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INDIANA STREAM-TEMPERATURE CHARACTERISTICS

By William J. Shampine

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CONVERSION FACTORS FOR ENLISH AND METRIC UNITS USED IN THIS REPORT

To convert column 1 into column 2 multiply by	Column 1	Column 2	To convert column 2 into column 1 multiply by
1.609	miles (mi)	kilometers (km)	0.621
5/9 (F-32)	degrees Fahrenheit (°F)	degrees Celsius	9/5C + 32

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ABSTRACT

Periodic stream-temperature data have been collected at 280 different sites in Indiana by the U.S. Geological Survey and the Indiana State Board of Health. These data have been analyzed using a simple-harmonic curve-fitting procedure.

When the equation coefficients are known, calculations can be made for a given stream to estimate the maximum and minimum temperatures, the temperature on a given day, the day that a given temperature is expected, or the length of time temperatures will exceed, or be less than, a specific value.

The calculated harmonic coefficients were related to 23 topographic, basin, and climatic characteristics, and were analyzed by multiple-regression analysis techniques. The regional regression analysis for the harmonic- mean stream temperature, M, resulted in the following arithmetic function of station latitude (LAT).

$$M = 41.36 - 0.7166\ (LAT)$$

The multiple correlation coefficient (r) was 0.72. Poor correlations were found for the harmonic phase-angle and amplitude coefficients, C and A, respectively. Constants of 4.32 radians for C and 11.27° Celsius for A are suggested as average statewide values in Indiana streams. The mean temperature of the White River at Indianapolis was raised 3.5° Celsius above expected ambient levels caused by climatic conditions alone, primarily as a result of discharges from powerplants.

In general, the harmonic coefficients depicting annual variability in stream temperatures, generated from the Indiana State Board of Health data collected every 2 weeks, are the same as coefficients generated from the U.S. Geological Survey data collected every 4-6 weeks.

INTRODUCTION

Purpose and Scope

The purpose of this study was twofold: (1) to compile Indiana stream-temperature data and (2) to develop an equation for estimating water-temperature characteristics, as represented by harmonic coefficients, at

locations where historical temperature data may not be available. Such estimates would be possible if values for the harmonic coefficients M, A, and C could be calculated from readily available physical or climatological data. Multiple-regression analysis techniques were utilized to investigate this technique.

Previous Studies

Water temperature affects fish and other aquatic life, chemical and biological reactions, water treatment, toxicity of contaminants, industrial and agricultural water uses, and taste, odor, and general quality of domestic water. The importance of temperature has led to many studies and reports on the subject utilizing a range of techniques from very simple to very complex.

The simplest type of temperature report is a compilation of basic data. Examples include the series of reports prepared by Blodgett (1970-72) on California streams and those of the U.S. Geological Survey (1976). Some investigators, such as Anderson (1971) in Florida, and Collings and Higgins (1973) in Washington, have summarized water-temperature data in graphic map form. Aagaard (1969), Dyar and Stokes (1973), and Lowham and others (1975), prepared plots of annual stream-temperature variations for many of the streams in Montana, Georgia, and Wyoming, respectively.

Ward (1963) proposed using a least-squares, simple-harmonic regression function to depict annual stream-temperature variability. His suggestions were subsequently applied by others (Collings, 1969; Steele and Gilroy, 1972; Calandro, 1973; Steele and others, 1974).

In other studies, the computer analysis was expanded to include study of specific aspects of stream-temperature characterization (Pluhowski, 1970; Moore, 1967; Gilroy and Steele, 1972). Collings (1973) and Steele and Dyar (1974) used single or multiple-regression techniques to relate stream-temperature characteristics to selected drainage-basin characteristics.

Data Available

The Geological Survey (USGS) has accumulated a large mass of stream-temperature measurements (averaging about 12 measurements per site per year) since about 1950, when the Survey began to measure stream temperature in addition to stream discharge. In Indiana, these periodic data are available for 209 stations scattered throughout the State (fig. 1 and table 4).

Daily records of temperature have been collected by the USGS at 21 stations for as many as 15 years (fig. 1). These records are stored as daily

maxima and minima and, as such, are not compatible with the analysis of periodic data. Because of this lack of compatibility only a few of the daily records were used in this report.

The Indiana State Board of Health (ISBH) (1957-71) has operated a water-quality monitoring network since 1957. Along with other water-quality variables, temperature is measured biweekly. Temperature data from 113 stations in this network were used in the study described in this report.

When the USGS[1] and ISBH[1] data were combined, locations of 42 stations were found to coincide; thus, stream-temperature data are available for 280 different sites throughout the State.

Acknowledgments

The author expresses his appreciation to the Indiana State Board of Health for providing their data on a computer magnetic tape, to Timothy D. Steele of the U.S. Geological Survey, who provided considerable consultive help, and to Amy Jo Mattson of the U.S. Geological Survey, who handled most of the data processing.

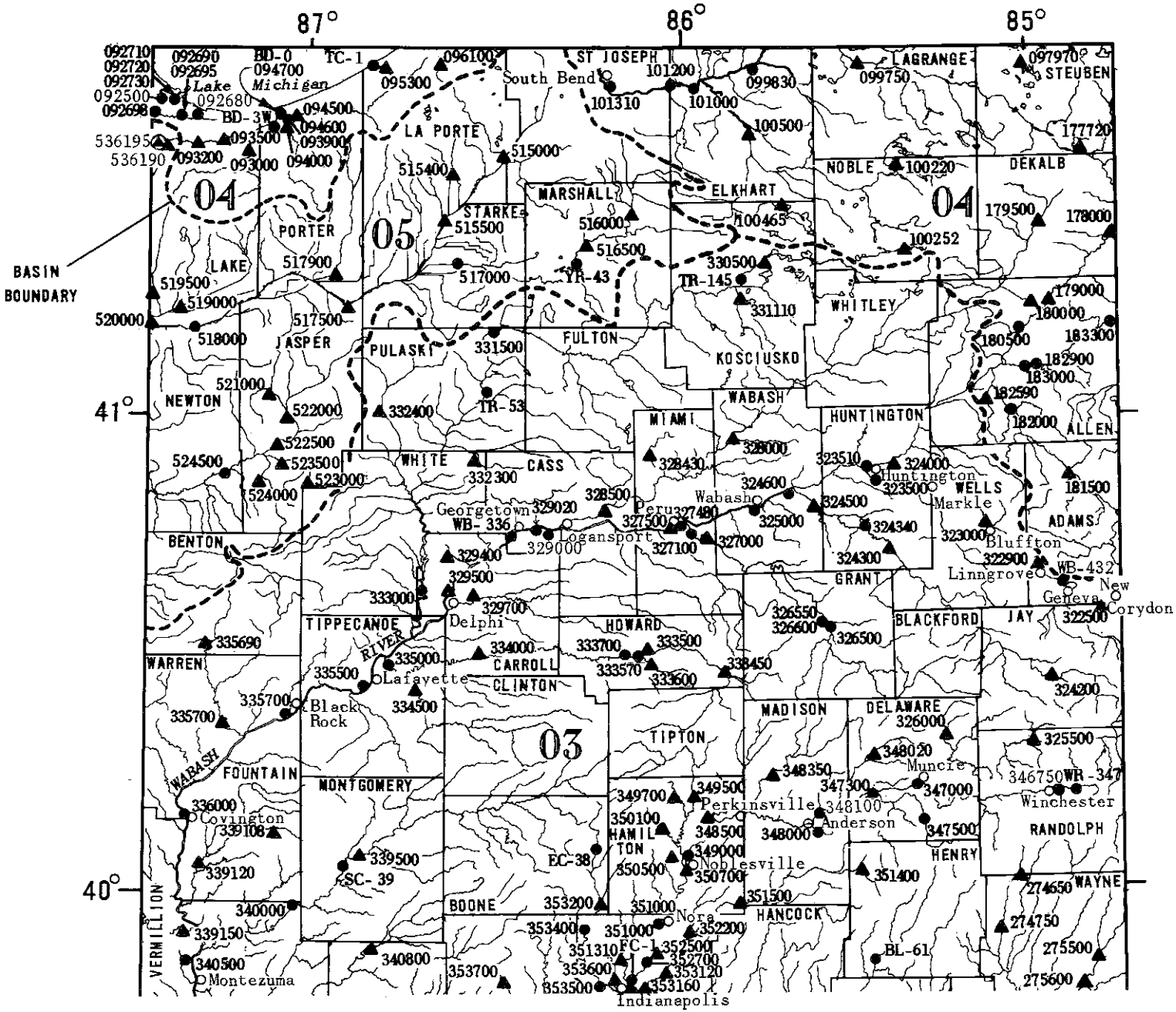
METHOD OF ANALYSIS

The annual variation of stream temperature has been shown (Ward, 1963; Collings, 1969; Steele and Gilroy, 1972) to be approximated by a simple-harmonic function of the form:

$$T = M + A \quad [\sin (bd + C)] \tag{1}$$

where T is the stream temperature, in degrees Celsius, on day d, as d varies from 1 to 366 (January 1 as day 1); M is the mean annual stream temperature, in degrees Celsius; A is the amplitude of the annual stream-temperature curve, in degrees Celsius; b is a constant equal to $2\pi/365$, or 0.0172 rad (radian) per day; and C is the phase coefficient of the annual cycle, in

[1] U.S. Geological Survey (USGS) site numbers increase in downstream direction along the main stem and on tributaries that enter the main stem. Site numbers in Indiana are preceded by 03, 04, or 05. (The State is divided into three areas identified by these numbers.) Indiana State Board of Health (ISBH) sites are located by either a downstream-order number as described above or a number preceded by one, two, or three letters (BD, BL, EC, EW, FC, MU, P, PGR, PLR, SC, TC, TR, WB, WR, YC, and YR).


87°
86°
85°
41°
40°
BASIN BOUNDARY
Lake Michigan
04
05
03
LAKE
PORTER
LA PORTE
STARKE
MARSHALL
ELKHART
LAGRANGE
STEUBEN
NOBLE
DEKALB
ST JOSEPH
South Bend
NEWTON
JASPER
PULASKI
FULTON
KOSCIUSKO
WHITLEY
WABASH
HUNTINGTON
ALLEN
WELLS
ADAMS
BENTON
WHITE
CASS
MIAMI
GRANT
BLACKFORD
JAY
WARREN
TIPPECANOE
HOWARD
CARROLL
CLINTON
TIPTON
MADISON
DELAWARE
HENRY
RANDOLPH
WAYNE
FOUNTAIN
MONTGOMERY
HAMILTON
HANCOCK
BOONE
VERMILLION
Lafayette
Delphi
Georgetown
Logansport
Peru
Wabash
Huntington
Markle
Bluffton
Linngrove
New Geneva
Corydon
Winchester
Muncie
Anderson
Perkinsville
Noblesville
Nora
Indianapolis
Black Rock
Covington
Montezuma
WABASH
RIVER
TC-1
BD-0
BD-3W
WB-336
YR-43
TR-145
TR-53
WB-432
WB-347
SC-39
EC-38
FC-1
BL-61

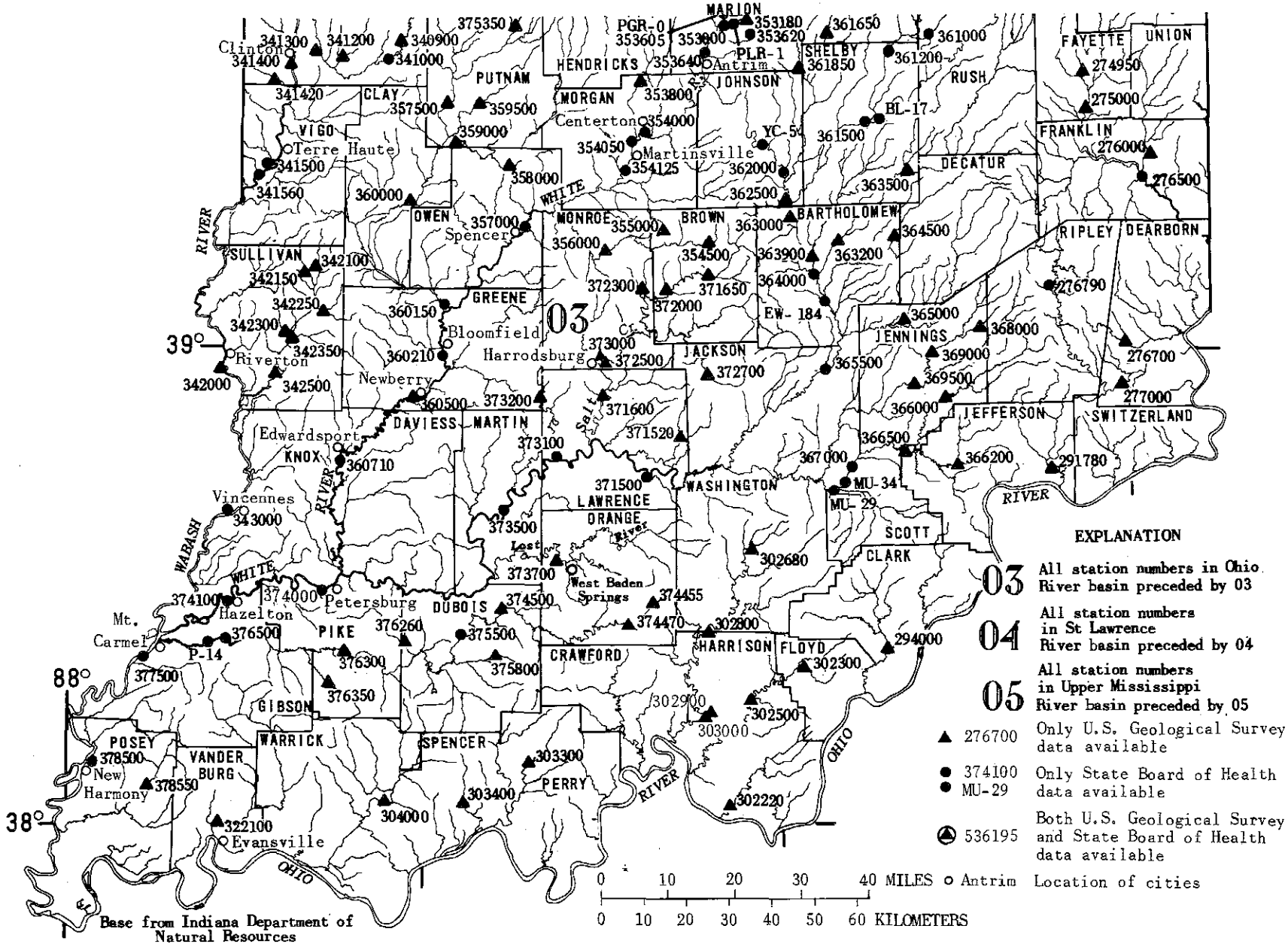


Figure 1.-- Locations of temperature-measurement sites on Indiana streams.

radians. A generalized curve illustrating these relationships is shown in figure 2. Tasker and Burns (1974) modified this functional relationship so that, for New England streams, the phase periodicity was determined only for that period of the year when water temperatures were above freezing.

Steele (1974) has documented USGS computer program (B260) based on regression analysis of a simple harmonic function as depicted in equation 1. The program, one of a series of programs in the SYSLAB system for data analysis of water-quality records, has a variety of operational modes and input-output options. In program B260, the available periodic or daily data for a given station record are plotted with temperature, in degrees Celsius, on the Y-axis (dependent variable) and time, in days (up to 366), on the X-axis (independent variable). The program user can specify the time increment of interest. The author used a calendar-year increment, but equivalent results could be expressed in water-year (or other) increments. The effect of a change in the time increment would be most appreciable in the phase-angle coefficient (C).

A harmonic curve of the general form depicted in equation 1 and figure 2 was fitted to the available stream-temperature data for each site. Harmonic coefficients M, A, and C, (eq. 1) were calculated from the fitted curve. A minimum of six well-spaced data points throughout the year are considered necessary to generate accurately a curve depicting annual stream-temperature variability.

The harmonic coefficients were generated for the USGS and ISBH periodic stream-temperature records both annually and for the entire period of record. Results of the harmonic analyses are listed in table 5 for USGS periodic data, table 6 for ISBH periodic data, and table 7 for the merged data set (USGS and ISBH data collected at the same site).

The RSQD (root mean square) term listed in tables 5-7 and elsewhere is a measure of the percentage of annual variability in the stream-temperature data explained by the harmonic function. An RSQD equal to or greater than 81 means that the variance of the data explained by the function exceeded 81 percent. This is equivalent to a coefficient of correlation of 0.9 or greater. The criterion of 81 percent explained variance is tentatively accepted as providing an adequate representation of the data by the fitted harmonic function. In tables 5-7, 98 percent of the stations satisfy this criterion. The SE term (tables 5-7) is the standard error of estimate. At each site two-thirds of the data points will generally plot within one standard error (plus or minus) of the curve.

To explore the possibility of generating a predictive statewide stream-temperature equation, a matrix of 23 characteristics affecting stream temperature was developed for each of the stations. These characteristics were regressed against the harmonic coefficients (M, A, and C) using a step-backward multiple-regression technique. USGS computer programs used were card-entry STATPAC D0092 (George Van Trump, written commun., 1971) and D0095 (Gary I. Selner, written commun., 1970), general regression (step-backward). Results of this regional analysis are described in a later section.

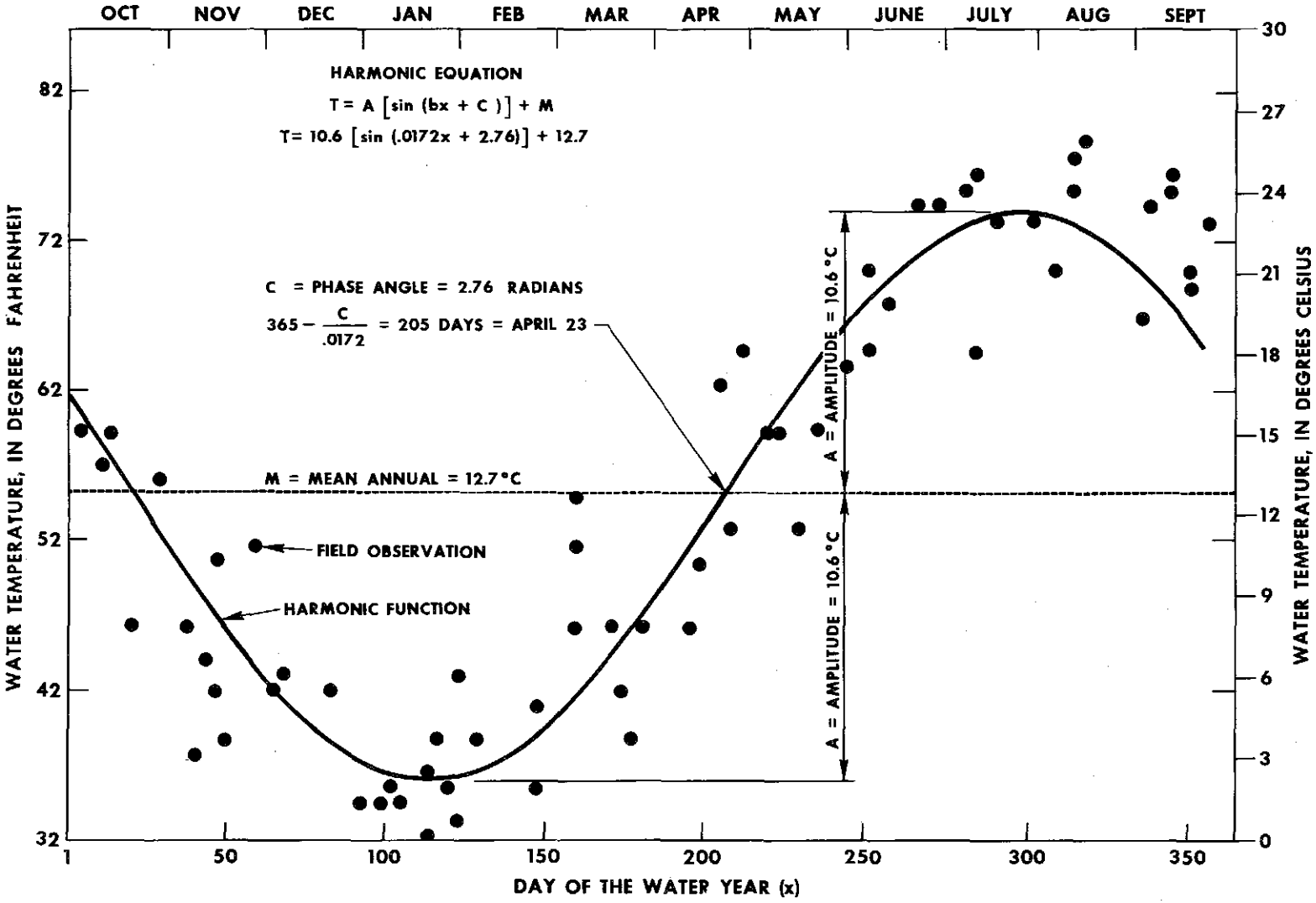


Figure 2.-- Generalized harmonic curve (from Zogorski and Kiesler, 1976).

MULTIPLE-REGRESSION ANALYSIS

Multiple-regression analysis consists of mathematically developing a relation between a dependent variable and one or more independent variables. The technique results in computation of an equation defining the relation, a measure of the usefulness of the independent variables to define the dependent variables (correlation coefficient, r), and a measure of the accuracy of the resultant equation (standard error of estimate, SE).

The general form of the multiple-regression model for obtaining regional estimates of the harmonic coefficients is:

$$Y = a + b_1 x_1 + b_2 x_2 + \ldots . b_n x_n$$

where

Y = harmonic coefficients M, A, or C;

$x_1 \ldots x_n$ = regional characteristics;

a = regression constant; and

b_1 to b_n = regression coefficients.

The 3 dependent variables considered were the harmonic coefficients M, A, and C, and the 23 independent variables considered were the following topographic, basin, and climatic characteristics:

Average direction of flow of stream (degrees)
Length of stream (miles)
Mean basin altitude (feet)
Lake and pond areas (percent)
Drainage area (square miles)
Mean annual discharge (cubic feet per second)
Site altitude (feet)
Stream source altitude (feet)
Slope of stream (feet per mile)
Air-temperature, annual amplitude (degrees Celsius)
Mean annual air temperature (degrees Celsius)
Mean monthly temperature for each month (degrees Celsius)

As a data base, 170 stations with stream-temperature records that were considered to be unaffected by man were selected for analysis. The values of the characteristics selected as independent variables were determined and correlated against each of the three dependent variables. A series of multiple linear regression equations were then computed using step-backward techniques. In the step-backward technique, an equation is computed using all the independent variables; then the least significant variable is dropped, and the equation recomputed. Analysis continues in this manner until only the most significant independent variable remains.

Multiple-regression models are based on the linearity of the relation between the dependent variable and the independent variables. In many instances the relation described may be only logarithmically linear. To satisfy the requisite for linearity, the analyses were performed in a variety of arithmetic, semilogarithmic, and logarithmic modes. Adequacy of the independent variables as predictors of the dependent variable was judged by the resultant correlation coefficients and the standard errors of estimate.

Harmonic Mean

The regional regression analysis for harmonic-mean stream temperature, (M), resulted in an arithmetic function of station latitude (LAT). Latitude was shown to be significant at the 99 percent probability level. The computed equation

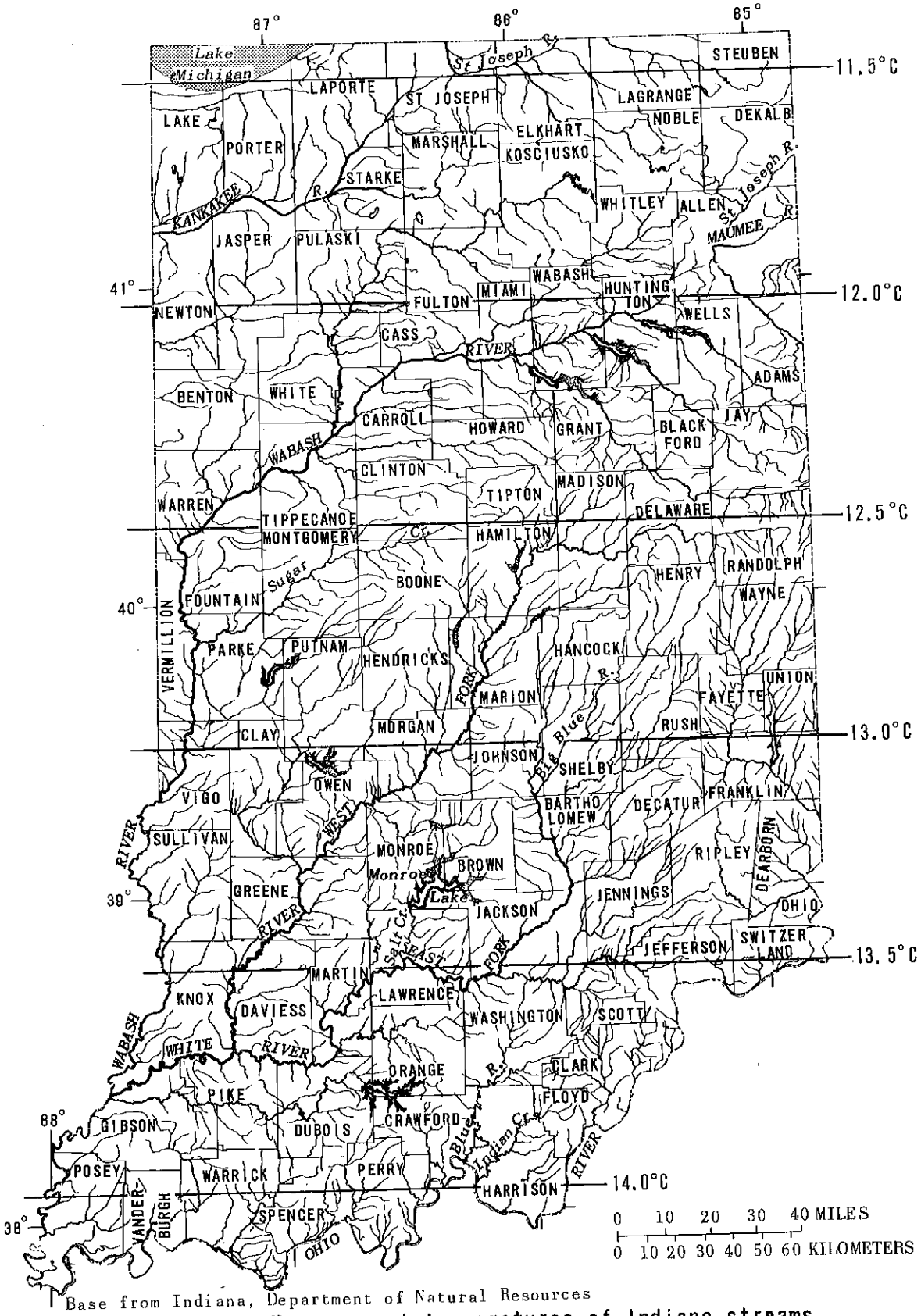
$$M = 41.36 - 0.7166\ (LAT) \qquad (2)$$

has a multiple correlation coefficient (r) of 0.72 with a standard error of estimate (SE) of 0.69°C (Celsius). When all 23 selected independent variables are included in the regional regression analysis, r is 0.78 and SE is 0.67°C. Based on the difficulty of generating the data for the other variables and the small gain in increased predictive accuracy, all the variables but latitude were discarded from further consideration for regionalizing this harmonic coefficient.

By applying equation 2, the map depicted in figure 3 can be generated showing the areal distribution of estimated harmonic coefficients for M throughout Indiana. As an example of using figure 3, the annual mean temperature of a stream (unaffected by man) should be 14.1°C near Evansville, 12.9°C near Indianapolis, and 11.5°C near South Bend, Ind. The M values calculated from available records for specific stations are listed in tables 5-7.

Phase Coefficient

None of the selected independent variables correlates very well with the phase coefficient (C). This coefficient is largely determined by climatic patterns and the choice of annual increment. Using all 23 independent variables in the regional regression analysis yields an equation with a correlation coefficient, r, of 0.47 and a standard error of estimate, SE, of 0.053 radian. Of the variables considered, latitude correlated best yielding an equation with an r of 0.32 and an SE of 0.053 radian. However, none of the functions determined by the regional regression analysis is considered adequate for estimating the phase-angle coefficient, C.



Base from Indiana, Department of Natural Resources

Figure 3.-- Mean annual temperatures of Indiana streams.

A second approach to estimating C is to use averages. Summarizing the data in tables 5-7 for the phase coefficient yields a range from 4.16 to 4.51, an average of 4.32, and a standard deviation of 0.05. Because the phase-angle coefficient is a measure of time, its values can be converted from radians to days by using the factor of 0.0172 radian per day. For example, the difference between the high and low ends (range) of the phase-angle coefficient is 0.35 radian ($4.51 - 4.16 \simeq 0.35$) or about 20 days ($0.35 \div 0.0172 \simeq 20$). Thus, 100 percent of the data considered have a variation of periodicity about the mean of plus or minus 10 days, and 95 percent of the data (those within two standard deviations) have a variation in periodicity of plus or minus 6 days ($0.10 \div 0.0172 \simeq 6$). The closeness of the data about the mean supports the conclusion that use of a constant value of 4.32 for the phase-angle coefficient, C, would be adequate for most data uses.

A third method of estimating C, where there are no historical data, is to plot the data listed in tables 5-7 for nearby stations. Such a plot may reveal a localized pattern of phase coefficient distribution at some sites, which might improve on the use of a constant; however, care should be used in interpreting the pattern. Discharge regulation by reservoirs, thermal discharge, or heavy ground-water discharge to streams will distort temperature patterns.

Amplitude

Amplitude (A) is the most difficult of the three harmonic coefficients to estimate accurately. As with the phase-angle coefficient, C, none of the independent variables correlates very well with A. Using all the variables yields an equation with a correlation coefficient, r, of 0.48 and a standard error of estimate, SE, of 0.93°C. Of the variables considered, stream length correlated best, yielding an equation with an r of 0.27 and an SE of 0.95°C.

As suggested for the phase-angle coefficient, C, an alternate approach to estimating A to be used in a statewide temperature equation is to use averages. Summarizing the data in tables 5-7 amplitude ranges from 5.80° to 13.99°C, and averages 11.27°C, with a standard deviation of 1.14°C.

A third method of estimating A at a site where there are no background data is to plot the data listed in tables 5-7 for nearby stations. As with the phase coefficient, such a plot may reveal a localized pattern of amplitude distribution at some sites, which might improve on the use of a constant; however, care should be used in interpreting the pattern.

TEMPERATURE PREDICTIONS

The harmonic coefficients M, A, and C can now be derived and used to estimate ambient stream-temperature conditions for sites throughout Indiana that are not appreciably affected by man. Harmonic coefficient values for many specific locations (fig. 1) are available from tables 5-7. Values of M for sites with no temperature records can be derived from figure 3 and constants C and A determined by methods previously outlined. The following discussion describes several applications of the study results.

The "maximum" and "minimum" terms used in this section do not reflect the scatter of temperature values described by the SE and are not meant to be absolute values. The calculated maximum and minimum temperatures are more properly called maximum mean daily temperature and minimum mean daily temperature; however, to avoid confusion, the author has eliminated the phrase "mean daily".

Example 1: Estimating annual maximum and minimum temperatures

The maximum or minimum temperature (T) likely to occur in a stream is obtained by adding or subtracting the amplitude (A) to or from the annual mean temperature (M).

$$T = M \pm A \qquad (3)$$

Given: M = 10.86°C, A = 9.42°C

Estimate: T max, T min, where M is greater than A

Solution:

T max = 10.86 + 9.42 = 20.28°C
T min = 10.86 - 9.42 = 1.44°C

Given: M = 10.93°C, A = 11.34°C

Estimate: T max, T min, where M is less than A

Solution:

T max = 10.93 + 11.34 = 22.27°C
T min = 10.93 - 11.34 = -0.41°C

[NOTE: The value 0°C should be used when the minimum temperature is calculated to be less than 0°C.]

To determine the level of error, temperatures estimated by the procedure described above were related to corresponding harmonic temperatures calculated from data collected at the 170 stations previously used in the multiple-regression analysis. The analysis yielded a relationship with a standard error of estimate of 8 percent and a correlation coefficient of 0.72. Thus, temperatures estimated by the procedure described above will yield results at an error level of $\pm$ 8 percent.

Example 2: Estimating temperature on a given day

The temperature at a given site on a specific day is estimated by applying the coefficients applicable to that site to the generalized statewide harmonic equation (equation 1).

$$T = M + A\,[\sin\,(0.0172\,d + C)] \qquad (1)$$

Where T = stream temperature, in degrees Celsius; M = mean annual stream temperature, in degrees Celsius; A = stream-temperature amplitude, in degrees Celsius; d = Julian date, and C = phase-angle coefficient.

Given: M = 11.54°C, A = 10.60°C, C = 4.27 radians

Estimate: T for d = 32 (Feb. 1)

Solution:

$$T = 11.54 + 10.60\,[\sin\,(0.0172 \times 32 + 4.27)]$$

$$T = 11.54 + 10.60\,[\sin\,(4.82)]$$

$$T = 11.54 + 10.60\,(-0.9942)$$

$$T = 1.00°C \text{ (temperature for Feb. 1)}$$

[NOTE: The sin function is in radian measure and must be located in a reference table as the sin of 4.82 radians. However, 1 radian = 57.3°, so the sin of 276.2° (4.82 x 57.3) would be an equivalent value.]

The mean monthly temperature can be estimated by calculating T for the 15th day of each month. Such estimates form part of the standardized output from computer program B260 (Steele, 1974).

Example 3: Estimating the time of year at which a given temperature will probably occur

Temperature data plotted over a year's time will yield a sin curve as depicted in figure 2. Except for the extremes (maximum and minimum) a given temperature will occur twice during the year -- once as the temperature is increasing (as in the spring) and again as the temperature is decreasing (as in the fall). This example involves use of equation 1 to show how to calculate the two dates of occurrence of a specified temperature within the estimated annual range of temperature.

$$T = M + A\,[\sin\,(0.0172\,d + C)] \tag{1}$$

where T = stream temperature, in degrees Celsius; M = mean annual stream temperature, in degrees Celsius;
A = stream temperature amplitude, in degrees Celsius; d = Julian date, and C = phase-angle coefficient

Simplifying,

$$\frac{T - M}{A} = \sin\,(0.0172\,d + C) \tag{4}$$

Solving for d,

$$d = \frac{[(-1^{k})\ \text{arc sin}\left(\frac{T - M}{A}\right) + k\pi] - C}{0.0172} \tag{5}$$

where k determines the quadrant and the sign of the sin function and is either 0 or 1. When k = 0 the calculated day represents the first occurrence of the T, and when k = 1 the day represents the second occurrence of the T. By adding the factor 365 to equation 5 the calculated d represents the Julian date of occurrence.

$$d = \frac{[(-1^{k})\ \text{arc sin}\left(\frac{T - M}{A}\right) + k\,\pi] - C}{0.0172} + 365 \tag{6}$$

The factor, arc sin $\left(\frac{T-M}{A}\right)$, ultimately must be in radian measure, but the function can be solved in either degrees or radians, depending on the available reference tables. Examples of both solutions follow.

Given: T = 6°C, M = 13.98°C, A = 11.49°C, C = 4.34 radians, the arc sin reference table is in radian measure.

Estimate: The dates of two annual occurrences of 6°C at a given stream location.

Solution:

For the first occurrence, k = 0 and equation 6 simplifies to

$$d = \frac{\text{arc sin}\left(\frac{T-M}{A}\right) - C}{0.0172} + 365 \qquad (7)$$

Solving for d,

$$d = \frac{\text{arc sin } (-0.69) - 4.34}{0.0172} + 365$$

$$d = \frac{-0.77 - 4.34}{0.0172} + 365$$

$$d = -297 + 365 = 68$$

Thus, with the indicated stream-temperature harmonic coefficients, the date of the first occurrence of 6°C in the stream will be about March 9 (Julian date = 68).

For the second occurrence, k = 1 and equation 6 becomes

$$d = \frac{\left[(-1) \text{ arc sin}\left(\frac{T-M}{A}\right) + \pi\right] - C}{0.0172} + 365 \qquad (8)$$

Solving for d,

$$d = \frac{[-\text{arc sin } (-0.69) + \pi] - 4.34}{0.0172} + 365$$

$$d = \frac{-(-0.77) + 3.14 - 4.34}{0.0172} + 365$$

$$d = \frac{3.91 - 4.34}{0.0172} + 365$$

$$d = -25 + 365 = 340$$

Thus, with the indicated harmonic coefficients, the date of the second occurrence of 6°C in the stream will be about December 6 (Julian date = 340).

Under the same values of M, A, and C used in the preceding calculations but with the arc-sin reference table in degrees, the solution for the first occurrence is as follows:

$$d = \frac{\dfrac{\text{arc sin}\left(\dfrac{T-M}{A}\right)}{57.3} - 4.34}{0.0172} + 365$$

$$d = \frac{\dfrac{-43.99}{57.3} - 4.34}{0.0172} + 365$$

$$d = \frac{-0.77 - 4.34}{0.0172} + 365$$

$$d = -297 + 365 = 68$$

which is the same result as that derived from equation 7.

<u>Example 4: Estimating the length of time a temperature will exceed, or be less than, a specified value</u>

By calculating the two dates of occurrence of a specified temperature, as described in example 3, it is possible to estimate how long the water temperature will exceed, or be less than, this specified temperature. Using the results calculated in example 3, the following solution is possible.

Given: D_1 = day 68, first occurrence of 6°C
D_2 = day 340, second occurrence of 6°C

Estimate: T_e = time, in days, the temperature exceeds 6°C
T_1 = time, in days, the temperature is less than 6°C

Solution:

$T_e = D_2 - D_1$ $\qquad$ $T_1 = 365 - T_e$

$T_e = 340 - 68$ $\qquad$ $T_1 = 365 - 272$

$T_e = 272$ days $\qquad$ $T_1 = 93$ days

FACTORS INFLUENCING STREAM TEMPERATURE

Powerplants

A graphic depiction of the effect of powerplant cooling water on the White River and the Wabash River may be seen in figures 4 and 5, respectively. In figures 4 and 5 two profiles of the mean water temperature are plotted along the length of both rivers. The first profile (indicated by a solid line) is the harmonic-mean coefficient, M, for all the available periodic station data for sites along the river. The calculated values are based on historical data and may not reflect current thermal conditions in the river. The second profile depicts estimated M values based on the equation resulting from the regional regression analysis (equation 2). This profile represents estimates of what the ambient mean water temperature should be as based on the effect of climatic conditions rather than the effect of human activities.

Throughout most of the length of White River, the mean temperature of water in the river has been raised above the value estimated as being caused by climatic conditions alone (fig. 4), although the reach above Indianapolis (around miles 250 to 275) has a mean temperature near the calculated ambient values. The river historically has received a significant thermal load from the powerplants at Indianapolis and near Martinsville. On the basis of historical data, the mean water temperature in the Indianapolis area was increased about 3.5°C above natural levels estimated as caused by climatic conditions alone. Thermal loading of the river both at and below Indianapolis is still measurable more than 100 mi downstream (fig. 4).

The same general pattern of thermal loading along the White River also applies to the Wabash River (fig. 5), although the overall effect is not as great as on the White River. The increase in the mean temperature around mile 290 (fig. 5) is due only to drainage from the urban area of Lafayette, as there are no powerplants nearby. The increases in mean temperature near miles 425, 400, 362, and 294 along the Wabash River (fig. 5) are due primarily to powerplant discharges.

Reservoirs

The effect of reservoirs on downstream stream temperatures depends on, among other factors, the release patterns and the depth at which the water is released from the reservoir. Temperature of the water throughout a reservoir is generally uniform during winter. As summer approaches and a reservoir stratifies, its upper layer (epilimnion) warms, and its lower layer (hypolimnion cools. Temperatures of 25° to 30°C in the epilimnion and 5° to 10°C in the hypolimnion are common in Indiana during late summer.

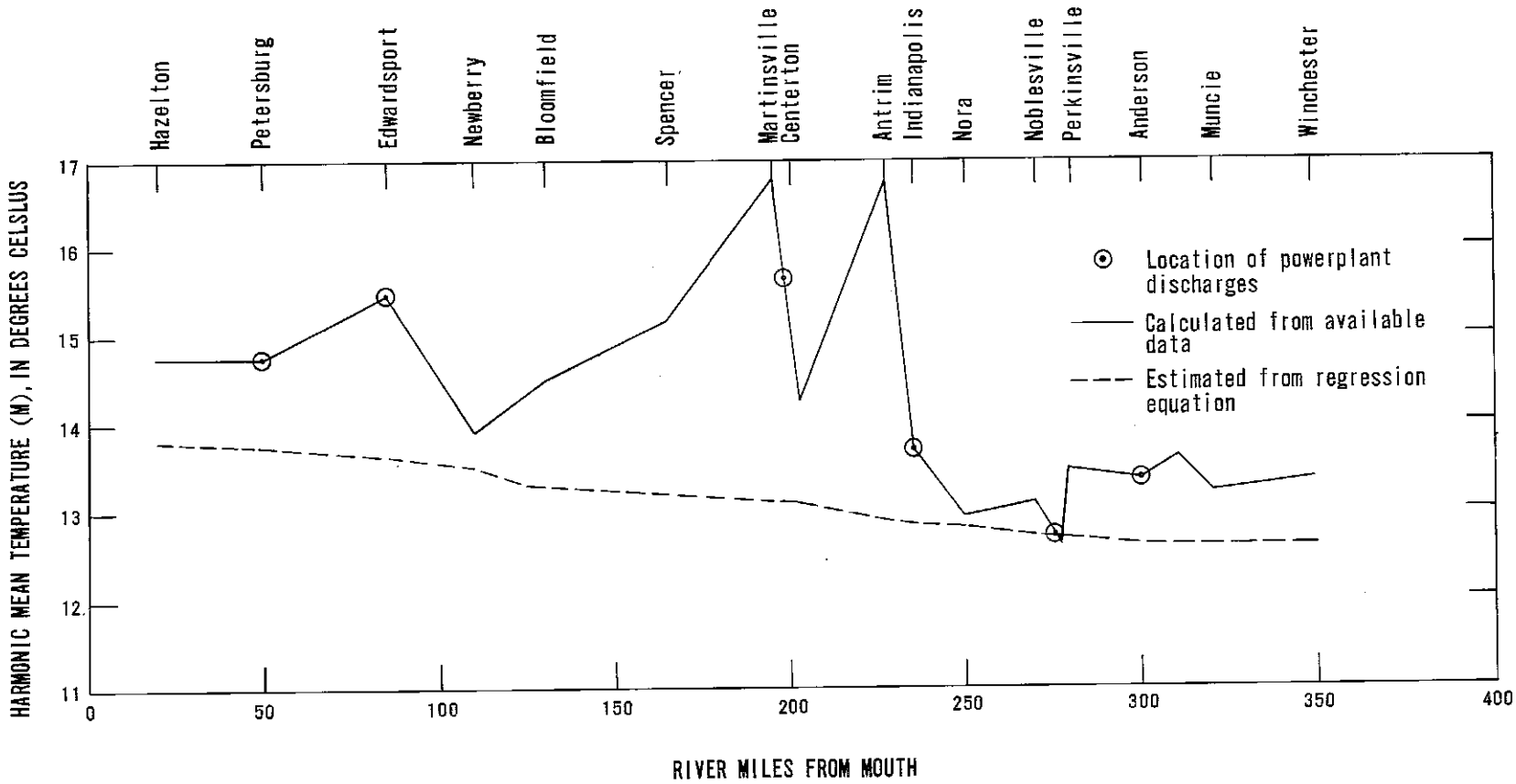


Figure 4.-- Downstream variation of temperature in the White River.

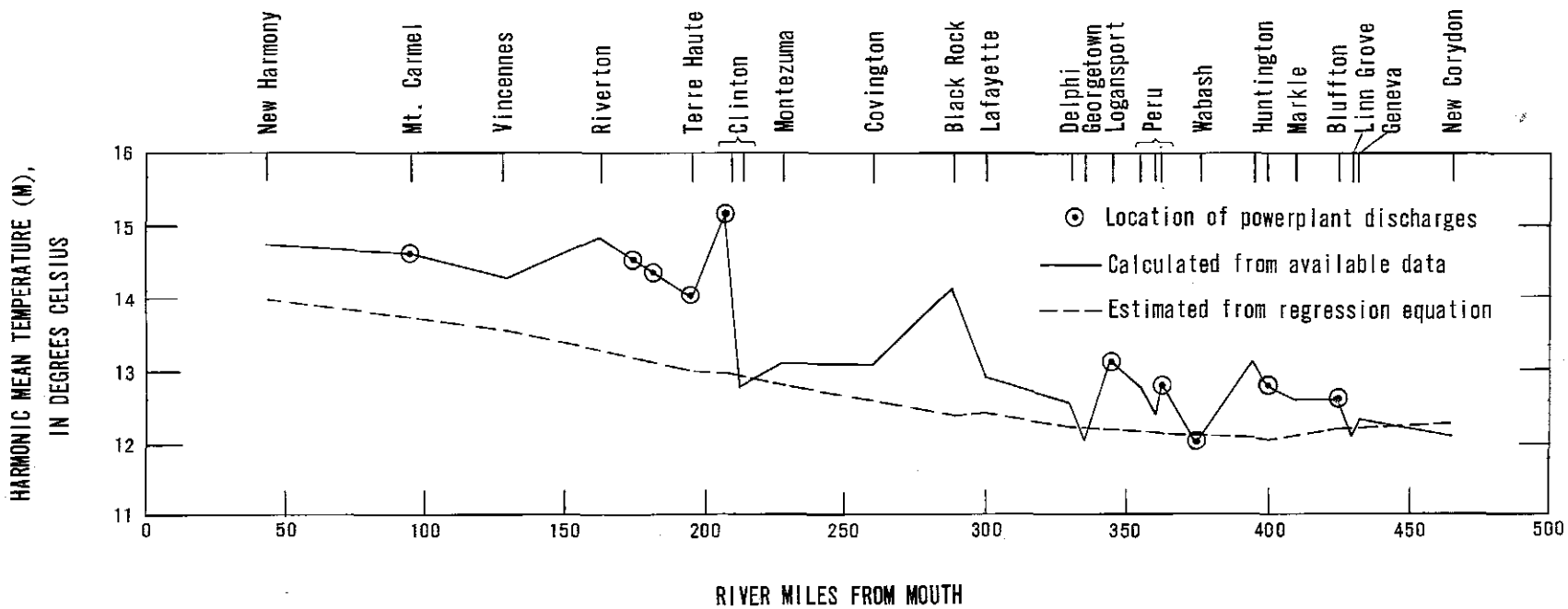


Figure 5.-- Downstream variation of temperature in the Wabash River.

Thus, water released from the hypolimnion during summer is usually cooler than the receiving stream water, whereas water from the epilimnion may be warmer. In any event, a common secondary effect of reservoir releases is a reduction in downstream daily-temperature fluctuations (Bolke and Waddell, 1975). This phenomenon is explained by the fact that the large mass of water in a reservoir is not as sensitive to a daily heat flux as the smaller amount of water in a stream.

Temperature records from 1955 to 1973 are available for the gaging station on Salt Creek near Harrodsburg (03372500, fig. 1). In 1960, a dam was built across Salt Creek above this gage to form Monroe Lake (fig. 3). Construction of the reservoir altered the temperature characteristics of the stream, as shown in figure 6 and table 1.

Water in Monroe Lake can be released from the surface, middle, or near the bottom of the reservoir (or from any combination of these three places). The overall effect of the Monroe Lake reservoir on the downstream temperature characteristics of Salt Creek near Harrodsburg (03372500, fig. 1) has been to increase M and decrease C (table 1). Application of the t test shows that the changes in the harmonic coefficients M and C are significant at the 99 percent level of significance; however, the apparent decrease in the harmonic coefficient A is not significant.

Table 1.--Change in stream-temperature characteristics of Salt Creek near Harrodsburg (03372500)

Harmonic coefficients	Pre-construction period (1955-60)	Post-construction period (1965-73)
M	12.2° ± 1.1°C	13.8° ± 0.9°C
A	11.8° ± 1.60°C	11.0° ± .9°C
C	4.35 ± .08 rad	4.11 ± .09 rad

Ground Water

Another factor having considerable influence on stream temperature is the contribution of ground water to streamflow (Stevens, Ficke, and Smoot, 1975, p. 14). The temperature of ground water is diurnally and seasonally less variable than stream temperature and generally approximates the average annual air temperature in a given area. Thus, if a stream consists largely

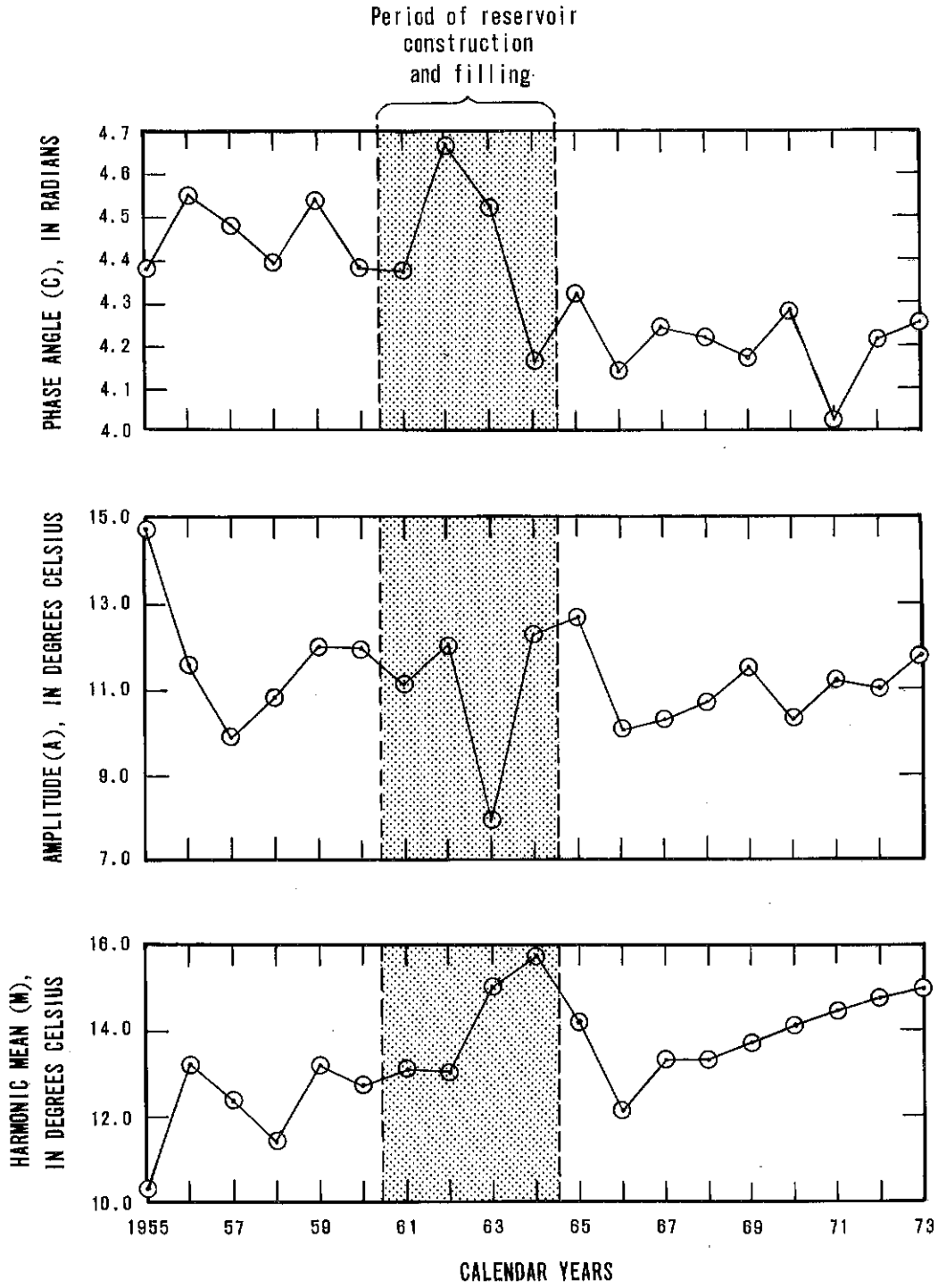


Figure 6.-- Effect of a reservoir on the harmonic coefficients for Salt Creek near Harrodsburg (03372500).

of ground water, such as from a flowing spring, A, and generally M, will be lower than for streams less dependent on ground water.

In the karst regions of southern Indiana, some of the streams go underground for varying distances before resurfacing. The effect of the water traveling underground is to cool the water in summer and warm it in winter. The net overall effect is to reduce A and M. An example of a stream going underground is the Lost River at West Baden Springs (03373700; fig. 1). At this sampling site on the Lost River the harmonic mean, M, estimated from a regional relationship (fig. 3), is 13.65°C; whereas, the M calculated from historical data is 12.45°C. The amplitude coefficient, A, is reduced to 7.83°C from a statewide average of 11.27°C.

Sample Frequency

Gilroy and Steele (1972) showed that in many instances the harmonic coefficients M, A, and C could be calculated with less than a daily frequency of temperature data with no significant loss of information on characterizing annual stream-temperature variability. A similar type of analysis was done in this study with similar results.

One option of the harmonic-analysis computer program B260 (Steele, 1974) is to calculate M, A, and C using every "i-th" day of a 1-year daily temperature record for a given station. Under this option, the program could calculate M, A, and C using 365, 73, 26, or 12 samples if the NMOD (designating the desired "i" increment, Steele, 1974) were set equal to 1, 5, 14, or 30, respectively. For example, if "i" were selected to be 5, then every fifth data value in the available daily record would be used in the analysis; thus, 73 values for the year would be used to determine the harmonic coefficients.

The sample-frequency option of computer program B260 was applied to 1972 data for Salt Creek near Harrodsburg (03372500, fig. 1); the results are shown in table 2. The data used were calculated mean daily temperatures. Data stored in the computer files include only the daily maximum and minimum temperatures. A mean value was calculated by averaging these two values and may differ from the true daily mean temperature.

The results summarized in table 2 indicate that, within a given data set, the calculated harmonic coefficients are consistent, even up to using every 45th data value. Using the coefficient values in table 2 for sample frequencies 1 to 45, the average M is 14.07° ±0.11°C, the average A is 11.15° ±0.08°C, and the average C is 4.15 radians ±0.02 radians. These averages are not significantly different from the initial values calculated using all the data (frequency equal to 1).

Table 2.--Comparison of stream-temperature harmonic coefficients with varying sample frequencies, Salt Creek near Harrodsburg (03372500), 1972

Sample frequency (days)	Number of data values	M (°C)	A (°C)	C (radians)
1	365	14.12	11.15	4.15
5	73	14.10	11.11	4.16
7	52	14.13	11.06	4.14
14	26	14.08	11.08	4.12
21	17	14.20	11.21	4.14
30	12	13.96	11.28	4.18
45	8	13.89	11.13	4.14
Periodic	9	14.73	10.94	4.11

Periodic water-temperature data collected by the USGS are seasonally and diurnally random. This random type of variation will cause the calculated harmonic coefficients of a periodic record to have a larger error term than that of the daily station, where the data are commonly collected at the same time each day. The periodic data yielded a higher M and slightly lower A and C than the daily data for the example given (table 2) but are still close to the values calculated from the daily record.

Another means of comparing the effects of sample frequency on the harmonic coefficients is to relate the values generated using data of the USGS and the ISBH. Temperature data have been collected by both agencies at 42 stations in Indiana (fig. 1 and table 7). In general, the ISBH data were collected every other week, whereas the USGS data were collected every 4 to 6 weeks. Data from both agencies were used to calculate the harmonic coefficients for each station. These calculated values are shown in table 7 and were related by dividing the USGS values by the ISBH values. A summary of the comparative results are shown in table 3. Values greater than 1.00 indicate that the harmonic coefficients calculated with USGS data are greater than the coefficients calculated with ISBH data. In general, the calculated coefficients for each data set are approximately equal (within ± 10 percent). Logically, where differences are found, values calculated from the larger data set (ISBH) may be accepted with greater confidence.

Table 3.--Comparison of stream-temperature harmonic coefficients calculated from data of the U.S. Geological Survey and the Indiana State Board of Health

Harmonic Coefficients	Ratio of USGS calculated values to ISBH calculated values			
	Maximum	Minimum	Mean	Standard Deviation
M	1.11	0.88	0.997	±0.047
A	1.16	.88	1.015	± .050
C	1.02	.95	.996	± .014

SUMMARY

Stream temperature is an important water-quality characteristic, both physically and ecologically. In Indiana, there is a substantial data base for study that includes 280 different sites, where temperature has been measured periodically by either the USGS or the Indiana State Board of Health since about 1950. These data have been analyzed using simple-harmonic-analysis techniques described by Steele (1974) and the equation

$$T = M + A\,[\sin\,(bd + C)]$$

where T is the stream temperature, in degrees Celsius, on day d; M is the mean annual stream temperature, in degrees Celsius; A is the amplitude of the annual stream temperature, in degrees Celsius; b is a constant equal to 0.0172 radian per day; and C is the phase-angle coefficient of the annual cycle, in radians. In the majority of cases, this functional relation adequately depicts the annual stream-temperature variability indicated by the available data.

In an analysis of statewide regional patterns of stream temperature, the calculated harmonic coefficients were related to a series of topographic, basin, and climatic characteristics and were analyzed by multiple-regression techniques. As a data base, 170 stations that were considered to be unaffected by man were selected for the regional analysis. The regional regression analysis for the harmonic-mean coefficient, (M), resulted in an arithmetic function of station latitude (LAT), where:

$$M = 41.36 - 0.7166\ (LAT).$$

None of the 23 independent variables considered correlated very well with either the phase-angle coefficient (C) or the harmonic amplitude (A). A constant of 4.32 radians is suggested as an average statewide value for C, and the average value of 11.27°C, for all the data for A in tables 5-7 is suggested as a regional value for A.

Examples are given to demonstrate how to calculate (1) maximum and minimum temperatures likely to occur in a stream, (2) stream temperature on a given day, (3) the day a given stream temperature will occur, and (4) length of time a stream temperature will exceed, or be less than, a specified value.

Effects of cooling-water discharges from powerplants are shown for the main stem White and Wabash Rivers. With few exceptions, the mean water temperature along the length of both rivers has been elevated by these discharges above the ambient mean temperature that would be expected as a result of climatic conditions alone.

Influence of reservoirs on downstream water temperatures is demonstrated by changes in some of the harmonic coefficients for Salt Creek near Harrodsburg (03372500). After construction of a reservoir immediately upstream from this station, the mean annual stream temperature increased from 12.2° to 13.8°C, and the phase coefficient decreased from 4.35 to 4.11 radians. The apparent decrease in amplitude is not statistically significant.

The influence of ground water on stream temperature is illustrated by an analysis of data for Lost River at West Baden Springs (03373700). At this site, the harmonic coefficient, M, is reduced from an expected value of 13.65° to 12.45°C, and the A, amplitude coefficient, is reduced from a statewide average of 11.27° to 7.83°C.

Analysis of daily temperature data for a single station using multiple sample frequencies representing data values for every 1st, 5th, 7th, 14th, 21st, 30th, and 45th day show that similar harmonic coefficients can be generated using any of these frequencies. By this approach the user is able to compare periodic sample data with daily data.

The harmonic coefficients generated from the Indiana State Board of Health water-quality monitoring network, where the stream-temperature data are collected every other week, are compared with the coefficients generated from comparable USGS data, where the data are collected every 4 to 6 weeks. The comparison indicates that the two sets of data depict the same annual stream-temperature characteristics despite differences in sampling frequency.

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Tables 4-7

Table 4.--List of stations showing the available stream-temperature data

Station number: Corresponds to number shown on figure 1, for location purposes. (U.S. Geological Survey station numbers in this table begin with 03, 04, or 05; "03" stations are in the Ohio River basin, "04" stations are in the St. Lawrence River basin, and "05" stations are in the upper Mississippi River basin.)

Collecting agency: B = Indiana State Board of Health, U = U.S. Geological Survey, M = combined Indiana State Board of Health and U.S. Geological Survey data.

Data used: P = Enough data available for harmonic analysis, O = some data available but not enough for harmonic analysis.

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
BD-0	B		P	P	P	P	P	P	P	P	P															
BD-3W	B		P	P	P	P	P	P	P																	
BL-17	B		P	O																						
BL-61	B		P	O																						
EC-38	B		P	O																						
EW-184	B		P	O																						
FC-1	B		P	P																						
MU-29	B				P	P	P	P	P		P	P	P	P	P	P	P	P								
MU-34	B		P	O																						
P-14	B		P	O																						
PGR-0	B		P	O																						
PLR-1	B		P	O																						
SC-39	B		P	O																						
TC-1	B		P	P	P	P																				
TR-53	B		P	O																						
TR-145	B		P	O																						
WB-336	B		O	O																						
WB-432	B		P	O																						
[a]WR-347	B				P	P	P	P	P																	

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
YC-5	B		P	O																						
YR-43	B		P	O																						
03274650	U	O	P	P	O																					
03274750	U	O	P	P	O																					
03274950	U	P	P	P	P	P																				
03275000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			
03275500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O		
03275600	U	P	P	P	P	P	P	P	P	O																
03276000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					
03276500	U	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				
03276500	B		P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03276500	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				
03276700	U	P	P	P	P	P	P	O	P	P	P	O	P	O												
03276790	B				P	P	P	P	P	P	P	P		P	P	P	P	P								
03277000	U	O	P	P	P	P																				
03291780	U	P	P	P	P	O																				
03294000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O					
03302220	U	P	P	P	P																					
03302300	U	P	P	P	P	P																				
03302500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O	
03302680	U	P	P	P	O																					
03302800	U	P	P	P	P	P	P																			
03302900	U			O	P	O																				
03303000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03303300	U	P	P	P	P	P	P	P	P	P	O	P	P	O												
03303400	U	P	P	P	P	O																				
03322100	U	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O					
03322500	U	P	P	P	P	O	P	O	P	P	P	O	P	P	P	P	P	P	P	P	P	P	O	P		
03322900	U	P	P	P	P	O	P	P	P	P	O															
03323000	U			P	P	P	O	O	P	P	P	O	P	P	P	P	P	P	P	P	P	O	O	O		
03323500	U	P	O	P	P	P	P	P	P	P	P	O	P	P	P	P	P	P	P	P	P	P	O	P		

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
03323500	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03323500	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P		
03323510	B		P	P																						
03324000	U	P	P	P	O	O	O	P	P	P	P	O	P	O	P	P	P	P	P	P	P	O	O	O		
03324200	U	P	P	P	P	P	P	P	P	P	P	O	P	P	P	O										
03324300	U	P	P	P	O	P	P	O	P	P	P	O	P	P	P	P	P	P								
03324340	B				P	P																				
03324500	U	P	P	P	O	P	O	P	O	P	P	O	P	P	P	P	P	P	P	P	P	O	O	O		
03324600	B		O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03325000	U	O	O	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03325000	B		P	P																						
03325000	M	O	P	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		O		
03325500	U	P	P	P	P	P	P	P	P	P	O	O	O	P	P	P	P	P	P	P	P	P	O	O	O	O
03326000	U			O	P	P	O	P	P	P	P	O	P	P	P	P	P	P	O	P	P	P	O			
03326500	U	P	P	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O		
03326500	B		P	P																						
03326500	M	P	P	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P		O	O		
03326550	B							P	P	P																
03326600	B				P	P	P																			
03327000	U	P	P	P	P	P	P	P	O	P	P		P	P	P	P	P	P	P	O	P	P	O			
03327100	B		P	P																						
03327480	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03327500	U	O	O	O	O	O	O	O	P	P	P	O	O	P	P	P	P	P	P	P	P	O	O	O		
03328000	U	P	P	P	P	P	O	P	P	P	P	O	P	P	P	O	O	P	P	P	P	O	O			
03328430	U	P	P	P	O																					
03328500	U	O	O	P	P	P	O	O	P	P	P	O	P	P	P	P	P	P	P	P	O	O				
03328500	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03328500	M	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				
03329000	U	O	O	P	O	O	O	O	P	P	O	O	O	P	P	P	P	P	P	O	O	P	O	O		
03329000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03329000	M	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		O		

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
03329020	B		P	P																						
03329400	U		P	P	P	P																				
03329500	U			O	O	O		O	P	P	O	O	O	P	O	P	P	P	P	O	P	P	O	O		
03329700	U	P	P	P	P	P	P	P	P	P	P	O	P	P	P	O	P	P	P	P	P	O	O	O		
03330500	U	O	P	P	P	P	P	P	P	P	O	P	P	P	O		O	P	P	P	P	P	O	P	P	O
03331110	U	O	P	P	P	O																				
03331500	U	P	O	P	O	P		O	P	O	O	P	O	P	P	P	P	P	P	P	P	P	O	O		
03331500	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03331500	M	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03332300	U	P	P	P	P	P	P	P	P	P	O	O	P	P	P	O										
03332400	U	O	O	O	O	O	P	P	P	P	P	O	P	P	P	P										
03333000	U	O	O	O	O	O	O	O	P	P	P	O	P	P	O	P	P	P	P	O	P	P	O	O		
03333000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03333000	M		P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P	P				
03333450	U	P	P	P	P	P	O	P	P	P	P	P	P	P												
03333500	U													O	P	P	P	P	P	P	P	P	O			
03333570	B		P	P																						
03333600	U	O	P	P	P	P	O	P	P	P	P	P	P	P	P	O										
03333700	U	O	O	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	O						
03333700	B		P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03333700	M	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P							
03334000	U	O	P	P	P	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O			
03334500	U	O	P	P	P	P	O	P	P	P	P	P	P	P	P	P	O	O	P	P	P	O	O	O	O	O
03335000	U	P	P	P	P	P	O	P	P	P	P	P	P	P	P	O	P	O	P	P	O					
03335000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03335000	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					
03335500	U		O	P	P	P	P	P	P	P	P	P	O	P	P	P	P	P	P	P	P	O	O	O		
03335500	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03335500	M		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O				
03335680	B		P	P																						
03335690	U	P	P	O																						

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
03335700	U	P	O	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	O						
03336000	U	O	O	P	O	O	P	P	P	P	P	O	O	P	P	P	O	O	P	O	P	O	O	O	O	O
03336000	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03336000	M		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P					
03339108	U	P	P	P	P	P	O																			
03339120	U		O	P	P	P	P	P	P	P	O															
03339150	U			O	P	P	P	P	P	P	O															
03339500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O	O
03340000	U			O	P	P	P	P	P	P	P	P	O	P	P	P	P	P	P	O	P	P	O	O		
03340000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03340000	M			O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				
03340500	U	O	P	O	P	P	P	P	P	P	P	P	O	O	P	P	O	P	P	P	P	O	O	O	O	O
03340500	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03340500	M		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					
03340800	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O								
03340900	U	O	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	O							
03341000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03341200	U			P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O							
03341300	U	O	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O							
03341400	U				P	O	O	O	P																	
03341420	U			P	P	P	P	P	P																	
03341500	U	O	O	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P	O		O		
03341500	B				P	P	P	P	P	P	P	P	P	P	P	P										
03341500	M		O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P					
03341560	B		P	P																						
03342000	U	O	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			
03342100	U	P	P	P	P	P	P	P	O	O																
03342150	U	P	P	P	P	O	P	P	O	O																
03342250	U	P	P	P	P	P	P	P	P	O																
03342300	U	P	P	P	P	P	P	P	P	O																
03342350	U	P	P	P	P	P	P	P	P	O																

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
03342500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03343000	U	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P	P	P	O	O			
03343000	B		O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03343000	M	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O				
03346750	B		P	P																						
03347000	U	P	P	P	P	P	P	P	P	P	P	O	P	P	P	P	P	P	P	P	P	P	O	O	O	
03347000	B		P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03347000	M		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03347300	B		P	P	P	P	P	P	P	P																
03347500	U	P	P	P	P	P	P	P	P	P	P	O	P	P	P	P	O	P	P	P	O					
03347500	B				P	P	P																			
03348000	U	O	P	P	P	P		P	P	P	P	O	O	P	P	P	O	P	P	P	P	P	O	O	O	O
03348000	B		P	P																						
03348000	M	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03348020	U	P	P	P	P	P																				
03348100	U						O	P	P	P	O	O	O	O												
03348100	B				P	P	P																			
03348100	M				P	P	P	P	P	P	P	O														
03348350	U	P	P	P	P	P																				
03348500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P		
03349000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		O
03349000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03349000	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P									
03349500	U	O	P	P	P	P	P	P	P	P	P	O	P	P	P	P	P	P	P	P	P					
03349700	U	P	P	P	P	P	P	P	P	P	P	O		P	P	P	P	P	P	O						
03350100	U	P	P	P	P	P	P	P	P	P	P	O	O	P	P	P	P	P	P	O						
03350500	U	O	P	P	P	P																				
03350700	U	P	P	P	P	P	P	O																		
03351000	U	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O		
03351000	B		P	O	P	P	P	P		P	P	P	P	P	P	P	P	P								
03351000	M	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P								

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
03351310	U	P	P	P	P	P																				
03351400	U	O	P	P	P	P																				
03351500	U	P	P	P	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			
03352200	U	P	P	O	P	P	O	P	P	P	P	P	P	P	P	P	O									
03352500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O		
03352700	B		P	O																						
03353000	U	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O		
03353000	B		P	P																						
03353000	M	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P	P		
03353120	U	O	P	P	O	O	O	O	P	P	P	O	P	P	P	O										
03353160	U	O	P	P	P	P	P	P	P	P	P	O	O	P	O	O										
03353180	U	P	P	P	O																					
03353200	U	P	P	P	O	P	O	O	P	P	P	O	P	P	P	P	P	O								
03353400	B		P	P																						
03353500	U	P	P	O	P	P	P	P	P	P	O	O	P	P	P	P	P	P	O	P	P					
03353500	B		P	P																						
03353500	M	P	P	P	P	P	P	P	P	P	O	O	P	P	P	P	P	P	P	P	P					
03353600	U	P	P	P	P	P	O	P	O	O	O	O	P	P	P	O										
03353605	B		P	P																						
03353620	U	P	P	P	O																					
03353620	B		P	P																						
03353620	M	P	P	P																						
03353640	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03353700	U	P	P	P	P	P	O	P	P	P	O	P	P	P	P	O										
03353800	U	P	P	P	P	P	O	P	P	P	P	P	P	P	P	P	P	O								
03353990	B				P	P	P																			
03354000	U	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03354050	B		P	P																						
03354125	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03354500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O		
03355000	U	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O			

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
03356000	U	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	
03357000	U			O	P	P	O	P	P	P	P	P.	P	P	P	P	P	O	P	P	P					
03357000	B			P	P	P	P	P	P	P	P	P	P	P	P	P	P	O								
03357000	M		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					
03357350	U	O	O	O	O	O																				
03357500	U	O	O	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O	O
03358000	U	O	O	O	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03359000	U	O	O	O	P	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O
03359500	U		O	P	P	P	O	O	P	P	P	P	P	P	P	P	P	P	P	P	O					
03360000	U	O	O	P	P	P	P	P	P	P	P	P	O	P	P	P	P	O	P	P	P	P				
03360150	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03360210	B				P	P	P	P	P	O	P	P	P	P	P	P	P	O								
03360500	U	P	P	O	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			
03360710	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03361000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	
03361000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03361000	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			
03361200	B				P	P	P	P	P	P	P															
03361500	U	O	P	P	P	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	
03361500	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O								
03361500	M	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			
03361650	U	O	P	P	P	P																				
03361850	U	O	P	P	P	P																				
03362000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P.	O				
03362000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03362000	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O				
03362500	U	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O		
03363000	U		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O		O
03363500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O		
03363900	U	P	P	P	O	P																				
03364000	U		P	P	O	O	P	P	P	P	O	O	P	P	P	P	P	P	P	P	P					

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
03364000	B		P	P																						
03364000	M		P	P	O	O	P	P	P	P	O		P	P	P	P	P	P	P	P	P					
03364200	U	O	P	P	P	P																				
03364500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	
03365000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O	
03365500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O		O
03365500	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03365500	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					
03366000	U	P	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O						
03366200	U	P	P	P	P	P																				
03366500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	
03367000	B		P	P																						
03368000	U	P	O	P	P	P	P	P	P	P	P	O	P	P	O	P	P	P	P	O						
03369000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	
03369500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	
03371500	U	O	O	O	O	P	P	P	P	P	P	P	P	P	P	P	P	O								
03371500	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03371500	M		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03371520	U	P	P	P	O																					
03371600	U			P	P	P	P	P	P	P	O	O	P	P	O											
03371650	U	O	P	P	P	P	P	P	P	P	P	P	P													
03372000	U			P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O	
03372300	U	P	P	P	O																					
03372500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P						
03372700	U			P	P	P	P	P	P	P	P	P	P	P	O											
03373000	U			P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03373100	B		P	P																						
03373200	U	P	P	P	P	P	P	P	P	P	P	P	P	O												
03373500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			
03373500	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
03373500	M		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				
03373700	U	P	P	O	P	P	P	P	P	P	O															
03374000	U	P	O	P	P	P	P	P	P	P	P	O	P	P	P	P	P	O	P	P	P	O	O	O		
03374000	B		P	P																						
03374000	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O				
03374100	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03374455	U	P	P	P	P	P																				
03374470	U	P	P	P	P	O																				
03374500	U		O	P	P	P	P	P	P	P	P	P	P	O												
03375500	U	O	P	P	P	P	P	P	P	P	P	P	P	P	O	P	P	P	P	O	O	O	O	O	O	O
03375500	B		P	P	P	P	P	P	P	P	P	P														
03375500	M	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			O	
03375800	U	P	P	P	O																					
03376260	U	P	P	P	P	P	P	P	P	P																
03376300	U	P	P	P	P	P	P	P	P	P	P	O														
03376350	U	P	P	P	P	P	P	P	P	P	O															
03376500	U	O	P	P	P	P	P	P	P	P	P	P	O	P	P	P	P	P	P	P	P	P	O	O	O	O
03376500	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
03376500	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			O
03377500	U	O	O	O	O	P	O	P	P	O	P	O														
03377500	B													P	P	P	P	P								
03377500	M			P	P	P		P	P		P			P	P	P	P	P								
03378500	B						P	P	P	P	P	P	P													
03378550	U	P	P	P	P	P	P	P	P	O																
04087600	B		P	P	P	P	P	P	P	P			P													
04092680	B		P	P	P	P	P	P	P	P	P															
04092690	B		P	P	P	P	P	P	P	P	P															
04092695	B		P	P	P	P	P	P	P	P	P															
04092698	B		P	P	P	P	P	P	P	P																

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																							
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
04092710	B		P	P	P	P	P	P	P	P	P															
04092720	B		P	P	P	P	P	P	P	P	P															
04092730	B		P	P	P	P	P	P	P	P	P															
04093000	U	P	P	P	P	P	P	P	P	P	P	O	P	P	P	P	O	P	P	P	P	P	O	O	O	O
04093200	U			O	P	P	O	P	P	P	O	O	O	P	O	O	O									
04093500	U	O	P	P	P	P	P	P	P	P	O	O	P	P	P	P	O	P	P	P	P	P	O	O		
04093950	B		P	P																						
04094000	U	O		P	P	P	P	P	P	P			P	P	P			P	P	P	P	O				
04094500	U	P	P	P	P	P	P	P	P	P	P	O	P	P	P	O	O	P	P	P	P	P	O	O		
04094600	B		P	P	P	P	P	P	P																	
04094700	B		P		P	P	P	P	P																	
04095300	U		O	P	P	O																				
04096100	U	P	P	P	P	O																				
04099750	U	P	P	P	O	P																				
04099830	B		P	P																						
04100220	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	P	P	O	P	P	O	O	O	O
04100252	U	P	P	P	P	O																				
04100465	U	P	P	P	P	O																				
04100500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O	P	P	O	O	O	
04101000	U	O	O	O	O	O	P	P	P	P	P	P	O		O	O	O	P	O	P	O	O	O	O		
04101000	B				P	P	P	P	P	P	P	P	P	P	P	O										
04101000	M		O		P	P	P	P	P	P	P	P	P	P	P	O	O	P	O	P				O		
04101200	B		P	P																						
04101310	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P									
04177720	U	P	P	P	P	O																				
04178000	U		O	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	P	O	P	P	O	O	O	O
04179000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	P	P	O						
04179500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	P	P	P	P	P	O	O	O	
04180000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P	P	P	P	O	O	O	O	O

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
04180500	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
04181500	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	P	P	P	P	P	O	O		
04182000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	P	P	P	P	O	O	O		O
04182000	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
04182000	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O		O		
04182590	U	P	P	P	P	P	P	P	P	P	O															
04182900	B		O	P																						
04183000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	P	O	P	P	O		O	O	
04183000	B		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P								
04183000	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	O				
04183300	B		P	P	O	P	P	P	P	P																
05515000	U	P	O	P	O	P	P	P	P	P	P	O	P	P	P	O	O	P	P	P	P	P	O	O		
05515400	U	P	P	P	O																					
05515500	U	O	O	O	P	P	P	O	O	O	P	P	O	O		O	P	P	O	P	P	O		O	O	O
05516000	U	O	O	P	O	P	O	P	P	P	P	O	P	P	P	O	O	P	P	O						
05516500	U	O	O	P	P	P	P	P	P	P	P	O	P	P	P	O	O	P	P	P	P	P	O	O	O	O
05517000	U	O	O	O	P	P	O	P	P	P	P	O	P	P	P	O	O	P	P	P	P	P	O	O		
05517000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
05517000	M			O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		O		
05517500	U	P	O	O	P	O	O	P	P	P	O	P	P	P	O	O	O	P	P	P	P	P	O	O		O
05517900	U			O	P	P																				
05518000	U	P	P	P	P	P	O	O	P	O	O	O	O	P	P	O	O	O	O	O	P	P	O	O		
05518000	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
05518000	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O			
05519000	U	P	P	P	P	P	O	P	P	P	P	O	P	P	P	P	O	P	P	P	P	P	O	O	O	O
05519500	U		P	P	P	P	P	P	P	P	O	O	O	P	P	O	O	P	P	P	P			O	O	O
05520000	U	O	P	O	P	P	P	P	P	O	O	P	P	P	O	O	O	P	P	O	P	P	O	O	O	O
05521000	U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	P	P	P	P	O	O	O		O
05522000	U	P	P	P	P	P	O	P	P	P	P	P	P	P	P	O	O	P	P	O	P	O	O	O		O

Table 4.--List of stations showing the available stream-temperature data--Continued

Station number	Collecting agency	Stream-temperature-data availability, by calendar year																								
		73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
05522500	U	P	P	P	P	P	O	P	P	P	P	P	P	P	P	O	O	P	P	O	P	O	O	O		O
05523000	U	P	P	P	P	O	O	P	P	P	P	P	P	P	P	P	P	P	P	P	P	O	O	O	O	O
05523500	U	P	P	P	P	O	O	P	P	P	O	P	P	P	P	O	O	P	P	P	P	O	O			O
05524000	U	P	P	P	P	O	O	P	P	P	P	P	O	P	P	O	O	P	P	P	P	P		O		O
05524500	U	P	P	O	P	P	O	P	P	P	P	P	P	P	P	O	O	P	P	P	P	O	O	O		O
05524500	B				P	P	P	P	P	P	P	P	P	P	P	P	P	P								
05524500	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					
[b]05536190	U	P	P	O	P	P	P	P	P	P	P	O	P	P	P	O	O	P	O	P	P	P	O			
[c]05536195	U		O	P	P	P	P	P	P	P	P	O	O	P	P	O										

a Formerly WR-334.
b Formerly 04087500.
c Formerly 04087600.

IDENTIFICATION OF STATION-NAME ABBREVIATIONS USED IN TABLE 5

Station name	Abbreviations	Station name	Abbreviations
BACK CREEK	BACK C	KINGSBURY CREEK	KINGSB
BEAN CREEK	BEAN C	KOKOMO CREEK	KOKOMO
BEANBLOSSOM CREEK	BEANBL	LAUGHERY CREEK	LAUGHE
BEAR CREEK	BEAR C	(SEE FOOTNOTES TABLE 5)	LITTLE
BICE DITCH	BICE D	LOST RIVER	LOST R
BIG CREEK	BIG CR	MIDDLE FORK ANDERSON RIVER	MIDDLE
BIG MONON CREEK	BIG MO	MILL CREEK	MILL C
BIG PINE CREEK	BIG PI	MISSISSINEWA RIVER	MISSIS
BIG RACCOON CREEK	BIG RA	MUD CREEK	MUD CR
BIG WALNUT CREEK	BIG WA	MUD PINE CREEK	MUD PI
BLUE RIVER	BLUE R	MUSCATATUCK RIVER	MUSCAT
BROUILLETTS CREEK	BROUIL	NORTH FORK SALT CREEK	NORTH
BRUSH CREEK	BRUSH	PATOKA RIVER	PATOKA
BUCK CREEK	BUCK C	PIGEON CREEK	PIGEON
BURNS DITCH	BURNS	PIPE CREEK	PIPE C
BUSSERON CREEK	BUSSER	PLEASANT RUN	PLEASA
BUTTERMILK CREEK	BUTTER	PLUM CREEK	PLUM C
CARPENTER CREEK	CARPEN	RATTLESNAKE CREEK	RATTLE
CEDAR CREEK	CEDAR	SALAMONIE RIVER	SALAMO
CICERO CREEK	CICERO	SALT CREEK	SALT C
CLEAR CREEK	CLEAR	SAND CREEK	SAND C
CLIFTY CREEK	CLIFTY	SILVER CREEK	SILVER
COAL CREEK	COAL C	SINGLETON DITCH	SINGLE
CROOKED CREEK	CROOKE	SLOUGH CREEK	SLOUGH
DEER CREEK	DEER C	SOUTH HOGAN CREEK	SOUTH
DEEP RIVER	DEEP R	SPRING CREEK	SPRING
DRIFTWOOD RIVER	DRIFTW	STEPHENS CREEK	STEPHE
EAGLE CREEK	EAGLE	ST. JOSEPH RIVER	ST. JO
EAST FORK WHITE RIVER	EAST F	ST. MARYS RIVER	ST. MA
EEL RIVER	EEL RI	STONY CREEK	STONY
ELKHART RIVER	ELKHAR	SUGAR CREEK	SUGAR
FALL CREEK	FALL C	COBB DITCH (FORMERLY STATE DITCH)	STATE
FISH CREEK	FISH C	TIPPECANOE RIVER	TIPPEC
FLAT CREEK	FLAT C	TRAIL CREEK	TRAIL
FLATROCK RIVER	FLATRO	TURKEY CREEK	TURKEY
FORKER CREEK	FORKER	VERNON FORK	VERNON
GALENA RIVER	GALENA	WABASH RIVER	WABASH
GRAHAM CREEK	GRAHAM	WALNUT CREEK	WALNUT
HALL CREEK	HALL C	WEESAU CREEK	WEESAU
(SEE FOOTNOTES TABLE 5)	HARBER	WEST CREEK	WEST C
HART DITCH	HART D	WEST FORK BLUE RIVER	WEST F
HAW CREEK	HAW CR	WHITE RIVER	WHITE
HINKLE CREEK	HINKLE	WHITEWATER RIVER	WHITEW
INDIAN-KENTUCK CREEK	INDIAN	WILDCAT CREEK	WILDCA
IROQUOIS RIVER	IROQUO	YELLOW RIVER	YELLOW
KANKAKEE RIVER	KANKAK		
KILLBUCK CREEK	KILLBU		

TABLE 5 HARMONIC COEFFICIENTS FOR USGS DATA

STA NO = STATION NUMBER.LOCATED ON FIGURE 1; NAME = ABBREVIATION OF STATION NAME; YR = LAST YEAR OF DATA CONSIDERED; NUM = NUMBER OF SAMPLES CONSIDERED;A = AMPLITUDE; C = PHASE COEFFICIENT; M = MEAN; SE = STANDARD ERROR OF ESTIMATE; RSQD = ROOT MEAN SQUARE A, M, AND SE ARE IN DEGREES CELSIUS; C IS IN RADIANS; ROOT MEAN SQUARE IS IN PERCENT; USGS STATION NUMBERS IN THIS TABLE BEGIN WITH 03, 04, OR 05; 03 STATIONS ARE IN OHIO R BASIN, 04 STATIONS ARE IN ST. LAWRENCE R BASIN, AND 05 STATIONS ARE IN UPPER MISSISSIPPI R BASIN.

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
03274650	WHITEW	1973	26	8.27	4.34	11.58	2.25	87.21
03274750	WHITEW	1973	28	9.37	4.35	12.13	2.79	84.48
[a]03274950	LITTLE	1973	45	12.09	4.48	13.38	3.11	87.08
03275000	WHITEW	1973	167	10.76	4.32	13.16	2.03	93.19
03275500	EAST F	1973	176	11.13	4.30	15.59	2.69	89.84
03275600	EAST F	1973	63	11.14	4.34	13.55	2.28	92.30
03276000	EAST F	1973	152	11.57	4.31	13.35	2.46	91.63
03276700	SOUTH	1973	95	13.39	4.29	14.01	2.65	92.53
03277000	LAUGHE	1973	36	13.03	4.29	14.04	2.52	92.87
03291780	INDIAN	1973	34	13.30	4.30	14.02	3.40	86.24
03294000	SILVER	1973	143	10.81	4.35	13.38	2.05	93.24
03302220	BUCK C	1973	38	8.29	4.38	13.69	2.85	79.96
[b]03302300	LITTLE	1973	50	10.43	4.34	15.05	3.51	81.48
03302500	INDIAN	1973	165	10.91	4.38	13.52	2.46	90.54
03302680	WEST F	1973	38	12.05	4.36	14.91	3.36	86.11
03302800	BLUE R	1973	55	9.99	4.33	13.81	2.43	89.25
03303000	SPRING	1971	23	5.80	4.30	13.73	1.33	89.64
03303000	BLUE R	1973	165	9.91	4.34	13.75	2.39	89.41
03303300	MIDDLE	1973	100	11.49	4.34	13.98	2.51	90.98
03303400	CROOKE	1973	31	11.63	4.35	14.68	4.01	80.81
03322100	PIGEON	1973	145	11.68	4.36	14.42	2.54	90.85
03322500	WABASH	1973	160	12.03	4.37	12.15	2.63	90.83
03322900	WABASH	1973	75	12.11	4.35	12.08	2.88	88.93
03323000	WABASH	1971	144	12.26	4.33	12.62	2.49	91.98
[c]03324000	LITTLE	1973	139	12.01	4.30	12.15	2.74	89.60
03324200	SALAMO	1973	116	12.20	4.30	12.97	3.09	88.28
03324300	SALAMO	1973	117	12.37	4.29	12.35	2.64	90.36
03324500	SALAMO	1973	133	11.74	4.28	11.93	2.48	91.07
03325500	MISSIS	1973	150	10.97	4.37	12.14	2.69	88.68
03326000	MISSIS	1971	130	12.09	4.38	12.34	3.00	88.55
03327000	MISSIS	1973	143	12.36	4.32	12.64	2.76	90.70
03327500	WABASH	1973	122	12.33	4.28	12.39	2.91	89.75
03328000	EEL RI	1973	138	11.28	4.34	12.21	2.58	90.61
03328430	WEESAU	1973	32	11.03	4.16	11.20	2.22	92.03
03329400	RATTLE	1973	47	10.46	4.28	13.37	2.89	85.86
03329500	WABASH	1971	114	12.08	4.29	12.63	3.62	83.42
03329700	DEER C	1973	148	12.36	4.34	12.52	2.45	92.24
03330500	TIPPEC	1973	157	12.86	4.29	12.84	2.18	94.71
03331110	WALNUT	1973	23	11.28	4.23	12.27	2.33	91.39
[b]03332300	LITTLE	1973	108	10.57	4.26	11.51	2.62	88.60
03332400	BIG MO	1973	103	11.36	4.29	11.90	2.67	90.31
03333450	WILDCA	1973	92	11.60	4.34	12.45	2.28	92.30
03333500	WILDCA	1961	70	11.80	4.32	11.42	2.55	90.86
03333600	KOKOMO	1973	108	9.45	4.32	11.00	2.29	88.83

TABLE 5 HARMONIC COEFFICIENTS FOR USGS DATA (CON'T)

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
03334000	WILDCA	1973	150	11.89	4.33	11.99	2.04	94.19
03334500	SOUTH	1973	144	11.19	4.34	12.61	2.44	90.92
03335690	MUD PI	1973	25	13.99	4.16	14.43	2.96	91.15
03335700	BIG PI	1973	119	11.60	4.33	12.28	2.55	90.13
03339108	EAST F	1973	51	11.05	4.29	13.01	3.04	86.86
03339120	COAL C	1972	66	11.36	4.34	12.19	2.98	87.49
d 03339150	LITTLE	1972	71	12.29	4.38	12.24	2.86	89.27
03339500	SUGAR	1973	148	11.98	4.33	13.21	2.86	89.13
03340800	BIG RA	1973	127	11.20	4.37	12.39	2.50	90.23
03340900	BIG RA	1973	129	10.33	4.24	12.27	2.51	89.24
e 03341200	LITTLE	1971	123	11.52	4.33	12.57	2.49	91.09
03341300	BIG RA	1973	119	10.98	4.33	12.13	2.35	91.18
03341400	WABASH	1970	30	12.46	4.35	12.75	2.04	94.58
03341420	BROUIL	1971	45	12.37	4.35	13.60	2.69	90.31
03342000	WABASH	1973	159	12.87	4.26	14.90	2.24	94.30
03342100	BUSSER	1973	80	12.17	4.37	13.53	3.11	85.97
03342150	WEST F	1973	76	10.02	4.39	11.63	2.63	86.15
03342250	MUD CR	1973	75	12.64	4.38	14.25	3.58	84.02
03342300	BUSSER	1973	90	10.55	4.38	12.66	2.66	87.94
03342350	BUTTER	1973	77	11.42	4.38	13.83	3.37	83.85
03342500	BUSSER	1973	166	11.57	4.34	12.46	2.62	90.01
03347500	BUCK C	1973	141	10.19	4.32	11.22	3.10	84.05
03348020	KILLBU	1973	45	10.66	4.28	12.16	2.01	93.53
03348350	PIPE C	1973	39	11.75	4.36	12.40	2.32	92.52
03348500	WHITE	1973	204	11.15	4.31	12.59	2.24	92.11
03349500	CICERO	1973	153	11.60	4.29	11.50	2.52	90.94
f 03349700	LITTLE	1973	136	12.20	4.30	11.90	2.37	92.64
03350100	HINKLE	1973	130	10.82	4.33	11.21	2.39	90.27
03350500	CICERO	1973	46	11.60	4.25	12.73	2.05	94.12
03350700	STONY	1973	59	11.20	4.30	12.60	2.29	92.33
03351310	CROOKE	1973	41	10.03	4.45	12.51	2.76	86.42
03351400	SUGAR	1973	41	12.02	4.31	12.23	2.77	90.43
03351500	FALL C	1973	181	10.88	4.30	11.96	2.27	91.11
03352200	MUD CR	1973	123	10.17	4.39	11.24	2.30	89.94
03352500	FALL C	1973	204	11.51	4.31	12.70	1.93	94.45
03353120	PLEASA	1973	90	11.16	4.35	12.88	3.00	86.47
03353160	PLEASA	1973	94	11.28	4.29	12.93	3.03	87.02
03353180	BEAN C	1973	29	9.66	4.43	14.58	3.59	77.46
03353200	EAGLE	1973	101	11.48	4.30	11.84	2.39	91.45
g 03353600	LITTLE	1973	94	11.95	4.32	13.43	2.98	88.96
03353700	WEST F	1973	109	11.65	4.31	12.69	3.17	86.45
03353800	WHITE	1973	120	11.46	4.32	12.85	2.69	89.83
03354000	WHITE	1973	145	11.64	4.24	14.23	2.20	93.74
03354500	BEANBL	1973	157	12.21	4.34	13.39	2.94	89.46
03355000	BEAR C	1973	157	13.17	4.41	15.28	3.66	85.81
03356000	BEANBL	1973	156	11.06	4.34	12.80	1.94	94.56
03357350	PLUM C	1973	26	10.72	4.29	11.39	2.22	93.30
03357500	BIG WA	1973	126	11.49	4.31	12.67	2.56	90.77
03358000	MILL C	1973	118	11.36	4.35	12.54	2.15	93.31
03359000	MILL C	1973	123	11.83	4.21	12.96	2.03	94.38

TABLE 5 HARMONIC COEFFICIENTS FOR USGS DATA (CON'T)

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
03359500	DEER C	1972	118	11.87	4.36	12.87	2.59	90.88
03360000	EEL RI	1973	116	11.68	4.27	12.72	2.13	93.36
03360500	WHITE	1973	151	12.37	4.29	13.88	2.44	92.61
03361650	SUGAR	1973	43	11.25	4.45	13.19	2.64	90.46
03361850	BUCK C	1973	39	10.43	4.39	12.40	1.62	95.43
03362500	SUGAR	1973	152	11.81	4.33	13.57	2.11	93.85
03363000	DRIFTW	1973	150	11.30	4.34	13.43	2.07	93.43
03363500	FLATRO	1973	154	12.18	4.31	13.50	2.61	90.21
03363900	FLATRO	1973	39	11.09	4.34	13.25	1.97	93.98
03364200	HAW CR	1973	40	10.94	4.40	13.84	2.39	91.35
03364500	CLIFTY	1973	158	12.03	4.37	13.39	2.81	89.14
03365000	SAND C	1973	156	12.27	4.37	13.23	2.65	91.29
03366000	GRAHAM	1973	137	11.68	4.36	13.36	2.55	91.25
h03366200	HARBER	1973	43	10.85	4.39	14.56	3.37	83.93
03366500	MUSCAT	1973	149	11.62	4.40	13.26	2.64	90.52
03368000	BRUSH	1973	123	10.70	4.35	12.21	2.74	87.55
03369000	VERNON	1973	180	12.35	4.38	14.00	2.18	94.28
03369500	VERNON	1973	159	12.14	4.37	13.61	2.70	90.78
03371520	BACK C	1973	35	11.54	4.30	14.16	2.85	89.22
03371600	SOUTH	1971	85	11.39	4.39	13.40	2.54	91.52
03371650	NORTH	1973	91	12.58	4.33	13.10	1.95	95.06
03372000	NORTH	1971	148	11.42	4.36	12.48	2.08	93.93
03372300	STEPHE	1973	35	10.80	4.26	13.33	2.46	90.71
03372500	SALT C	1973	152	11.08	4.24	13.26	2.31	92.02
03372700	CLEAR	1971	92	10.63	4.40	13.30	2.83	87.22
03373000	SALT C	1971	126	10.63	4.30	13.23	1.97	93.76
03373200	INDIAN	1973	115	10.94	4.35	13.62	2.55	90.48
03373700	LOST R	1973	79	8.03	4.33	12.18	2.34	85.15
03374455	PATOKA	1973	41	11.00	4.21	14.59	2.85	88.62
03374470	PATOKA	1973	39	9.45	4.30	12.94	2.17	90.51
03374500	PATOKA	1972	98	10.23	4.33	12.90	2.25	91.06
03375800	HALL C	1973	29	11.51	4.26	14.88	3.18	86.29
03376260	FLAT C	1973	72	10.23	4.45	13.14	2.86	85.47
03376300	PATOKA	1973	77	11.53	4.34	13.32	2.46	91.20
03376350	SOUTH	1973	81	10.93	4.35	14.28	3.40	82.82
03378550	BIG CR	1973	81	11.33	4.40	14.53	2.74	89.17
04093000	DEEP R	1973	159	12.95	4.36	12.72	2.61	92.06
i04093200	LITTLE	1971	90	12.37	4.39	12.22	3.18	87.98
04093500	BURNS	1973	130	12.58	4.34	12.45	2.48	92.41
i04094000	LITTLE	1973	149	10.18	4.34	10.92	2.31	90.45
04094500	SALT C	1973	148	10.65	4.34	11.32	2.60	89.01
04095300	TRAIL	1972	31	10.77	4.34	11.41	2.41	90.06
04096100	GALENA	1973	36	8.88	4.34	11.04	2.57	84.69
04099750	PIGEON	1973	39	10.79	4.26	12.31	3.37	82.73
04100220	NORTH	1973	147	12.92	4.29	12.77	2.33	93.73
04100252	FORKER	1973	42	10.81	4.25	11.14	2.96	86.04
04100465	TURKEY	1973	41	9.59	4.36	11.64	1.99	91.59
04100500	ELKHAR	1973	159	11.57	4.37	12.09	2.31	92.21

TABLE 5 HARMONIC COEFFICIENTS FOR USGS DATA (CON'T)

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
04177720	FISH C	1973	38	11.48	4.27	11.69	2.28	92.59
04178000	ST. JO	1972	119	12.02	4.29	11.48	2.07	93.77
04179000	ST. JO	1973	115	12.35	4.29	12.15	2.06	94.61
04179500	CEDAR	1973	142	10.60	4.27	11.54	2.14	92.54
04180000	CEDAR	1973	141	10.78	4.32	11.48	2.07	92.81
04181500	ST. MA	1973	127	12.24	4.33	12.40	2.30	93.38
[j]04182590	HARBER	1973	84	11.42	4.33	12.43	3.20	85.07
05515000	KANKAK	1973	146	8.53	4.30	11.32	2.50	85.57
05515400	KINGSB	1973	29	7.06	4.28	11.56	2.57	78.34
05515500	KANKAK	1973	119	10.06	4.30	11.53	2.24	90.58
05516000	YELLOW	1973	123	10.12	4.25	11.27	2.53	88.35
05516500	YELLOW	1973	150	10.64	4.27	11.32	2.28	91.39
05517500	KANKAK	1973	133	10.78	4.34	11.65	2.36	91.17
05517900	STATE	1972	23	9.70	4.32	11.88	2.25	87.48
05519000	SINGLE	1973	149	11.70	4.30	12.40	2.69	90.13
05519500	WEST C	1972	130	11.81	4.30	12.23	2.73	89.69
05520000	SINGLE	1973	132	12.12	4.30	11.85	2.83	89.20
05521000	IROQUO	1973	143	11.19	4.34	11.65	3.04	86.60
05522000	IROQUO	1973	140	11.90	4.35	12.06	2.92	88.37
05522500	IROQUO	1973	141	11.58	4.29	11.89	2.65	89.96
05523000	RICE D	1973	154	12.18	4.28	12.32	2.78	90.22
05523500	SLOUGH	1973	144	12.31	4.31	12.51	3.29	86.70
05524000	CARPEN	1973	127	11.96	4.31	11.95	2.90	88.25
[k]05536190	HART D	1973	150	10.98	4.28	11.10	2.35	91.26
[i,l]05536195	LITTLE	1972	107	11.86	4.30	11.72	2.74	89.15

[a] Little Williams Creek

[b] Little Indian Creek

[c] Little River

[d] Little Vermilion River

[e] Little Raccoon Creek

[f] Little Cicero Creek

[g] Little Eagle Creek

[h] Harberts Creek

[i] Little Calumet River

[j] Harber ditch

[k] Formerly 04087500

[l] Formerly 04087600

IDENTIFICATION OF STATION-NAME ABBREVIATIONS USED IN TABLE 6

Station name	Abbreviation
BIG RACCOON CREEK	BIG
BLUE RIVER	BLU
BUCK CREEK	BUC
BURNS DITCH	BUR
EAGLE CREEK	EAG
EAST FORK WHITE RIVER	EAS
EEL RIVER	EEL
FALL CREEK	FAL
GRAND CALUMET RIVER	GRA
INDIANA HARBOR CANAL	IND
LAUGHERY CREEK	LAU
LITTLE CALUMET RIVER	LIT
MAUMEE RIVER	MAU
MISSISSINEWA RIVER	MIS
MUSCATATUCK RIVER	MUS
PATOKA RIVER	PAT
PLEASANT RUN	PLE
POGUES RUN	POG
SALAMONIE RIVER	SAL
ST. JOSEPH RIVER	ST.
SUGAR CREEK	SUG
TIPPECANOE RIVER	TIP
TRAIL CREEK	TRA
WABASH RIVER	WAB
WHITE RIVER	WHI
WILDCAT CREEK	WIL
WOLF LAKE	WOL
YELLOW RIVER	YEL
YOUNGS CREEK	YOU

TABLE 6 HARMONIC COEFFICIENTS FOR ISBH DATA

STA NO = STATION NUMBER,LOCATED ON FIGURE 1; NAME = ABBREVIATION OF STATION NAME; YR = LAST YEAR OF DATA CONSIDERED; NUM = NUMBER OF SAMPLES CONSIDERED;A = AMPLITUDE; C = PHASE COEFFICIENT; M = MEAN; SE = STANDARD ERROR OF ESTIMATE; RSQD = ROOT MEAN SQUARE
A, M, AND SE ARE IN DEGREES CELSIUS; C IS IN RADIANS; ROOT MEAN SQUARE
USGS STATION NUMBERS IN THIS TABLE BEGIN WITH 03, 04, AND 05;
03 STATIONS ARE IN OHIO R BASIN, 04 STATIONS ARE IN ST. LAWRENCE R BASIN, AND 05 STATIONS ARE IN UPPER MISSISSIPPI R BASIN.

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
BD-0	BUR	1972	161	10.54	4.31	13.68	2.71	88.68
BD-3W	BUR	1972	111	11.77	4.38	11.89	2.86	88.03
BL-17	BIG	1972	31	9.91	4.26	12.69	2.47	88.55
BL-61	BIG	1972	30	8.99	4.45	13.41	2.57	85.68
EC-38	EAG	1972	30	9.20	4.37	10.38	3.41	77.19
FW-184	EAS	1972	33	10.66	4.27	13.99	2.46	90.34
FC-1	FAL	1972	27	12.02	4.40	12.55	2.76	89.26
MU-29	MUS	1971	190	11.43	4.38	13.26	2.34	92.08
MU-34	MUS	1972	45	11.17	4.34	13.09	2.52	90.55
P-14	PAT	1972	22	11.01	4.37	13.81	2.48	89.90
PGR-0	POG	1972	31	8.38	4.25	18.51	3.13	77.56
PLR-1	PLE	1972	30	11.87	4.30	13.44	2.62	90.07
SC-39	SUG	1972	31	9.75	4.23	14.46	3.08	81.02
TC-1	TRA	1972	72	10.65	4.30	11.95	2.20	91.92
TR-53	TIP	1972	23	11.42	4.33	11.89	2.95	82.67
TR-145	TIP	1972	25	12.36	4.19	12.67	3.03	88.86
WB-336	WAB	1972	22	13.20	4.29	12.03	3.42	82.67
WB-432	WAB	1972	29	10.72	4.26	12.36	2.51	89.42
WR-347	WHI	1970	96	10.59	4.43	11.59	3.28	81.55
YC-5	YOU	1972	32	10.52	4.27	12.89	2.43	90.50
YR-43	YEL	1972	29	9.78	4.25	11.12	2.31	88.98
03276790	LAU	1970	150	11.89	4.39	12.91	2.41	91.40
03302800	BLU	1972	32	10.61	4.27	13.99	2.51	90.23
03323510	WAB	1972	35	12.26	4.30	13.12	2.48	92.74
03324340	SAL	1970	42	11.82	4.38	12.82	2.52	91.19
03324600	SAL	1972	193	11.73	4.31	12.53	2.61	90.28
03326550	MIS	1967	60	12.36	4.32	14.10	2.80	89.12
03326600	MIS	1970	67	11.77	4.42	13.07	2.75	89.54
03327100	MIS	1972	29	11.93	4.22	13.06	3.01	88.72
03327480	WAB	1972	230	12.33	4.34	12.78	2.49	92.14
03329020	WAB	1972	28	12.02	4.23	13.17	3.24	85.73
03333570	WIL	1972	28	12.11	4.28	13.21	2.81	90.82
03335680	WAB	1972	34	10.82	4.23	14.20	2.50	89.47
03341000	BIG	1970	191	10.37	4.32	12.18	2.46	89.54
03341560	WAB	1972	35	12.23	4.32	15.21	2.82	89.99
03346750	WHI	1972	31	9.86	4.32	13.34	2.38	89.45
03347300	WHI	1972	142	11.21	4.35	13.63	2.82	88.42
03347500	BUC	1970	67	8.83	4.45	11.23	2.91	81.14
03352700	FAL	1972	23	11.48	4.29	13.54	2.48	91.20
03353400	EAG	1972	33	10.35	4.37	11.13	3.25	81.68
03353605	EAG	1972	32	12.10	4.29	14.29	2.24	93.69
03353640	WHI	1970	241	12.24	4.21	16.76	3.36	87.13
03353990	WHI	1970	61	10.49	4.46	12.74	3.30	82.04
03354050	WHI	1972	35	11.34	4.37	14.95	2.41	91.45

TABLE 6 HARMONIC COEFFICIENTS FOR ISBH DATA (CON'T)

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
03354125	WHI	1972	221	12.25	4.21	16.75	2.86	89.95
03360150	EEL	1970	196	11.84	4.32	13.63	2.62	90.52
03360210	WHI	1970	195	12.25	4.30	14.47	2.61	91.45
03360710	WHI	1972	212	12.43	4.27	15.45	2.44	92.73
03361200	BIG	1970	123	9.55	4.41	11.74	2.58	86.53
03367000	MUS	1972	45	11.17	4.34	13.09	2.52	90.55
03373100	EAS	1972	20	10.86	4.30	14.27	2.18	90.33
03374100	WHI	1972	220	12.61	4.30	14.76	2.32	93.38
03378500	WAB	1968	116	12.93	4.33	14.78	2.23	94.09
04092500	WOL	1972	127	11.57	4.37	11.34	3.59	83.40
04092680	GRA	1972	149	9.20	4.25	19.24	2.48	87.73
04092690	GRA	1972	162	9.08	4.24	19.00	2.45	87.61
04092695	GRA	1972	162	8.04	4.19	15.12	2.63	82.82
04092698	GRA	1972	149	7.83	4.23	14.56	2.89	79.17
04092710	IND	1972	165	8.74	4.23	18.44	2.44	86.69
04092720	IND	1972	162	9.20	4.29	18.83	2.68	85.71
04092730	IND	1972	159	9.26	4.25	18.23	2.53	87.13
04093950	LIT	1972	34	9.54	4.21	10.83	2.53	85.14
04094600	BUR	1972	126	9.86	4.32	12.79	2.44	89.44
04094700	BUR	1972	114	10.46	4.37	12.23	2.48	90.06
04099830	ST.	1972	27	11.99	4.31	12.57	2.71	87.94
04101200	ST.	1972	27	12.13	4.23	13.48	2.88	86.50
04101310	ST.	1972	213	11.58	4.28	12.88	2.62	90.21
04180500	ST.	1972	182	11.72	4.31	12.18	2.40	91.48
04182900	MAU	1972	34	12.83	4.27	12.62	2.82	90.41
04183300	MAU	1972	110	12.00	4.30	12.50	2.74	90.15
05536195	LIT	1972	151	10.94	4.35	11.32	3.17	84.54

IDENTIFICATION OF STATION-NAME ABBREVIATIONS USED IN TABLE 7

Station name	Abbreviation
BIG BLUE RIVER	BIG BL
BIG BLUE RIVER	BIG
EAGLE CREEK	EAGLE
EAGLE CREEK	EAG
EAST FORK WHITE RIVER	EAST F
EAST FORK WHITE RIVER	EAS
EEL RIVER	EEL RI
EEL RIVER	EEL
IROQUOIS RIVER	IROQUO
IROQUOIS RIVER	IRO
KANKAKEE RIVER	KANKAK
KANKAKEE RIVER	KAN
KILLBUCK CREEK	KILLBU
KILLBUCK CREEK	KIL
LICK CREEK	LICK C
LICK CREEK	LIC
MAUMEE RIVER	MAUMEE
MAUMEE RIVER	MAU
MISSISSINEWA RIVER	MISSISS
MISSISSINEWA RIVER	MIS
PATOKA RIVER	PATOKA
PATOKA RIVER	PAT
ST. JOSEPH RIVER	ST. JO
ST. JOSEPH RIVER	ST.
ST. MARYS RIVER	ST. MA
ST. MARYS RIVER	ST.
SUGAR CREEK	SUGAR
SUGAR CREEK	SUG
TIPPECANOE RIVER	TIPPEC
TIPPECANOE RIVER	TIP
WABASH RIVER	WABASH
WABASH RIVER	WAB
WHITE RIVER	WHITE
WHITE RIVER	WHI
WHITEWATER RIVER	WHITEW
WHITEWATER RIVER	WHI
WILDCAT CREEK	WILDCA
WILDCAT CREEK	WIL
YELLOW RIVER	YELLOW
YELLOW RIVER	YEL
YOUNGS CREEK	YOUNGS
YOUNGS CREEK	YOU

TABLE 7 HARMONIC COEFFICIENTS FOR USGS(TOP), ISBH (MIDDLE), AND MERGED (BOTTOM) DATA

STA NO = STATION NUMBER,LOCATED ON FIGURE 1; NAME = ABBREVIATION OF STATION NAME; YR = LAST YEAR OF DATA CONSIDERED; NUM = NUMBER OF SAMPLES CONSIDERED;A = AMPLITUDE; C = PHASE COEFFICIENT; M = MEAN; SE = STANDARD ERROR OF ESTIMATE; RSQD = ROOT MEAN SQUARE A, M, AND SE ARE IN DEGREES CELSIUS; C IS IN RADIANS; ROOT MEAN SQUARE IS IN PERCENT; USGS STATION NUMBERS IN THIS TABLE BEGIN WITH 03, 04, OR 05; 03 STATIONS ARE IN OHIO R BASIN, 04 STATIONS ARE IN ST. LAWRENCE R BASIN, AND 05 STATIONS ARE IN UPPER MISSISSIPPI R BASIN.

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
03276500	WHITEW	1973	159	11.57	4.30	13.72	2.36	92.14
03276500	WHI	1972	194	10.85	4.34	12.86	2.64	89.22
03276500	WHITEW	1973	270	11.08	4.32	13.25	2.48	90.79
03323500	WABASH	1973	158	12.20	4.28	12.59	3.41	85.54
03323500	WAB	1972	193	12.37	4.33	13.02	2.40	92.45
03323500	WABASH	1973	270	12.50	4.32	12.79	2.25	93.45
03325000	WABASH	1973	123	12.15	4.29	11.94	2.43	92.24
03325000	WAB	1972	32	11.73	4.19	12.44	2.67	90.73
03325000	WABASH	1973	142	12.08	4.27	11.99	2.30	92.93
03326500	MISSIS	1973	128	12.70	4.30	12.15	2.44	92.60
03326500	MIS	1972	31	12.77	4.26	13.42	2.81	90.67
03326500	MISSIS	1973	128	12.70	4.30	12.15	2.44	92.60
03328500	EEL RI	1973	125	12.38	4.28	12.09	2.48	91.86
03328500	EEL	1970	177	12.04	4.36	12.27	2.38	92.03
03328500	EEL RI	1973	233	12.10	4.33	12.18	2.26	93.00
03329000	WABASH	1973	120	12.61	4.26	12.27	2.48	91.87
03329000	WAB	1970	184	12.80	4.35	13.16	2.55	92.45
03329000	WABASH	1973	245	12.60	4.32	12.79	2.45	92.84
03331500	TIPPEC	1973	149	11.38	4.30	12.02	2.17	93.29
03331500	TIP	1970	177	11.47	4.39	11.98	2.18	92.61
03331500	TIPPEC	1973	253	11.36	4.36	11.94	2.09	93.26
03333000	TIPPEC	1973	128	12.40	4.27	12.70	2.46	92.38
03333000	TIP	1970	184	12.48	4.32	12.78	1.97	95.03
03333000	TIPPEC	1973	247	12.49	4.30	12.75	2.00	94.95
03333700	WILDCA	1973	127	11.13	4.17	14.49	2.92	87.93
03333700	WIL	1970	233	11.27	4.29	14.50	2.54	90.94
03333700	WILDCA	1973	282	11.13	4.25	14.52	2.68	89.64
03335000	WILDCA	1973	134	12.18	4.33	12.47	2.30	92.62
03335000	WIL	1970	190	11.64	4.38	12.29	2.13	93.44
03335000	WILDCA	1973	247	11.79	4.35	12.30	2.03	94.06

TABLE 7 HARMONIC COEFFICIENTS FOR USGS (TOP), ISBH (MIDDLE), AND MERGED (BOTTOM) DATA (CON'T)

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
03335500	WABASH	1972	139	12.40	4.30	13.07	2.14	94.32
03335500	WAB	1972	206	12.29	4.32	12.84	2.30	92.75
03335500	WABASH	1972	257	12.37	4.31	12.89	1.98	94.86
03336000	WABASH	1973	106	12.23	4.33	12.86	2.35	92.55
03360000	WAB	1972	201	12.13	4.34	13.13	2.41	92.00
03336000	WABASH	1973	245	12.11	4.35	13.09	2.24	93.18
03340000	SUGAR	1971	128	12.66	4.37	12.84	2.19	93.82
03340000	SUG	1970	183	11.85	4.40	12.66	2.51	90.97
03340000	SUGAR	1971	240	12.18	4.38	12.72	2.29	92.92
03340500	WABASH	1973	129	12.29	4.32	12.91	2.33	92.84
03340500	WAB	1972	204	12.33	4.36	13.16	2.48	91.96
03340500	WABASH	1973	255	12.34	4.35	13.11	2.31	93.17
03341500	WABASH	1973	125	12.89	4.26	13.89	2.30	93.90
03341500	WAB	1970	176	11.91	4.28	14.44	2.86	88.98
03341500	WABASH	1973	237	12.40	4.28	14.09	1.98	94.93
03343000	WABASH	1973	140	12.40	4.32	13.88	2.51	92.03
03343000	WAB	1972	209	12.70	4.27	14.64	2.34	93.43
03343000	WABASH	1973	268	12.67	4.30	14.35	2.20	94.19
03347000	WHITE	1973	158	11.78	4.33	12.49	3.40	85.79
03347000	WHI	1972	202	11.98	4.33	13.38	2.57	91.09
03347000	WHITE	1972	272	11.95	4.34	13.10	2.84	89.43
03348000	WHITE	1973	151	11.99	4.31	13.38	2.48	92.24
03348000	WHI	1971	194	11.54	4.34	13.26	2.72	89.56
03348000	WHITE	1973	268	11.76	4.32	13.34	2.36	92.39
03348100	KILLBU	1968	45	11.01	4.39	11.85	2.68	89.85
03348100	KIL	1970	66	9.53	4.48	11.21	2.85	84.03
03348100	KILLBU	1970	103	10.13	4.44	11.58	2.64	88.02
03349000	WHITE	1973	231	11.14	4.30	13.45	2.41	91.22
03349000	WHI	1970	205	11.84	4.34	12.99	2.58	90.97
03349000	WHITE	1973	274	11.50	4.32	13.08	2.05	94.09
03351000	WHITE	1973	220	11.74	4.32	13.03	2.09	93.99
03351000	WHI	1972	213	11.70	4.33	12.87	2.42	91.93
03351000	WHITE	1973	282	11.74	4.33	12.91	1.98	94.69
03353000	WHITE	1973	200	12.15	4.27	13.70	2.77	90.76
03353000	WHI	1972	28	11.86	4.30	13.56	1.88	94.47
03353000	WHITE	1973	206	12.19	4.27	13.69	2.70	91.19

TABLE 7 HARMONIC COEFFICIENTS FOR USGS (TOP), ISBH (MIDDLE), AND MERGED (BOTTOM) DATA (CON'T)

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
03353500	EAGLE	1973	130	11.95	4.33	13.24	3.16	86.38
03353500	EAG	1972	27	11.57	4.32	12.07	2.89	87.20
03353500	EAGLE	1973	146	11.84	4.33	13.03	3.01	87.53
03353620	LICK C	1973	31	9.67	4.34	15.18	3.40	79.36
03353620	LIC	1972	30	11.02	4.31	13.70	3.01	85.55
03353620	LICK C	1973	58	10.22	4.31	14.48	3.25	81.85
03357000	WHITE	1971	118	12.35	4.28	14.48	2.70	91.10
03357000	WHI	1972	229	11.74	4.29	15.43	3.95	81.20
03357000	WHITE	1972	274	11.88	4.28	15.16	3.63	84.26
03361000	BIG BL	1973	171	10.03	4.33	12.40	2.29	90.64
03361000	BIG	1970	176	9.61	4.36	11.49	2.27	89.52
03361000	BIG BL	1973	270	9.84	4.34	11.82	2.04	91.99
03361500	BIG BL	1973	157	10.89	4.30	12.86	2.76	87.60
03361500	BIG	1972	189	10.71	4.32	12.89	2.40	90.56
03361500	BIG BL	1973	257	10.88	4.32	12.80	2.24	91.77
03362000	YOUNGS	1973	156	10.66	4.34	13.18	2.27	91.58
03362000	YOU	1970	223	10.62	4.38	12.51	2.44	90.28
03362000	YOUNGS	1973	287	10.61	4.37	12.76	2.29	91.59
03364000	EAST F	1973	119	11.53	4.36	13.36	2.17	92.78
03364000	EAS	1972	34	10.62	4.28	13.65	2.48	90.48
03364000	EAST F	1973	144	11.32	4.34	13.42	2.24	92.20
03365500	EAST F	1973	159	11.72	4.33	13.54	2.10	94.07
03365500	EAS	1970	188	11.37	4.35	13.63	2.33	92.16
03365500	EAST F	1973	279	11.61	4.34	13.63	2.09	93.70
03371500	EAST F	1973	110	11.97	4.35	14.33	2.28	92.93
03371500	EAS	1972	218	12.05	4.32	14.24	2.39	92.50
03371500	EAST F	1973	248	12.02	4.33	14.26	2.18	93.77
03373500	EAST F	1973	99	12.40	4.28	14.59	2.28	93.68
03373500	EAS	1972	226	12.46	4.32	14.29	2.16	94.23
03373500	EAST F	1972	268	12.46	4.32	14.29	1.98	95.15
03374000	WHITE	1973	155	12.50	4.30	14.52	2.45	92.74
03374000	WHI	1972	23	11.71	4.35	16.56	2.80	89.62
03374000	WHITE	1973	165	12.45	4.30	14.72	2.51	92.39
03375500	PATOKA	1973	152	10.62	4.33	13.41	2.33	91.00
03375500	PAT	1970	141	11.56	4.36	13.64	2.38	92.11
03375500	PATOKA	1973	240	11.05	4.34	13.52	2.29	91.78

TABLE 7 HARMONIC COEFFICIENTS FOR USGS (TOP), ISBH (MIDDLE), AND MERGED (BOTTOM) DATA (CON'T)

STA NO	NAME	YR	NUM	A	C	M	SE	RSQD
03376500	PATOKA	1973	171	11.69	4.40	13.28	2.24	93.03
03376500	PAT	1970	205	11.74	4.37	13.80	2.32	92.38
03376500	PATOKA	1973	279	11.77	4.38	13.60	2.05	94.07
03377500	WABASH	1973	56	12.25	4.35	14.39	2.54	91.74
03377500	WAB	1961	94	13.05	4.26	14.83	2.58	92.15
03377500	WABASH	1973	131	12.82	4.29	14.71	2.59	92.12
04101000	ST. JO	1973	107	11.70	4.35	12.20	2.23	92.70
04101000	ST.	1970	138	11.73	4.36	12.47	1.82	95.34
04101000	ST. JO	1973	199	11.71	4.36	12.32	1.88	95.00
04182000	ST. MA	1973	116	12.30	4.32	12.74	2.60	91.52
04182000	ST.	1972	177	11.86	4.32	12.54	2.67	89.22
04182000	ST. MA	1973	235	11.97	4.32	12.63	2.41	91.99
04183000	MAUMEE	1973	132	12.20	4.27	12.95	2.40	92.75
04183000	MAU	1972	207	12.01	4.27	12.99	2.42	92.03
04183000	MAUMEE	1973	266	12.11	4.26	13.00	2.23	93.58
05517000	YELLOW	1973	131	10.87	4.31	11.84	2.22	92.19
05517000	YEL	1970	183	10.64	4.40	11.48	2.34	90.31
05517000	YELLOW	1973	258	10.70	4.36	11.63	2.22	91.62
05518000	KANKAK	1973	124	10.80	4.34	12.02	2.68	89.41
05518000	KAN	1970	175	11.07	4.39	11.91	2.26	91.36
05518000	KANKAK	1973	240	10.91	4.37	11.91	2.18	92.34
05524500	IROQUO	1973	137	11.49	4.31	11.98	2.59	89.39
05524500	IRO	1970	174	11.58	4.37	11.97	2.38	91.10
05524500	IROQUO	1973	244	11.63	4.34	12.07	2.28	92.22

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