in North Carolina during critical crop growing stages is often one of the driving factors in the acquisition of irrigation systems for a farmer/grower.

Following is a general description of North Carolina precipitation from the State Climate Office (web address: http://www.nc-climate.ncsu.edu/climate/ncclimate.html). Some of the rainfall amounts were updated with NRCS PRISM rainfall data which is shown in Figure NC1-4.

While there are no distinct wet and dry seasons in North Carolina, average rainfall does vary around the year. Summer precipitation is normally the greatest, and July is the wettest month. Summer rainfall is also the most variable, occurring mostly in connection with showers and thunderstorms. Daily showers are not uncommon, nor are periods of one to two weeks without rain. Autumn is the driest season, and November the driest month. Precipitation during winter and spring occurs mostly in connection with migratory low pressure storms, which appear with greater regularity and in a more even distribution than summer showers. In southwestern North Carolina, where moist southerly winds are forced upward in passing over the mountain barrier, the average annual precipitation can go as high as 119 inches. This region has the highest annual precipitation in the eastern United States. Less than 50 miles to the north, in the valley of the French Broad River, sheltered by mountain ranges on all sides, is the driest point south of Virginia and east of the Mississippi River. Here the average annual precipitation is only 39 inches. East of the Mountains, average annual rainfall ranges mostly between 40 and 57 inches.

Winter-type precipitation usually occurs with southerly through easterly winds, and is seldom associated with very cold weather. Snow and sleet occur on an average once or twice a year near the coast, and not much more often over the southeastern half of the State. Such occurrences are nearly always connected with northeasterly winds, generated when a high pressure system over the interior, or northeastern United States, causes a southward flow of cold dry air down the coastline, while offshore a low pressure system brings in warmer, moist air from the North Atlantic. Farther inland, over the Mountains and western Piedmont, frozen precipitation sometimes occurs in connection with low pressure storms, and in the extreme west with cold front passages from the northwest. Average winter snowfall over the State ranges from about (one) inch per year on the outer banks and along the lower coast to about 10 inches in the northern Piedmont and 16 inches in the southern Mountains. Some of the higher mountain peaks and upper slopes receive an average of nearly 50 inches a year.

1c - Irrigation in North Carolina

North Carolina is a diverse state for irrigation system types and crops to be irrigated. Rainfall, although abundant, often does not occur during critical stages of plant growth, and sometimes does not occur for extended periods that can exceed 30 to 60 days. Some crops are very susceptible to production losses or reduced quality related to drought. North Carolina is in a humid region where irrigation applications should be adjusted by some method of irrigation scheduling, for the prevailing rainfall conditions. Irrigation scheduling is the use of water management strategies to prevent over-application of water while minimizing yield loss due to drought stress. Irrigation scheduling computer programs are available both from NRCS and others.

North Carolina has about 343 thousand acres of agricultural land under irrigation according to the 1997 NRCS National Resource Inventory (NRI) data. Statewide, approximately 28 percent of tobacco, 10.5 percent of peanuts, 2 percent of cotton, and 11 percent of corn is irrigated (1994 memo from Dr. Robert Evans, NC State University-Department of Biological and

Agricultural Engineering). More than 87 percent of the agriculture related irrigation water comes from surface waters, such as streams, canals, and ponds (1997 NRCS NRI). However, a U.S. Geological Survey (USGS) study (Open-File Report 97-599, Walters, 1997) indicated that in 1995, 76 percent of irrigation water was derived from surface waters. This is probably not a change in the amount of surface water used for irrigation, but indicative of the amount of error in the estimates. The amount of irrigation acreage increased between 1982 and 1992 by about 70.8 thousand acres (about 21%), but only increased by 3 thousand acres (about 1%) between 1992 and 1997 (NRCS NRI).

Changes in commodity prices often drive the percent of a crop and the amount of land that is irrigated. Corn and soybeans are seeing potential increased production in North Carolina driven by a developing biofuels market and associated price increases. This may help to increase the percentage of corn (current preferred input for ethanol based biofuel production) that will be under irrigation in the future. Soybeans are the preferred crop for biodiesel fuels and could also see an increased future demand as this market develops. Many other North Carolina crops, such as sweet potatoes, also have the potential for use in the developing biofuels market.

1d - Water Supply for Irrigation in North Carolina

Water rights have not been a large issue in the past for North Carolina. However, it is still an issue that should be considered by the irrigation designer. Over-drafting of groundwater, salt water intrusion, interbasin transfer, and aquifer water quality degradation can also be issues that deserve consideration. The North Carolina Water Use Act of 1967 allows the Environmental Management Commission to designate an area as a Capacity Use Area (CUA) if it finds that the long-term sustainability of the water resource is threatened or that water use in an area requires coordination to protect the public interest. Within a designated CUA, all persons withdrawing more than 100,000 gallons of water per day (about 69 gpm, which many irrigation systems will exceed) may need to obtain a permit from the NC Department of Environment and Natural Resources (DENR) Division of Water Resources (DWR). In 1998, 15 counties in the central coastal plain region of North Carolina were declared a CUA due to significant dewatering of the Black Creek and Upper Cape Fear aquifers (Jennifer Adams and Ronald Cummings, North Georgia Water Planning and Policy Center, Water Policy Working Paper # 2004-002). Water use permits for irrigation withdrawal wells may be required in these areas. The irrigation system designer is advised to check with local and state officials for any local requirements or permits.

Concerns in North Carolina about withdrawals from subsurface aquifers are generally focused on the coastal plains region. The USGS has found that ground-water levels throughout the North Carolina coastal plains are declining (USGS Fact sheet FS-033-95), with an area near Lumberton declining more than 12 feet from 1988 to 1992. Many North Carolina communities rely on groundwater for public water supplies for large municipal systems. There are also many smaller community well-water systems serving small subdivisions, mobile home parks, schools, and churches. Irrigation systems often compete with these other uses when well water is used as the irrigation water supply.

Wells supply the drinking water needs of more than 50 percent of the North Carolina population and in some areas represents the only practical source of water for domestic use (Dan Bius, draft North Carolina Groundwater Implementation Plan- A Comprehensive Groundwater Decision Support System, 05/16/03). Some groundwater sources have naturally

high levels of phosphorus that are considered pollutants to nutrient sensitive waters in North Carolina (Pixie A. Hamilton and Timothy L. Miller, “Managing the Water Above and Below”, Geotimes, May 2002). Saltwater intrusion may also be a concern when a well site is in near proximity to coastal waters. There are also indications that neighboring states (see proposed South Carolina Bill H 3486, Apr 2007) of North Carolina are looking at ways to control and monitor water use in this state. Interbasin water transfers have also been an issue in North Carolina and the surrounding states, and should be avoided if possible. Water usage requirements could change in the future as the population and competition for water resources increase.

The first requirement for irrigation is an adequate supply of good quality water during those periods when the need for irrigation is greatest. The number of acres that can be properly irrigated at such times is dependent on the available water supply. The water supply should be adequate to irrigate the intended area of crops during a prolonged dry period before serious crop damage occurs. “Irrigating less land better will generally yield more benefits than inadequate irrigation of a larger area.”

Wells, ponds, streamflow, and even cisterns may be found supplying water to irrigation systems in North Carolina. Streams can become unreliable sources during extreme drought conditions when the irrigation system most needs the water supply. Some systems use tailwater recovery, and many use a sophisticated management and control system. Losses are an inherent part of every irrigation system. Careful management, well designed systems, and methods of water recovery, can help reduce the water needs and cost of an irrigation system. Water control structures have been effectively used in flat coastal areas to maintain a higher water table in the effective rooting depth of the plants and thus reducing the irrigation demand.

Issues associated with artificially elevated groundwater levels can stem from either an increased rate of groundwater recharge (from surface irrigation water, for example), water table management where drainage release is controlled, or a disruption in groundwater discharge to surficial waters (recent construction for example). Irrigation impacts to groundwater are generally localized to the field, as in the case of water table management, and should not extend much beyond the intended area. Common effects of elevated groundwater levels include mineralized soils, increased runoff from rainfall, slowness of soil to dry out, new wet spots, basement flooding, and foundation saturation.

Recharge areas for aquifers may also be a concern in the future to the irrigator since there is the potential for significant deep percolation to an underlying aquifer. However, aquifer recharge areas are not well defined, and a properly designed/managed irrigation system should not present an increase in adverse impacts when compared to non-irrigated farmland. Deep soaking rainfalls occur in North Carolina and can translocate farming associated plant nutrients, whether irrigated or not, down below the rooting zone.

Chapter 2 (NEH 652.0204) North Carolina NRCS Irrigation Guide Supplement-Soils

North Carolina has six general regions as discussed in the Introduction (NEH 652.0106) section. They are the Mountains, Piedmont, Sandhills, Inner Coastal Plains, Outer Coastal Plains and Coastal (Barrier) Islands. Each region has its own irrigation resource challenges associated with the soil-crop systems that are indigenous. For example, the Sandhills region of North Carolina can be found to support a multitude of cactus not found in the other regions. Cactus would not be irrigated of course, but it does illustrate how different this region is, because of its hot almost desert-like climate and light colored sandy soils. North Carolina has a wide variety of soil types and these cannot be irrigated alike. An accurate, detailed soil survey of the area to be irrigated is necessary. On-site testing of soil properties may also be justified.

Instrumentation to measure soil moisture contents at multiple depths that represent the crop rooting zone is essential to any good irrigation management system. Moisture measurements should be taken at multiple locations in the irrigated area to accurately give an indication of the field moisture condition for irrigation scheduling. Field soil moisture should be managed to ensure most of the irrigated water is used by the crop and not lost from the rooting zone.

2a - Soil Surveys

Knowledge of soils is essential for the efficient use of water for crop production. Soil survey maps and data for most of the state are now available online through the NRCS Web Soil Survey (WSS), http://websoilsurvey.nrcs.usda.gov/app/. See Exhibit NC2-1 for instructions on how to use and access the NRCS WSS. The WSS is replacing the familiar, traditional paper copies of soil survey reports that were previously available at the NRCS County office. As new and updated soil surveys are completed, NRCS is distributing the results of these surveys by means of the WSS instead of published reports. The WSS allows NRCS to update the information more rapidly and ensures a single source for official data. Those without computer access can still acquire soil survey information from an NRCS field office (look under Government listing in local Phone Book) or local library via WSS.

Important physical and chemical characteristics of each kind of soil are recorded in soils handbooks or soil survey publications. This soils information is available for download through the NRCS Soil Data Mart, http://soildatamart.nrcs.usda.gov/, or online at the WSS. See Exhibit NC2-2 for instructions on how to access and use the NRCS Soil Data Mart. Some physical characteristics of these soils that are important to understanding soil-moisture plant relationships are discussed in this guide. They include available water capacity, permeability, intake rate, slope, wetness (drainage and depth to water table), and surface texture. Note that in the Soil Survey, most of these physical soil characteristic terms are estimated and have a wide range of values. In most cases the estimated Soil Survey physical soil characteristic data should be verified with actual on-site testing.

1b - Rainfall and Drought in North Carolina

North Carolina has abundant yearly rainfall that is well distributed throughout the year. However, drought is not an uncommon occurrence during the North Carolina growing season. Extended periods of no rain (< 0.1”/day) that exceed 30 days have been noted in most North Carolina rain gage stations that have at least 50 years of data. It is recognized that estimates of drought conditions rely on not only rainfall (or lack thereof), but other factors such as temperature, solar radiation, wind, crop type, rooting depth, drainage, and soil moisture storage capacity that is available to the crop.

An agricultural drought condition is usually defined as a period when the moisture needs of the crop are not met by the available soil moisture and is often manifest by reduced crop growth and/or wilting. One study estimated that 1 in 5 years will have from 55 to more than 80 days that meet drought conditions within North Carolina (“Agricultural Drought in North Carolina”, North Carolina Agricultural Experiment Station, Tech. Bul. No. 122, June 1956).

The grower will probably be aware of how often and to what extent his crop production has been affected by drought conditions. An estimate of direct monetary losses to drought conditions can probably be estimated from this data if there is sufficient detail to determine drought years. Crop quality and consistency are generally improved by an irrigation system and therefore must also be considered a monetary benefit. Lack of rain and/or drought

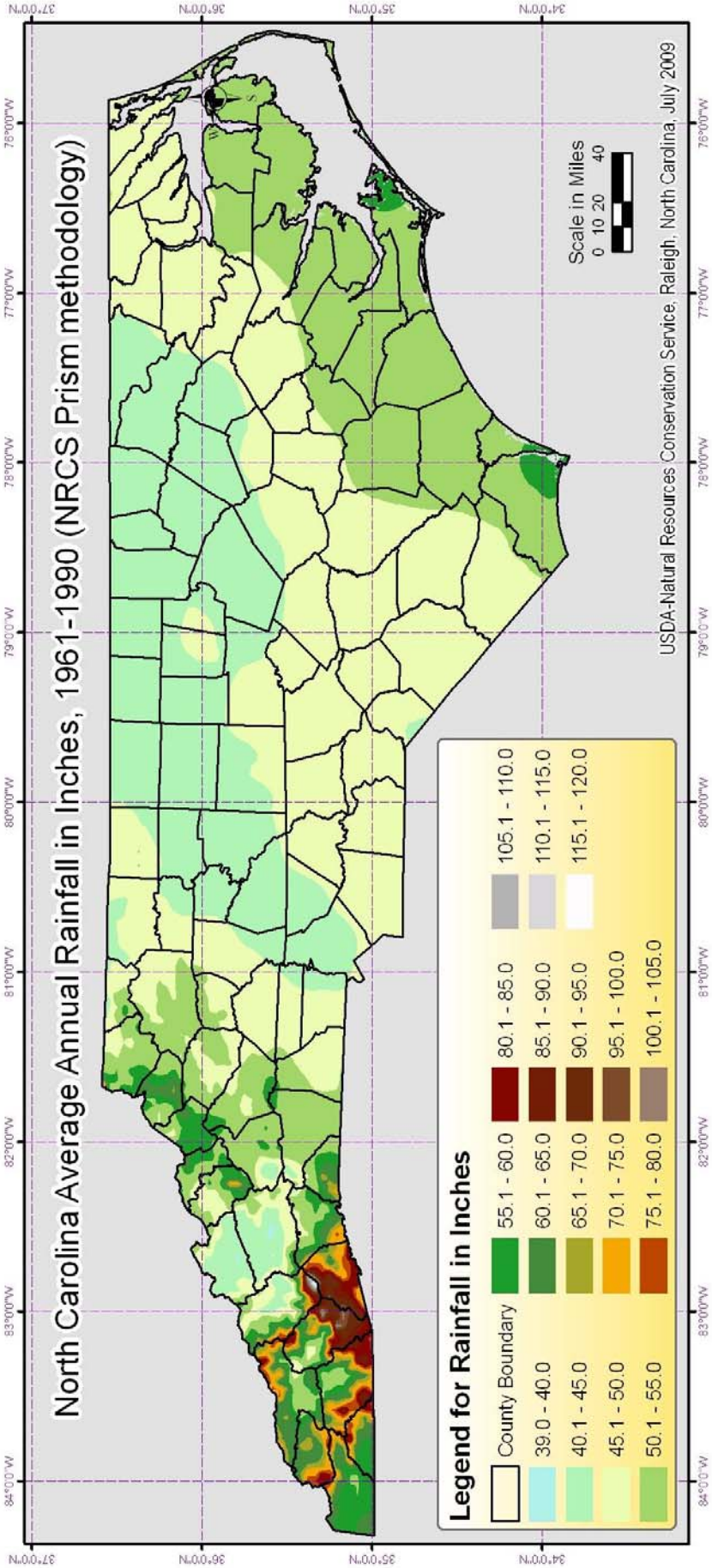

Figure NC1-4: Average Annual Rainfall