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:

$$APE_{it} = \left| \frac{\hat{Y}_{it} - Y_{it}}{Y_{it}} \right| x\,100 \tag{D.3}$$

In a log-linear model of the form shown in Equation 1.3, the APE in the log scale is given by:

$$APE_{it} = \left| \frac{ln\hat{Y}_{it} - lnY_{it}}{lnY_{it}} \right| x\,100 \tag{D.4}$$

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:

$$E\left(Y \mid explanatory\, variables\right) = e^{\sigma^2_\varepsilon/2}(e^{\ln \mathrm{Y}}) \tag{D.5}$$

Thus, in log-linear models, the predicted raw scale value denoted as $\widetilde{Y}$ is given by:

$$\widetilde{Y} = e^{\hat{\sigma}^2_\varepsilon/2}(e^{\ln \hat{} \mathrm{Y}}) \tag{D.6}$$

where:

$\hat{\sigma}^2_\varepsilon$= 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:

$$APE_{it} = \left| \frac{\widetilde{Y_{it}} - Y_{it}}{Y_{it}} \right| x\,100 \tag{D.7}$$

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 >ltl
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 >ltl
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			

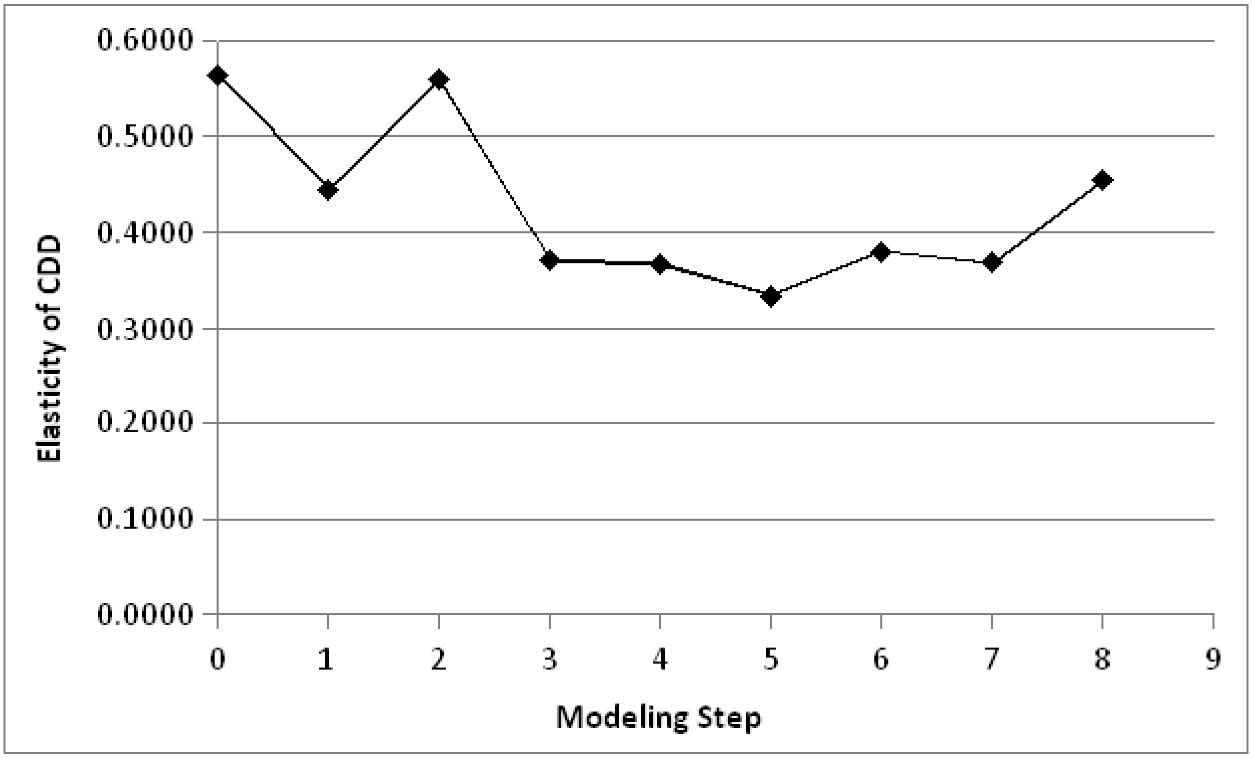

Figure D.1: Effects of binary site variables and spike dummies on estimated elasticity of cooling degree days.

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.*

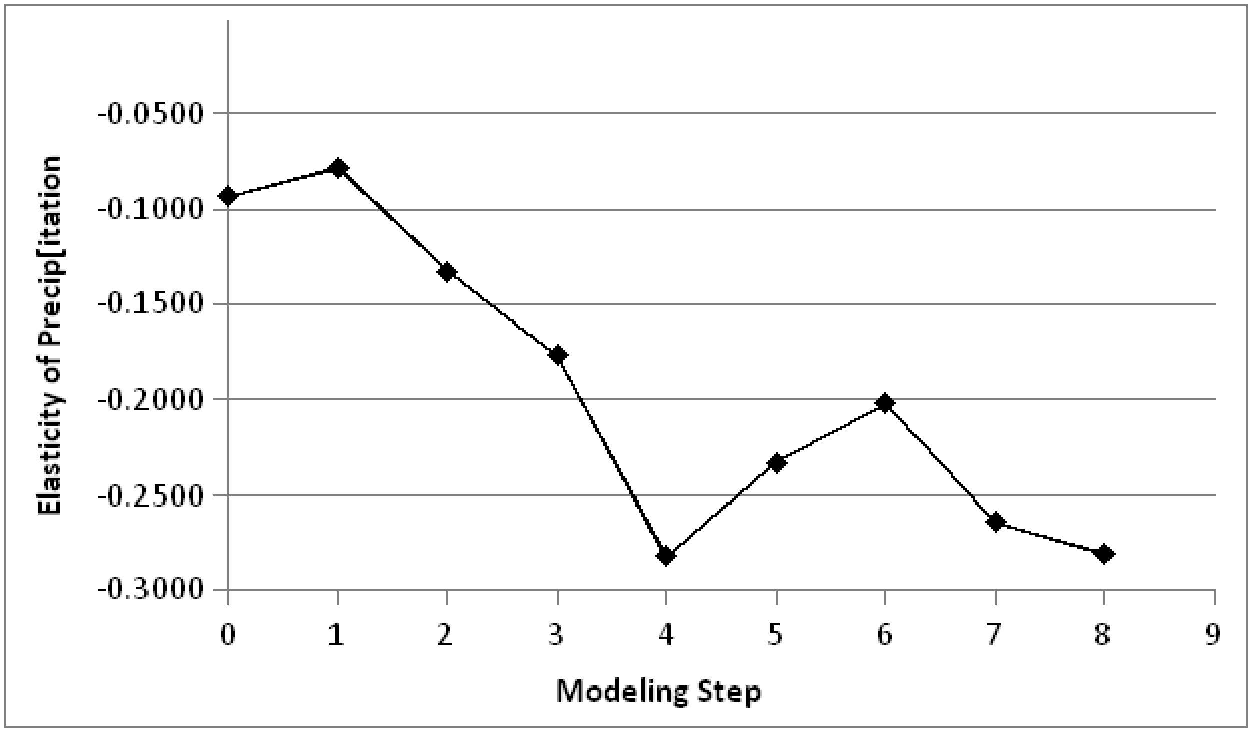

Figure D.2: Effects of binary site variables and spike dummies on estimated elasticity of precipitation.

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 >ltl
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.

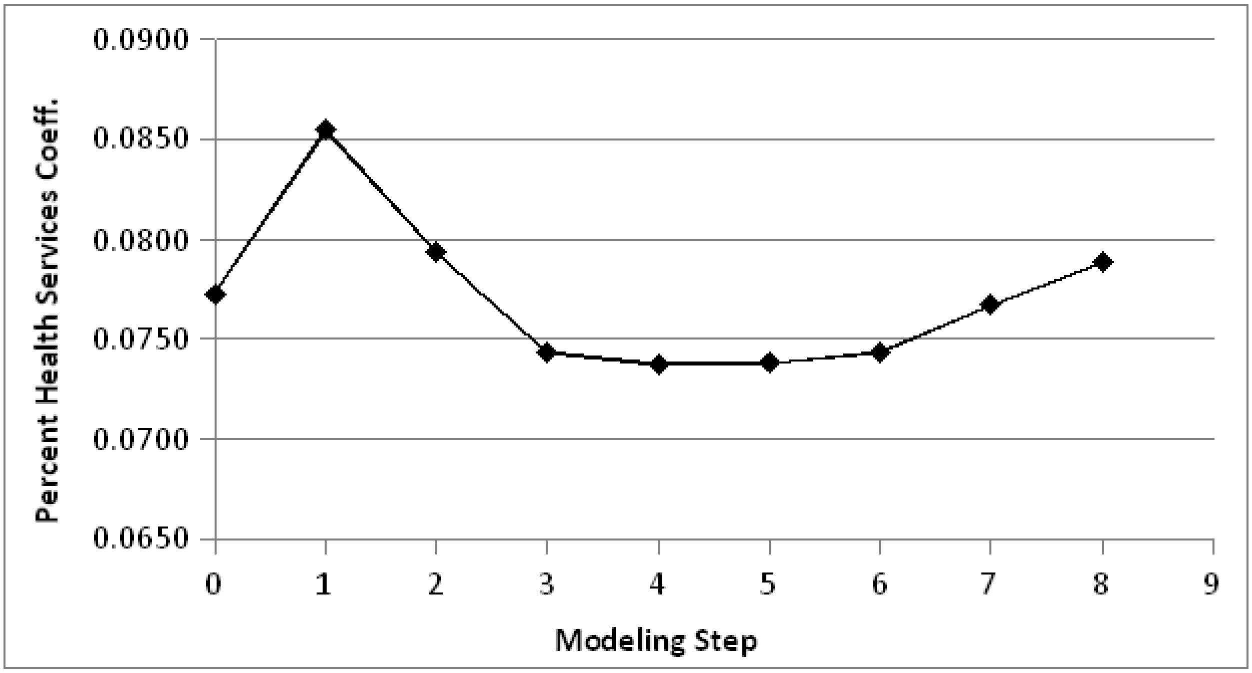

Figure D.3: Effects of binary site variables and spike dummies on estimated coefficient of percent employment in health services.

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.

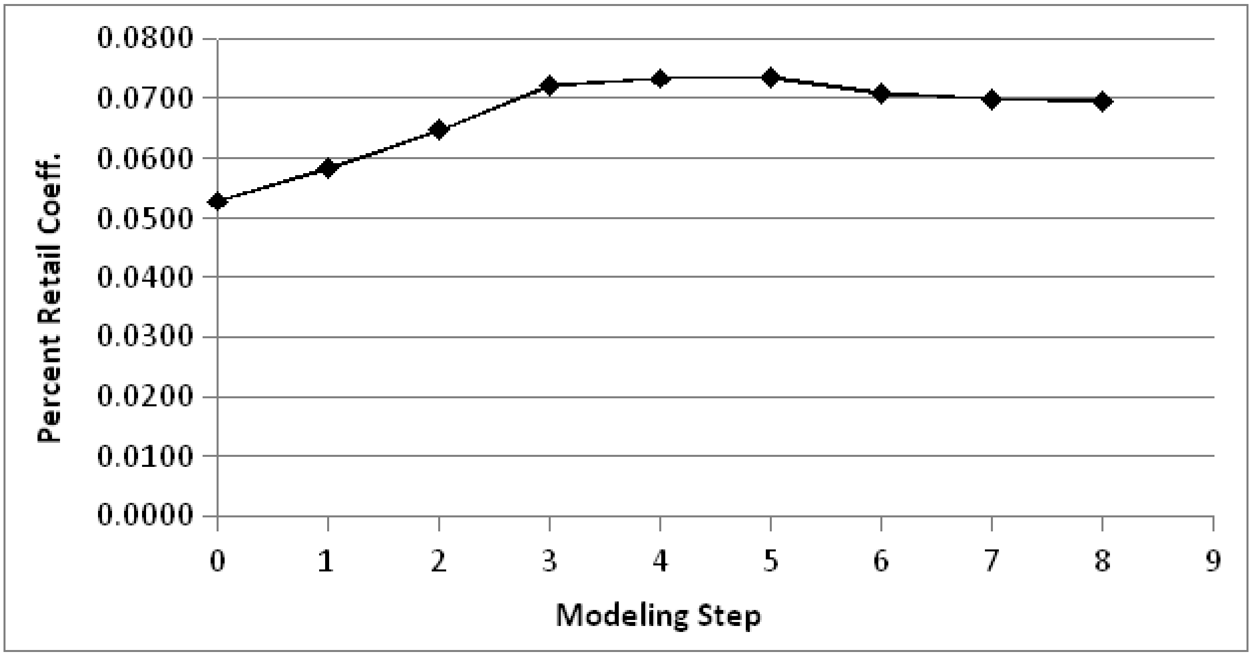

Figure D.4: Effects of binary site variables and spike dummies on estimated coefficient of percent employment in retail trade.

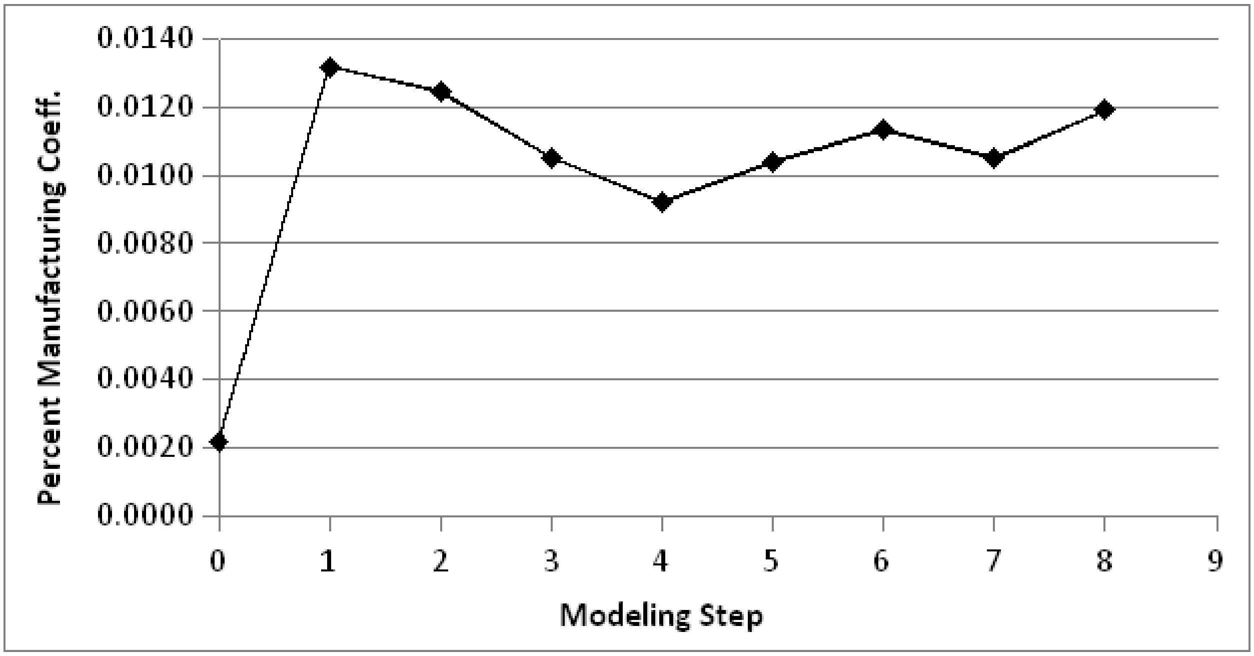

Figure D.5: Effects of binary site variables and spike dummies on estimated coefficient of percent employment in manufacturing.

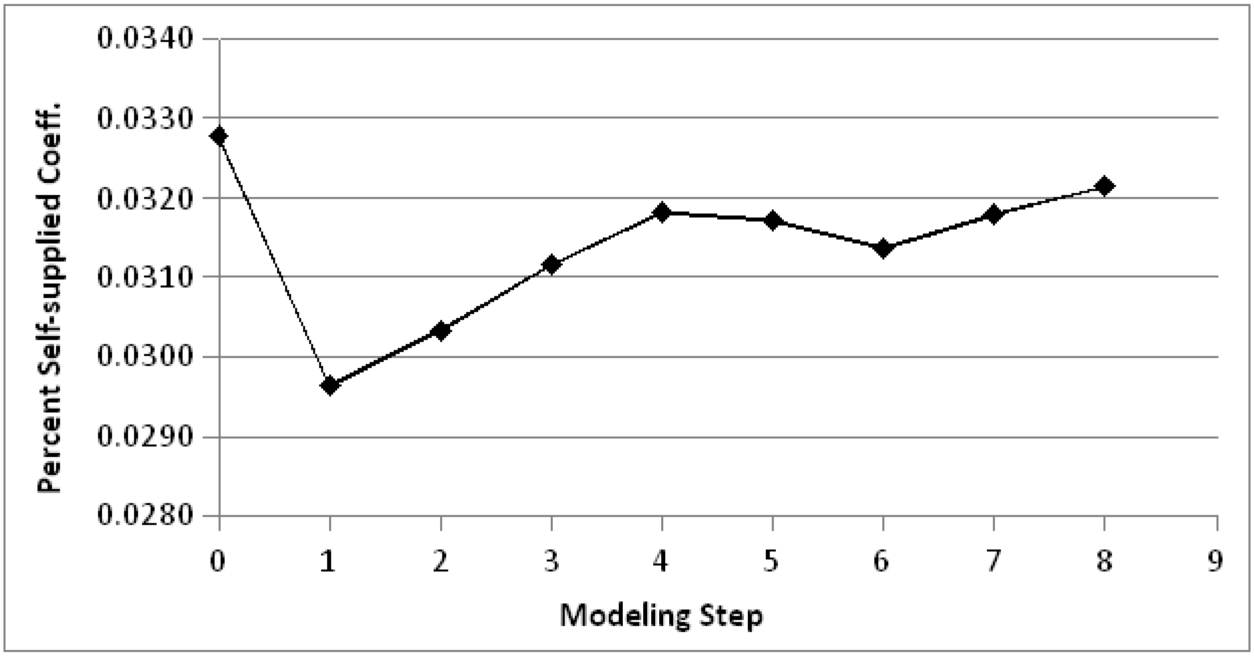

Figure D.6: Effects of binary site variables and spike dummies on estimated coefficient of percent self-supplied commercial and industrial water demand.

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.

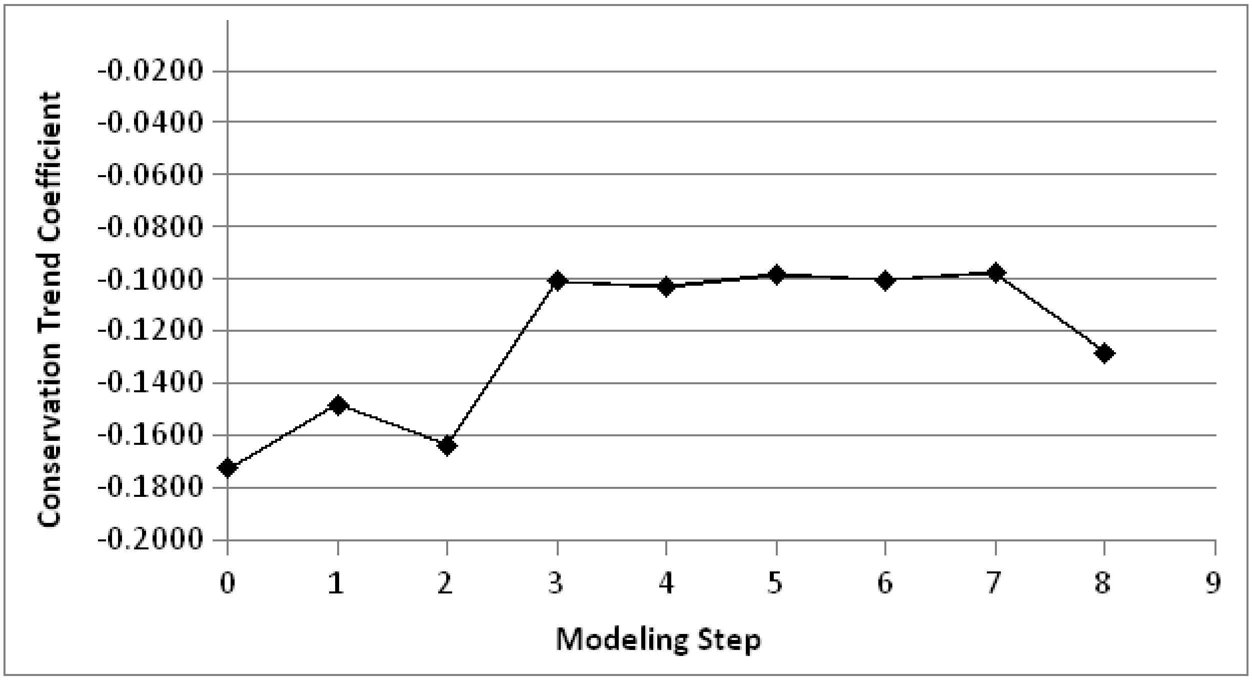

Figure D.7: Effects of binary site variables and spike dummies on estimated coefficient of conservation trend variable.

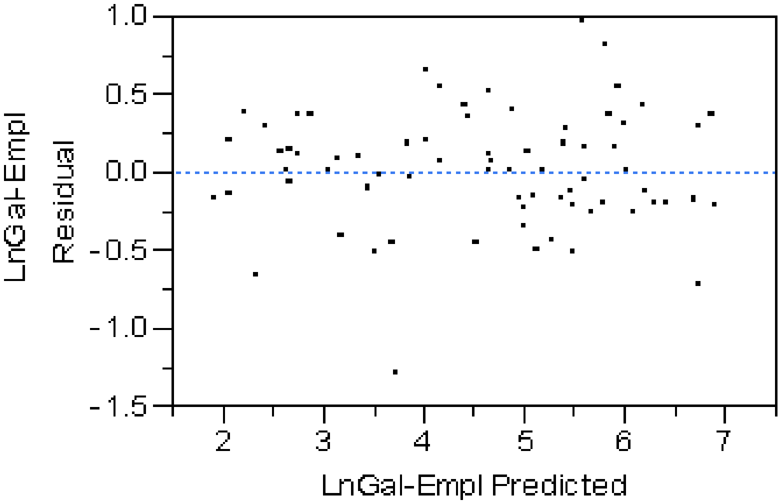

Figure D.8: Residuals plot for the model in Table D.5.

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