

## Chapter 3

### Step 1 - Gather Information and Data

#### Introduction

The first step in the process of calibrating a conceptual hydrologic model to an entire river basin is to gather all the information and data that will be needed. This includes basic information on the climatology of the area, physical features, control structures and other modifications to natural flow, and operational forecast data and requirements. It also includes all available sources of historical data. This step also involves accessing the relevant historical data and converting it to the form needed for further processing in subsequent steps.

When doing an extension of the data record the exact same historical data requirements pertain to the extension period as are described in this chapter for the initial calibration period. In addition to data for the extension period, data for about 10 years prior to that period should also be gathered so that the consistency of the records over time can be evaluated. When doing an extension of the historical record the basic information that should be gathered is that which indicates changes that occurred during this period such as new reservoirs or other control structures, new forecast requirements, and changes involving agricultural practices, vegetation cover, and land use.

This chapter lists the basic information and historical data that may be needed for the calibration of a river basin, possible sources of the information and data, and data selection criteria. The exact way that the information and data are used in the calibration process are described in subsequent chapters.

#### Basic Information Requirements

A variety of items should be gathered at the beginning of the calibration process. This includes information about the climate of the basin, physical features such as topography, soils, and vegetation, the location and operating procedures of control structures, and real time data and forecast locations. A number of these should be able to be accessed via the Calibration Assistance Program (CAP). The current features, capabilities, and user instructions for CAP are described in sources outside of this manual. For some basins reports from agencies such as the USGS and Corps of Engineers contain a variety of these types of information that can be helpful in understanding the hydrology of the area.

#### Climatological Information

- Isohyetal maps showing annual, seasonal, and/or monthly average values of precipitation over the area. This is most important in mountainous areas, but there may be other areas where the variation of average precipitation over the area cannot be ignored when analysing precipitation data and generating areal average time series for model input. Such areas include t

hose with lake or ocean influences (e.g. areas that include zones affected by lake effect snow patterns). The most common source of digital isohyetal maps is the PRISM maps produced by the NRCS and Oregon State University [Daly *et al.*, 1994]. There may be other isohyetal maps for parts of the United States that also should be examined.

- Evaporation analyses that show the magnitude and variation of evaporation over the river basin. One source is NOAA Technical Reports NWS 33 and 34, “Evaporation Atlas for the Contiguous 48 United States” [Farnsworth and Peck, 1982] and “Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States” [Farnsworth and Thompson, 1982]. These reports contain maps of May-October pan evaporation, May-October Free Water Surface (FWS) evaporation, annual FWS evaporation, and pan coefficients over the lower 48 states. The reports also contain tables of monthly, seasonal, and annual pan evaporation for various sites in each state derived from pan data and computed from meteorological factors. There is also some information on the variation of pan evaporation with elevation. There may be other reports, typically by government agencies or universities, on evaporation analyses for a given river basin or state which would be helpful to have available.

- Other climatological analyses involving variables such as temperature, runoff, snow cover, frozen ground and/or glaciers. The PRISM project has developed maps of average temperature values. In some river basins maps showing how runoff varies over the area have been produced. These maps are generally done as part of a water balance study. Maps of average snow depth or water equivalent may be available for some basins, as well as reports on the variation in frost depth. In Alaska and in the Pacific northwest it is important to know whether the basin is affected by glaciers and if so, the location and coverage of the glaciated area. Reports on how the glaciers are changing over time can also be very helpful.

### Physical Information

- A basic map of the river basin. The map should show location of rivers and streams, major lakes and reservoirs, and contain topographic information. The maps may also contain general information about vegetation cover and show locations of glaciers. The maps can not only be used to get a general understanding of the physical layout of the river basin, but are useful to visualize drainage areas and gage locations.

- Information on vegetation cover and land use. It is important to know how much of the basin is covered by vegetation, and the type of vegetation, as well as how the vegetation or crop patterns may have changed over time (e.g. changes to the amount of forest cover due to reforestation, suburbanization, or large forest fires). It is also helpful to know which portions of the basin contain agricultural areas and which are urbanized. In addition, NDVI Greenness fraction data can assist in determining the seasonal variation in vegetation activity.

- Soils information. Can be used to subjectively assess how various soil moisture parameters may vary relatively over the basin. Soils data can also be used to compute initial estimates of parameters for the Sacramento Model. In some northern areas permafrost may exist over

er portions of the basin and can have an effect on streamflow.

- Geological information. Can be helpful in determining how parameters may vary over the basin, especially groundwater parameters. Such information can also help to determine if parts of the basin significantly contribute to deep groundwater recharge or if karst regions may exist.

#### Information on Controls and Transfers

- Reservoirs and large lakes. It is important to know where these features are located, how they control the flow, and the magnitude of their effect. Ideally these features should be modeled. In order to do this information such as area-elevation and elevation-discharge curves are needed. For reservoirs, details on how the dams are operated is important.
- Other types of structures. These include small dams (including farm detention reservoirs) and power plants. These structures primarily affect low flows, small storms, and flows after dry periods. It is important to know the general type of such structures and where they exist in the river basin.
- Diversions of water across watershed boundaries for purposes such as water supply, irrigation, and power generation. Diversions can also occur at high water levels when rivers or impoundments may overflow across drainage divides. It is critical to know where such diversions occur so that data can be obtained to model the diversion or adjust the streamflow records to reflect natural flow conditions if the magnitude is significant.
- Irrigation that occurs within a given watershed. Besides removing water from the river, the irrigated land is kept wetter than would naturally occur thus affecting the amount of runoff from subsequent storms, and some of the removed water may reenter the stream later as return flow. It is important to know the amount of irrigated acreage, the rules governing the removal of water, and seasonal changes in irrigation demands.
- Drainage systems. In some agricultural regions drain tiles have been installed underground to control the drainage of excess water from the soil. In other areas wetlands have been drained or farming practices may affect runoff generation. It is important to know about these items and when they occurred and how they may have changed over time.
- Large springs. May represent a large portion of the flow at low levels, or they may contain areas where a significant portion of the percolated water can go to deep aquifers. Both of these occurrences can have an important effect on the modeling of baseflow and need to be known and, if possible, quantified.

#### Operational Information

- Operationally available data. Knowledge of available real time data, especially river and r

eservoir observations, is needed to help determine how the river basin should be divided for modeling purposes.

- Location of current forecast points and future user requirements. Needed to help determine how the basin is divided for historical data processing and model calibration.

### Historical Data Requirements

A variety of historical data needs to be gathered for direct use in calibration. Hopefully the data are already in digital form, however, in some cases critical data may only exist in tabular form and would have to be converted in order to be used. Besides finding the data and determining which records are needed for calibration, the actual data values need to be put into the format required for use by the calibration programs (currently in NWSRFS this is the DATACARD format).

The period of record needed for historical time series depends on how the calibration results are to be used for operational applications. If there is any possible application of the results for extended ensemble predictions, then the longest possible period of precipitation and temperature data should be used in order to generate the most statistically reliable results. Since only a limited number of stations are available in digital form in the National Climatic Data Center (NCDC) climatological records prior to 1948, the longest reasonable data period to process is that from water year 1949 to the time of the most recent available data. If significant changes occurred in the station network over the years, the data for this entire period might not produce time series that consistently represent a reasonable estimate of what occurred over the river basin. For example, in some western areas there were few if any high elevation stations until the advent of the SNOTEL network maintained by the Natural Resources Conservation Service (NRCS). In this case time series produced from only low elevation sites prior to the installation of the SNOTEL stations likely would not produce reasonable estimates of conditions, especially the timing and amount of precipitation, at the higher elevations. Only the period of record after the beginning of the SNOTEL network would likely produce reasonable estimates of model input values and thus would be the period selected for accessing historical data. Chapter 5 contains more information concerning this situation and how to determine if periods of record with very different networks can be mixed.

If the calibration results are only going to be used for short term river forecasting, then possibly a shorter period of record will be sufficient. In this case only the period of record needed to calibrate the models is required. Chapter 5 contains recommendations for selecting a calibration period for a given location, however, since the data are being processed for an entire river basin, the data period must cover the calibration periods of all flow points within the basin. This will allow for the calibration of each point and the routing of flows downstream.

If there are any questions concerning whether a given station should be included at this stage, it is best to include it. When the data are later analyzed, as described in Chapter 6, stations with problems or those that don't add information content can easily be removed, but it is inefficient to

go back and retrieve additional data.

The exact programs or procedures to view and access the data are generally not included in this manual. Much of the historical data can be obtained via the NOAA Hydrologic Data System (NHDS). Some of the data are obtained from the agency responsible for collecting the information and then stored and possibly reformatted for use in the NHDS. Various NHDS programs are then available to view and access the data. Other data are obtained directly from agency websites and then converted into the format needed for NWSRFS by NHDS provided utilities. In other cases individual RFCs have developed programs and procedures to obtain various data from other agencies. Since many of the procedures for obtaining data are changing periodically and may vary from one office to another, this information will not be covered. This manual concentrates on the data needed, selection criteria, and how to use the data.

### Precipitation Data

Daily and hourly precipitation data are required in order to generate Mean Areal Precipitation (MAP) time series from historical data.

- Daily Precipitation from the National Climatic Data Center (NCDC). The recommended guidelines for selecting daily precipitation stations for further analysis are:
  - stations within the river basin boundaries and stations slightly outside the boundaries that could be assigned Thiessen weights when computing MAP or would be likely estimates for stations within the boundary that have significant periods of missing data,
  - in mountainous areas, stations that are outside the basin boundaries but represent elevation zones and orographic precipitation patterns within the basin, and
  - stations with at least about 5 years of generally complete data (about 5 years of data are needed to determine a reasonable estimate of the mean precipitation at a given site). Even such short periods of precipitation records are generally included because of its significant spatial variability.

The NCDC climatological network is comprised primarily of volunteers who receive minimal payments for making observations, thus there are many cases when new observers must be found and stations are moved from one location to another. NCDC station data records are defined by a station number. In some cases when a station is relocated the number remains the same, while in other cases a new number is assigned and thus a new data record is established. Sometimes a station can be moved 10 miles and the number remains the same, whereas other times one station is discontinued and a new station immediately established only a few miles away. In at least one case a new station was established when there was no site or equipment change, only the name was changed. One option when a station is discontinued and a new station established a short distance away, is to merge the data from the two stations into a single data record. This can be done even when the new location has less than 5 years

rs of data and is especially important to do if the new station is part of the operational network.

- Daily precipitation data from other available networks or sources. One such source is the SNOTEL network that is maintained by the NRCS. This data source is very important in most of the west and Alaska. Daily precipitation data may also be available from other networks such as IFLOWS, statewide or local ALERT installations, regional climate centers, historical data bases maintained by some RFCs, and from Canadian or Mexican sources. The recommendations for which stations to include are the same as for the NCDC network. The situation of station relocations normally doesn't exist for automated networks.

- Hourly precipitation from NCDC. The recommended guidelines for selecting hourly precipitation stations for further analysis are:

- stations within the river basin boundaries, plus stations surrounding the basin that will be used to time distribute records of previously selected daily stations,
- in mountainous areas, stations that are outside the basin boundaries but represent elevation zones and orographic precipitation patterns within the basin, and
- stations with at least about 5-10 years of generally complete data.

By having hourly stations surrounding the daily stations, there is a tendency to dampen the precipitation intensity as a storm moves across the basin, however, this is probably better than having an hourly station in only one direction used to time distribute a daily amount and thus offsetting when the event occurred. Where daily and hourly records both exist at the same location, it is generally best to include both, since there is a tendency for more missing data and less accurate estimates of missing amounts at hourly stations using the NWSRFS programs (the estimation of missing hourly data is only based on other hourly stations, whereas missing daily data are filled in using all stations). Hourly stations that may be assigned weights when computing MAP need only about 5 years of data, whereas one may decide to use only those with a slightly longer data period to time distribute daily records. For those stations used only for time distribution of daily data, their period of record should overlap that of the stations they will be used to distribute. Comments regarding NCDC network relocations and merging of records given for daily stations also apply to hourly stations.

- Hourly precipitation data from other available automated networks or sources. The recommendations for which stations to include are the same as for the NCDC network. The situation of station relocations normally doesn't exist for automated networks.

### Temperature Data

Air temperature data are needed for snow model computations, frozen ground effects in conjunction with the Sacramento Model, and ET computations in the consumptive use operation (alternat

ive to using a PE time series). The air temperature data are used to compute Mean Areal Temperature (MAT) time series. Currently the calibration program used to compute MAT only uses daily maximum and minimum air temperatures, as opposed to the operational MAT program which uses both instantaneous and max/min temperature data.

- Daily maximum and minimum temperatures from the NCDC climatological network. The recommended guidelines for selecting max/min temperature stations for further analysis are:
  - stations within the river basin boundaries and stations slightly outside the boundaries that could be assigned weight when computing MAT or would be likely estimators for stations within the boundary that have significant periods of missing data,
  - in mountainous areas, stations that are outside the basin boundaries but represent elevation zones within the basin that have limited temperature observations, and
  - if possible, stations with generally complete data for the entire or at least a majority of the period of record, though stations with shorter records should be included when there are elevation zones and portions of the basin that are not represented by stations with more complete data. Stations with shorter records are most commonly used in mountainous areas that don't have sufficient high elevation stations with extended records.

Air temperature doesn't have nearly the amount of spatial variability as precipitation, thus one can be more selective when choosing which temperature stations to use. It is not necessary to include stations with short records that represent portions of the basin or elevation zones that have sufficient stations with longer records.

When analyzing temperature data and computing mean areal time series, all stations must have mean monthly max and min values. Unlike for precipitation, there is currently no preliminary processing program that will estimate mean values for the entire period of record in a consistent manner from stations with varying lengths of data observations. Mean monthly values are computed from the existing data for each station. Thus in order to get a good estimate of the long term mean, the station should have data for as much of the period of record as possible (ideally for 70% or more of the historical data period being used). When stations with short data periods are included, the mean monthly values will need to be estimated manually using the procedure outlined in Section 6-4.

- Daily maximum and minimum temperature data from SNOTEL stations and any other available sources including regional climate centers and historical data bases maintained by some RFCs. The selection guidelines are the same as for NCDC stations.

### Evaporation Data

Evaporation data are used by several of the NWSRFS rainfall-runoff models (SAC-SMA, API-CONT as an option, API-HAR, API-HAR2, and XIN-SMA), reservoir models to compute surface

evaporation losses (RES-J and RES-SNGL as options), and some other operations (CHANLOSS as an option to compute stream evaporation loss and CONS\_USE as an option to compute evaporation from irrigated areas). Several of these operations will accept evaporation input in two forms, daily time series or average mean monthly values. Also, the quantities needed vary from Potential Evaporation (PE), to mean values adjusted for vegetation activity, to lake evaporation adjusted for heat storage. In order to obtain the proper input for a given operation, the starting point is either daily or average monthly estimates of PE.

- Daily estimates of PE are obtained in one of two ways:

- Computed from meteorological factors at selected synoptic sites using NHDS programs.

These programs currently estimate solar radiation from manual sky cover observations using the method of Thompson [1976]. Since the advent of the ASOS, these sky cover observations are no longer available. Other methods exist for determining solar radiation including direct observations, computing from percent sunshine data, and satellite derived values. None of these options are currently included in the NHDS programs. Based on a study by Lindsey and Farnsworth [1992], it was shown that using sky cover to estimate solar radiation causes the resulting PE estimates to be biased. The bias varies spatially over the lower 48 states. The NHDS procedure includes an adjustment for each available station to remove this bias so that the average annual PE that is produced matches the average annual lake evaporation given by NOAA Technical Report NWS 33.

- Generated using the Mean Areal Potential Evaporation (MAPE) program. This program can use daily PE time series computed from meteorological variables and daily pan evaporation time series to generate daily MAPE values. Daily pan data are obtained from NCDC. Missing pan data are estimated in the MAPE program. Pan coefficients, used to adjust pan observations to become lake evaporation estimates, must be included in the consistency corrections applied to the stations.

- Average monthly estimates of PE can be obtained in the following ways:

- Use the average monthly values computed from meteorological factors generated by the NHDS programs or tabulated in NOAA Technical Report NWS 34.

- Apply the proper pan coefficient to the average monthly pan evaporation values obtained for NCDC stations with pan observations or tabulated in Technical Report 34.

- Use annual and seasonal average lake evaporation values shown in NOAA Tech Report NWS 33 and prorate these to monthly values using distributions based on stations given in NOAA Tech Report NWS 34 or obtained from NCDC stations with pan measurements.

These lake evaporation values have been digitized and seasonally distributed using formulas based on Report 34 data so that monthly estimates of PE can be obtained using CAP.

## Streamflow Data

Streamflow data are needed at all river locations where comparisons are going to be made between simulated and observed flows during the calibration of the river basin. Streamflow data may also be needed at locations just downstream from reservoirs so that reservoir inflow can be computed and thus compared to simulated inflow even if the operation of the reservoir itself is not going to be modeled (pool elevation or storage data are also required to compute inflow). Streamflow at locations below a reservoir or at the lower end of an area that is not yet or cannot be reasonably modeled, are also used to generate flows to route downstream. In addition, streamflow data can be used in calibration to remove the contribution from a portion of a watershed significantly affected by a control structure, diversions, irrigation, or another influence which is going to be accounted for operationally, but not during calibration (i.e. information is available in real time to estimate the contribution, but not historically – during calibration only the uncontrolled portion of the watershed is to be modeled).

Since at this point in the process a determination has not yet been made as to which river locations are to be included in the calibration process (to be determined during step 3 and described in chapter 5), it is best to just determine exactly what streamflow data are in a readily available form and wait to access the data and put it in the proper form until the river basin breakdown is completed.

Streamflow data can be in the form of mean daily flows or instantaneous discharges. Mean daily flow values are used to determine the volume of flow and its general timing. Instantaneous discharges are needed for faster responding streams and for locations with diurnal variations in flow in order to refine the timing of the simulated streamflows. Mean daily flows are needed on a continuous basis over many years to verify model performance, whereas it is generally sufficient to have instantaneous discharges available only during major events.

- Mean daily flow time series are primarily available at locations maintained by the U.S. Geological Survey (USGS) and available via the USGS web site. These data have been checked and quality controlled. There may also be some other sources of daily flow data in some parts of the country and in Canada and Mexico.
- Instantaneous discharge data is generally more difficult to obtain. Such data may be available, at least for a portion of the historical record, from the local USGS district office. Typically the district offices have such data in digital form for more recent years. These may be raw values that have not had the same quality control checks and adjustments as the mean daily flow data. Data for earlier years are for the most part only available in a hard copy form, such as printouts of periodic stage readings or strip charts. In this case the values must be extracted and converted to discharge using the appropriate rating curves.

Instantaneous discharge data can also be obtained from the RFC's archived operational files. Programs are available within the NHDS to assist in extracting data from the operational files and generating time series. Instantaneous discharges obtained from operational files are

based on real time stage reports and were converted to discharges using the rating curve defined at that time in the RFC files. There are no quality control checks or adjustments applied, plus the time when rating curve changes are applied may not be the same as used by the USGS when processing the mean daily flow data.

Instantaneous discharges may also be able to be obtained from other agencies or from Canadian and Mexican sources for rivers that cross these international boundaries.

In addition to continuous flow data, peak flow values can also be useful in model calibration. The USGS maintains an archive of peak flow data on their web.. Unfortunately the USGS only archives the peak flow, peak stage, and day of occurrence of the peak. The time of the peak during the day, which is available in the USGS Water Resources Data reports, is not maintained in the archive files. The peak flow data can be downloaded and put in a form that can be used by the NWSRFS PEAKFLOW operation by following the directions given in the NWSRFS User's Manual.

### Reservoir and Lake Data

Reservoir data are needed during calibration to either compute reservoir inflow time series or to verify simulated reservoir operations. This also applies to lakes which have a significant influence on the timing and magnitude of stream flows. The main data that are frequently available historically for reservoirs and large lakes are pool or lake elevation and/or storage (storage can be computed from elevation or vice versa using an elevation-storage relationship). To compute inflows either pool elevation or storage values are needed, as well as outflow data. Some reservoirs may have design features and/or operating rules that would require obtaining additional historical time series in order to compute inflows or verify operations.

- The USGS maintains records of daily pool elevation or storage for a number of reservoirs around the country. These records are published in the USGS Water Resources Data reports for each state. At this point in time these reservoir and lake data are generally not available via the USGS web site and there is only limited reservoir data available via the NHDS.
- Reservoir data may also be available from the agency or private company that operates the dam. This includes the Corp of Engineers, Bureau of Reclamation, government authorities such as BPA and TVA, local river basin commissions, and power companies.

### Snow Data

Snow data can be used during calibration to verify computations of the snow model. This includes checking and adjusting, if necessary, the form of precipitation and comparisons of observed and computed water equivalent, areal snow cover, and snow depth. Thus, the snow data that are most useful during calibration are water equivalent, snowfall, depth of snow on ground, and areal extent of snow cover.

- Daily values of new snowfall and depth of snow on the ground are available at many climatological stations from NCDC. Water equivalent data are also available at a few of these stations.
- Daily water equivalent at SNOTEL sites as measured by sensors located under the snow cover.
- Periodic snow course data (water equivalent and depth) are collected at many sites throughout the U.S.. In most of the western states and Alaska the data are collected by the NRCS. In California, west of the Sierra Nevada mountains, snow course data are collected by the State of California. In the upper mid-west and northeast parts of the country, these data are collected by various government agencies and private power companies. Access or information on these data can be obtained from NOHRSC.
- The NOHRSC archives two types of snow data that they are responsible for collecting and processing. The first is snow water equivalent determined from aerial gamma measurements from airplanes. These data represent the average water equivalent over a flight line. Measurements are typically made when requested during periods of significant snow accumulation. The second is areal extent of snow cover determinations derived from satellite data. These data are generated periodically on a routine basis over most of the western states. Data are available for specific drainages and for specified elevation bands within many of the watersheds. Data are also available in a form for visual display and processing using GIS applications. Areal snow cover data are also available for some periods for other parts of the U.S. from the NOHRSC.

### Other Data Types

There are other data types that are needed or can be helpful when calibrating a river basin. Which of these data types are available or are needed depends on the hydrology and climatology of the basin and the types of transfers across watershed divides.

- When water is transferred across watershed divides it is necessary to have data to quantify the magnitude and timing of the diversions. In some cases it is possible to get only a general idea of the magnitude of the diversion. If the magnitude is small relative to the total amount of flow and actual data values are not readily available, the diversion may only implicitly be included in the modeling process. If the amount of the diversion is significant, it should be directly accounted for in one way or another. There are two general ways of handling significant diversions. One way is to adjust the mean daily flow hydrograph to reflect natural flow conditions by adding or subtracting daily diversion flows (may be routed first if travel times are significant). The other way is to explicitly model the diversion and verify by comparing simulated and observed diversion amounts.

Daily data on some diversions are available from the USGS via their web site. Monthly values of some diversions are also published in the Water Resources Data reports of the USGS.

Monthly values in many cases can reasonably be distributed into daily amounts for use in adjusting mean daily flow data. It may also be possible to obtain diversion data from the agency, group, or private concern that operates the diversion.

- In some watersheds large springs exist which may contribute a significant portion of the overall flow. The flow from such springs should be explicitly accounted for if possible rather than lumping their effect into the rainfall-runoff computations. The USGS Water Resources Data reports contain periodic flow measurements just below such springs in some cases. These measurements can be used to adjust the daily flow records to remove the contribution from the spring.
- In some river basins water flows across watershed divides during times of high flows. This typically occurs in regions or parts of the basin with little topographic relief. The USGS Water Resources Data reports will normally note where such conditions exist and may at least indicate when such occurrences took place. Further inquiries may be needed in order to quantify the magnitude of such transfers.
- Data on frost depths may be available in some northern areas to help in verifying model simulations of frozen ground effects. These may be in the form of soil temperature measurements at specific sites or direct estimates of frost depth. For example, the Wisconsin State climatologist, gets measurements of frost depth from grave diggers and produces periodic maps of estimated frost depth over the state.

### Meta Data

Besides gathering actual data values for use in calibration, it is also very important to obtain information on the methods of making the measurements and how these may have changed over time. This includes the type of equipment used, the observation time, and station relocations. For precipitation especially, it is important to know the type of gage that is used and whether the gage had a wind shield and whether either of these changed over time. Studies have shown significant differences in precipitation catch based on the type of gage and kind of wind shield. The observation time of daily precipitation and temperature data is important in getting the data values assigned to the proper time. Information on equipment changes and site relocations are very important in trying to assess the consistency of the data and when determining if adjustments should be applied to correct for inconsistencies. General knowledge of measurement methods can be very helpful in assessing the magnitude of possible errors in all the data types and thus the overall reliability of the values. This will be of great benefit in evaluating possible problems in observed data and thus determining when simulated values should possibly not match observations.

- Information on station relocations and observation times of daily reports can be obtained for the NCDC climatological network via the NHDS. Observation times and changes to these times are available only for stations with long records that were used in computing 30 year normals. Similar information for climatological stations are also available from the B44 for

ms that are filed by the network managers periodically and when changes occur and from information published by NCDC in the Daily Climatological Bulletins. These sources may also contain information as to if and when precipitation gages were equipped with a wind shield. However as a word of caution, the meta data available from NCDC from these sources is not always accurate or complete. This is partly due to the minimal amount of money allocated to the climatological data program. Comparisons between these various sources of meta data for specific stations have shown that the information is not consistent and certainly no one source is complete. One cannot say with certainty that a relocation or equipment change did not occur just because it is not listed in one of these sources. Information on changes at synoptic stations used in the computation of PE from meteorological factors are documented in the NCDC Local Climatological Data Bulletins. Changes in anemometer height should be included in a file used by the NHDS program that computes PE from meteorological factors.

- Meta data for other measurement sites should be obtained from the agency that maintains the data. Information on changes over time to USGS stations is included in the Water Resources Data reports. Location information and observation times for SNOTEL sites is available from the NRCS.