August 13, 2002

Mr. Morris Bell, Chairman
Imperial Valley Water Authority
P.O. Box 503
Havana, Illinois 62644-0503

Dear Mr. Bell:

This letter describes the results of the project conducted by the U.S. Geological Survey (USGS) in cooperation with the Imperial Valley Water Authority (IVWA) designed to improve the annual withdrawal estimates for irrigation water use made by the IVWA in Mason and Tazewell Counties, Illinois. These estimates are to be improved by using an updated conversion factor for transforming energy consumption by irrigation systems (well and pivot) to actual gallons pumped. The conversion factor was updated by the USGS by recording the instantaneous electrical demand and water discharge at a predetermined sampling of irrigation systems, calculating the conversion factor for each system, and determining the average value of the conversion factor for the sampled systems.

The permission forms received by our office from the Central Illinois Irrigated Growers Association enabled 79 irrigation systems to be located and accessed for this project. The necessary data could not be collected at 2 wells. One system, in the north half of sections 28 and 29 T20N R9W, owned by Dan Pfeiffer, could not be measured because of interference caused either by air bubbles or sediment in the water stream inside the pipe or by the pipe material. Another irrigation system in the ne1/4 sw1/4 sec 32 T20N R9W, owned by Jeff Clark, was powered through the same electric meter as an adjacent irrigation system, so the electrical demand and water discharge were combined for these two systems into one calculation. Thus, calculations for the conversion factor were made for 77 irrigation systems.

The enclosed data table provides results of the data collection. Irrigation-system size (in acres), electrical-meter number, and control-box number (for Menard Electric Cooperative meters) are listed in the table for identification purposes only. The acreage shown was not verified. The water-discharge measurements have been rounded to the nearest 5 gallons per minute (gpm) except for those values less than 300 gpm that have been rounded to the nearest 1 gallon (gal). The electrical demand was determined either by counting the number of revolutions of the rotating disc on the old-style analog meters for at least 1 minute or by reading voltage and current information accessed by interrogating the new-style digital meters. The applicable equations were used with this information to calculate the instantaneous electrical demand, in kilowatts-hours (Kwh), by the irrigation system.
The water-discharge measurement was made with a non-invasive flow meter usually placed on the horizontal pipe between the well and pivot point with 8 feet (ft) or more of straight unobstructed pipe upstream and about 3 ft downstream, where possible. Several measurements were made on the vertical pipe at the pivot point (if the power cord or other obstructions were not present) when the horizontal pipe was too short and/or obstructions were present inside the pipe that may have been disrupting the water flow. The error of the measurement is within 2 percent of the indicated flow when the setup is under optimum conditions. Several setups were made on shorter than optimum lengths along the horizontal pipe because the vertical pivot pipe contained obstructions. Also, less than optimum conditions inside the pipe may not always have been recognized from outward appearances. Various indicators are given by the flow meter that it is sensing a less than optimum situation. One indicator is a higher or lower value than normal for sonic velocity of the water as measured by the meter. Systems where outlier sonic-velocity values, which were arbitrarily determined to be one standard deviation greater or less than the mean sonic velocity, were measured are indicated in the table. The error of the water-discharge measurements obtained at these systems may be somewhat greater than 2 percent. The water-discharge measurements with outlier sonic-velocity values did not consistently result in conversion factors considered as outliers because only two systems had both values as an outlier.

It is not known whether the sampling of irrigation systems in this project is representative of all the irrigation systems in the area covered by the IVWA. The range in measured discharge was from 100 to 1,410 gpm. High-pressure impact sprinkler heads were used at ten of the measured irrigation systems. The size of the irrigation systems ranged from about 12 to 320 acres. Five of the irrigation systems had multiple pivots supplied from one well. Eleven irrigation systems did not swing through a full circle. The well pumps ranged from a 5 horsepower (hp) submersible pump to a 100 hp turbine pump.

The conversion factor (Q/Kwh) for each irrigation system was calculated with the following equation:

\[ \frac{Q \text{ (discharge in gallons per minute)}}{Kwh \text{ (electrical demand in Kilowatt-hours)}} \times 80 \text{ (minutes per hour)} = Q/Kwh \text{ (conversion factor in gallons per Kilowatt-hour).} \]

The Q/Kwh values for the individual systems are listed in the data table. The average value for Q/Kwh from the 77 sampled irrigation systems is 1.259 gal per Kwh. This value is appreciably lower than the value of 1.505 gal per Kwh currently used by the IVWA. This updated value indicates that the estimated water withdrawn may have been over estimated by about 20 percent.

The large range in Q/Kwh values, from 767 to 1,762 gal per Kwh, obtained on the individual systems could be the result of many different conditions. The lowest Q/Kwh value was made on a system with high-pressure impact sprinkler heads, and the wellhead discharge appeared to have been valved back about one-half. Variations in the depth to water in the well, the efficiency of the well screen and the pump, and the friction losses because of the differing length of and number of bends in the pipe between the well and the pivot will result in a range of values for Q/Kwh.
Mr. Morris Bell

Hopefully, this update of the conversion factor will result in a more accurate accounting of the withdrawals for irrigation made in the area. Accurate figures of withdrawal amounts are needed when assessing the impact of withdrawals from wells on water levels in an aquifer and are a very critical input to any computerized simulation of ground-water flow that is made for a resource assessment of an aquifer.

If there are any questions about this project or if we can be of any more assistance, please contact Chuck Avery at (217) 344-0037, extension 3029, or email cfavery@usgs.gov. If the Central Illinois Irrigated Growers Association could use the data table in another format, such as an electronic spreadsheet file, to prepare the notification of the participants of the results, please let us know. It has been a pleasure dealing with you, the IVWA, the Central Illinois Irrigated Growers Association, and the individual farmers of the area.

Sincerely,

Richard D. Hayes
Acting District Chief
Illinois District

Enclosure

electronic copy
analysis by size of system
suggest database be built of systems age of systems rated pump rate
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Note: The table contains data on system location, system arrangement, president, system number, output, system type, electrical output, electrical input, electrical efficiency, electrical power factor, electrical power, electrical current, control panel, control panel number, electrical efficiency, control panel location, control panel type, electrical panel power, and control panel power factor.