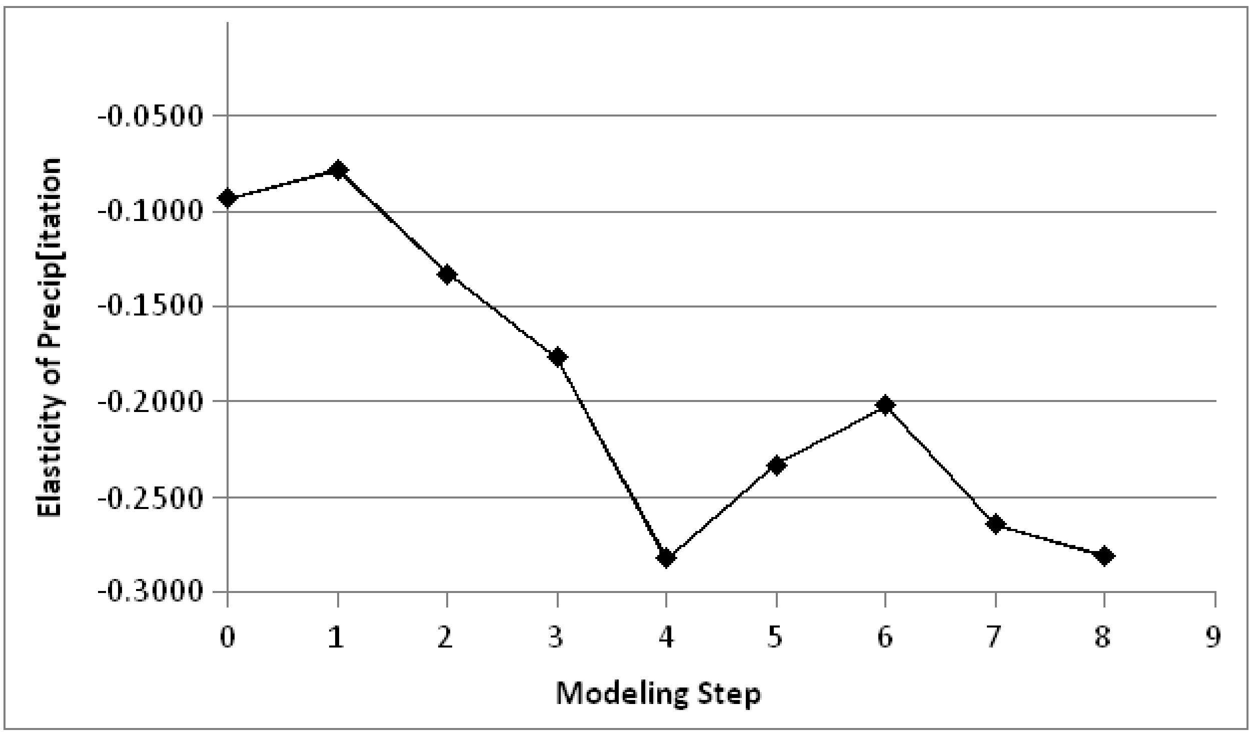

Figure D.2: Effects of binary site variables and spike dummies on estimated elasticity of precipitation.

Table D.4: Step 6 log-linear model of per employee water demand in commercial and industrial sector (ln GPED).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Structural model			
Intercept	-0.5931	-0.16	0.8743
Annual cooling degree days (ln)	0.4033	0.81	0.4222
Summer precipitation (ln)	-0.1632	-0.60	0.5493
Health services employment (%)	0.0678	3.14	0.0026
Retail employment (%)	0.0715	3.69	0.0005
Manufacturing Employment (%)	0.0126	1.45	0.1509
Percent self-supplied C&I demand (%)	0.0309	15.91	<.0001
Conservation trend (ln)	-0.1279	-1.55	0.1256
County intercepts			
DeWitt	0.7314	2.75	0.0078
Ford	0.5252	2.21	0.0307
Mason	1.2291	4.58	<.0001
Logan	0.6579	2.55	0.0132
Spike Binaries			
DeWitt 1990	-1.2039	-2.23	0.0296
Logan 2000	0.9759	1.79	0.0779
N = 75, R^2= 0.910, Mean Y = 4.599, Root MSE = 0.478; MAPE = 41%			

ln = log; GPED = gallons per employee per day.

Table D.5: Final log-linear model per employee water demand in commercial and industrial sector (ln GPED).

Variables	Estimated coefficient	t Ratio	Probability >|t|
Structural model			
Intercept	-1.1465	-0.34	0.7322
Annual cooling degree days (ln)	0.5297	1.20	0.2369
Summer precipitation (ln)	-0.2766	-1.13	0.2611
Health services employment (%)	0.0618	3.25	0.0019
Retail employment (%)	0.0740	4.34	<.0001
Manufacturing Employment (%)	0.0098	1.30	0.1997
Percent self-supplied C&I demand (%)	0.0324	18.58	<.0001
Conservation trend (ln)	-0.1262	-1.70	0.0941
County intercepts			
DeWitt	0.9598	3.64	0.0006
Ford	0.6978	2.96	0.0045
Mason	1.0791	4.60	<.0001
Logan	1.1742	4.42	<.0001
Spike Binaries			
DeWitt90	-1.3492	-2.79	0.0072
Logan00	0.5303	1.09	0.2823
DeWitt85	-0.8070	-1.62	0.1106
Ford95	-0.8444	-1.73	0.0897
Iroquois95	-0.8042	-1.91	0.0617
Logan05	-1.9276	-3.77	0.0004

N = 75, R^2= 0.937, Mean Y = 4.599, Root MSE = 0.414; MAPE = 33%

Model specification tests (statistic and significance): Ramsey power 2 = 0.1495 (0.7004), Ramsey power 3 = 0. 7399 (0. 4818), Ramsey power 4 = 1. 0476 (0.3791)

Heteroscedasticity tests (statistic and significance):

White's test = 46.15 (0. 8232), Breusch-Pagan test =10.43 (0. 8848)

ln = log; GPED = gallons per employee per day.

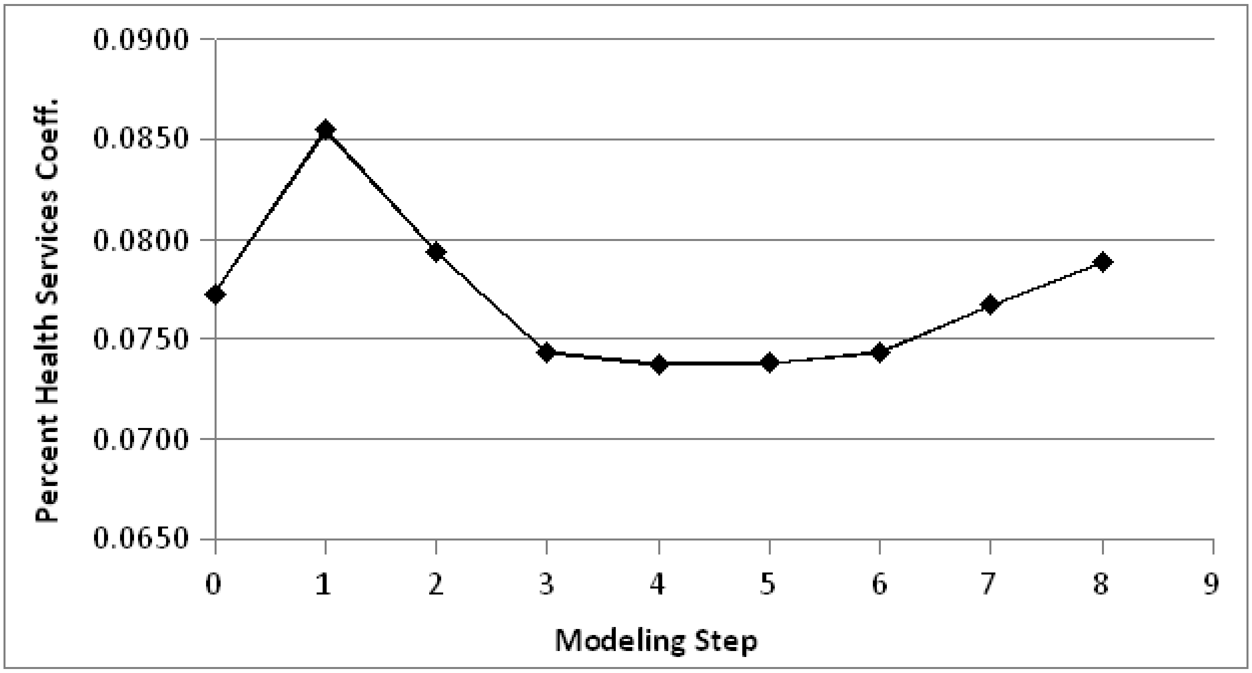

Figure D.3: Effects of binary site variables and spike dummies on estimated coefficient of percent employment in health services.

specification error (i.e., none of the Ramsey tests is statistically significant) and heteroscedasticity (i.e., non-constant error problems, both the White's test and Breusch-Pagan test are not statistically significant). Also, the plot of residuals by predicted values shown on Figure D.8 below does not indicate the presence of heteroscedasticity.

D.2.5 In-Sample prediction errors

The accuracy of the predictive model shown in Table D.5 was evaluated by the mean absolute percentage error (MAPE) by using the regression equation to estimate the historical values of water demand in the data.

The regression model from Table D.5 has the MAPE value for in-sample predictions of 33 percent. The actual and predicted values of per capita water use in the data are shown in Table D.6 below.

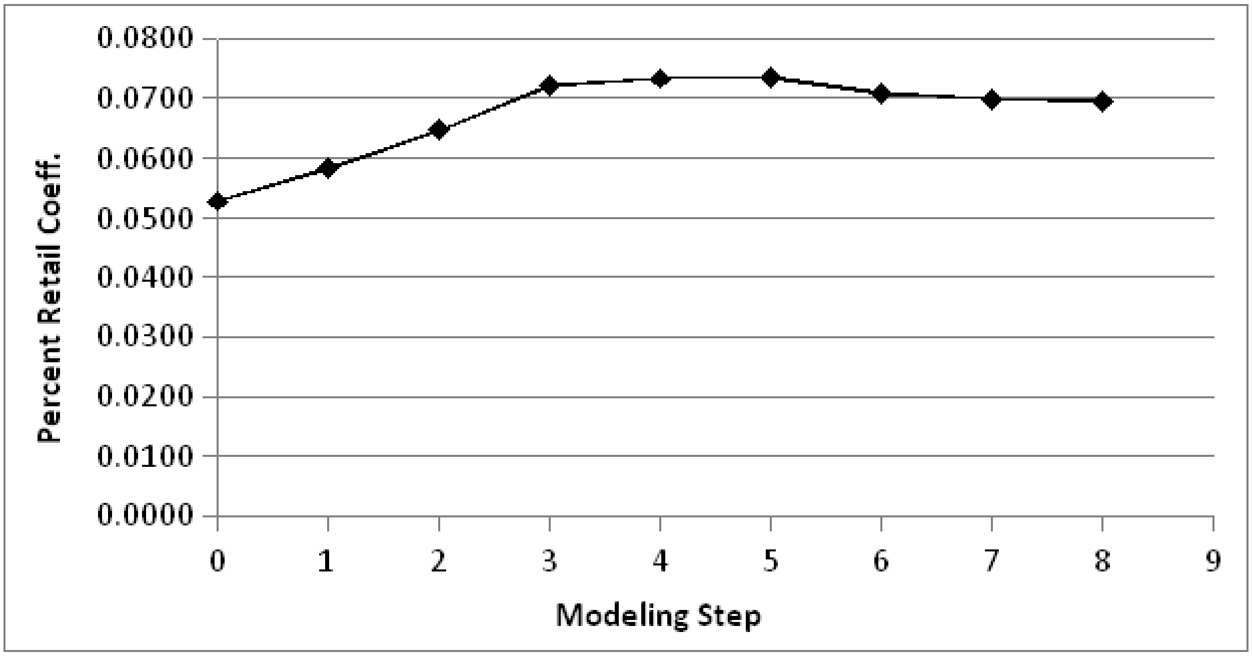

Figure D.4: Effects of binary site variables and spike dummies on estimated coefficient of percent employment in retail trade.

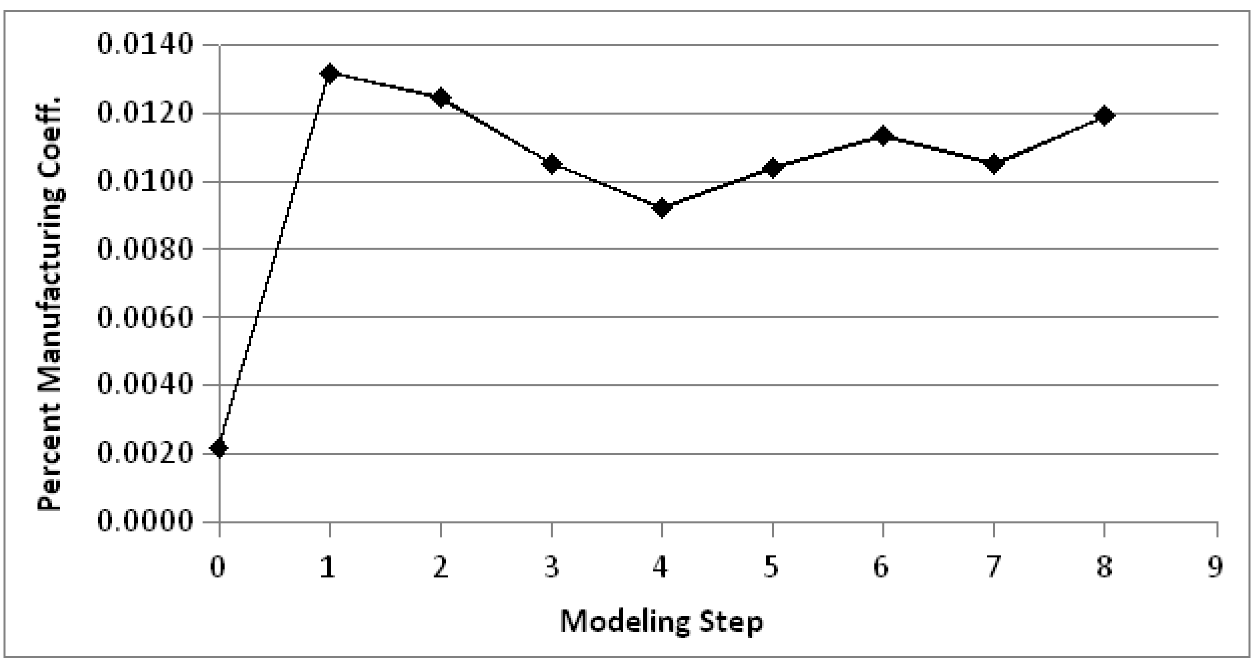

Figure D.5: Effects of binary site variables and spike dummies on estimated coefficient of percent employment in manufacturing.

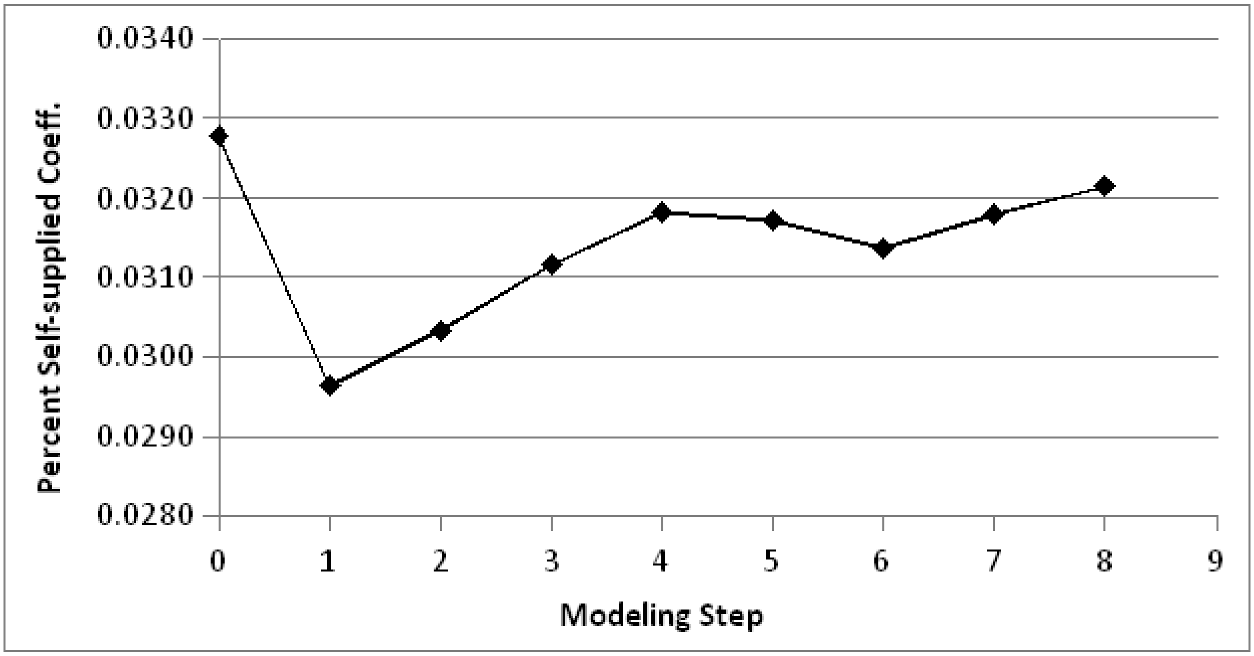

Figure D.6: Effects of binary site variables and spike dummies on estimated coefficient of percent self-supplied commercial and industrial water demand.

Table D.6: Model-predicted and actual values of per employee water demand.

Study Area and Year	Actual GPED	Predicted GPED	Difference in GPED	Absolute % difference
Cass 1985	174.1	169.5	-4.6	2.6
Cass 1990	342.5	488.1	145.5	42.5
Cass 1995	254.3	297.8	43.5	17.1
Cass 2000	313.4	294.0	-19.4	6.2
Cass 2005	263.2	355.7	92.5	35.1
Champaign 1985	205.7	254.8	49.2	23.9
Champaign 1990	189.6	261.5	71.9	37.9
Champaign 1995	145.2	267.6	122.4	84.3
Champaign 2000	116.3	91.0	-25.4	21.8
Champaign 2005	114.1	118.3	4.2	3.7
De Witt 1985	21.2	23.1	1.9	8.9
De Witt 1990	14.1	15.3	1.3	8.9
De Witt 1995	46.3	53.0	6.6	14.3

Table D.6: Model-predicted and actual values of per employee water demand.

Study Area and Year	Actual GPED	Predicted GPED	Difference in GPED	Absolute % difference
De Witt 2000	31.8	31.8	0.0	0.0
De Witt 2005	34.1	38.6	4.4	13.0
Ford 1985	66.5	60.7	-5.8	8.8
Ford 1990	54.3	50.0	-4.2	7.8
Ford 1995	179.4	195.5	16.0	8.9
Ford 2000	439.1	545.7	106.6	24.3
Ford 2005	496.4	668.3	171.9	34.6
Iroquois 1985	25.0	43.4	18.4	73.3
Iroquois 1990	11.4	45.3	34.0	298.4
Iroquois 1995	13.9	15.1	1.2	8.9
Iroquois 2000	25.2	25.5	0.3	1.2
Iroquois 2005	22.6	17.3	-5.4	23.7
Logan 1985	125.0	90.1	-34.9	28.0
Logan 1990	116.9	115.3	-1.6	1.3
Logan 1995	101.4	184.3	83.0	81.8
Logan 2000	103.7	112.9	9.3	8.9
Logan 2005	105.7	115.2	9.4	8.9
Macon 1985	416.2	941.8	525.5	126.3
Macon 1990	545.1	438.5	-106.6	19.6
Macon 1995	437.9	595.5	157.6	36.0
Macon 2000	432.7	402.8	-29.9	6.9
Macon 2005	409.9	446.4	36.5	8.9
Mason 1985	1358.2	1043.0	-315.3	23.2
Mason 1990	1114.7	921.9	-192.8	17.3
Mason 1995	653.2	870.4	217.2	33.2
Mason 2000	661.7	867.3	205.6	31.1
Mason 2005	792.1	1095.2	303.1	38.3
McLean 1985	68.3	71.1	2.7	4.0
McLean 1990	28.5	34.8	6.3	22.1
McLean 1995	19.8	37.0	17.2	87.0

Table D.6: Model-predicted and actual values of per employee water demand.

Study Area and Year	Actual GPED	Predicted GPED	Difference in GPED	Absolute % difference
McLean 2000	25.6	19.7	-5.9	23.1
McLean 2005	16.1	26.5	10.4	64.6
Menard 1985	13.2	10.0	-3.3	24.7
Menard 1990	9.5	8.6	-1.0	10.0
Menard 1995	5.2	11.2	6.0	115.1
Menard 2000	5.7	7.4	1.8	31.0
Menard 2005	6.8	8.7	1.9	27.6
Piatt 1985	178.0	231.2	53.2	29.9
Piatt 1990	118.9	165.3	46.4	39.0
Piatt 1995	126.5	215.3	88.8	70.2
Piatt 2000	116.9	152.0	35.1	30.0
Piatt 2005	139.9	179.9	40.0	28.6
Sangamon 1985	57.7	100.2	42.5	73.8
Sangamon 1990	106.5	61.1	-45.4	42.6
Sangamon 1995	109.7	69.6	-40.1	36.6
Sangamon 2000	102.9	162.0	59.1	57.4
Sangamon 2005	128.5	140.5	12.0	9.3
Tazewell 1985	745.4	533.5	-211.9	28.4
Tazewell 1990	495.0	382.8	-112.2	22.7
Tazewell 1995	651.5	418.7	-232.8	35.7
Tazewell 2000	682.1	289.5	-392.6	57.6
Tazewell 2005	757.3	370.1	-387.2	51.1
Vermilion 1985	298.2	250.5	-47.7	16.0
Vermilion 1990	260.5	239.6	-20.9	8.0
Vermilion 1995	223.9	320.0	96.0	42.9
Vermilion 2000	196.6	146.1	-50.5	25.7
Vermilion 2005	169.4	112.6	-56.8	33.5
Woodford 1985	17.2	17.0	-0.3	1.5
Woodford 1990	14.5	14.2	-0.3	2.3
Woodford 1995	16.5	15.6	-0.9	5.3

Table D.6: Model-predicted and actual values of per employee water demand.

Study Area and Year	Actual GPED	Predicted GPED	Difference in GPED	Absolute % difference
Woodford 2000	15.0	12.2	-2.8	18.5
Woodford 2005	13.3	15.7	2.4	17.8
MAPE %	–	–	–	33.0

GPED = gallons per employee per day.

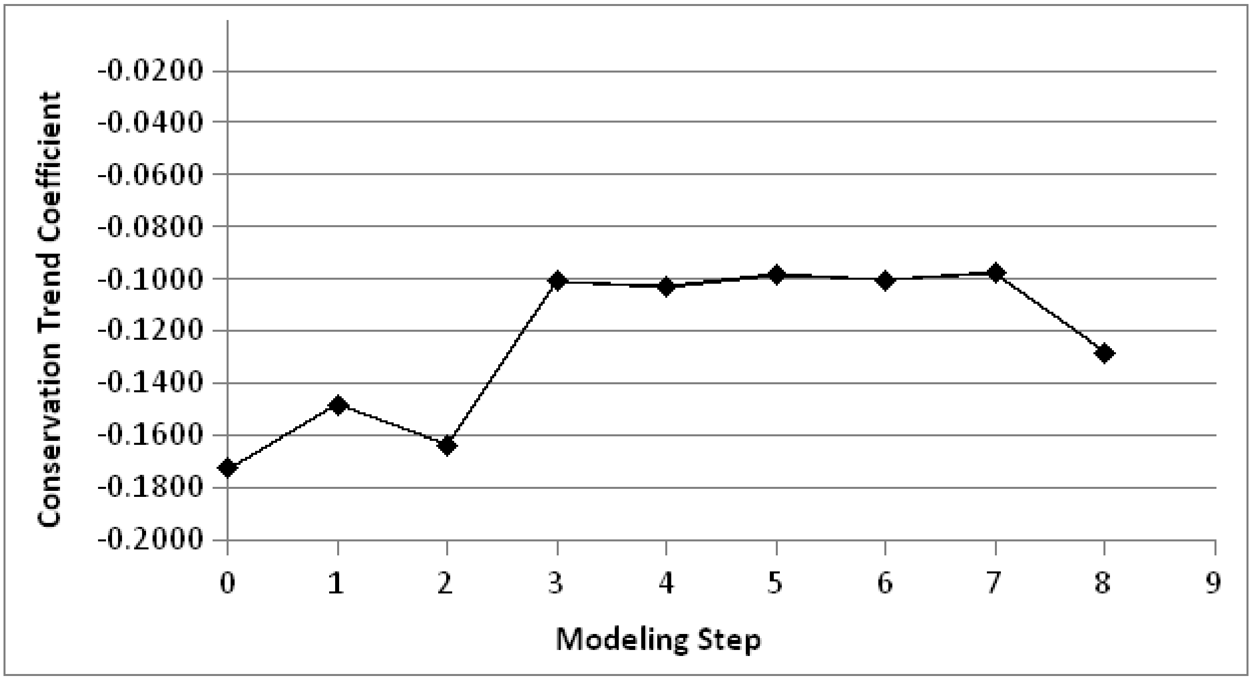

Figure D.7: Effects of binary site variables and spike dummies on estimated coefficient of conservation trend variable.

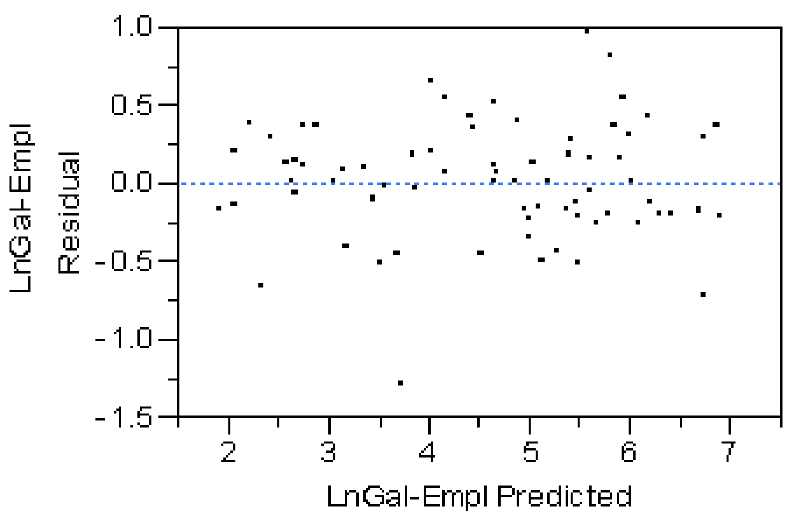

Figure D.8: Residuals plot for the model in Table D.5.

D.3 Weather stations used in the study

Table D.7: Weather stations in East-Central Illinois.

County	Station name / location	Station no.
Cass	Virginia	118870
Cass	Beardstown	110492
Champaign	Urbana	118740
Champaign	Rantoul	117150
DeWitt	Clinton 1 SSW	111743
Ford	Gibson City 1 E	113413
Ford	Paxton	116663
Ford	Piper City	116819
Iroquois	Watseka 2 NW	119021
Logan	Lincoln	115079
Logan	Mount Pulaski	115927
Macon	Decatur	112193
Mason	Havana 4 NNE	113940
Mason	Mason City 1 W	115413
McLean	Normal	116200
McLean	Bloomington Waterworks	110761
McLean	Chenoa	111475
Menard	Petersburg 2 SW	116765
Menard	Petersburg 3 SSW	116760
Piatt	Monticello No 2.	115792
Sangamon	Springfield WSO AP	118179
Tazewell	Mackinaw 1 N	115272
Vermilion	Danville	112140
Vermilion	Danville Sewage Plant	112145
Vermilion	Hoopeston	114198
Vermilion	Sidell 5 NW	117952
Peoria	Peoria GTR Peoria Regional AP	116711
Woodford	Minonk	115712
Morgan	Jacksonville 2E	114442

Source: Illinois State Climatologist, Illinois State Water Survey, 2007.

D.4 Commercial and industrial data tables

Table D.8: Self-supplied commercial and industrial water withdrawals in MGD for the baseline (BL) scenario for each county.

County	2005	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-2050	
	Weather	Normal										MGD	%
Cass	1.87	1.53	1.55	2.29	2.39	2.50	2.62	2.75	2.88	3.02	3.16	1.63	107
Champaign	5.74	4.82	6.60	6.93	7.32	7.70	8.10	8.51	8.92	9.33	9.74	4.92	102
DeWitt	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	-
Ford	3.02	2.54	4.34	4.55	4.80	5.06	5.34	5.63	5.93	6.23	6.54	4.00	157
Iroquois	0.02	0.02	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.46	7300
Logan	1.10	0.84	0.91	2.18	2.26	2.34	2.43	2.53	2.62	2.72	2.82	1.98	236
Macon	15.89	12.88	16.16	17.37	18.77	20.10	21.44	22.78	24.10	25.37	26.59	13.71	106
Mason	5.44	3.88	3.45	4.98	5.29	5.61	5.96	6.32	6.70	7.09	7.48	3.60	93
McLean	0.01	0.01	0.43	1.68	1.73	1.78	1.84	1.90	1.96	2.01	2.07	2.06	20600
Menard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Piatt	1.15	0.94	1.06	1.11	1.16	1.22	1.28	1.35	1.42	1.49	1.56	0.62	66
Sangamon	5.01	4.13	4.74	5.10	5.52	5.93	6.34	6.75	7.16	7.55	7.93	3.80	92
Tazewell	43.35	29.75	33.16	36.07	39.52	42.99	46.66	50.47	54.35	58.24	62.05	32.30	109
Vermilion	2.74	2.36	3.92	4.15	4.41	4.67	4.94	5.22	5.50	5.78	6.04	3.68	156
Woodford	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	-
Totals	85.34	63.70	77.75	87.85	94.62	101.36	108.42	115.69	123.03	130.34	137.51	73.81	116

Weather = model generated results using 2005 weather data

Normal = model generated results using normal weather data

MGD = millions of gallons per day

Table D.9: Self-supplied commercial and industrial water withdrawals in MGD for the less resource intensive (LRI) scenario for each county.

County	2005	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-2050	
	Weather	Normal										MGD	%
Cass	1.87	1.53	1.37	1.93	2.01	2.10	2.19	2.29	2.40	2.51	2.63	1.10	72
Champaign	5.74	4.82	5.65	5.91	6.22	6.53	6.85	7.18	7.51	7.84	8.17	3.35	70
DeWitt	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-
Ford	3.02	2.54	3.66	3.83	4.04	4.25	4.47	4.71	4.95	5.20	5.45	2.91	115
Iroquois	0.02	0.02	1.07	1.07	1.08	1.09	1.10	1.10	1.11	1.12	1.13	1.11	5550
Logan	1.10	0.84	0.80	1.76	1.83	1.89	1.97	2.04	2.12	2.20	2.28	1.44	171
Macon	15.89	12.88	14.29	15.26	16.39	17.46	18.55	19.63	20.69	21.71	22.69	9.81	76
Mason	5.44	3.88	3.05	4.21	4.46	4.73	5.01	5.31	5.62	5.94	6.26	2.38	61
McLean	0.01	0.01	0.38	1.32	1.36	1.41	1.45	1.50	1.55	1.60	1.64	1.63	16300
Menard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Piatt	1.15	0.94	0.94	0.98	1.02	1.06	1.11	1.16	1.22	1.27	1.33	0.39	41
Sangamon	5.01	4.13	4.19	4.48	4.82	5.15	5.49	5.82	6.15	6.47	6.76	2.63	64
Tazewell	43.35	29.75	29.07	31.45	34.29	37.14	40.16	43.29	46.47	49.66	52.77	23.02	77
Vermilion	2.74	2.36	3.29	3.48	3.69	3.90	4.12	4.35	4.58	4.81	5.02	2.66	113
Woodford	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-
Totals	85.34	63.70	67.78	75.70	81.24	86.74	92.50	98.41	104.40	110.36	116.16	52.46	82

Weather = model generated results using 2005 weather data

Normal = model generated results using normal weather data

MGD = millions of gallons per day

Table D.10: Self-supplied commercial and industrial water withdrawals in MGD for the more resource intensive (MRI) scenario for each county.

County	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005-2050 MGD	2005-2050 %
Cass	1.87	1.53	1.90	2.85	3.00	3.16	3.32	3.50	3.69	3.88	4.08	2.55	167
Champaign	5.74	4.82	8.13	8.62	9.17	9.72	10.28	10.86	11.45	12.03	12.62	7.80	162
DeWitt	0.00	0.00	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	-
Ford	3.02	2.54	5.35	5.66	6.02	6.38	6.77	7.17	7.59	8.02	8.45	5.91	233
Iroquois	0.02	0.02	1.75	1.76	1.78	1.79	1.80	1.82	1.83	1.84	1.86	1.84	9200
Logan	1.10	0.84	1.12	2.72	2.83	2.95	3.07	3.20	3.34	3.47	3.61	2.77	330
Macon	15.89	12.88	19.85	21.58	23.54	25.40	27.30	29.19	31.06	32.88	34.63	21.75	169
Mason	5.44	3.88	4.24	6.19	6.63	7.08	7.56	8.06	8.59	9.13	9.68	5.80	149
McLean	0.01	0.01	0.53	2.10	2.17	2.24	2.31	2.39	2.47	2.56	2.63	2.62	26200
Menard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	-
Piatt	1.15	0.94	1.31	1.38	1.46	1.54	1.63	1.73	1.83	1.93	2.04	1.10	117
Sangamon	5.01	4.13	5.82	6.33	6.93	7.49	8.07	8.66	9.23	9.79	10.33	6.20	150
Tazewell	43.35	29.75	40.77	44.82	49.54	54.32	59.36	64.62	70.00	75.40	80.73	50.98	171
Vermilion	2.74	2.36	4.85	5.16	5.52	5.88	6.26	6.65	7.04	7.43	7.80	5.44	231
Woodford	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-
Totals	85.34	63.70	95.66	109.21	118.63	127.99	137.78	147.90	158.17	168.42	178.52	114.82	180

Weather = model generated results using 2005 weather data

Normal = model generated results using normal weather data

MGD = millions of gallons per day

Table D.11: Historical values of dependent and independent variables for each study area.

Study Area	Year	Self-supplied C&I withdrawals (MGD)	Delivered C&I water (MGD)	Total county employment	Health services employment (%)	Retail trade employment (%)	Manufacturing employment (%)	Annual CDD	Total summer precip.
Cass County	1985	0.77	0.25	5,881	3.0	8.5	23.0	754.0	17.72
	1990	1.99	0.06	5,977	7.6	11.0	28.0	1038.0	26.79
	1995	1.59	0.20	7,068	4.3	10.5	31.4	1019.0	20.17
	2000	2.00	0.12	6,761	6.3	7.5	30.7	1020.0	23.48
	2005	1.83	0.10	7,324	5.1	6.8	33.8	1242.0	11.49
Champaign County	1985	8.97	6.96	77,446	7.0	19.6	11.3	911.0	19.71
	1990	10.87	5.83	88,079	8.6	18.6	11.4	908.0	24.04
	1995	7.60	5.58	90,789	8.7	19.9	12.1	1221.0	18.60
	2000	5.33	5.79	95,579	10.2	11.3	10.6	902.0	18.27
	2005	5.54	5.65	98,084	10.8	11.3	11.1	1303.0	17.59
De Witt County	1985	0.00	0.16	7,739	3.1	11.6	10.3	958.0	19.07
	1990	0.01	0.10	7,639	5.5	13.0	17.4	964.0	23.81
	1995	0.00	0.42	8,986	6.4	12.0	15.5	1169.0	18.68
	2000	0.00	0.28	8,655	4.9	8.8	10.7	990.0	18.55
	2005	0.00	0.27	8,023	5.9	9.3	6.1	1249.0	15.17
Ford County	1985	0.05	0.39	6,602	6.9	10.7	13.6	738.0	14.75
	1990	0.02	0.33	6,580	8.8	12.2	13.7	825.5	21.06
	1995	0.79	0.40	6,635	7.7	15.8	11.1	1148.5	22.78
	2000	2.66	0.43	7,040	10.1	9.8	11.5	836.5	17.69
	2005	3.03	0.44	6,994	11.8	8.4	13.0	1128.0	16.21

MGD = million gallons per day; CDD = cooling degree days; precip = precipitation

Table D.12: Historical values of dependent and independent variables for each study area. (continued)

Study Area	Year	Self-supplied C&I withdrawals (MGD)	Delivered C&I water (MGD)	Total county employment	Health services employment (%)	Retail trade employment (%)	Manufacturing employment (%)	Annual CDD	Total summer precip.
Iroquois County	1985	0.10	0.25	14,014	6.0	9.8	13.2	710.0	18.53
	1990	0.05	0.11	13,986	7.5	10.1	15.1	766.0	19.61
	1995	0.05	0.18	16,771	7.6	9.7	12.0	1116.0	18.77
	2000	0.10	0.30	15,691	8.9	6.6	8.8	820.0	19.28
	2005	0.02	0.34	15,923	9.5	6.8	6.0	1083.0	16.55
Logan County	1985	0.07	1.68	13,963	6.5	12.4	12.8	958.0	18.94
	1990	0.21	1.30	12,902	8.1	14.1	14.9	964.0	26.52
	1995	0.06	1.20	12,354	16.2	16.8	13.6	1169.0	22.20
	2000	0.13	1.37	14,433	9.6	8.5	10.5	990.0	20.03
	2005	1.00	0.34	12,718	10.3	9.5	11.5	1249.0	12.24
Macon County	1985	19.52	2.30	52,423	8.7	18.2	26.7	1006.0	17.70
	1990	20.81	8.67	54,085	9.3	19.2	26.7	1107.0	24.08
	1995	19.30	5.45	56,529	10.0	18.3	24.6	1274.0	16.22
	2000	17.17	5.74	52,936	12.8	13.5	20.6	1325.0	19.32
	2005	15.73	4.85	50,203	14.3	12.5	15.4	1558.0	17.03
Mason County	1985	8.98	0.19	6,755	1.9	9.2	3.2	1020.5	14.11
	1990	7.56	0.09	6,869	2.4	11.0	6.1	1126.5	26.62
	1995	4.83	0.12	7,580	4.8	8.2	6.8	1224.5	21.28
	2000	4.87	0.06	7,446	6.1	7.3	5.8	1110.0	17.54
	2005	5.58	0.10	7,175	6.7	6.4	2.9	1496.0	8.79

MGD = million gallons per day; CDD = cooling degree days; precip = precipitation

Table D.13: Historical values of dependent and independent variables for each study area. (continued)

Study Area	Year	Self-supplied C&I withdrawals (MGD)	Delivered C&I water (MGD)	Total county employment	Health services employment (%)	Retail trade employment (%)	Manufacturing employment (%)	Annual CDD	Total summer precip.
McLean County	1985	0.65	3.31	57,943	6.7	19.4	10.3	978.0	18.43
	1990	0.04	1.93	69,166	6.6	19.5	13.7	997.0	23.11
	1995	0.06	1.48	77,949	7.0	18.8	12.9	1193.0	21.86
	2000	0.01	2.11	82,590	9.2	12.0	8.7	1006.5	19.63
	2005	0.01	1.36	84,570	9.9	11.7	7.3	1306.0	10.27
Menard County	1985	0.00	0.07	5,286	1.5	5.0	2.2	1020.0	17.53
	1990	0.00	0.05	5,603	1.4	7.2	0.9	1144.0	28.13
	1995	0.00	0.03	5,807	2.0	8.2	1.0	1327.0	15.85
	2000	0.00	0.04	6,760	2.1	5.0	0.9	1094.0	18.22
	2005	0.00	0.05	6,751	2.2	4.2	2.6	1432.0	13.09
Piatt County	1985	1.18	0.14	7,414	2.3	8.0	8.4	906.0	19.02
	1990	0.80	0.13	7,795	2.8	8.6	6.8	937.0	24.57
	1995	0.81	0.14	7,524	3.8	10.3	7.9	1156.0	19.89
	2000	0.90	0.12	8,713	4.3	6.5	5.1	955.0	20.98
	2005	1.09	0.15	8,858	3.7	6.6	2.9	1304.0	15.61
Sangamon County	1985	1.58	3.70	91,552	9.8	15.8	4.8	1020.0	17.53
	1990	1.92	8.32	96,147	10.4	17.5	4.9	1144.0	28.13
	1995	1.26	9.42	97,376	12.3	18.6	4.7	1327.0	15.85
	2000	5.06	5.38	101,455	17.6	12.1	4.0	1094.0	18.22
	2005	5.06	7.99	101,526	17.1	12.3	3.2	1432.0	13.09

MGD = million gallons per day; CDD = cooling degree days; precip = precipitation

Table D.14: Historical values of dependent and independent variables for each study area. (continued)

Study Area	Year	Self-supplied C&I withdrawals (MGD)	Delivered C&I water (MGD)	Total county employment	Health services employment (%)	Retail trade employment (%)	Manufacturing employment (%)	Annual CDD	Total summer precip.
Tazewell County	1985	34.37	3.07	50,234	4.6	15.6	15.4	876.0	18.81
	1990	27.06	2.46	59,634	4.8	15.7	15.9	883.0	29.70
	1995	39.08	3.86	65,915	4.6	15.2	12.6	1117.0	18.01
	2000	37.41	6.57	64,472	7.2	11.1	10.8	1031.0	13.30
	2005	43.20	7.24	66,606	7.5	10.6	11.5	1432.0	9.73
Vermilion County	1985	3.23	4.95	27,423	9.6	20.5	36.8	938.5	17.44
	1990	2.99	4.60	29,133	13.4	21.5	31.7	937.0	23.12
	1995	2.65	3.83	28,945	14.8	23.1	25.4	1164.5	18.58
	2000	2.37	3.33	28,983	15.0	14.3	23.3	992.0	19.44
	2005	2.70	3.38	35,850	12.8	10.9	14.0	1269.3	17.04
Woodford County	1985	0.00	0.22	12,702	5.0	9.6	7.3	761.0	15.91
	1990	0.01	0.22	15,832	5.0	9.9	8.3	871.0	22.19
	1995	0.01	0.28	17,810	6.0	9.5	9.5	1146.0	24.30
	2000	0.00	0.27	18,119	6.5	6.4	12.0	981.0	15.88
	2005	0.00	0.26	19,509	6.8	6.4	9.6	1295.0	8.27

MGD = million gallons per day; CDD = cooling degree days; precip = precipitation

Table D.15: Historical reported and modeled gallons per employee per day (GPED) for the commercial & industrial sector.

County	Type	1985	1990	1995	2000	2005
Cass	Reported	174.1	342.5	254.3	313.4	263.2
	Modeled	169.9	487.9	297.7	293.9	266.7
Champaign	Reported	205.7	189.6	145.2	116.3	114.1
	Modeled	254.7	261.3	267.4	91.0	118.3
DeWitt	Reported	21.2	14.1	46.3	31.8	34.1
	Modeled	23.2	15.3	53.0	31.8	38.6
Ford	Reported	66.5	54.3	179.4	439.1	496.4
	Modeled	60.6	50.0	195.4	545.4	494.9
Iroquois	Reported	25.0	11.4	13.9	25.2	22.6
	Modeled	43.2	45.3	15.1	25.5	17.3
Logan	Reported	125.0	116.9	101.4	103.7	105.7
	Modeled	90.2	115.2	184.2	112.9	115.9
Macon	Reported	416.2	545.1	437.9	432.7	409.9
	Modeled	942.2	438.3	595.1	402.6	414.0
Mason	Reported	1358.2	1114.7	653.2	661.7	792.1
	Modeled	1047.3	921.4	870.0	869.6	771.3
McLean	Reported	68.3	28.5	19.8	25.6	16.1
	Modeled	71.5	35.1	37.2	19.8	26.7
Menard	Reported	13.2	9.5	5.2	5.7	6.8
	Modeled	9.8	8.5	8.2	7.3	8.7
Piatt	Reported	178.0	118.9	126.5	116.9	139.9
	Modeled	230.5	165.2	215.2	152.0	147.2
Sangamon	Reported	57.7	106.5	109.7	102.9	128.5
	Modeled	100.1	61.1	69.6	161.9	127.1
Tazewell	Reported	745.4	495.0	651.5	682.1	757.3
	Modeled	532.1	382.6	418.5	289.3	759.8
Vermilion	Reported	298.2	260.5	223.9	196.6	169.4
	Modeled	250.1	239.5	319.8	146.0	172.2
Woodford	Reported	17.2	14.5	16.5	15.0	13.3
	Modeled	16.9	14.2	15.6	12.2	15.7

Appendix E

Irrigation and Agriculture Sector

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Table E.1: Total Agriculture and Irrigation withdrawals (MGD) for the baseline (BL) scenario for each county.

County	2005 (Weather)	2005 (Normal)	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	14.42	9.44	13.98	14.77	15.55	15.61	15.66	15.71	15.76	15.80	15.84	6.40	68
Champaign	4.90	3.85	5.03	5.27	5.49	5.69	5.85	5.98	6.07	6.13	6.15	2.30	60
DeWitt	0.95	0.74	0.79	0.83	0.86	0.89	0.91	0.93	0.94	0.94	0.94	0.20	27
Ford	0.82	0.70	0.76	0.79	0.83	0.86	0.88	0.90	0.91	0.92	0.92	0.22	31
Iroquois	2.62	2.52	2.73	2.85	2.96	3.06	3.14	3.20	3.23	3.25	3.25	0.73	29
Logan	2.15	1.62	1.74	1.82	1.89	1.96	2.01	2.04	2.07	2.08	2.08	0.46	28
Macon	0.32	0.29	0.31	0.32	0.34	0.35	0.36	0.37	0.39	0.40	0.41	0.12	41
Mason	161.95	88.60	95.44	101.01	106.58	106.87	107.15	107.43	107.70	107.98	108.26	19.66	22
McLean	2.04	1.60	1.72	1.80	1.89	1.96	2.02	2.07	2.11	2.14	2.15	0.55	34
Menard	2.80	1.82	2.54	2.66	2.77	2.87	2.95	3.02	3.06	3.09	3.09	1.27	70
Piatt	0.47	0.38	0.42	0.43	0.45	0.46	0.48	0.49	0.49	0.49	0.49	0.11	29
Sangamon	1.56	1.25	1.34	1.40	1.46	1.51	1.55	1.58	1.61	1.63	1.64	0.39	31
Tazewell	36.08	25.01	33.85	36.09	38.32	38.47	38.61	38.75	38.89	39.02	39.14	14.13	56
Vermilion	0.59	0.52	0.56	0.59	0.62	0.64	0.66	0.68	0.70	0.71	0.72	0.20	38
Woodford	1.47	1.09	1.17	1.22	1.27	1.31	1.34	1.36	1.38	1.39	1.39	0.30	28
Total	233.12	139.44	162.37	171.87	181.28	182.49	183.57	184.51	185.31	185.97	186.46	47.02	34

2005 (Weather) = model generated results using 2005 weather data

2005 (Normal) = model generated results using normal weather data

MGD = millions of gallons per day

Table E.2: Total Agriculture and Irrigation withdrawals (MGD) for the less resource intensive (LRI) scenario for each county.

County	2005 (Weather)	2005 (Normal)	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	14.42	9.44	13.31	14.06	14.80	14.86	14.91	14.96	15.00	15.04	15.07	5.63	60
Champaign	4.90	3.85	4.99	5.17	5.34	5.48	5.60	5.69	5.76	5.80	5.82	1.97	51
DeWitt	0.95	0.74	0.78	0.81	0.83	0.86	0.87	0.89	0.89	0.90	0.90	0.16	22
Ford	0.82	0.70	0.75	0.78	0.80	0.83	0.84	0.86	0.87	0.87	0.88	0.18	26
Iroquois	2.62	2.52	2.68	2.78	2.86	2.94	3.00	3.04	3.07	3.09	3.08	0.56	22
Logan	2.15	1.62	1.72	1.78	1.84	1.89	1.93	1.96	1.98	1.99	1.98	0.36	22
Macon	0.32	0.29	0.30	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.38	0.09	31
Mason	161.95	88.60	90.67	95.97	101.26	101.53	101.79	102.06	102.32	102.58	102.84	14.24	16
McLean	2.04	1.60	1.70	1.77	1.84	1.90	1.95	2.00	2.03	2.05	2.06	0.46	29
Menard	2.80	1.82	2.52	2.62	2.70	2.77	2.83	2.88	2.91	2.93	2.94	1.12	62
Piatt	0.47	0.38	0.41	0.42	0.44	0.45	0.46	0.46	0.47	0.47	0.47	0.09	24
Sangamon	1.56	1.25	1.32	1.37	1.42	1.46	1.50	1.52	1.55	1.56	1.57	0.32	26
Tazewell	36.08	25.01	32.19	34.31	36.43	36.57	36.70	36.83	36.95	37.07	37.19	12.18	49
Vermilion	0.59	0.52	0.55	0.58	0.60	0.62	0.64	0.66	0.67	0.68	0.68	0.16	31
Woodford	1.47	1.09	1.16	1.20	1.24	1.27	1.30	1.32	1.34	1.34	1.34	0.25	23
Total	233.12	139.44	155.05	163.93	172.74	173.76	174.68	175.49	176.18	176.76	177.21	37.77	27

2005 (Weather) = model generated results using 2005 weather data

2005 (Normal) = model generated results using normal weather data

MGD = millions of gallons per day

Table E.3: Total Agriculture and Irrigation withdrawals (MGD) for the more resource intensive (MRI) scenario for each county.

County	2005 (Weather)	2005 (Normal)	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	14.42	9.44	14.66	15.48	16.30	16.36	16.42	16.47	16.52	16.56	16.60	7.16	76
Champaign	4.90	3.85	5.07	5.37	5.65	5.90	6.11	6.28	6.40	6.48	6.50	2.65	69
DeWitt	0.95	0.74	0.81	0.85	0.89	0.92	0.95	0.97	0.99	0.99	0.99	0.25	34
Ford	0.82	0.70	0.77	0.81	0.85	0.89	0.92	0.94	0.95	0.96	0.96	0.26	37
Iroquois	2.62	2.52	2.77	2.93	3.06	3.18	3.28	3.35	3.40	3.42	3.42	0.90	36
Logan	2.15	1.62	1.77	1.87	1.95	2.03	2.09	2.13	2.16	2.18	2.17	0.55	34
Macon	0.32	0.29	0.31	0.33	0.34	0.36	0.38	0.39	0.41	0.42	0.43	0.14	48
Mason	161.95	88.60	100.20	106.06	111.91	112.21	112.50	112.80	113.09	113.38	113.67	25.07	28
McLean	2.04	1.60	1.74	1.84	1.93	2.02	2.09	2.15	2.20	2.23	2.25	0.65	41
Menard	2.80	1.82	2.56	2.71	2.85	2.97	3.08	3.16	3.22	3.25	3.26	1.44	79
Piatt	0.47	0.38	0.42	0.44	0.47	0.48	0.50	0.51	0.52	0.52	0.52	0.14	37
Sangamon	1.56	1.25	1.36	1.43	1.49	1.55	1.61	1.65	1.68	1.70	1.72	0.47	38
Tazewell	36.08	25.01	35.51	37.86	40.21	40.37	40.52	40.67	40.82	40.96	41.10	16.09	64
Vermilion	0.59	0.52	0.57	0.60	0.63	0.66	0.69	0.71	0.73	0.74	0.76	0.24	46
Woodford	1.47	1.09	1.18	1.24	1.29	1.34	1.38	1.41	1.43	1.43	1.43	0.34	31
Total	233.12	139.44	169.69	179.82	189.85	191.25	192.50	193.59	194.51	195.24	195.77	56.33	40

2005 (Weather) = model generated results using 2005 weather data

2005 (Normal) = model generated results using normal weather data

MGD = millions of gallons per day

Table E.4: Irrigated cropland acreage for the baseline (BL) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Acres	%
Cass	12,250	18,397	19,436	20,474	20,524	20,574	20,624	20,674	20,724	20,774	8,524	70
Champaign	5,049	6,750	7,075	7,368	7,623	7,835	8,002	8,118	8,183	8,194	3,145	62
DeWitt	840	913	954	991	1,021	1,047	1,065	1,077	1,082	1,080	240	29
Ford	688	748	781	811	836	857	872	882	886	885	197	29
Iroquois	2,627	2,856	2,984	3,097	3,194	3,272	3,331	3,368	3,384	3,378	751	29
Logan	1,591	1,730	1,807	1,876	1,934	1,982	2,017	2,040	2,049	2,046	455	29
Macon	15	16	17	18	18	19	19	19	19	19	4	29
Mason	91,811	130,530	138,146	145,761	146,128	146,494	146,861	147,228	147,594	147,961	26,775	61
McLean	920	1,000	1,045	1,085	1,119	1,146	1,166	1,180	1,185	1,183	263	29
Menard	2,098	3,026	3,172	3,303	3,418	3,513	3,587	3,640	3,669	3,674	1,576	75
Piatt	451	490	512	532	548	562	572	578	581	580	129	29
Sangamon	781	849	887	921	950	973	990	1,001	1,006	1,004	223	29
Tazewell	30,748	41,869	44,638	47,407	47,540	47,674	47,807	47,940	48,074	48,207	17,459	57
Vermilion	273	297	310	322	332	340	346	350	352	351	78	29
Woodford	738	802	838	870	897	919	936	946	951	949	211	29
Total	150,880	210,274	222,602	234,834	236,082	237,207	238,196	239,042	239,739	240,284	60,029	59

Table E.5: Irrigated cropland acreage for the less resource intensive (LRI) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Acres	%
Cass	12,250	17,477	18,464	19,450	19,498	19,545	19,593	19,640	19,688	19,735	7,485	61
Champaign	5,049	6,698	6,939	7,153	7,338	7,491	7,610	7,693	7,738	7,746	2,697	53
DeWitt	840	895	925	951	973	991	1,004	1,013	1,016	1,015	175	21
Ford	688	733	757	779	797	811	822	829	832	831	143	21
Iroquois	2,627	2,797	2,891	2,973	3,042	3,098	3,139	3,166	3,177	3,172	545	21
Logan	1,591	1,694	1,751	1,800	1,842	1,876	1,901	1,917	1,924	1,921	330	21
Macon	15	16	17	17	17	18	18	18	18	18	3	20
Mason	91,811	124,004	131,238	138,473	138,821	139,170	139,518	139,866	140,215	140,563	48,752	53
McLean	920	980	1,012	1,041	1,065	1,085	1,099	1,109	1,113	1,111	191	21
Menard	2,098	3,003	3,111	3,207	3,290	3,358	3,412	3,449	3,469	3,473	1,375	66
Piatt	451	480	496	510	522	532	539	544	545	545	94	21
Sangamon	781	832	859	884	904	921	933	941	944	943	162	21
Tazewell	30,748	39,775	42,406	45,037	45,163	45,290	45,417	45,543	45,670	45,797	15,049	49
Vermilion	273	291	300	309	316	322	326	329	330	330	57	21
Woodford	738	786	812	835	855	870	882	889	892	891	153	21
Total	150,880	200,459	211,977	223,418	224,444	225,378	226,214	226,946	227,572	228,091	77,211	51

Table E.6: Irrigated cropland acreage for the more resource intensive (MRI) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Acres	%
Cass	12,250	19,317	20,407	21,498	21,550	21,603	21,655	21,708	21,760	21,813	9,563	78
Champaign	5,049	6,803	7,214	7,589	7,918	8,195	8,413	8,566	8,652	8,667	3,618	72
DeWitt	840	933	985	1,032	1,072	1,105	1,130	1,146	1,153	1,150	310	37
Ford	688	764	807	845	878	905	925	938	944	942	254	37
Iroquois	2,627	2,916	3,080	3,226	3,353	3,456	3,533	3,583	3,604	3,596	969	37
Logan	1,591	1,766	1,865	1,954	2,031	2,093	2,140	2,170	2,183	2,178	587	37
Macon	15	17	18	18	19	20	20	20	21	21	6	40
Mason	91,811	137,057	145,053	153,049	153,434	153,819	154,204	154,589	154,974	155,359	63,548	69
McLean	920	1,021	1,079	1,130	1,174	1,210	1,237	1,255	1,262	1,259	339	37
Menard	2,098	3,050	3,234	3,402	3,550	3,674	3,772	3,841	3,879	3,886	1,788	85
Piatt	451	501	529	554	576	593	607	615	619	617	166	37
Sangamon	781	867	916	959	997	1,027	1,050	1,065	1,072	1,069	288	37
Tazewell	30,748	43,962	46,870	49,777	49,917	50,057	50,197	50,337	50,477	50,617	19,869	65
Vermilion	273	303	320	335	348	359	367	372	375	374	101	37
Woodford	738	819	865	906	942	971	993	1,007	1,013	1,010	272	37
Total	150,880	220,094	233,241	246,276	247,760	249,089	250,245	251,214	251,986	252,558	101,678	67

Table E.7: Total cropland withdrawals (MGD) for the baseline (BL) scenario for each county.

County	2005 (Weather)	2005 (Normal)	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	13.95	8.99	13.49	14.26	15.02	15.06	15.09	15.13	15.17	15.20	15.24	6.25	70
Champaign	4.42	3.44	4.61	4.83	5.03	5.20	5.35	5.46	5.54	5.58	5.59	2.15	62
DeWitt	0.78	0.58	0.63	0.65	0.68	0.70	0.72	0.73	0.74	0.74	0.74	0.16	29
Ford	0.60	0.48	0.53	0.55	0.57	0.59	0.60	0.61	0.62	0.62	0.62	0.14	29
Iroquois	2.16	2.06	2.24	2.34	2.43	2.51	2.57	2.61	2.64	2.66	2.65	0.59	29
Logan	1.69	1.17	1.28	1.33	1.38	1.43	1.46	1.49	1.51	1.51	1.51	0.34	29
Macon	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.003	29
Mason	161.77	88.44	95.26	100.82	106.38	106.65	106.91	107.18	107.45	107.72	107.98	19.54	22
McLean	1.02	0.71	0.77	0.80	0.83	0.86	0.88	0.90	0.91	0.91	0.91	0.20	29
Menard	2.53	1.58	2.29	2.40	2.49	2.58	2.65	2.71	2.75	2.77	2.77	1.19	75
Piatt	0.39	0.31	0.33	0.35	0.36	0.37	0.38	0.39	0.39	0.39	0.39	0.08	29
Sangamon	0.79	0.59	0.64	0.67	0.70	0.72	0.73	0.75	0.76	0.76	0.76	0.17	29
Tazewell	35.29	24.32	33.11	35.30	37.49	37.60	37.70	37.81	37.91	38.02	38.12	13.80	57
Vermilion	0.22	0.19	0.20	0.21	0.22	0.23	0.23	0.24	0.24	0.24	0.24	0.05	29
Woodford	0.88	0.56	0.61	0.64	0.66	0.68	0.70	0.71	0.72	0.72	0.72	0.16	29
Total	226.51	133.43	155.99	165.16	174.26	175.17	176.00	176.72	177.35	177.86	178.27	44.84	34

2005 (Weather) = model generated results using 2005 weather data

2005 (Normal) = model generated results using normal weather data

MGD = millions of gallons per day

Table E.8: Total cropland withdrawals (MGD) for the less resource intensive (LRI) scenario for each county.

County	2005 (Weather)	2005 (Normal)	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	13.95	8.99	12.82	13.54	14.27	14.30	14.34	14.37	14.41	14.44	14.48	5.5	61
Champaign	4.42	3.44	4.57	4.73	4.88	5.01	5.11	5.19	5.25	5.28	5.28	1.8	53
DeWitt	0.78	0.58	0.61	0.63	0.65	0.67	0.68	0.69	0.69	0.70	0.70	0.1	21
Ford	0.60	0.48	0.52	0.53	0.55	0.56	0.57	0.58	0.58	0.58	0.58	0.1	21
Iroquois	2.16	2.06	2.20	2.27	2.33	2.39	2.43	2.46	2.48	2.49	2.49	0.4	21
Logan	1.69	1.17	1.25	1.29	1.33	1.36	1.38	1.40	1.41	1.42	1.42	0.2	21
Macon	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.0	21
Mason	161.77	88.44	90.50	95.78	101.06	101.31	101.57	101.82	102.08	102.33	102.59	14.1	16
McLean	1.02	0.71	0.75	0.78	0.80	0.82	0.83	0.85	0.85	0.86	0.85	0.1	21
Menard	2.53	1.58	2.27	2.35	2.42	2.48	2.54	2.58	2.60	2.62	2.62	1.0	66
Piatt	0.39	0.31	0.33	0.34	0.35	0.35	0.36	0.36	0.37	0.37	0.37	0.1	21
Sangamon	0.79	0.59	0.63	0.65	0.67	0.68	0.70	0.70	0.71	0.71	0.71	0.1	21
Tazewell	35.29	24.32	31.45	33.54	35.62	35.72	35.82	35.92	36.02	36.12	36.22	11.9	49
Vermilion	0.22	0.19	0.20	0.20	0.21	0.22	0.22	0.22	0.22	0.23	0.22	0.0	21
Woodford	0.88	0.56	0.60	0.62	0.63	0.65	0.66	0.67	0.67	0.68	0.68	0.1	21
Total	226.51	133.43	148.70	157.27	165.78	166.53	167.22	167.83	168.37	168.84	169.22	35.8	27

2005 (Weather) = model generated results using 2005 weather data

2005 (Normal) = model generated results using normal weather data

MGD = millions of gallons per day

Table E.9: Total cropland withdrawals (MGD) for the more resource intensive (MRI) scenario for each county.

County	2005 (Weather)	2005 (Normal)	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	13.95	8.99	14.17	14.97	15.77	15.81	15.85	15.88	15.92	15.96	16.00	7.01	78
Champaign	4.42	3.44	4.64	4.92	5.18	5.40	5.59	5.74	5.84	5.90	5.91	2.47	72
DeWitt	0.78	0.58	0.64	0.67	0.71	0.73	0.76	0.77	0.79	0.79	0.79	0.21	37
Ford	0.60	0.48	0.54	0.57	0.59	0.62	0.64	0.65	0.66	0.66	0.66	0.18	37
Iroquois	2.16	2.06	2.29	2.42	2.53	2.63	2.71	2.77	2.81	2.83	2.82	0.76	37
Logan	1.69	1.17	1.30	1.38	1.44	1.50	1.54	1.58	1.60	1.61	1.61	0.43	37
Macon	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.004	37
Mason	161.77	88.44	100.03	105.86	111.70	111.98	112.26	112.54	112.82	113.10	113.38	24.94	28
McLean	1.02	0.71	0.79	0.83	0.87	0.90	0.93	0.95	0.97	0.97	0.97	0.26	37
Menard	2.53	1.58	2.30	2.44	2.57	2.68	2.77	2.85	2.90	2.93	2.93	1.35	85
Piatt	0.39	0.31	0.34	0.36	0.37	0.39	0.40	0.41	0.42	0.42	0.42	0.11	37
Sangamon	0.79	0.59	0.65	0.69	0.72	0.75	0.78	0.79	0.80	0.81	0.81	0.22	37
Tazewell	35.29	24.32	34.77	37.07	39.36	39.48	39.59	39.70	39.81	39.92	40.03	15.71	65
Vermilion	0.22	0.19	0.21	0.22	0.23	0.24	0.25	0.25	0.25	0.26	0.25	0.07	37
Woodford	0.88	0.56	0.62	0.66	0.69	0.71	0.74	0.75	0.76	0.77	0.77	0.21	37
Total	226.51	133.43	163.29	173.06	182.75	183.84	184.81	185.66	186.38	186.95	187.37	53.94	40

2005 (Weather) = model generated results using 2005 weather data

2005 (Normal) = model generated results using normal weather data

MGD = millions of gallons per day

Table E.10: Golf course acreage for baseline (BL) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Acres	%
Cass	19	19	19	19	19	19	19	19	19	19	0	0
Champaign	367	385	404	422	441	459	478	496	514	533	166	45
DeWitt	37	37	37	37	37	37	37	37	37	37	0	0
Ford	40	43	46	48	51	53	56	59	61	64	24	60
Iroquois	77	77	77	77	77	77	77	77	77	77	0	0
Logan	59	59	59	59	59	59	59	59	59	59	0	0
Macon	267	280	294	307	320	333	346	359	372	386	119	45
Mason	37	48	58	69	79	90	100	111	121	132	95	257
McLean	369	390	411	432	453	474	495	516	537	558	189	51
Menard	59	61	64	66	68	71	73	75	78	80	21	36
Piatt	19	19	19	19	19	19	19	19	19	19	0	0
Sangamon	403	419	435	450	466	482	498	514	529	545	142	35
Tazewell	326	352	378	405	431	457	484	510	536	563	237	73
Vermilion	220	233	246	260	273	286	299	312	325	339	119	54
Woodford	139	139	139	139	139	139	139	139	139	139	0	0
Totals	2,439	2,562	2,686	2,809	2,933	3,056	3,180	3,303	3,426	3,550	1,111	46

Table E.11: Golf course acreage for less resource intensive (LRI) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Acres	%
Cass	19	19	19	19	19	19	19	19	19	19	0	0
Champaign	367	381	395	408	422	436	450	464	478	491	124	34
DeWitt	37	37	37	37	37	37	37	37	37	37	0	0
Ford	40	42	44	46	48	50	52	54	56	58	18	45
Iroquois	77	77	77	77	77	77	77	77	77	77	0	0
Logan	59	59	59	59	59	59	59	59	59	59	0	0
Macon	267	277	287	297	307	317	326	336	346	356	89	33
Mason	37	45	53	61	69	77	85	92	100	108	71	192
McLean	369	385	400	416	432	448	464	479	495	511	142	38
Menard	59	61	63	65	67	69	71	73	75	77	18	31
Piatt	19	19	19	19	19	19	19	19	19	19	0	0
Sangamon	403	415	427	439	450	462	474	486	498	510	107	27
Tazewell	326	345	365	385	405	424	444	464	484	503	177	54
Vermilion	220	230	240	250	260	269	279	289	299	309	89	40
Woodford	139	139	139	139	139	139	139	139	139	139	0	0
Totals	2,439	2,532	2,625	2,717	2,810	2,903	2,996	3,088	3,181	3,274	835	34

Table E.12: Golf course acreage for more resource intensive (MRI) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Acres	%
Cass	19	19	19	19	19	19	19	19	19	19	0	0
Champaign	367	390	413	436	459	482	505	528	551	574	207	56
DeWitt	37	37	37	37	37	37	37	37	37	37	0	0
Ford	40	44	47	50	53	57	60	63	67	70	30	75
Iroquois	77	77	77	77	77	77	77	77	77	77	0	0
Logan	59	59	59	59	59	59	59	59	59	59	0	0
Macon	267	284	300	317	333	349	366	382	399	415	148	55
Mason	37	50	64	77	90	103	116	129	142	156	119	322
McLean	369	395	421	448	474	500	527	553	579	606	237	64
Menard	59	62	65	69	72	75	79	82	85	88	29	49
Piatt	19	19	19	19	19	19	19	19	19	19	0	0
Sangamon	403	423	443	462	482	502	522	541	561	581	178	44
Tazewell	326	359	392	424	457	490	523	556	589	622	296	91
Vermilion	220	237	253	269	286	302	319	335	352	368	148	67
Woodford	139	139	139	139	139	139	139	139	139	139	0	0
Totals	2,439	2,594	2,748	2,903	3,057	3,212	3,367	3,521	3,676	3,831	1,392	57

Table E.13: Golf course water use (MGD) per day for baseline (BL) scenario for each county.

County	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0
Champaign	0.32	0.25	0.26	0.28	0.29	0.30	0.31	0.33	0.34	0.35	0.36	0.11	44
DeWitt	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0
Ford	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.01	33
Iroquois	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.00	0
Logan	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.00	0
Macon	0.23	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30	0.09	43
Mason	0.04	0.03	0.03	0.04	0.05	0.06	0.07	0.07	0.08	0.09	0.10	0.07	233
McLean	0.41	0.28	0.30	0.32	0.33	0.35	0.36	0.38	0.40	0.41	0.43	0.15	54
Menard	0.07	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.02	50
Piatt	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0
Sangamon	0.41	0.30	0.32	0.33	0.34	0.35	0.36	0.38	0.39	0.40	0.41	0.11	37
Tazewell	0.35	0.26	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.18	69
Vermilion	0.18	0.15	0.16	0.17	0.18	0.19	0.20	0.20	0.21	0.22	0.23	0.08	53
Woodford	0.17	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.00	0
Totals	2.42	1.81	1.91	2.00	2.09	2.18	2.27	2.37	2.46	2.55	2.64	0.83	46

Weather = model generated results using 2005 weather data

Normal = model generated results using normal weather data

MGD = millions of gallons per day

Table E.14: Golf course water use (MGD) for less resource intensive (LRI) scenario for each county.

County	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0
Champaign	0.32	0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.09	36
DeWitt	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0
Ford	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.01	33
Iroquois	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.00	0
Logan	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.00	0
Macon	0.23	0.21	0.21	0.22	0.23	0.24	0.24	0.25	0.26	0.27	0.27	0.06	29
Mason	0.04	0.03	0.03	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.08	0.05	167
McLean	0.41	0.28	0.30	0.31	0.32	0.33	0.34	0.36	0.37	0.38	0.39	0.11	39
Menard	0.07	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.02	50
Piatt	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0
Sangamon	0.41	0.30	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.38	0.08	27
Tazewell	0.35	0.26	0.27	0.29	0.30	0.32	0.34	0.35	0.37	0.38	0.40	0.14	54
Vermilion	0.18	0.15	0.16	0.16	0.17	0.18	0.18	0.19	0.20	0.20	0.21	0.06	40
Woodford	0.17	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.00	0
Totals	2.42	1.81	1.88	1.95	2.02	2.09	2.16	2.23	2.30	2.37	2.44	0.63	35

Weather = model generated results using 2005 weather data

Normal = model generated results using normal weather data

MGD = millions of gallons per day

Table E.15: Golf course water use (MGD) for more resource intensive (MRI) scenario for each county.

County	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050 MGD	2005 - 2050 %
Cass	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0
Champaign	0.32	0.25	0.27	0.28	0.30	0.31	0.33	0.34	0.36	0.38	0.39	0.14	56
DeWitt	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0
Ford	0.04	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.02	67
Iroquois	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.00	0
Logan	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.00	0
Macon	0.23	0.21	0.22	0.23	0.24	0.26	0.27	0.28	0.29	0.31	0.32	0.11	52
Mason	0.04	0.03	0.04	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.08	267
McLean	0.41	0.28	0.30	0.32	0.34	0.36	0.38	0.41	0.43	0.45	0.47	0.19	68
Menard	0.07	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.03	75
Piatt	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0
Sangamon	0.41	0.30	0.32	0.33	0.35	0.36	0.38	0.39	0.41	0.42	0.44	0.14	47
Tazewell	0.35	0.26	0.28	0.31	0.34	0.36	0.39	0.41	0.44	0.47	0.49	0.23	88
Vermilion	0.18	0.15	0.16	0.17	0.18	0.20	0.21	0.22	0.23	0.24	0.25	0.10	67
Woodford	0.17	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.00	0
Totals	2.42	1.81	1.93	2.04	2.16	2.27	2.39	2.50	2.62	2.74	2.85	1.04	57

Weather = model generated results using 2005 weather data

Normal = model generated results using normal weather data

MGD = millions of gallons per day

Table E.16: Beef cattle livestock for baseline (BL) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Cattle	%
Cass	9,409	10,061	10,671	11,223	11,707	12,111	12,425	12,642	12,756	12,764	3,355	36
Champaign	5,062	5,413	5,741	6,038	6,299	6,516	6,685	6,801	6,863	6,867	1,805	36
DeWitt	3,591	3,840	4,073	4,283	4,468	4,622	4,742	4,825	4,868	4,871	1,280	36
Ford	5,675	6,069	6,436	6,769	7,061	7,305	7,494	7,625	7,694	7,699	2,024	36
Iroquois	18,682	19,978	21,187	22,285	23,246	24,048	24,671	25,102	25,328	25,344	6,662	36
Logan	6,037	6,456	6,846	7,201	7,512	7,771	7,972	8,111	8,185	8,190	2,153	36
Macon	3,584	3,833	4,065	4,275	4,459	4,613	4,733	4,816	4,859	4,862	1,278	36
Mason	6,225	6,657	7,060	7,425	7,746	8,013	8,221	8,364	8,439	8,445	2,220	36
McLean	10,282	10,995	11,661	12,265	12,794	13,235	13,578	13,815	13,940	13,948	3,666	36
Menard	5,400	5,774	6,124	6,441	6,719	6,951	7,131	7,256	7,321	7,326	1,926	36
Piatt	2,181	2,332	2,473	2,602	2,714	2,807	2,880	2,930	2,957	2,959	778	36
Sangamon	10,705	11,447	12,140	12,769	13,320	13,779	14,137	14,384	14,513	14,522	3,817	36
Tazewell	8,809	9,420	9,990	10,508	10,961	11,339	11,633	11,836	11,943	11,950	3,141	36
Vermilion	8,236	8,807	9,340	9,824	10,248	10,601	10,876	11,066	11,166	11,173	2,937	36
Woodford	6,958	7,441	7,891	8,300	8,658	8,956	9,189	9,349	9,433	9,439	2,481	36
Totals	110,836	118,522	125,698	132,209	137,910	142,668	146,369	148,923	150,264	150,358	39,522	36

Table E.17: Dairy cattle livestock for baseline (BL) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											cattle	%
Cass	0	0	0	0	0	0	0	0	0	0	0	0
Champaign	0	0	0	0	0	0	0	0	0	0	0	0
DeWitt	0	0	0	0	0	0	0	0	0	0	0	0
Ford	12	13	14	15	16	17	18	18	18	18	6	50
Iroquois	1,007	1,106	1,201	1,290	1,368	1,434	1,486	1,522	1,541	1,541	534	53
Logan	0	0	0	0	0	0	0	0	0	0	0	0
Macon	0	0	0	0	0	0	0	0	0	0	0	0
Mason	0	0	0	0	0	0	0	0	0	0	0	0
McLean	2,840	3,120	3,388	3,637	3,858	4,045	4,192	4,293	4,345	4,346	1,506	53
Menard	109	120	130	140	148	155	161	165	167	167	58	53
Piatt	113	124	135	145	154	161	167	171	173	173	60	53
Sangamon	252	277	301	323	342	359	372	381	386	386	134	53
Tazewell	608	668	725	779	826	866	897	919	930	930	322	53
Vermilion	167	183	199	214	227	238	246	252	256	256	89	53
Woodford	205	225	245	263	278	292	303	310	314	314	109	53
Totals	5,313	5,837	6,339	6,804	7,218	7,568	7,842	8,031	8,129	8,131	2,818	53

Table E.18: Hog livestock for baseline (BL) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Hogs	%
Cass	82,080	87,081	91,705	95,860	99,461	102,433	104,711	106,244	106,998	106,956	24,876	30
Champaign	21,158	22,447	23,639	24,710	25,638	26,404	26,992	27,387	27,581	27,570	6,412	30
DeWitt	22,107	23,454	24,699	25,818	26,788	27,589	28,202	28,615	28,818	28,807	6,700	30
Ford	29,874	31,694	33,377	34,889	36,200	37,282	38,111	38,669	38,943	38,928	9,054	30
Iroquois	32,137	34,095	35,906	37,532	38,942	40,106	40,998	41,598	41,893	41,877	9,740	30
Logan	80,755	85,676	90,225	94,313	97,856	100,780	103,021	104,529	105,271	105,229	24,474	30
Macon	6,397	6,787	7,147	7,471	7,752	7,983	8,161	8,280	8,339	8,336	1,939	30
Mason	13,521	14,345	15,107	15,791	16,384	16,874	17,249	17,502	17,626	17,619	4,098	30
McLean	92,321	97,946	103,147	107,820	111,871	115,214	117,776	119,500	120,348	120,300	27,979	30
Menard	30,859	32,739	34,478	36,040	37,394	38,511	39,367	39,944	40,227	40,211	9,352	30
Piatt	8,072	8,564	9,019	9,427	9,781	10,074	10,298	10,448	10,523	10,518	2,446	30
Sangamon	50,810	53,906	56,768	59,340	61,570	63,409	64,819	65,768	66,235	66,209	15,399	30
Tazewell	74,762	79,317	83,529	87,313	90,594	93,300	95,375	96,772	97,459	97,420	22,658	30
Vermilion	19,056	20,217	21,291	22,255	23,091	23,781	24,310	24,666	24,841	24,831	5,775	30
Woodford	82,337	87,354	91,992	96,160	99,773	102,754	105,039	106,577	107,333	107,291	24,954	30
Totals	646,246	685,624	722,027	754,741	783,096	806,494	824,428	836,500	842,438	842,101	195,855	30

Table E.19: Horse livestock for baseline (BL) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Horses	%
Cass	214	214	214	214	214	214	214	214	214	214	0	0
Champaign	522	522	522	522	522	522	522	522	522	522	0	0
DeWitt	228	228	228	228	228	228	228	228	228	228	0	0
Ford	93	93	93	93	93	93	93	93	93	93	0	0
Iroquois	514	514	514	514	514	514	514	514	514	514	0	0
Logan	188	188	188	188	188	188	188	188	188	188	0	0
Macon	346	346	346	346	346	346	346	346	346	346	0	0
Mason	216	216	216	216	216	216	216	216	216	216	0	0
McLean	759	759	759	759	759	759	759	759	759	759	0	0
Menard	206	206	206	206	206	206	206	206	206	206	0	0
Piatt	286	286	286	286	286	286	286	286	286	286	0	0
Sangamon	1,536	1,536	1,536	1,536	1,536	1,536	1,536	1,536	1,536	1,536	0	0
Tazewell	656	656	656	656	656	656	656	656	656	656	0	0
Vermilion	504	504	504	504	504	504	504	504	504	504	0	0
Woodford	358	358	358	358	358	358	358	358	358	358	0	0
Totals	6,626	6,626	6,626	6,626	6,626	6,626	6,626	6,626	6,626	6,626	0	0

Table E.20: Sheep livestock for baseline (BL) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Sheep	%
Cass	176	176	176	176	176	176	176	176	176	176	0	0
Champaign	371	371	371	371	371	371	371	371	371	371	0	0
DeWitt	111	111	111	111	111	111	111	111	111	111	0	0
Ford	296	296	296	296	296	296	296	296	296	296	0	0
Iroquois	908	908	908	908	908	908	908	908	908	908	0	0
Logan	458	458	458	458	458	458	458	458	458	458	0	0
Macon	189	189	189	189	189	189	189	189	189	189	0	0
Mason	357	357	357	357	357	357	357	357	357	357	0	0
McLean	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	0	0
Menard	115	115	115	115	115	115	115	115	115	115	0	0
Piatt	230	230	230	230	230	230	230	230	230	230	0	0
Sangamon	401	401	401	401	401	401	401	401	401	401	0	0
Tazewell	578	578	578	578	578	578	578	578	578	578	0	0
Vermilion	358	358	358	358	358	358	358	358	358	358	0	0
Woodford	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,387	0	0
Totals	8,114	8,114	8,114	8,114	8,114	8,114	8,114	8,114	8,114	8,114	0	0

Table E.21: Chicken livestock for baseline (BL) scenario for each county.

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
											Chickens	%
Cass	0	0	0	0	0	0	0	0	0	0	0	0
Champaign	3,772	3,772	3,772	3,772	3,772	3,772	3,772	3,772	3,772	3,772	0	0
DeWitt	536	536	536	536	536	536	536	536	536	536	0	0
Ford	0	0	0	0	0	0	0	0	0	0	0	0
Iroquois	0	0	0	0	0	0	0	0	0	0	0	0
Logan	237	237	237	237	237	237	237	237	237	237	0	0
Macon	214	214	214	214	214	214	214	214	214	214	0	0
Mason	106	106	106	106	106	106	106	106	106	106	0	0
McLean	503	503	503	503	503	503	503	503	503	503	0	0
Menard	285	285	285	285	285	285	285	285	285	285	0	0
Piatt	177	177	177	177	177	177	177	177	177	177	0	0
Sangamon	1,463	1,463	1,463	1,463	1,463	1,463	1,463	1,463	1,463	1,463	0	0
Tazewell	478	478	478	478	478	478	478	478	478	478	0	0
Vermilion	504	504	504	504	504	504	504	504	504	504	0	0
Woodford	0	0	0	0	0	0	0	0	0	0	0	0
Totals	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	0	0

Table E.22: Livestock water use in millions of gallons per day for baseline (BL) scenario for each county.

County	2005	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2005 - 2050	
	Weather	Normal										MGD	%
Cass	0.44	0.44	0.47	0.50	0.52	0.54	0.56	0.57	0.58	0.58	0.58	0.14	32
Champaign	0.15	0.15	0.16	0.17	0.18	0.19	0.19	0.20	0.20	0.20	0.20	0.05	33
DeWitt	0.13	0.13	0.14	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.18	0.05	38
Ford	0.19	0.19	0.20	0.21	0.22	0.23	0.24	0.24	0.25	0.25	0.25	0.06	32
Iroquois	0.40	0.40	0.42	0.45	0.47	0.49	0.51	0.52	0.53	0.53	0.53	0.13	33
Logan	0.40	0.40	0.42	0.45	0.47	0.48	0.50	0.51	0.52	0.52	0.52	0.12	30
Macon	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.03	43
Mason	0.13	0.13	0.14	0.15	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.05	38
McLean	0.61	0.61	0.65	0.68	0.72	0.75	0.77	0.79	0.81	0.81	0.81	0.20	33
Menard	0.19	0.19	0.21	0.22	0.23	0.24	0.25	0.25	0.26	0.26	0.26	0.07	37
Piatt	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.02	29
Sangamon	0.36	0.36	0.38	0.40	0.42	0.44	0.45	0.46	0.47	0.47	0.47	0.11	31
Tazewell	0.44	0.44	0.46	0.49	0.51	0.53	0.55	0.56	0.57	0.57	0.57	0.13	30
Vermilion	0.19	0.19	0.20	0.21	0.22	0.23	0.24	0.24	0.25	0.25	0.25	0.06	32
Woodford	0.43	0.43	0.45	0.48	0.50	0.52	0.54	0.55	0.56	0.56	0.56	0.13	30
Totals	4.20	4.20	4.47	4.71	4.94	5.14	5.30	5.42	5.51	5.55	5.55	1.35	32

Weather = model generated results using 2005 weather data

Normal = model generated results using normal weather data

MGD = millions of gallons per day

Table E.23: Total number of beef cattle, dairy catle, hogs, horses, and sheep reported.

County	Year	Beef Cattle	Dairy Cattle	Hogs	Horses	Sheep	Chickens
Cass	1982	1,936	46	82,155	235	432	19
	1987	1,979	8	92,257	127	402	570
	1992	1,992	D	104,165	76	372	501
	1997	1,997	D	115,528	102	216	98
	2002	2,002	D	82,080	176	214	D
Champaign	1982	1,301	681	28,721	963	2,069	55
	1987	1,244	743	28,846	744	2,127	D
	1992	1,625	367	23,240	707	1,355	36
	1997	1,919	78	19,479	677	1,046	D
	2002	2,002	D	21,158	522	371	3,772
DeWitt	1982	1,901	81	10,154	250	664	24
	1987	1,934	53	9,025	211	489	D
	1992	1,992	D	5,351	155	321	D
	1997	1,947	50	6,118	151	166	350
	2002	2,002	D	22,107	228	111	536
Ford	1982	1,677	305	34,551	37	1,254	31
	1987	1,718	269	39,842	157	1,210	D
	1992	1,813	179	44,138	128	661	D
	1997	1,742	255	40,055	145	460	722
	2002	1,990	12	29,874	93	296	D
Iroquois	1982	-1,228	3,210	52,282	590	2,833	74
	1987	-393	2,380	53,327	634	2,024	D
	1992	229	1,763	58,891	438	1,930	D
	1997	357	1,640	47,486	432	922	D
	2002	995	1,007	32,137	514	908	D

D = data withheld due to data disclosure limitations.

Source: U. S. Department of Agriculture Census, various years.

Table E.24: Total number of beef cattle, dairy cattle, hogs, horses, and sheep reported, continued.

County	Year	Beef Cattle	Dairy Cattle	Hogs	Horses	Sheep	Chickens
Logan	1982	1,665	317	69,610	211	1,387	D
	1987	279	1,708	77,704	164	899	D
	1992	48	1,944	81,765	118	756	D
	1997	1,997	D	89,142	162	664	191
	2002	2,002	D	80,755	188	458	237
Macon	1982	1,852	130	21,621	547	889	D
	1987	1,850	137	17,331	608	1,361	D
	1992	1,992	D	23,462	504	862	D
	1997	1,997	D	11,777	246	537	219
	2002	2,002	D	6,397	346	189	214
Mason	1982	1,890	92	33,954	324	303	13,525
	1987	1,987	D	22,529	261	162	1,484
	1992	1,992	D	45,174	141	470	794
	1997	1,997	D	43,409	255	169	186
	2002	2,002	D	13,521	216	357	106
McLean	1982	972	1,010	84,232	982	3,378	57,718
	1987	599	1,388	89,891	876	3,420	41,336
	1992	1,160	832	84,753	674	3,077	557
	1997	994	1,003	100,529	626	1,517	772
	2002	-838	2,840	92,321	759	2,179	503
Menard	1982	1,982	D	59,169	60	393	924
	1987	1,978	9	52,555	464	374	2,160
	1992	1,992	D	49,812	246	587	2,352
	1997	1,783	214	26,573	333	155	191
	2002	1,893	109	30,859	206	115	285

D = data withheld due to data disclosure limitations.

Source: U. S. Department of Agriculture Census, various years.

Table E.25: Total number of beef cattle, dairy cattle, hogs, horses, and sheep reported, continued.

County	Year	Beef Cattle	Dairy Cattle	Hogs	Horses	Sheep	Chickens
Piatt	1982	1,844	138	22,420	190	773	675
	1987	1,813	174	20,556	143	682	256
	1992	1,852	140	16,551	135	301	85
	1997	1,997	D	15,859	138	169	152
	2002	1,889	113	8,072	286	230	177
Sangamon	1982	1,567	415	84,178	1,197	2,323	D
	1987	1,721	266	73,660	791	1,582	D
	1992	1,798	194	74,258	887	1,522	D
	1997	1,397	600	69,227	836	862	D
	2002	1,750	252	50,810	1,536	401	1,463
Tazewell	1982	921	1,061	105,288	524	2,002	109,525
	1987	954	1,033	121,092	549	1,847	D
	1992	1,138	854	109,534	513	1,346	D
	1997	997	1,000	111,818	553	708	566
	2002	1,394	608	74,762	656	578	478
Vermilion	1982	1,569	413	45,921	570	1,544	18,309
	1987	1,576	411	45,395	551	1,323	4,550
	1992	1,594	398	34,236	412	793	D
	1997	1,877	120	16,953	389	512	376
	2002	1,835	167	19,056	504	358	504
Woodford	1982	917	1,065	92,005	305	4,839	98,557
	1987	1,102	885	96,217	324	4,130	63,648
	1992	1,042	950	97,829	274	3,194	D
	1997	1,820	177	85,600	221	1,914	D
	2002	1,797	205	82,337	358	1,387	D

D = data withheld due to data disclosure limitations.

Source: U. S. Department of Agriculture Census, various years.

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Appendix F

Sensitivity Analysis

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F.1 Public water supply sector climate change results by county

Table F.1: Effects of temperature increase on PWS by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.9	2.0	2.1	2.1	2.2	2.3	2.4	2.5	2.6
Champaign	26.0	27.6	29.3	30.8	31.7	33.2	34.5	35.8	37.2
DeWitt	1.4	1.5	1.6	1.6	1.7	1.8	1.9	1.9	2.0
Ford	1.8	1.9	2.0	2.1	2.1	2.2	2.3	2.4	2.5
Iroquois	2.5	2.6	2.7	2.9	2.9	3.1	3.2	3.4	3.5
Logan	3.4	3.5	3.7	3.8	3.9	4.0	4.2	4.3	4.4
Macon	25.4	26.3	27.5	28.6	29.7	30.8	32.1	33.3	34.6
Mason	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
McLean	16.7	18.0	19.4	20.6	21.6	22.7	24.0	25.3	26.7
Menard	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.2
Piatt	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.6
Sangamon	23.2	24.5	26.2	27.6	28.9	30.3	31.8	33.4	35.1
Tazewell	16.1	17.3	18.6	19.9	20.8	22.0	23.3	24.7	26.1
Vermilion	10.2	10.4	10.7	11.1	11.6	12.1	12.6	13.1	13.7
Woodford	2.1	2.3	2.4	2.6	2.7	2.9	3.1	3.2	3.4
Totals	133.4	140.8	149.2	156.9	163.2	170.9	178.8	187.0	195.6

Table F.2: Effects of precipitation increase only on PWS by county.

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.8	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.3
Champaign	25.5	26.6	28.0	29.0	29.6	30.6	31.4	32.3	33.2
DeWitt	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8
Ford	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.2
Iroquois	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.3
Logan	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.9	3.9
Macon	25.0	25.3	26.2	27.0	27.7	28.5	29.3	30.1	30.9
Mason	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
McLean	16.4	17.3	18.4	19.4	20.1	20.9	21.8	22.8	23.7
Menard	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Piatt	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.4
Sangamon	22.7	23.6	24.9	26.0	26.9	27.9	29.0	30.1	31.3
Tazewell	15.8	16.7	17.7	18.7	19.4	20.3	21.2	22.2	23.2
Vermilion	10.0	10.0	10.2	10.4	10.8	11.1	11.5	11.8	12.2
Woodford	2.1	2.2	2.3	2.5	2.5	2.7	2.8	2.9	3.0
Totals	130.9	135.7	142.2	147.8	152.1	157.5	163.0	168.6	174.4

Table F.3: Effects of precipitation decrease on PWS by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.3	2.4
Champaign	25.9	27.5	28.9	30.0	30.6	31.6	32.5	33.4	34.3
DeWitt	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9
Ford	1.8	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.3
Iroquois	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.3	3.4
Logan	3.4	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.1
Macon	25.4	26.3	27.1	27.9	28.7	29.5	30.3	31.2	32.0
Mason	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0
McLean	16.7	18.0	19.2	20.2	20.8	21.7	22.7	23.6	24.6
Menard	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.1
Piatt	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.5
Sangamon	23.2	24.6	25.9	27.0	28.0	29.0	30.2	31.3	32.6
Tazewell	16.1	17.3	18.4	19.4	20.1	21.1	22.0	23.0	24.1
Vermilion	10.2	10.4	10.5	10.8	11.2	11.5	11.9	12.3	12.6
Woodford	2.1	2.3	2.4	2.6	2.6	2.8	2.9	3.0	3.2
Totals	133.3	140.8	147.5	153.3	157.8	163.4	169.1	174.9	181.0

Table F.4: Effects of temperature increase and precipitation increase on PWS by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.9	1.9	2.0	2.1	2.2	2.3	2.3	2.4	2.5
Champaign	25.8	27.2	29.0	30.4	31.3	32.7	34.0	35.4	36.8
DeWitt	1.4	1.5	1.5	1.6	1.7	1.8	1.8	1.9	2.0
Ford	1.8	1.9	2.0	2.0	2.1	2.2	2.3	2.4	2.5
Iroquois	2.5	2.6	2.7	2.9	3.0	3.1	3.3	3.5	3.6
Logan	3.4	3.5	3.6	3.7	3.9	4.0	4.1	4.2	4.4
Macon	25.2	25.9	27.1	28.2	29.3	30.4	31.6	32.9	34.2
Mason	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
McLean	16.6	17.7	19.1	20.3	21.2	22.4	23.6	24.9	26.3
Menard	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.1
Piatt	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6
Sangamon	23.0	24.2	25.8	27.2	28.4	29.9	31.4	32.9	34.6
Tazewell	16.0	17.1	18.4	19.6	20.5	21.7	23.0	24.3	25.7
Vermilion	10.1	10.2	10.5	10.9	11.4	11.9	12.4	13.0	13.5
Woodford	2.1	2.2	2.4	2.6	2.7	2.8	3.0	3.2	3.4
Totals	132.5	138.9	147.2	154.8	161.1	168.7	176.4	184.6	193.0

Table F.5: Effects of temperature increase and precipitation decrease on PWS by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.9	2.0	2.1	2.2	2.3	2.4	2.4	2.5	2.6
Champaign	26.2	28.1	29.9	31.4	32.4	33.9	35.2	36.6	38.0
DeWitt	1.4	1.5	1.6	1.7	1.7	1.8	1.9	2.0	2.1
Ford	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6
Iroquois	2.5	2.7	2.8	3.0	3.1	3.3	3.4	3.6	3.7
Logan	3.5	3.6	3.8	3.9	4.0	4.1	4.2	4.4	4.5
Macon	25.7	26.9	28.1	29.2	30.3	31.5	32.8	34.0	35.4
Mason	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.1
McLean	16.9	18.4	19.8	21.1	22.1	23.3	24.5	25.9	27.3
Menard	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.1	1.2
Piatt	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6
Sangamon	23.4	25.2	26.8	28.3	29.6	31.1	32.7	34.3	36.0
Tazewell	16.3	17.7	19.1	20.4	21.3	22.6	23.9	25.2	26.7
Vermilion	10.3	10.6	10.9	11.3	11.9	12.4	12.9	13.4	14.0
Woodford	2.1	2.3	2.5	2.7	2.8	3.0	3.1	3.3	3.5
Totals	134.9	144.1	152.7	160.6	167.1	175.0	183.0	191.5	200.3

F.2 Commercial and industrial sector climate change results by county

Table F.6: Effects of temperature increase on C&I by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.6	2.4	2.5	2.7	3.0	3.2	3.4	3.7	4.0
Champaign	6.8	7.4	8.1	8.8	9.5	10.3	11.1	12.0	12.9
DeWitt	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04
Ford	4.6	5.0	5.4	5.9	6.4	6.9	7.5	8.2	8.8
Iroquois	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.6
Logan	1.0	2.3	2.5	2.6	2.8	2.9	3.1	3.3	3.5
Macon	17.4	19.3	21.6	24.0	26.4	28.9	31.6	34.2	36.9
Mason	3.7	5.4	5.9	6.4	7.0	7.7	8.4	9.1	9.9
McLean	0.5	1.8	1.9	1.9	2.0	2.1	2.2	2.3	2.4
Menard	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.01	0.01
Piatt	1.1	1.2	1.3	1.4	1.6	1.7	1.8	2.0	2.2
Sangamon	4.9	5.5	6.1	6.8	7.5	8.3	9.1	9.9	10.6
Tazewell	35.5	40.0	45.5	51.2	57.4	64.2	71.4	78.8	86.5
Vermilion	4.0	4.4	4.8	5.2	5.7	6.2	6.7	7.3	7.8
Woodford	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Totals	82.5	96.2	107.1	118.6	130.9	144.1	158.0	172.3	187.1

Table F.7: Effects of precipitation increase only on C&I by county.

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.5	2.2	2.3	2.4	2.6	2.7	2.8	2.9	3.1
Champaign	6.5	6.8	7.1	7.5	7.9	8.3	8.7	9.1	9.5
DeWitt	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Ford	4.3	4.4	4.7	4.9	5.2	5.5	5.8	6.1	6.4
Iroquois	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5
Logan	0.9	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
Macon	15.9	16.8	18.2	19.5	20.8	22.0	23.3	24.6	25.7
Mason	3.4	4.9	5.2	5.5	5.8	6.2	6.5	6.9	7.3
McLean	0.5	1.7	1.8	1.8	1.9	1.9	2.0	2.0	2.1
Menard	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004
Piatt	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.5
Sangamon	4.6	4.9	5.3	5.7	6.1	6.5	6.9	7.3	7.6
Tazewell	32.6	34.9	38.2	41.6	45.1	48.8	52.6	56.3	60.0
Vermilion	3.9	4.1	4.3	4.6	4.8	5.1	5.4	5.6	5.9
Woodford	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Totals	76.6	85.4	91.9	98.4	105.2	112.2	119.3	126.4	133.3

Table F.8: Effects of precipitation decrease on C&I by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.6	2.4	2.5	2.6	2.7	2.9	3.0	3.2	3.3
Champaign	6.7	7.2	7.6	8.0	8.5	8.9	9.3	9.8	10.2
DeWitt	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
Ford	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.5	6.9
Iroquois	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
Logan	0.9	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
Macon	16.6	18.3	19.8	21.2	22.6	24.0	25.4	26.8	28.0
Mason	3.5	5.2	5.5	5.9	6.2	6.6	7.0	7.4	7.9
McLean	0.4	1.7	1.8	1.8	1.9	1.9	2.0	2.1	2.1
Menard	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
Piatt	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.6	1.6
Sangamon	4.9	5.4	5.9	6.3	6.7	7.2	7.6	8.0	8.4
Tazewell	34.0	38.1	41.7	45.4	49.3	53.3	57.4	61.6	65.6
Vermilion	4.0	4.3	4.6	4.9	5.1	5.4	5.7	6.0	6.3
Woodford	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Totals	79.7	92.3	99.5	106.6	114.0	121.7	129.5	137.2	144.8

Table F.9: Effects of temperature increase and precipitation increase on C&I by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.5	2.3	2.5	2.7	2.9	3.1	3.3	3.6	3.9
Champaign	6.8	7.2	7.9	8.6	9.3	10.0	10.8	11.7	12.5
DeWitt	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04
Ford	4.5	4.8	5.3	5.7	6.2	6.8	7.3	7.9	8.6
Iroquois	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5
Logan	1.0	2.3	2.4	2.6	2.7	2.9	3.1	3.3	3.5
Macon	17.1	18.7	20.9	23.2	25.6	28.0	30.6	33.1	35.7
Mason	3.6	5.2	5.7	6.3	6.8	7.5	8.1	8.9	9.6
McLean	0.5	1.8	1.9	1.9	2.0	2.1	2.2	2.3	2.4
Menard	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006
Piatt	1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1
Sangamon	4.8	5.3	5.9	6.6	7.3	8.0	8.7	9.5	10.3
Tazewell	34.9	38.7	44.0	49.5	55.6	62.1	69.0	76.2	83.6
Vermilion	4.0	4.3	4.7	5.1	5.6	6.0	6.6	7.1	7.6
Woodford	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Totals	81.2	93.3	103.9	115.0	126.9	139.6	153.1	167.0	181.3

Table F.10: Effects of temperature increase and precipitation decrease on C&I by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	1.6	2.5	2.7	2.9	3.1	3.3	3.6	3.9	4.2
Champaign	7.0	7.7	8.4	9.2	10.0	10.8	11.7	12.6	13.5
DeWitt	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04
Ford	4.7	5.2	5.7	6.2	6.7	7.3	7.9	8.6	9.3
Iroquois	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.6
Logan	1.0	2.4	2.5	2.7	2.9	3.0	3.2	3.4	3.7
Macon	17.8	20.4	22.8	25.3	27.8	30.5	33.3	36.1	38.9
Mason	3.8	5.6	6.2	6.7	7.4	8.1	8.8	9.6	10.4
McLean	0.5	1.8	1.9	1.9	2.0	2.1	2.2	2.3	2.4
Menard	0.003	0.003	0.004	0.004	0.004	0.005	0.01	0.01	0.01
Piatt	1.1	1.3	1.4	1.5	1.7	1.8	1.9	2.1	2.3
Sangamon	5.0	5.8	6.5	7.3	8.0	8.8	9.6	10.5	11.3
Tazewell	36.4	42.3	48.0	54.1	60.7	67.8	75.4	83.3	91.4
Vermilion	4.1	4.6	5.0	5.5	6.0	6.5	7.0	7.6	8.2
Woodford	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Totals	84.6	101.0	112.6	124.7	137.7	151.7	166.4	181.6	197.2

F.3 Irrigation and agriculture sector climate change results by county

Table F.11: Effects of temperature increase on IR&AG by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	14.1	15.0	15.9	16.0	16.2	16.3	16.5	16.6	16.8
Champaign	5.1	5.3	5.6	5.8	6.1	6.2	6.4	6.5	6.5
DeWitt	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Ford	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0
Iroquois	2.7	2.9	3.0	3.1	3.2	3.3	3.4	3.4	3.4
Logan	1.5	1.5	1.5	1.6	1.6	1.7	1.7	1.7	1.7
Macon	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Mason	96.1	102.4	108.8	109.8	110.8	111.8	112.8	113.8	114.9
McLean	1.7	1.8	1.9	2.0	2.1	2.1	2.2	2.2	2.2
Menard	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3
Piatt	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sangamon	1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.7
Tazewell	34.1	36.5	39.0	39.4	39.8	40.2	40.6	40.9	41.3
Vermilion	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.8
Woodford	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.4
Totals	163.1	173.7	184.4	186.8	189.1	191.3	193.3	195.2	196.9

Table F.12: Effects of precipitation increase only on IR&AG by county.

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	13.6	13.3	14.0	14.0	14.1	14.1	14.1	14.2	14.2
Champaign	4.4	4.2	4.4	4.6	4.7	4.8	4.9	4.9	4.9
DeWitt	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Ford	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9
Iroquois	2.2	2.2	2.3	2.3	2.4	2.5	2.5	2.5	2.5
Logan	1.6	1.5	1.6	1.7	1.7	1.7	1.7	1.8	1.8
Macon	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mason	89.0	86.6	91.4	91.6	91.9	92.1	92.4	92.6	92.8
McLean	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	1.9
Menard	2.2	2.1	2.2	2.3	2.3	2.4	2.4	2.4	2.4
Piatt	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Sangamon	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.5
Tazewell	28.8	28.3	30.1	30.2	30.3	30.4	30.5	30.6	30.7
Vermilion	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7
Woodford	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.1
Totals	148.4	144.8	152.7	153.7	154.6	155.4	156.1	156.6	157.0

Table F.13: Effects of precipitation decrease on IR&AG by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	16.0	18.3	19.3	19.4	19.4	19.5	19.6	19.6	19.7
Champaign	5.3	6.2	6.4	6.7	6.8	7.0	7.1	7.2	7.2
DeWitt	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
Ford	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
Iroquois	2.6	3.0	3.1	3.2	3.3	3.3	3.4	3.4	3.4
Logan	1.8	2.0	2.1	2.2	2.2	2.3	2.3	2.3	2.3
Macon	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Mason	106.0	122.7	129.5	129.9	130.2	130.5	130.9	131.2	131.5
McLean	1.8	2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.4
Menard	2.6	2.9	3.1	3.2	3.3	3.3	3.4	3.4	3.4
Piatt	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Sangamon	1.5	1.6	1.7	1.8	1.8	1.8	1.9	1.9	1.9
Tazewell	34.4	40.1	42.5	42.7	42.9	43.0	43.2	43.3	43.5
Vermilion	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8
Woodford	1.1	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4
Totals	176.2	203.6	214.8	216.2	217.4	218.5	219.4	220.2	220.8

Table F.14: Effects of temperature increase and precipitation increase on IR&AG by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	13.6	13.4	14.3	14.4	14.6	14.7	14.9	15.0	15.1
Champaign	4.4	4.3	4.5	4.7	4.9	5.0	5.2	5.3	5.3
DeWitt	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
Ford	0.8	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9
Iroquois	2.3	2.2	2.3	2.4	2.5	2.6	2.6	2.6	2.6
Logan	1.6	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.8
Macon	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mason	89.6	88.0	93.6	94.5	95.5	96.5	97.5	98.5	99.4
McLean	1.6	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.0
Menard	2.2	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.6
Piatt	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5
Sangamon	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.6	1.6
Tazewell	29.1	28.7	30.8	31.1	31.5	31.8	32.2	32.5	32.9
Vermilion	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7
Woodford	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.2
Totals	149.4	146.9	156.2	158.4	160.5	162.5	164.4	166.2	167.9

Table F.15: Effects of temperature increase and precipitation decrease on IR&AG by county (in MGD).

County	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	16.0	18.5	19.6	19.8	20.0	20.1	20.3	20.4	20.6
Champaign	5.4	6.2	6.5	6.8	7.1	7.3	7.4	7.5	7.6
DeWitt	0.9	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2
Ford	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
Iroquois	2.6	3.0	3.1	3.3	3.4	3.4	3.5	3.5	3.6
Logan	1.8	2.0	2.1	2.2	2.3	2.3	2.4	2.4	2.4
Macon	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Mason	106.7	124.1	131.7	132.8	133.8	134.9	136.0	137.1	138.2
McLean	1.8	2.0	2.1	2.2	2.3	2.3	2.4	2.4	2.4
Menard	2.6	3.0	3.1	3.2	3.4	3.4	3.5	3.6	3.6
Piatt	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Sangamon	1.5	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.0
Tazewell	34.6	40.5	43.3	43.7	44.1	44.5	44.9	45.2	45.6
Vermilion	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9
Woodford	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.2
Totals	177.1	205.6	218.1	220.6	223.1	225.4	227.6	229.5	231.4

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Appendix G

Summary

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Table G.1: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the baseline scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	PWS	1.7	1.8	1.6	1.9	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.3
	SS Domestic	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	C&I	1.8	1.9	1.5	1.6	2.3	2.4	2.5	2.6	2.8	2.9	3.0	3.2
	IR & AG	16.9	14.4	9.4	14.0	14.8	15.6	15.6	15.7	15.7	15.8	15.8	15.8
	Total w/out PG	20.8	18.5	13.0	17.8	19.4	20.3	20.6	20.8	21.0	21.3	21.5	21.8
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	20.8	18.5	13.0	17.8	19.4	20.3	20.6	20.8	21.0	21.3	21.5	21.8
Champaign	PWS	26.6	26.6	24.6	25.7	26.9	28.3	29.4	29.9	31.0	31.8	32.7	33.6
	SS Domestic	1.3	1.3	1.3	2.3	2.3	2.4	2.4	2.5	2.4	2.5	2.5	2.6
	C&I	5.5	5.7	4.8	6.6	6.9	7.3	7.7	8.1	8.5	8.9	9.3	9.7
	IR & AG	5.4	4.9	3.8	5.0	5.3	5.5	5.7	5.9	6.0	6.1	6.1	6.2
	Total w/out PG	38.8	38.6	34.6	39.6	41.5	43.5	45.2	46.4	47.9	49.3	50.7	52.1
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	38.8	38.6	34.6	39.6	41.5	43.5	45.2	46.4	47.9	49.3	50.7	52.1
DeWitt	PWS	1.3	1.4	1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8
	SS Domestic	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	C&I	0.0	0.0	0.0	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
	IR & AG	1.0	1.0	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	Total w/out PG	2.6	2.7	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.1	3.2
	Power Generation	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4
	Total	813.0	813.1	812.8	812.9	813.0	813.1	813.2	813.3	813.4	813.5	813.5	813.6

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.2: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the baseline scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Ford	PWS	1.7	1.8	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.3
	SS Domestic	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
	C&I	3.0	3.0	2.5	4.3	4.6	4.8	5.1	5.3	5.6	5.9	6.2	6.5
	IR & AG	0.9	0.8	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9
	Total w/out PG	5.9	5.9	5.1	7.1	7.4	7.8	8.1	8.5	8.9	9.2	9.6	10.0
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.9	5.9	5.1	7.1	7.4	7.8	8.1	8.5	8.9	9.2	9.6	10.0
Iroquois	PWS	2.2	2.4	2.3	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3
	SS Domestic	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	1.0
	C&I	0.0	0.0	0.0	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
	IR & AG	2.7	2.6	2.5	2.7	2.9	3.0	3.1	3.1	3.2	3.2	3.3	3.3
	Total w/out PG	5.6	5.8	5.6	7.4	7.6	7.9	8.1	8.3	8.5	8.7	8.9	9.0
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.6	5.8	5.6	7.4	7.6	7.9	8.1	8.3	8.5	8.7	8.9	9.0
Logan	PWS	3.6	3.6	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9	4.0
	SS Domestic	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	C&I	1.0	1.1	0.8	0.9	2.2	2.3	2.3	2.4	2.5	2.6	2.7	2.8
	IR & AG	2.2	2.2	1.6	1.7	1.8	1.9	2.0	2.0	2.0	2.1	2.1	2.1
	Total w/out PG	7.4	7.5	6.4	6.7	8.1	8.4	8.6	8.8	9.0	9.2	9.4	9.6
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	7.4	7.5	6.4	6.7	8.1	8.4	8.6	8.8	9.0	9.2	9.4	9.6

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data. 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.3: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the baseline scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Macon	PWS	25.3	25.4	24.1	25.1	25.7	26.6	27.3	28.1	28.9	29.7	30.5	31.3
	SS Domestic	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	C&I	15.7	15.9	12.9	16.2	17.4	18.8	20.1	21.4	22.8	24.1	25.4	26.6
	IR & AG	0.6	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	Total w/out PG	42.0	41.9	37.6	41.8	43.6	45.9	48.0	50.1	52.2	54.3	56.5	58.5
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	42.0	41.9	37.6	41.8	43.6	45.9	48.0	50.1	52.2	54.3	56.5	58.5
Mason	PWS	0.8	0.9	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0
	SS Domestic	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.6	0.6	0.6	0.6
	C&I	5.6	5.4	3.9	3.5	5.0	5.3	5.6	6.0	6.3	6.7	7.1	7.5
	IR & AG	163.9	161.9	88.6	95.4	101.0	106.6	106.9	107.2	107.4	107.7	108.0	108.3
	Total w/out PG	170.9	168.8	93.8	100.3	107.4	113.3	113.9	114.5	115.2	115.9	116.6	117.2
	Power Generation	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
	Total	275.9	273.8	198.8	205.3	212.4	218.3	218.9	219.5	220.2	220.9	221.6	222.2
McLean	PWS	17.5	17.6	15.4	16.5	17.6	18.7	19.7	20.4	21.2	22.1	23.1	24.1
	SS Domestic	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6
	C&I	0.0	0.0	0.0	0.4	1.7	1.7	1.8	1.8	1.9	2.0	2.0	2.1
	IR & AG	2.5	2.0	1.6	1.7	1.8	1.9	2.0	2.0	2.1	2.1	2.1	2.2
	Total w/out PG	21.1	20.7	18.1	19.8	22.3	23.6	24.8	25.6	26.6	27.7	28.7	29.8
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	21.1	20.7	18.1	19.8	22.3	23.6	24.8	25.6	26.6	27.7	28.7	29.8

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.4: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the baseline scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Menard	PWS	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
	SS Domestic	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	C&I	0.0	0.0	0.0	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004
	IR & AG	2.9	2.8	1.8	2.5	2.7	2.8	2.9	3.0	3.0	3.1	3.1	3.1
	Total w/out PG	3.6	3.6	2.6	3.4	3.5	3.7	3.8	3.9	4.0	4.1	4.1	4.2
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	3.6	3.6	2.6	3.4	3.5	3.7	3.8	3.9	4.0	4.1	4.1	4.2
Piatt	PWS	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.4
	SS Domestic	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
	C&I	1.1	1.1	0.9	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.6
	IR & AG	0.5	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Total w/out PG	3.2	3.3	2.9	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	3.2	3.3	2.9	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
Sangamon	PWS	24.8	24.9	23.0	22.9	24.0	25.3	26.4	27.3	28.3	29.4	30.6	31.7
	SS Domestic	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5
	C&I	5.1	5.0	4.1	4.7	5.1	5.5	5.9	6.3	6.8	7.2	7.6	7.9
	IR & AG	2.1	1.6	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.6
	Total w/out PG	33.1	32.7	29.6	30.2	31.7	33.6	35.1	36.5	38.1	39.7	41.2	42.9
	Power Generation	371.3	371.3	371.3	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5
	Total	404.4	404.0	400.9	361.7	363.2	365.1	366.6	368.0	369.6	371.2	372.7	374.4

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.5: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the baseline scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Tazewell	PWS	17.7	18.4	16.2	17.1	18.2	19.4	20.5	21.2	22.2	23.2	24.3	25.4
	SS Domestic	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	C&I	43.2	43.3	29.7	33.2	36.1	39.5	43.0	46.7	50.5	54.4	58.2	62.1
	IR & AG	37.3	36.1	25.0	33.9	36.1	38.3	38.5	38.6	38.8	38.9	39.0	39.1
	Total w/out PG	98.0	97.8	70.9	84.2	90.5	97.3	102.1	106.6	111.5	116.6	121.7	126.7
	Power Generation	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
	Total	123.9	123.7	96.8	110.1	116.4	123.2	128.0	132.5	137.4	142.5	147.6	152.6
Vermilion	PWS	9.7	9.8	9.2	8.8	8.8	8.9	9.1	9.4	9.7	10.0	10.2	10.5
	SS Domestic	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
	C&I	2.7	2.7	2.4	3.9	4.2	4.4	4.7	4.9	5.2	5.5	5.8	6.0
	IR & AG	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7
	Total w/out PG	13.6	13.7	12.7	13.9	14.1	14.5	15.0	15.6	16.2	16.8	17.4	17.9
	Power Generation	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	Total	16.4	16.5	15.5	16.7	16.9	17.3	17.8	18.4	19.0	19.6	20.2	20.7
Woodford	PWS	2.3	2.3	2.0	2.1	2.2	2.4	2.5	2.6	2.7	2.8	3.0	3.1
	SS Domestic	1.1	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.4	1.5	1.5	1.6
	C&I	0.0	0.0	0.0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
	IR & AG	1.6	1.5	1.1	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.4
	Total w/out PG	5.1	4.8	4.1	4.4	4.7	4.9	5.2	5.3	5.5	5.7	5.9	6.1
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.1	4.8	4.1	4.4	4.7	4.9	5.2	5.3	5.5	5.7	5.9	6.1

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.6: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the less resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	PWS	1.7	1.8	1.6	1.8	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.2
	SS Domestic	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	C&I	1.8	1.9	1.5	1.4	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6
	IR & AG	16.9	14.4	9.4	13.3	14.1	14.8	14.9	14.9	15.0	15.0	15.0	15.1
	Total w/out PG	20.8	18.5	13.0	16.9	18.3	19.2	19.3	19.5	19.7	19.9	20.1	20.3
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	20.8	18.5	13.0	16.9	18.3	19.2	19.3	19.5	19.7	19.9	20.1	20.3
Champaign	PWS	26.6	26.6	24.6	25.3	26.1	27.0	27.6	27.7	28.1	28.5	28.8	29.1
	SS Domestic	1.3	1.3	1.3	2.3	2.3	2.4	2.4	2.5	2.4	2.5	2.5	2.6
	C&I	5.5	5.7	4.8	5.7	5.9	6.2	6.5	6.9	7.2	7.5	7.8	8.2
	IR & AG	5.4	4.9	3.8	5.0	5.2	5.3	5.5	5.6	5.7	5.8	5.8	5.8
	Total w/out PG	38.8	38.6	34.6	38.2	39.5	41.0	42.1	42.6	43.5	44.2	44.9	45.6
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	38.8	38.6	34.6	38.2	39.5	41.0	42.1	42.6	43.5	44.2	44.9	45.6
DeWitt	PWS	1.3	1.4	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.6	1.6
	SS Domestic	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	C&I	0.0	0.0	0.0	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	IR & AG	1.0	1.0	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9
	Total w/out PG	2.6	2.7	2.4	2.5	2.5	2.6	2.7	2.7	2.8	2.8	2.9	2.9
	Power Generation	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4
	Total	813.0	813.1	812.8	812.9	812.9	813.0	813.1	813.1	813.2	813.2	813.3	813.3

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.7: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the less resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Ford	PWS	1.7	1.8	1.7	1.8	1.8	1.9	1.9	1.9	1.9	1.9	2.0	2.0
	SS Domestic	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
	C&I	3.0	3.0	2.5	3.7	3.8	4.0	4.3	4.5	4.7	5.0	5.2	5.5
	IR & AG	0.9	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9
	Total w/out PG	5.9	5.9	5.1	6.4	6.6	6.9	7.2	7.4	7.7	8.0	8.3	8.6
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.9	5.9	5.1	6.4	6.6	6.9	7.2	7.4	7.7	8.0	8.3	8.6
Iroquois	PWS	2.2	2.4	2.3	2.4	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9
	SS Domestic	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	1.0
	C&I	0.0	0.0	0.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	IR & AG	2.7	2.6	2.5	2.7	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.1
	Total w/out PG	5.6	5.8	5.6	7.0	7.1	7.3	7.5	7.6	7.8	7.9	8.0	8.1
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.6	5.8	5.6	7.0	7.1	7.3	7.5	7.6	7.8	7.9	8.0	8.1
Logan	PWS	3.6	3.6	3.3	3.3	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	SS Domestic	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	C&I	1.0	1.1	0.8	0.8	1.8	1.8	1.9	2.0	2.0	2.1	2.2	2.3
	IR & AG	2.2	2.2	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.0	2.0	2.0
	Total w/out PG	7.4	7.5	6.4	6.5	7.6	7.7	7.8	8.0	8.1	8.2	8.3	8.4
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	7.4	7.5	6.4	6.5	7.6	7.7	7.8	8.0	8.1	8.2	8.3	8.4

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;
PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.
2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.8: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the less resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Macon	PWS	25.3	25.4	24.1	24.8	25.0	25.4	25.8	26.1	26.4	26.7	27.0	27.3
	SS Domestic	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	C&I	15.7	15.9	12.9	14.3	15.3	16.4	17.5	18.6	19.6	20.7	21.7	22.7
	IR & AG	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
	Total w/out PG	42.0	41.9	37.6	39.6	40.7	42.4	43.8	45.2	46.6	48.0	49.3	50.6
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	42.0	41.9	37.6	39.6	40.7	42.4	43.8	45.2	46.6	48.0	49.3	50.6
Mason	PWS	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	SS Domestic	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.6	0.6	0.6	0.6
	C&I	5.6	5.4	3.9	3.1	4.2	4.5	4.7	5.0	5.3	5.6	5.9	6.3
	IR & AG	163.9	161.9	88.6	90.7	96.0	101.3	101.5	101.8	102.1	102.3	102.6	102.8
	Total w/out PG	170.9	168.8	93.8	95.1	101.6	107.1	107.6	108.2	108.7	109.3	109.9	110.5
	Power Generation	105.0	105.0	105.0	105.0	105.0	94.0	83.0	72.0	61.0	50.0	50.0	50.0
	Total	275.9	273.8	198.8	200.1	206.6	201.1	190.6	180.2	169.7	159.3	159.9	160.5
McLean	PWS	17.5	17.6	15.4	16.2	17.0	17.8	18.4	18.7	19.2	19.6	20.1	20.6
	SS Domestic	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6
	C&I	0.0	0.0	0.0	0.4	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.6
	IR & AG	2.5	2.0	1.6	1.7	1.8	1.8	1.9	2.0	2.0	2.0	2.1	2.1
	Total w/out PG	21.1	20.7	18.1	19.5	21.3	22.3	23.1	23.5	24.1	24.7	25.3	25.9
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	21.1	20.7	18.1	19.5	21.3	22.3	23.1	23.5	24.1	24.7	25.3	25.9

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.9: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the less resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Menard	PWS	0.8	0.8	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	SS Domestic	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	C&I	0.0	0.0	0.0	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004
	IR & AG	2.9	2.8	1.8	2.5	2.6	2.7	2.8	2.8	2.9	2.9	2.9	2.9
	Total w/out PG	3.6	3.6	2.6	3.3	3.5	3.6	3.7	3.7	3.8	3.8	3.8	3.9
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	3.6	3.6	2.6	3.3	3.5	3.6	3.7	3.7	3.8	3.8	3.8	3.9
Piatt	PWS	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	SS Domestic	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
	C&I	1.1	1.1	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3
	IR & AG	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
	Total w/out PG	3.2	3.3	2.9	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.4	3.5
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	3.2	3.3	2.9	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.4	3.5
Sangamon	PWS	24.8	24.9	23.0	22.6	23.3	24.2	24.9	25.3	25.9	26.5	27.1	27.7
	SS Domestic	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5
	C&I	5.1	5.0	4.1	4.2	4.5	4.8	5.2	5.5	5.8	6.2	6.5	6.8
	IR & AG	2.1	1.6	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6
	Total w/out PG	33.1	32.7	29.6	29.3	30.4	31.8	32.8	33.7	34.7	35.7	36.6	37.6
	Power Generation	371.3	371.3	371.3	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5
	Total	404.4	404.0	400.9	360.8	361.9	363.3	364.3	365.2	366.2	367.2	368.1	369.1

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;
PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.
2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.10: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the less resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Tazewell	PWS	17.7	18.4	16.2	16.9	17.7	18.5	19.3	19.6	20.2	20.8	21.4	22.0
	SS Domestic	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	C&I	43.2	43.3	29.7	29.1	31.5	34.3	37.1	40.2	43.3	46.5	49.7	52.8
	IR & AG	37.3	36.1	25.0	32.2	34.3	36.4	36.6	36.7	36.8	37.0	37.1	37.2
	Total w/out PG	98.0	97.8	70.9	78.2	83.5	89.3	93.1	96.6	100.4	104.3	108.2	112.1
	Power Generation	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
	Total	123.9	123.7	96.8	104.1	109.4	115.2	119.0	122.5	126.3	130.2	134.1	138.0
Vermilion	PWS	9.7	9.8	9.2	8.8	8.8	8.9	9.1	9.4	9.7	10.0	10.2	10.5
	SS Domestic	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
	C&I	2.7	2.7	2.4	3.9	4.2	4.4	4.7	4.9	5.2	5.5	5.8	6.0
	IR & AG	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7
	Total w/out PG	13.6	13.7	12.7	13.9	14.2	14.5	15.0	15.6	16.2	16.8	17.4	17.9
	Power Generation	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	Total	16.4	16.5	15.5	16.7	17.0	17.3	17.8	18.4	19.0	19.6	20.2	20.7
Woodford	PWS	2.3	2.3	2.0	2.0	2.1	2.3	2.3	2.4	2.4	2.5	2.6	2.6
	SS Domestic	1.1	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.4	1.5	1.5	1.6
	C&I	0.0	0.0	0.0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	IR & AG	1.6	1.5	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3
	Total w/out PG	5.1	4.8	4.1	4.4	4.6	4.8	5.0	5.1	5.2	5.3	5.5	5.6
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.1	4.8	4.1	4.4	4.6	4.8	5.0	5.1	5.2	5.3	5.5	5.6

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.11: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the more resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Cass	PWS	1.7	1.8	1.6	1.9	1.9	2.0	2.1	2.2	2.2	2.3	2.4	2.4
	SS Domestic	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	C&I	1.8	1.9	1.5	1.9	2.9	3.0	3.2	3.3	3.5	3.7	3.9	4.1
	IR & AG	16.9	14.4	9.4	14.7	15.5	16.3	16.4	16.4	16.5	16.5	16.6	16.6
	Total w/out PG	20.8	18.5	13.0	18.8	20.7	21.7	22.0	22.3	22.6	22.9	23.2	23.6
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	20.8	18.5	13.0	18.8	20.7	21.7	22.0	22.3	22.6	22.9	23.2	23.6
Champaign	PWS	26.6	26.6	24.6	25.8	27.2	28.8	30.0	30.7	31.9	33.0	34.1	35.2
	SS Domestic	1.3	1.3	1.3	2.3	2.3	2.4	2.4	2.5	2.4	2.5	2.5	2.6
	C&I	5.5	5.7	4.8	8.1	8.6	9.2	9.7	10.3	10.9	11.5	12.0	12.6
	IR & AG	5.4	4.9	3.8	5.1	5.4	5.7	5.9	6.1	6.3	6.4	6.5	6.5
	Total w/out PG	38.8	38.6	34.6	41.3	43.5	46.0	48.1	49.6	51.5	53.3	55.1	56.9
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	38.8	38.6	34.6	41.3	43.5	46.0	48.1	49.6	51.5	53.3	55.1	56.9
DeWitt	PWS	1.3	1.4	1.3	1.4	1.5	1.5	1.6	1.7	1.7	1.8	1.9	1.9
	SS Domestic	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	C&I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	IR & AG	1.0	1.0	0.7	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
	Total w/out PG	2.6	2.7	2.4	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.3
	Power Generation	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4	810.4
	Total	813.0	813.1	812.8	812.9	813.1	813.2	813.3	813.4	813.5	813.6	813.7	813.7

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.12: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the more resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Ford	PWS	1.7	1.8	1.7	1.8	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.4
	SS Domestic	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
	C&I	3.0	3.0	2.5	5.4	5.7	6.0	6.4	6.8	7.2	7.6	8.0	8.5
	IR & AG	0.9	0.8	0.7	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0
	Total w/out PG	5.9	5.9	5.1	8.1	8.6	9.1	9.5	10.0	10.5	11.0	11.5	12.0
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.9	5.9	5.1	8.1	8.6	9.1	9.5	10.0	10.5	11.0	11.5	12.0
Iroquois	PWS	2.2	2.4	2.3	2.5	2.6	2.7	2.9	3.0	3.1	3.2	3.3	3.5
	SS Domestic	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	1.0
	C&I	0.0	0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9
	IR & AG	2.7	2.6	2.5	2.8	2.9	3.1	3.2	3.3	3.4	3.4	3.4	3.4
	Total w/out PG	5.6	5.8	5.6	7.8	8.1	8.4	8.7	8.9	9.1	9.3	9.5	9.7
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.6	5.8	5.6	7.8	8.1	8.4	8.7	8.9	9.1	9.3	9.5	9.7
Logan	PWS	3.6	3.6	3.3	2.5	2.6	2.7	2.9	3.0	3.1	3.2	3.3	3.5
	SS Domestic	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	C&I	1.0	1.1	0.8	1.1	2.7	2.8	3.0	3.1	3.2	3.3	3.5	3.6
	IR & AG	2.2	2.2	1.6	1.8	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.2
	Total w/out PG	7.4	7.5	6.4	6.0	7.8	8.2	8.5	8.8	9.1	9.4	9.7	10.0
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	7.4	7.5	6.4	6.0	7.8	8.2	8.5	8.8	9.1	9.4	9.7	10.0

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.13: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the more resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Macon	PWS	25.3	25.4	24.1	25.3	26.0	27.0	27.9	28.8	29.8	30.8	31.8	32.8
	SS Domestic	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	C&I	15.7	15.9	12.9	19.9	21.6	23.5	25.4	27.3	29.2	31.1	32.9	34.6
	IR & AG	0.6	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	Total w/out PG	42.0	41.9	37.6	45.6	48.1	51.1	53.9	56.7	59.6	62.4	65.3	68.1
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	42.0	41.9	37.6	45.6	48.1	51.1	53.9	56.7	59.6	62.4	65.3	68.1
Mason	PWS	0.8	0.9	0.8	0.8	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0
	SS Domestic	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.6	0.6	0.6	0.6
	C&I	5.6	5.4	3.9	4.2	6.2	6.6	7.1	7.6	8.1	8.6	9.1	9.7
	IR & AG	163.9	161.9	88.6	100.2	106.1	111.9	112.2	112.5	112.8	113.1	113.4	113.7
	Total w/out PG	170.9	168.8	93.8	105.8	113.7	120.0	120.7	121.5	122.3	123.2	124.0	124.9
	Power Generation	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
	Total	275.9	273.8	198.8	210.8	218.7	225.0	225.7	226.5	227.3	228.2	229.0	229.9
McLean	PWS	17.5	17.6	15.4	16.6	17.8	19.0	20.1	20.9	21.9	23.0	24.1	25.2
	SS Domestic	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6
	C&I	0.0	0.0	0.0	0.5	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.6
	IR & AG	2.5	2.0	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.2	2.2	2.3
	Total w/out PG	21.1	20.7	18.1	20.0	22.9	24.4	25.7	26.7	27.9	29.1	30.4	31.6
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	21.1	20.7	18.1	20.0	22.9	24.4	25.7	26.7	27.9	29.1	30.4	31.6

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.14: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the more resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Menard	PWS	0.8	0.8	0.7	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.1	1.1
	SS Domestic	0.01	0.0	0.0	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	C&I	0.0	0.0	0.0	0.003	0.004	0.004	0.004	0.004	0.01	0.01	0.01	0.01
	IR & AG	2.9	2.8	1.8	2.6	2.7	2.9	3.0	3.1	3.2	3.2	3.3	3.3
	Total w/out PG	3.6	3.6	2.6	3.4	3.6	3.8	3.9	4.1	4.2	4.3	4.3	4.4
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	3.6	3.6	2.6	3.4	3.6	3.8	3.9	4.1	4.2	4.3	4.3	4.4
Piatt	PWS	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5
	SS Domestic	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
	C&I	1.1	1.1	0.9	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2.0
	IR & AG	0.5	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Total w/out PG	3.2	3.3	2.9	3.4	3.5	3.7	3.8	3.9	4.1	4.2	4.4	4.5
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	3.2	3.3	2.9	3.4	3.5	3.7	3.8	3.9	4.1	4.2	4.4	4.5
Sangamon	PWS	24.8	24.9	23.0	23.0	24.2	25.7	26.9	28.0	29.2	30.5	31.9	33.3
	SS Domestic	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5
	C&I	5.1	5.0	4.1	5.8	6.3	6.9	7.5	8.1	8.7	9.2	9.8	10.3
	IR & AG	2.1	1.6	1.3	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7
	Total w/out PG	33.1	32.7	29.6	31.4	33.2	35.4	37.3	39.1	41.0	42.9	44.8	46.8
	Power Generation	371.3	371.3	371.3	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5	331.5
	Total	404.4	404.0	400.9	362.9	364.7	366.9	368.8	370.6	372.5	374.4	376.3	378.3

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

Table G.15: Water withdrawals (MGD) for each county in East-Central Illinois by water demand sector for the more resource intensive scenario.

County	Sector	2005 Reported	2005 Weather	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Tazewell	PWS	17.7	18.4	16.2	17.2	18.4	19.7	20.9	21.8	22.9	24.1	25.3	26.6
	SS Domestic	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	C&I	43.2	43.3	29.7	40.8	44.8	49.5	54.3	59.4	64.6	70.0	75.4	80.7
	IR & AG	37.3	36.1	25.0	35.5	37.9	40.2	40.4	40.5	40.7	40.8	41.0	41.1
	Total w/out PG	98.0	97.8	70.9	93.6	101.2	109.6	115.7	121.8	128.3	135.0	141.8	148.6
	Power Generation	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
	Total	123.9	123.7	96.8	119.5	127.1	135.5	141.6	147.7	154.2	160.9	167.7	174.5
Vermilion	PWS	9.7	9.8	9.2	8.9	8.9	9.1	9.3	9.7	10.0	10.4	10.7	11.1
	SS Domestic	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
	C&I	2.7	2.7	2.4	4.9	5.2	5.5	5.9	6.3	6.7	7.0	7.4	7.8
	IR & AG	0.6	0.6	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.8
	Total w/out PG	13.6	13.7	12.7	14.9	15.3	15.8	16.5	17.3	18.0	18.8	19.5	20.3
	Power Generation	2.8	2.8	2.8	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
	Total	16.4	16.5	15.5	40.8	41.2	41.7	42.4	43.2	43.9	44.7	45.4	46.2
Woodford	PWS	2.3	2.3	2.0	2.1	2.2	2.4	2.6	2.7	2.8	2.9	3.1	3.2
	SS Domestic	1.1	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.4	1.5	1.5	1.6
	C&I	0.0	0.0	0.0	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	IR & AG	1.6	1.5	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.4
	Total w/out PG	5.1	4.8	4.1	4.5	4.7	5.0	5.3	5.4	5.6	5.9	6.1	6.3
	Power Generation	-	-	-	-	-	-	-	-	-	-	-	-
	Total	5.1	4.8	4.1	4.5	4.7	5.0	5.3	5.4	5.6	5.9	6.1	6.3

PWS = public water supply; SS Domestic = self-supplied domestic; C&I = commercial and industrial; IR & AG = irrigation and agriculture;

PG = power generation; w/out = without; MGD = million gallons per day; 2005 Reported = 2005 value reported from the original data source; not a modeled value.

2005 Weather = model generated results using actual 2005 weather data; 2005 Normal = model generated results using normal (1971-2000) weather data.

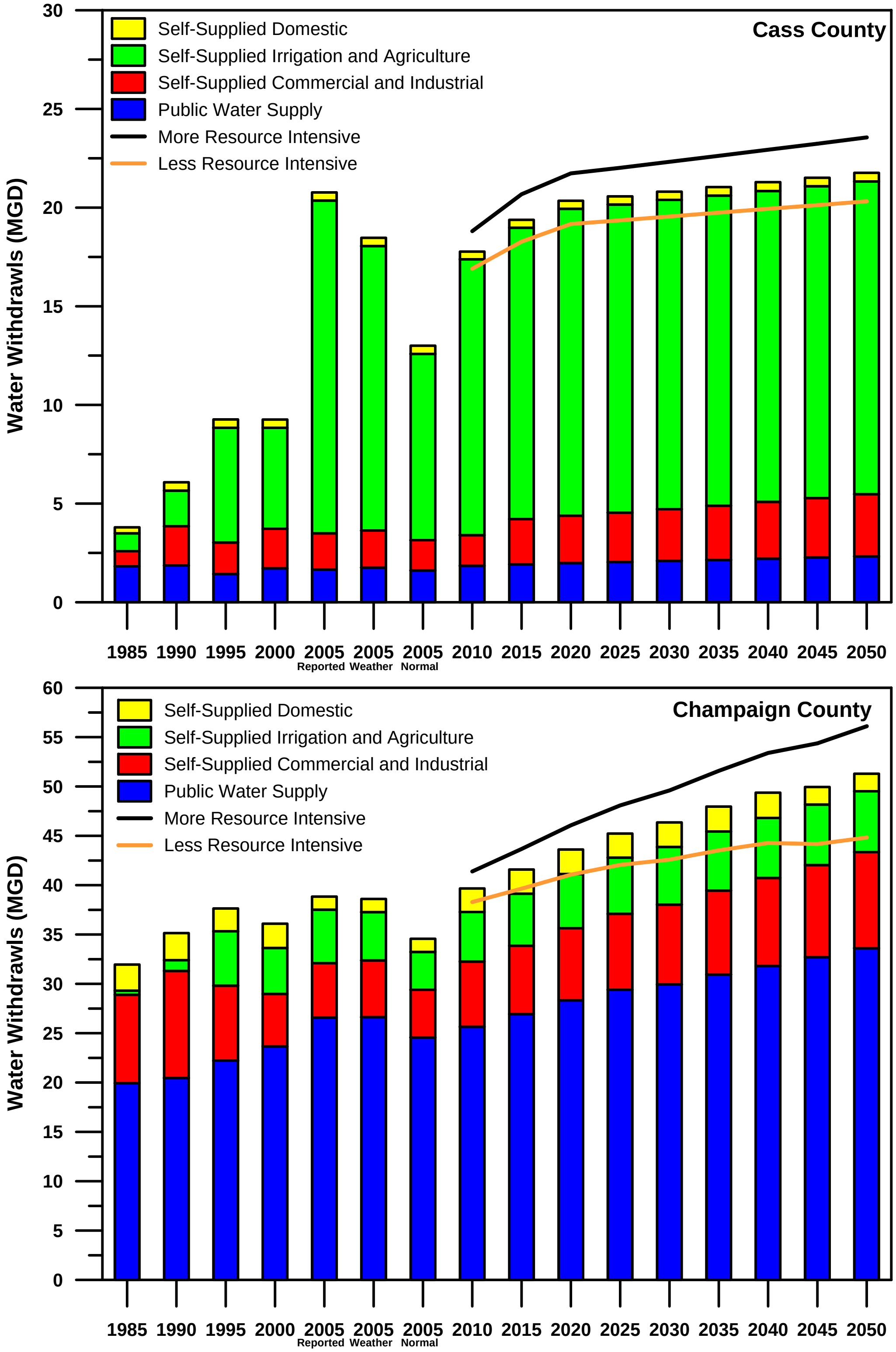
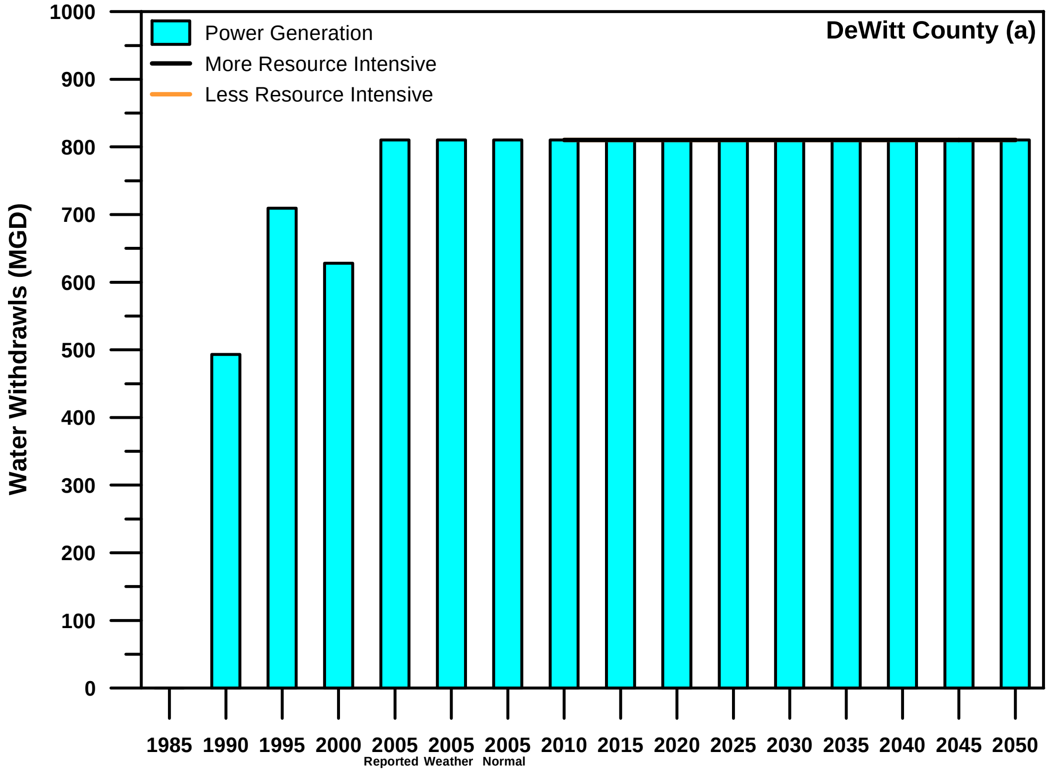


Figure G.1: Summary of water withdrawals for Cass and Champaign counties.



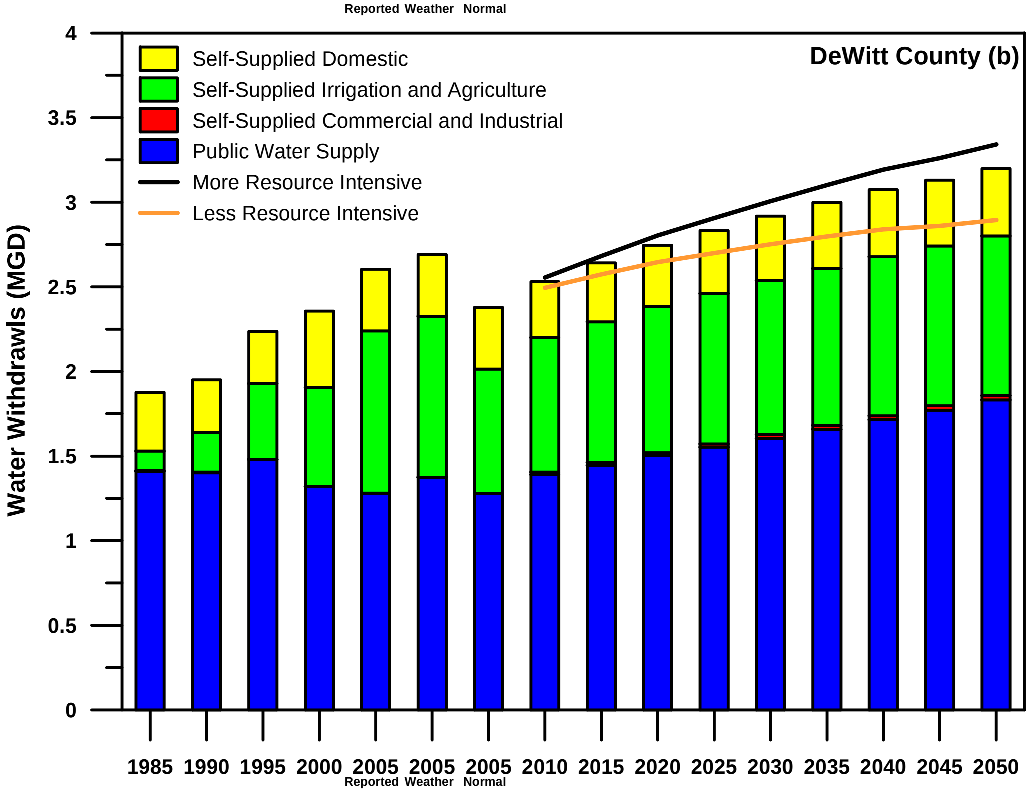
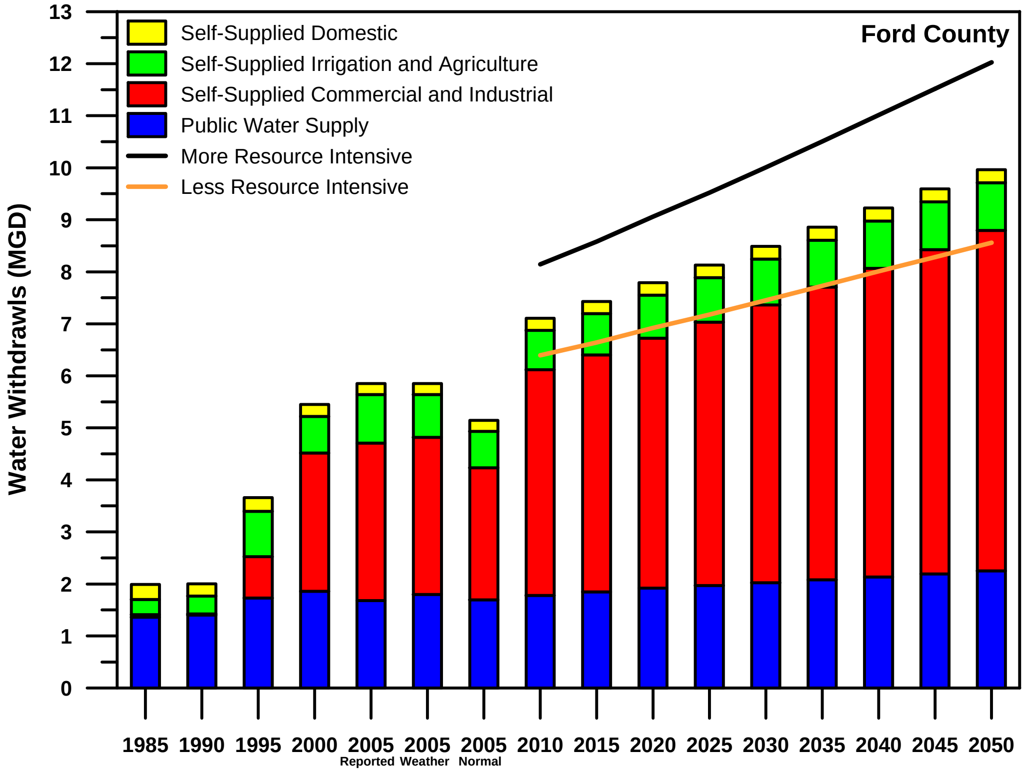


Figure G.2: Summary of water withdrawals for DeWitt County.



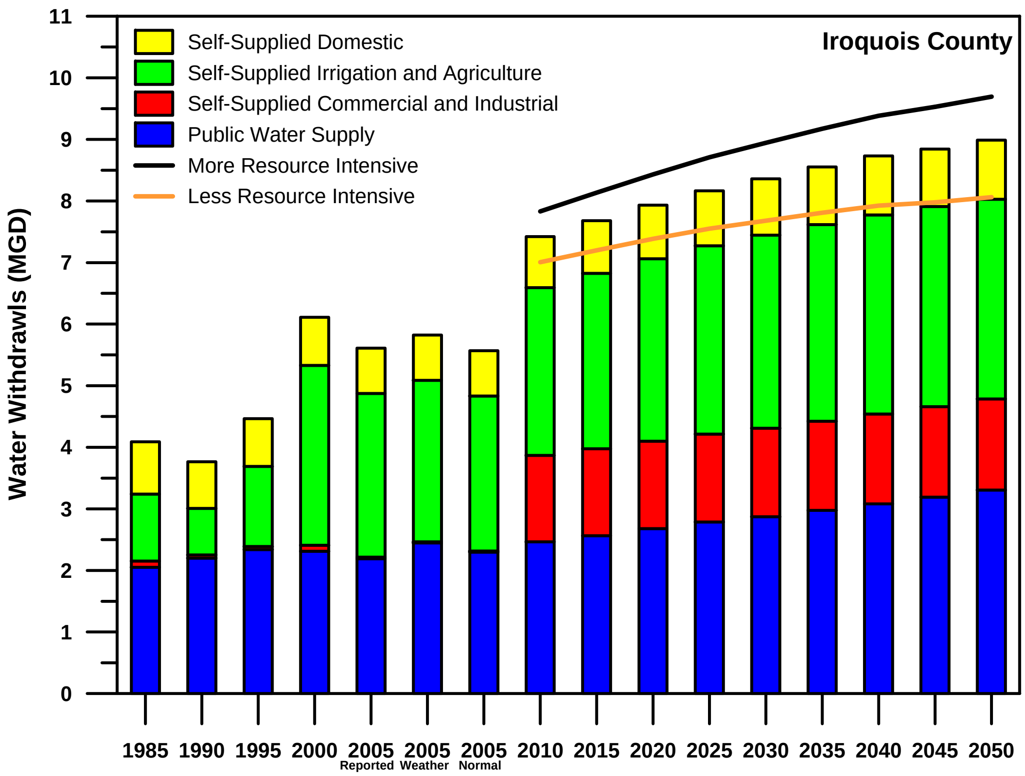


Figure G.3: Summary of water withdrawals for Ford and Iroquois counties.

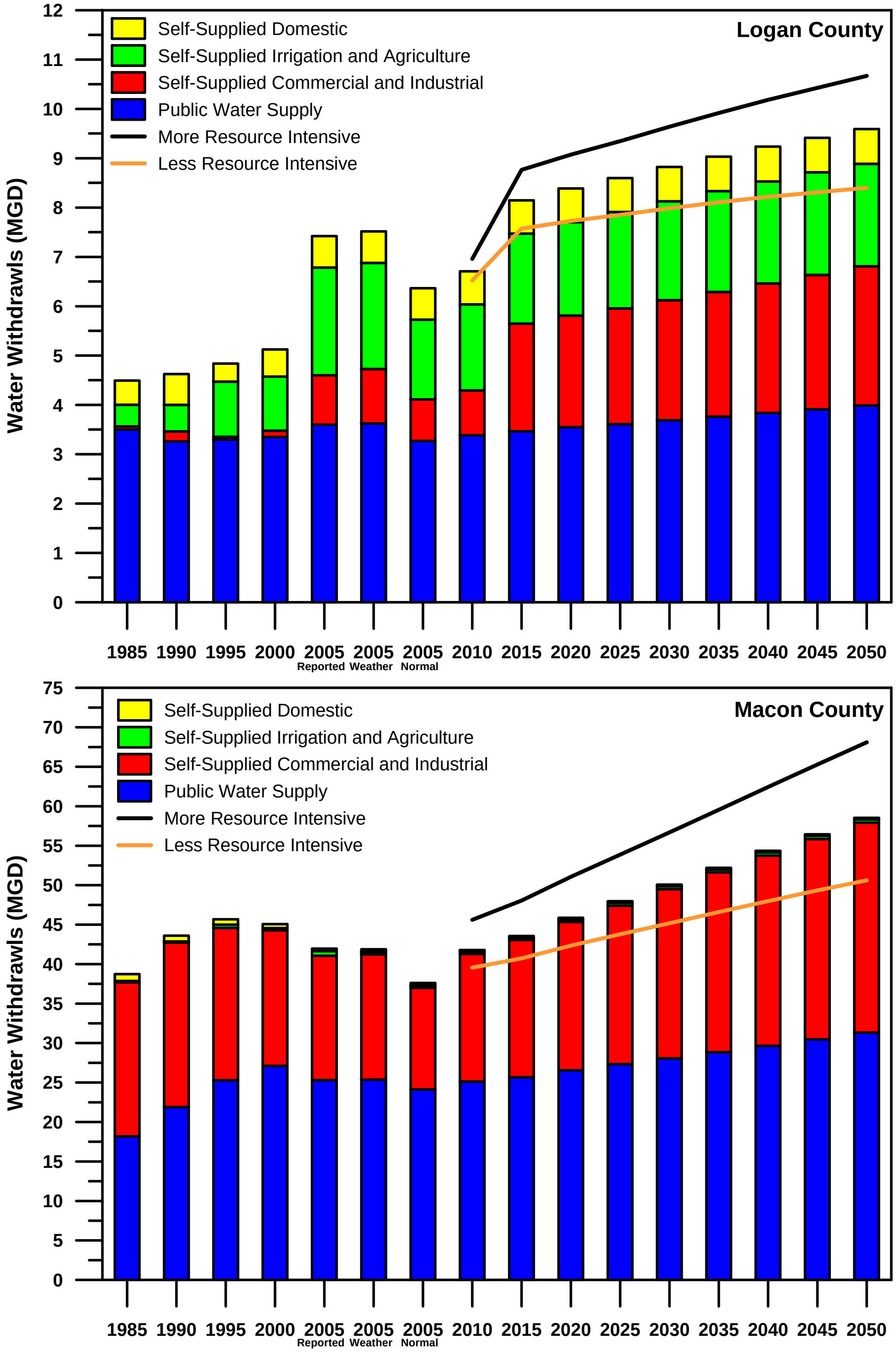


Figure G.4: Summary of water withdrawals for Logan and Macon counties.

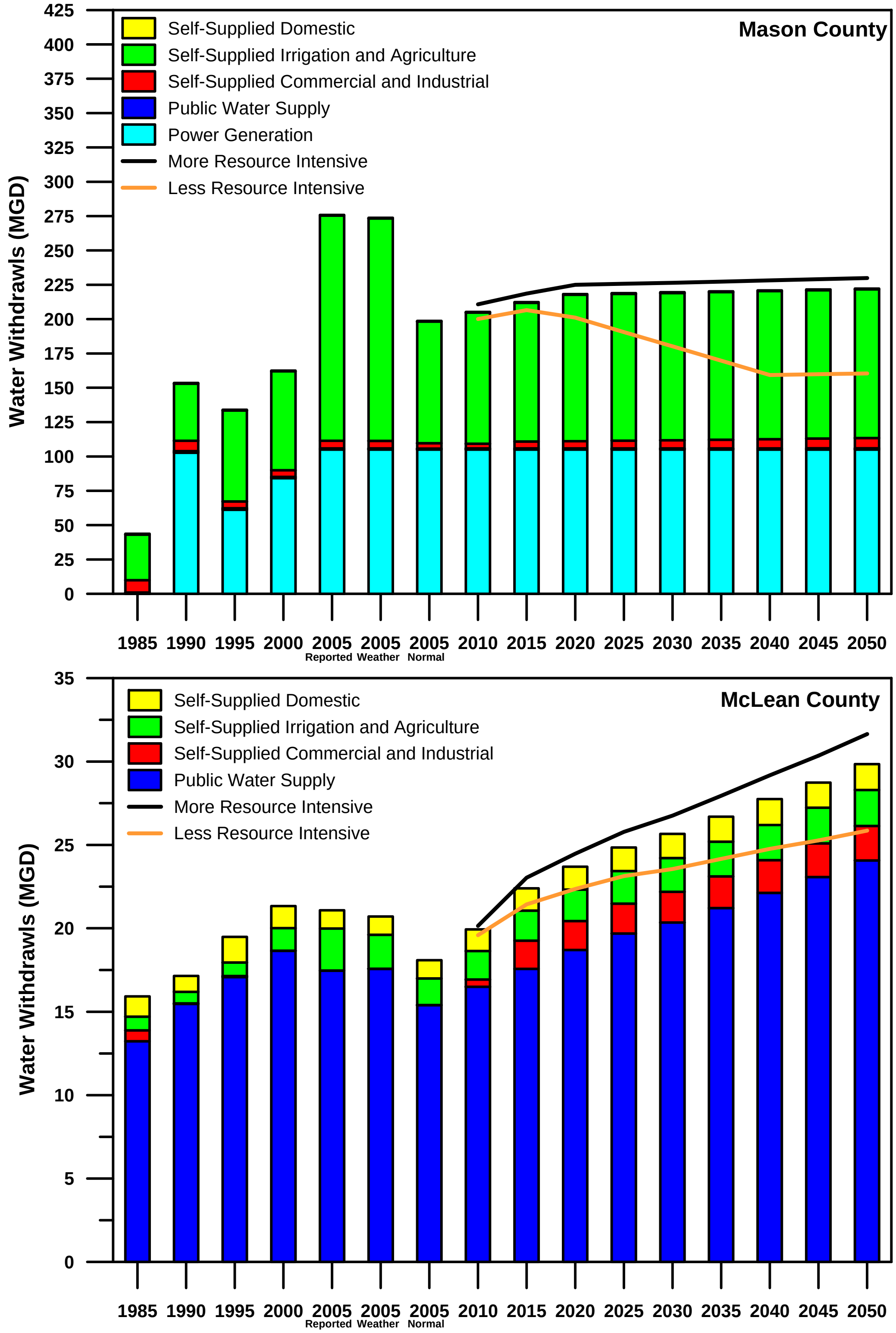


Figure G.5: Summary of water withdrawals for Mason and McLean counties.

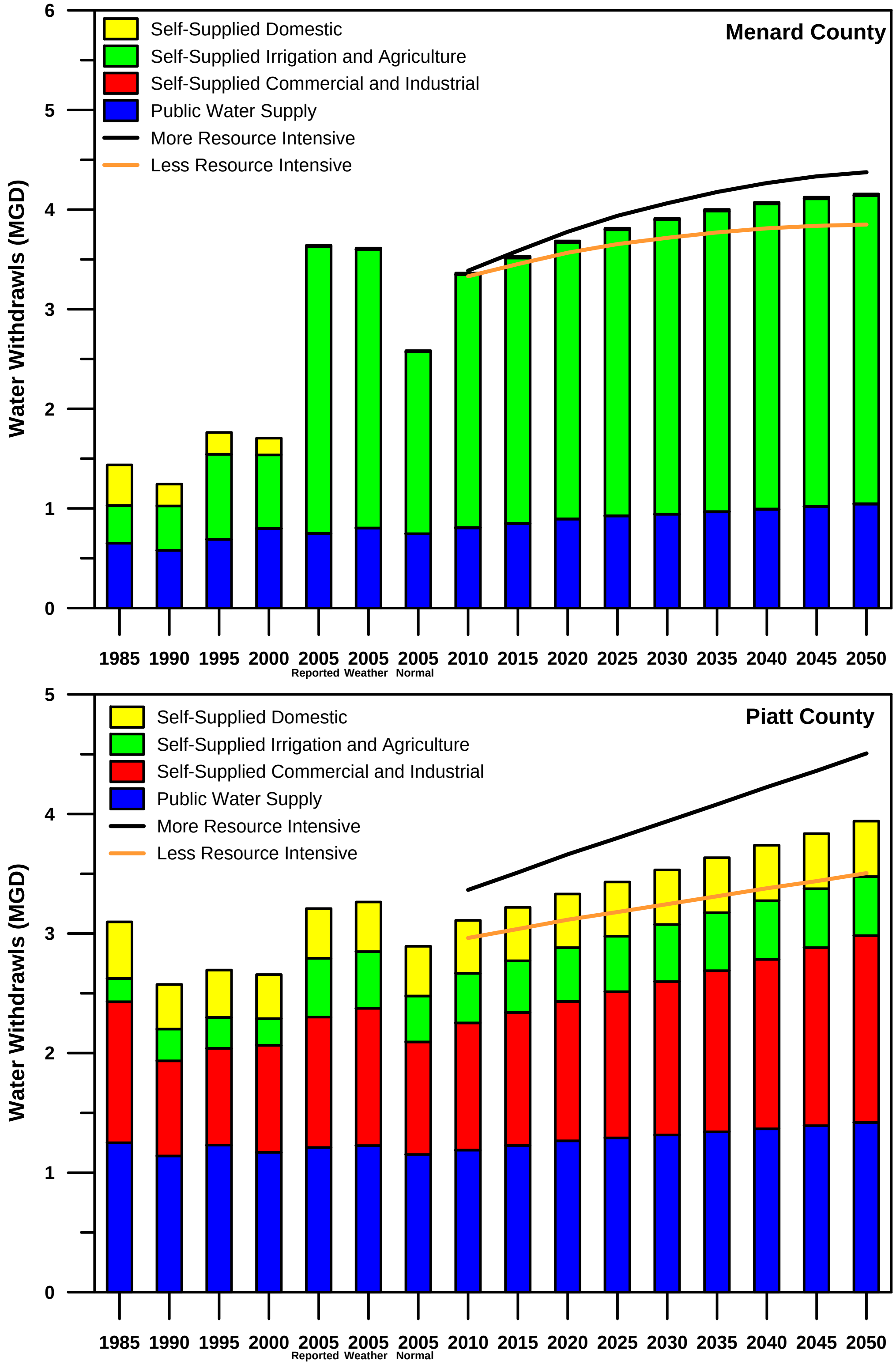


Figure G.6: Summary of water withdrawals for Menard and Piatt counties.

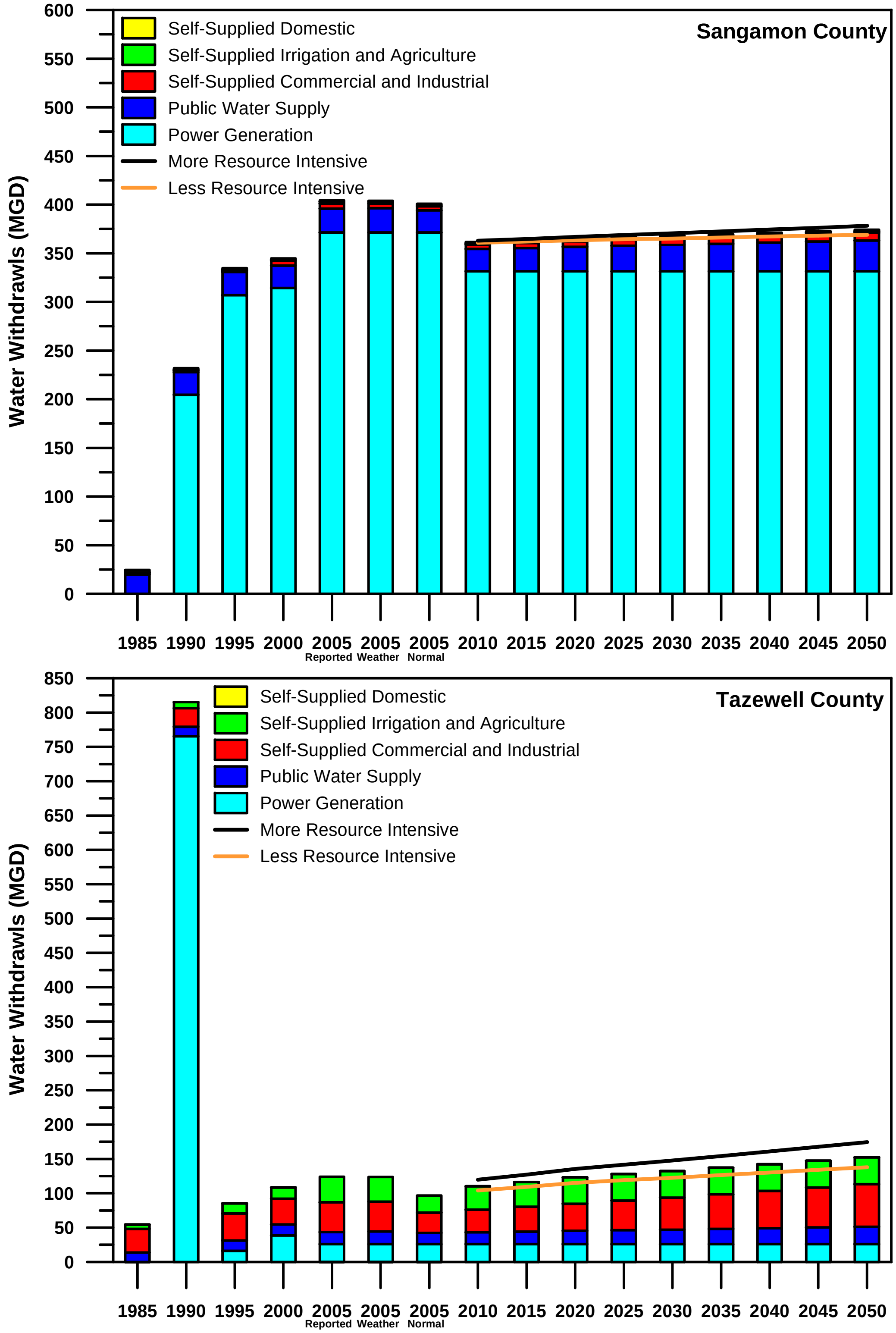


Figure G.7: Summary of water withdrawals for Sangamon and Tazewell counties. *Note: Large Tazewell County Power Generation withdrawals in 1990 due variation in reporting method. See Chapter 3 for more information.*

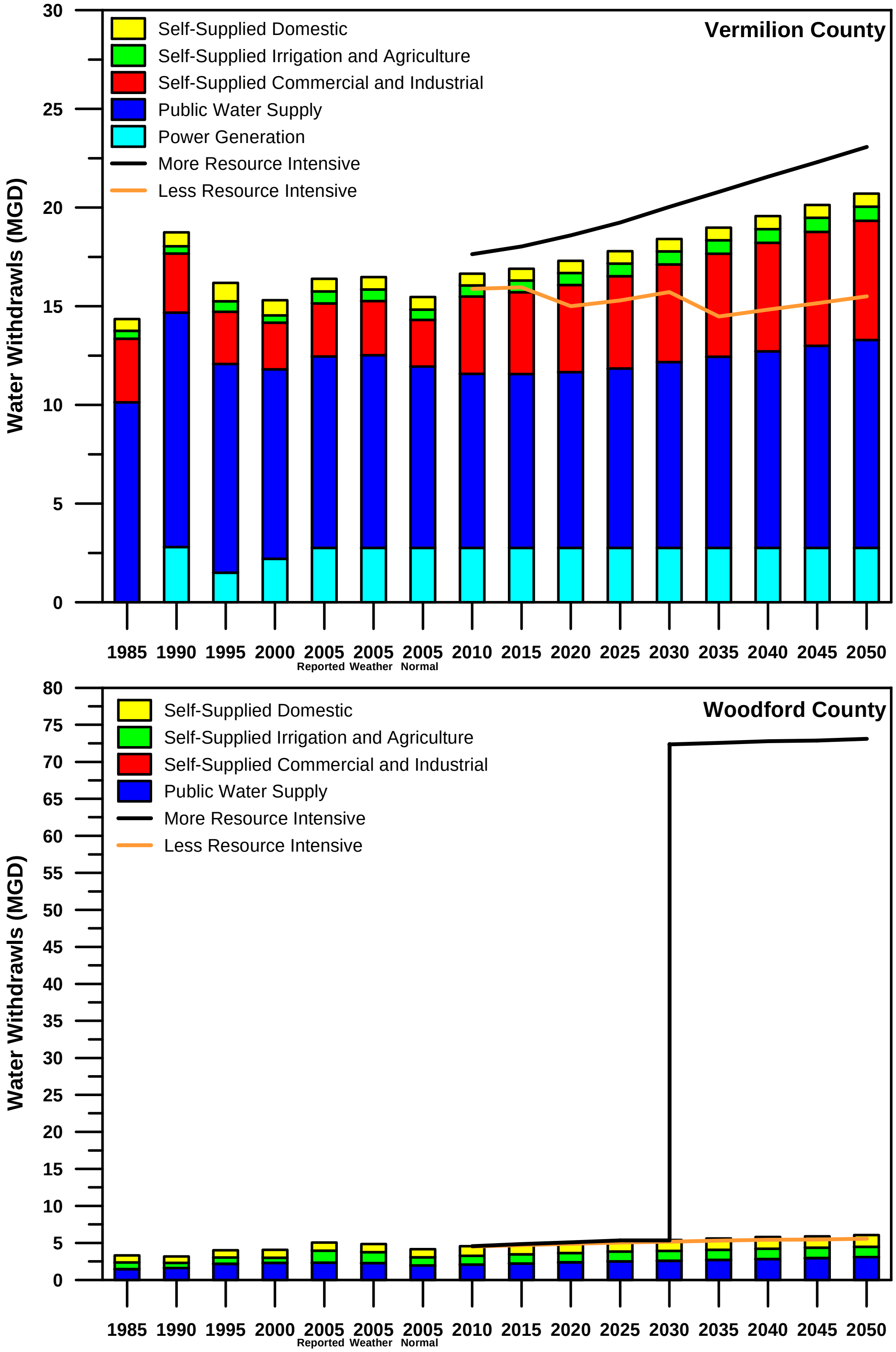


Figure G.8: Summary of water withdrawals for Vermilion and Woodford counties.