Northern Water

WEATHER STATION NETWORK

Background Information

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Northern Water Weather Station Network – Purpose and Background

The purpose of Northern Water's weather station network is to provide accurate and representative crop and turf water use information to area residents. Automated, electronic weather stations are the least costly means to accomplish this objective over a large area. When properly sited, maintained, and sensors are kept calibrated – weather stations will provide accurate data for calculation of reference evapotranspiration (abbreviated as ETrs for full cover alfalfa or ETos for cool-season turf). Reference ET is subsequently factored using crop growth curves to adjust reference ET to be crop water use for agricultural operations or turf water use for urban landscapes, both abbreviated as ETc.

Northern Water installed its first weather station in 1986 at its former headquarters in Loveland. The instruments were manually read at 8 a.m. each morning. The network is now fully automated and includes 19 stations within Northern Water's boundaries in Northeastern Colorado and two stations on Colorado's Western Slope. Ten of these stations are sited in irrigated alfalfa fields and are considered to be agricultural weather stations. Nine of the remaining stations are sited in large urban turf areas such as golf courses and athletic fields. Two stations are sited at higher elevation, one in an open area of native grass alongside a river and the other next to a reservoir.

Northern Water does not forecast the weather. The weather station network only measures and reports weather conditions that have occurred. None of the stations include a barometer, a basic forecasting instrument. Weather forecasts may be obtained from the National Weather Service, local TV stations, Internet sites, or the Weather Channel on cable/satellite TV.

Operational Standards

Northern Water strives to comply with the published standard: ASAE EP505.1 APR2015 Measurement and Reporting Practices for Automatic Agricultural Weather Stations.

Calculation of reference evapotranspiration by Northern Water follows the 'ASCE Standardized Reference Evapotranspiration Equation', 2005, American Society of Civil Engineers. Hourly calculations of standardized reference ET are performed – except for older data sets containing only daily summaries, where daily calculations are then necessitated. Northern Water also utilizes the guidelines in 'Appendix D – Weather Data Integrity Assessment and Station Siting' and in 'Appendix E – Estimating Missing Climatic Data'.

Northern Water follows rigorous preventive maintenance and quality assurance / quality control (QA/QC) programs. Significant resources are allocated to properly operating and maintaining the weather stations to insure the accuracy and representativeness of the weather data obtained. However, short term outages may result from damaged equipment or from scheduled maintenance activities. Data are continuously reviewed and evaluated to quickly identify, correct, and minimize dissemination of faulty data.

Key Terminology

Evapotranspiration – one of the most basic components of the hydrologic cycle – is the combination of water transpired by vegetation and evaporated from soil, water, and plant surfaces.

Standardized reference evapotranspiration – evapotranspiration from a uniform surface of dense, actively growing vegetation having specified height and surface resistance, not short of soil water, and representing an expanse of at least 100 meters of the same or similar vegetation. Full-cover alfalfa (0.5-meter or 20-inch height) is typically considered the tall crop representative of ETrs. Clipped, cool-season grass (0.12 meter or 4.7-inch height) is typically considered the short crop for ETos. Calculation of reference evapotranspiration by Northern Water follows 'ASCE Standardized Reference Evapotranspiration Equation', 2005, American Society of Civil Engineers. This is a very well regarded, nationally standardized method of calculating reference ET.

Kc – or crop curve factors are used to factor ETrs or ETos to derive crop and turf water use or ETc. The crop curves utilized by Northern Water are traceable to curves derived by J. Wright (1982) based on lysimeter measurements at Kimberly, Idaho. Wright's time-based, basal crop curves were published in ASCE Manual 70, 'Evapotranspiration and Irrigation Water Requirements', M. Jensen, 1990.

Kp – class A pan coefficient is part of the FAO-24 Pan Evaporation Method as presented in ASCE Manual 70, 'Evapotranspiration and Irrigation Water Requirements', M. Jensen and R. Allen, 2016, pp. 214-218. Basically, ETo = Kp x Epan. Although pan evaporation or Epan is a simple, direct measurement, the service and maintenance requirements of a class A pan are very high and fraught with problems. Hence Epan is often estimated from ETo values calculated from weather data.

Effective precipitation – is the fraction of measured precipitation that meets crop water use or ETc. Precipitation that is 'lost' to surface runoff or deep percolation – not stored in the plant root zone – is considered non-effective. By definition, effective precipitation is not included in crop and turf water use calculations or ETc. It is included in calculations of the irrigation requirement where it is subtracted from ETc.

Tipping bucket rain gauges – measure liquid rainfall utilizing small 'buckets' balanced on a pivot, much like a seesaw. Falling rain drops into a funnel, which directs the water into the bucket on one side of the seesaw. When the bucket fills, its increased weight tips the seesaw, emptying that bucket but bringing the bucket on the other side upwards and into position to capture the water draining from the funnel. Each tip of the seesaw closes a reed switch, triggering an electrical pulse to the data logger. The data logger counts the pulses or tips, with each tip typically representing either 0.01-inches or 0.005-inches of rainfall.

Advantages of tipping bucket rain gauges are:

1. Lower equipment costs
2. Clear start/stop periods for rainfall events

Disadvantages include:

1. If rainfall stops just before a bucket fills and tips, that amount of rain will not be recorded until additional rain occurs (it may evaporate if the delay is significant),
2. Heavy rainfall tends to be under measured because of the 'spillage' occurring at the moment the seesaw tips
3. The small orifice of the collection funnel is subject to plugging from windblown debris or bird droppings
4. Frozen precipitation (hail, snow, etc.) is not measured until it is melted by a heater or by warming air temperatures. None of the tipping buckets at Northern Water weather stations incorporate heating elements, hence they are normally operated from March through October.

Weighing bucket precipitation gauges – capture all precipitation, whether liquid or frozen, into a catchment or storage bucket. The weight of the bucket is converted to an electronic signal recorded by the data logger. The change or difference in recorded weight overtime represents the measured precipitation.

Advantages of weighing bucket precipitation gauges are:

1. They measure all forms of falling precipitation (rain, sleet, hail, snow, etc.).
2. They do not underestimate intense rainfall (no ‘spillage’ losses).

Disadvantages include:

1. Increased equipment cost
2. Potential for measurement noise or bounce especially during high winds
3. Increased maintenance requirements. A surface oil film in the catchment bucket reduces evaporation and an antifreeze mixture minimizes the catchment volume of snow. If the bucket is neglected and allowed to overfill and spill, precipitation measurements are lost until the gauge is emptied and recharged.

Rso – is the calculated short wave, incoming solar radiation under clear sky conditions. On cloud free days it matches measured solar radiation or Rs. Northern Water utilizes the most complete Rso equation with improved coefficients as included in REF-ET 3.01 by R. Allen, University of Idaho, abbreviated as RsoSTƵDb, based on complete Rso equation included in Appendix D, ASCE Standardized Reference Evapotranspiration Equation, ASCE.

U@2m – is the wind speed at 2-meter height over clipped grass. It is required by the ASCE Standardized Reference Evapotranspiration equation. However the wind sensors at the Northern Water weather stations are typically installed higher than 2-meters and the majority of them are not sited over turf grass. Consequently, measured wind speed at each weather station is adjusted according to the procedures presented in ASABE Publication Number 711P0810cd by T.W. Ley, R.G. Allen, and M.E. Jensen in Phoenix, AZ, December 2010