Elko County Nevada
Water Resource Management Plan
2017

Echo Lake - Ruby Mountains

Elko County Board of Commissioners
Elko County Natural Resource Management Advisory Commission

December 6, 2017

Executive Summary

The Elko County Water Resource Management Plan has been prepared to guide the development, management and use of water resources in conjunction with land use management over the next twenty-five (25) years. Use by decision makers of information contained within this plan will help to ensure that the environment of the County is sustained while at the same time enabling the expansion and diversification of the local economy. Implementation of the Elko County Water Resource Management Plan will assist in maintaining the quality of life enjoyed by residents and visitors of Elko County now and in the future. Achievement of goals outlined in the plan will result in water resources found within Elko County being utilized in a manner beneficial to the residents of Elko County and the State of Nevada.

The *State of Nevada Water Plan* represents that Elko County will endure a loss of population and agricultural lands over the next twenty-five years. Land use and development patterns prepared by Elko County do not agree with this estimated substantial loss of population and agricultural lands. The trends show that agricultural uses in Elko County are stable with minimal notable losses each year. Development patterns represent that private lands that are not currently utilized for agricultural are being developed in cooperation and conjunction with agricultural uses.

In 2007, Elko County was the largest water user in the State of Nevada. However, by 2010 Clark County surpassed Elko County as the largest water user among Nevada's 17 counties. The 2010 Census shows Elko County's population grew to 48,818 but the water use fell from 23.2% to 14% of the estimated total water withdrawals within Nevada. The largest of the water users being agriculture irrigation at approximately 94% or 335.4 Mgal/day down from 97% in 2007. Current water use in Elko County including domestic, recreation, commercial, industrial, mining, livestock and irrigated agriculture is estimated to be approximately 253,160 Mgal/day (millions of gallons per day) annually or 24% of the total state wide use. The *State of Nevada Demographer* and *State of Nevada Division of Water Planning* has provided estimates and forecast representing a decrease in population and a loss of agricultural lands in Elko County through 2026. Forecasts and estimates based on development patterns provided by **Elko County** represents continued growth of population, anticipated commercial and industrial growth, projected numbers of tourists visiting Elko County annually and sustained or minimal loss of agricultural lands. Should these estimates and forecasts come to realization annual water duties in Elko County could increase for domestic, commercial and municipal/ industrial consumptive uses by as much as 100 acre feet annually? However, this also represents a loss of Agricultural lands averaging 0.1% annually. Assuming that all of the elements of the economic and forecasted populations are achieved, the total water use in the year 2025 may exceed **918,000** acre feet annually. This represents a decrease of 1.6% primarily due to the loss of agricultural lands.

Studies conducted by the United States Geological Survey (USGS) indicate that the quantity of groundwater being lost to evapotranspiration is generally more than double than that estimated in previous evaluations. Hydrographic Analysis Reports of this plan suggest that recharge over the specific areas of Elko County is significantly greater than previous estimates. However, research and analysis is characterized by considerable uncertainty and additional confirmation is required. The implications for this water plan are that more water is available and may be made available for development and use within Elko County. This mandates that additional Hydrographic Analysis Reports are necessary for the upper Humboldt River basin as well as all basins and hydrographic areas in Elko County to determine perennial yields based on current technology.

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Abbreviations and Acronyms

AF	Acre-Feet (or Acre-Foot)
AFY	Acre-Feet per Year
AWWA	American Water Works Association
BFE	Base Flood Elevation (FEMA)
BIA	Bureau of Indian Affairs (USDI)
BLM	Bureau of Land Management (USDI)
CFS	Cubic Feet per Second
CORPS	U.S. Army Corps of Engineers (also USACE)
CWA	Clean Water Act (EPA)
DOW	Division of Wildlife (DCNR)
DWR	Division of Water Resources (DCNR)
DWP	Division of Water Planning (DCNR)
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map (FEMA)
FIS	Flood Insurance Study (FEMA)
GIS	Geographic Information System
GPC	Gallons per Capita (Person)
GPCD	Gallons per Capita per Day
GPD	Gallons per Day
GPED	Gallons per Employee per Day
M&I	Municipal and Industrial
MGD	Million Gallons per Day
MSL	Mean Sea Level
NDOW	Nevada Division of Wildlife (DCNR)
NDSP	Nevada Division of State Parks (DCNR)
NDWP	Nevada Division of Water Planning (DCNR)
NFIP	National Flood Insurance Program (FEMA)
NPS	Non-Point Source [Pollution]
PWS	Public Water System/Public Water Supply
S.A.	Seasonally Adjusted
SDWA	Safe Drinking Water Act (EPA)
SFHA	Special Flood Hazard Area (FEMA)
SFIP	Standard Flood Insurance Policy (FEMA)
SNOTEL	snowpack Telemetry (NRCS)
SPF	Standard Project Flood (FEMA)
USACE	U.S. Army Corps of Engineers (also Corps)
USBR	U.S. Bureau of Reclamation (USDI)
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USFS	U.S. Forest Service (USDA)
USFWS	U.S. Fish and Wildlife Service (USDI)
USGS	U.S. Geological Survey (USDI)
WRD	Water Resources Division (USGS)

WATER EQUIVALENT TABLE

1 cubic foot = 7.48 gallons = 62.4 pounds of water
1 acre-foot = 43,560 cubic feet = 325,851 gallons
1 cubic foot per second (cfs) = 449 gallons per minute (gpm)
1 cfs for 24 hours = 1.9835 acre-feet
1 cfs for 30 days = 59.5 acre-feet
1 cfs for 1 year = 724 acre-feet
1 million gallons = 3.07 acre-feet
1 million gallons per day (Mgal/d) = 1,120 acre-feet per year = 1.55 cubic feet per second 1,000 gallons per minute = 4.42 acre-feet per day

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ORIGINAL AUTHORS

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Elko County, Assistant County Manager / Natural Resource Management Division Principal areas of responsibility for original 2007 plan: Overall compilation and direction of accumulated data. Compilation of text with direction from the Water Planning Commission.

Elko County Water Planning Commission Members

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2017 UPDATE

Natural Resources Management Advisory Commission

Heston Johns - Chairman 2016/2017
Teresa Conner - Vice Chairman 2016/2017
John C. Carpenter
Richard Genseal
Zachary Woodbury
Dave Voth
Kristina Radel
Ralph R. Sacrison
Craig Spratling

Principal areas of responsibility for the 2017 update of the plan: Overall accumulation and assembling of data. Compilation of text with direction from the Natural Resource Management Advisory Commission.

Elko County Approval

Elko County Natural Resources Advisory Commission:

The **Elko County Water Resource Management Plan** is formally approved and adopted by the **Elko County Natural Resource Management Advisory Commission**, on this the 27th day of November, 2017.

Heston Johns, Chairman

Teresa Conner, Vice Chairman

Richard Genseal

Dave Voth

Ralph R. Sacrison

Craig Spratling

Zachary Woodbury

Elko County Board of Commissioners:

The **Elko County Water Resource Management Plan** is formally approved and adopted by the **Elko County Board of Commissioners**, on this the 6th day of December, 2017.

Cliff Eklund, Chairman

Delmo Andreozzi, Vice Chairman

Demar Dahl, County Commissioner

Jon Karr, County Commissioner

Rex Steninger, County Commissioner

Elko County
Water Resource Management Plan

Section 1

Mountain Lake- Ruby Mountains

SECTION 1
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INTRODUCTION

The Elko County Water Resource Management Plan was developed by the Elko County Division of Planning and Zoning under direction of the Elko County Water Planning Commission and the Elko County Board of Commissioners. Data was obtained through the Elko County Assessor's Office, State of Nevada Department of Conservation and Natural Resources, State of Nevada Division of Water Resources, State of Nevada Engineer, State of Nevada Health Department, State of Nevada Demographer, State of Nevada Division of Forestry, The United States Bureau of Land Management, United States Forest Service, United States Geological Survey, private Hydrology and Engineering Consultants and the general public of Elko County. The Plan is a comprehensive effort to unite and direct land use planning and water use planning directions in Elko County, by realizing the **Economic and Quality of Life Benefits of Water Right Protection, Water Shed Protection and Water Conservation**.

Nevada is the driest state in the United States with mean annual precipitation ranging from 24" in the northwest to less than 6" in the south. The dry arid high desert and mountainous region of Elko County receives an average of only 12" per year. Therefore, the necessity of planning future water needs to accommodate existing populations as well as projected population and development increases is imperative to our way of life.

Across the country, counties and municipalities are realizing the many benefits of water management and conservation plans, not just the economic values, but the health and quality of life issues as well. Reports and plans have been prepared and developed to promote and develop consistent and feasible future development of residential, commercial and industrial use of water, as well as to maintain existing uses. Agriculture, recreation and conservation have been a primary focus with the inclusion of the economic impacts of water availability to specifically planned residential communities and recreational areas. The reality of many of these referenced plans reflects the economic impact of quality of life issues in reference to potential water based recreation, commercial and industrial development. The economic value, quality of life and health benefits contribute to commercial, industrial, residential, agricultural and recreational development in areas where development typically has not been considered feasible.

The creation and implementation of the Elko County Water Resource Management Plan will provide the necessary information to develop proper water resource management and conservation procedure. The plan is designed to promote new technology in the identification of recharge and perennial yield analysis.

The purposes of the plan are to:

- Develop and implement a plan to protect the public interest by maintaining existing water rights and water resources.
- Develop a water conservation program.
- Provide accurate measurement of hydrologic area perennial yields to encourage and promote economic diversity in Elko County.

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The plan will provide comprehensive information to specific areas of high-density development and aid in the development of private and public lands within the specific boundaries. This will provide data for short and long range planning to ensure that water supply and quality will not be affected by over development. The plan will provide pertinent general data about rural areas and comprehensive data on the specific hydrographic areas as outlined in Section 3 and provide the tools necessary for proper long range land use planning.

The Water Resource Management Plan is designed to guide the growth and development patterns for Elko County for a time of **Twenty-five years (25),** the plan will require review every five years. A comprehensive review is required at the twenty fifth (25^{th}) year anniversary in **2032**. The Water Resource Management Plan is intended to provide the reader with pertinent water supply and demand information for future development.

In 2015, a review of the Water Resource Management Plan was conducted by the Elko County Natural Resource Management Advisory Commission. Information was updated using the most current data available from the Nevada State Demographer, Nevada State Department of Taxation, Nevada Division of Water Resources, United States Census Bureau, United States Department of Agriculture - 2012 Census of Agriculture, and the United States Geological Survey - Estimated Water Use in the United States for 2010. The USGS National Water Use Information Program has compiled and published the Nation's water-use data every five years since 1950.

High Mountain Meadows - near Coon Creek Summit, Jarbidge Area

INSTITUTIONAL FRAMEWORK & HISTORY

HISTORY

April 17, 1997 a letter from the *State of Nevada Division of Water Resources* was delivered to the Elko County Division of Planning and Zoning. The letter was prepared by Mr. Michael Turnipseed, P.E., State of Nevada Engineer and Director of the Division of Water Resources. The letter was concerning the creation of additional parcels within the Elko Segment of the Humboldt River Basin. Mr. Turnipseed recommended to Elko County that for each new parcel under 40 acres created within the Elko Segment 2.02 acre feet of water rights in good standing must be relinquished and abandoned to the State of Nevada. This meant that for each Parcel map or Subdivision that created parcels smaller than forty (40) acres in size that required the development of individual domestic wells, the developer would be required to acquire water rights that equaled 1800gpd or 2.02 acre feet per each parcel before the Parcel map or Subdivision could be approved.

Mr. Turnipseed's letter provided a land status inventory of the Elko Segment, stating that approximately 4,500 parcels were at that time in existence and each parcel had been allocated for domestic wells. This number did not take into consideration access to other utilities, ingress / egress, topographic features or other limiting factors to the development of the parcel. The letter also recommended to Elko County that the creation and implementation of an Elko County Water Plan would be needed.

The letter was forwarded to the Elko County Board of Commissioners. The Commissioners directed staff to request the State Engineer to attend a regularly scheduled meeting at his convenience. Mr. Hugh Ricci, Deputy Director of the State of Nevada Division of Water Resources did attend and provide explanation as to the letter. His response was that the letter was only a recommendation to Elko County to proceed with new land development within the Elko Segment with caution as to the water allocation and to create and implement an Elko Segment or County Water Plan.

THE ELKO COUNTY BOARD OF COMMISSIONERS

In December of 1997, the Elko County Board of Commissioners approved by resolution the creation of the Elko County Water Planning Commission as an Advisory Board. The Water Planning Commission was charged with the duty to create and implement the Elko County Water Resources Plan. The Elko County Water Planning Commission was established and first met in February 1998. Upon the creation of the Plan, the Elko County Water Planning Commission was to submit the Plan, Recommendations and Policies to the Board of County Commissioners for approval.

THE ELKO COUNTY WATER PLANNING COMMISSION

The Elko County Board of Commissioners instructed staff to prepare project outlines and cost analysis for the Elko County Water Plan. In September of 1997, the Elko County Planning and Zoning Division prepared a project outline for the creation and implementation of the Elko County Water Plan and submitted it to the Elko County Board of Commissioners. The first priority was establishing the Elko County Water Planning Commission.

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COMPOSITION OF THE WATER PLANNING COMMISSION

The Water Planning Commission was a seven member board, with an additional seven member voting alternates, created to act in an advisory role to the Board of County Commissioners. The Water Planning Commission consisted of:

Voting Members:

Elko County Board of Commissioners, one member, and staff
City of Elko, one member, and staff
City of Wells, one member, and staff
City of West Wendover, one member, and staff
City of Carlin, one member, and staff
At Large Members, two members

Voting Alternates:

Elko County Board of Commissioners, one member
City of Elko, one member
City of Wells, one member
City of West Wendover, one member
City of Carlin, one member
At Large Members, two members

The method of selecting and appointing the members of the Elko County Water Planning Commission was conducted as follows:

1) Request to the City Council of each Incorporated City within the boundary of Elko County, to appoint one voting member from the planning commission or city council and one voting alternate, to be accompanied by any support staff that may be available and qualified.

2) Request applications from the general public for the appointment of two at large voting members and two alternate members.

3) Elko County Planning and Zoning Division was the primary staff and coordinated all planning activities.

The Water Planning Commission was charged with the task of creating and implementing a comprehensive Elko County Water Resource Management Plan, as directed and approved by the Elko County Board of Commissioners. The Water Planning Commission was a working board for the creation of the Elko County Water Resource Management Plan, including the gathering and compilation of needed data.

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THE ELKO COUNTY NATURAL RESOURCE MANAGEMENT ADVISORY COMMISSION

In 2009, the Water Planning Commission was replaced by the Elko County Natural Resource Management Advisory Commission (NRMAC) which was created by Ordinance 01-2009 effective July 27, 2009, to act in an advisory capacity to the Elko County Board of County Commissioners regarding all natural resource issues within Elko County. The NRMAC board operates under Elko County Code Chapter 12: (2015)

(1) The Natural Resource Management Advisory Commission shall consist of seven (7) members, which may be comprised of members representing specific specialties or disciplines as follows:

(a) Federally managed public lands.
(b) Surface/ground water resources.
(c) Recreation.
(d) Ranching/agriculture.
(e) Mining/milling.
(f) Private land use development.
(g) Wildlife management.
(h) "Nonvoting" staff as needed and determined.

(2) Each member shall be a resident of Elko County, state of Nevada.

(3) The members of the Natural Resource Management Advisory Commission shall be appointed by the Elko Board of County Commissioners from a list of qualified and interested persons.

ELKO COUNTY WATER RESOURCES MANAGEMENT PLAN MISSION STATEMENT

The mission of the Elko County Water Resource Management Plan is to create a comprehensive plan of Elko County to protect existing and future water rights and water resources of the general public and individual land owners. The Water Resource Management Plan will ensure that future development in Elko County is managed and do not result in diverse impacts on our water resources. The Water Resource Management Plan is to be created by the public of Elko County and approved by the Governing Board of County Commissioners for the health, safety and welfare needs of the citizens of Elko County.

PLANNING DATA CRITERIA OF THE ELKO COUNTY WATER RESOURCE MANAGEMENT PLAN

There are areas of intense development that will require more in-depth comprehensive information and data areas of low or no development activity will not require comprehensive study. These different areas are identified, and are established using development patterns and potential land use as the major influence.

The areas include:

Elko Segment Water Basin, extending from Carlin to Osino along the Humboldt River Basin. This area has historically and currently shown a high rate of residential, commercial and industrial development patterns over the past 15 years, especially within 3 to 8 miles from the incorporated boundary of the City of Elko, primarily east along the Humboldt River. Most all-commercial development has occurred within the City of Elko limits. Industrial development is sporadic along East Idaho Street, primarily within the City of Elko limits, with pockets of industrial uses directly adjacent to the city boundary.

Spring Creek, Lamoille, and South Fork Areas. Currently these areas are being developed at a high rate. A large percentage of this area is serviced by water systems; Great Basin Water Company (*formerly Spring Creek Utilities*) and Lamoille Water Users Association. Other rural landowners are developing parcels for residential use, utilizing individual domestic wells and septic systems. These areas are part of the Spring Creek / Lamoille Master Plan and South Fork Master Plan. The Spring Creek / Lamoille Master Plan designates extensive areas for potential commercial and industrial development. However, the Dixie Creek / Ten Mile basin water resources will prohibit specific high consumption of water for industrial or commercial uses. This is due primarily to the residential development of the valley.

The Elko County Board of County Commissioners adopted Ordinance No. 01-2008 which added to the Elko County Code the requirement for the relinquishment of 2.0 acre feet of water rights for the approval of parcel maps under 40 acres in certain designated groundwater basins: (1) Basin 048 - Dixie Creek/Tenmile (2) Basin 049 - Elko Segment (3) Basin 153 - Diamond Valley; pursuant to S.B. 275 of the 2007 Nevada Legislature.

North Fork Humboldt and Humboldt River Area (I-80 Corridor) from the ***Osino Area***, to east of the ***City of Wells***. This area represents areas of low to moderate growth. The potential of residential and commercial development is present, as evidenced by numerous existing subdivisions and industrial zoned areas along the Interstate 80 corridor. The ***Adobe Range*** north along ***Mountain City Highway (SR 225)*** to the ***Wild Horse Reservoir*** This area represents an area of low to moderate development. This area is increasing in developmental activity and is primarily an area of agricultural - residential development in ten acre parcels. The potential for higher density is present, primarily in the Adobe Summit area north towards Lone Mountain Station.

Elko County (Remainder). Slow, steady development has been occurring throughout the remainder of the County. Agricultural use is dominant for much of rural Elko County; however, development patterns show a loss of agricultural lands to development of residential subdivisions. These subdivisions are creating parcels ranging from five acres to 40 acres.

GOALS & OBJECTIVES

The goals and objectives of the Elko County Water Resource Management Plan are presented along with principles that guided the Elko County Water Planning Commission in the development of this plan. The plan provides a history of the processes that were used to develop the Water Resource Management Plan and the relationship between this plan and other land use planning documents.

GOALS: The Elko County Water Resource Management Plan is prepared and implemented to ensure that adequate supplies of water remain available in Elko County to; maintain and enhance the cultural integrity of the environment; maintain and improve the quality of life for residents and visitors to Elko County and to expand and diversify our economy.

OBJECTIVES:

1) Identify and define all existing water resources in Elko County utilizing current science and technology.

2) Identify existing water uses in Elko County.

3) Identify projected growth patterns and water supply demands for the twenty-five (25) year plan life.

4) Continue to identify water supply issues that are pertinent to the protection, conservation and distribution of Elko County water resources.

5) Identify short and long-term water demands in Elko County that benefit the environment and citizens.

6) Identify specific basin recharge rates and demands.

7) Conduct perennial yield and recharge rate studies in using current technologies that provide sound water resource information for future development.

8) Educate the general public about the effects of state and local laws, policies and issues.

9) Provide water resource management information and policy to existing and future land use Master Plans of Elko County.

10) Review this plan every 5th year anniversary and conduct a comprehensive review at the 25th anniversary.

11) Provide comprehensive water planning data for specific regions of Elko County, to allow proper Land Use planning.

12) Comply with and adopt all Applicable Federal and State Laws concerning Water Resource Management.

13) Determine impact of proposed federal actions related to water use and water law within Elko County.

GUIDING PRINCIPLES

1) All water resources of Elko County belong to the public and are managed by the State of Nevada Division of Water Resources, the State Engineer and Nevada Revised Statutes 533 and 534.

2) Water resource needs of current and future Elko County residents must be managed with a balanced approach that provides for Elko County's economic goals without detriment to the social, aesthetic, cultural, recreational, individual and ecological values of Elko County.

3) The appropriation and beneficial use of Elko County's water resources is administered by the Nevada State Engineer in accordance with the requirements and provisions of Nevada Water Law and by state and federal decrees and regulations.

4) Public education and public input is imperative to the success of water resource management planning and all units of local government.

5) Water rights in Nevada are private property and may be bought, sold and traded under free market conditions.

6) Elko County, in filing for ground and surface rights within the Elko County Boundary is only interested in augmenting and enhancing the water resources for Elko County citizens and promoting the economic diversity.

7) All water resource development in Elko County should be conducted in a manner that is technically, environmentally and economically sound and consistent with state and federal laws.

8) Water conservation and re-use methods are important components of the planning and management of Elko County water resources.

9) The Elko County Water Resource Management Plan must be based on sound science and water resource evaluation and management principles.

10) The Elko County Water Resource Management Plan is to be adopted as an element to the Elko County Master Plan pursuant to Nevada Revised Statutes 278.150 through 278.265 inclusive.

11) Accept the current 2003 State of Nevada Drought Plan.

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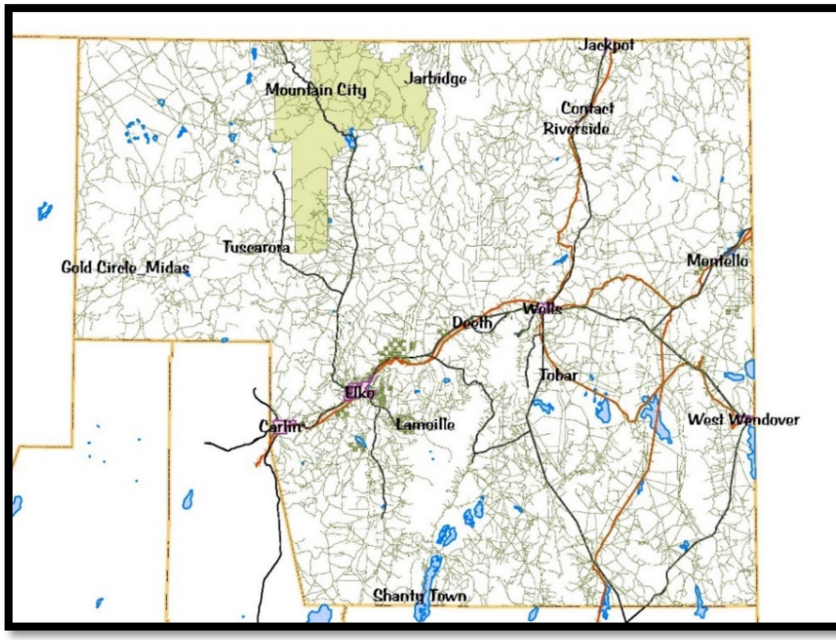
DEMOGRAPHICS

GEOGRAPHICS:



Elko County was created March 5, 1869 from a portion of Lander County. Its 17,181 square miles are spread over the northeast corner of the State of Nevada. It is Nevada's second largest County and is the fourth largest in the United States, excluding Alaska. The County seat is the City of Elko. Elko County is bounded on the west by Humboldt County and on the south by Lander, Eureka and White Pine Counties. Elko County is bounded on the east by the state of Utah and on the north by the state of Idaho. Elko County is approximately 200 miles wide east to west and 180 miles north to south. Most of the County lies above the 5,000 foot mean sea level elevation (MSLE). The land consists of rugged mountain ranges, broad fertile valleys, various sagebrush species, tree covered canyons and lofty peaks. The mountain ranges and valleys run primarily in a north south direction. Several peaks are over 10,000 feet MSLE, including the Matterhorn, Spruce Mountain, Pilot Peak, Hole in the Mountain and Ruby Dome. Elko County contains a substantial portion of the Humboldt River Basin as well as portions of the Ruby Mountains, Mary's River, North Fork, South Fork, Maggie Creek, Elko Reach, Pine Valley and Battle Mountain sub-basins. The Humboldt River flows generally westward terminating in the Humboldt sink, located in north central Nevada.

Jarbidge Mountains Viewing West

Physiographically Elko County can be divided into mountains, intermediate slopes or uplands, and grass valleys or lowlands. Geologic uplift, warping and faulting has contributed to the present relief. Several mountain ranges have steep fronts with sharply incised canyons and less steeply dipping back slopes. Glacial scouring and deposits occur in few of the high mountain ranges, most notably in the Ruby and Jarbidge Mountains.

ELKO COUNTY CLIMATE & PRECIPITATION:

The climate of Elko County is generally considered to be semi-arid or arid. Summers are hot especially at lower elevations and winters are cold. Annual precipitation is normally light in the Lake Bonneville region (east quarter of the county), averaging less than 8 inches. Valleys in the rest of the county receive on average 9 inches of precipitation. The county is subject to short duration high intensity, summer convection storms. At higher elevations, precipitation is much greater usually in excess of 20 inches. Much of this precipitation falls as snow during the winter and early spring and accumulates to considerable depths. The snowmelt irrigates crops in adjacent valleys or runs off and is stored in man-made reservoirs. The average temperatures are in the 20's in the winter and low to upper 80's in the summer. The sun shines about 80 percent of the day in the summer and about 70 percent in winter. The prevailing wind is from the southwest, with the highest average wind speed of 7 miles per hour occurring in the spring.

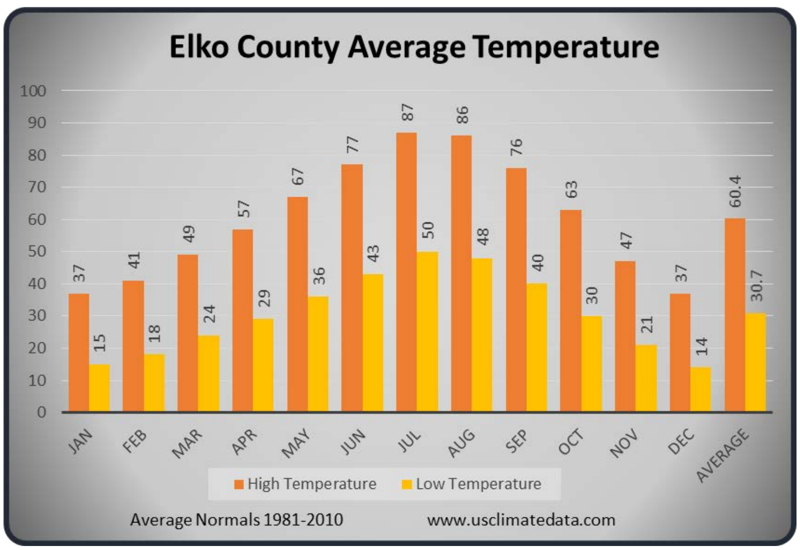


Figure 1 - Elko County Average Temperature

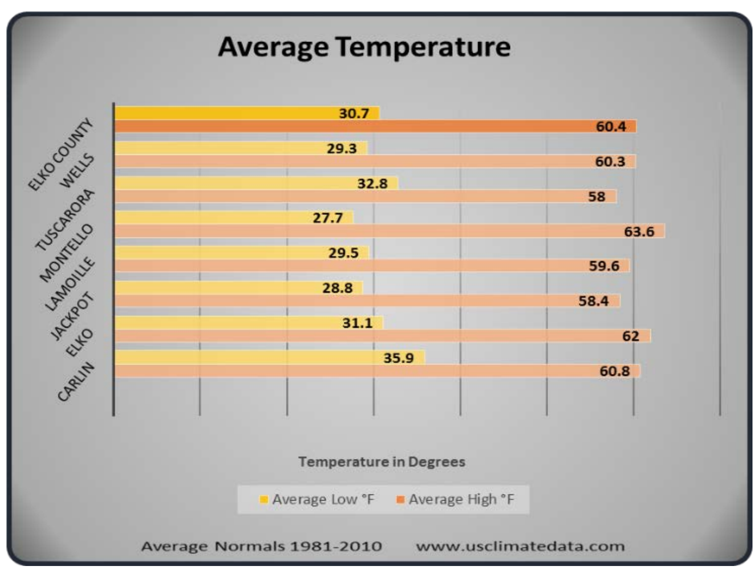
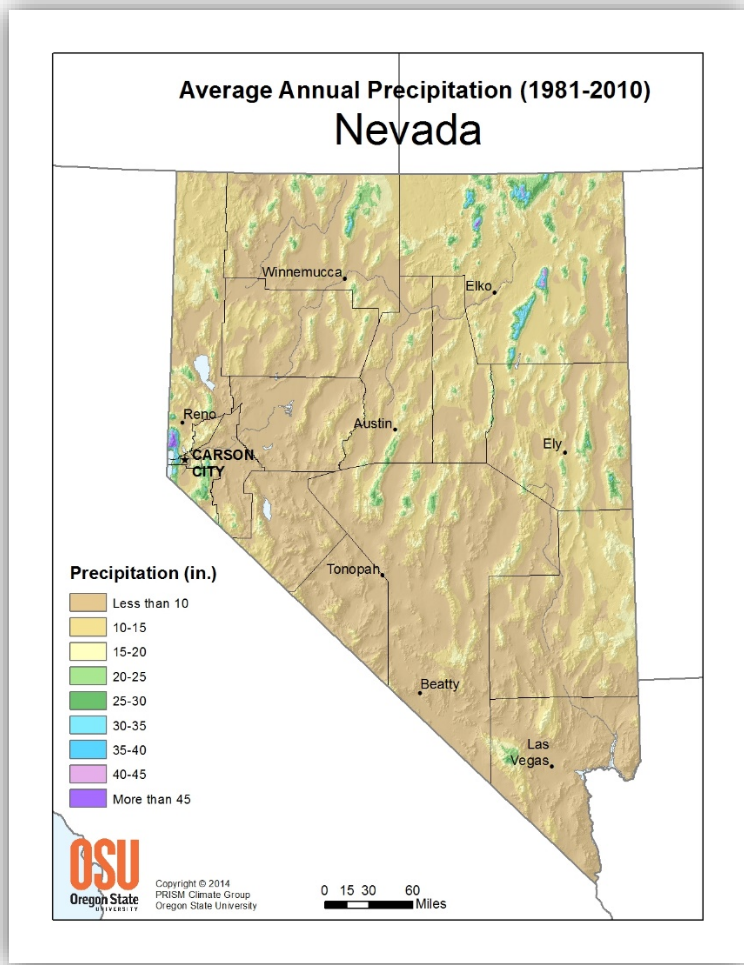


Figure 2 - Elko County/Cities Average Temperatures

NEVADA CLIMATE AND PRECIPITATION

The climate of Nevada is characterized as semi-arid to arid with precipitation and temperature varying widely between the northern and southern regions of the State, and between valley floors and mountaintops. With temperatures that fall below -40° F during some months in the northeast, and rise over 120° F during a few summer days in the south, and precipitation that ranges from only three to four inches in southern Nevada to over 40 inches (and over 300 inches of snowfall) in the Carson Range portion of the Sierra Nevada, Nevada is truly a land of great climatic contrast (James, J.W., State Climatologist, Climate of Nevada, Paper No. 84-12, Bureau of Business and Economic Research, University of Nevada, Reno, 1984). Total precipitation averages approximately 9 inches per year (53,000,000 acre-feet) making Nevada the most arid State in the Nation (Geraghty, J.J. et al., Water Atlas of the United States, Water Information Center, Port Washington, N.Y., 1973). Of the total annual average precipitation amount, approximately 10 percent accounts for stream runoff and ground water recharge. The remaining 90 percent is lost through evaporation and transpiration. Average lake surface evaporation rates vary widely across the State from less than 36 inches per year in the west to over 80 inches per year in the south (State Engineer's Office. *The Future Role of Desalting in Nevada*, Carson City, Nevada, April 1973.)

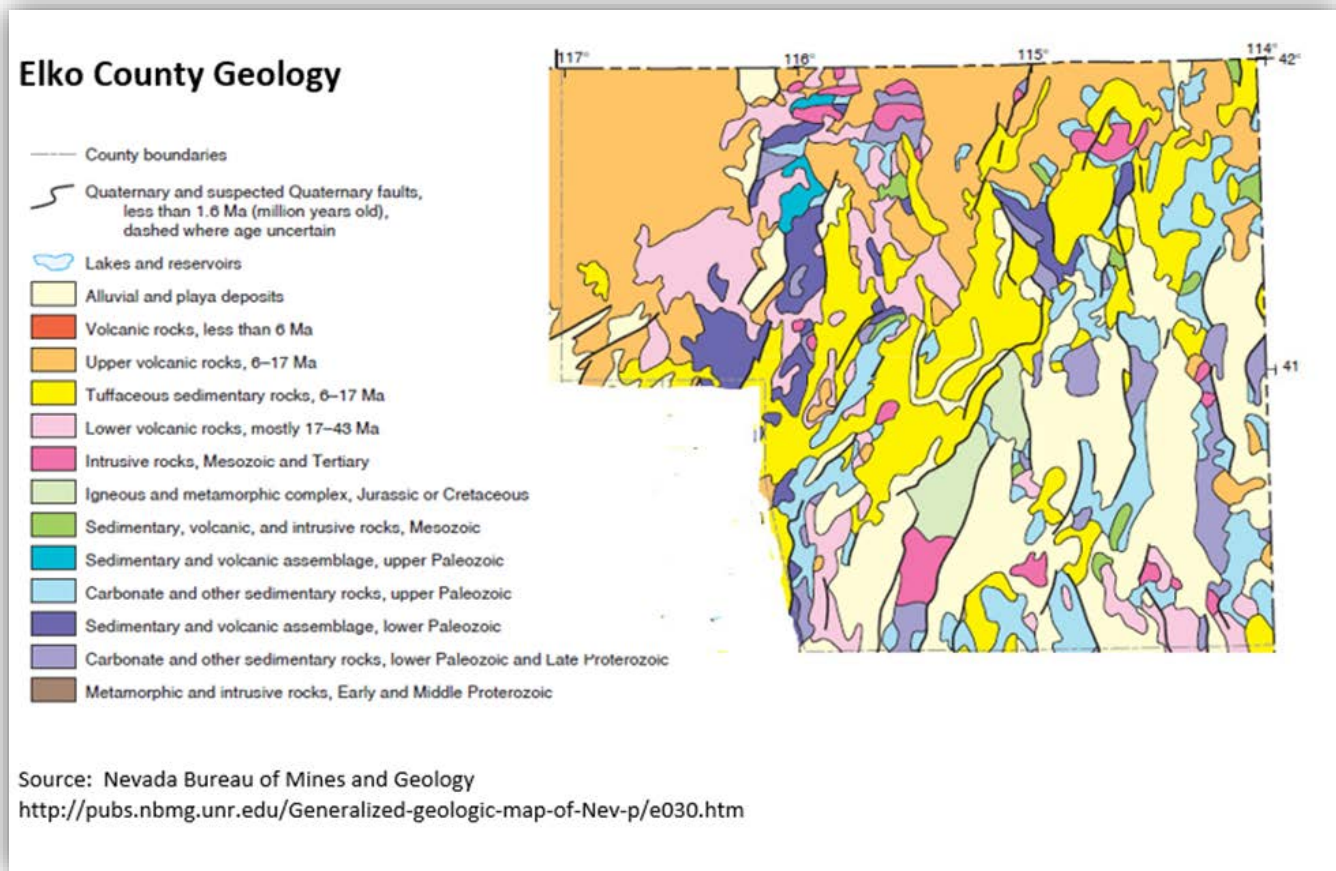
Figure 3
Nevada Average Precipitation



GEOLOGY AND SOILS:

Hills and mountains consist mainly of Tertiary volcanic extrusive, Devonian limestone and Cretaceous granite. Valleys consist of consolidated and unconsolidated Tertiary and Pleistocene alluvial deposits of ash, tuff and clastic material. Floodplains are of recent unconsolidated Holocene alluvium. Basin floors in the east quarter of the county consist of Pleistocene, Holocene lacustrine, and beach deposits. Typical soils found in the mountains and hills are steep, very gravelly, medium textured and moderately deep to bedrock. Valley soils are gently sloping, medium textured and are moderately deep to a hardpan. Soils on floodplains are nearly level, salt and alkali affected, fine textured and very deep. Soils found on basin floors in the Lake Bonneville region of the county are salt and alkali affected, nearly level, fine textured (upper horizon), coarse textured (lower horizons) and are very deep.

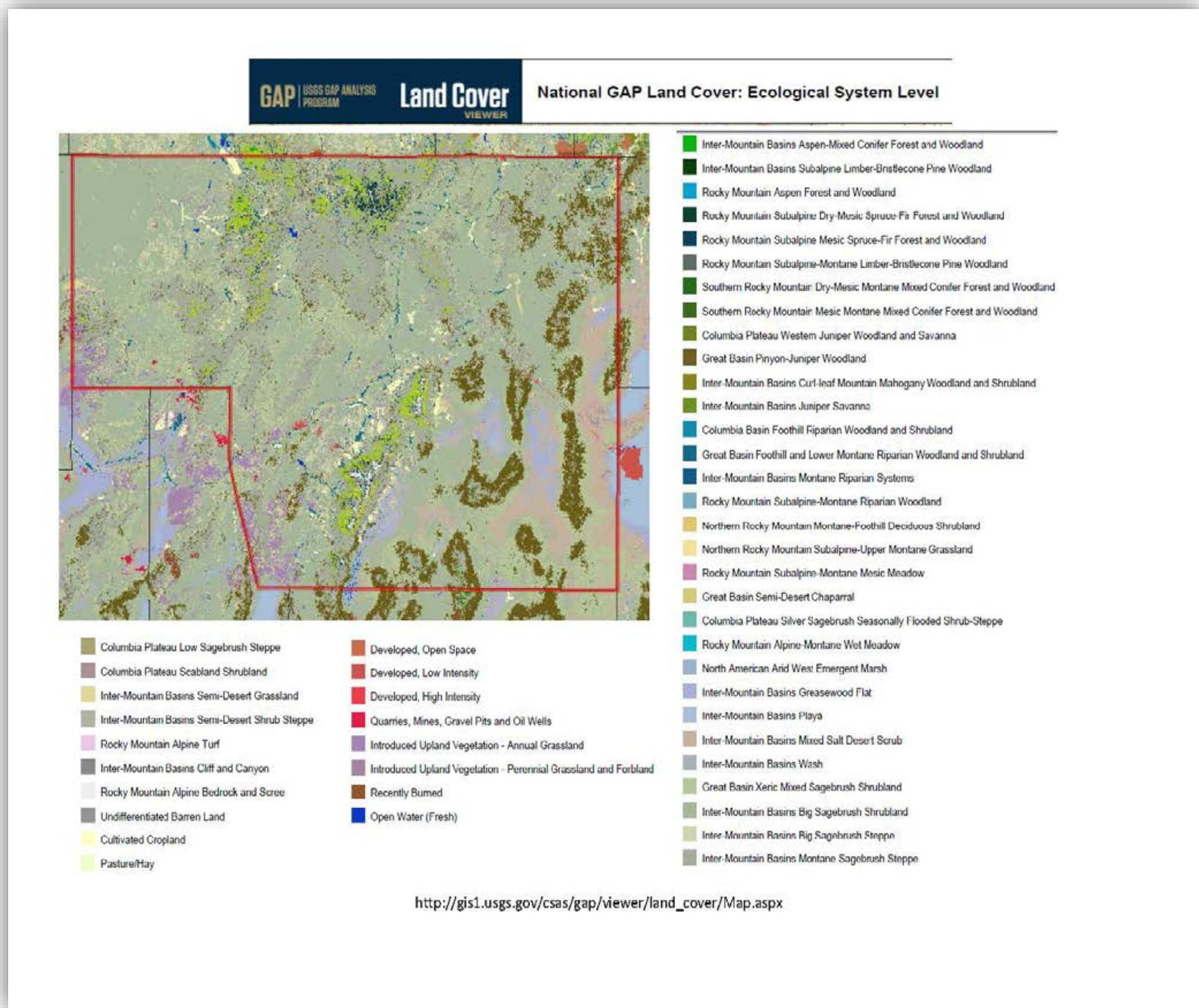
Figure 4 – Elko County General Geology



VEGETATION:

Major plant associations in the area typify the general zonation of vegetation common in the Great Basin Region. Basin floors in the southeast quarter of the county are dominated by salt-desert shrub plant communities consisting of shadscale, budsage and winterfat. Valley floors above the salt-desert shrub zone are dominated by sagebrush-grass plant communities consisting of Wyoming big sagebrush, black sagebrush, basin big sagebrush and blue bunch wheatgrass. Mountain big sagebrush, low sagebrush, Antelope bitterbrush and Idaho fescue dominate the hills and mountains. Cur leaf mountain mahogany and stands of aspen are common at the highest elevations. Single leaf pinyon and Utah Juniper are extensive in the hills and mountains in the southern half of the county. Riparian areas along floodplains, stringer meadows and springs and seeps are characterized by diverse plant species consisting of herbaceous meadow vegetation and willows.

Figure 5 - Elko County General Vegetation



LAND MASS:

The total area of Elko County is **17,181** square miles or **10,995,840** acres; Office of the Elko County Assessor official acreage. Of this total area **72.54%**, or **7,949,921.65** acres, is managed by Federal Agencies: the Bureau of Land Management (BLM) 62.54%, the U.S. Forest Service (USFS) 9.75% and U.S. Fish and Wildlife Service 0.25%. Privately owned property in Elko County is **25.85%** or **2,832,944.83** acres.

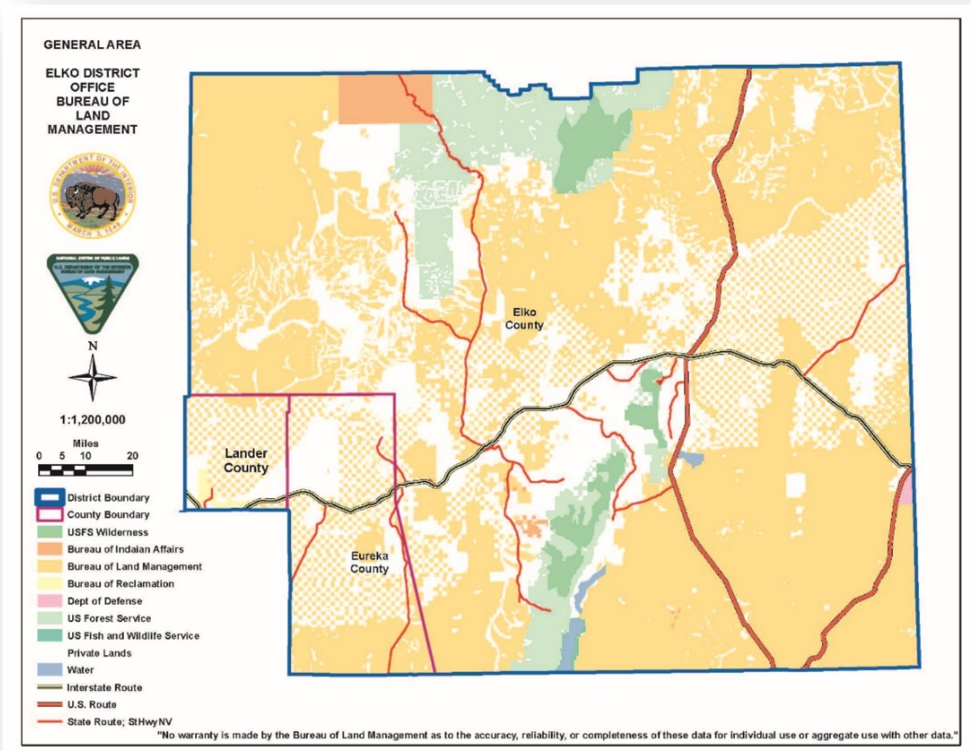


Figure 6- Elko County Land Ownership Map

*****Note:*** *Acreage and populations were calculated from information provided by the Bureau of Land Management, United States Forest Service, State of Nevada Demographer and the Elko County Assessor. A common error exists in deeds prepared without the benefit of a survey and the error is normally within the deed acreage not being correct. An example of this error may be that a deed reflects a section of land or a square mile containing exactly 640 acres, while the actual or true acreage may be more or less than 640 acres or that a specific lot may have a legal description such as the NW1/4 of the NW 1/4 containing 40 acres while the actual acreage may be more or less than 40 acres. Currently, the total parcel count in Elko County is 49,696 parcels and it is estimated that only 25% of these parcels calculated acreage is based on a survey for accuracy. Therefore, calculated total acres in Elko County indicated herein is more than the actual calculated total area of Elko County. The error is 0.38% or 42,000 acres.*

POPULATION:

The U.S. Census counts every resident of the United States every 10 years as mandated by the U.S. Constitution. The last Census was completed in April 2010. The Nevada State Demographer's Office prepares annual population estimates for Nevada's Counties, Cities and Unincorporated Towns. The 2016 Official State of Nevada Demographer Estimates for Elko County are:

<u>Incorporated Cities:</u>	
City of Carlin -	**2,684**
City of Elko -	**20,704**
City of Wells -	**1,388**
City of West Wendover -	**4,474**
<u>Unincorporated towns:</u>	
Town of Jackpot -	**897**
Town of Montello -	**62**
Town of Mountain City -	**95**
<u>Unincorporated areas:</u>	
Elko County -	**23,693**
Elko County total -	**53,997**

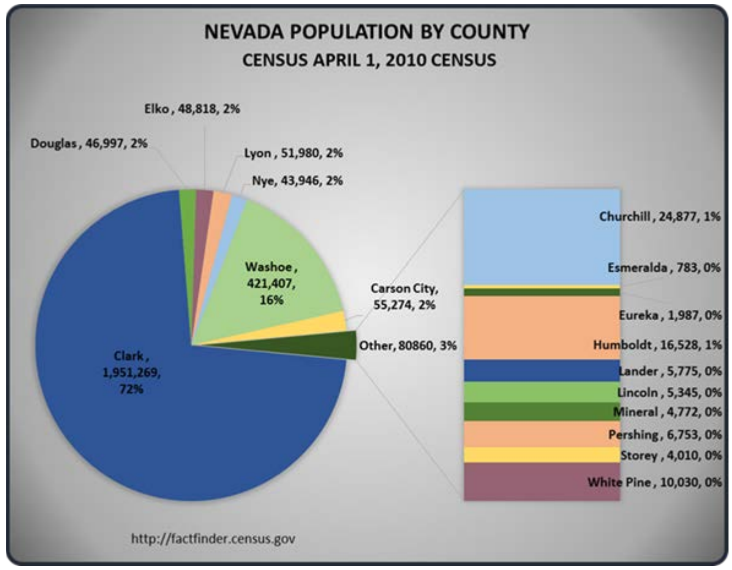


Figure 7- 2010 Census Nevada Population by County

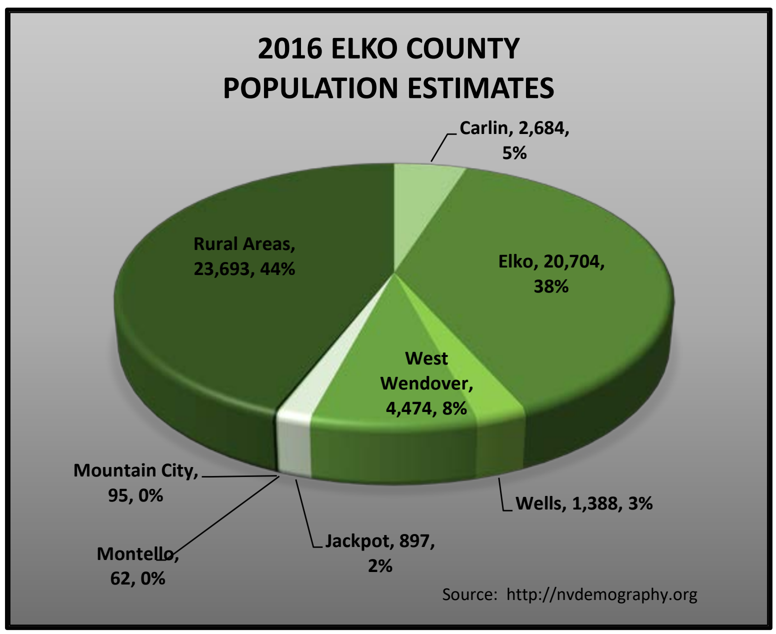


Figure 8- 2016 Elko County Population Estimates

MUNICIPAL BOUNDARIES:

Elko County has four incorporated cities. Lands within the municipal boundaries of the Cities of Elko, Carlin, Wells and West Wendover are approximately 33 square miles, 21,120 acres, or 0.19% of the total surface area or land mass. Uses within the incorporated cities include commercial, industrial, recreation, residential and some agricultural. Population estimates for 2016 in Elko County show that approximately 29,250 or 54% of the total population in Elko County live in the incorporated cities. According to the 2010 Census, 13,614 people, or 25% of the total population within Elko County live in the Spring Creek, Lamoille and South Fork areas in the 89815 and 89828 ZIP codes. After consideration of the unincorporated towns' population of 1,054 people, or 2%, that leaves a remainder of 10,079 people, or 19% of the total population, living in the rural areas outside of urban or adjacent communities.

LAND USES

AGRICULTURAL USES:

According to the Elko County Assessor, privately owned agricultural deferred land in 2014 comprises 2.27 million acres, down from 2.47 million acres in 2007. The farms typically produce ~~alfalfa~~ hay for winter-feeding. The ranches are cow/calf operations, and the current year's crop is generally sold in the fall and exported. The ranches commonly utilize public lands for seasonal livestock grazing. Spring runoff from the nearby mountains provided early seasonal irrigation. At higher elevations, small springs and seeps provide limited watering facilities for livestock.

Table 1 - 2012 Elko County Profile Census of Agriculture

Census of Agriculture - Elko County Profile 2012			
	2002	**2007**	**2012**
Number of Farms	397	456	552
Land in Farms (acres)	2,472,143	2,085,135	2,126,980
Average Size of Farm (acres)	6,250	4,573	3,853
Market Value of All Products sold	$45,311,000	$95,599,000	$95,618,000
http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Nevada/cp32007.pdf			

Elko County typifies a true "Cow County" with vast lands amid rugged mountains. The county has remained first in the ranking within Nevada in the number of beef cows tabulated in the USDA 2012 Census of Agriculture. Agricultural production is focused around the Ruby Mountains including Wells, Clover Valley, Starr Valley, Ruby Valley, Lamoille and Jiggs. Other areas of agriculture include the areas of North Fork, Mountain City and Tuscarora, along the Independence Mountain Range, the ranching communities of O'Neil and Jarbidge in the northeastern portion of the county and the areas along the Humboldt River including Metropolis, Elko, Deeth, Halleck and Carlin.

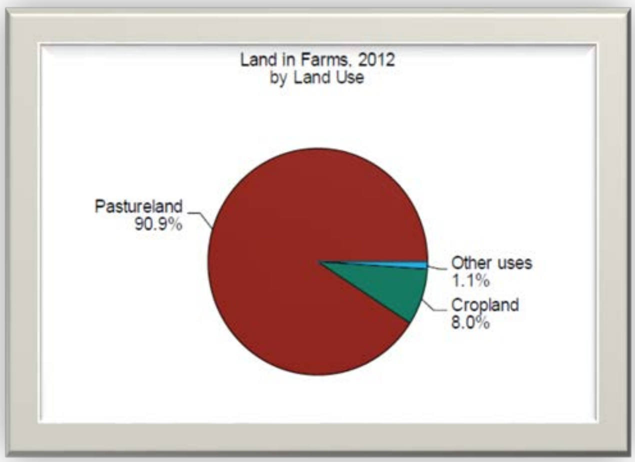


Figure 9 - Elko County Land in Farms by Land Use 2012 www.agcensus.usda.gov

RESIDENTIAL USES:

Residential uses in Elko County vary from parcels of 6,000 square feet or smaller to larger parcels of more than 40 acres in size. Residential development increased during the boom years of the 1980's and1990's to its current status of a deficiency of developable land. Platting of residential subdivisions in Elko County has primarily occurred through subdivision of lands previously used for agricultural purposes. Numerous subdivisions platted in the early 1960's, prior to N.R.S. subdivision law, did not provide for legal access, roads or utilities. Many of these subdivisions to date have not been developed or are developing at a slower rate. Most residential development has occurred within the incorporated boundaries of Elko and the surrounding areas, such as Spring Creek, South Fork, Lamoille and areas directly adjacent to the City of Elko, or along the Interstate 80 highway corridor, including Osino and Ryndon.

Average lot sizes within City boundaries are approximately 6,000 s.f. and are restricted to residential uses. Residential parcels in unincorporated Elko County average 2.5 acres permitting limited hobby (non- commercial) agricultural uses. Other residentially zoned properties in Elko County, such as Special Lands, encourage the development of agricultural uses to maintain the agricultural environment while providing residential uses.

COMMERCIAL USES:

Commercial uses and developments in Elko County are primarily within the incorporated cities or highly developed subdivision areas. The commercial uses in Elko County are diverse in nature supplying a wide variety of professional and common services, as well as all types of commercial retail and wholesale sales. Gaming in Elko County is one of the County’s largest sources of revenue. The total area of commercially zoned property within Elko County is approximately 1,000 acres, with less than 400 acres currently developed for existing businesses. Master Planned commercially designated property equals approximately 5,000 acres. Development of major commercial properties have been made within the City of Elko making the city a central regional retail hub for northeastern and east central Nevada.

INDUSTRIAL USES:

Industrial uses and developments in Elko County are primarily within the incorporated cities or lands adjacent to their boundaries. The industrial uses in Elko County are diverse in nature supplying a wide variety of services. A large portion of the industrial business is specific to mining in northern Nevada. Several specific areas or parcels are zoned light or general industrial. These parcels are primarily used for small private businesses related to public services. There are three industrial subdivisions that provide areas of concentrated industrial type uses primarily for business specific to the local needs. In 2006, the Northeastern Nevada Regional Railport (Industrial Area) was developed by Elko County. The Northeastern Nevada Regional Railport (NNRP) is managed under its own land use master plan. The acreage set aside for the industrial uses is approximately 35 acres. The total area of industrial zoned property within Elko County is approximately 535 acres, with less than 200 acres currently developed for existing businesses. Master planned industrial designations equal approximately 2,000 acres for industrial zoning. To date manufacturing is not provided in Elko County, primarily due to the lack of sufficient water resources and our proximity to major urban areas.

RECREATIONAL USES:

Privately owned and operated open space recreation areas within Elko County including the incorporated cities, excluding gaming, is virtually nonexistent. According to the Elko County Assessor in 2016, there were 1,297 acres of privately owned land dedicated and zoned recreational. The recreational uses of this zone primarily are the operation of dude ranches, hunting/fishing guide services, helicopter Snow skiing and remote gathering and lodging facilities.

Public water-based recreational uses in Elko County are primarily state or federally owned and/or managed lands. The BLM currently manages four campgrounds within the Elko District: Wilson Reservoir, North Wild horse, Zunino/Jiggs Reservoir and Tabor Creek campgrounds with approximately 60 campsites total. The Forest Service currently manages seven campgrounds: three within the Mountain City Ranger District, Big Bend, Jack Creek, and Wild horse Crossing campgrounds and four within the Ruby Mountains Ranger District, Angel Creek, Angel Lake, South Ruby, and Thomas campgrounds with approximately 150 individual campsites total. The State of Nevada provides approximately 60 campsites within the South Fork State Park and Wild Horse Recreation Area with some open camping allowed in designated areas along the shoreline.

The BLM and USFS note that use of the developed recreational sites is decreasing. One of the reasons for the decrease in use is the increasing use of undeveloped public lands for camping and other recreation. This trend is referred to as *Dispersed Recreation*. The land managers are now educating the public about the impacts of Dispersed Recreation.

It was calculated by the author of the 1971 Elko County General Plan that approximately 35% of the total land mass of Elko County was utilized for recreation. Recreation and tourism in the 1971 General Plan were considered "Bridge Traffic," meaning while traveling from other points, travelers merely traversed Elko County with occasional stops. Recreation was primarily utilized by the local population and hunters that ventured to Elko County for hunting opportunities. Over the past 30 years, Elko County has become a nationally recognized destination due to the diversity of recreational, historical, cultural and ethnic special events and attractions. Recreation, as pointed out in the 1971 General Plan, was primarily hunting, fishing, equestrian use and camping in our many pristine nature areas. Recreational uses have expanded over the last 30 years to include all-terrain vehicles, cross-country motorcycle racing, long-range highway auto racing, hiking, nature viewing, photography, snow skiing, cross country skiing, boating and numerous other uses.

Lamoille Canyon - Beaver Ponds

NATURAL RESOURCE MINING AND EXPLORATION USES:

Very little attention was given to mining in Elko County in the 1971 General Plan, due to most of the mining activities of the area being developed in neighboring Eureka County. However, very few envisioned the impact the mining boom of the 1980's and 1990's would have on the City of Elko and surrounding areas. Due to the proximity of the City of Elko, development of the Newmont, Barrick and Freeport mines produced urban sprawl. Extensive development of residential areas in the vicinity of the City of Elko occurred. Commercial and industrial development also expanded.

Mining and exploration has become one of Elko County's most reliable and efficient economic stabilizers. The mining industry, even though primarily located outside of the Elko County boundaries, has provided thousands of jobs to the residents of our county. The mining industry also was responsible for the development of professional services such as engineering, surveying, land use development, construction, geology and many other related fields. These economic developments improved the condition of the area by providing infrastructure and revenue to our local governments and population. The mining industry is currently Elko County's largest employer. As a result, average wages per household are among the highest in the nation. This helps provide economic stability and quality of life to our communities.

PRIVATE OWNERSHIP AND DEVELOPMENT:

Private land ownership is diverse due to past history of subdivision and development. Development of residential areas has occurred through subdivision of lands previously used for agricultural purposes. Many of these subdivisions were created in the early 1960's, prior to **N.R.S.** subdivision law or Elko County ordinance and did not provide for access, utilities or legal water rights. Many of these subdivisions have never been fully developed or inhabited.

Development of residential uses has historically been within municipal boundaries and areas surrounding the City of Elko, including Spring Creek, Lamoille, South Fork and areas directly adjacent to the City of Elko. A recent trend is division of land into large parcels of 40 acres or more. This trend has generated many residential parcels with agricultural potential. Most of these divisions of land occur in close proximity to incorporated cities.

The City of West Wendover was incorporated in 1991, making it Elko County's second largest city with a population of 4,420. The development of legalized gambling, retail sales and services required residential development to accommodate the new employees and families. The City of West Wendover currently has limited expansion potential due to the lack of developed water supply. The City of West Wendover currently pipes water from a source approximately 35 miles to west to accommodate its water needs. Some non-potable water is available from ground locations within the corporate limits for irrigation use only.

Other areas that developed during the 1990's include the rural subdivision of Spring Creek. The area has commercial, industrial, recreation and residential uses. According to the Spring Creek Association as of July 2015, 4,659 of the total number of the 5,420 lots within Spring Creek were occupied. Which would put Spring Creek at 86% total capacity. The 2010 Census shows 13,614 people live in the Spring Creek, Lamoille and South Fork areas within the 89815 and 89828 ZIP codes. Other areas such as Osino, Ryndon and River Ranch have also developed with primarily residential uses.

TRANSPORTATION:

Elko County has ten primary highway transportation routes crossing the county from east to west and north to south. Interstate 80 is a four-lane divided highway that extends approximately 130 miles from the eastern state line at West Wendover to the western boundary with Eureka County near Carlin. This route bisects Elko County. The second most traveled route is Highway 93, which is a two-lane highway 140 miles long from the southern boundary with White Pine County to the northern state line at Jackpot. State Route 225 begins in the city of Elko and traverses north approximately 90 miles to the Idaho border. State Routes 227 and 228 are primarily local area access routes. State Route 227 begins in the City of Elko and traverses southeast approximately 25 miles to the town of Lamoille. State Route 228 intersects State Route 227 in a portion of Spring Creek area, and trends southerly approximately 30 miles, providing access to the South Fork Recreation Area, the community of Jiggs and the Ruby Marshes Wildlife Refuge, to the base of the Ruby Mountains at Harrison Pass.

State Routes 27B and 766 cross a small area of southwestern Elko County and both are two-lane roads originating in the City of Carlin. State Route 27B is a major transportation route to the Town of Eureka, in Eureka County. Highway 766 provides access to the mining areas in northern Eureka County and western Elko County. State Route 226 intersects State Route 225 near Lone Mountain Station in central Elko County and treks northwesterly approximately 40 miles providing access to the town of Tuscarora and Independence Valley. State Route 233 intersects Interstate 80 at Oasis Interchange going northeast through the town of Montello to the Utah border. State Route 93A begins in West Wendover and traverses southwest approximately 35 miles to the Elko and White Pine County border. Elko County currently maintains approximately 1,200 miles of gravel and asphalt surface roads. It is estimated that less than 40 miles of these roads are asphalt surfaces, the remainder being gravel and dirt surfaces. The average width of Elko County Maintained roads is 26 feet, providing for two way traffic flows.

Most all county roads commence at intersections with state or federal highways. These roads in most all cases are the primary accesses to remote areas, rural towns, ranches, farms, recreation areas or other rural developments. For the most part, all of the Elko County road system are maintained roads within an implied or prescriptive use right of way. Very few descriptive right of ways exist, most all of the descriptive right of ways are short stretches of less than a mile and were dedicated because of a land action or subdivision. The lack of descriptive right of way is primarily due to the historical location of the roads. For the most part the roads themselves have never been relocated or surveyed for location. Historical value can be given to most of Elko County's road system due to their very location and specific destinations.

Elko County also provides for air transportation and railway service. Commercial airfreight and passenger service is provided by the City of Elko Municipal Airport. The current passenger service is primarily to Salt Lake City, Utah from Elko. Connections to any destination can be made from that location. Railway service is provided by Union Pacific Railroad and Amtrak including both freight and passenger service.

NEVADA AND ELKO COUNTY PUBLIC LAND HISTORY:

Until 1976, public lands in Nevada were available for private acquisition. The amount of public land in Nevada is a direct result of choices made by the territorial government at the time of statehood and the state government for a number of years thereafter and also private citizens between the mid-1800's and 1976. The United States government acquired lands in the area that is now Nevada through the Treaty of Guadalupe Hidalgo in 1848. This treaty ended hostilities between the United States and the Mexican governments at the close of the Mexican American War. Nevada was given sections 16 and 36 in every township as state land equaling approximately four million acres.

At the request of Nevada, the U.S. Congress changed this in 1870, to allow Nevada to select up to two million acres of land of their choice in lieu of the four million acres of the specified sections. The apparent reason for the State's request was their belief that at least half of the acreage in sections 16 and 36 was on mountaintops or otherwise unusable land. After 1870, the State selected lands based on requests by Nevada citizens, such as Pedro Altube, John Sparks and Governor Blasdel.

WESTERN SETTLEMENTS OF PUBLIC LANDS:

The Pre-emption Act of 1830, the Homestead Act of 1862, the Mining Law of 1872, and the Desert Land Act of 1877, as well as other land laws were passed to promote the settlement of the West. Although most of these laws were on the books until 1976, they were not taken advantage of in Nevada. The primary reason that more land was not homesteaded in this state was because of the arid nature of the lands and its general unsuitability for agriculture in many places. By contrast, most of Washington, Idaho and a major part of Colorado are private lands because they were largely successfully homesteaded for farming and ranching in the late 1800's and early 1900's. The passage of the Federal Land Policy and Management Act (FLPMA) in 1976 repealed the Homestead Act and other laws that provided for public entry.

1800's Homestead - Ruby Valley

SECTION 1
Elko County Water Resource Management Plan
Plan Development Information

SOCIOECONOMIC OVERVIEW

HISTORY:

Elko County was named for the town of Elko, which was first settled by George F. Paddleford in December of 1868. It is believed that the town of Elko was named by Charles Crocker, or some other official of the Central Pacific Railroad, for the name is a typical railroad name denoting stations in Alabama, Colorado, Georgia, Minnesota, South Carolina, Virginia, and British Columbia.

As the source of the Humboldt River, the only major waterway in Nevada which is wholly contained within the state, Elko County was visited by many famous early explorers and emigrant trains headed for California and Oregon. Upon entering Nevada on the California (Humboldt) Trail, the springs of Humboldt Wells (presently the City of Wells) provided much-needed refreshment during the period 1845-1870 to thousands of travelers each year who rested and refitted from their arduous journey and prepared them for the grueling 300-mile trek along the Humboldt River and Valley through the present-day sites of Elko, Winnemucca, and Lovelock.

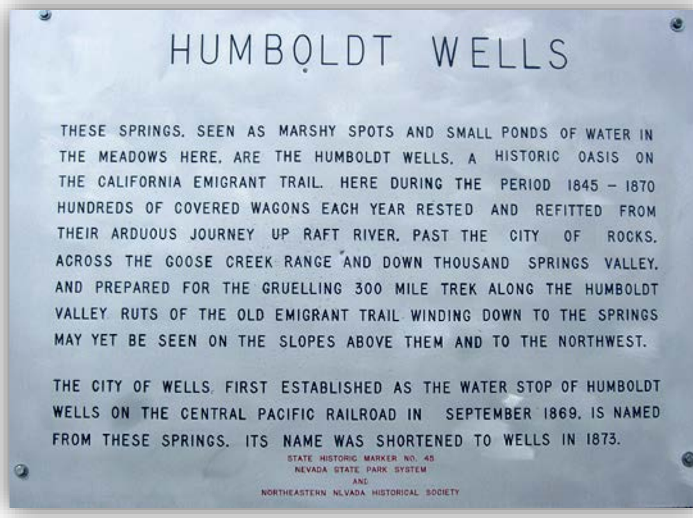
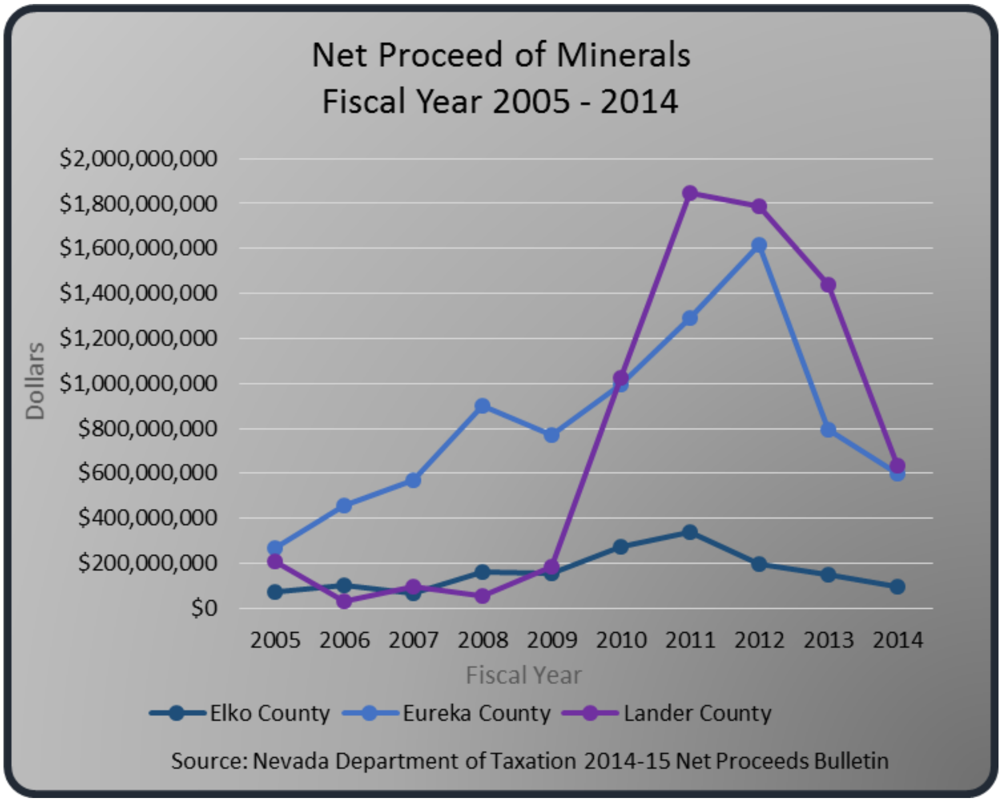


Figure 10 -
Nevada Historical Marker No. 45 - Humboldt Wells

On December 29, 1868, representatives of the Central Pacific Railroad started laying out lots for the future town of Elko and the town grew up as a rail stop on the transcontinental railroad, which was completed in 1869. By 1870, the thriving town had 5,000 people. There was an immense volume of freight and passenger traffic over the stage line roads north and south from the railhead at Elko to the local mining areas. The University of Nevada was originally established in Elko in 1874 and remained here until 1885, when it was moved 290 miles west to its present location in the city of Reno. By the early 1870's, Elko became the marketing and economic center for northeastern Nevada. In the 1870's and 1880's, great ranching enterprises were built on Elko County's vast rangelands and were ruled over by such powerful and colorful cattle kings as L.R. "Broadhorns" Bradley, Nevada's second Governor and its first "cowboy" Governor; the French Garat family, Spanish Altubes, and John Sparks, Governor of Nevada in the early years of the twentieth century. To this day, Elko remains the economic hub of Nevada's greatest range area. In addition to mining operations in Elko County and in adjacent Eureka County to the west, the city of Elko has also become a major recreation and tourism center in northeast Nevada.

Since the county's formation in 1869, Elko County's mining industry has constituted a crucial underpinning to the county's growth and economic well-being. In addition to mining operations within Elko County, the city of Elko also serves as an important mining center for operations along the Carlin Trend in nearby Eureka and Lander counties.

Figure 11 - Net Proceeds of Minerals
FY 2005 - 2014



According to the Net Proceeds of Minerals 2014-2015 Bulletin, there are 13 active mining operations within Elko County with net proceeds of $98,286,778 primarily from gold in the fiscal year 2014-2015. There were currently 6 active mining operations in Eureka County with net proceeds of $597,732,878, and 8 active mining operations in Lander County with net proceeds $634,033,829.

Exploration for oil & gas within Elko County was initiated in 2012. The growing demand for energy including fossil fuels and alternative energy sources have increased the interest in Elko County's largely unexplored potential. A geothermal electrical generation plant was constructed in 2010 north of the city of Elko.

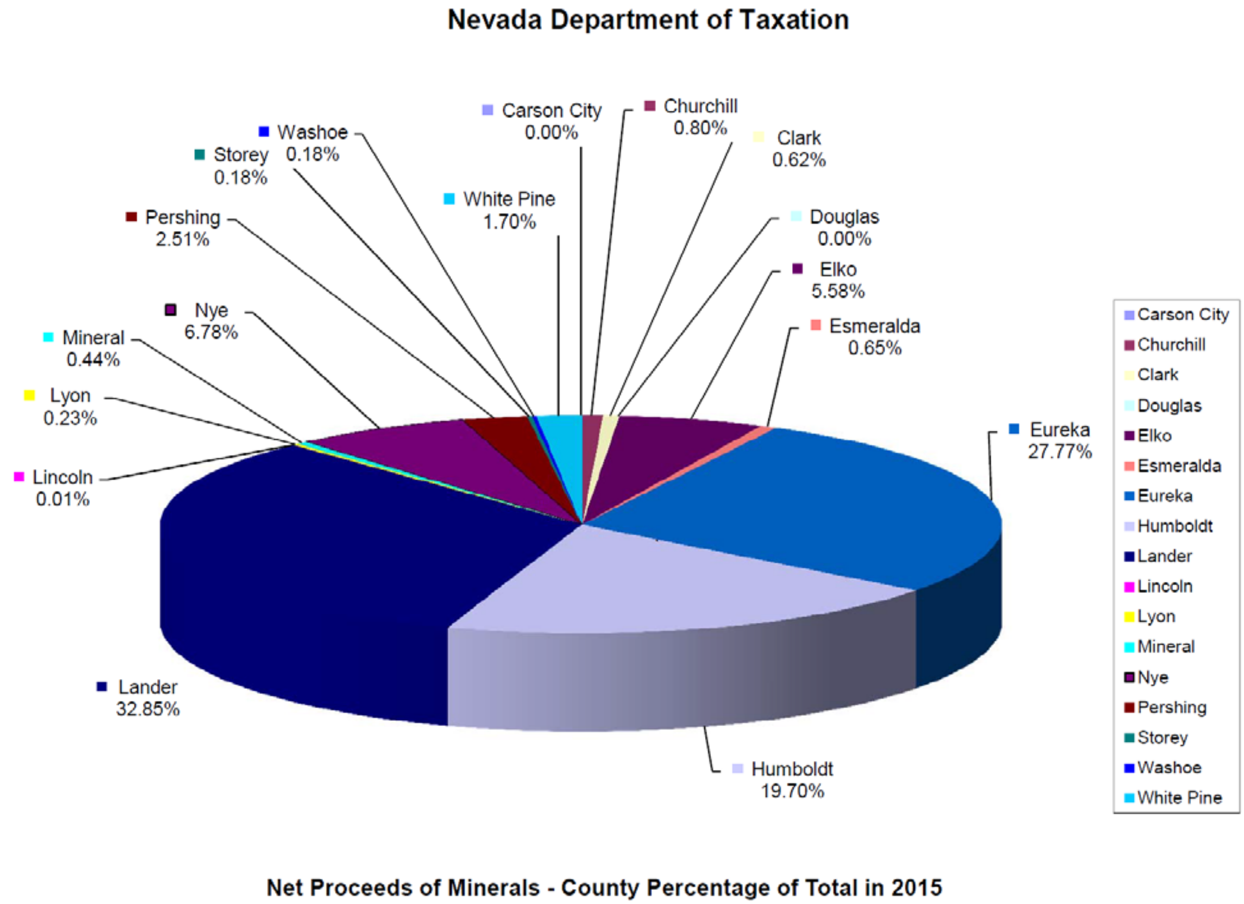


**Figure 12 - Net Proceeds of Minerals
County Percentage of Total in 2015**

Early agricultural development in Elko County was bolstered to serve the needs of the various mining districts. Runoff from several large mountain ranges including the Jarbidge Mountains and the Ruby Mountains insured abundant water to serve the local farming and ranching industry. Gaming has constituted a major industry sector in the county, primarily in Wendover, Elko, and Jackpot. While Elko County's growth has been dependent on the health of Nevada's gold mining industry and the county's strategic location to mining operations in Eureka County in particular, also important to the county's well-being has been its growing strength as a gaming and tourism center serving markets in Idaho and Utah. Water availability, of course, plays a crucial role here.

Agriculture continues to be an important part of Elko County's economic viability. Based on the 2012 Census of Agriculture, the market value of agriculture products sold was $95.618 million up 78% compared to $53.599 million in 2007. In 1995, the market value of agriculture products sold for Elko County was $40.527 million, down 23.6 percent from $53.071 million in the market value of agriculture products sold in 1990, but up 21.4% over $33.379 million in the market value of agriculture products sold in 1985.

Table 2 - 2012 Census of Agriculture Elko County Profile

2012 Census of Agriculture
Elko County - Nevada Profile

Ranked items among the 17 state counties and 3,079 U.S. counties, 2012

Item	Quantity	State Rank	Universe [1]	U.S. Rank	Universe [1]
MARKET VALUE OF AGRICULTURAL PRODUCTS SOLD ($1,000)					
Total value of agricultural products sold	95,618	3	17	1,211	3,077
Value of crops including nursery and greenhouse	14,642	7	17	1,886	3,072
Value of livestock, poultry, and their products	80,977	1	17	602	3,076
VALUE OF SALES BY COMMODITY GROUP ($1,000)					
Grains, oilseeds, dry beans, and dry peas	(D)	9	13	(D)	2,926
Tobacco	-	-	-	-	436
Cotton and cottonseed	-	-	-	-	635
Vegetables, melons, potatoes, and sweet potatoes	(D)	7	11	(D)	2,802
Fruits, tree nuts, and berries	(D)	9	11	(D)	2,724
Nursery, greenhouse, floriculture, and sod	(D)	11	12	(D)	2,678
Cut Christmas trees and short rotation woody crops	-	-	1	-	1,530
Other crops and hay	14,318	7	16	228	3,049
Poultry and eggs	22	5	13	2,001	3,013
Cattle and calves	76,146	1	16	179	3,056
Milk from cows	(D)	6	7	(D)	2,038
Hogs and pigs	5	8	12	2,319	2,827
Sheep, goats, wool, mohair, and milk	(D)	3	14	(D)	2,988
Horses, ponies, mules, burros, and donkeys	1,233	3	16	189	3,011
Aquaculture	(D)	2	7	(D)	1,366
Other animals and other animal products	24	6	12	1,810	2,924
TOP CROP ITEMS (acres)					
Forage-land used for all hay and haylage, grass silage, and greenchop	101,359	2	17	29	3,057
Barley for grain	(D)	4	6	(D)	1,158
Wheat for grain, all	(D)	9	9	(D)	2,537
Spring wheat for grain	(D)	6	8	(D)	633
Corn for silage	(D)	7	11	(D)	2,237
TOP LIVESTOCK INVENTORY ITEMS (number)					
Cattle and calves	120,474	1	16	87	3,063
Sheep and lambs	20,192	3	14	47	2,897
Horses and ponies	4,527	1	17	86	3,072
Layers	3,011	4	15	1,035	3,040
Goats, all	614	5	16	1,010	2,996

http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Nevada/cp32007.pdf

SECTION 1
Elko County Water Resource Management Plan
Plan Development Information

GEOGRAPHY AND HYDROLOGY:

Elko County is located in the extreme northeastern portion of Nevada and is bordered by Utah to the east and Idaho to the north. Elko County is the second largest county in Nevada (after Nye County) and covers approximately 17,181 square miles, accounting for 15.5 percent of Nevada's total surface area of 110,540 square miles. According to the BLM, Elko District office, a total area **of 72.54%**, or **7,949,921.65** acres within Elko County is managed by Federal Agencies including the Bureau of Land Management (BLM), the U.S. Forest Service (USFS) and U.S. Fish and Wildlife Service.

Table 3- Elko County Land Ownership

Elko County Land Ownership

Agency	Acres	%
Bureau of Indian Affairs	160,792.35	1.47%
Bureau of Land Management	6,853,835.39	62.54%
Bureau of Reclamation	-	
Department of Defense	15,162.53	0.14%
U.S. Fish and Wildlife Service	27,088.11	0.25%
Private Ownership (all non-federal)	2,832,944.83	25.85%
U.S. Forest Service	1,068,998.15	9.75%
Total	10,958,821.36	100.00%

Source: BLM Elko District Office, 2015

The lands managed by the USFS include two large sections of the Humboldt National Forest. The northern tract is located in the Jarbidge Mountains and includes one source of the North Fork of the Humboldt River; the southern tract lies in the Ruby Mountains and includes a primary source of the South Fork of the Humboldt River. Elko County ranks eleventh highest in terms of its percentage of federal land ownership and first in terms of acreage of federal land ownership among all of Nevada's counties.

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Elko County stretches across four of Nevada's fourteen hydrographic regions or water basins (watersheds). However, a major portion of the county is contained within two river basins: the Snake River Basin (Hydrographic Basin 3), which drains to the north, out of the state and into the Columbia River System, and the Humboldt River Basin (Hydrographic Basin 4), which is the only principal river system wholly contained within Nevada. In addition, the extreme eastern edge of the county lies within the Great Salt Lake Basin (Hydrographic Basin 11) and the southeastern portion of the county lies within the Central Region (Hydrographic Basin 10). Within the four major hydrographic regions, Elko County also contains, either wholly or partially, forty-two hydrographic areas and sub-areas. These areas are defined as hydrographic units within a major water basin and typically consisting of a single valley or discrete drainage area.

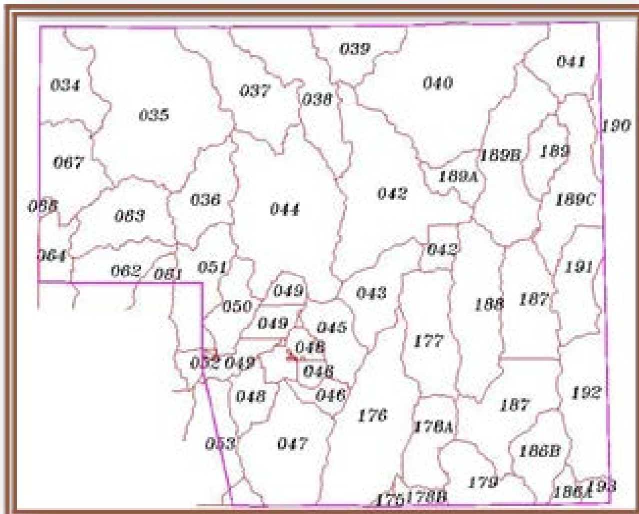


Figure 13 - Elko County Hydrographic Areas

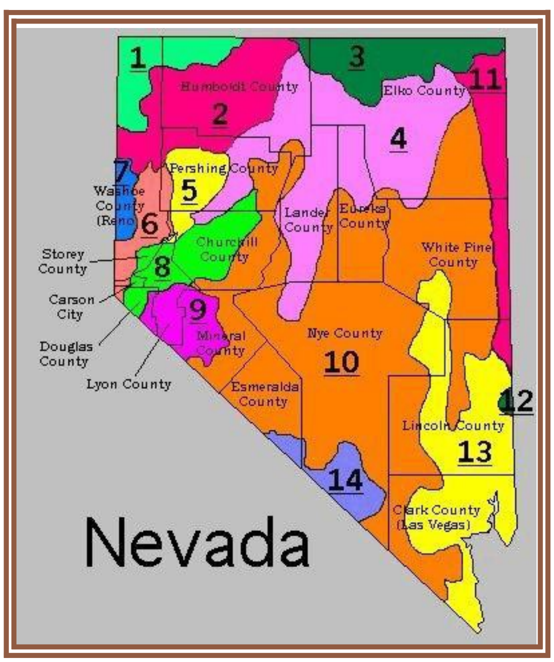


Figure 14 - Nevada's Hydrographic Regions

WATER RESOURCES and WATER USES

Much of the water for agriculture, ranches, recreation areas, and communities of the county is provided by snowfall from the high watersheds. The highest average precipitation in the River Basin is to be found in the Ruby Mountains. Some 44% of the total basin water yield comes from the Ruby Mountains and the East Humboldt Range. Water yield from 65% of the Basin is negligible while a 10,000 acre area in the Ruby Mountains yields more than 30 inches per acre of water annually. Some water from the west slope of the Ruby Mountains is diverted to the east slope due to fault planes and fractures in the limestone formation of the mountains south of Harrison Pass.

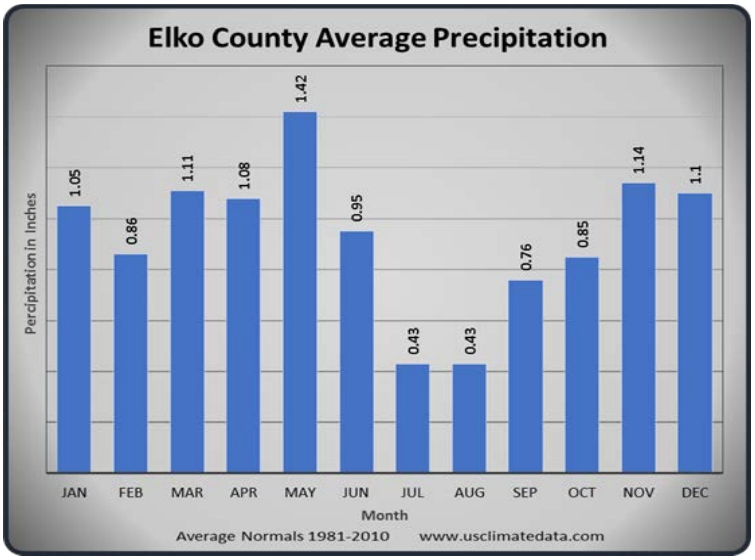


Figure 15 - Elko County Average Precipitation

Three of Elko County's four incorporated cities, Carlin, Elko, and Wells lie within the Humboldt River Basin. The basin encompasses 15% of the state and is composed of approximately 20 sub-watershed areas. Through conservation, these watersheds could yield more water resources. The Humboldt River Basin receives 9,285,000-acre feet of water per year resulting from rain and snow.

Average Annual Rainfall in Inches 1981-2010

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Carlin	1.46	1.02	1.22	1.22	1.57	1.1	0.24	0.31	0.67	0.91	1.5	1.69	12.91
Elko	1.10	0.83	0.98	0.98	0.94	0.67	0.35	0.35	0.55	0.75	1.1	1.18	9.78
Jackpot	0.83	0.67	0.94	1.1	1.57	1.1	0.47	0.67	0.67	0.87	0.98	0.75	10.62
Lamoille	1.26	1.14	1.61	1.42	2.05	1.14	0.47	0.51	1.1	1.1	1.26	1.02	14.08
Montello	0.63	0.51	0.75	0.79	1.1	0.91	0.67	0.51	0.71	0.63	0.59	0.47	8.27
Tuscarora	1.18	0.98	1.26	1.1	1.46	0.83	0.35	0.28	0.71	0.91	1.57	1.69	12.32
Wells	0.91	0.87	1.02	0.94	1.22	0.87	0.43	0.39	0.94	0.79	0.98	0.87	10.23
Elko County	1.05	0.86	1.11	1.08	1.42	0.95	0.43	0.43	0.76	0.85	1.14	1.10	11.17

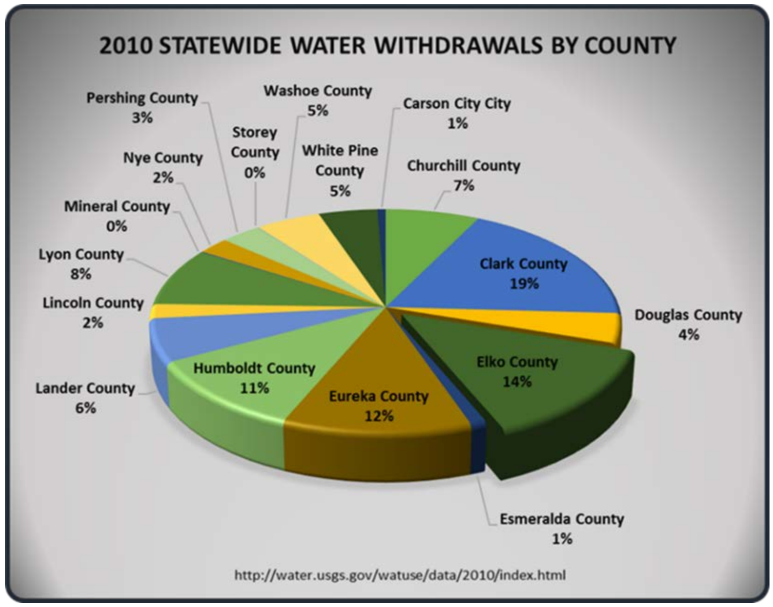
Average Normals 1981-2010 www.usclimatedata.com

Table 4 - Elko County Average Annual Rainfall

According to the USGS data, by 2010 Clark County had surpassed Elko County as the largest water user among Nevada's seventeen counties at 486.64 Mgal/d or 1,493.44 acre feet compared to Elko County at 357.05 Mgal/d or 1,095.74 acre-feet. Clark County's largest category for water withdrawal was Public Supply at 439.43 Mgal/d followed by domestic use at 251.07 Mgal/d with a population of 1,951,269.

In Elko County the 2010 public supply water withdrawals were estimated at 13.34 Mgal/day, (14,942.70 acre feet annually {afa}) or 4% of the county's total water withdrawals. The percentage of water used for irrigation purposes decreased substantially from 898,321 afa in 2005 to 375,695 afa in 2010. This significant decrease is most likely due to agricultural water conservation efforts and improvements as well as the decrease in estimated acres of irrigated lands shown in the 2012 Census of Agriculture. In 2010, the Census showed Elko County's population grew to 48,818 but the estimated total water withdrawals fell from 23.2% to 14% of the total for Nevada due to the increase in Clark County's population.

Figure 16 - Nevada 2010 Statewide Water Withdrawals by County



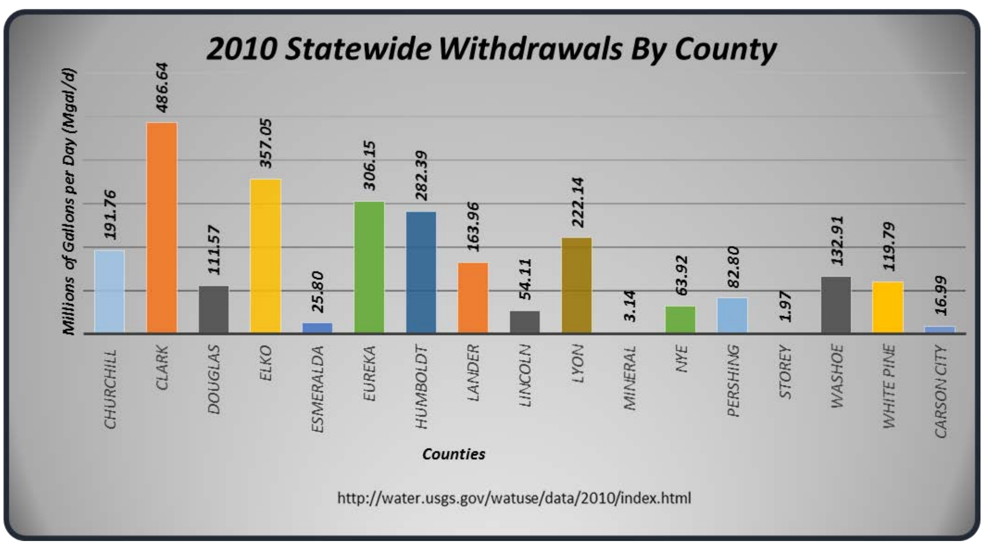
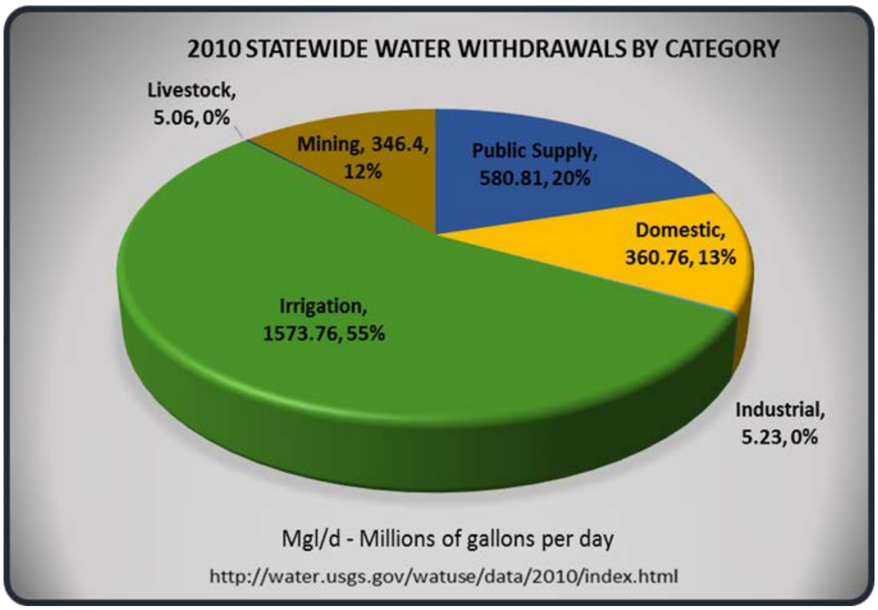


Figure 17 - 2010
Statewide Water Withdrawals by County

According to the Census of Agriculture the estimated acres of irrigated land has steadily decreased within Elko County over the last few decades. According to the 2012 Census of Agriculture the estimated acres of irrigated land in 2007 was 182,233 acres, and decreased to 132,213 acres irrigated land by 2012; which dropped Elko County to second place behind Humboldt County at 137,470 acres of Nevada's 687,790 acres total irrigated land.

Figure 18 - Statewide Water Withdrawals by Category



The Humboldt River system represents a highly efficient irrigation water conveyance and distribution mechanism. Agricultural water users along this river system, stretching from the river's headwaters in Elko County through Eureka, Lander, Humboldt and into Pershing County, benefit from a continuous process of water diversion, application, return flow, and reuse. Consequently, measures of irrigation conveyance losses and water withdrawals do not fully reflect the actual workings of the overall river system.

SECTION 1
Elko County Water Resource Management Plan
Plan Development Information

SECTION 1 - SUMMARY

Section 1 offers general information concerning the Institutional framework of the Elko County Water Planning Commission and its creation and implementation of the Elko County Water Resource Management Plan. The Water Planning Commission was established with the sole purpose of the creation of the plan. The plan was developed to provide guidelines for future water resource management by the general public and Elko County staff. The Water Planning Commission has been dissolved since this plan was developed and this update has been developed by the Natural Resource Management Advisory Commission in 2015/2016.

Demographics were provided by the *State of Nevada Division of Water Planning*, *State of Nevada Demographer* and Elko County staff. The data and information represented in Section 1 and Section 2 depict the geographics, climate geology, vegetation, land mass, population and municipal boundaries. Demographic information concerning population provided by the *State of Nevada* indicates a decrease in population and a loss of agricultural lands in Elko County over the next twenty-five years. In contrast, Elko County staff predicts an increase in population and sustained agricultural lands. This is based on historical data representing development patterns and recent economic trends. The trend of increased population and sustained agricultural lands has continued in 2015, although with the increased demand for residential development, environmental concerns and the decline in commodity prices, the future of the agricultural and mining industries are uncertain.

The Elko County Planning & Zoning Division, Elko County Assessor, Bureau of Land Management and U.S. Forest Service have provided information concerning land uses and development patterns. This information is based on a twenty-year history establishing trends and development. Specific types of land uses are represented and explained as part of Section 1. Specific lands uses are as follows:

- ✓ Agriculture
- ✓ Residential
- ✓ Commercial
- ✓ Industrial
- ✓ Recreation
- ✓ Mining
- ✓ Private Development
- ✓ Transportation
- ✓ Public Land History
- ✓ Western Settlements

The socioeconomic overview is provided by the *State of Nevada Division of Water Planning* as part of the Nevada Water Plan. Some issues within the State Plan depict an evaluation by the State of Nevada and are not necessarily the views of the Natural Resource Management Advisory Commission or County staff. The overview provides pertinent information related to History, Hydrology, Water Resources and Water uses.

The authors of the Elko County Water Resource Management Plan establish **Section 1** as general information concerning water resources, issues and data specific to the state, region and Elko County. Section 1 is not intended to provide comprehensive data concerning water resources and uses of any specific area. The Water Resource Management Plan is intended to encourage future analysis of hydrographic areas in Elko County utilizing current scientific data.

Elko County
Water Resource Management Plan
Section 2
2017

Lamoille Church & Ruby Mountains

NEVADA WATER LAW

The water in Nevada on the surface and below the ground surface belongs to the people of the State. Entities within the State can apply for the right to use that water. Nevada Water Law was founded on the doctrine of prior appropriation - **"first in time, first in right."** Under the appropriation doctrine, the first user of water from a watercourse acquired a priority right to the use and to the extent of its use (Shamberger, H.A., Evolution of Nevada's Water Laws, as Related to the Development and Evaluation of the State's Water Resources from 1866 to about 1960, U.S. Geological Survey Water Resources Bulletin 46, 1991).

Nevada Water Law is set forth in Nevada Revised Statutes (NRS), Chapters 533 and 534. In addition, there are numerous court decisions, which have helped define Nevada Water Law. The State Engineer is the water rights administrator and is responsible for the appropriation, adjudication, distribution and management of water in the State. To carry out these duties he is vested with broad discretionary powers.

As part of the duties of the office, the State Engineer reviews applications for new water rights appropriations. In approving or rejecting an application, the State Engineer considers the following questions as set forth in NRS 533.370: 1) is there unappropriated water in the proposed source?; 2) would the proposed use impair existing rights?; and 3) will the proposed use prove detrimental to the public interest? Public interest is not defined by statute and the State Engineer can consider different issues, depending upon the individual application.

All water rights are considered real property and thus are conveyed by deed. Water rights can be bought and sold, and the location and type of use changed. The attributes of appropriative water rights in Nevada are: 1) beneficial use is the measure and the limit of the right to the use of the water; 2) rights are stated in terms of definite quantity, manner of use, and period of use; and 3) a water right can be lost by abandonment or forfeiture. Abandonment is determined by the intent of the water user to forsake the use of the water. A groundwater right is lost by forfeiture if the right is not used for 5 years. Water lost through abandonment or forfeiture reverts back to the public and is subject to future appropriation.

The Nevada Division of Water Resources is responsible for administering and enforcing Nevada Water Law, which includes the adjudication and appropriation of groundwater and surface water in the state. The appointed administrative head of this division is the State Engineer, whose office was created by the Nevada Legislature in 1903. The purpose of the 1903 legislation was to account for all of the existing water use according to priority. The 1903 act was amended in 1905 to set out a method for appropriation of water not already being put to a beneficial use.

It was not until the passage of the Nevada General Water Law Act of 1913 that the Nevada Division of Water Resources was granted jurisdiction over all wells tapping artesian water or water in definable underground aquifers. The 1939 Nevada Underground Water Act granted the Nevada Division of Water Resources total jurisdiction over all groundwater in the state.

The 1913 and 1939 acts have been amended a number of times, and Nevada's Water Law is considered one of the most comprehensive water laws in the West. The above-mentioned acts provide that all water within the boundaries of the state, whether above or beneath the surface of the ground, belongs to the public, as referenced in NRS 533.025 and is subject to appropriation for beneficial use under the laws of the state (NRS 533.030 and NRS 534.020).

SOCIOECONOMIC CHARACTERISTICS

In terms of socioeconomic characteristics, a large percentage of Elko County's population tends to be concentrated in or near the vicinity of the incorporated City of Elko. The 2000 census estimated the county's total population at 45,291 persons. As of 2006, the state of Nevada Demographer estimated the county's population at 48,339. The 2010 census estimated Elko County's population at 48,818, the Nevada State Demographer's 2014 estimate increased to 53,358.

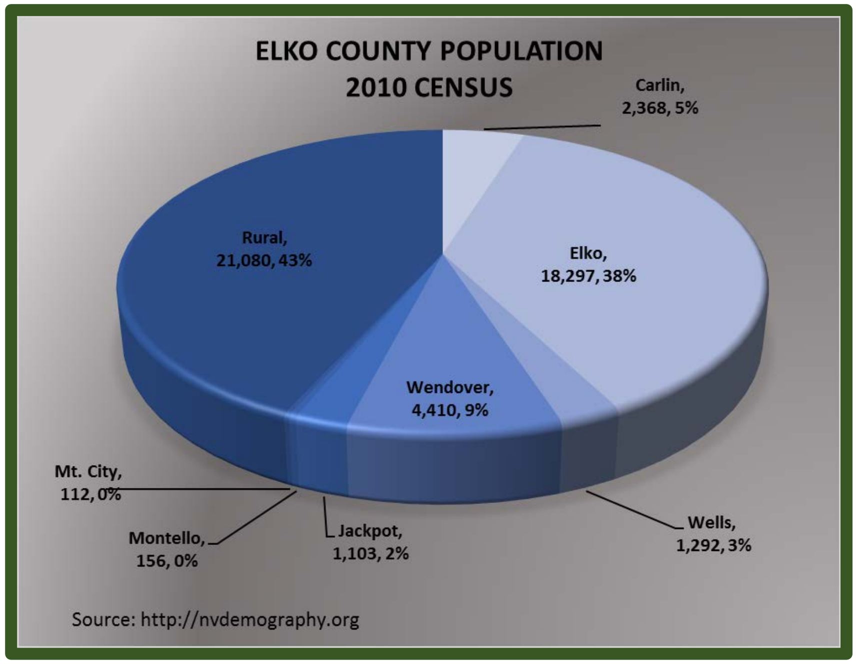


Figure 19 - Elko County Population
2010 Census

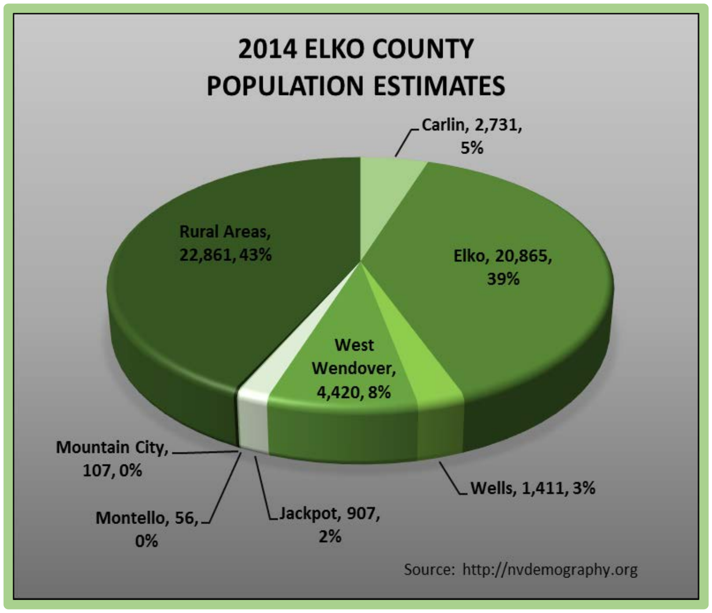
The county's population is divided by cities and communities as follows:

	2006	2006 Estimated % of Total	2010 Census	2010 Estimated % of Total	2014	2014 Estimated % of Total
Incorporated Cities:						
Carlin	**2,281**	**4.7%**	**2,368**	**5%**	**2,731**	**5%**
Elko	**18,183**	**37.6%**	**18,297**	**38%**	**20,865**	**39%**
Wells	**1,449**	**3%**	**1,292**	**3%**	**1,411**	**3%**
West Wendover	**4,871**	**10%**	**4,410**	**9%**	**4,420**	**8%**
Unincorporated Towns:						
Jackpot	**1,293**	**-**	**1,103**	**2%**	**907**	**2%**
Montello	**175**	**-**	**156**	**0%**	**56**	**0%**
Mountain City	**125**	**-**	**112**	**0%**	**107**	**0%**
Elko County	**48,339**		**48,818**		**53,358**	

Source: http://nvdemography.org/wp-content/uploads/2010/10/Popul-of-Nevadas-Counties-and-Incorp-cities-2014-Final-Certified-Series-011514.pdf

Another important population and growth area is centered in the Spring Creek/ Lamoille / Southfork areas, located approximately fifteen miles east southeast of Elko which has been included in the Elko County general or rural category. The 2010 Census showed 13,614 people live in the Spring Creek, Lamoille and South Fork areas within the 89815 and 89828 ZIP codes.

2010 Census determined the total population of Elko County is 48,818.



The Spring Creek population was estimated at 12,346 for 2014 based on Spring Creek Association's December 2014 Analysis of Occupied Lots (4,609) multiplied by the 2010 Census multiplier of 2.65 people per housing unit.

Rural Elko County population estimate of 10,515 is the total Elko County population estimates - all estimates for the cities & towns - the Spring Creek population estimate. (53,358 - 30,497 -12,346= 10,515)

Figure 20 - Elko County Population Estimates
Data provided by Nevada State Demographer's

According to the 2010 Census Housing Data for Elko County, the Housing occupancy is: Total housing units, 19,492, with 17,324 occupied units (88.9%) and 2,168 vacant units (11.1%)

Population Forecast from State of Nevada Demographer **July 21, 2006** - www.nsbdc.org/demographer/pubs/ **2006** State Demographer estimates represent a 1.6% increase from 2005. Population projections from the Nevada State Demographer - http://nvdemography.org/data-and-publications, as of October 1, 2014 based on 2013 estimates show a steady increase in the population of Elko County for the next five years.

Between 1990 and 1997, the county's population growth averaged 5.1 percent per year. By decade, Elko County's population has grown at annual average rates as follows: 1950's—0.3 percent per year; 1960's—1.5 percent per year; 1970's—2.2 percent per year) and 1980's—6.9 percent per year. During the entire 1950–1997 time period, Elko County's population has averaged a rate of growth of 3.0 percent per year as compared to a 5.2 percent annual rate of population growth for the entire state. The relatively slower rate of population growth in Elko County, particularly during the decades of the 1950's, 1960's, and 1970's, was due to the agrarian nature of the economy and the existence of little economic diversification. Beginning in the late 1980's, however, the mining boom along the Carlin Trend, particularly in adjoining Eureka County, began a period of rapid growth as the City of Elko served as a primary base of operations for many of the mining endeavors. Following the mining boom and resultant population increase, Elko also expanded rapidly in casino gaming, both in the City of Elko, Jackpot located on the Nevada-Idaho Border and in West Wendover, located on the Nevada-Utah border. Elko County's population will continued to increase with the expansion of the mining industry and the exploration and development of oil and natural gas.

Table 5 - Forecasted Elko County Population 2014 - 2033 (2015)
Data provided by Nevada State Demographer's Office October 1, 2014

Elko County Population Projections for 2014 - 2033			
Year	**Total Population**	**Change Previous Year**	**Percentage Change**
2013	53,384		
2014	54,301	917	1.7%
2015	54,998	697	1.3%
2016	55,540	542	1.0%
2017	56,060	520	0.9%
2018	56,594	534	1.0%
2019	57,053	459	0.8%
2020	57,449	396	0.7%
2021	57,745	296	0.5%
2022	57,965	220	0.4%
2023	58,116	151	0.3%
2024	58,214	99	0.2%
2025	58,253	39	0.1%
2026	58,247	-6	0.0%
2027	58,205	-42	-0.1%
2028	58,140	-65	-0.1%
2029	58,037	-103	-0.2%
2030	57,939	-98	-0.2%
2031	57,874	-65	-0.1%
2032	57,829	-45	-0.1%
2033	57,773	-56	-0.1%

Nevada State Demographer's Office October 1, 2014 Projections produced by the Regional Economics Model Inc (REMI) model. Based on 2013 Estimates
http://nvdemography.org/wp-content/uploads/2014/10/Nevada-Population-Projections-2014-Full-Document.pdf

The 2013 US Census Bureau, American Fact Finder Average found the average age of Elko County's population was 33.3 years compared to 36.6 years for the state of Nevada, making Elko County the "youngest" of Nevada's seventeen counties. The 2010 population density remained at 2.8 persons per square mile, compared to the State at 24.6 persons per square mile. Making Elko County the seventh most densely populated county within Nevada although it has the second largest area in square miles at 17,181 square miles.

Elko County's covered employment estimates for 2014 for all industries (excluding agriculture) was 22,318. The leisure and hospitality or service industry remained the highest portion of employment at 26 percent with 5,857 jobs, trade, transportation & utilities was second with 19 percent at 4,148 jobs, government was third with 16 percent at 3,588 jobs, natural resources & mining was fourth within the county with 10 percent and 2,284 jobs, and construction was a close fifth at 9 percent and 2,101 jobs. These figures may show significant increases and changes in percentages in the future due to the development of the Emigrant Mine and Long

Canyon Mine projects and the increase in oil exploration within the county.
The USGS's National Water Use Information Program compiles and publishes the Nation's water-use data. Public access to some of these data is provided via the USGS Water Data for the Nation site (additional background). Water use refers to water that is used for specific purposes. Water-use data is collected by area type (State, county, watershed or aquifer) and source such as rivers or groundwater, and category such as public supply or irrigation. Water-use data has been reported every five years since 1950, for years ending in "0" and "5". The USGS works in cooperation with local, State, and Federal agencies as well as academic and private organizations to collect and report total withdrawals. (http://water.usgs.gov/watuse)

In 1995, when Elko County's population was estimated to be 43,050 persons, it was estimated that total water withdrawals were approximately 936,593 acre-feet, or 23.2 percent of estimated total water withdrawals within Nevada. This made Elko County the largest water user among all of Nevada's seventeen counties. Estimated water use in Elko County in 1995 was 2.1 percent greater than in 1990, but 11.5 percent below total water use in 1985.

According to the 2010 USGS water use data, Clark County surpassed Elko County in total gallons of water withdrawn by 129.59 Mgal/d or 145,159.25 acre-feet. Clark County's 486.64 Mgal/d or 545,106.09 acre feet is mainly public/domestic usage compared to Elko County's 357.05 Mgal/d or 399,946.84 acre feet, which is primarily irrigation. Irrigation remained the highest usage at 55% of the total within the State of Nevada.

Of the total 1995 total water withdrawals, public supplied (i.e., municipal and industrial, or M&I) water withdrawals were estimated at 14,920 acre-feet, or 1.6 percent of the county's total water withdrawn for all purposes. Most of the water withdrawals in Elko County have been used for irrigation purposes (97.0 percent of total water withdrawals in 1995) while water withdrawals for domestic purposes, i.e., residential use from all sources, constituted only 1.2 percent of total water withdrawals in 1995.

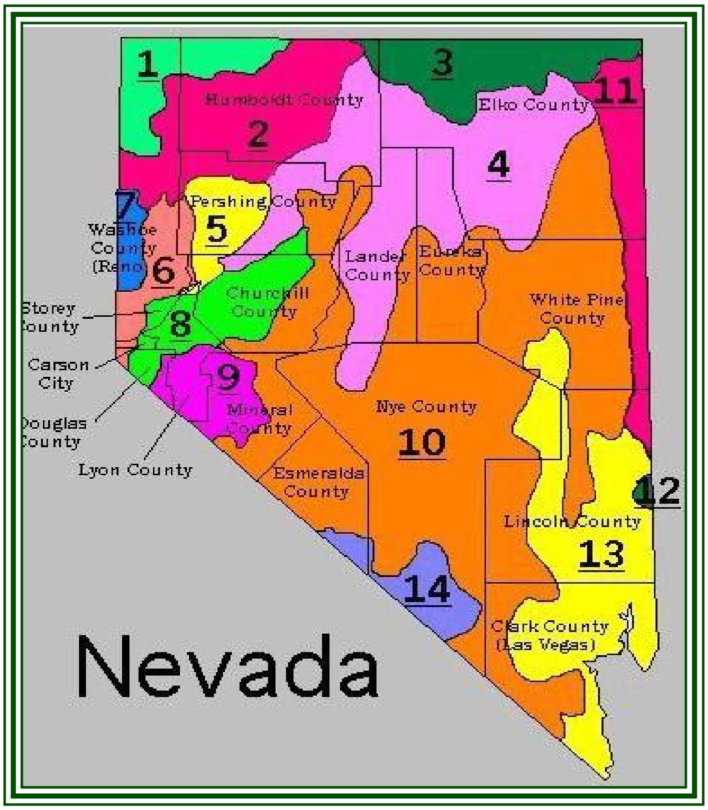
The 2010 water withdrawals top two uses in Elko County remained irrigation and public supply. Public supply was estimated at 14,942.70 acre feet or 4% and irrigation was 375,648.00 acre feet or 94% of the total. The amount used for irrigation purposes decreased from 97% to 94% due to the increase in amount used for public supply.

Based on the 1995 water use data, along with comparable period population and employment figures, it is estimated that Elko County's public supplied water use per person (also referred to as municipal and industrial, or M&I, water use per capita), based only on the estimated population served by public supply water systems, was 332 gallons per person per day as compared to a usage rate of 456 gallons per person per day in 1985 and 348 gallons per person per day in 1990. Table 1 below presents a number of estimated water usage rates for Elko County for the years 1985, 1990, and 1995 based on water use per person, per worker, and per occupied household or housing unit.

From a 1995 survey, it was estimated that 213,903 acres were irrigated in Elko County (243,960 irrigated acres in 1985 and 210,150 irrigated acres in 1990). This amount of irrigated acreage comprised approximately 29.9 percent of the state's total 1995 irrigated acreage of 715,439 acres (843,760 acres in 1985 and 728,650 acres in 1990). This 1995 level of irrigated acreage placed Elko County as the highest in terms of county irrigated acreage in Nevada at that time (and well above the second-place county of Humboldt with 142,558 irrigated acres).

Based on 1995 estimates of both total irrigated acreage and total irrigation water withdrawals, the average water use (withdrawals) on irrigated acres in Elko County was estimated at approximately 4.2 acre-feet per acre per year. Elko County’s 1995 irrigation conveyance losses were estimated at 0.9 acre-feet per acre per year, thereby leaving irrigation water available for consumptive use of 3.3 acre-feet per acre per year. Considered in its entirety, the Humboldt River system represents a highly efficient irrigation water conveyance and distribution mechanism. Agricultural water users along this river system, stretching from the river’s headwaters in Elko County through Eureka, Lander, Humboldt, Churchhill and into Pershing County, benefit from a continuous process of water diversion, application, return flow, and reuse. Consequently, measures of irrigation conveyance losses and water withdrawals do not fully reflect the actual workings of the overall river system.

REGIONAL HYDROGRAPHIC DATA



[1] Northwest Region
[2] Black Rock Desert Region
[3] Snake River Basin
[4] Humboldt River Basin
[5] West Central Region
[6] Truckee River Basin
[7] Western Region
[8] Carson River Basin
[9] Walker River Basin
[10] Central Region
[11] Great Salt Lake Basin
[12] Escalante Desert Basin
[13] Colorado River Basin
[14] Death Valley Basin

Figure 21 - Nevada Hydrographic Regions

Regional Hydrogeologic Features

The U.S. Geological Survey (Harrill and Prudic, 1998) has identified 20 flow systems and 282 hydrographic areas within the Great Basin Region of the southwestern United States. Of these, 14 flow systems and 252 hydrographic areas are wholly or partially within Nevada. Four flow systems are located in Elko County, three within the Great Basin (Humboldt River, Great Salt Lake Basin, and Central Region), with the fourth within the Snake River Plain (Figure 2). Within these four flow systems, there are 50 hydrographic areas in the county. The eight (8) hydrographic areas currently under evaluation by Elko County in partnership with the U.S.G.S. are within the Humboldt River Flow System, specifically identified by the USGS as the Upper Humboldt River Basin. (Appendix “A” Hydrogeologic Framework and Occurrence and Movement of Ground Water in the Upper Humboldt River Basin, Northeastern Nevada Scientific Investigations Report 2009-5014)

Although most flow systems are confined to one or two areas in the Basin and Range area, several areas are linked together in an extended ground-water flow system in places. In the majority of the areas, flow passes through the basin-fill sediments that cover the valley floors, as in the Humboldt system. However, where carbonate rocks underlie the basins, data indicate that some basins are hydrologically linked by the carbonate rocks and that large quantities of ground water flow through them and discharge through the overlying basin-fill sediments to large springs. Because few wells are drilled into the carbonate rocks, data is scarce and several assumptions have been made to account for flow in these rocks.

One assumption is that the carbonate rocks and the basin-fill deposits form a single hydrologic unit. At locations where wells have been drilled in both rock types, the water levels in each aquifer have been similar. Another piece of evidence that the two rock types act as one hydrologic unit comes from the Ash Meadows area in southern Nevada. Irrigation wells in that area that withdrew water from the basin-fill deposits drew down water levels in the carbonate-rock aquifers more than 1 foot from 1969 to 1972 (Harrill and Prudic, 1998).

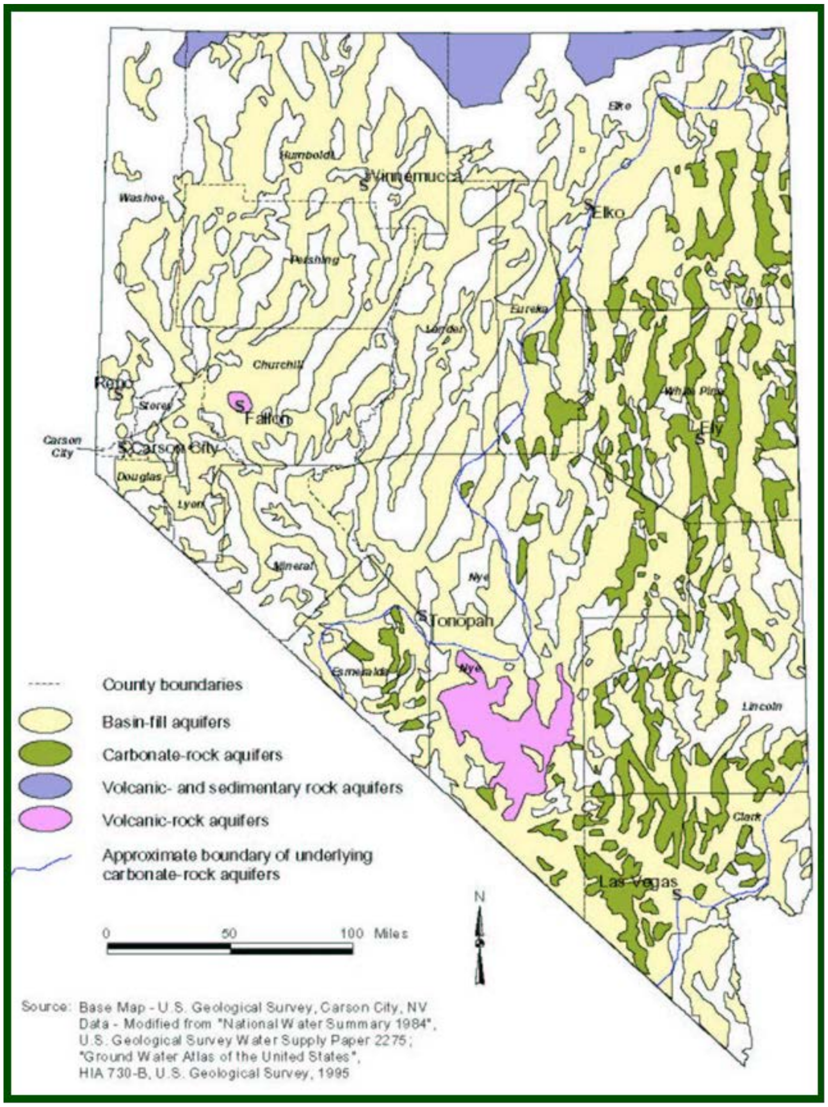


Figure 22 – Nevada Major Aquifers

The topography of the drainage area within each hydrographic area controls the movement of ground water at a regional scale. Because of the topographic effect of the mountains, the amount of precipitation increases as the altitude increases (Maxey and Eakin, 1958; and Avon and Durbin, 1992). Conversely, the amount of evapotranspiration decreases as altitude increases, as a consequence of lower temperatures at higher altitudes (Robinson, 1970). The distribution of recharge and discharge is additional evidence of interbasin flow.

Large local flow systems are characterized by predominantly interbasin flow and flow paths that are confined to a single basin. Springs connected to these systems have moderate to large discharges and moderate seasonal ranges in discharge. Very short flow paths generally characterize small local flow systems, usually no more than a few miles in length. Springs connected to these systems have highly variable annual ranges in discharge. (USGS, 2001).

REGIONAL HYDROGRAPHIC BASINS & AREAS

[3] Snake River Basin — Covers 5,230 square miles (13,546 square kilometers or 3,347,200 acres) in parts of Elko and Humboldt counties and includes eight hydrographic areas; extends into the states of Oregon and Idaho to the north and the State of Utah to the east.

Figure 23 - Regional Flow System **Snake River Basin**

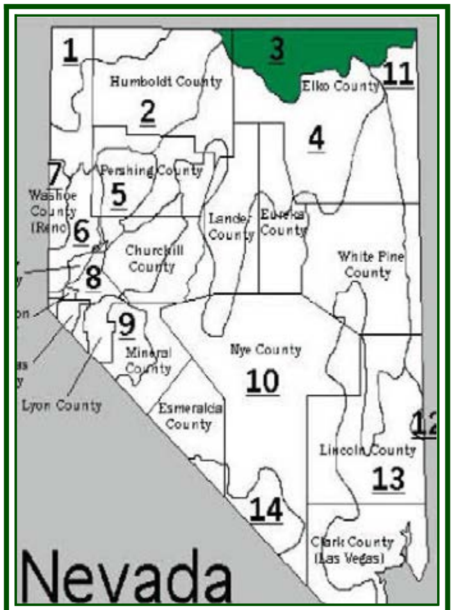


Table 6 - Snake River Basin Hydrographic Areas

Basin Num [1]	Area Num [2]	Size (sq mi) [3]	Size (acres) [4]	Hydrographic Area/Sub-Area Name	Counties Included [5]	Nearest Cities	Desig [6]
3	34	716	458,240	Little Owyhee River Area	Elko, Humboldt	McDermitt	No
3	35	1,310	838,400	South Fork Owyhee River Area	Elko	Jack Creek, Tuscarora	No
3	36	345	220,800	Independence Valley	Elko	Tuscarora	No
3	37	533	341,120	Owyhee River Area	Elko	Owyhee, Mountain City	No
3	38	514	328,960	Bruneau River Area	Elko	Mountain City, Jarbidge	No
3	39	278	177,920	Jarbidge River Area	Elko	Jarbidge	No
3	40	1,218	779,520	Salmon Creek Area	Elko	Jackpot, Contact	Yes
3	41	316	202,240	Goose Creek Area	Elko	Jackpot	No
	Total	**5,230**	**3,347,200**	**Square miles/acres**			

[4] Humboldt River Basin — Covers 16,843 square miles (43,623 square kilometers or 10,779,520 acres) in parts of eight counties — Elko, White Pine, Eureka, Humboldt, Lander, Nye, Pershing, and Churchill — and the largest river (Humboldt River) wholly contained within Nevada. This basin contains 34 hydrographic areas and one hydrographic sub-area and is one of only two that are wholly contained within the State of Nevada. It originates in the Ruby, Jarbidge, Independence, and East Humboldt Mountain ranges (Elko County) and terminates in the Humboldt Lake and Sink (Pershing and Churchill counties). During particularly wet years, the Humboldt Sink may drain into the Carson Sink by means of the Humboldt Slough.

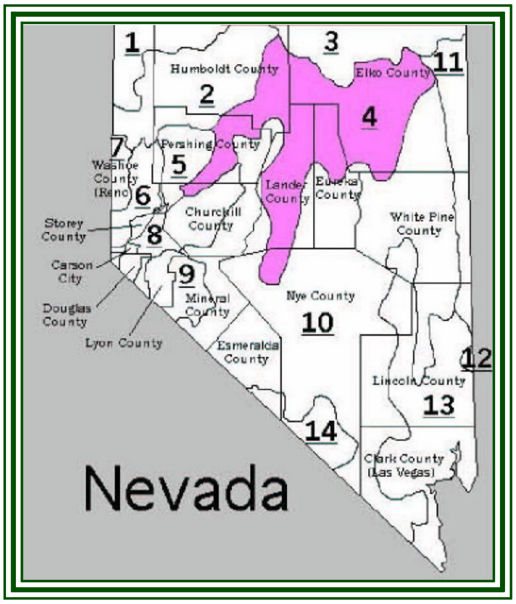


Figure 24 - Regional Flow System **Humboldt River Basin**

Table 7 - Humboldt River Basin Hydrographic Areas

Basin Num [1]	Area Num [2]	Size (sq mi) [3]	Size (acres) [4]	Hydrographic Area/Sub-Area Name	Counties Included [5]	Nearest Cities	Desig [6]
4	42	1,073	686,720	Marys River Area	Elko	Wells, Deeth	Yes
4	43	332	212,480	Starr Valley	Elko	Halleck, Deeth	Yes
4	44	1,110	710,400	North Fork Area	Elko	North Fork, Halleck	Yes
4	45	257	164,480	Lamoille Valley	Elko	Lamoille, Elko	Yes
4	46	99	63,360	South Fork Area	Elko	Lamoille, Jiggs	Yes
4	47	787	503,680	Huntington Valley	Elko, White Pine	Jiggs	Yes
4	48	392	250,880	Dixie Creek Area-Tenmile Creek Area	Elko	Elko, Spring Valley	Yes
4	49	314	200,960	Elko Segment	Elko, Eureka	Elko	Yes
4	50	223	142,720	Susie Creek Area	Elko, Eureka	Carlin	Yes
4	51	396	253,440	Maggie Creek Area	Elko, Eureka	Carlin	Yes
4	52	61	39,040	Marys Creek Area	Eureka, Elko	Palisade, Carlin	Yes
4	53	1,002	641,280	Pine Valley	Eureka, Elko	Carlin	Yes
4	61	544	348,160	Boulder Flat	Eureka, Lander, Elko	Beowawe, Battle Mountain	Yes
4	62	444	284,160	Rock Creek Valley	Elko, Lander, Eureka	Battle Mountain	No
4	63	405	259,200	Willow Creek	Elko	Midas	No
4	64	720	460,800	Clovers Area	Humboldt, Lander, Elko	Battle Mountain	Yes
4	65	299	191,360	Pumpernickel Valley	Humboldt, Pershing	Golconda, Valmy	No
4	66	301	192,640	Kelley Creek Valley	Humboldt, Elko	Golconda	Yes
4	67	975	624,000	Little Humboldt Valley	Humboldt, Elko	Paradise Valley	No
4	68	167	106,880	Hardscrabble Area	Humboldt	Paradise Valley	No
4	69	600	384,000	Paradise Valley	Humboldt	Paradise Valley, Winnemucca	Yes
4	70	435	278,400	Winnemucca Segment	Humboldt	Winnemucca, Golconda	Yes
4	71	520	332,800	Grass Valley	Pershing, Humboldt	Winnemucca	Yes
4	72	771	493,440	Imlay Area	Pershing	Imlay, Humboldt, Mill City	Yes
4	73	635	406,400	Lovelock Valley	Pershing, Churchill	Rye Patch, Lovelock	Yes
4	73A	98	62,720	Lovelock Valley/Oreana Sub-Area	Pershing	Lovelock, Toulon	No
4	74	164	104,960	White Plains	Churchill, Pershing	Lovelock, Fernley	Yes

[10] Central Region — By far the largest hydrographic region in Nevada covering 46,783 square miles (121,167 square kilometers or 29,941,120 acres) in thirteen Nevada counties—Nye, Elko, White Pine, Lincoln, Clark, Humboldt, Pershing, Churchill, Lander, Eureka, Lyon, Mineral, and Esmeralda. This region includes 78 hydrographic areas, ten of which are divided into two sub-areas and one into three sub-areas; extends to the south and west into the State of California.

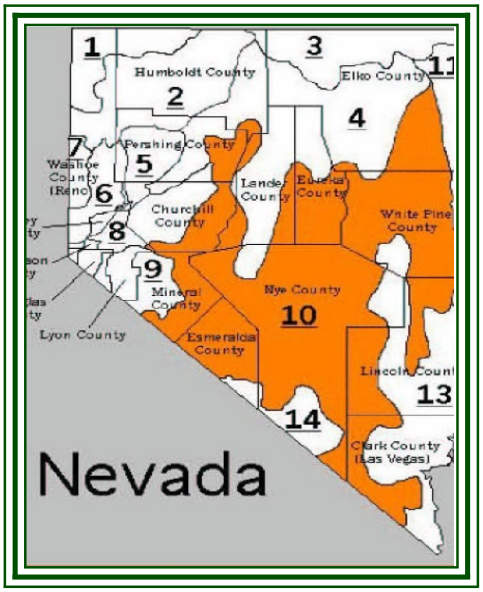


Figure 25 - Regional Flow System **Central Region**

Table 8 - Central Region Hydrographic Areas

Basin Num [1]	Area Num [2]	Size (sq mi) [3]	Size (acres) [4]	Hydrographic Area/Sub-Area Name	Counties Included [5]	Nearest Cities	Desig [6]
10	175	651	416,640	Long Valley	White Pine, Elko	Ely, Eureka	No
10	176	1,004	642,560	Ruby Valley	Elko, White Pine	Elko, Ruby Valley	Yes
10	177	464	296,960	Clover Valley	Elko	Wells, Ruby Valley	Yes
10	178A	271	173,440	Butte Valley/Northern Part	Elko	Currie, Ruby Valley	No
10	178B	739	472,960	Butte Valley/Southern Part	White Pine, Elko	Cherry Creek, Ely	No
10	179	1,942	1,242,880	Steptoe Valley	White Pine, Elko	Ely, Cherry Creek	Yes

11] Great Salt Lake Basin — Covers 3,807 square miles (9,860 square kilometers or 2,436,480 acres) of the easternmost portions of Elko, White Pine, and Lincoln counties; includes eight hydrographic areas, one of which is divided into four hydrographic sub-areas; extends to the east into the State of Utah.

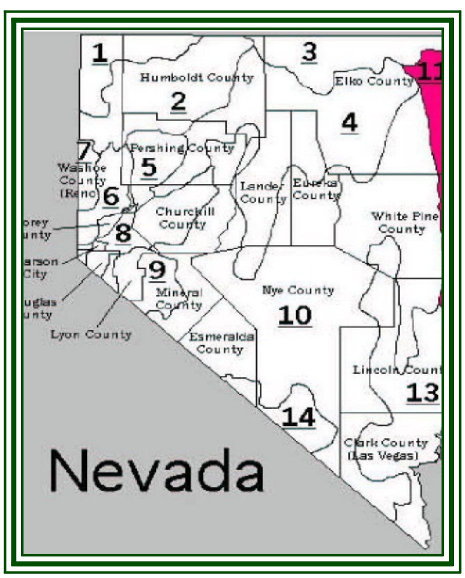


Figure 26 - Regional Flow System **Great Salt Lake Basin**

Table 9 - Great Salt Lake Basin Region Hydrographic Areas

Basin Num [1]	Area Num [2]	Size (sq mi) [3]	Size (acres) [4]	Hydrographic Area/Sub-Area Name	Counties Included [5]	Nearest Cities	Desig [6]
11	189A	163	104,320	Thousand Springs Valley/ Herrill Siding-Brush Creek Area	Elko	Wells, Contact	Yes
11	189B	618	395,520	Thousand Springs Valley/ Toano-Rock Spring Area	Elko	Jackpot, Wells	Yes
11	189C	183	117,120	Thousand Springs Valley/ Rocky Butte Area	Elko	Montello, Jackpot	Yes
11	189D	482	308,480	Thousand Springs Valley/ Montello-Crittenden Creek Area	Elko	Montello	Yes
11	190	55	35,200	Grouse Creek Valley	Elko	Grouse Creek, Jackpot	No
11	191	326	208,640	Pilot Creek Valley	Elko	Wendover	Yes
11	192	507	324,480	Great Salt Lake Desert	Elko	Wendover	No
11	193	208	133,120	Deep Creek Valley	White Pine, Elko	Wendover	No

Elko County Hydrographic Basins, Areas & Sub-Areas

Figure 27 - Elko County Boundary

Hydrographic Regions, Areas, and Sub-Areas Table Notes:
A Basin is defined as a geographic area drained by a single major stream or an area consisting of a drainage system comprised of streams and often natural or man-made lakes. Also referred to as Drainage Basin, Watershed, or Hydrographic Region. The U.S. Geological Survey and the Nevada Division of Water Resources, Department of Conservation and Natural Resources, have divided the state into discrete hydrologic units for water planning and management purposes. These have been identified as 232 Hydrographic Areas (256 areas and sub-areas, combined) within 14 major Hydrographic Regions or Basins.

[1] Nevada Hydrographic Basin Number (1-14).

[2] Nevada Hydrographic Area/Sub-Area Number (1-232; hydrographic sub-areas designated A, B, C, etc.). There are a total of 256 hydrographic areas and sub-areas.

[3] and [4] Hydrographic areas and sub-areas in square miles and acres, respectively, and include acreage only contained within Nevada.

[5] Counties are listed in order of their share of the hydrographic area/sub-area.

[6] Desig = Designated Groundwater Basin (Area or Sub-Area). Designated groundwater basins are basins where permitted ground water rights approach or exceed the estimated average annual recharge and the water resources are being depleted or require additional administration. Under such conditions, a state's water officials will so designate a groundwater basin and, in the interest of public welfare, declare preferred uses (e.g., municipal and industrial, domestic, agriculture, etc.). Also referred to as Administered Groundwater Basins. For Nevada, in the interest of public welfare, the Nevada State Engineer, Division of Water Resources, Department of Conservation and Natural Resources, is authorized by statute (Nevada Revised Statute 534.120) and directed to designate a groundwater basin and declare preferred uses within such designated basin. The State Engineer has additional authority in the administration of the water resources within a designated groundwater basin. *source Data:* Office of the State Engineer, NDWR Department of Conservation and Natural Resources.

Table 10 – Northeast Nevada Hydrographic Areas

[3] SNAKE RIVER BASIN (Hydrographic Basin 3):							
3	34	716	458,240	Little Owyhee River Area	Elko, Humboldt	Mcdermitt	No
3	35	1,310	838,400	South Fork Owyhee River Area	Elko	Jack Creek, Tuscarora	No
3	36	345	220,800	Independence Valley	Elko	Tuscarora	No
3	37	533	341,120	Owyhee River Area	Elko	Owyhee, Mountain City	No
3	38	514	328,960	Bruneau River Area	Elko	Mountain City, Jarbidge	No
3	39	278	177,920	Jarbidge River Area	Elko	Jarbidge	No
3	40	1,218	779,520	Salmon Creek Area	Elko	Jackpot, Contact	Yes
3	41	316	202,240	Goose Creek Area	Elko	Jackpot	No
	Total	**5,230**	**3,347,200**	**Square miles/acres**			
[4] HUMBOLDT RIVER BASIN (Hydrographic Basin 4):							
4	42	1,073	686,720	Marys River Area	Elko	Wells, Deeth	Yes
4	43	332	212,480	Starr Valley	Elko	Halleck, Deeth	Yes
4	44	1,110	710,400	North Fork Area	Elko	North Fork, Halleck	Yes
4	45	257	164,480	Lamoille Valley	Elko	Lamoille, Elko	Yes
4	46	99	63,360	South Fork Area	Elko	Lamoille, Jiggs	Yes
4	47	787	503,680	Huntington Valley	Elko, White Pine	Jiggs	Yes
4	48	392	250,880	Dixie Creek Area-Tenmile Creek Area	Elko	Elko, Spring Valley	Yes
4	49	314	200,960	Elko Segment	Elko, Eureka	Elko	Yes
4	50	223	142,720	Susie Creek Area	Elko, Eureka	Carlin	Yes
4	51	396	253,440	Maggie Creek Area	Elko, Eureka	Carlin	Yes
4	52	61	39,040	Marys Creek Area	Eureka, Elko	Palisade, Carlin	Yes
4	53	1,002	641,280	Pine Valley	Eureka, Elko	Carlin	Yes
4	62	444	284,160	Rock Creek Valley	Elko, Lander, Eureka	Battle Mountain	No
4	63	405	259,200	Willow Creek	Elko	Midas	No
4	64	720	460,800	Clovers Area	Humboldt, Lander, Elko	Battle Mountain	Yes
4	66	301	192,640	Kelley Creek Valley	Humboldt, Elko	Golconda	Yes
4	67	975	624,000	Little Humboldt Valley	Humboldt, Elko	Paradise Valley	No
	Total	**16,843**	**10,779,520**	**Square miles/acres**			
[10] CENTRAL REGION (Hydrographic Basin 10):							
10	176	1,004	642,560	Ruby Valley	Elko, White Pine	Elko, Ruby Valley	Yes
10	177	464	296,960	Clover Valley	Elko	Wells, Ruby Valley	Yes
10	178A	271	173,440	Butte Valley/Northern Part	Elko	Currie, Ruby Valley	No
10	178B	739	472,960	Butte Valley/Southern Part	White Pine, Elko	Cherry Creek, Ely	No
10	179	1,942	1,242,880	Steptoe Valley	White Pine, Elko	Ely, Cherry Creek	Yes
10	186A	125	80,000	Antelope Valley/Southern Part	Elko, White Pine	Wendover, Ely	No
10	186B	270	172,800	Antelope Valley/Northern Part	Elko, White Pine	Wendover, Ely	No
10	187	954	610,560	Goshute Valley	Elko	Oasis, Shafter	Yes
10	188	562	359,680	Independence Valley (Pequop Valley)	Elko	Wells, Oasis	Yes
	Total	**46,783**	**29,941,120**	**Square miles/acres**			
[11] GREAT SALT LAKE BASIN (Hydrographic Basin 11):							
11	189A	163	104,320	Thousand Springs Valley/Herrill Siding-Brush Creek Area	Elko	Wells, Contact	Yes
11	189B	618	395,520	Thousand Springs Valley/Toano-Rock Spring Area	Elko	Jackpot, Wells	Yes
11	189C	183	117,120	Thousand Springs Valley/Rocky Butte Area	Elko	Montello, Jackpot	Yes
11	189D	482	308,480	Thousand Springs Valley/Montello-Crittenden Creek Area	Elko	Montello	Yes
11	190	55	35,200	Grouse Creek Valley	Elko	Grouse Creek, Jackpot	No
11	191	326	208,640	Pilot Creek Valley	Elko	Wendover	Yes
11	192	507	324,480	Great Salt Lake Desert	Elko	Wendover	No
11	193	208	133,120	Deep Creek Valley	White Pine, Elko	Wendover	No
	Total	**3,807**	**2,436,480**	**Square miles/acres**			

ELKO COUNTY HYDROGRAPHIC BASINS, AREAS & SUB-AREAS (CONTINUED)

Figure 28 – Map of Elko County Hydrographic Areas

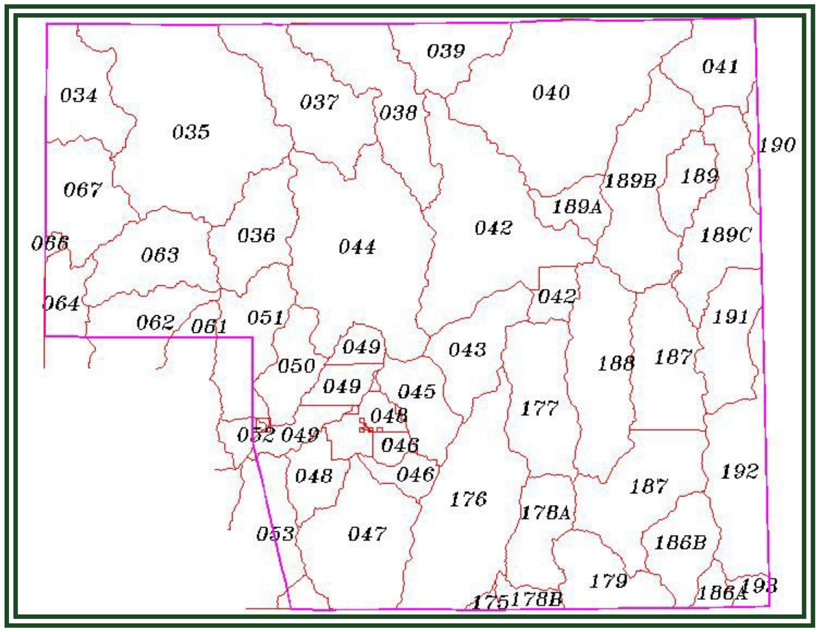


Table 11 - Elko County Hydrographic Areas

Snake River Basin

34	-	Little Owyhee River Area
35	-	South Fork Owyhee River Area
36	-	Independence Valley
37	-	Owyhee River Area
38	-	Bruneau River Area
39	-	Jarbidge River Area
40	-	Salmon Falls Creek Area

Humboldt River Basin

42	-	Mary's River Area
43	-	Starr Valley Area
44	-	North Fork Area
45	-	Lamoille Valley
46	-	South Fork Area
47	-	Huntington Valley
48	-	Dixie Creek - Tenmile Creek area
49	-	Elko Segment
50	-	Susie Creek Area
51	-	Maggie Creek Area
52	-	Mary's Creek Area
53	-	Pine Valley
61	-	Boulder Flat
62	-	Rock Creek Valley
63	-	Willow Creek Valley
64	-	Clover's Area
66	-	Kelly Creek Area
67	-	Little Humboldt Valley

Central Region

153	-	Diamond Valley
175	-	Long Valley Ruby
176	-	Valley Clover
177	-	Valley
178A	-	Butte Valley North Butte
178B	-	Valley South Steptoe
179	-	Valley
186A	-	Antelope Valley South
186B	-	Antelope Valley North
187	-	Goshute Valley
188	-	Independence Valley

Great Salt Lake Basin

189	-	Rock Butte Area
189A	-	Herill Siding - Brush Creek Area 189B
	-	Toano - Rock Spring Area
189C	-	Montello - Crittenden Creek Area
190	-	Grouse Creek Valley
191	-	Pilot Creek Valley
192	-	Great Salt Lake Desert
193	-	Deep Creek Valley

REGIONAL & LOCAL DATA

COMMITTED & UN-COMMITTED GROUNDWATER RESOURCES

To acquire a water permit, an application must be made on an approved form and filed with the State Engineer (NRS 533.325). Pursuant to Nevada Water Law, the application must be supported by a map prepared in a prescribed form by a water rights surveyor. The supporting map must show the point of diversion and place of use of the water within the proper legal subdivisions. No application shall be for the water of more than one source to be used for more than one purpose (NRS 533.330).

When the application and map are properly completed, a notice must be sent to a newspaper of general circulation in the area where the application was filed. This notice is published for approximately 30 days (NRS 533.360). Interested parties may file a formal protest up until 30 days after the last day of publication explaining their objections to the application and requesting denial of the application or other appropriate action by the State Engineer (NRS 533.365).

After the expiration of the protest period, the application is ready for action by the State Engineer. When considering an application for approval or denial, the State Engineer must consider the following:

- Is there unappropriated water at the source?
- Will the use of the water under the proposed application conflict with existing rights?
- Will the use of the water under the proposed application prove detrimental to the public interest?
- Will the use of the water under the proposed application adversely impact domestic wells?

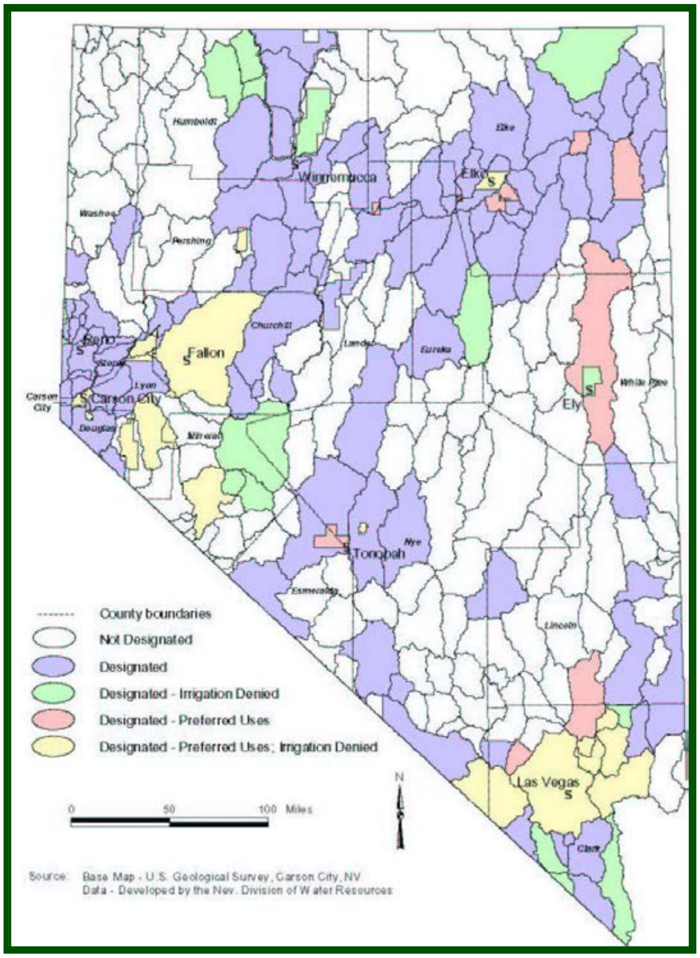
In addition to these items, other criteria within NRS 533.370 deal with impacts within irrigation districts, the good faith intent of the applicant to construct the works of diversion and put the water to beneficial use, and the financial ability and reasonable expectation to construct the works of diversion and put the water to beneficial use. The State Engineer may require any additional information needed prior to approval or rejection of an application (NRS 533.375). The State Engineer also has the discretion to hold a hearing prior to any decision.

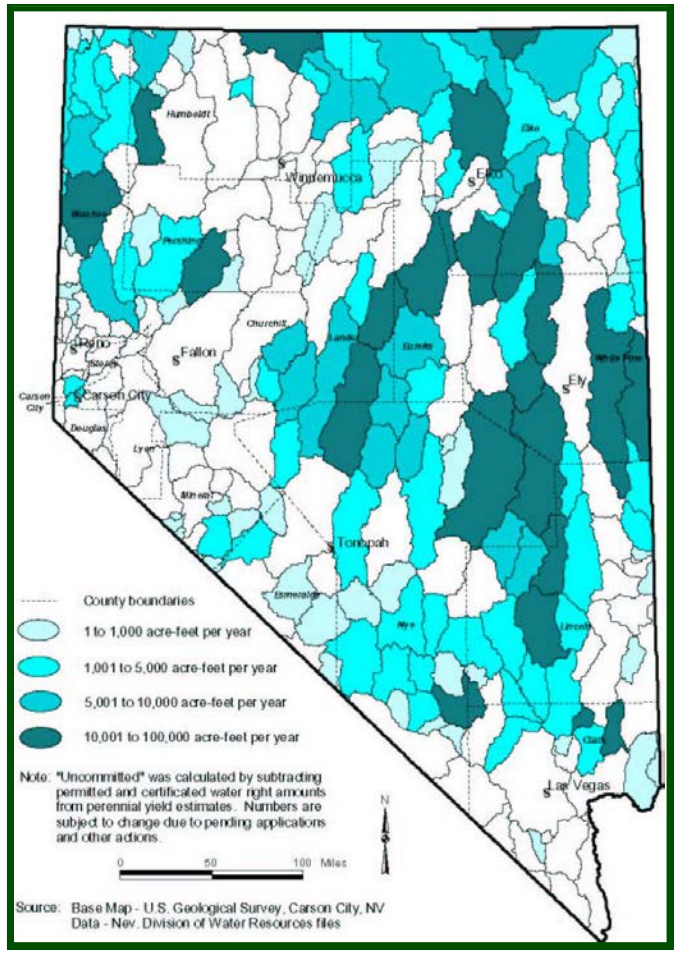
The State Engineer reviews any pertinent information and either approves or denies the application. When an application is denied, the State Engineer notifies the applicant of denial, retains the denied application for the record and will not pursue any further action under the application. The denial may be appealed in the appropriate court of jurisdiction within 30 days after the denial action (NRS 533.450). When a water permit is approved, the permit terms and limitations are specified as part of the permit. A fee is also required for any permit issued in accordance with NRS 533.435. Once a permit is issued, the applicant may initiate the work to divert and use the water established as the beneficial use.

Once granted, water rights in Nevada have the standing of both real and personal property - meaning they are conveyed as an appurtenance to real property unless they are specifically excluded in the deed of conveyance. When water rights are purchased or sold as personal property or treated as a separate appurtenance in a real estate transaction, the water rights are conveyed specifically by a deed of conveyance. It is possible to buy or sell water rights and change the water's point of diversion, manner of use and place of use by filing the appropriate application with the State Engineer.

Figure 29 - Nevada Committed Groundwater Resources

Figure 30 - Nevada Un-Committed Groundwater





As shown in **Figure 29 and Figure 30,** the State of Nevada has identified sub-areas of available or un-committed water resources within the watershed or flow systems. The un-committed areas shown in Elko County are primarily located within rural un-developed areas of the county. Primarily the uses within the un-committed areas are agricultural irrigation or stock water. The un-committed water in the sub-areas represent potential future use whether for extended agricultural uses or for the transfer to adjacent areas of development.

Table 12 Depicts an inventory conducted by the Elko County Planning Division representing all sub-basins within Elko County. The inventory concerns Basin Resource Summary Perennial-Yield as per the U.S.G.S. and the State Engineer, Permitted Water and Pending Applications through 2015. (Reference State of Nevada Division of Water Resources website) As the table represents, many of the highly developed areas in Elko County are over allocated. The table also identifies areas adjacent to the developed areas as potential resources for future sustainability and growth.

Table 12 - Basin Resource Summary Perennial-Yield, Permitted Water in Acre Feed/ Annually (AF/An) - **April 2015**

SNAKE RIVER BASIN	Area in Sq. Miles	Designated	Perennial Yield AF/An	Permitted AF/An	Other Ground Water
Little Owyhee River - No. 34	716	N	1,400	28.04	0
South Fork Owyhee River - No. 35	1,310	N	8,000	2,433.63	0
Independence Valley - No. 36	345	N	12,000	13,106.40	0
Owyhee River - No. 37	533	N	7,000	1,513.77	3,143.47
Bruneau River - No. 38	514	N	10,000	15.93	0
Jarbidge River - No. 39	278	N	12,000	36.30	0
Salmon Falls Creek - No. 40	1,218	Y	7,400	7,148.03	0
Goose Creek - No. 41	316	N	1,700	1,235.64	0
Yield Reference(s) - USGS file reports & recons					

HUMBOLDT RIVER BASIN	Area in Sq. Miles	Designated	Perennial Yield AF/An	Permitted AF/An	Other Ground Water
Mary's River - No. 42	1,073	Y		26,031.69	6.72
Starr Valley - No. 43	332	Y		3,208.06	0
North Fork - No. 44	1,110	Y		15,315.92	0
Lamoille Valley - No. 45	257	Y		8,206.72	0
Combined Yield for 042 ,043, 044 & 045		*Y*	*83,000*	*52,762.39*	
South Fork - No. 46	99	Y	3,000	72.41	0
Huntington Valley - No. 47	787	Y	15,000	9,757.62	0
Dixie Cr. / Tenmile Cr. - No. 48	392	Y	13,000	16,304.28	0
Elko Segment - No. 49	314	Y	11,000	20,695.04	0
Suzie Creek - No. 50	223	Y	2,000	917.90	0
Maggie Creek - No. 51	396	Y	4,000	13,539.36	0
Mary's Creek - No. 52	61	Y	2,000	1,939.71	0
Pine Valley - No. 53	1,002	Y	20,000	16,508.25	0
Rock Creek - No. 62	444	N	2,800	2,260.43	0
Willow Creek - No. 63	376	N	4,000	4,015.17	0
Clovers Area - No. 64	720	Y		44,126.11	0
Kelly Creek - No. 66	301	Y		21,601.77	0
Combined Yield for 64, 65 & 66			*72,000*	*65,727.77*	
Little Humboldt River - No. 67	975	N		10,225.39	0
Combined Yield for 67,68 & 69			*34,000*	*125,567.81*	

CENTRAL REGION BASIN	Area in Sq. Miles	Designated	Perennial Yield AF/An	Permitted AF/An	Other Ground Water
Long Valley - No. 175	651	N	6,000	4,749.36	0
Ruby Valley - No. 176	1,004	Y	37,000	23,855.16	0
Clover Valley - No. 177	464	Y	19,000	20,862.73	0
Butte Valley - North - No. 178A	271	N	6,000	74.58	0
Butte Valley - South - No. 178B	739	N	14,000	321.16	0
Steptoe Valley - No. 179	1,942	Y	70,000	118,426.96	25,317.22
Antelope Valley - South - No. 186A	125	N	800	1,548.39	0
Antelope Valley - North - No. 186B	270	N	1,700	2,694.68	0
Goshute Valley - No. 187	954	Y	11,000	11,665.86	0
Pequop V.- No. 188	562	Y	9,000	9,736.49	3.22

GREAT SALT LAKE BASIN	Area in Sq. Miles	Designated	Perennial Yield AF/An	Permitted AF/An	Other Ground Water
Thousand Springs V. - No. 189A	163	Y	1,800	3,453.28	0
Thousand Springs V. - No. 189B	618	Y	2,600	1,564.27	0
Thousand Springs V. - No. 189C	183	Y	1,400	452.05	0
Thousand Springs V. - No. 189D	482	Y	14,000	20,748.17	0
Grouse Creek - No. 190	55	N	350	32.56	0
Pilot Creek Valley - No. 191	326	Y	4,500	1,532.70	0
Great Salt Lake - No. 192	507	N	5,000	5.59	0
Deep Creek - No. 193	208	N	2,000	0	0

Nevada Division of Water Resources http://water.nv.gov/data/underground/
Perennial Yield Reference(s) - United States Geological Service

Table 13 - Domestic Well Inventories **- February 2016**

Note: **Table 13** represents all developed Domestic Wells in Elko County according to the Nevada Division of Water Resources online data in 2016, Elko County has 3,499 domestic wells equaling 6,998 acre feet of water annually. In 2007, the Nevada Legislature changed the calculations for a domestic well from 2.02 acre feet to flat 2 acre feet annually.

Elko County Domestic Well Inventory Data

Hydrographic Basin	Sub Basin Number & Name	Domestic Wells
Snake River	034 - Little Owyhee River Area	0
	035 - South Fork Owyhee River Area	6
	036 - Independence Valley	23
	037 - Owyhee River Area	107
	038 - Bruneau River Area	6
	039 - Jarbidge River Area	1
	040 - Salmon Falls Creek Area	28
	041 - Goose Creek Area	1
	Total Basin	**172**
Humboldt River	042 - Mary's River Area	168
	043 - Starr Valley Area	67
	044 - North Fork Area	432
	045 - Lamoille Valley	390
	046 - South Fork Area	55
	047 - Huntington Valley	54
	048- Dixie Creek / Tenmile	536
	049 - Elko Segment	1239
	050 - Susie Creek Area	21
	051 - Maggie Creek Area	12
	052 - Mary's Creek Area	16
	053 - Pine Valley	0
	061 - Boulder Flat	3

	062 - Rock Creek Valley	1
	063 - Willow Creek Valley	5
	064 - Clovers Area	1
	066 - Kelly Creek Area	0
	067 - Little Humboldt Valley	1
	Total Basin	**3,001**
Central Region	175 - Long Valley	2
	176 - Ruby Valley	115
	177 - Clover Valley	60
	178A - Butte Valley North	2
	178B - Butte Valley South	0
	186A - Antelope Valley South	0
	186B - Antelope Valley North	1
	187 - Goshute Valley	9
	188 - Independence Valley	19
	Total Basin	**208**
Great Salt Lake	189 - Rocky Butte Area	0
	189A - Herrill Siding - Brush Creek Area	14
	189B - Toano - Rock Spring Area	10
	189C - Montello - Crittenden Creek Area	1
	190 - Grouse Creek Valley	2
	191 - Pilot Creek Valley	87
	192 - Great Salt Lake Desert	3
	193 - Deep Creek Valley	1
	Total Basin	**118**
	Totals All Basins	**3,499**

Nevada Division of Water Resources; Well Log Search 2/10/2016 http://water.nv.gov/data/welllog/

Domestic wells in Nevada are not required to be a permitted water right. The permitted consumption of a domestic well is 2 acre feet annually or 1,800 gallons per day as per N.R.S. 534.180. Estimated yield from each Domestic Well is 275 gallons per day (gpd) during non- irrigation months, November - March, and 650 gallons per day (gpd) during irrigation months, April - October. The estimated daily average yield from each

Domestic Well is 493.75 gallons per day (gpd) or 180,219 gallons per year. Total estimated use for 2,363 domestic wells is 1,166,730 gallons per day (gpd) or 425,856,709 gallons per year. The total estimated use is1,307 acre feet, the permitted use for a domestic well at 2 (1,800 gpd) acre feet annually per well is 4,773 acre feet.

Table 14 - Un-Incorporated Town Rural Communities Municipal Resource Availability

Elko County Un-Incorporated Towns / Rural Communities Municipal / Quasi-Municipal / Domestic Wells Water & Sanitary Sewer Sources - 2015							
Town / Community / Area	**Municipal Water System**	**Individual Domestic Wells**	**Sanitary Sewer System**	**Individual Septic System**	**High Projected Growth**	**Moderate Projected Growth**	**Low Projected Growth**
Clover Valley (4)		X		X		X	
I-80 Corridor (4) Elburz - Wendover		X		X		X	
Jackpot (1)	X		X			X	
Jarbidge (2)	X			X			X
Lamoille	X	X		X		X	
Midas (3)	X			X			X
Montello (1)	X		X				X
Mountain City	X		X				X
North Adobe (4)		X		X			X
Pilot Valley (4)		X		X			X
Ryndon (4)		X		X		X	
Southfork (4) (Lucky Nugget & Western Hills)		X		X			X
Spring Creek (5)	X	X		X		X	
Tuscarora (3)	X			X			X

(1) Un-Incorporated Town Limits
(2) Un-Incorporated Water / Sewer Service
(3) Private Water User Association or General Improvement District
(4) Rural Area no systems
(5) Privately Owned Utility Company

Table 15 - Permitted Towns /Rural /Municipal / Quasi-Municipal / Domestic

Elko County Un-Incorporated Towns / Rural Communities Municipal Water Resources - 2016						
Town / Community / Area	**Municipal Ground Water (afa)**	**Municipal Surface Water (afa)**	**Quasi-Municipal Water (afa)**	**Undeveloped Residential Lots**	**Potential Addition to Municipal Annual Duty (afa)**	**Potential Total Municipal Annual Duty (afa)**
Jackpot (1)	10,458	0	5,340.5	70	33.6	5,374.1
Jarbidge (1)	0	4,048.5	4,099.6	80	33.6	4,133.2
Lamoille (2)	1,810.6	0	233.6	25	16.8	250.4
Midas (1)	166.6	14.5	55.9	25	16.8	72.7
Montello (1)	0	5,967.7	5,882.4	75	33.6	5,916
Mountain City (1)	0	2,983.9	2,982.4	31	33.6	3,016
Spring Creek (4)	17,147.50			763		
Tuscarora (3)	181.1	724.2	742.2	20	16.8	759

(afa) - Acre Feet Annually   Certificated and permitted water rights
Nevada Division of Water Resources; Hydrographic Abstracts/ Elko County 4/15/2015
http://water.nv.gov/data/hydrographic/   Spring Creek Association - Spring Creek Analysis of Occupied Lots 2015

(1) Un-Incorporated Town System Limits
(2) Incorporated City System Limits
(3) Private Water User Association or General Improvement District (GID)
(4) Privately Owned Utility Company

Table 16 - Elko County Incorporated Towns and Cities Permitted Water Resources

Town / City	**Municipal Ground Water (afa)**	**Municipal Surface Water (afa)**	**Quasi- Municipal Water (afa)**	**Effluent Water Storage**
Carlin	2,525.00	592.70		1085.96
Elko	38,786.86	0	112.01	2,800.00
Wells	7,324.00	166.51		368.83
Wendover	5,490.61	2,838.12	543.28	1,448.00

(afa) - Acre Feet Annually Certificated and Permitted water
Nevada Division of Water Resources; Hydrographic Abstracts/ Elko County 3/29/2016
http://water.nv.gov/data/hydrographic/

Table 17 - Elko County Rural Communities and Areas Domestic Water Resources

Elko County Un-Incorporated Towns / Rural Communities / Domestic Well Water Resources - 2016

Rural Area (Hydrographic Sub-Area)	Domestic Self Service Wells	Current Annual Allocation	Undeveloped Residential Lots (Vacant Lots)	Potential Increase Allocation	Potential Total Allocation at Build Out
Dixie/Tenmile (048)	536	1,072	419	838	1,910
Elko Segment (049)	1,239	2,478	4,068	8,136	10,614
Lamoille (045)	390	780	489	978	1,758
Midas (061-064) (066, 067)	11	22	154	308	330
Montello (189D)	1	2	1,016	2,032	2,034
Mountain City (037)	107	214	31	62	276
Tuscarora (036)	23	46	20	40	86
Clover Valley (177)	60	120	40	80	200
North Adobe (050)	21	42	21	42	84
Pilot Creek Valley (191)	87	174	523	1,046	1,220
Ryndon (044)	432	864	1,905	3,810	4,674
I-80 Corridor Elburz - Wendover (042,043, 187, 188,192)	266	532	756	1,512	2,044
Total Un-incorporated Areas	**3,173**	**6,346**	**9,442**	**18,884**	**25,288**
Remainder County	326	652	12,432	24,704	26,458
TOTALS	**3,499**	**6,998**	**21,874**	**43,748**	**50,746**

Nevada Division of Water Resources; Well Log Search 2/10/2016 http://water.nv.gov/data/welllog/
Vacant Lots: Assessor's Records (Query vacant lots Land use code 120- May 2015 & March 2016)

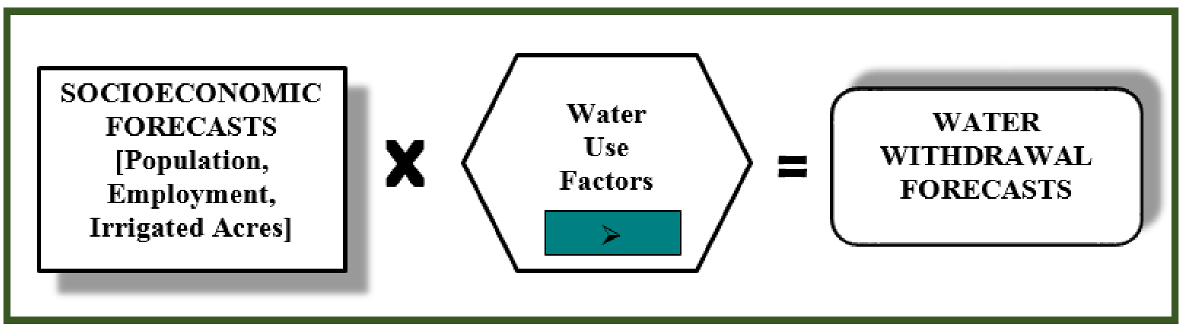
Note: All Information Shown in **Table 16** pertains to areas outside water system limits within the specified Hydrographic Area or Sub-Area.

Municipal, Domestic, Commercial, Industrial & Agricultural Water Use Forecast

Rapid population growth in Elko County has been due in large part to trends in the mining industry, especially since the late 1980's. Between 1950 and 1970, Elko County's population grew by only 2,243 persons. However, over the next 27 years the population grew by nearly 30,000 persons. Much of this growth was due to mining, in Elko County and neighboring Eureka County. While gaming and tourism have had significant impacts on growth in Clark and Washoe counties, mining has had major influences on many of the rural counties' population and employment growth, demographic trends, and economic development. Since 1989, gold mining in Nevada has made a major contribution to a number of rural counties' economic growth, or specifically Elko, Eureka, Humboldt, Lander, Nye, and Pershing counties.

The forecast methodology developed for the Elko County Water Resource Management Plan uses a forecast of key socioeconomic variables multiplied by a water use factor or coefficient to produce a water withdrawal forecast. This process is depicted in its simplest form in Flow Chart (Figure 31), Basic Forecasting Methodology. Specifically, forecasts of population, employment (which itself is derived from the population forecast), and irrigated acreage provide the means to develop a number of water withdrawal forecasts by water use category, including withdrawals for domestic (both public and self-supplied), municipal and industrial (M&I), public use and losses, commercial and industrial, irrigation and livestock water withdrawals.

Figure 31 - Water Withdrawal Forecast Equation



Merrit Mountain

DEVELOPMENT CONSIDERATIONS

WATER RESOURCE & CONSERVATION EDUCATION

Being the driest state in the nation it is important that Elko County residents understand the fundamental science of water, how water is managed in the state, and the issues affecting water management. An educated populace is clearly a key to future management of water resources, and therefore, water education must become a priority.

Benefits of Water Education: The overall goal of water education is to develop more knowledgeable citizens who can participate in public discussion and debate about water issues. Information improves a person's ability to examine and evaluate information provided and the information that is not presented. With a basic understanding of water, residents can respond intelligently to issues such as the need to develop water supplies or wastewater treatment facilities, the benefits and costs of conservation, the dangers associated with leaking contaminants, the risks posed by poor water quality and the benefits and costs of river restoration or flood control.

The Elko County water management and planning activities adhere to the requirements of the Nevada Revised Statutes Chapter 540- Planning and Development of Water Resources.

DROUGHT CONDITIONS

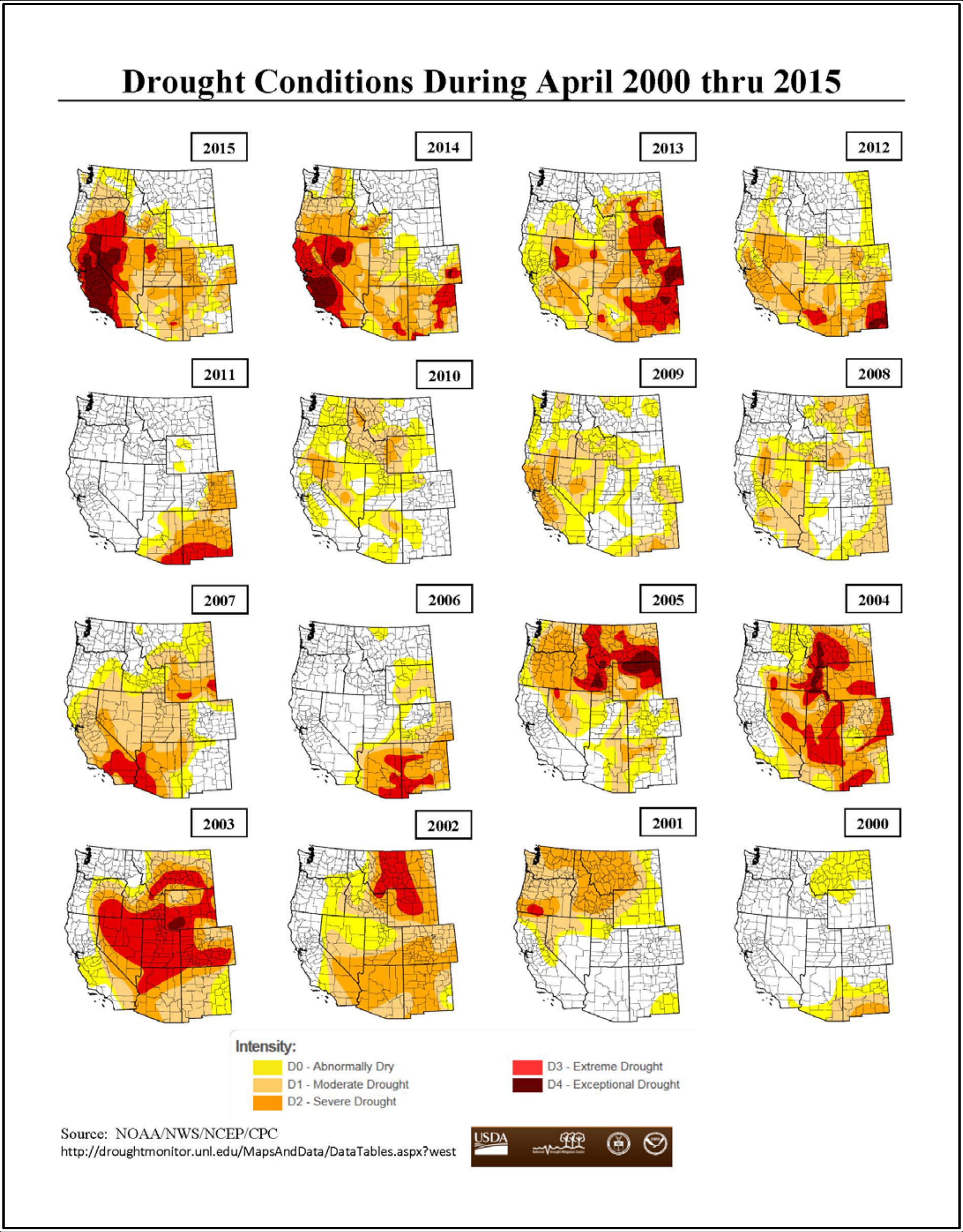
As Nevada is the driest State in the Nation, drought is relatively common and expected. Every 6 out of 10 years, the major rivers in the State experience below average flows. For most of Nevada, which depends mostly on streamflow for water supply, a drought is considered to be a period of 2 or more consecutive years in which streamflow is much less than average. The most significant droughts were during 1928-37, 1953-55, 1959-62, 1976-77, 1987-92 and the current drought beginning in 2001. Droughts can magnify quality problems for surface and ground-water sources. By decreasing streamflow, droughts tend to lessen the quality of remaining water for human and wildlife uses. Droughts also can cause more reliance on ground-water sources which may stress the resource beyond its long- term potential.

The **Nevada State Drought Plan** revised in 2003 further defines a drought as follows:

"Drought is a complex physical and social phenomenon of widespread significance. Drought is not usually a statewide phenomena, differing situations in the state make drought more regional in focus. Despite all the problems droughts have caused, drought has proven difficult to define. There is no universally accepted definition because: 1) drought, unlike flood, is not a distinct event, and 2) drought is often the result of many complex factors acting on and interacting within the environment. Complicating the problem of a drought definition is the fact that drought often has neither a distinct beginning nor end. It is recognizable only after a period of time and, because a drought may be interrupted by short spells of one or more wet months, its termination is difficult to recognize." *(State of Nevada Drought Plan- Revised July 2003)*

The State of Nevada Drought Plan is a strategic operations plan that describes the procedural framework for initiating and maintaining State-level actions under three different stages of drought. Natural resources identified in the Drought Plan include water resources (e.g., stream flow, reservoir storage), fish and wildlife and soil.

Figure 32 – Western States Drought Conditions



In 1987 Governor Bryan formed the Drought Review and Reporting Committee (DRRC) to inform the citizens of Nevada about climatological conditions and the severity of the current drought. As the drought progressed, the DRRC helped produce a State Drought Plan that outlines State and Federal actions that can be taken during various stages of drought. (*1987-1992 Drought Impact Summary)*

Smaller communities in Elko County have done very well coping with drought conditions. Midas and Tuscarora have had their springs dry up resulting in temporary water hauling operations to provide drinking water. Both of these towns are switching to more reliable ground-water supplies. Water management and water conservation efforts have allowed the citizens of Elko, Spring Creek and West Wendover to continue outdoor watering, even with their main source of water greatly reduced. Agriculture has also been severely impacted by the drought.

Fish and wildlife have been significantly stressed due to the drought conditions. Many of Elko County's wetland areas were either dry or severely diminished. These wetlands are important resting stops for migratory birds. The limited availability of food and habitat stressed the birds during migration and increased mortality rates. The drought resulted in minimum pools in most of our reservoirs until 2017. The fisheries in these pools were significantly stressed due to increases in temperature and oxygen depletion.

Water-based recreation had been severely impacted at Wild Horse Reservoir, South Fork Reservoir, Ruby Marshes and several other smaller reservoirs. Visitor counts at these reservoirs had been lower than previous non- drought years, and boating access was limited or nonexistent.

The State of Nevada Drought plan was revised in 2003.
[http://water.nv.gov/programs/planning/July2003DroughtPlan.pdf]

The stated purpose of the Drought Plan Is: This State Drought Plan establishes an administrative coordinating and reporting system between agencies that should be involved in providing assistance to help mitigate drought impacts. The intent of this document is to establish a system for determining drought severity, for establishing a framework within which agencies would function, and to establish a process for obtaining federal assistance if required. This plan does not establish specific conservation measures for local entities nor does it affect existing water rights. This plan answers the question, "What is the state's response during a drought?"

The County Plan adheres to the guiding principles outlined within the State Drought Plan.

During times of drought, communities and economic sectors are impacted in a multitude of ways, including public health. The environment is also impacted in a variety of ways. The impacts can range from a decreased water supply to the increased risk of wildland fires. With the decrease in water supplies, communities are forced to implement water restrictions in order to ration water consumption and conserve water resources. The quality of the water resources is also affected. Often, the contaminants that are normally present in all water sources become more concentrated due to the lack of fresh water introduced into the systems as well as the temperature of the water increasing. The stress on existing water supplies increases as the demand for the limited resources increases. The effects on public health can range from surges in heat related, waterborne, and mental health illnesses, as well as limited food supplies to the increase in living expenses due to reduced agricultural yields and hydroelectric production. The environment suffers due to the dry condition of the habitat, which increases the risk of wildland fires, reduces the amount of forage and water for wildlife and increases the amount of wind and water erosion to what can already be considered a stressed environment.

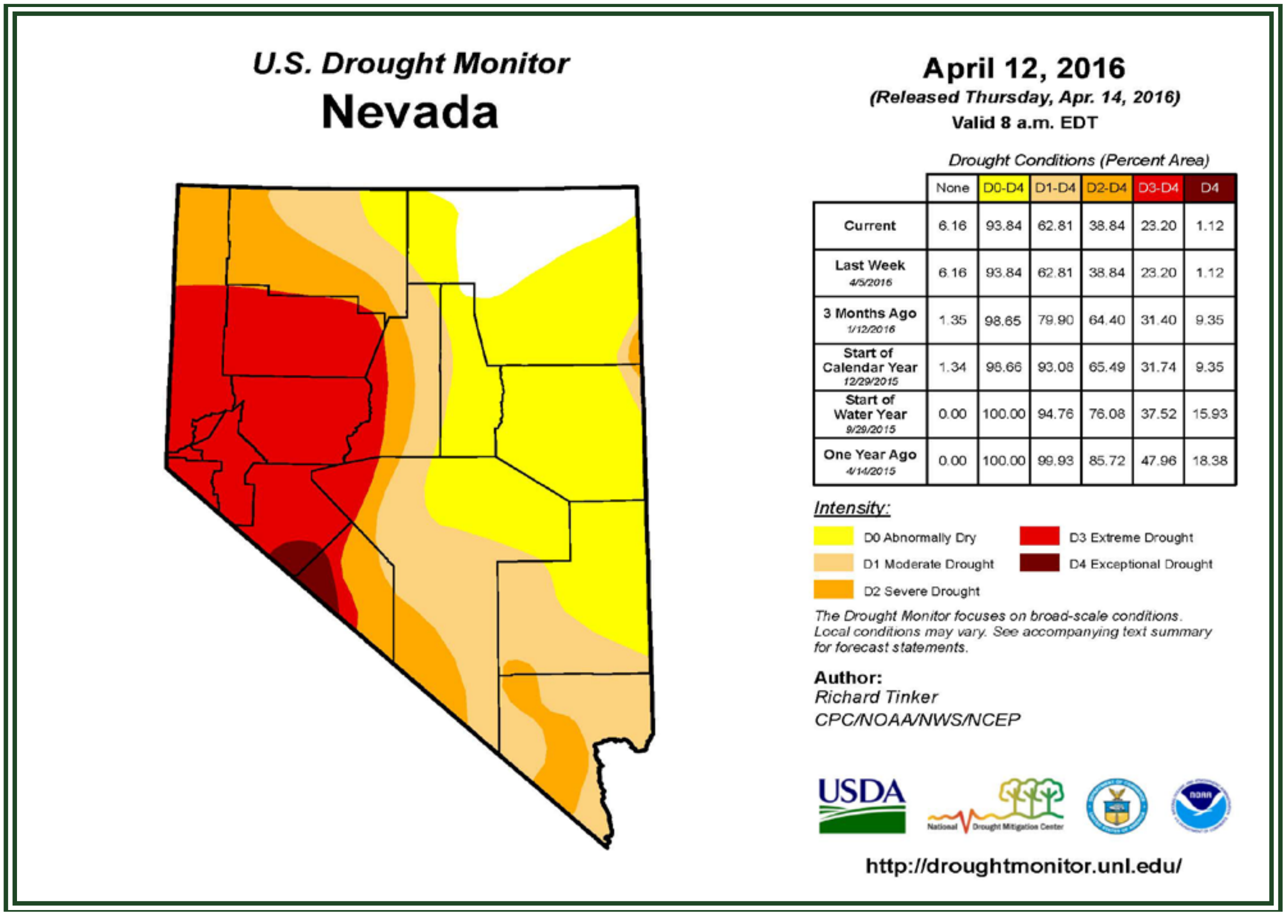
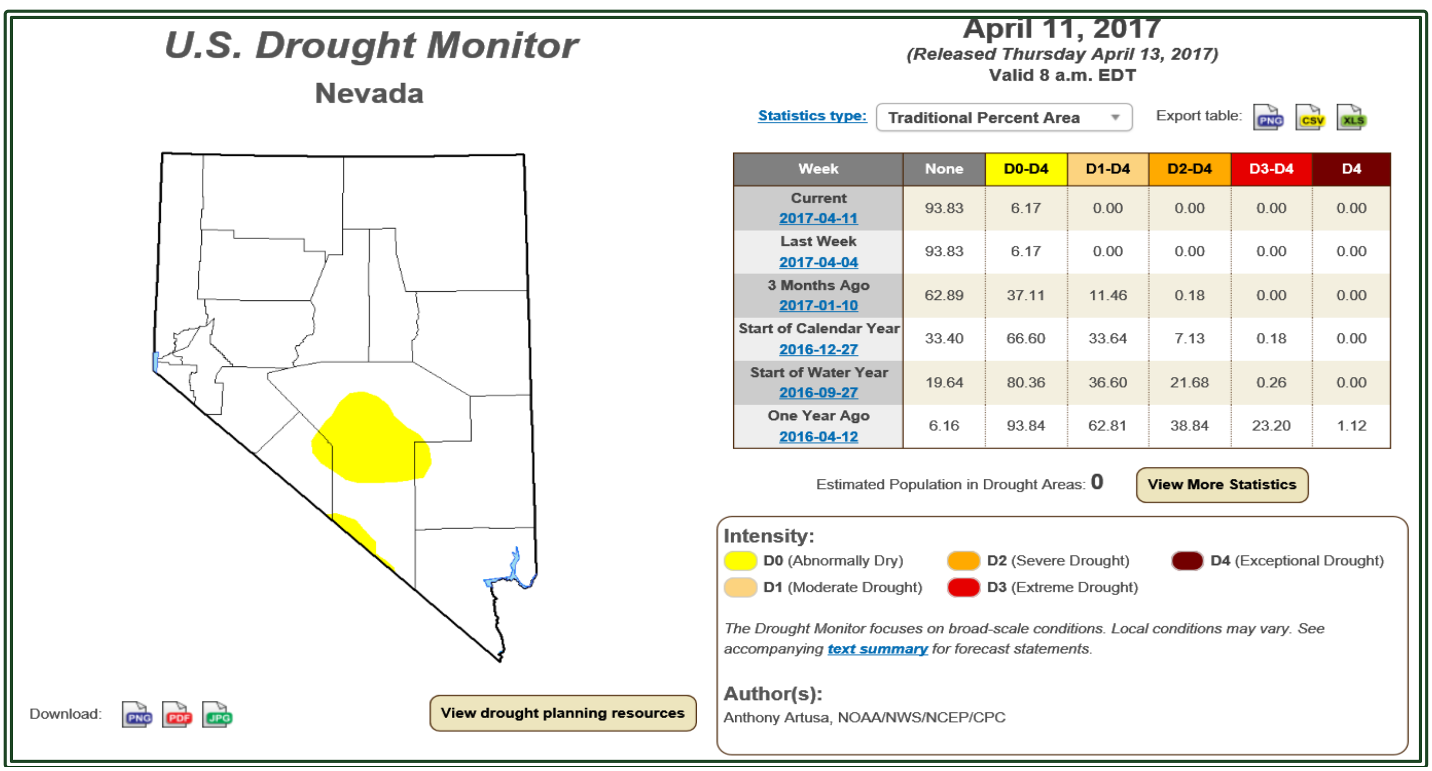


Figure 33 - Nevada Drought Monitor Map - April 2016

Figure 34 - Nevada Drought Monitor Map - April 2017



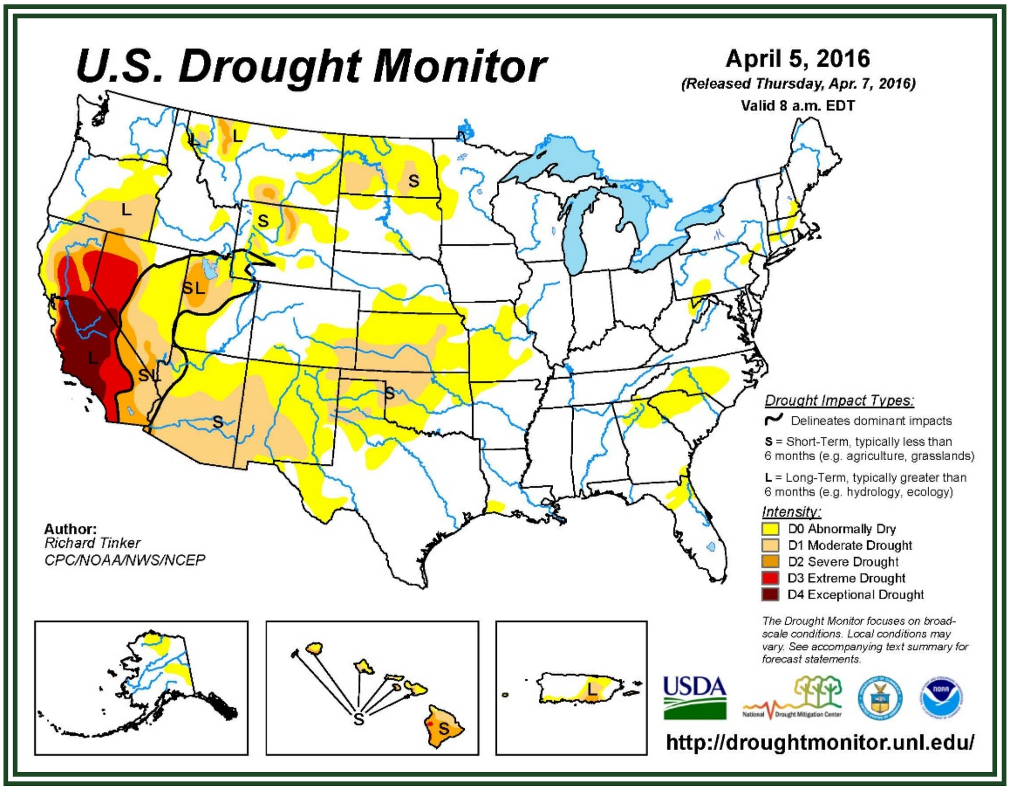
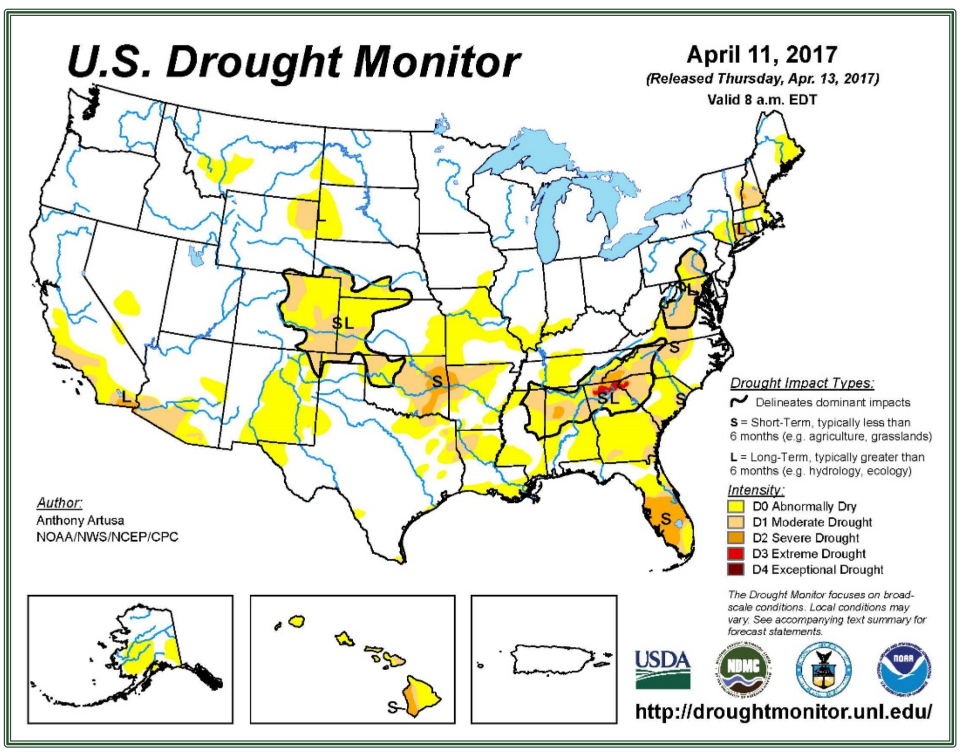


Figure 35 - U.S. Drought Monitor Map- April 2016

Figure 36 - U.S. Drought Monitor Map- April 2017



WATER RESOURCE CONSERVATION

The growing population and economy of Elko County will require ever increasing amounts of water in the future, however available sources for meeting these needs are limited. Part of the solution is the implementation of water conservation measures. The ability of conservation measures to extend supplies, and delay and/or reduce the need for future supply development has been documented.

Water conservation will continue to be a critical component of overall water management. As William O. Maddaus ("Integrating Water Conservation Into Total Water Management", *American Water Works Association Journal*, Vol. 82, No. 5, May 1990) notes, "the time is past when [water supply] needs can be met simply by building more water storage and delivery systems." The challenge facing water suppliers in today's political, environmental, and economic climate is to fully integrate our findings on demand management into long-range water supply planning." For Elko County this means understanding population and development trends and matching current and future water conservation practices and policies.

Recognizing the need for conservation, the 1991 State Legislature passed Assembly Bill (AB) 359 and Senate Bill (SB) 360. AB 359 requires each county and city to impose certain minimum standards for plumbing fixtures, by building codes or ordinance, for new residential, commercial, or industrial construction beginning on or after March 1, 1992 (*NRS 278.580, 244.3675, 444.340 through 444.430, 268.413*). In accordance with the amended Nevada Revised Statutes, each supplier of water for municipal, industrial or domestic purposes is required to adopt a water conservation plan based on the climate and the living conditions of its service area. The plan is to include provisions relating to:

1. Increasing public awareness of the State's limited water supply and the need to conserve;

2. Identifying and reducing leakage in water supplies, inaccuracies in water meters, and high pressure situations;

3. Increasing the reuse of wastewater treatment plant effluent;

4. Contingency plan for drought conditions that ensures an adequate supply of potable water; and

5. Adoption of a plan to provide incentives to encourage water conservation; to retrofit existing structures with reduced flow plumbing fixtures; and for installation of landscaping that uses a minimal amount of water.

Increasingly stringent wastewater discharge requirements coupled with scarce supplies of freshwater are inducing municipalities and industries to seek alternative uses of wastewater rather than treatment and subsequent discharge to a stream or to a ground-water aquifer. The most common use of treated wastewater is land application for irrigation of agricultural land or urban areas, such as golf courses.

The reuse of wastewater treatment plant effluent has increased in Nevada in recent years. Current uses of reclaimed wastewater effluent in Nevada include agricultural irrigation, golf course and landscape irrigation, industrial uses, wetlands applications, and construction water.

EFFECTS OF GROUNDWATER PUMPING

Any withdrawal of ground water results in removal of water from storage. Large-scale withdrawals in many areas in the Southwest have resulted in wide spread lowering of water tables (**Figure 37**) which reflects a quantity of ground water that is no longer available. Several other aspects of lowered water tables affect future water availability. Lowering of water tables results in increased costs to lift water a greater distance. For some water uses such as agriculture, pumping costs from deep aquifers could be prohibitively high. Lowered water tables can result in loss of well productivity and adversely effect water quality. In most basins, shallower sediments are less compacted and more readily release water to wells than deeper sediments. Lowered water tables can result in the need to drill more and deeper wells to maintain a desired rate of ground-water withdrawal.

Figure 37 - Effects of Groundwater Pumping Water Level Decline in Feet

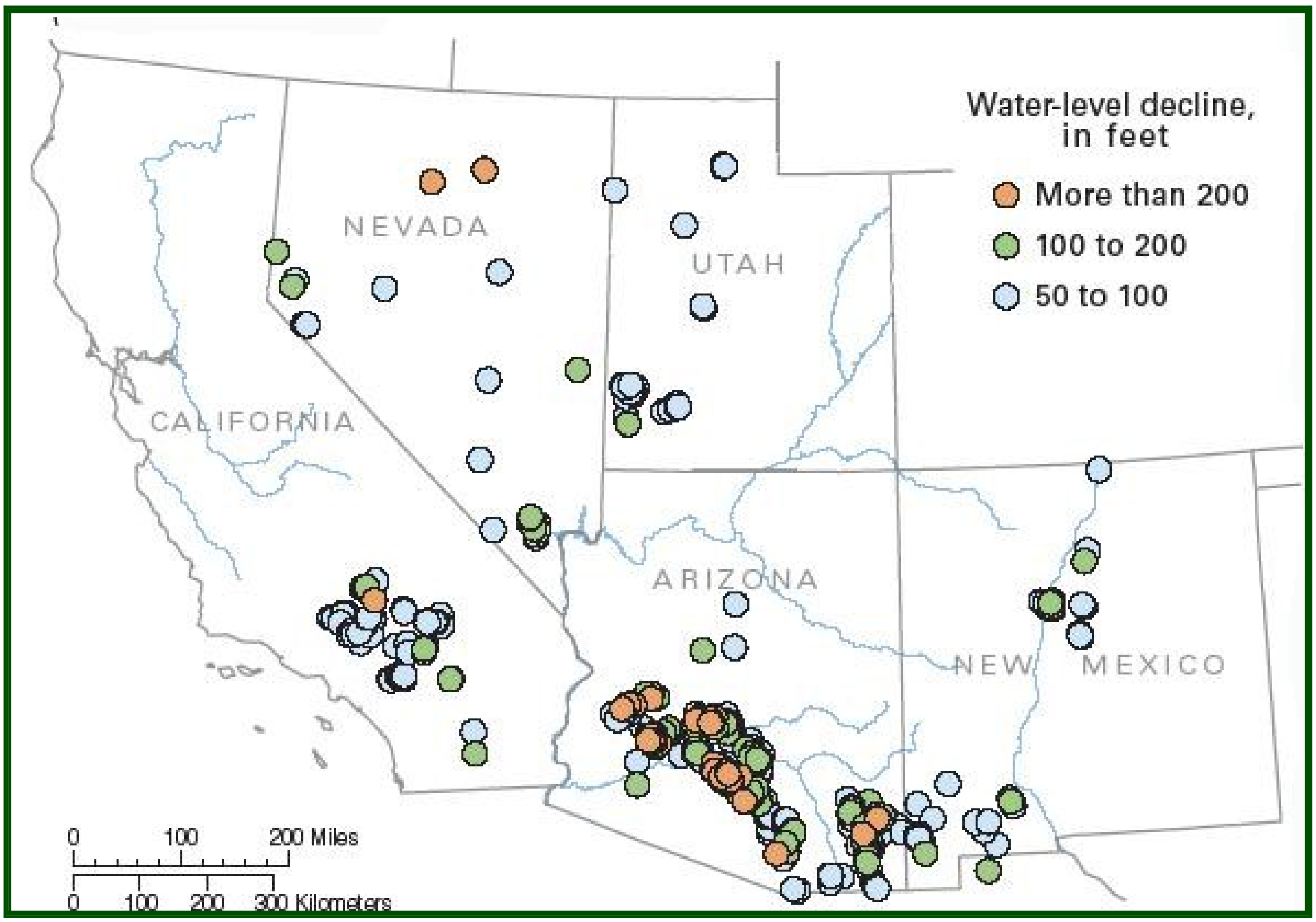
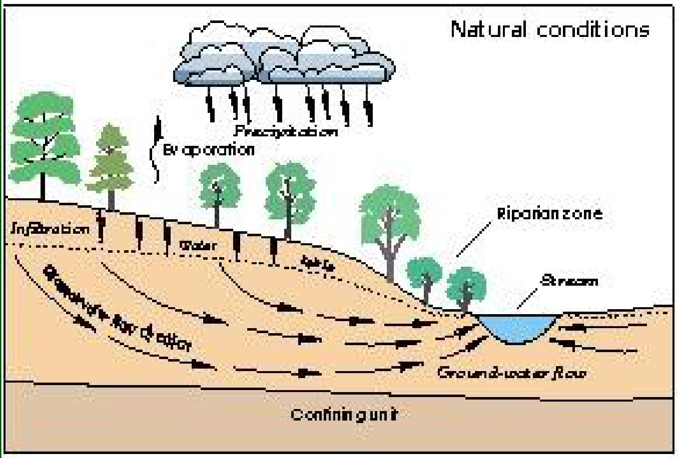


Figure 38 - Effects of Groundwater Pumping Natural Conditions

Figure 39- Effects of Groundwater Pumping Water Level Declines



Water is recharged to the ground-water system by percolation of water from precipitation and then flows to the stream through the ground-water system.

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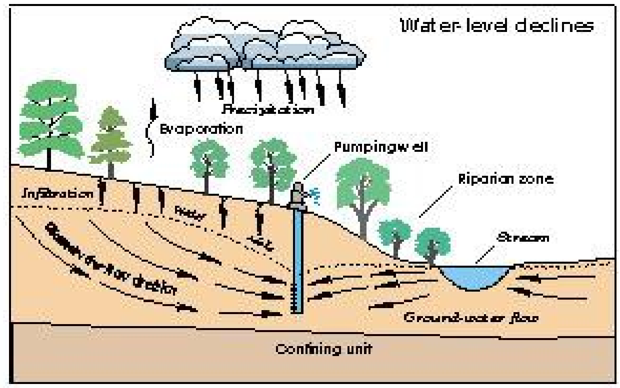
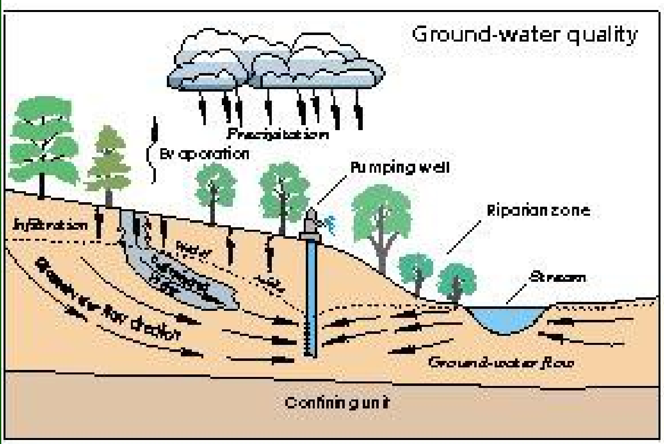


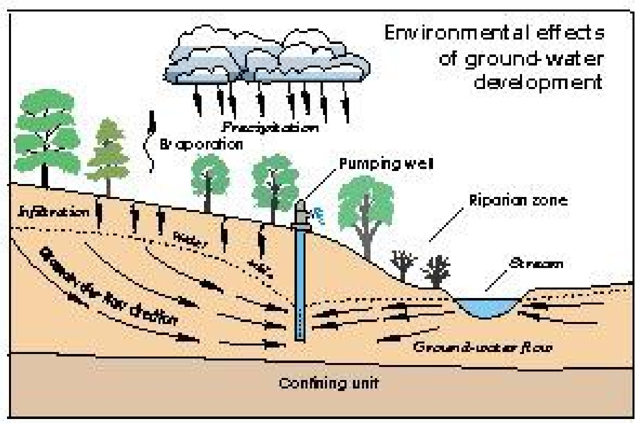
Water pumped from the ground-water system causes the water table to lower and alters the direction of ground-water movement. Some water that flowed to the stream no longer does so and some water may be drawn in from the stream into the ground-water system, thereby reducing the amount of streamflow.

Figure 40 - Effects of Groundwater Pumping Groundwater Quality

Figure 41 - Effects of Groundwater Pumping Environmental Effects



Contaminants introduced at the land surface may infiltrate to the water table and flow towards a point of discharge, either the well or the stream. (Not shown, but also important, is the potential movement of contaminants from the stream into the ground-water system.)



Water-level declines may affect the environment for plants and animals. For example, plants in the riparian zone that grew because of the close proximity of the water table to the land surface may not survive as the depth to water increases. The environment for fish and other aquatic species also may be altered as the stream level drops.

WELLHEAD PROTECTION

The Wellhead Protection (WHP) Program was established by the 1986 Amendments to the Safe Drinking Water Act (SDWA). The purpose of the program is to protect public ground-water supplies from contamination and prevent the need for costly treatment of water to meet drinking water standards. The program is based upon the concept that the development and application of land-use controls and other preventative measures can protect groundwater. A comprehensive WHP Program comprises several distinct and essential elements:

1. Specification of roles and duties of State agencies, local government entities, and public water suppliers;
2. Delineation of the wellhead protection area (WHPA) for each well;
3. Identification of potential sources of contaminants within each WHPA;
4. Development of management approaches to protect the water supply within the WHPA;
5. Contingency planning for the provision of alternate drinking water supplies in the event of well or well field contamination;
6. Consideration of all potential contaminant sources within the expected wellhead area of a new water well; and
7. Provisions for public participation.

The Nevada Division of Environmental Protection (NDEP) is encouraging water purveyors in the State to develop a WHP Program for their area. As part of this voluntary program, NDEP is providing technical and possibly financial support for WHP Program development. Well Head Protection Programs have been implemented in Jackpot, West Wendover, Wells, Carlin, Montello, Lamoille and the City of Elko. This Plan endorses and implements the State of Nevada Well Head Protection Program in and for Elko County.

The Nevada Division of Environmental Protection (NDEP) has been delegated the authority to implement aspects of the federal Clean Water Act (CWA) of 1977 and Safe Drinking Water Act of 1974 programs as well as numerous state programs that exist to protect, control and restore the quality of the waters of the State. Apart from the NDEP permits issued under the CWA, NDEP issues Water Pollution Control Permits with a zero-discharge performance standard for certain mining facilities, and State Ground Water Permits for infiltration basins, land application of treated effluent, large septic systems and industrial facilities. In addition to these permitting processes, NDEP reviews subdivision plans to ensure that wastewater is disposed of adequately. Also, NDEP regulates highly hazardous substances under the chemical accident prevention program. Remediation of polluted soil and/or groundwater falls under the State Corrective Actions Program that includes authorities under two federal acts: the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The State Environmental Commission (SEC), established by State law, has adopted regulations, which define State programs to carry out the provisions of Nevada's Water Pollution Control Laws. These laws, contained in Chapter 445A of the Nevada Revised Statutes (NRS), establish the authority to implement portions of the CWA and the Safe Drinking Water Act in addition to several non-federal water pollution control programs. In addition to adopting regulations, the SEC establishes fee schedules for permits, advises, consults and cooperates with other governmental agencies regarding water pollution matters, establishes qualifications for sewage treatment plant operators, and holds hearings regarding the actions of the (NDEP). The powers and duties of the SEC are listed primarily in NRS 445A.425, and also in NRS 445A.135, 445A.160, 445A.180, 445A.428, 445A.430, 445A.605, and 445A.610.

NONPOINT SOURCE POLLUTION

Clean water is essential to all life. Yet every-day activities impair water quality and thus reduce the availability of good water supplies. Throughout the U.S. and Nevada water resource experts and agencies are finding that the leading cause of water quality impairment is nonpoint source (NPS) pollution. Pollution from nonpoint, or diffuse, sources is more difficult to control than pollution from point sources, which are discharges through pipes or channels from a distinct source. Almost any activity can increase runoff and add to NPS pollution. Commonly identified sources, activities and facilities such as mining, construction, grading, roads and trails, septic systems, underground storage tanks, modified water courses, feed lots, grazing and timber harvesting are commonly identified sources. These widespread activities can stir up, produce and release pollutants which are then picked up by runoff from melting snow, rain fall, or irrigation and deposited downstream in pulses.

NPS pollution occurs wherever water flowing across the land or underground picks up nutrients, salts, metals, organic material, soil, or chemicals and delivers the accumulated pollutants to streams, lakes, wetlands or ground water aquifers in amounts greater than natural background levels. The excess pollutants may result in impacts such as nutrient enrichment, undesirable algae growth, higher total dissolved solids, turbidity, lower dissolved oxygen, pH changes, higher temperatures and increases in pathogenic microorganisms. These conditions negatively affect water supplies by fouling water systems and increasing treatment requirements and operation and maintenance costs. Aquatic ecosystems may also be impacted by diffuse sources.

The presence of wetlands and water availability are important factors determining the degree of NPS impact to water quality. One of the reasons wetlands and riparian zones are valued and protected by regulation is their treatment capacity, which is the ability to detain, trap, convert and assimilate sediment, nutrients, and organic wastes. The actual relationship between stream flow and water quality is complex, but in general, where river flows are lowered by drought and/or upstream diversions and nonpoint pollution is present, the negative water quality impacts can be amplified.

Dry climate, infrequency of rainfall events, and diversions from streams often are significant factors influencing the degree of nonpoint pollution impacts on water resources. Circumstances vary on each river, so intensive field investigations are helpful in explaining site specific cause and effect relationships between nonpoint sources and hydrologic conditions that contribute to NPS pollutant discharges and water quality impairment.

Preventing and controlling NPS pollution is accomplished primarily by implementing Best Management Practices (BMPs). BMPs work on the principle that materials belonging on the land should be kept there, and that decreasing the distance runoff travels from the source minimizes control costs. Some general categories of BMPs applicable to many source activities are soil conservation, re-vegetation of disturbed areas, erosion and storm water controls, fertilizer management planning, integrated pest management, wetland protection and enhancement, and storm water treatment cells. Land use planning practices such as open space master plan designations, zoning controls, and subdivision development ordinances also have been used to ameliorate nonpoint source pollution potential of land development.

State agency water quality assessments, have found that urban areas, irrigation, grazing, and flow regulation practices are the largest nonpoint pollutant contributors. Statewide, the most common NPS pollutants of concern include suspended solids, total dissolved solids (salinity and chlorides), total phosphates, nitrogen species, turbidity, and thermal energy. In some waters, arsenic, boron, selenium, lead, and iron levels are elevated. These elements are in areas associated with geothermal sources, and become concentrated in closed basins by high evaporation rates.

Given the prevalence of these factors in Nevada, all major rivers are impacted to some degree by NPS pollution. Much is being done cooperatively by state, local, federal agencies and land owners to manage nonpoint source pollution through education. Encouraging and funding implementation of pollution prevention and BMP retrofit projects, installation of control technologies, monitoring and assessment of nonpoint sources, improving our understanding of the cause and effect relationships between water quality impairment and pollutant sources. Researching and implementing new, more effective strategies is an ongoing effort of all agencies within the Department of Conservation and Natural Resources.

Local Agencies Involvement with Nonpoint Sources

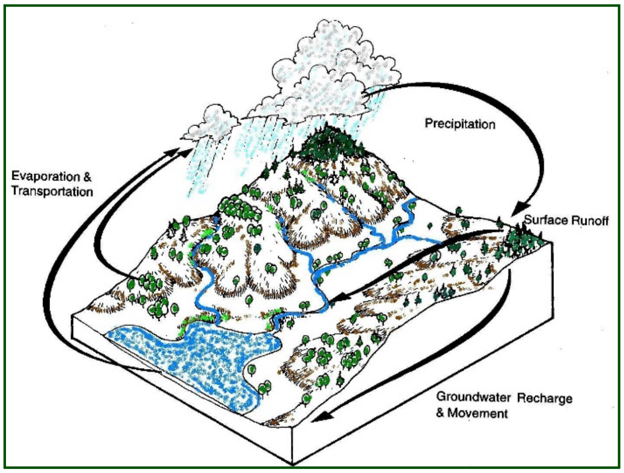
Nevada's nonpoint source control program places an emphasis on local management and enforcement. Local governments have a variety of tools available to accomplish this, including: 1)identifying environmentally sensitive lands during the Master Land Use Planning process; 2) adopting development ordinances with design criteria intended to minimize soil disturbance and erosion, retain wetlands and riparian zones, and preserve natural drainages and stream channels; 3) acquiring open space to achieve environmental objectives; and 4) adoption of ordinances requiring application of BMPs. Cities and counties also collaborate with conservation districts and the University of Nevada Cooperative Extension offices to enhance public education efforts on pollution prevention and to review development plans for NPS concerns.

FLOOD PLAIN MANAGEMENT

Flood plain management experience indicates that the best damage reduction plans are occurring in those counties that have provided leadership strong enough to stay the course between high profile flood events. The Western Governors Association Floods Task Force concludes that pre-disaster flood planning and floodplain management are "essential" elements in reducing flood risk. All levels of government should place greater emphasis on these two policy areas. Detailed local planning will play an essential role in river-basin management in the future. Leadership must focus on a balance of structural and non-structural flood plain management tools. With urbanization rapidly expanding in the west, decision makers must recognized that storm-water management planning is an integral component of an overall strategy to reduce flood losses.

Conditions for flooding in the west are much different than those in eastern states. The mountainous regions provide the environment for flash flooding, high velocity flows, excessive erosion, and torrent storm patterns. The gradual flood build-up of major rivers that devour small towns and remain high for weeks is a condition that exists primarily in the east. Alluvial fans, a common topographic feature in the west, will continue to present a tremendous challenge to local planners until an effective model for mapping alluvial fan flooding is developed and accepted by those in the engineering, urban and rural planning, and flood plain management professions. The great number of homes and businesses on alluvial fans pose high risk to western communities, a risk that must be better understood and mitigation strategies developed.

Accurate maps are vital to the local flood plain administrator to make sound management decisions. These maps are used by the flood plain administrator to determine if and how a structure can be built in a flood plain. In some western states, the Flood Insurance Rate Maps were last updated in the late 1970's and 1980's. FEMA is currently working to improve and modernize the flood mapping process. Currently, all maps are needed to reflect new growth and changes in flood plains to correct inaccuracies in the original maps and to show the annexation of new land that is not mapped.



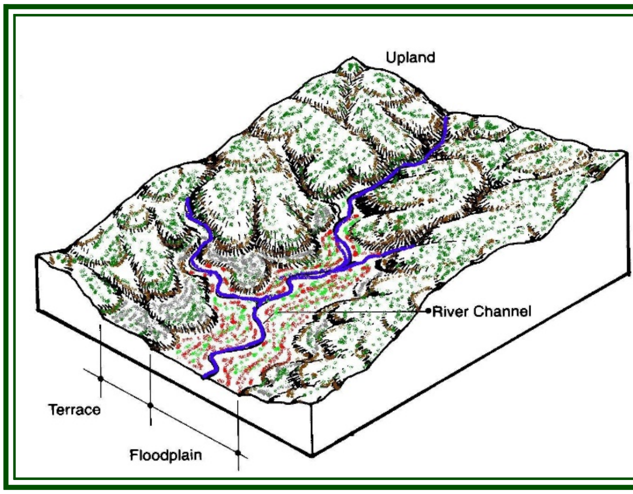


Figure 42 - Groundwater Recharge & Movement

Figure 43 - Flood Plain & Terrace diagram

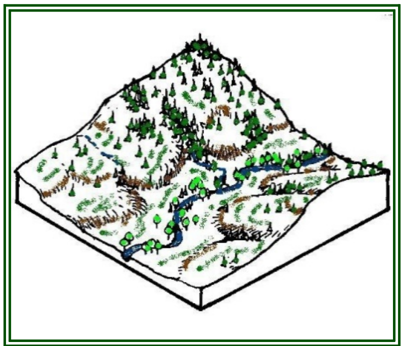


Figure 44 - Every community must recognize that decisions about flood plain resources are decisions about the communities future. With careful consideration and planning, rivers and streams can be aesthetic and functional assets that reflect community pride and ingenuity. However, a community that ignores the importance of natural flood plain functions may ultimately face flood losses and deteriorating water quality. In the end it would be less costly to plan well now.

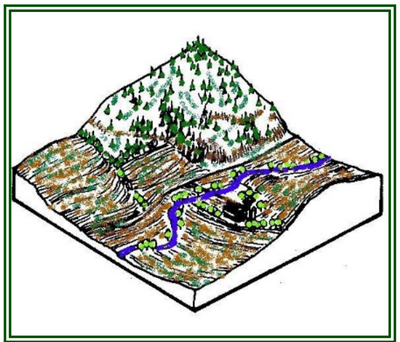


Figure 45 - Well placed parks and recreation areas that include vegetation are often ideal for maintaining flood plain storage capacity that help support flood plain functions that protect water quality and sustain wildlife habitat. Open space areas, such as agricultural lands, can help to rally functioning flood plains, such as protecting or planting vegetated buffer strips and creating channel alterations for fish habitat improvement.

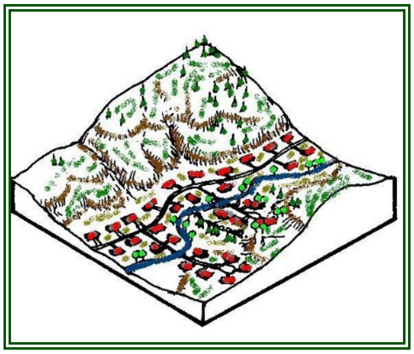


Figure 46 - Development within flood plains often occurs without consideration of the effects on flood plain natural resource functions. If an area is built up during a period when there have been few floods, the need for flood storage capacity of a naturally functioning flood plain may have been overlooked. The loss of natural flood plain functions in heavily developed areas not only impedes flood storage, but can also increase erosion and reduces the mitigating effects that vegetated areas can have on the pollution of water ways.

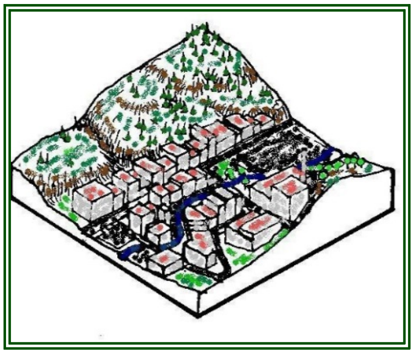


Figure 47 - Impermeable surfaces such as buildings and pavements replace vegetation as ground cover, increasing the runoff that would have infiltrated in a natural flood plain. The removal of vegetation, destruction of wetlands and paving in urban and suburban settings can thus increase the risk of flooding. Upstream development outside the floodplain can also increase erosion and sedimentation, which may cover spawning areas and bury food sources in streams. Loss of vegetation also removes sources of shelter and food for wildlife and human made structures may present barriers to migration and reproductive activity.

REPORT FINDINGS and WATER RESOURCE USE FORECASTS

Agricultural Water Use Forecast: In 2005 Agricultural uses in the State of Nevada were 83.2% of all waters within the state, by far the largest water user group. 2005 information from the Nevada Division of Water Resources indicates that Elko County withdraws approximately 898,321 acre feet annually for agricultural uses. Growth and development patterns indicates that agricultural uses in Elko County will minimally decrease or hold steady through 2025. It is estimated by the *State Division of Water Planning* that by the year 2025 Elko County total agriculture water uses will withdraw 830,610 acre feet annually. This represents a decrease from total water use in 2005 of 898,321 acre feet annually or a total loss of -7.5 %. **Elko County** data forecasts that by the year 2025 total agriculture uses will withdraw **880,489** acre feet annually a loss of 0.1 % annually or a total loss of 2.0%.

Domestic Water Use: It is estimated by the City of Elko, and other water purveyors as well as the Elko County Division of Natural Resources that domestic water users of Elko County use approximately 250 gallons per day per person, including interior and exterior use. The State of Nevada Water Plan indicates that every person in Nevada uses 240 gallons of water per day. Nevada Revised Statutes (NRS) stipulates that every new and existing parcel over 40 acres in Nevada that utilizes an individual domestic well uses 1,800 gpd or 2.02 acre feet of water annually. The 2000 Census cites that households in Elko County equate to 2.6 persons per household. Using 250 gallons per day per person this would equate to 650 gallons per day per household, approximately one third of the water allocated for each domestic well by the State Engineer.

The *State of Nevada Demographer* and the *State of Nevada Division of Water Planning*, estimates total domestic water uses in **2015** are **16,729** acre feet. The forecasted domestic uses for **2025** will be **14,780** acre feet annually. This represents a decline in domestic uses of 1,949 acre feet or -11.65%. **Elko County** forecasts that over the same period domestic uses will increase by 6.67% or **17,844** acre feet annually in **2025**.

Table 18 – Typical Household Water Usage

	Without Water Saving Fixtures	With Water Saving Fixtures
Toilet, per flush	3.5 - 7 gallons	1.6 gallons
Showerhead, per 5 minutes	15 - 40 gallons	10 - 12.5 gallons
Kitchen/lavatory faucet, 5 minutes	14 - 35 gallons	11 gallons
Dishwasher, per load	14 gallons	9.5 - 12 gallons
Washing machine, per full load	55 gallons	42 - 47.5 gallons

Average annual residential use....................................200 gpcd
Outdoor use...110 gpcd
Indoor use... 90 gpcd

Sources;

California Dept. of Water Resources, "Water Plan: Benefit/Cost Analysis Software for Water Management Planning- Water Conservation Assumptions", Oct. 1989.

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Vickers, A., "Water-Use Efficiency Standards for Plumbing Fixtures: Benefits of National Legislation," American Water Works Association Journal, Vol. 82, No. 5, May 1990.

Westpac Utilities, "Water Conservation Plan for Reno/Sparks Metropolitan Area - Draft Report", Reno, Nevada, March 1992.

COMMERCIAL & INDUSTRIAL WATER USE FORECAST: Northeastern Nevada region is the third largest gold mining community in the world and is also home to many casinos, hotels/motels and recreational uses. While the mining industry is going to be a large part of this region’s economy for the next 15 plus years, it is through strategic planning and forward-thinking that diversification will be accomplished. Economic diversification in this region while the economy is strong rather than relying on mining to be the prime underpinning of the region’s economy is imperative. Mining and its supporting industries are a very important basis to begin from in diversifying the economy.

The City of Elko serves a five county area as a hub for retail, services, and housing, especially as it relates to the mining jobs located outside of this core area. Casinos or casino hotels employ approximately 4,800 persons in Elko County and are expanding. However, many of the people that work in Jackpot and West Wendover casinos live and/or spend their earnings in Idaho or Utah, respectively, and exist to attract the target markets of those states for gambling. The City of Elko is experiencing moderate growth in the gaming industry. Forecast for commercial and industrial uses in Elko County are primarily uses related to mining, transportation, recreation and gaming based businesses. Currently there are numerous vacant industrial and commercial land and future Industrial uses are anticipated to be primarily mining and transportation based due to our proximity to resources necessary for manufacture, including water.

Potentially, incorporated cities could provide necessary resources, such as water for manufacturing or beverage production. However, location and transportation issues have caused the manufacturing companies to locate elsewhere. The Elko County Board of Commissioners and the Elko County Economic Diversification Authority have developed a Multi-Modal Trans-loading Facility. The development of this facility has provided open rail and transportation corridors to establish Elko County as a manufacturing and transportation hub for Northeastern Nevada.

Elko County estimates, based on current growth and development patterns, indicate that Commercial and Industrial uses in Elko County will increase or hold steady through 2025. It is estimated that by the year 2025 Elko County total Commercial & Industrial water uses will withdraw **17,597** acre feet annually. This represents an increase from total water use in 2005 of **16,493** acre feet annually, or 6.3 %.

WATER RIGHTS: The water in Nevada on the surface and below the ground surface belongs to the people of the State. Entities within the State can apply for the right to use that water. Nevada Water Law is founded on the doctrine of prior appropriation - "first in time, first in right." Under the appropriation doctrine, the first user of water from a water course acquired a priority right to the use and to the extent of its use.

Nevada Water Law is set forth in Nevada Revised Statutes (NRS), Chapters 533 and 534. In addition, there are numerous court decisions which have helped define Nevada water law. The State Engineer is the water rights administrator and is responsible for the appropriation, adjudication, distribution and management of water in the State. To carry out these duties he is vested with broad discretionary powers. As state statute cites, entities within Nevada are permitted to file and acquire water rights. Elko County should utilize this as a tool to potentially protect exportation of ground and surface waters from the county as well as ensure that water rights are available for future uses. Filing for ground and surface water should be made and held by the county for application of future needs. It should not be the intention of the county to hold water rights for any other reason other than the protection of Elko County water for municipal uses associated with specific uses. The application and acquisition of water rights by Elko County has implemented this policy through the Elko County Natural Resource Manager.

DROUGHT MANAGEMENT: As Nevada is the driest State in the Nation, drought is relatively common and expected. Every 6 out of 10 years, the major rivers in the state experience below average flows. For most of Nevada, which depends mostly on stream flow for water supply, a drought is considered to be a period of 2 or more consecutive years in which stream flow is much less than average. The most significant droughts were during 1928-37, 1953-55, 1959-62, 1976-77, and 1987-92. Droughts can magnify quality problems for surface and ground-water sources. By decreasing stream flow, droughts tend to lessen the quality of remaining water for human and wildlife uses. Droughts also can cause more reliance on ground-water sources which may stress the resource beyond its long-term potential.

Communities in Elko County have done very well coping with drought conditions. Midas and Tuscarora have had their springs dry up resulting in temporary water hauling operations to provide drinking water. Both of these towns are switching to more reliable ground-water supplies. Water management and water conservation efforts have allowed the citizens of Elko, Carlin, Wells, Spring Creek and West Wendover to continue outdoor watering, even with their main source of water greatly reduced. Agriculture has also been severely impacted by drought conditions. The Elko County Water Resources Management Plan, by the document, adopts and implements the State of Nevada Drought Plan. The enforcement of all conservation methods and policies provided herein are performed by the Elko County Natural Resource Manager.

RURAL LAND USE AND WATER MANAGEMENT PLANNING: Historically, rural planning in Elko County has been based on development patterns and ***Local Area Master Plans***; Spring Creek / Lamoille Master Plan, South Fork Master Plan, Jackpot Master Plan and the 1971 Elko County General Plan and land use zoning. Land use patterns in Elko County now command that a full comprehensive Land Use Master Plan be created that addresses Urban and Rural Development as well as to implement elements of the Water Resource Management Plan. Future land use planning and development criteria will ultimately need to address water consumption and usage. Most residential or domestic development in rural Elko County consists of the development of larger parcels between 2.5 acres and 40 acres. Specific build out Master Plans should be required prior to development to help identify the potential total water consumption of a proposed development along with the potential impacts to a specific area or basin.

Certain aspects of the Elko County Code, Titles 4 (zoning) and Title 5 (subdivision), require review and amendment to examine and provide methods of proper rural planning. Currently, NRS 278 subdivision code provides methods and provisions that permit local government to require land use / water planning and review during the planning process. These provisions should be included in the Elko County Code pertaining to zoning, subdivision and building criteria.

Water Resource Management and Conservation practices should be included within the development criteria. Elko County should also take an active role in the management of waters in Elko County. This has been accomplished by the development and implementation the Elko County Natural Resources Manager. An active role in the protection of water in Elko County will require the filing of water rights applications by the governing body, either the county or specific incorporated city / unincorporated town. Filing and developing water rights for domestic/municipal/agricultural use for the future growth of Elko County will help promote orderly and affirmative development and will help discourage future loss of agricultural lands. Potentially the acquisition of water rights by Elko County will provide for a sustained growth in specific areas that currently provide infrastructure and will support future development. This concept would help to control the pocket, or spot development, that creates hardships to local services such as fire protection, police protection and emergency services.

CONSERVATION & MANAGEMENT: Water Conservation in Elko County has historically been achieved on a voluntary basis. Most of Elko County's incorporated cities have ordinances that employ water conservation methods as well as contain verbiage that mandates specific water conservation provisions. Current Elko County development criteria does not address water conservation issues. The development of specific mandatory and voluntary water conservation policies and standards code in Elko County is imperative for future development and protection of existing resources. As with all conservation issues, public education, acceptance and implementation are necessary. Ordinance and planning provisions should require a public education process that will promote the need of water conservation during development phases of all subdivisions and structures.

Implemented conservation programs have the potential to influence the State Engineer's policy of requiring 1,800 gallons per day or 2.02 acre feet annually per domestic well. As previously stated, the *Nevada State Water Plan* cites that per capita a person in Nevada uses 200 gallons of water per day. As cited by Nevada Division of Natural Resources, 250 gallons per day for 2.6 persons per household equates to 650 gallons per day per household approximately 1/3 of the total allocated for a domestic well. This would indicate that the State Engineer could revise the state statute, thus, providing the potential for higher population densities in areas currently restricted by local and state policies and/or ordinance.

Other conservation techniques include the re-use of treated wastewater for irrigation purposes. For the most part, the use of treated wastewater requires the development of sanitary sewer facilities or retrofitting exiting facilities to treat the water for irrigation use. This is a potential in several outlying areas and un-incorporated towns and communities such as Jackpot, Montello, Mountain City and Spring Creek. The City of Elko currently utilizes the use of grey water for irrigation of several agricultural fields as well as the municipal golf course.

Conservation programs and policies have been implemented and are enforced by the Incorporated Cities in Elko County. Education and voluntary conservation programs are to be developed and implemented by Elko County including, Planning, Zoning and Building Codes that encourage conservation in residential and commercial plumbing fixtures. The Elko County Water Resources management plan promotes that Elko County develop, adopt and implement a water conservation ordinance as well as enforcement policies and procedures. This is to be included within Title 4 and Title 5 of Elko County Code. Conservation should also be promoted within the policies and procedures of the adopted Elko County building code.

Flood Plain Management: Flood hazards in Nevada are typically underestimated due to the arid climate, few perennial streams, and low precipitation. This state is subject to two types of flooding; rivers overtopping their banks and alluvial fan or flash flooding. Alluvial fan/ flash flooding (*dry mantle*) is potentially more dangerous than riverine (*wet mantle*) flooding because it is unpredictable and the threat is often not apparent, particularly to new residents in the state unfamiliar with the desert environment.

Accurate maps are vital to the local flood plain administrator to make sound management decisions. These maps are used by the flood plain administrator to determine if and how a structure can be built in a flood plain. In some western states, the Flood Insurance Rate Maps were last updated in the late 1970's and 1980's. FEMA is currently working to improve and modernize the flood mapping process. Currently, all maps are needed to reflect new growth and changes in flood plains to correct inaccuracies in the original maps and to show the annexation of new land that is not mapped.

Elko County Code Title 4 Chapter 13 adopts the Flood Plain Management Ordinance as approved by the State of Nevada Flood Plain Administrator. The ordinance provides procedures for aspects of development in a flood plain. Historically, enforcement of Title 4 Chapter 13 has been through the Building Permit process. This process is reactionary to a building permit application. As demonstrated through flooding of annual and perennial flow streams and rivers in Elko County, it is imperative that a pro-active approach be made to administration of flood plains in Elko County. Detailed local planning will play an essential role in river-basin management in the future. Leadership must focus on a balance of structural and non-structural flood plain management tools.

Recognition In Memory Of:

During the ten year development of the Plan two members of the Elko County Water Plan passed away. The two members were Mr. Jeffery Borhauer a representative from Carlin and Mr. Jerry Parker an Elko County at large representative. These two members provided a great deal of knowledge, experience and stimulus into the development of this document. Thank you Mr. Borhauer and Mr. Parker for all that you have provided to this document and to Elko County. During the 2015 - 2017 review and amendment Mr. John C. Carpenter unexpectedly passed away. Mr. Carpenter was very involved and instrumental in the revision of the document.

Elko County Board of County Commissioners
Elko County Water Planning Commission
Elko County Natural Resources Advisory Commission

SECTION 2 SUMMARY

Section 2 of the Elko County Water Resource Management Plan has provided information and data on a wide range of topics. The data compiled covers information supplied by various entities, including the State of Nevada and county departments. The purpose of the data is to provide the reader with information regarding water uses and the fundamentals of Nevada Water Law regarding management of water rights and usage throughout the state.

Socioeconomic characteristics specific to Elko County are provided in Section 2. This information provides the reader data pertaining to economic studies developed by the State of Nevada Division of Water Planning. Historical demographics are provided that identify the county's current usage of water and natural resources. This also provides data specific to the economics of Elko County including industry, agriculture, commercial and residential uses while providing estimates of overall consumptive uses of water for each individual demographic.

The Regional Hydrographic Data and Regional and Local Data of Section 2 provides information as to the four hydrographic regions and forty four hydrographic areas located in Elko County. This data is provided by the State of Nevada Division of Water Resources. The data provides data sets such as committed and uncommitted water resources, hydrographic area perennial yields, water right permits and pending applications. The information also provides information pertaining to domestic and municipal uses in the listed areas. Population estimates and projections are depicted from the State of Nevada Demographer and Elko County. The estimates and projections offer a separate and completely different conclusion of future water requirements and demands. Development considerations and statutory planning provisions offer information to assist land use planning considerations of future water requirements. These provisions also discuss the need for planning, considering drought conditions, conservation measures and the effects of groundwater pumping, non-point source pollution, safe drinking water flood plain management and other federal, state and local programs related to water resource management.

Report findings summarize all of the data and information of Section 2. The findings address Agricultural, Domestic Commercial / Industrial and Municipal water use estimates and forecasts in the county over the 25 year life of the plan. The findings summarize water rights and water law as well as state programs such as drought management, flood plain management, local interest in the creation of conservation programs, and Rural Land Use.

Based on the data and information provided in Section 2, the Elko County Water Planning Commission and the Elko County Board of Commissioners have developed the following Conclusions and Plan Directives. The Conclusions and Plan Directives offer solutions to fulfill the mission of the Elko County Water Resource Management Plan. The Conclusions and Plan Directives offer a method of implementation of the programs and solutions outlined in Section 2. Future compiled data and information will be included to augment the nature and comprehensiveness of this plan, including hydrographic area analysis and findings utilizing current science and technology.

CONCLUSIONS AND PLAN DIRECTIVES

Preamble: Based on the data and information provided in Section 2, the Elko County Water Planning Commission and the Elko County Board of Commissioners have developed the following Conclusions and Plan Directives:

I. Elko County Water Resource Management Policy:

A) The protection of existing water rights, water uses and un-appropriated water within Elko County is of paramount importance to Elko County's economic and cultural prosperity. Therefore, transfers of water use shall be carefully reviewed and considered in relationship to history, traditions and culture of Elko County.

B) Elko County recognizes that the protection and development of water resources are essential to its short and long term economic base.

C) Elko County shall review and consider the impacts of all existing water users as well as future water rights for all uses including:

1) Agricultural
2) Municipal
3) Quasi-Municipal
4) Commercial / Industrial
5) Domestic
6) Geothermal
7) De-watering

D) Elko County shall encourage alternate methods of water uses including but not limited to:

A) Geothermal
B) Hydroelectric
C) Conservation
D) Re-Use

E) Inter-basin transfers of groundwater must be approved or rejected by the State of Nevada Engineer. As per State Statute the State Engineer shall consider:

1) Whether the applicant has justified the need to import the water from another basin;
2) If the State Engineer determines that a plan for conservation of water is advisable for the basin into which the water is to be imported, whether the applicant has demonstrated that such a plan has been adopted and is being effectively implemented and enforced;
3) Whether the proposed action is environmentally sound as it relates to the basin from which the water is exported;
4) Whether the proposed action is an appropriate long-term use which will not unduly limit the future growth and development in the basin from which the water is exported; and
5) Any other factor the State Engineer determines relevant.

F) Elko County generally agrees with these provisions regarding inter-basin and intra-basin transfers and hereby adopts them in development of the Elko County Water Resource Management Plan with the following reservations and provisions:

1) State & Private Ownership Monitoring Program
2) Inter-basin & Intra-basin Transfers Monitoring program

II. Elko County Natural Resource Management:

A) Development and implementation of an Elko County Division of Natural Resources including but not limited to the following duties and responsibilities:

1) Track and administrate all Surface and Groundwater water rights, usage, annual duties and withdrawals in Elko County.
    a) Governmental application and usage. (Surface / Groundwater / Other)
        1) Applications made by all governing entities.
            a) Local
            b) County
            c) State
            d) Federal
        2) Usage and annual duties
            a) Current allocation, usage and withdrawal
            b) Future forecasts of usage and withdrawal
            c) Commercial and Industrial uses and annual duties
            d) Residential uses and duties
            e) Municipal uses and duties
            f) Municipal recharges and alternate uses

    b) Private application and usage. (Surface / Groundwater / Other)
        1) Applications made by private parties.
            a) Domestic Well
            b) Quasi-Municipal
            c) Commercial / Industrial
            d) Agricultural
        2) Usage and annual duties
            a) Current allocation, usage and withdrawal
            b) Future forecasts of usage and withdrawal
            c) Agricultural uses and duties

    c) Identify and track all water rights applications, requests for inter-basin or inter-county transfers and other considerations that would have any impacts to the hydrographic basins of Elko County.
        1) Correspond and provide guidance to the Elko County Board of Commissioners and county staff regarding future impacts or potential withdrawals of ground or surface water within Elko County hydrographic areas.

2) Coordinate all planning efforts of all governmental agencies including:

a) Elko County
1) Public Works
2) Planning & Zoning
3) Assessor

b) City of Elko
1) Public Works
2) Planning
3) Engineering

c) City of Carlin
1) Public Works
2) Planning
3) Engineering

d) City of Wells
1) Public Works
2) Planning
3) Engineering

e) City of West Wendover
1) Public Works
2) Planning
3) Engineering

f) Bureau of Land Management

g) United States Forest Service

h) State of Nevada Land Use Planning

i) State of Nevada Division of Water Resources

3) Coordinate and track all Water Right applications made and certificated by and for Elko County.

a) Identify hydrographic areas with available ground or surface water rights.

b) Advise the Elko County Board of Commissioners of potential filings.

c) Coordinate, develop and implement a Public Education Program concerning Elko County filings for the acquisition of water rights.

4) Safe Drinking Water Act Compliance:

a) Track all Quasi-Municipal and Municipal water delivery systems for compliance with the Safe Drinking Water Act.

III. Elko County Land Use Planning:

A) Develop a comprehensive Land Use Master Plan including the following information and considerations:

- 1) Land use development patterns
  - a) Identify existing and potential areas of growth and development
  - b) Identify existing local master plans (public & private)
    - 1) Review and identify master plans that may have conflicting or negative impacts to their respective plan areas concerning water usage, annual duties or projected forecasts.

- 2) Forecasted or designated land uses and population densities
  - a) Commercial / Industrial
  - b) Residential
  - c) Domestic
  - d) Agricultural
  - e) Recreation

- 3) Hydrographic Areas
  - a) Current allocation and annual duties
  - b) Projected annual duties and necessities for development
  - c) Perennial Recharge rates
    - 1) Hydrology studies or assessment
      - a) Recharge rates as per study
      - b) Recharge rates as per Nevada State Engineer

- 4) Flood Plains
  - a) Identification of Flood Plains pursuant to FIRM and FEMA
    - 1) Methods of mitigation
    - 2) Active enforcement of Flood Plain management pursuant to Elko County Code.

- 5) Water Resource Conservation Programs:
  - a) Develop a county conservation education program
  - b) Develop a comprehensive county conservation program
    - 1) Building codes utilizing conservation materials
    - 2) Irrigation and outdoor water conservation program

B) Adopt and implement the 2003 State of Nevada Drought Management Plan within all planning activities including:

- 1) Private Development Master Plan

- 2) Local Area Public Master Plan

- 3) County Land Use Master Plan

- 4) Any method of Subdivision or Re-division of Private Lands

C) Review and amendment of existing Subdivision and Zoning actions within Elko County Code, Title 4 and Title 5.

1) Title 4: all chapters of Land Use Zoning
   a) Create and implement conservation program

2) Title 5: all chapters of Land Subdivision
   a) Create conservation program
   b) Identify potential water use impacts
   c) Identify potential impacts to the hydrographic area
   d) Develop water right allocation and dedication program through the Natural Resources Division.

IV. USGS and Division of Water Resources Hydrographic Analysis:

A) Groundwater and Surface water Hydrographic Analysis Studies of all hydrographic areas of Elko County are to be conducted to provide water recharge rates and perennial yield rates using current technology and science.

B) Partner with the USGS and the State Division of Water Resources to conduct and prepare comprehensive Hydrographic Analysis Studies of upper Humboldt River Basin. **(Appendix "A")**

C) The Elko County Water Resource Management Plan is to include and incorporate findings of all new studies upon completion and approval of the State of Nevada, the Elko County Water Planning Commission and the Elko County Board of Commissioners.

D) Provide presentation and representation of recharge rate and perennial yield rate data to the State of Nevada Engineer and Division of Water Resources.

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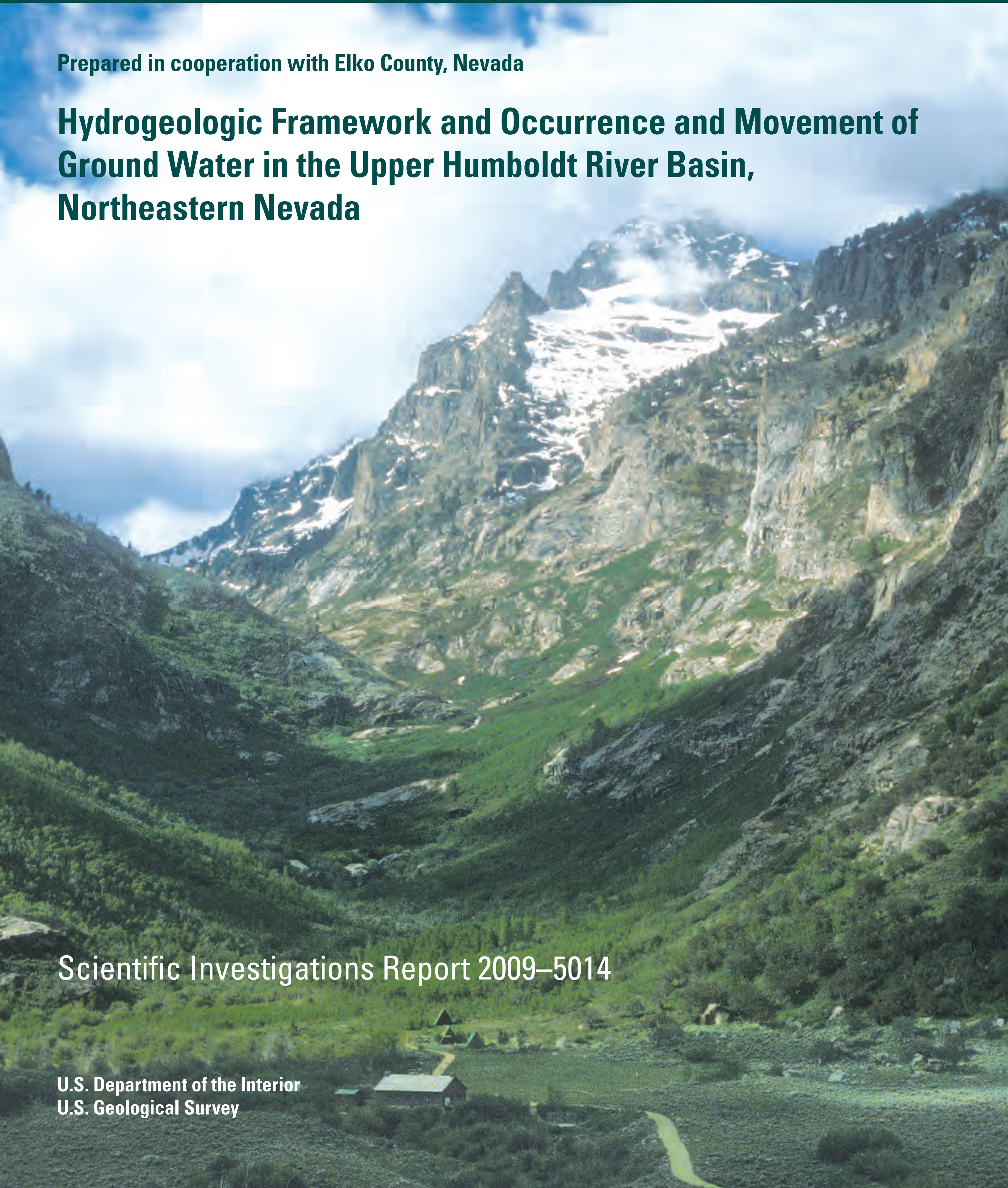
Hydrogeologic Framework and Occurrence and Movement of Ground Water in the Upper Humboldt River Basin, Northeastern Nevada



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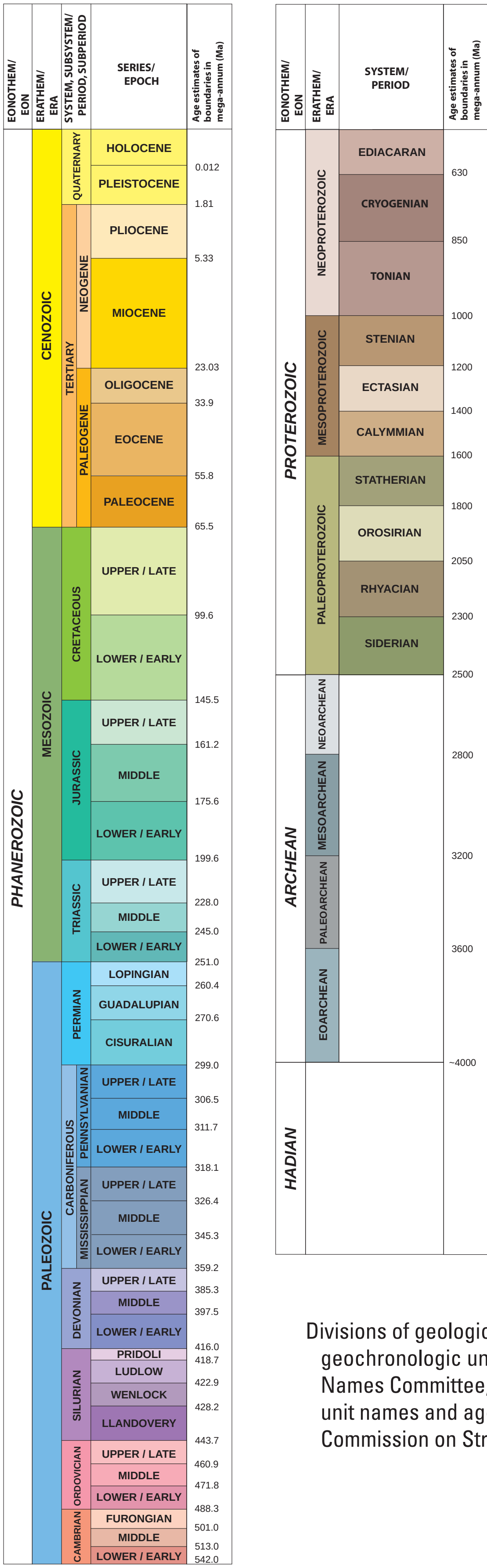

Photograph of Marys River looking south at the East Humboldt Range. (Photograph taken by Russell Plume, U.S. Geological Survey, Carson City, Nevada, April 1994.)

Photograph of late Eocene basin-fill deposits exposed at a gravel pit along State Route 226 about 1.3 miles west of State Route 225 (Mountain City Highway). The sediments exposed here are fairly typical of Tertiary age sediments that underlie basins of the study area (Alan Wallace, U.S. Geological Survey, written and oral commun., 2008). (Photograph taken by Russell Plume, U.S. Geological Survey, Carson City, Nevada, June 2007.)

Divisions of geologic time - major chronostratigraphic and geochronologic units (U.S. Geological Survey Geologic Names Committee, 2007). Reflects accepted and ratified unit names and age estimates from the International Commission on Stratigraphy.

Cover: Photograph of Right Fork Lamoille Canyon looking south. (Photograph taken by Russell Plume, U.S. Geological Survey, Carson City, Nevada, June 1981.)

Hydrogeologic Framework and Occurrence and Movement of Ground Water in the Upper Humboldt River Basin, Northeastern Nevada

By Russell W. Plume

Prepared in cooperation with Elko County, Nevada

Scientific Investigations Report 2009–5014

U.S. Department of the Interior
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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
square foot per day (ft^2/d)	0.09290	square meter per day (m^2/d)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness $[(ft^3/d)/ft^2]ft$. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Hydrogeologic Framework and Occurrence and Movement of Ground Water in the Upper Humboldt River Basin, Northeastern Nevada

By Russell W. Plume

Abstract

The upper Humboldt River basin encompasses 4,364 square miles in northeastern Nevada, and it comprises the headwaters area of the Humboldt River. Nearly all flow of the river originates in this area. The upper Humboldt River basin consists of several structural basins, in places greater than 5,000 feet deep, in which basin-fill deposits of Tertiary and Quaternary age and volcanic rocks of Tertiary age have accumulated. The bedrock of each structural basin and adjacent mountains is composed of carbonate and clastic sedimentary rocks of Paleozoic age and crystalline rocks of Paleozoic, Mesozoic and Cenozoic age. The permeability of bedrock generally is very low except for carbonate rocks, which can be very permeable where circulating ground water has widened fractures through geologic time.

The principal aquifers in the upper Humboldt River basin occur within the water-bearing strata of the extensive older basin-fill deposits and the thinner, younger basin-fill deposits that underlie stream flood plains. Ground water in these aquifers moves from recharge areas along mountain fronts to discharge areas along stream flood plains, the largest of which is the Humboldt River flood plain. The river gains flow from ground-water seepage to its channel from a few miles west of Wells, Nevada, to the west boundary of the study area.

Water levels in the upper Humboldt River basin fluctuate annually in response to the spring snowmelt and to the distribution of streamflow diverted for irrigation of crops and meadows. Water levels also have responded to extended periods (several years) of above or below average precipitation. As a result of infiltration from the South Fork Reservoir during the past 20 years, ground-water levels in basin-fill deposits have risen over an area as much as one mile beyond the reservoir and possibly even farther away in Paleozoic bedrock.

Introduction

Background

The Humboldt River basin is the largest river basin that is entirely within the State of Nevada. Numerous diversions reduce flow in the river, and the diverted surface water is used almost exclusively for irrigation of crops and meadows, especially in the middle and lower reaches. Even though the upper Humboldt River basin encompasses only about 25 percent of the entire river basin (fig. 1), the upper Humboldt River basin is the source of almost all of the total flow of the river.

Elko County officials and citizens are concerned about growing demand for water within the county and increasing external demands that are occurring statewide. Because flow of the Humboldt River and its tributaries is fully appropriated, any additional water needed to support growth in the upper Humboldt River basin presumably would come from ground water. However, ground water and streamflow can be intimately connected in lowland areas where ground-water discharge to the stream channel sustains flow (baseflow) during low runoff periods. Decisions to further develop the ground-water resources of the upper Humboldt River basin will need to consider the potential effects of such development on streamflow. County and State water-resource managers need information that will enable them to make informed decisions regarding future use of the ground-water resources of the upper Humboldt River basin. To address these needs and concerns, the U.S. Geological Survey (USGS), in cooperation with Elko County, evaluated the water resources of the upper Humboldt River basin in northeastern Nevada during Federal fiscal years 2007–08 (fig. 1).

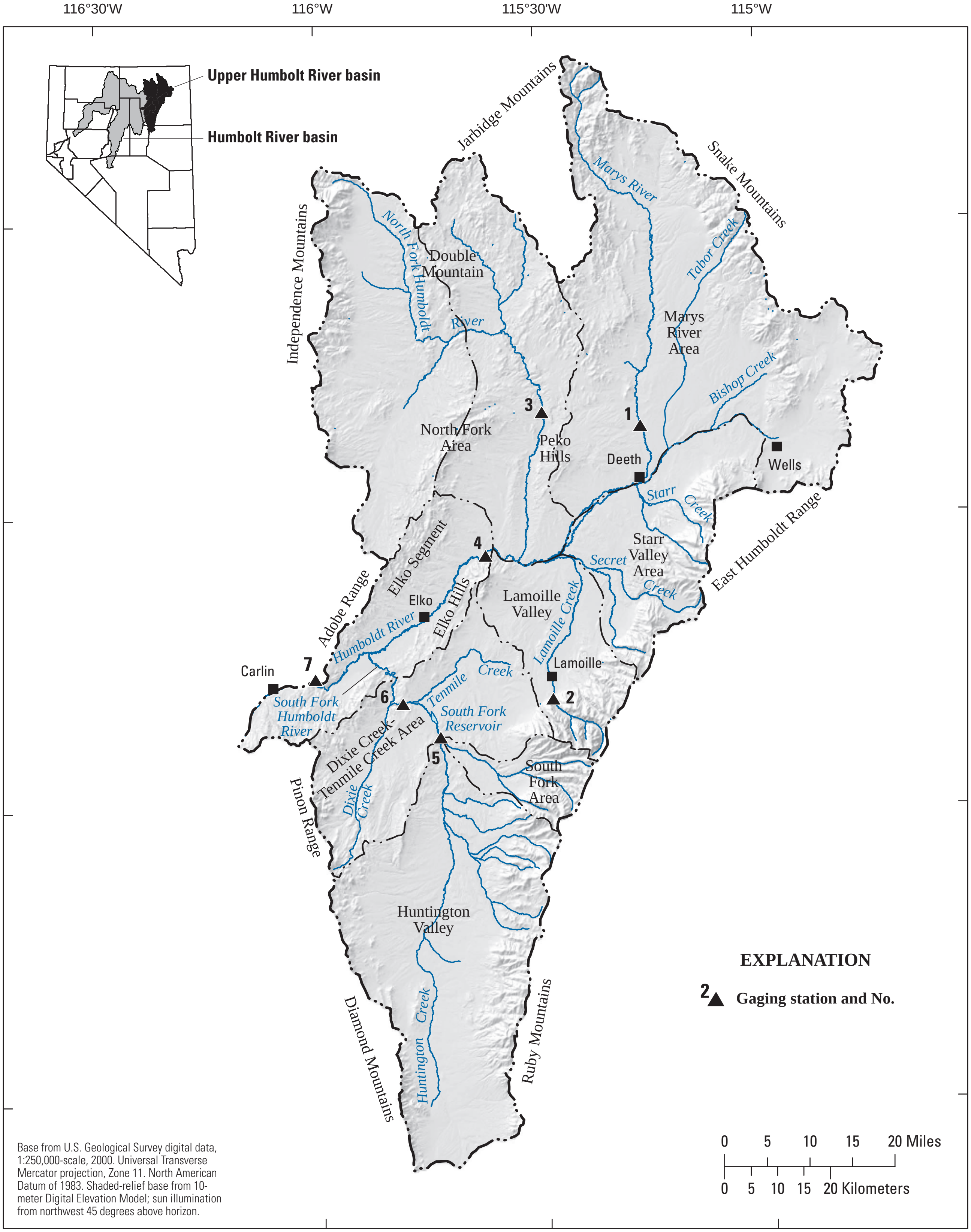

Figure 1. Selected features of the upper Humboldt River basin and location of streamflow-gaging stations, northeastern Nevada.

Purpose and Scope

This report presents the Upper Humboldt River basin phase one results. The objective of this report is to provide hydrologic information that improves the understanding of the water resources of the upper Humboldt River basin; specifically the delineation of the hydrogeologic framework and descriptions of the occurrence and movement of ground water in and between the eight hydrographic areas that make up the basin. The hydrogeologic framework of the study area comprises the extent, both areally and at depth, of rocks and deposits that store and transmit ground water (aquifers) and rocks and deposits that impede the movement of ground water (confining or semiconfining units). Delineation of the hydrogeologic framework of the upper Humboldt River basin is based on geologic and hydrogeologic studies completed during the past 60–70 years. The discussion of the occurrence and movement of ground water is based on water levels that were measured during the spring and summer of 2007 in about 160 wells.

Description of Study Area

The upper Humboldt River basin covers an area of 4,364 mi^2 in northeastern Nevada, and consists of eight hydrographic areas—Marys River Area, Starr Valley Area, North Fork Area, Lamoille Valley, South Fork Area, Huntington Valley, Dixie Creek–Tenmile Creek Area, and Elko Segment (fig. 1, table 1). These eight areas encompass the headwaters of the Humboldt River, which is the source of nearly all of the total flow of the river in years of average flow. From west to east, gaged tributaries of the upper Humboldt River are South Fork Humboldt River, North Fork Humboldt River, Lamoille Creek, and Marys River. Other tributaries include Secret, Starr, Tabor, and Bishop Creeks. Altitudes of land surface in the study area range from 4,900 to 5,900 ft along the flood plain of the Humboldt River to greater than 11,000 ft in the highest parts of the Ruby Mountains. Each of the hydrographic areas is described briefly below.

The Marys River Area covers 1,073 mi^2 and is drained by Marys River and its tributaries on the north and west and by Bishop and Tabor Creeks on the east (fig. 1). The area is bounded by the Snake Mountains to the east, the Jarbidge Mountains to the north, the Peko Hills to the west, and by the Humboldt River to the south.

The Starr Valley Area covers 332 mi^2 and is drained by Starr and Secret Creeks (fig. 1). The area consists of a northwest sloping pediment bounded by the East Humboldt Range to the east and the Humboldt River to the northwest.

The North Fork Area covers 1,110 mi^2 and consists of an upper and lower basin, both of which are drained by the North Fork Humboldt River and its numerous tributaries (fig. 1).

Table 1. Hydrographic areas of the upper Humboldt River basin, northeastern Nevada.

[See fig. 1 for locations of hydrographic areas. **Hydrographic area:** Formal hydrographic areas in Nevada were delineated systematically by the U.S. Geological Survey and Nevada Division of Water Resources in the late 1960s (Cardinalli and others, 1968; Rush, 1968). These areas have been the basic units for assembling hydrologic data and for regulating water use in the State since 1968. The official hydrographic area names, numbers, and geographic boundaries continue to be used in U.S. Geological Survey scientific reports and Nevada Division of Water Resources administrative activities. **Area (square miles):** From Rush (1968)]

Hydrographic area			
Name	Number	Area (square miles)	Area (acres)
Marys River Area	42	1,073	686,720
Starr Valley Area	43	332	212,480
North Fork Area	44	1,110	710,400
Lamoille Valley	45	257	164,480
South Fork Area	46	99	63,360
Huntington Valley	47	787	503,680
Dixie Creek–Tenmile Creek Area	48	392	250,880
Elko Segment	49	314	200,960
Totals (rounded)		4,364	2,793,000

The upper basin is bounded by the Independence Mountains to the west, the south end of the Jarbidge Mountains to the northeast, and the north end of the Adobe Range to the southeast. The lower basin is bounded by the Adobe Range and Peko Hills to the west and east, respectively, the south end of the Jarbidge Mountains to the north, and the Humboldt River to the south.

Lamoille Valley covers an area of 257 mi^2 and is drained by Lamoille Creek and its tributaries (fig. 1). The area consists of Lamoille Canyon in the Ruby Mountains and a northwest sloping pediment bounded to the southeast by the mountains, to the northwest by the Humboldt River, and by low topographic divides between the Starr Valley Area to the east and the Dixie Creek–Tenmile Creek Area to the west.

The South Fork Area covers 99 mi^2 and is drained by the South Fork Humboldt River and its numerous tributaries (fig. 1). The area is bounded by topographic divides between the Dixie Creek–Tenmile Creek Area to the north and Huntington Valley to the south. The two divides converge to the northwest and join at the confluence of the South Fork Humboldt River and Huntington Creek. The Ruby Mountains form the high altitude uplands of the area.

Huntington Valley covers 787 mi^2 and is drained by Huntington Creek and by several tributaries that originate in the northeast part of the area. The area is bounded by the Ruby Mountains to the east, by the Diamond Mountains and Pinon Range to the west, by low topographic divides to the south and north.

The Dixie Creek–Tenmile Creek Area covers 392 mi^2 and is drained by the South Fork Humboldt River and its two main tributaries in the area—Dixie and Tenmile Creeks (fig. 1). Since December 1987, flow has been regulated by the South Fork Reservoir, which has a maximum altitude of 5,231.4 ft. The Dixie Creek–Tenmile Creek Area is bounded by the South Fork Area and Huntington Valley to the south, Lamoille Valley to the east, the Pinon Range to the west, and by a group of unnamed hills to the north that extend from the Elko Hills to the north end of the Pinon Range.

The Elko Segment covers 314 mi^2 and consists of the Humboldt River flood plain and adjacent uplands (fig. 1). The area is bounded by the Adobe Range to the north and the Elko Hills and north end of the Pinon Range to the south.

Streamflow is an important component of the water resources of the upper Humboldt River basin. Although a detailed discussion of the streamflow characteristics of the study area is beyond the scope of this report, a short summary, with examples, will help to emphasize the importance of streamflow and its interactions with ground water. See Eakin and Lamke (1966) and Prudic and others (2006) for more details on streamflow characteristics of the Humboldt River.

The streamflow characteristics of the upper Humboldt River and its tributaries are summarized by the flow-duration curves in figure 2, which show the frequency, as percent of time, that a given stream discharge per square mile of drainage area was equaled or exceeded during the period of record for water years 1992–2007. The term "water year" means a 12-month period beginning on October 1 and ending the following September 30. The curves in figure 2 represent streamflow conditions of the Humboldt River at the Elko and Carlin gaging stations and at Marys River, Lamoille Creek, and South Fork Humboldt River above Tenmile Creek (see fig. 1 and table 2 for station locations and descriptions). All curves tend to flatten at their upper ends, indicating that high flows are dominated by snowmelt runoff (Searcy, 1959, p. 22).

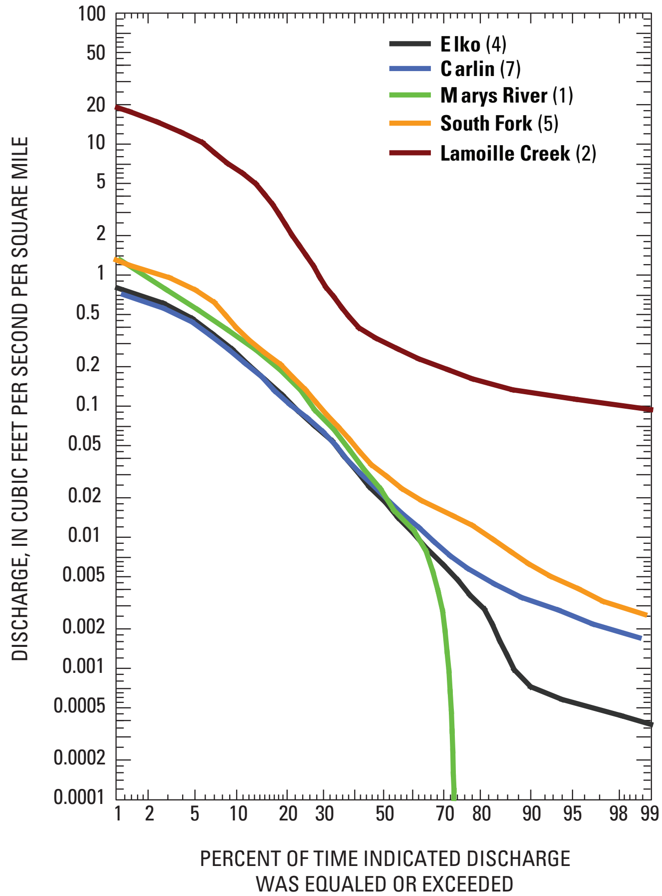

Figure 2. Flow-duration curves for water years 1992–2007 at the Humboldt River near Elko and Carlin, Marys River below Twin Buttes, Lamoille Creek near Lamoille, and South Fork Humboldt River above Tenmile Creek gaging stations, northeastern Nevada. Numbers in parentheses refer to streamflow-gaging stations in figure 1 and table 2.

Table 2. Streamflow-gaging stations in the upper Humboldt River basin, northeastern Nevada.

[Streamflow-gaging station numbers are shown in figure 1. USGS site identification No.: This unique number can be used to access streamflow data for a streamflow-gaging station at http://waterdata.usgs.gov/nv/nwis/current/?type=flow]

Streamflow-gaging station and No.	USGS site identification No.	Name
1	10315600	Marys River below Twin Buttes near Deeth
2	10316500	Lamoille Creek near Lamoille
3	10317500	North Fork Humboldt River at Devils Gate near Halleck
4	10318500	Humboldt River near Elko
5	10319900	South Fork Humboldt River above Tenmile Creek near Elko
6	10320000	South Fork Humboldt River above Dixie Creek near Elko
7	10321000	Humboldt River near Carlin

At their lower ends, the curves for the Elko, Carlin, Lamoille Creek, and South Fork stations also flatten, which indicates that late summer and autumn baseflow of each stream is sustained by ground-water discharge to the stream channel (Searcy, 1959, p. 22). In contrast, the curve for the Marys River station steepens at its lower end indicating the stream at this site has no baseflow and goes dry every summer and autumn.

The curves also indicate that the runoff yield (discharge per square mile of drainage area) of Lamoille Creek is much greater than that of the other four stations. The reason for this is that the entire watershed above the Lamoille Creek station is at high altitude and is underlain by low permeability crystalline rocks. In contrast, the watersheds above the other four stations include large areas of low altitude and they are underlain by rocks of varying permeability.

Curves for the Elko and Carlin stations indicate similar flow characteristics at high to medium flows. At low flows, however, the curves diverge and flow at Carlin is an order of magnitude greater. Two reasons for this are that: (1) regulated flow of the South Fork Humboldt River provides a perennial source of discharge to the mainstem of the river between Elko and Carlin, and (2) flow in the Humboldt River increases downstream of the Elko gaging station due to ground-water discharge.

On October 19, 1992, after several years of below average precipitation, USGS measured the flow of the Humboldt River and its main tributaries and diversions at 35 sites from the Elko to Imlay gaging stations (Emett and others, 1994, p. 475). Three sites were measured that day in the vicinity of Elko—Humboldt River near Elko, Humboldt River near Carlin (sites 4 and 7, fig. 1) and South Fork Humboldt River near Elko at its confluence with the mainstem Humboldt River. The timing of these measurements was such that daily minimum temperatures had been low enough to have minimized the effects of evapotranspiration, but not low enough to cause formation of ice and consequent reduction of streamflow. The three measurements together (Carlin station minus Elko station minus South Fork Station) indicate that the Elko to Carlin reach of the Humboldt River was gaining about 9.1 ft^3/s or about 6,600 acre-ft/yr, as ground-water discharge to the river channel. This might be a minimum value of ground-water discharge to the river channel because several years of drought preceded the time of the measurements.

Geologic Setting

The upper Humboldt River basin consists of several deep structural basins in which basin-fill deposits of Tertiary and Quaternary[1] age and volcanic rocks of Tertiary age have accumulated. The bedrock of each basin and adjacent mountains are composed of carbonate and clastic sedimentary rocks of Paleozoic age, and crystalline rocks of Cambrian, Jurassic, and Tertiary age. Numerous geologic studies have been conducted in the area since about the 1930s in efforts to identify and characterize the different rocks and deposits that underlie the study area and to map their distribution.

[1] This term, and others such as Tertiary or Paleozoic, denotes ranges of geologic age. The geologic time scale on the inside front cover of this report gives ages in millions of years for these terms.

Hydrogeologic Units

The numerous rock units and sedimentary deposits identified in previous studies were grouped into hydrogeologic units by Maurer and others (2004). These hydrogeologic units were regrouped into six hydrogeologic units in this report (pl. 1, table 3**)**. The units, in order of decreasing age, are: (1) carbonate rocks and interbedded clastic sedimentary rocks of Cambrian to Permian age; (2) clastic sedimentary rocks of Ordovician to Devonian age; (3) crystalline rocks consisting of granitic intrusive and metamorphic rocks of Cambrian, Jurassic, and Tertiary age; (4) volcanic rocks of Tertiary age; (5) older basin-fill deposits of Tertiary age that comprise most of the alluvial fill in each basin; and (6) younger basin-fill deposits of Quaternary age that consist mostly of deposits along stream flood plains. Basin-fill deposits and carbonate rocks can have high permeability and transmit ground water, whereas, the other rocks generally have low permeability and impede the flow of ground water (Maurer and others, 2004). The lithology and water-bearing characteristics of each unit are discussed below and summarized in table 3.

Carbonate and Clastic Sedimentary Rocks

Carbonate and clastic sedimentary rocks consist of: (1) carbonate rocks (limestones and dolomites) with interbedded shales and sandstones of Cambrian through Devonian age, (2) mostly shales and sandstones of Mississippian and Pennsylvanian age, and (3) interbedded carbonate rocks, sandstones, and shales of Pennsylvanian and Permian age (pl. 1, table 3). The thickness of this sequence of rocks is at least 20,000 ft in the southern Ruby Mountains, 10,000 ft in the Pinon Range and Snake Mountains, and 4,000 ft in the Independence Mountains (Coats, 1987, p. 13–47). Parts of the unit that consist of carbonate rocks of Cambrian to Devonian age are exposed extensively in the southern Ruby Mountains, southern Pinon Range, and to a limited extent in western parts of the Snake Mountains and northeastern parts of the Independence Mountains (Coats, 1987, pl. 1). Clastic sedimentary rocks, such as sandstone and shale of the Diamond Peak Formation and Chainman Shale, are exposed extensively in the Pinon Range, Adobe Range, and Peko Hills where they overlie the older carbonate rocks (Coats, 1987, pl. 1).

Table 3. Lithology, thickness, extent, and water-bearing characteristics of hydrogeologic units in the upper Humboldt River basin, northeastern Nevada.

[**Abbreviations**: ft, foot; Fm, formation]

Hydrogeologic unit	Geologic age	Rock or stratigraphic unit	Lithology	Thickness and extent	Water-bearing characteristics
Younger basin-fill deposits	Quaternary	Alluvium and glacial moraines	Sorted and interbedded clay, sand, and gravel along stream flood plains. Poorly sorted to unsorted clay, silt, sand, gravel, and boulders of alluvial fans and moraines.	Deposits of flood plains probably do not exceed a few tens of feet in thickness. Moraines and deposits of alluvial fans probably range from hundreds to more than 1,000 ft thick.	Together with older basin-fill deposits, comprise shallow water-table aquifers and deeper confined aquifers. Permeability highly variable depending on lithology.
Older basin-fill deposits	Quaternary and Tertiary	Older alluvium of stream terraces (Coats, 1987, p. 70), sedimentary deposits of the Miocene and Pliocene Elko Basin (Wallace and others, 2008, p. 59–62), and limestone, conglomerate, sandstone, shale, and tuff of Oligocene to Paleocene age (Coats, 1987, p. 51–62).	Poorly consolidated deposits of fluvial and lacustrine origin. Includes deposits of alluvial fans, stream flood plains, and shallow lakes. Deposits commonly are tuffaceous and are extensively interbedded with volcanic rocks.	Total thickness including interbedded volcanic rocks ranges from less than 500 ft mostly along basin margins to more than 5,000 ft in a deep and narrow structural basin that extends from southern Huntington Valley to northern Marys River Area (fig. 3).	Together with younger basin-fill deposits, comprise shallow water-table aquifers and deeper confined aquifers. Permeability highly variable depending on lithology.
Volcanic rocks	Tertiary	Volcanic rocks	Ash-flow and air-fall tuffs, lava flows, and domes. Compositions include basalt, andesite, dacite, latite, and rhyolite (Coats, 1987, pl. 1 and p. 51–67).	Extensively interbedded with older basin-fill deposits. See above for composite thickness.	Mostly impede ground-water flow because tuffs weather to clay and because of interbedded fine-grained lake deposits. Presence of perennial streams in watersheds underlain by these rocks also indicates low permeability.
Crystalline rocks	Cambrian and Jurassic	Metamorphic rocks	Metamorphic rocks include marble, schist, and gneiss. They are metamorphosed carbonate and clastic sedimentary rocks of Paleozoic age in the central and northern Ruby Mountains and Elko Hills.	Thickness of metamorphic rocks probably similar to nearby unmetamorphosed carbonate and clastic sedimentary rocks of Paleozoic age. Granitic rocks extend to great depths and can be much more extensive than indicated by outcrop area.	Impedes the movement of ground water.
	Tertiary and Jurassic	Granitic intrusive rocks	Granite and granodiorite in the central Ruby Mountains and alaskite in the southern Independence Mountains.		
Clastic sedimentary rocks	Devonian to Ordovician	Woodruff Fm Valmy Fm Vinini Fm	Shale, siltstone, sandstone, quartzite, chert, and marine volcanic rocks. Structurally overlie along the Roberts Mountains thrust various units of carbonate rocks.	Thickness about 2,000 ft in the Snake Mountains, 9,000 ft in northern Independence Mountains, 4,700 ft in the Pinyon Range, and 4,000–10,000 ft in the Ruby Mountains (Coats, 1987, p. 10–13 and 29–34).	Generally impedes movement of ground water. Presence of perennial streams in watersheds underlain by these rocks also indicates low permeability.

Table 3. Lithology, thickness, extent, and water-bearing characteristics of hydrogeologic units in the upper Humboldt River basin, northeastern Nevada.—Continued

[**Abbreviations**: ft, foot; Fm, formation]

Hydrogeologic unit	Geologic age	Rock or stratigraphic unit	Lithology	Thickness and extent	Water-bearing characteristics
Carbonate and clastic sedimentary rocks	Permian, Pennsylvanian and Mississippian	Edna Mountain Fm Schoonover Fm Diamond Peak Fm Chainman Shale Webb Fm	Shale, sandstone, sandy limestone, conglomerate, and chert. Depositionally overlie various units of carbonate rocks	Thickness at least 20,000 ft in the Ruby Mountains, 10,000 ft in the Pinyon Range and Snake Mountains, and about 4,000 ft in the Independence Mountains. An oil well penetrated 4,500 ft of carbonate rocks from the Devils Gate Limestone to the Hanson Creek Formation at the north end of the Pinon Range (Coats, 1987, p. 13–47).	Comprise carbonate-rock aquifers generally beneath basin-fill aquifers. High permeability due to solution widening of fracture zones. Absence of perennial streams in watersheds even partly underlain by these rocks indicates high permeability.
	Permian to Cambrian	Phosphoria Fm Strathearn Fm Moleen Fm Tomera Fm Ely Limestone Joana Limestone Pilot Shale Devils Gate Limestone Nevada Formation Lone Mountain Dolomite Roberts Mountains Fm Hanson Creek Fm Eureka Quartzite Pogonip Group Windfall Fm Dunderberg Shale Hamburg Dolomite Secret Canyon Shale Geddes Limestone Eldorado Dolomite Pioche Shale Prospect Mountain Quartzite	Intervals of limestone and dolomite interrupted by thinner intervals of shale, quartzite, and conglomerate. All units rarely present in a single mountain range. Underlie entire study area, but are concealed over large parts of mountain ranges by various units of clastic sedimentary rocks.		

The permeability of the combined unit of carbonate and clastic sedimentary rocks undoubtedly varies over a wide range because of the differing lithologies present. The permeability of clastic parts of the unit probably is relatively low. In contrast, carbonate rocks can be very permeable where circulating ground water has widened fractures through geologic time. Hydraulic conductivity ranges from 0.0005 to 900 ft/d based on estimates from 23 carbonate rock aquifer tests conducted throughout the Great Basin (Plume, 1996, p. 13). Additionally, the hydraulic conductivity of the carbonate rocks ranged from 0.1 to greater than 150 ft/d at two large gold mines (west of the study area) in the vicinity of Carlin (Maurer and others, 1996, p. 9–11). Lowest values reflect hydraulic properties of dense, unfractured rock and highest values reflect hydraulic properties of fracture zones that have been widened by dissolution. This range of values illustrates the importance of faulting and fracturing in the development of secondary porosity and permeability in carbonate rocks. A qualitative indication of the high permeability of carbonate rocks in the study area is the absence of perennial streams in watersheds of the southern Ruby Mountains (fig. 1), which are underlain almost entirely by carbonate rocks (pl. 1; Coats, 1987, pl. 1). In other parts of the study area, perennial mountain streams are common.

Clastic Sedimentary Rocks

Shale, siliceous shale, chert, quartzite, siltstone, and minor amounts of limestone and andesitic volcanic rocks of Ordovician through Devonian age were deposited in a deep-water marine environment adjacent to the continental shelf of Western North America, offshore from where carbonate rocks were being synchronously deposited. During Late Devonian to Early Mississippian time, the clastic sedimentary rocks were thrust eastward as much as 90 mi over the carbonate rocks along a low-angle fault named the Roberts Mountains thrust (Stewart, 1980, p. 36). This tectonic event is known as the Antler orogeny (Stewart, 1980, p. 36). Along the Roberts Mountains thrust in the study area, these clastic sedimentary rocks overlie carbonate and clastic rocks of equivalent age (Coats, 1987, p. 80–81). This hydrogeologic unit is exposed extensively in the Snake and Independence Mountains and to a lesser extent in the Adobe and Pinon Ranges and Diamond and Ruby Mountains (pl. 1).

The permeability of clastic sedimentary rocks of Ordovician to Devonian age varies widely depending on the degree to which the unit has been affected by faulting. At two large gold mines in the area of Carlin just west of the study area, the hydraulic conductivity of this unit was found to range from 0.001 to 0.5 ft/d in unfractured rock to as much as 100 ft/d along faults (Maurer and others, 1996, p. 9–11).

Crystalline Rocks

Two types of crystalline rocks are found in the study area—metamorphic rocks and granitic rocks (pl. 1). Metamorphic rocks occur in the central and northern Ruby Mountains and East Humboldt Range. They formed as a result of the metamorphism (re-crystallization due to heat and pressure) of carbonate and clastic sedimentary rocks of Cambrian to Devonian age during part of the Paleozoic and again in the Mesozoic (Coats, 1987, p. 77–79). Textures and compositions include metaquartzite, calcite marble, gneiss, and schist. The thickness of metamorphic rocks may be as much as 20,000 ft, which is similar to that of unmetamorphosed carbonate rocks in southern parts of the Ruby Mountains.

Granitic rocks occur in the central Ruby Mountains, Elko Hills, southern Independence Mountains, and Pinon Range (pl. 1). Compositions include granite of Jurassic age and granodiorite of Tertiary age in the Ruby Mountains and alaskite of Tertiary age in the southern Independence Mountains and Pinon Range (Coats, 1987, pl. 1, p. 73–77). These rocks extend to great depth, and their distribution at depth can be much greater than that indicated by outcrop area.

The low permeability of crystalline rocks can be inferred from the presence of numerous perennial streams in the central and northern Ruby Mountains and East Humboldt Range. Every watershed in these parts of the mountain ranges has a stream that is perennial at least to the mountain front.

Volcanic Rocks and Sedimentary Basin-Fill Deposits

A thick sequence of alternating sedimentary deposits and volcanic rocks accumulated in structural basins of the study area from Eocene time to Holocene time (Coats, 1987, p. 50–71). The sequence consists of three hydrogeologic units listed in table 3 and shown on plate 1—volcanic rocks, older basin-fill deposits, and younger basin-fill deposits. Herein, the three units are discussed together because they are complexly interbedded. The composite thickness[2] of the three units ranges from 1,000 ft to more than 5,000 ft in a deep narrow structural basin that extends from southern Huntington Valley to the southern Marys River Area paralleling the Ruby Mountains and East Humboldt Range (fig. 3). Thicknesses also range from 1,000 ft to more than 5,000 ft in northern parts of the Marys River and North Fork Areas and in part of the Elko Segment. Sixteen oil exploration wells drilled since 1951 penetrated differing thicknesses of basin-fill deposits and volcanic rocks overlying older bedrock (fig. 3; table 4) as follows:

- 6,475 and 3,310 ft at wells 1 and 6 in the Marys River Area;
- 4,230 and 410 ft at wells 2 and 5 in the North Fork Area;
- 3,150 and 3,070 ft at wells 9 and 11 in Lamoille Valley;
- 1,900 and 5,490 ft at wells 8 and 10 in the Elko Segment; and
- 9,538, 8,170, and 3,700 ft at wells 14, 15, and 16 in Huntington Valley.

Well 13 in Huntington Valley penetrated 11,926 ft of basin-fill deposits and never encountered pre-Tertiary bedrock. Logs for several of the wells also illustrate the complex interbedding of older and younger basin-fill deposits with volcanic rocks. Well 2 penetrated 1,690 ft of older basin fill, 1,110 ft of volcanic rocks, and another 1,430 ft of older basin fill. Well 10 penetrated 3,420 ft of older basin fill, 900 ft of volcanic rocks, and another 1,170 ft of older basin fill. Well 11 penetrated 909 ft of younger basin fill, 243 ft of older basin fill, 1,243 ft of volcanic rocks, and another 684 ft of older basin fill.

The oldest basin-fill deposits and volcanic rocks in the study area, consisting of basal conglomerate overlain by a sequence of welded tuffs, deposits of the Elko Formation (claystone, siltstone, shale, limestone, and tuff), and rhyolitic lava flows and domes, are of Eocene and earliest Oligicene age and are almost entirely north of the Humboldt River (Coats, 1987, p. 51–58). All of the basin-fill deposits are tuffaceous to differing extents. The total thickness exceeds 3,000 ft; however, these rocks and deposits apparently do not constitute a continuous blanket over northern parts of the study area. According to Henry (2008), these deposits accumulated in and along at least three deep and wide eastward draining valleys during Eocene time. The valleys were separated by uplands from which any air-fall tuffs were eroded and re-deposited in the valleys.

From late Eocene to middle Miocene, the upper Humboldt River basin probably was an area undergoing erosion since deposits and volcanic rocks of this age span are absent. About 15–14 Ma (millions of years before present), during the middle Miocene, the Elko basin began to form as low-angle and high-angle faulting began along the west sides of the Ruby Mountains, East Humboldt Range, and Snake Mountains (Wallace and others, 2008, p. 58–61).

[2] Combined basin fill and volcanic rock thicknesses discussed above and shown in figure 3 are from a depth to pre-Tertiary basement grid developed for northern Nevada. The depths shown should be considered estimates that do not always agree with depths recorded for oil wells in table 4. (D.A. Ponce, U.S. Geological Survey, written and oral commun., 2007). The process of developing the grid and its uncertainties are described by Ponce (2004, p. 71–74 and figs. 6–3 and 6–9).

Table 4. Hydrogeologic units penetrated by oil exploration wells in the upper Humboldt River basin, northeastern Nevada.

[See pl. 1 and fig. 3 for well locations. Data obtained in 2007 from Nevada Bureau of Mines and Geology at http://www.nbmg.unr.edu/lists/oil/oil.htm. American Petroleum Institute (**API**) No.**:** Oil exploration wells are identified by their API number, which consists of three groups of digits separated by dashes. The API number for the first well in this table is 27-007-05010. The first two digits denote state (Nevada is 27). The second three digits denote county (Elko County is 007). The last five digits are assigned sequentially to wells as they are permitted and drilled]

Well No.	Nevada permit No.	API No.	Altitude of land surface (feet)	Total depth (feet)	Depth of unit top (feet)	Hydrogeologic units penetrated	Thickness (feet)
1	16	27-007-05010	5,973	6,612	0	Basin-fill deposits	1,600
					1,600	Volcanic rocks	4,875
					6,475	Carbonate rocks	
2	178	27-007-05208	6,050	7,106	0	Older basin-fill deposits	1,690
					1,690	Volcanic rocks	1,110
					2,800	Older basin-fill deposits	1,430
					4,230	Paleozoic rocks	
3	552	27-007-05245	6,619	8,843	0	Mississippian clastic rocks	3,600
					3,600	Devonian carbonate rocks	
4	404	27-007-05233	6,076	10,000	0	Volcanic rocks	1,850
					1,850	Older basin-fill deposits	200
					2,050	Vinini Formation	4,400
					6,450	Chainman Shale	
5	377	27-007-05232	6,034	12,573	0	Younger basin-fill deposits	84
					84	Volcanic rocks	88
					172	Older basin-fill deposits	238
					410	Mississippian clastic rocks	5,538
					5,948	Carbonate rocks	
6	12	27-007-05006	5,505	5,465	0	Younger basin-fill deposits	370
					370	Older basin-fill deposits	2,940
					3,310	Mississippian clastic rocks	
7	729	27-007-05253	6,174	10,415	0	Volcanic rocks	1,230
					1,230	Mississippian clastic rocks	7,579
					8,809	Carbonate rocks	
8	428	27-007-05234	5,910	8,865	0	Younger basin-fill deposits	115
					115	Volcanic rocks	845
					960	Older basin-fill deposits	940
					1,900	Mississippian clastic rocks	4,040
					5,940	Carbonate rocks	
9	0	27-007-05004	5,250	4,125	0	Older basin-fill deposits	3,150
					3,150	Carbonate rocks	500
					3,650	Mississippian clastic rocks	
10	182	27-007-05209	5,182	5,670	0	Older basin-fill deposits	3,420
					3,420	Volcanic rocks	900
					4,320	Older basin-fill deposits	1,170
					5,490	Paleozoic rocks	
11	24	27-007-05003	5,308	7,349	0	Younger basin-fill deposits	909
					909	Older basin-fill deposits	243
					1,152	Volcanic rocks	1,234
					2,386	Older basin-fill deposits	684
					3,070	Paleozoic rocks	

Table 4. Hydrogeologic units penetrated by oil exploration wells in the upper Humboldt River basin, Nevada.—Continued

[See pl. 1 and fig. 3 for well locations. Data obtained in 2007 from Nevada Bureau of Mines and Geology at http://www.nbmg.unr.edu/lists/oil/oil.htm. American Petroleum Institute (**API**) No.**:** Oil exploration wells are identified by their API number, which consists of three groups of digits separated by dashes. The API number for the first well in this table is 27-007-05010. The first two digits denote state (Nevada is 27). The second three digits denote county (Elko County is 007). The last five digits are assigned sequentially to wells as they are permitted and drilled]

Well No.	Nevada permit No.	API No.	Altitude of land surface (feet)	Total depth (feet)	Depth of unit top (feet)	Hydrogeologic units penetrated	Thickness (feet)
12	590	27-007-05248	6,376	9,050	0	Mississippian clastic rocks	4,498
					4,498	Carbonate rocks	
13	246	27-007-05214	5,443	11,926	0	Older basin-fill deposits	11,926
14	263	27-007-05217	5,557	10,950	0	Younger basin-fill deposits	2,102
					2,102	Older basin-fill deposits	7,436
					9,538	Paleozoic rocks	
15	297	27-007-05223	5,535	10,320	0	Younger basin-fill deposits	3,400
					3,400	Older basin-fill deposits	4,770
					8,170	Paleozoic rocks	
16	716	27-007-05252	5,955	4,157	0	Younger basin-fill deposits	1,710
					1,710	Older basin-fill deposits	1,990
					3,700	Carbonate rocks	

The Elko basin was large, extending from southern Huntington Valley to northern Marys River and from the structurally active Ruby Mountains–East Humboldt Range–Snake Mountains on the east to the structurally inactive Adobe and Pinon Ranges on the west (Wallace and others, 2008, p. 58). Materials eroded from these mountain ranges spread across the basin accumulating as fine-grained lake deposits in lowlands and as alluvial fan and stream flood-plain deposits toward basin margins. This pattern of deposition continued into late Miocene (10–9 Ma) when the Elko basin began to drain externally resulting in non-deposition of sediments and erosion of existing ones (Wallace and others, 2008, p. 63). Non-deposition, erosion, and transport of sediments out of the basin continued through late Miocene and most of the Pliocene except for a brief period in middle Pliocene when ash-rich sediments similar to those of middle Miocene age accumulated (Wallace and others, 2008, p. 61).

Younger basin-fill deposits in the upper Humboldt River basin consist mostly of unconsolidated sand and gravel along active stream channels (pl. 1; Coats, 1987, p. 70–71). The deposits also form a thin cover overlying pediments of older basin-fill deposits in the northern Marys River and North Fork Areas (pl. 1 and A.R. Wallace, U.S. Geological Survey, oral and written commun., 2008). The younger basin-fill deposits in Huntington Valley, especially those on the east side, also could be a thin veneer of glacial outwash of Pleistocene age from the Ruby Mountains overlying older basin fill of middle Miocene age (A.R. Wallace, U.S. Geological Survey, oral commun., 2008). In Huntington Valley, thicknesses of younger basin-fill deposits penetrated by oil exploration wells range from 1,710 to 3,400 ft (wells 14, 15, and 16; table 4). However, distinguishing younger basin fill from older at such depths is problematic and could be open to different interpretations.

The hydraulic properties of basin-fill deposits and volcanic rocks have not been evaluated in the upper Humboldt River basin. Farther west, however, the hydraulic properties of basin-fill deposits have been evaluated at large gold mines along the Carlin Trend. The basin-fill deposits in this area are of Miocene age and accumulated under conditions similar to those of the middle Miocene Elko basin (Wallace and others, 2008, p. 52–58). Near Carlin at the Gold Quarry mine, the transmissivity of older basin-fill deposits ranges from 780 to 3,600 ft^2/d and hydraulic conductivity ranges from 2 to 7 ft/d (Plume, 1995, p. 17). Using well drillers' logs to determine the ratio of coarse- to fine-grained sediments in the upper 100 ft of flood-plain deposits along the Humboldt River (about 60 mi west of the study area), Bredehoeft and Farvolden (1963, p. 201) estimated the sand-shale ratio to vary from 20 to 70 percent. The hydraulic conductivity determined from specific capacity of selected wells varied from 25 to 40 ft/d (Bredehoeft and Farvolden, 1963, p. 201). These ratios and values of hydraulic conductivity also may apply to the upper Humboldt River basin, and a similar analysis of well logs would be very useful for making estimates of basin-fill aquifer properties in the study area.

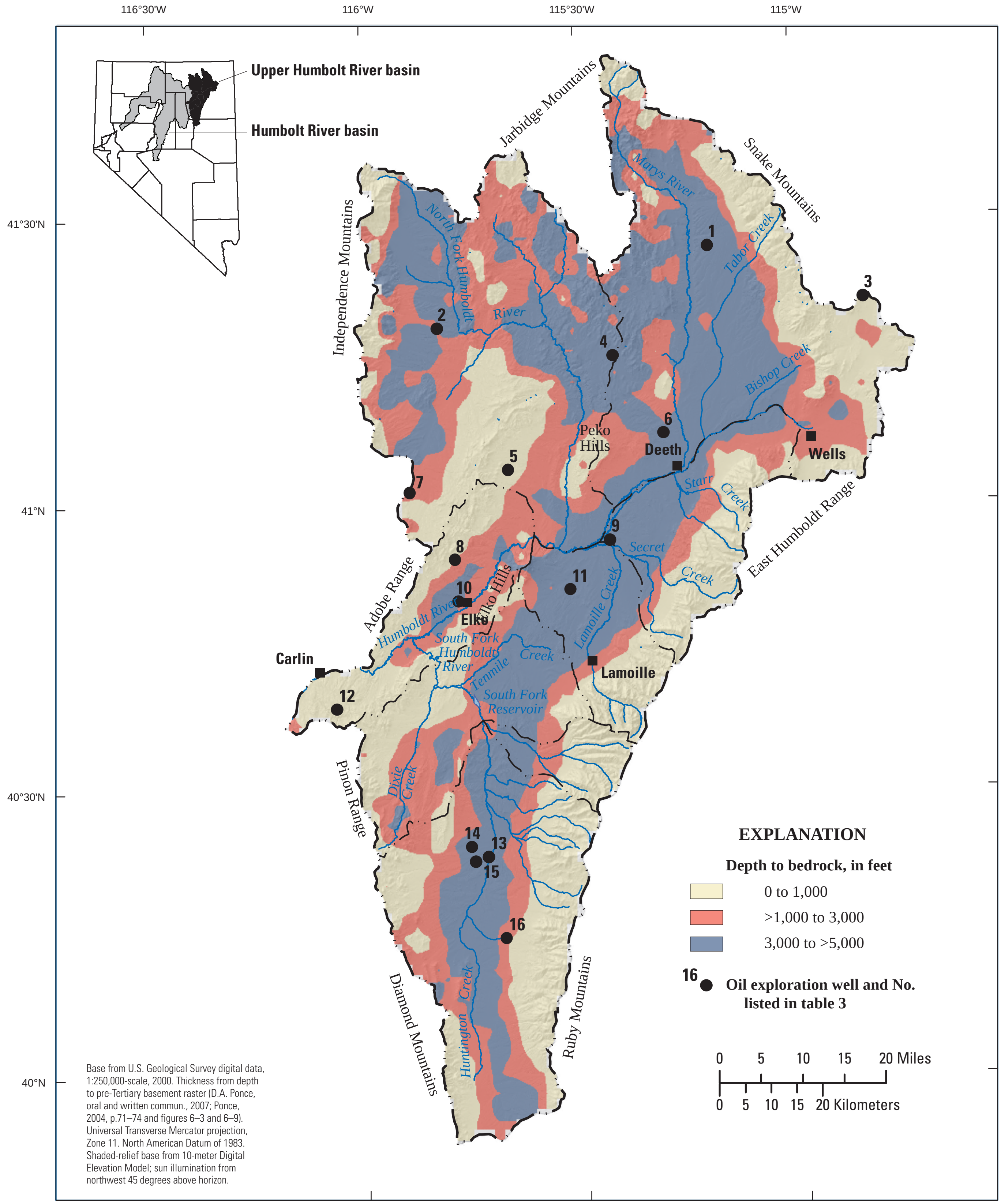

Figure 3. Combined thickness of younger and older basin-fill deposits and volcanic rocks, and location of oil exploration wells, upper Humboldt River basin, northeastern Nevada.

Structural Features

Faults and related fractures can function as enhanced conduits for ground water flow, or impede flow where hydrogeologic units of differing permeability are juxtaposed or filled by fault gouge (pulverized rock along the fault zone produced by friction when a fault moves). Near large gold mines along the Carlin Trend, faults impede the movement of ground water where carbonate rocks are juxtaposed against volcanic and clastic sedimentary rocks (Plume, 2005, p. 6–7). The evidence that faults are barriers to flow in this area is the substantial water level difference, greater than 1,000 ft, across the faults after more than 15 years of pumping for mine dewatering (Plume, 2005, p. 6). In other cases, however, the effects of faults may not be known until large-scale pumping stresses are applied to an aquifer.

Ground Water in the Upper Humboldt River Basin

Occurrence and Movement

The occurrence and movement of ground water in the upper Humboldt River basin is interpreted using ground-water levels in 161 wells measured by personnel from the USGS, Nevada Division of Water Resources, and Newmont Mining Corporation during the spring and summer 2007. Water levels ranged from at or near land surface in younger basin-fill deposits along stream flood plains to 300–400 ft below land surface in older basin-fill deposits mostly along basin margins. Water-level contours in ft above sea level primarily reflect ground-water levels in older and younger basin-fill deposits, but also may reflect water levels in unconfined carbonate rock aquifers (pl. 1).

Driven by hydraulic gradient, ground water moves through permeable zones from areas of recharge to areas of discharge. Recharge occurs mostly along mountain fronts, but also in mountainous areas underlain by carbonate rocks. Discharge occurs mostly on valley floors by evaporation from open water and moist soils and transpiration by plants called phreatophytes[3], ground water seepage to stream channels, and pumpage. The main discharge area in the upper Humboldt River basin is the river flood plain, which can be as much as a mile wide.

In Huntington Valley and the South Fork Area, ground-water flow is from the western base of the Ruby Mountains toward Huntington Creek and its confluence with the South Fork Humboldt River. In Huntington Valley, ground-water flow also is from the eastern base of the Diamond Mountains and Pinon Range toward Huntington Creek. Water-level gradients range from 200 ft/mi adjacent to the Ruby Mountains to 10 ft/mi between the Pinon Range and Huntington Creek (pl. 1). This range of gradients either indicates that more recharge originates from the Ruby Mountains than from mountain ranges on the west side of the valley or that basin-fill deposits on the east side of the valley are less permeable than those on the west side. Rush and Everett (1966, p. 26–27) noted that basin-fill deposits on the east side of Huntington Valley are saturated to near land surface and that potential recharge is rejected and leaves the area as streamflow. The sharp, upstream inflections of water-level contours along the axis of Huntington Valley indicate that ground water discharges to the channel of Huntington Creek. However, ground water also flows northward along the axis of the valley along gradients of 5–10 ft/mi.

The high permeability of carbonate rocks likely result in recharge rather than runoff as indicated by the absence of perennial streams in the southern Ruby Mountains (fig. 1 and pl. 1). This, combined with the eastward dip of the rocks, probably results in ground-water flow from the west side of the southern Ruby Mountains to Ruby Valley east of the study area where numerous large springs emanate from the eastern base of the Ruby Mountains (Rush and Everett, 1966, p. 15; Dudley, 1967, p. 88–98). Dudley (1967, p. 97) also determined that the ground-water divide between Huntington and Ruby Valleys may be as much as 2 mi west of the topographic divide between the two valleys suggesting that most of the high-altitude precipitation in the southern Ruby Mountains does not recharge the upper Humboldt River basin.

Ground-water flow from Huntington Valley and the South Fork Area continues northward into the Dixie Creek–Tenmile Creek Area. In addition, ground water flows west and northwest from the recharge area along the mountain front of the Ruby Mountains and north and northeast from the Pinon Range. A low topographic divide separates the Dixie Creek–Tenmile Creek Area from Lamoille Valley to the northeast. A group of unnamed hills separates the Dixie Creek–Tenmile Creek Area from the Humboldt River downstream from Elko. The water-level contours on plate 1 indicate that ground water flows northwest through these hills to the river flood plain.

In Lamoille Valley and Starr Valley Area ground-water flow is from a recharge area along the base of the Ruby Mountains, which are composed entirely of low permeability crystalline rocks. As a result, ground-water recharge is predominantly from infiltration of runoff from the mountains as it crosses the pediment between the mountains and Humboldt River flood plain. A portion of the water leaves the two basins as runoff because aquifers in both valleys are saturated to near land surface and have limited storage available for recharge (Eakin and Lamke, 1966. p. 31).

[3] Phreatophytes are plants that have their roots in ground water. They include greasewood, big sage, rabbit brush, various meadow grasses, willows, and cottonwoods. Evapotranspiration is the primary ground-water discharge process in the Humboldt River Basin and the term incorporates two processes—evaporation from open water and soils, and transpiration by phreatophytes.

Ground-water flow is to the northwest in Lamoille Valley and to the west in Starr Valley Area. Water-level gradients range from 50–100 ft/mi adjacent to the mountains to 10–30 ft/mi near the Humboldt River flood plain.

Ground-water flow in the Marys River Area generally is southward to the Humboldt River. The lower reaches of Marys River are ephemeral, and water-level contours have no upstream inflection unlike other streams in the study area. Near the Humboldt River flood plain, water-level gradients are about 20 ft/mi.

The North Fork Area consists of upper and lower topographic basins that are connected by streamflow through a canyon in the northern Adobe Range (fig. 1). The upper basin consists of an east sloping pediment of flat-lying to tilted older basin-fill deposits overlain by a thin cover of younger basin-fill deposits (A.R. Wallace, U.S. Geological Survey, oral commun., 2008), as much as 5 mi wide, between the Independence Mountains to the west and Double Mountain and the Adobe Range to the east. Sparse water-level data indicate that ground-water flow is eastward from a recharge area along the eastern base of the Independence Mountains. Water-level data are not sufficient to determine whether the direction of ground-water flow on the east side of the area turns northeastward parallel with the Adobe Range or continues eastward through the range. The first possibility would require a sharp change in the direction of flow from eastward to northeastward. The second does not seem likely because the principle rock types the Adobe Range are 4,000–5,500 ft of poorly permeable shale and sandstone of the Diamond Peak Formation and Chainman Shale (oil wells 8 and 5, pl. 1, table 4).

Ground-water flow in the lower part of the North Fork Area is southeastward from the Adobe Range, and as indicated by the 5,300- and 5,400-ft water-level contours southwestward from the Peko Hills toward the North Fork Humboldt River and then southward along the basin axis toward the Humboldt River (pl. 1). The Peko Hills are underlain by the Diamond Peak Formation, Chainman Shale, and by older and younger carbonate rocks.

Sharp upstream inflections of the water-level contours indicate that the Humboldt River gains flow from ground-water seepage from a few miles west of Wells to the west boundary of the study area. Water-level gradients along the flood plain range from about 7 to 30 ft/mi east of the Elko Hills. Ground-water flow in the Elko Segment (Elko Hills to the west boundary of the study area) is to the southeast from the Adobe Range and northwest from the Dixie Creek–Tenmile Creek Area through the unnamed hills between the Elko Hills and the South Fork Humboldt River. Streamflow gains of the river in the Elko Segment are about 6,600 acre-ft/yr. This ground-water seepage to the river channel primarily moves through a 10-mi wide section of the unnamed hills (pl. 1) under a water-level gradient of 40 ft/mi (0.008 ft/ft).

Transmissivity can be estimated using these values and a form of Darcy's law:

$$T = Q/(iw), \qquad (1)$$

where

- T is transmissivity, in feet squared per day;
- Q is flow through the section, in cubic feet per day;
- i is the water table gradient, in feet per foot; and
- w is the width of the flow section, in feet.

The estimated transmissivity of the rocks and deposits in the flow section is about 2,000 ft^2/d. However, this is a rough estimate because some subsurface flow resulting in the streamflow gains comes from the Adobe Range.

Water-Level Change

Water levels in the upper Humboldt River basin fluctuate: (1) annually in response to wetter (spring runoff) and drier (lack of summer rain) hydrologic conditions; and (2) to longer term (multiyear) variations in climate. Water-level data from nine wells were used to evaluate these fluctuations. The locations of these wells are shown in figure 4.

Wells 1 and 2 near Deeth and Lamoille, respectively, were measured monthly from 1949 to 1958 (fig. 4, fig. 5 *A–B*). Well 1 (fig. 5*A*) is in the flood plain near the confluence of Marys River and the Humboldt River, and water levels at this well probably respond rapidly to changes in stage of either stream. Water levels were about 10 ft below land surface in late winter to early spring, but rapidly rose to within 5 feet of land surface by early to late June. Although no drillers' log is available for well 1, the log for a nearby well (Nevada log number 76997, table 5) penetrated interbedded sand, gravel, and clay from land surface to depths of 28 ft and blue clay to a depth of 112 ft. The sands and gravels above the blue clay function as a shallow water-table aquifer that is recharged mostly by the spring snowmelt runoff.

Monthly water-level fluctuations at well 2 were similar to those at well 1 (fig. 5*B*). Well 2 is located about one-half mile from Lamoille Creek in an area dissected by a network of ditches used to irrigate meadows and fields. Depth to water at this well was more than 10 ft in early to late winter, but typically rose abruptly between May and June approaching land surface by late spring or early summer. Annual water-level rises at this well are dependent on the distribution and timing of irrigation and not necessarily on the magnitude of the spring snowmelt runoff. The rapid water-level rise each year indicates a good hydraulic connection through a thin unsaturated zone and limited available storage in the aquifer, which agrees with conclusions from the reconnaissance reports published decades earlier (Eakin and Lamke, 1966, p. 31; Rush and Everett, 1966, p. 26–27).

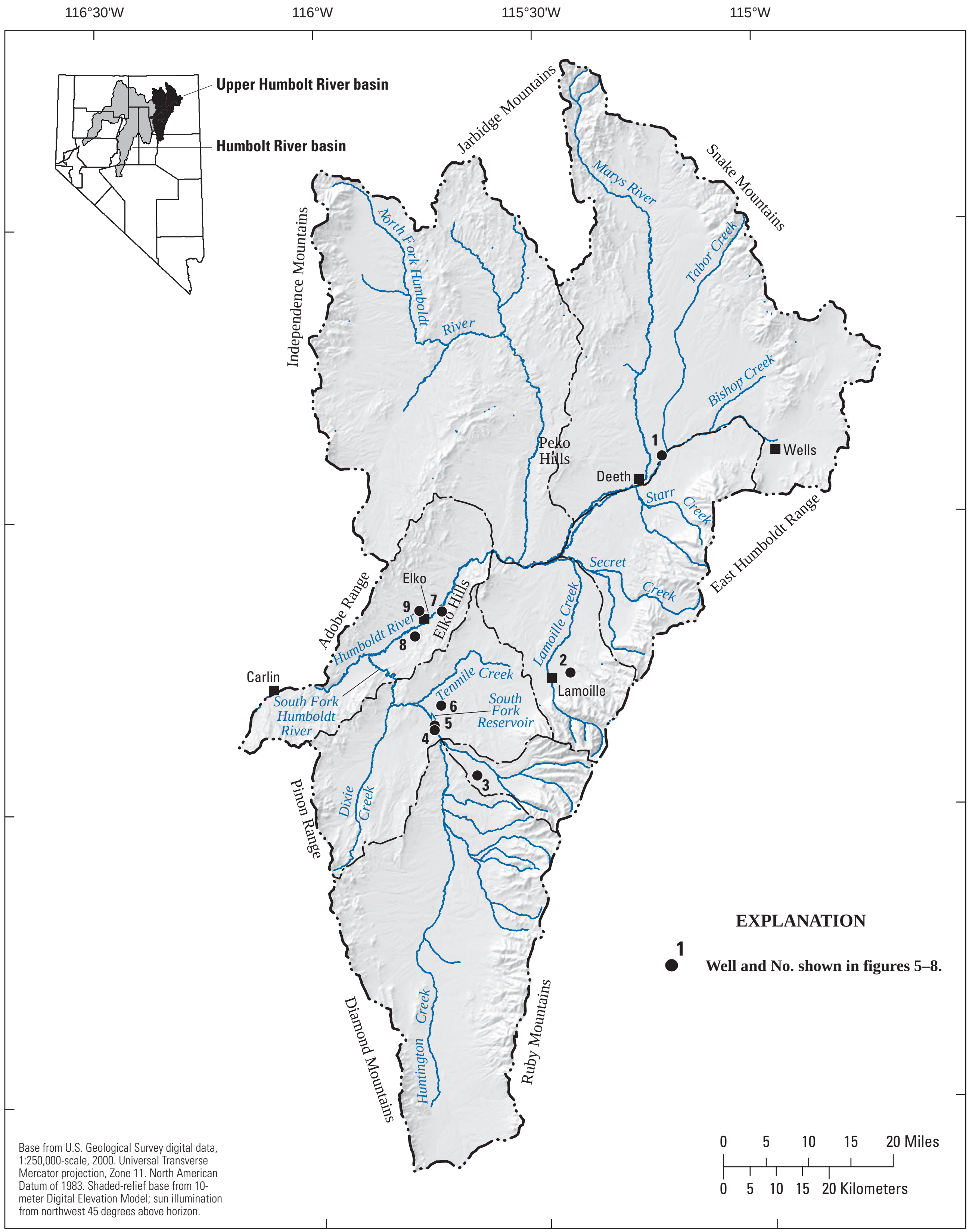

Figure 4. Selected wells where water levels have fluctuated, upper Humboldt River basin, northeastern Nevada.

Table 5. Lithologies penetrated by wells 1–9, upper Humboldt River basin, northeastern Nevada.

[Well locations are shown in figure 4]

Well No.	Nevada log No.	Altitude (feet)	Total depth (feet)	Perforated interval (feet)	Depth of top (feet)	Lithology penetrated	Thickness (feet)
1*	76997	5,340	112	90–112	0	Topsoil	5
					5	Sand and gravel	1
					6	Clay	9
					15	sand and gravel	13
					28	Blue clay	
2	23164	5,880	123	102–122	0	Soil	2
					2	Gravel	33
					35	Sandy Clay	65
					100	Sand and gravel	
4	28404	5,320	258	220–258	0	Topsoil	2
					2	Sand and gravel	34
					36	Sand and clay	27
					63	Gravel	17
					80	Sand and clay	92
					172	Sand	18
					190	Sand and clay	20
					210	Sand	40
					250	Sand and clay	
5	13830	5,260	157	107–157	0	Soil	2
					2	Sandy clay	8
					10	Gravel and cobbles	16
					26	Sand, gravel, clay	117
					143	Gravel	1
					144	Clay	
6	30036	5,340	170	150–170	0	Soil	4
					4	Green clay	23
					27	Soft sandstone	118
					145	Green clay	3
					148	Sand	
7	15700	5,240	510	128–510	0	Soil	4
					4	Alluvium	106
					110	Gravel	2
					112	Volcanic rocks	66
					178	Shale	77
					255	Limestone	7
					262	Fractured shale	
8	9288	5,200	200	160–180	0	Gravel	15
					15	Sandstone	5
					20	Sandy clay	140
					160	Sand and gravel	2
					162	Rock and clay	
9	11004	5,090	415		0	Clay and gravel	27
					27	Gravel	4
					31	Gravel and clay	27
					58	Clay and gravel	42
					100	Gravel	5
					115	Clay and gravel	87
					202	Gravel and clay	63
					265	Gravel	7
					272	Gravel and clay	33
					305	Gravel	15
					320	Sandy clay	27
					347	Clay	15
					362	Sandy clay	

* No log is available for well 1. The log shown here is for a well about 500 feet to the west.

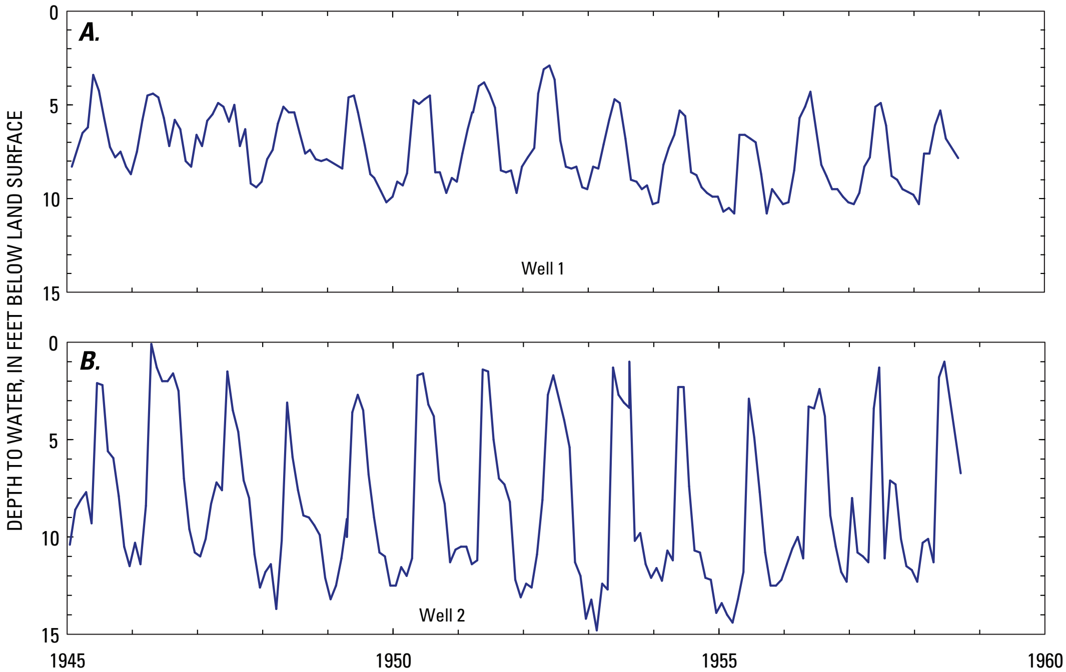

Figure 5. Water-level fluctuations at (*A*) wells near Deeth (well 1) and (*B*) Lamoille (well 2). See figure 4 for well locations.

Well 3 is a stock well at the southwest side of the South Fork Area that has been measured annually by USGS since 1964 (fig. 6*A*). Depth to water at this well ranged from about 71 ft in 1984 and 1986 to 98 ft in 1995. Annual water levels in the well show multiyear periods of increasing and decreasing levels. Water levels rose 20 ft from 1970 to 1986, declined 27 ft from 1986 to 1995, rose 16 ft from 1995 to 2001, and declined 16 ft by 2003 (fig. 6*A*). These periods of water-level rise and fall generally correspond to long-term variations in annual precipitation (fig. 6*B*). The water-level rise from 1970 to 1984 was a 15-year period during which annual precipitation was 8 to 90 percent above average during 8 years and 5 to 50 percent below average during 7 years. However, the total amount of precipitation during above average years was about twice the amount during below average years. Overall, the 15-year period was one of well above average precipitation, and this explains the upward trend of water levels in the well during that period. Similarly, a severe and continuous drought from 1985 through 1994 (fig. 6*B*) coincides with the abrupt water-level decline from 1986 to 1995 (fig. 6*A*). The water-level rise from 1995 to 2001 and its decline by 2003 also can be explained by the precipitation record, indicating that water levels in well 3 respond rapidly to variations in climate.

Filling of the South Fork Reservoir has resulted in water-level rises in basin-fill deposits over an area of uncertain extent. The Nevada Division of Water Resources began measuring water levels in wells in the vicinity of the South Fork Reservoir when filling began in December 1987. The time required for filling to a spillway elevation of 5,231 ft is not known and the stage of the reservoir probably fluctuates annually in response to runoff from the South Fork Area and Huntington Valley. Since 1988, water levels have risen 6 ft and 8 ft at two wells about 3,000 ft and 1,000 ft, respectively, from the southwest side of the reservoir (wells 4 and 5 figs. 4 and 7*A–B*). Both wells are adjacent to the flood plain of the South Fork Humboldt River and penetrate interbedded clay, sand, and gravel to depths of 144–250 ft (table 5). Water levels at a stock well about 1 mi northeast of the reservoir were at about 89 ft through 1992, rose 2 ft in 1993, and fluctuated 1–2 ft through 1997 (well 6, figs. 4 and 7*C*). Water levels were not measured at the well again until 2005 when the depth to water was about 83 ft. Since then the water level has not changed. Although this well is at a higher altitude than the South Fork Reservoir, the well depth, at 170 ft (5,172 ft altitude), is below the reservoir elevation of 5,231 ft. In addition, this well penetrated interbedded clay and sand (table 5). Water-level rises at the wells 4, 5, and 6 are the result of infiltration of surface water during filling of the reservoir.

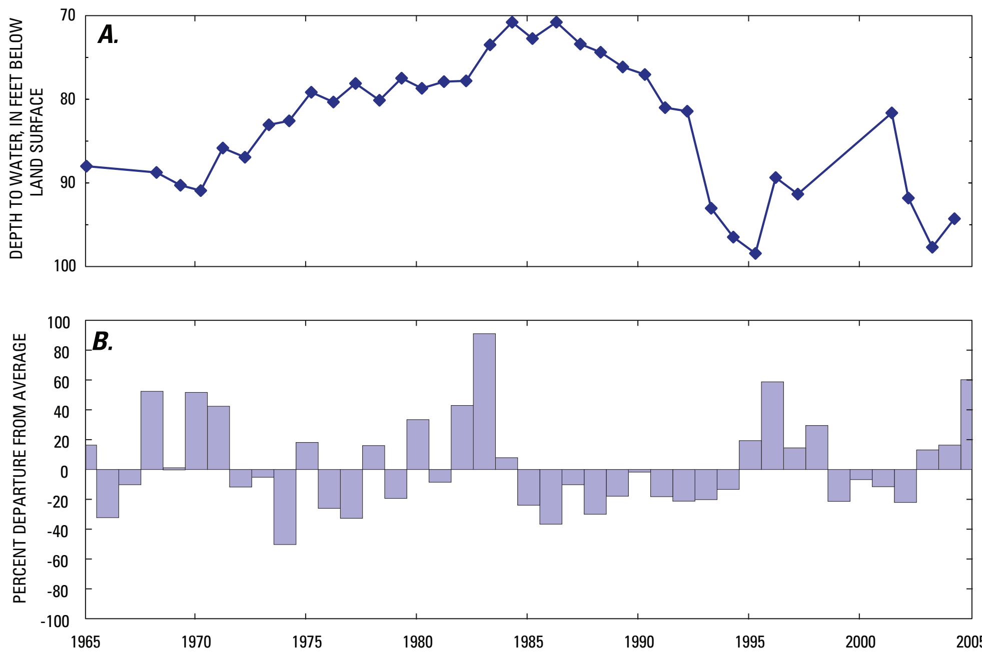

Figure 6. (*A*) water-level fluctuation at well 3, 1965–2005 (fig. 4), and (*B*) annual precipitation as percent departure from average at Elko, Nevada, 1965–2005. Long-term (1947–2007) average is 9.6 inches per year.

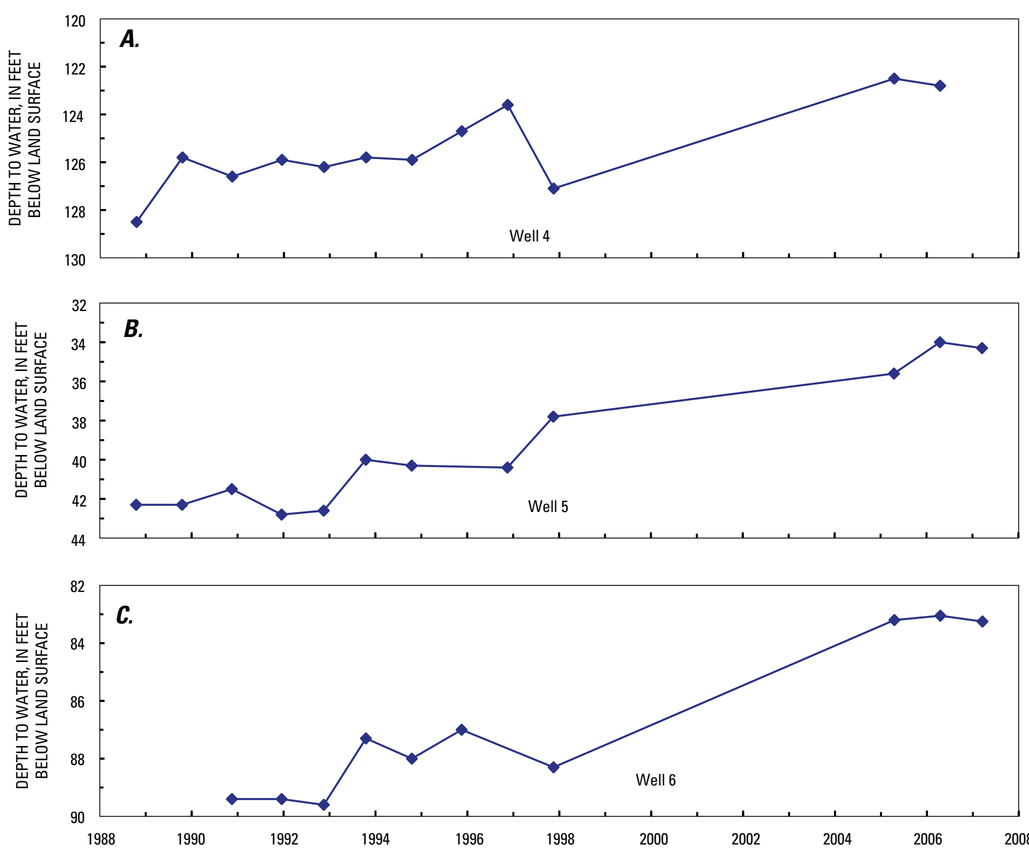

Figure 7. Water-level fluctuations at wells 4, 5, and 6 near South Fork Reservoir, Elko, Nevada.

Water levels also have risen at two wells on the northwest side of the group of hills that extends from the Elko Hills on the northeast to the north end of the Pinon Range on the southwest (wells *7* and 8, figs. 4 and 8*A–B*). These hills lie between the Humboldt River flood plain and the Dixie Creek-Tenmile Creek Area. The depth to water at well 7 rose from 225 ft in 1989 to 109 ft in 2008. This well was drilled in 1976 and its log (well 7, table 5) indicates that it penetrated alluvium and gravel to 112 ft, volcanic rocks from 112 to 178 ft, shale from 178 to 255 ft, limestone from 255 to 262 ft, and then faulted shale to a depth of 510 ft. The casing was perforated from 128 to 510 ft. The reason for the continuous water-level rise at this well is not clear because no nearby source of water is evident. One reason could be infiltration from the South Fork Reservoir into carbonate rocks, which are exposed in the canyon where the dam was constructed (pl. 1; Coats, 1987, pl. 1). However, the distance between the dam and well 7 is about 10 mi.

Water levels at well 8 rose from a depth of about 200 ft in 1989 to 145 ft by 2003 (fig. 8*B*). This well was drilled in 1966 and its log (table 5) indicates that it penetrated gravel, clay, and sandstone to 162 ft and rock and clay from 162 to 200 ft. The casing was perforated from 160 to 180 ft. Center-pivot irrigation and infiltration ponds for disposing of treated sewage, both constructed just west of this well in the early 1990s, are the reason for the water-level rise.

Pumping in the Elko Segment, especially for municipal purposes, probably has resulted in water-level declines. However, water-level monitoring has not been sufficient to identify the areal extent or magnitude of any declines. A secondary effect of municipal pumping can be that of water levels rising because of lawn watering in residential neighborhoods. The graph for well 9 (figs. 4 and 8*C*) indicates that water levels rose about 43 ft from 1988 through 2008. This well is next to a park and residential neighborhoods on the west side of Elko.

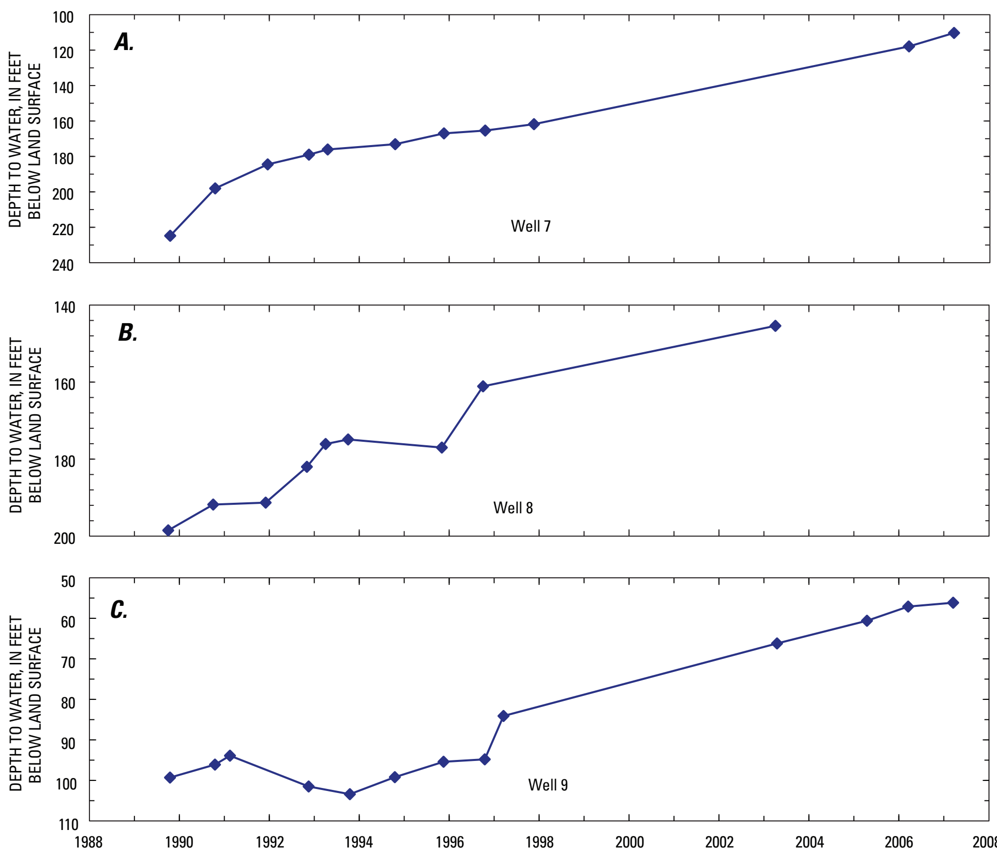

Figure 8. Water-level fluctuations at wells 7, 8, and 9 near Elko, Nevada.

Summary

This report presents the results of a study of the water resources of the upper Humboldt River basin done in 2007–08 by the U.S. Geological Survey in cooperation with Elko County. The report provides Elko County and State water-resource managers information needed to make informed decisions regarding future use and development of the ground-water resources of the basin. The overall objective of the report is to develop an improved understanding of the water resources of the upper Humboldt River basin. This report describes the hydrogeologic framework, and the occurrence and movement of ground water.

The upper Humboldt River basin covers an area of 4,364 mi^2 in northeastern Nevada, and consists of eight hydrographic areas—Marys River Area, Starr Valley Area, North Fork Area, Lamoille Valley, South Fork Area, Huntington Valley, Dixie Creek–Tenmile Creek Area, and the Elko Segment. These eight areas are the headwaters of the Humboldt River, and nearly all of the annual flow of the river in years of average flow originates in these areas. The main tributaries of the upper Humboldt River are South Fork Humboldt River, North Fork Humboldt River, Lamoille Creek, Marys River, and Bishop Creek. High flows during the spring and early summer are dominated by snowmelt runoff and low flows of late summer and autumn of each stream generally are sustained by ground-water discharge to the stream channel. The main exception is the lower reach of Marys River, which has no baseflow and goes dry every summer and autumn.

The upper Humboldt River basin consists of several deep structural basins in which basin-fill deposits of Tertiary and Quaternary age and volcanic rocks of Tertiary age have accumulated. The bedrock of each basin and adjacent mountains are composed of carbonate and clastic sedimentary rocks of Paleozoic age and crystalline rocks of Paleozoic, Mesozoic and Cenozoic age. The permeability of bedrock generally is very low except for carbonate rocks, which can be very permeable where circulating ground water has widened fractures through geologic time. The contrast in permeability of carbonate rocks with other bedrock is evident in the Ruby Mountains. Watersheds in the south end of the mountain range are underlain by carbonate rocks and are drained by ephemeral streams. Watersheds in central and northern parts of the mountain range are underlain by crystalline rocks and are drained by perennial streams.

A thick sequence of alternating sedimentary deposits and volcanic rocks accumulated in basins of the study area from Eocene time to the present. The sequence consists of three hydrogeologic units—volcanic rocks, older basin-fill deposits, and younger basin-fill deposits. The composite thickness of the three units exceeds 5,000 ft in a deep narrow structural basin that extends from southern Huntington Valley to the northern Marys River Area parallel with the Ruby Mountains, East Humboldt Range, and Snake Mountains. Lithologic logs for oil exploration wells indicate that the older basin-fill deposits and volcanic rocks are commonly interbedded. In addition, older basin-fill deposits usually are tuffaceous and consist of interbedded fine-grained lake deposits and coarse-grained deposits of alluvial fans and stream flood plains. Younger basin-fill deposits consist mostly of unconsolidated sand and gravel along stream channels and as thin veneers covering older basin-fill deposits in the northern Marys River and North Fork Areas and in southern Huntington Valley. The principal aquifers in the upper Humboldt River basin are in basin-fill deposits. However, little is known regarding the hydraulic properties of these aquifers. Analysis of aquifer tests and well drillers' logs would be very useful for making estimates of aquifer properties in the study area.

Ground water in the upper Humboldt River basin moves from recharge areas, which are along mountain fronts, and is discharged as seepage to stream channels, evapotranspiration, and pumpage. The main discharge area in the upper Humboldt River basin is the river flood plain, which can be as much as a mile wide. South of the Humboldt River, ground-water flow is from an extensive recharge area along the western base of the Ruby Mountains and East Humboldt Range and to a lesser extent the eastern base of the Diamond Mountains and Pinon Range. Flow generally is northward along the axes of Huntington Valley and the Dixie Creek–Tenmile Creek Area through a group of unnamed hills to the Humboldt River flood plain west of Elko. Ground-water flow in Lamoille Valley and Starr Valley Area is northwestward directly to the river flood plain. Water-level contours indicate that ground water discharges as seepage to stream channels in areas south of the river.

Ground-water flow in the Marys River Area is to the southwest from the Snake Mountains and south from other parts of the basin to the Humboldt River flood plain. Ground water does not discharge as seepage to the channel of the lower reaches of Marys River.

The North Fork Area consists of two ground-water basins that are connected by streamflow. Sparse water-level data for the upper basin indicate that most ground-water flow is eastward from a recharge area along the base of the Independence Mountains. However, water-level data are not sufficient to determine the direction of ground-water flow in other parts of the upper basin. Ground-water flow in the lower part of the North Fork Area is eastward from the Adobe Range and westward from the Peko Hills toward the North Fork Humboldt River and then southward along the basin axis toward the Humboldt River flood plain.

Water-level contours indicate that the Humboldt River gains flow from ground-water seepage over its entire length in the study area. The contours show sharp upstream inflections where they cross the river and its flood plain from a few miles west of Wells to the west boundary of the study area. Ground-water flow in the Elko Segment is to the southeast from the Adobe Range and northwest from the Dixie Creek–Tenmile Creek Area through the unnamed hills between the Elko Hills and the South Fork Humboldt River. This reach of the river gains about 6,600 acre-ft/yr as ground-water seepage to the river channel. The estimated transmissivity of the aquifer in this flow section is 2,000 ft^2/d.

Water levels in the upper Humboldt River basin fluctuate in response to the annual snowmelt runoff, to long-term variations in climate, and to human activities. From 1949 to 1958, water levels at a well in the Marys River and Humboldt River flood plains near Deeth ranged from 8 to 11 ft below land surface in late winter to early spring, but rapidly rose to within several feet of land surface by early to late June. Annual water-level changes at a well near Lamoille were similar to those at the well near Deeth. The Lamoille well is about half a mile from the nearest stream, but it is in an area where streamflow diverted from Lamoille Creek is distributed to meadows and fields by a network of irrigation ditches. Water levels at the well ranged from 11 to 15 ft in early to late winter and rose abruptly to near land surface by late spring or early summer. Water-level rises at this well are dependent on the distribution and timing of irrigation and not on the magnitude of the spring snowmelt runoff.

Water-level changes at a stock well at the southwest side of the South Fork Area are believed to be related to variations in annual precipitation. Since 1970, water levels either rose or declined during four time periods ranging from a few to 15 years. These periods correspond closely with periods of above or below average annual precipitation measured at Elko, and indicate that water levels in the well respond rapidly to variations in climate.

Filling of the South Fork Reservoir, which began in 1988, has resulted in water-level rises in the basin-fill deposits that underlie uplands on the east and west sides of the reservoir. Water level rises at another well, which is about 10 miles north of the reservoir, also could be the result of infiltration losses. Water-level rises at two wells west of Elko are the result of agricultural irrigation and infiltration of treated sewage and residential lawn watering, respectively.

Acknowledgments

This study was done in cooperation with Elko County, and it is the result of discussions with, and input from, the Elko County Board of Commissioners and Elko County Water Planning Commission over several years. The author thanks well owners in the study area for providing USGS field personnel access to their wells. The author also thanks Alan Wallace with USGS in Reno for several helpful discussions regarding Cenozoic basins in northeastern Nevada.

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