2.0 DESCRIPTION OF HYDROLOGIC STUDY AREA

The area of study for the baseline characterization investigation encompasses the Project Basins and the additional basins contained within the study area shown on Figure 2-1. A description of each of the Project Basins and a description of the physiographic setting, climate, vegetation, and regional flows systems is provided for the study area.

2.1 Project Basins

The following sections provide a brief description of the Project Basins that are shown on Figure 2-1.

2.1.1 Spring Valley

Spring Valley is approximately 120 mi long and averages 16 mi wide. This project basin is part of the Great Salt Lake Desert flow system. Spring Valley is bounded by the Schell Creek Range to the west, the Antelope Range to the north, the Snake Range and the Limestone Hills to the east, the Wilson Creek Range to the south, and the Fortification Range to the southwest. Most of Spring Valley is in White Pine County except for the very southern portion located in Lincoln County. U.S. Highway 50 bisects the valley and U.S. Highway 93 runs along the valley's western flank. The predominant uses of water in the valley are for irrigation and stockwater (see Section 7.0).

2.1.2 Snake Valley

Snake Valley is approximately 95 mi long and 40 mi wide near Garrison, Utah. This project basin is part of the Great Salt Lake Desert flow system. Snake Valley is bounded by the Snake Range to the west, the Confusion Range, Conger Range, and Burbank Hills to the east, and a low-alluvial divide to the south. To the north, Snake Valley opens to the Great Salt Lake Desert. U.S. Highway 50 traverses the southern one-third of the valley and runs east-west through the Snake Range, then exits the valley in the east. The predominant use of water in the valley is for irrigation and stockwater (see Section 7.0).

2.1.3 Cave Valley

Cave Valley is approximately 40 mi long and averages approximately 12 mi in width. This project basin is part of the White River Flow System (WRFS). The valley is bounded in the east by the southern portion of the Schell Creek Range and the smaller Fairview Range, and in the west by the Egan Range. The southern portion of the valley is truncated where the Egan and Schell Creek ranges merge. Cave Valley is accessible using improved gravel roads that enter the valley through Shingle Pass (west side from SR 318), Sidehill Pass (east side from U.S. Highway 93), and other smaller and

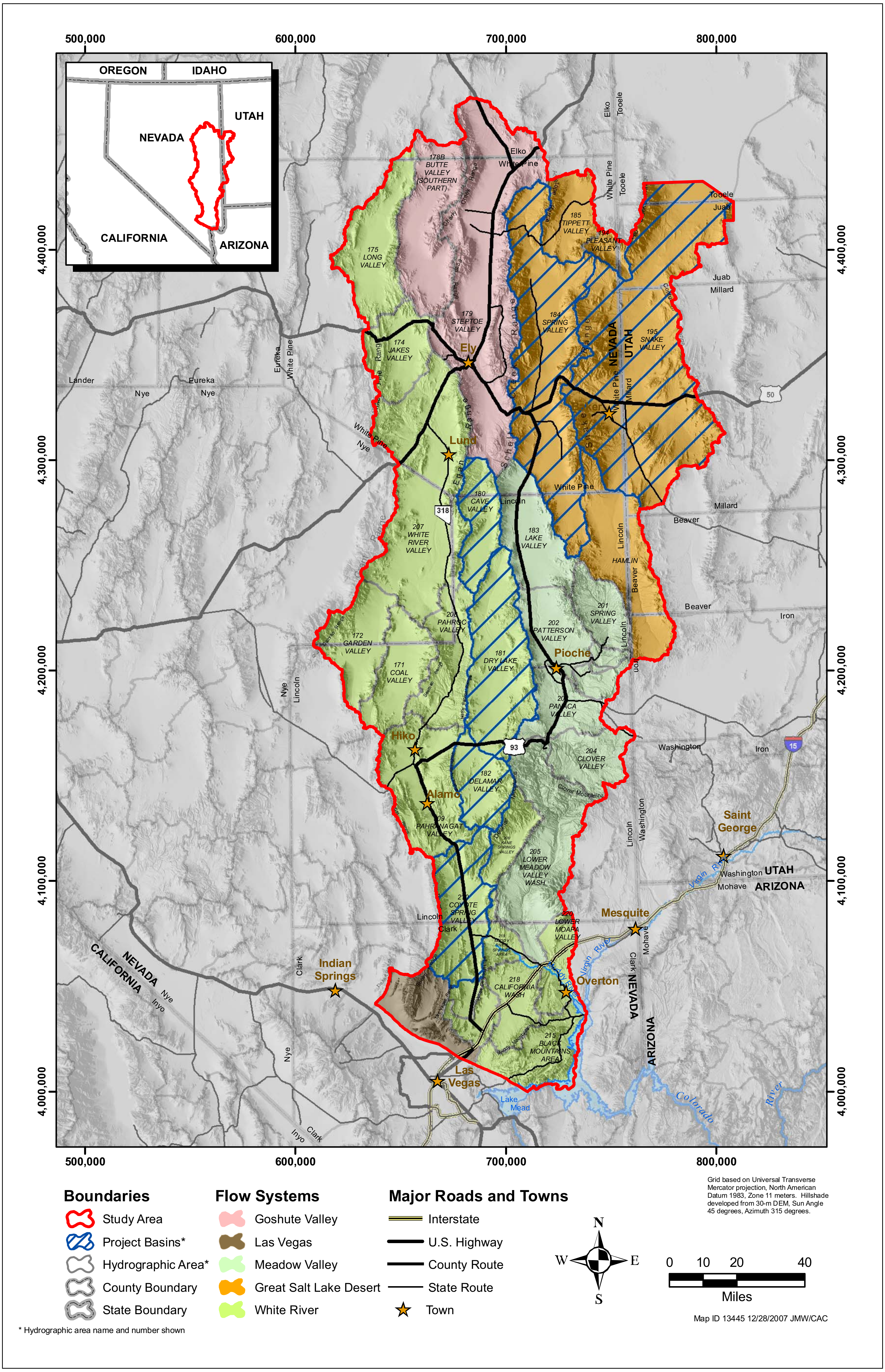

Figure 2-1
Project Basins

less maintained dirt roads. The predominant use of water in the valley is for stockwater (see Section 7.0).

2.1.4 Dry Lake Valley

Dry Lake Valley is approximately 60 mi long and averages approximately 20 mi wide. This project basin is part of the White River flow system. The valley is bounded to the west by the southern extension of the Schell Creek Range. The Pahroc, Fairview, Bristol, and Highland Peak ranges bound the valley to the east. Dry Lake Valley is accessible using improved gravel roads that enter the valley from the south via U.S. Highway 93, and from the east via U.S. Highway 93 in Lake Valley through Bristol Pass. There has been minimal development of water in this valley with the predominant use being for stockwater (see Section 7.0).

2.1.5 Delamar Valley

Delamar Valley is approximately 25 mi long and averages approximately 17 mi wide. This project basin is part of the WRFS. The valley is bounded to the east by the Delamar Mountains and to the west by the Pahroc Range. Delamar Valley is accessible from U.S. Highway 93, which crosses the valley in the north. There has been minimal development of water in this valley with the predominant use being for stockwater (see Section 7.0).

2.1.6 Coyote Spring Valley

Coyote Spring Valley is approximately 45 mi long and approximately 14 mi wide. This project basin is part of the WRFS. The valley is bounded to the west by the Sheep Range. The Delamar Mountains, Meadow Valley Mountains, and Arrow Canyon Range bound the valley to the east. U.S. Highway 93 traverses the valley from north to south. The predominant uses of water in the valley are industrial and municipal (see Section 7.0).

2.2 Physiographic Setting

The Project Basins are within the Basin and Range Physiographic Region described by Fenneman (1931). The Basin and Range Region is a series of parallel to subparallel, north-trending mountain ranges separated by elongated alluvial valleys (basins). The basins and ranges are formed by generally north-striking normal faults that elevated the ranges above the valleys. According to Rowley and Dixon (2001), the Basin and Range Province has undergone the most severe structural extension of the continental crust in the world. The alluvial valleys are further classified by Heath (1984) as being in the Alluvial Basins Ground Water Region. The basins of interest are also part of the carbonate rock province of eastern Nevada and western Utah described by Plume and Carlton (1988). Figure 2-2 depicts the relation of the Project Basins to the Basin and Range and carbonate rock provinces.

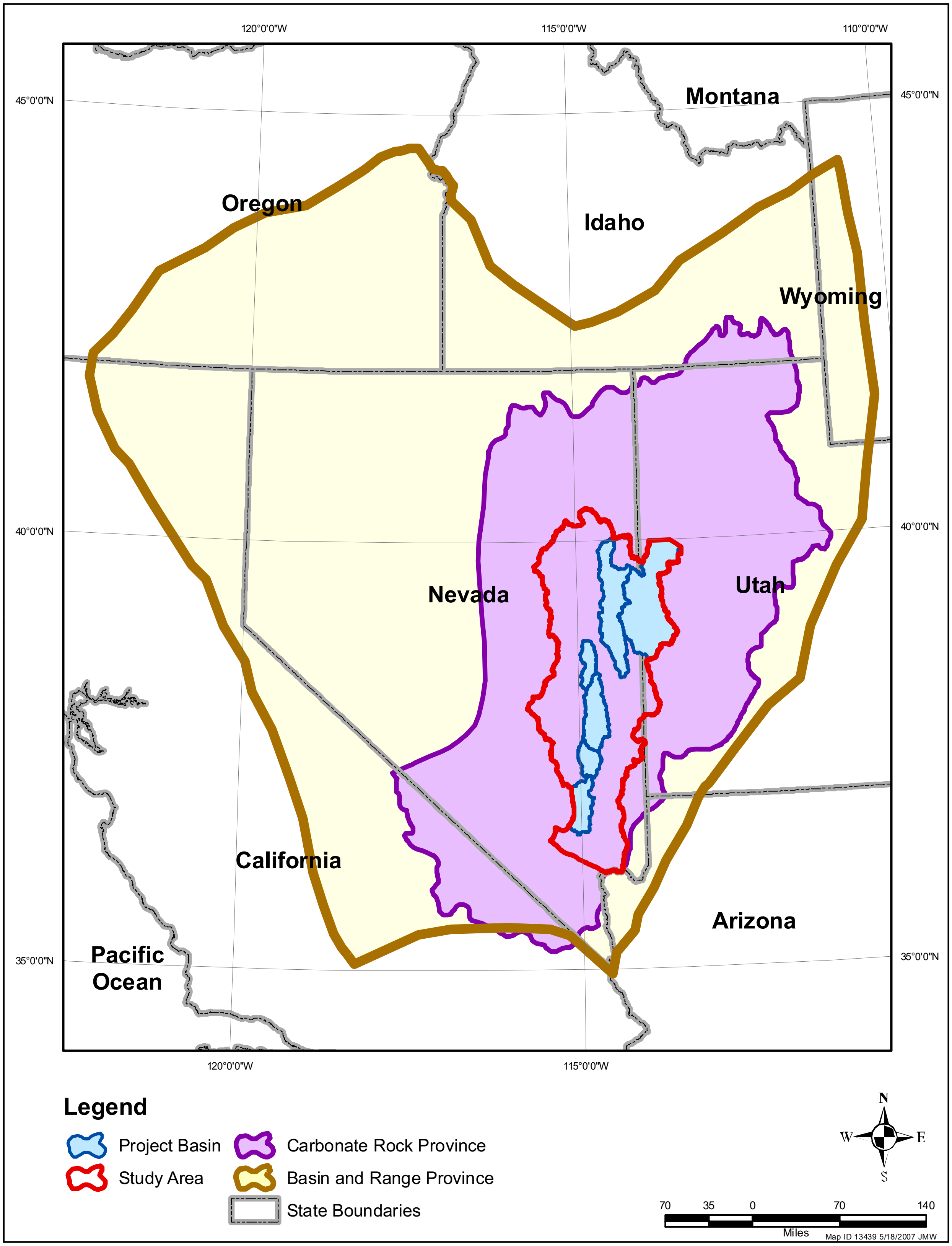

Figure 2-2
Physiographic Setting of Project Basins

2.3 Climate

The climate within the study area is characterized as being predominantly dry, with large ranges in daily temperature, infrequent severe storms, and great variation associated with elevation changes. There are three geographic factors influencing the region's climate: latitude, elevation, and the barrier provided by Pacific mountain systems to the west, which prevent winds off the Pacific Ocean from reaching Nevada (Houghton et al., 1975). Precipitation in the area varies by season and is the result of Pacific fronts, Great Basin lows, and summer thundershowers. For much of the study area annual precipitation ranges from 8 to 12 in. The amount of precipitation varies across the study area with Ely, Nevada, receiving 9 in. per year while Las Vegas receives 4.2 in. (NDWR, 2007a). Large precipitation events are more common in the winter months, but short duration and high intensity rainfall events associated with isolated thunderstorms are common in the summer. Temperatures within the study area have large annual variations. The mean annual temperatures across the area vary by approximately 20°F and range from the mid-40s to the mid-60s. This temperature variability is also observed on a daily basis. The clear skies of Nevada allow for heating of the ground in the day and radiational cooling at night. This results in temperature variability in local areas over a 24-hour period. Wind speed and direction are controlled by prevailing storm tracks and orographic effects induced by basin and range topography. Evaporation rates within the study area are controlled by low humidity, abundant sunshine, and dry winds. Within the study area annual evaporation rates range from approximately 45 to 72 in. (Houghton et al., 1975). Additional information and analysis of climatological data will be presented in the report titled Conceptual Model of Groundwater Flow for Clark, Lincoln, and White Pine Counties Groundwater Development Project (SNWA, 2007e).

2.4 Vegetation

The study area encompasses the Mojave Desert and the Great Basin ecological systems. The exact boundary between the Mojave Desert and the Great Basin is vague, but the two systems can be distinguished by the occurrence of differing vegetation communities and plant species.

The Mojave Desert scrub, or creosote bush scrub, is the dominate vegetation community within the Mojave Desert. The occurrence of this vegetation community is one of the main characteristics distinguishing the Mojave Desert from the Great Basin. Creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*) dominate this community; however, the Mojave Desert is a diverse landscape with a variety of other shrubs, yuccas (*Yucca spp.*), cholla (*Opuntia spp.*) and cacti.

The valley floors of the Great Basin are typical of a xeric sagebrush-shrubland community with big sagebrush (*Artemisia tridentata*) as the dominant species. Big sagebrush is not typically found in the Mojave Desert. Common companions include greasewood (*Sarcobatus vermiculatus*), green and rubber rabbitbrush (*Chrysothamnus viscidiflorus* and *Chrysothamnus nauseosus*), snakeweed (*Gutierrezia sarothrae*), spiny hopsage (*Grayia spinosa*) and littleleaf and gray horsebrush (*Tetradymia glabrata* and *Tetradymia canescens*). More saline-tolerant species include shadscale (*Atriplex confertifolia*), saltgrass (*Distichlis spicata*), and winterfat (*Ceratoides lanata*). Greasewood can also be found to occur on and around playas or in salt-encrusted soils. Riparian species such as cottonwood (*Populus fremontii*), willow (*Chilopsis linearis*), tules (*Scirpus spp.*), and cattails (*Typha spp.*) occur within the spring complexes. The pinyon-juniper community dominates the higher elevations of the Great Basin. The dominant trees are pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*). Shrubs in this community can include snakeweed, green and rubber rabbitbrush, western serviceberry (*Amelanchier alnifolia*), various currants and gooseberries and snowberry (*Symphoricarpos spp.*) (Mozingo, 1987).

Of particular interest are a group of plants that are referred to as phreatophytes. Phreatophytes were first defined by Meinzer (1927) as plants that are able to obtain a perennial and secure supply of water by sending their roots down to the groundwater table. This plant assemblage is composed primarily of greasewood, saltgrass, and rabbitbrush. Spiny hopsage, shadscale, and big sagebrush, although not generally considered phreatophytic, can occur within this assemblage. The riparian species mentioned above are also of interest. Phreatophytes have the ability to use both soil moisture and shallow groundwater to survive in desert environments via transpiration. Evapotranspiration (ET), a combination of evaporation and transpiration of water, is a key component when estimating groundwater discharge in a basin; therefore, identifying the location of phreatophytes within a basin and quantifying their groundwater use are important when evaluating basin water budgets.

The distribution of the phreatophytic areas for each valley within the study area will be described in further detail in the report titled Conceptual Model of Groundwater Flow for Clark, Lincoln, and White Pine Counties Groundwater Development Project (SNWA, 2007e).

2.5 Regional Flow Systems

The regional groundwater flow systems prevailing within the study area and vicinity are composed of multiple hydrographic areas (HA), also called valleys or basins. In many of the northern valleys, ET is the principal source of groundwater discharge. However, the valleys that are in the central-southern part of the system, have a significant amount of groundwater discharge as subsurface outflow through the carbonate aquifer. Although numerous structural features (Dettinger et al., 1995; SNWA, 2003a) compartmentalize different parts of the carbonate aquifer system, the hydraulic connectivity of the valleys is believed to be expansive.

A flow system is comprised of a set of hydraulically connected valleys. A single valley that is not hydraulically connected to other valleys can form its own flow system. Several flow systems, defined by Harrill et al. (1988) and Nichols (2000), occur within the study area. The primary flow systems of interest to this project are the White River, Goshute Valley, Great Salt Lake Desert, and Meadow Valley flow systems (Figure 2-1).

2.5.1 White River Flow System

The WRFS is the longest flow system in Nevada. Eakin (1966) and Harrill et al. (1988) consider this flow system to be part of the Colorado Flow System which also includes the Meadow Valley Flow System (MVFS). For the purpose of this report, however, the WRFS and MVFS will be addressed separately.

This flow system extends from Long Valley in the north to Lower Moapa Valley in the south, and is comprised of eighteen HAs. The HAs that make up this flow system are Long, Jakes, White River, Cave, Dry Lake, Delamar, Garden, Coal, Pahroc, Pahranagat, Kane Springs, Coyote Spring, Muddy

River Springs Area, Hidden, Garnet, California Wash, Black Mountain, and Lower Moapa valleys. The straight-line distance from the northern end of Long Valley to the Colorado River is about 250 mi. The maximum width of the flow system is from the western edge of Garden Valley to the eastern edge of Dry Lake Valley, nearly 60 mi. The flow system is bounded by Maverick Springs, White Pine, Granite, Quinn Canyon, Pahranagat, and Sheep mountain ranges to the west; and by the Egan, Schell Creek, Bristol, Highland, and Chief ranges, and the Clover, Delamar, and Muddy mountains to the east.

Groundwater moves through carbonate rocks that comprise parts of the surrounding mountain ranges and underlie basin fill. Flow is generally from north to south, from areas of recharge on high altitude mountain ranges to areas of groundwater discharge. Planert and Williams (1995) state that 70 percent of the recharge to the WRFS is estimated to occur in the northern half of the WRFS because of the higher altitudes and lower temperatures. Major areas of groundwater recharge in the WRFS include the Egan Range, Butte Mountains, and White Pine Range (Harrill and Prudic, 1998). North-south trending normal faults and permeability within the carbonate rocks provide the most likely conduits for groundwater movement.

A dominant hydrologic feature of this flow system is the large groundwater discharge from numerous carbonate springs scattered throughout the area. For example, the springs located in Pahranagat Valley and the Muddy Rivers Springs Area. In Pahranagat Valley, Hiko, Crystal, and Ash springs have a combined spring discharge of approximately 35 cfs or about 25,000 afy (Eakin, 1963). In the Muddy Rivers Springs Area, the Muddy Springs discharge about 37,000 afy (adjusted for ET) and are virtually unchanged since first estimated by Eakin (1966). The Muddy Springs form the headwaters of the Muddy River, a tributary to the Colorado River and present-day Lake Mead.

2.5.2 Meadow Valley Flow System

Nine valleys comprise the MVFS: Lake, Patterson, Spring (HA 201), Eagle, Rose, Dry, Panaca, Clover, and Lower Meadow Valley Wash. This flow system is tributary, both in groundwater and surface water, to the WRFS and is part of the Colorado Flow System previously mentioned. The MVFS is roughly parallel to the WRFS starting in Lake Valley and ending where Meadow Valley Wash joins the Muddy River (WRFS) in Upper Moapa Valley.

The MVFS is bounded to the west by the Bristol, Highland Peak, and Chief ranges, and the Delamar and Meadow Valley mountains; and by the Fortification and Wilson Creek ranges, and the Clover and Mormon mountains to the east. Groundwater flow in the MVFS is generally north to south through both basin-fill materials and the underlying carbonate rock, where present. Areas of groundwater recharge in the MVFS include the Fairview, Fortification, and Wilson Creek Ranges in Lake Valley, and the Highland Range and the Clover Mountains in Panaca Valley (LVVWD, 2001).

2.5.3 Goshute Valley Flow System

Southern Butte, Goshute, and Steptoe valleys comprise this three-valley system as defined by Harrill et al. (1988). Though SNWA does not have groundwater applications in the Goshute Valley

Flow System (GVFS), baseline conditions have been established in Steptoe and Butte valleys to evaluate future changes in the groundwater system.

The Cherry Creek Mountains and Egan Range bound Steptoe Valley to the west, and the Schell Creek Range forms the eastern boundary of the flow system. Groundwater discharge in Steptoe Valley is primarily through ET by phreatophytes, with a minor amount of groundwater outflow to the north to Goshute Valley. Major areas of groundwater recharge for the GVFS include the Egan Range, Cherry Creek Mountains, and the Schell Creek Range (Harrill and Prudic, 1998). No surface-water outflow occurs from Steptoe Valley. Butte Valley is bound by the Butte Mountains to the west and the Cherry Creek Mountains and Egan Range to the east.

2.5.4 Great Salt Lake Desert Flow System

Twenty HAs were considered by Harrill et al. (1988) to comprise the Great Salt Lake Desert Flow System (GSLDFS). The hydrographic areas include Grouse Creek Valley, Pilot Valley, Deep Creek Valley, Snake Valley, Pine Valley, Wah Wah Valley, Tule Valley, Fish Springs Flat, Dugway-Government Creek Valley, West Park Valley, West Part of Great Salt Lake Desert, Spring Valley, Tippett Valley, Northern and Southern Antelope valleys, Herrell-Brush Creek, Toano-Rock Spring, Rocky Butte Area, Montello-Crittenden, and Pilot Creek Valley. Rush (1968), however, considered the Snake Valley hydrographic area to be composed of 3 separate hydrographic areas including Hamlin, Snake, and Pleasant valleys. Only Spring, Hamlin, and Snake valleys were extensively studied as part of the baseline characterization for this report.

The GSLDFS found in the study area is bounded to the west by the Schell Creek Range and to the east by the San Francisco, House, and Fish Springs mountain ranges. Other major mountain ranges throughout the area include the Wilson Creek, Snake, Deep Creek, and Confusion ranges. There are no perennial streams that connect any two of the GSLDFS valleys, and the only interbasin ephemeral drainage is from Hamlin Valley Wash to Snake Valley. According to Harrill et al. (1988), groundwater flow in the GSLDFS is generally from the south to the north-northeast in the carbonate-rock aquifer, and northerly from Snake Valley to the Great Salt Lake Desert in the basin-fill. Major areas of groundwater recharge for the GSLDFS include the Schell Creek Range, Snake Range, and Deep Creek Range (Harrill and Prudic, 1998).