Exhibit No.:	
Issue:	Weather Normalization,
Witness:	Timothy L. Waldron
Type of Exhibit:	Surrebuttal Testimony
Sponsoring Party:	Laclede Gas Company
Case No.:	GR-99-315

LACLEDE GAS COMPANY

GR-99-315

SURREBUTTAL TESTIMONY

OF

TIMOTHY L. WALDRON

SURREBUTTAL TESTIMONY
OF
TIMOTHY LEE WALDRON

Q. Please state your name and business address.

A. My name is Timothy Lee Waldron, and my business address is #34 Deborah Drive, Saint Peters, Missouri, 63376.

Q. What is your educational and previous professional background?

A. I received my BS degree in Professional Meteorology from Saint Louis University (SLU) in 1973 and continued with graduate studies at SLU in boundary layer meteorology and atmospheric acoustics from 1973-1978. I was previously employed by the Environmental Monitoring & Services Center (EMSC) of Rockwell International Corp. as an environmental meteorologist and program manager from 1974-1983. While employed at the EMSC, I was responsible for a large number of environmental programs including the development of the upper-air monitoring network for the St. Louis based Regional Air Pollution Study (RAPS), and the multi-year St. Louis Boundary Layer Study sponsored by the United States Environmental Protection Agency (USEPA).

Q. What is your current position?

A. I am currently President of Met Associates (META), a meteorological and environmental consulting firm.

Q. Please state how long you have held your position and briefly describe your responsibilities.

A. I have held my current position since I founded Met Associates in February 1983. I have overall responsibility for the operation of the company from both a business and technical standpoint. Technically, I am responsible for completion and quality review of all technical work completed by META and its subcontractors for each project. Primary technical areas include installation of meteorological monitoring instrumentation and data systems, quality assurance of acquired atmospheric data, performance audits of existing third party meteorological sensors and measurement systems, atmospheric measurements from remote sensing platforms, evaluation of siting characteristics for atmospheric measurements, and applied meteorological research and development.

Q. What is the purpose of your surrebuttal testimony?

A. I will respond to the testimony of Staff witness Dennis Patterson appearing at page 2, lines 4-9; page 4, lines 2-3; and page 6, lines 14-23 of his rebuttal testimony, where he argues that Dr. Hu's "adjustments" should be made to the official National Oceanic and Atmospheric Administration (NOAA) data utilized by Company witness Pat Krieger. In addition, I will respond to the rebuttal testimony of Staff witness Patterson relating to the proper period that should be used for determining heating degree day normals and to the rebuttal testimony of Staff witnesses James Gray and Henry Warren concerning Staff's application of water heating degree days (WHDD) to "normalize" gas water heating usage and to determine test year water heating usage.

Q. Why should Company witness Krieger not utilize Dr. Hu's adjustments as argued by Mr. Patterson in his rebuttal testimony?

A. There are numerous reasons why the "adjustments" of Dr. Hu are not appropriate for use in this case. These generally fall into two primary areas of deficiency; a general

deficiency in the statistical methodology employed, and the failure to account properly for meteorological effects on atmospheric measurements.

Q. What are the statistical deficiencies that make the Staff sponsored "adjustments" invalid?

A. Both Company witnesses Turner and Krieger have discussed in detail the statistical, factual and theoretical deficiencies underlying these adjustments. My surrebuttal testimony will focus on the meteorological flaws that warrant Ms. Krieger's rejection of these adjustments.

Q. What are the meteorological shortfalls in the Staff's analysis that would make the use of these "temperature adjustments" by Ms. Krieger inappropriate?

A. Actually there are several areas where the proposed Staff adjustments fail to accommodate meteorological issues. But first I want to make a distinction here between the climatological and meteorological aspects involved in this type of analysis. It should be noted that climatology is an attempt to generalize or "average" the meteorological conditions experienced at a particular site. The meteorological conditions at a given site, and at a given time, describe the state of the atmosphere existing at that point in time. Averaging meteorological data must be done with care so as not to reflect conditions that may not actually exist. For example, a site that always experiences calm winds every night for 12 hours, and 10 mph steady winds for 12 hours every day of the year would have a "climatological" average wind speed of 5 mph, even though that meteorological condition never existed at the site. It is important that climatological analyses reflect true meteorological conditions and not modify them through statistical manipulation.

Q. How is this relevant to the proposed Staff adjustments to the St. Louis Lambert Station (Lambert) temperature data in the current case?

A. It is relevant because the Staff, in proposing a single "year-round" adjustment factor, has completely failed to consider and account for the critical fact that the meteorological conditions that contribute to measurement differences at Lambert or any other site can and will vary on a daily and seasonal basis. In some instances, these daily and seasonal variations can be significant. As a result, while a portion of the measurement discrepancy between two sensors will likely be due to a difference in the internal electronic means used to obtain the temperature, part of it will also reflect the sensor's response to existing meteorological conditions. Although the electronic measurement difference may be a constant (for example, a constant offset in a resistance measurement), the meteorological differences are likely to be variable as a function of time of day (diurnal, 24 hour variation pattern), day of year (seasonal variation), occurring wind speed, wind direction, cloud cover, solar radiation intensity, etc.

Q. Can you provide an example of how data from a sensor, or from two different sensors, can be affected differently by these meteorological factors?

A. Yes. For instance, if the housing that contains the temperature sensor is not very effective in shielding solar radiation effects, the temperature could be overestimated as a function of solar intensity.

Q. Would this necessarily affect all temperatures measured by this device in a consistent manner?

A. No. In fact, the effect on the data can be negated, or even reversed, depending on meteorological effects. In the above example, cloudy or windy conditions, or simple

darkness, can negate the deficiency in the measurement system. Dr. Hu's adjustments have failed to consider these types of variable meteorological effects on measurements. This flaw is critical because such differences will vary, and such variations must be accounted for.

Q. Have other investigators found and isolated these variable effects?

A. Yes. There are several published works, both within NOAA and the National Climatic Data Center (NCDC), as well as other published works, which have identified and quantified these separate effects. For example, Guttman and Baker (NCDC, 1996) have segregated the meteorological conditions (windy, clear, cloudy, day, night, etc.) when examining temperature differences between ASOS (Automated Surface Observing System) and conventional measuring equipment. Their primary conclusions included the following:

> *The most important conclusion from this study is that differences in site characteristics, even at the same airport, play as much, if not more, of a role in assessing the comparability of measurements from the two observing systems as does the instrument bias. The instrument bias at most stations is on the order of a few tenths of a degree Fahrenheit, but the siting differences can lead to biases on the order of a couple of degrees.... This study shows that there is not a straightforward, simple, average correction that can be applied to adjust one block of data to another block.*

The variation of the important meteorological parameters as a function of season are classic and well known for the St. Louis area. Winds are higher in the winter with a minimum in the summer months. Radiative effects are of course higher in the summer. Both of these conditions would minimize biases (and any corresponding adjustment) during the winter season and maximize them during the summer season. Keiser and Griffiths (International Journal of Climatology, Vol. 17., 497, 1997) clearly show that homogeneity corrections to climatic temperature series vary greatly by season and must

be accounted for. Similarly, Quayle, Easterling, Karl, and Hughes (NOAA, NCDC, Bulletin of the American Meteorological Society, Vol 72, No. 11, 1991) found that corrections for maximum and minimum temperatures for thermometer changes may even have different signs (i.e., +/-).

In summary, the failure of Staff to even discuss, much less account for, these seasonal variations makes the use of its "corrected" data not only inappropriate for Ms. Krieger's analysis, but for Staff's as well.

Q. Are there other concerns that negate the Staff's proposed corrections to the temperature data?

A. Yes. For instance, urban warming. The area around the St. Louis airport has undergone significant urbanization over the last 25 years or so, which must be accounted for in any long-term trend analysis. I have personally observed this gradual warming through the years as the areas surrounding Lambert have gone from "rural" in nature, to more urban. Hence, there has been a slow warming (bias) in the Lambert data compared to earlier years due to the increasing development around the airport location. Use of data from stations experiencing urbanization effects should be avoided as pointed out by Karl & Williams (1987), page 1762.

> ... "4) stations with nonclimatic progressive changes due to urbanization may lead to inappropriate adjustments at nearby stations.... Probably the best solution is to avoid the use of urban stations in the adjustment method and to use an iterative procedure with methods that do and do not use station histories."

The continuous urbanization effect on the Lambert data casts additional doubt on Dr. Hu's suggested adjustments for the 1979 and 1988 time periods, which he claims are solely a result of station changes.

Q. In your opinion, are the data available for Lambert and the coop stations sufficient to determine precise corrections to the time series data as Dr. Hu's adjustments suggest?

A. No. I have performed various analyses to discover and correct for relatively small effects in temperature time series data in the St. Louis area. However, I have found that in order to achieve success in such endeavors, more detailed data are necessary. For instance, hourly (or sub-hourly) temperature data, including maximums, minimums, and period standard deviations, must be obtained. The hourly information available in this case from Lambert and the daily summary data available from the comparative coop stations are simply not sufficient to detect accurately and correct for small data effects.

As pointed out in the paper by Guttman and Baker (NCDC, 1996), even with the recent advances in the NWS (National Weather Service) ASOS measurement system, the NWS data remain sufficient to support aviation functions, but not necessarily for more demanding applications. Meteorological use of the data (remember that NWS temperatures are rounded to the nearest degree) for applications demanding high data precision and accuracy, such as Dr. Hu's determination of "adjustments," is not appropriate.

WATER HEATING DEGREE DAYS

Q. Do you have any comments in response to the rebuttal testimony of James Gray and Henry Warren concerning the Staff's use of Water Heating Degree Days (WHDD) to calculate and normalize baseload volumes?

A. I have a number of concerns about Mr. Gray's contention at pages 7-8 of his rebuttal testimony that the Company's baseload volumes need to be normalized, presumably

based on Staff's calculation of WHDDs. In my opinion, there is no valid basis for normalizing these volumes through use of the method proposed by Staff.

Q. What is your concern with the Staff's calculation of water heating degree days?

A. Actually there are several and they are quite serious. Staff's rebuttal testimony references the June 1999 direct testimony of Dennis Patterson, wherein Mr. Patterson states that "*Subsequent staff analysis has shown that Missouri River water temperatures (RWT) observed at Chain of Rocks treatment plant serves as a statistically reliable proxy for inlet water temperatures in the St. Louis region.*" (p. 3, lines 6-8). However, none of the "*subsequent staff analysis*" is presented or even referenced, and this assumption is not valid.

Q. Why do you believe that this assumption is not valid?

A. Staff's use of data from an unknown, uninspected sensor as the basis for an eventual calculation of 30 years of WHDD's is extremely dangerous. First, any data from the measurement sensor must be validated by calibration records or by comparison to other nearby measurements in the Missouri River. Staff gives no indication that supporting documents for data quality were provided by the Corps of Engineers or the City of St. Louis. My experience with industrial process water temperatures is that they are often not calibrated for the entire service life once placed in service. Use of the data must be supported by some evidence of data quality.

Q. If Staff could show support for validation of the Chain of Rocks water temperature data, would use of the data be appropriate?

A. No. First of all, the Staff would have to show that this single point reference base was a reasonable estimate of inlet temperatures for not only the Missouri River, but also the

Mississippi and Meramec rivers. That is very unlikely given the large difference in river size (flow and depth) between the Missouri and Meramec (the Meramec would heat and cool in response to air temperatures much more rapidly). There are many other factors that also affect river water temperatures.

Q. What are some of these additional factors affecting water temperature data?

A. First of all is the height (depth) of the sensor. Unless the sensor is on a free-floating gauge support, the measurement is being made at a continuously varying depth below the surface that can vary in its rate of response to weather effects, especially depending on river depth. Second, the upstream environment needs to be documented for thermal influences, including runoffs, water outlet locations, etc. There are many river temperature models available that can model these effects given documentation of the upstream environment.

Q. What data was used by Staff in their calculations?

A. The Staff acquired Missouri River daily RWT (River Water Temperature) for the period of 1986 through 1998, all days inclusive, from either the Corps of Engineers or the City of St. Louis. However, because Mr. Patterson did not believe these data were sufficient to calculate normal daily WHDD for the present case, he performed a statistical correlation of the 13 years of RWT and mean daily temperatures and then simply fabricated the 25 years of data he was missing from 1961-through 1985! This data "creation" allowed him to have numbers for a complete set of 1961-1990 RWT data. Then the calculation of WHDD was made for the period 1961 through 1990. Thus, his determination of WHDDs was based on a 30-year series of river water temperatures, of

which 25 years were fabricated! This is certainly not an acceptable methodolgical approach that will produce meaningful results.

Q. Would the measurement of Missouri River water temperature, as used by Staff to determine WHDDs, provide a reasonable estimate of the actual inlet temperature experienced at a residential water heater?

A. Except in a few cases of coincidence, surely not. The residence time of the water within the system distribution piping, after leaving the river inlet point, is significant enough that the water temperature will become more representative of the subsurface soil temperature at the time it enters the inlet to the customers water heater where actual usage occurs. As a result, it will be substantially different from the river water temperatures, even when correlated with air temperatures. Given these considerations, it is clear that the Staff's method of trying to normalize water heating gas usage with river temperatures, or current weather, is totally inappropriate. Mr. Gray is, therefore, completely mistaken when he states that Ms. Krieger should have calculated and normalized base volumes as Staff has.

30-YEAR NORMALS

Q. From a meteorological standpoint, do you have any comments regarding the statements made by Mr. Patterson at pages 3-7 of his rebuttal testimony concerning Staff's use of the 30-year period ended 1990 to determine normal heating degree days (HDD)?

A. I find the NOAA 30-year published normals quite useful for quickly assessing the climate and variability of weather at any given location. However, I find it inappropriate and discouraging to use the static 30-year normals (those calculated at the end of each decade

based on the temperature data of the prior three decades) for purposes of setting rates for the future.

Q. Why do you feel that way?

A. Using static 30-year values of HDD as the benchmark to represent future annual HDDs no longer makes sense. As shown by Company witness Turner in his surrebuttal testimony and references, the most appropriate time period for short-term trends turns out to be in the 5 -7 year range for rolling averages, not surprising since that is probably the most dominant time cycle in U.S. climate patterns. Dr. Turner has calculated raw performance statistics for these shorter averaging periods that have shown their superiority in estimating near-term HDDs compared to using 30-year fixed normals.

Q. Do you have any final comments concerning Mr. Patterson's statement in his rebuttal testimony that a 30-year normal is more appropriate than a 10-year normal?

A. Yes. The Staff's avoidance of the urbanization issue for the Lambert data continues to be troublesome from a meteorological viewpoint. As I indicated previously, being in the St. Louis area and attuned to the Lambert meteorology since 1969, I have watched firsthand the reported Lambert data, day by day, year by year, undergo the urbanization effect. Indeed, I have operated instrumentation in the last 10 years at Weldon Spring, Times Beach, Desoto, Barnhart, etc., and I can verify that Lambert temperatures, under the proper conditions, are much warmer than the rural measurements. In other words, the urbanization around the Lambert site is very real. Given this urbanization induced warming trend, it is far more appropriate to use a more recent 10-year normal that reflects this warming trend than to use weather data that is nearly 40 years old and precedes the beginning of this urbanization effect by a decade or more.

Q. Does this conclude your testimony?

A. Yes it does.

BEFORE THE PUBLIC SERVICE COMMISSION

OF THE STATE OF MISSOURI

In the Matter of Laclede Gas Company's Tariff to Revise Natural Gas Rate Schedules.	)	Case No. GR-99-315

AFFIDAVIT

STATE OF MISSOURI	)	
	)	SS.
CITY OF ST. LOUIS	)	

Timothy L. Waldron, being first duly sworn, deposes and states:

1. My name is Timothy L. Waldron. My business address is #34 Deborah Drive, St. Peters, Missouri 63376; and I am President and Founder of Met Associates, a meteorological and environmental consulting firm.

2. Attached hereto and made part hereof for all purposes is my surrebuttal testimony, consisting of pages 1 to 12, inclusive.

3. I hereby swear and affirm that my answers contained in the attached testimony to the questions therein propounded are correct to the best of my knowledge and belief.

Timothy L. Waldron

Subscribed and sworn to before me this 19th day of August, 1999.

JOYCE L. JANSEN
Notary Public — Notary Seal
STATE OF MISSOURI
St. Louis County
My Commission Expires: July 2, 2001