Forecasting Water Demand in the Humboldt River Basin: Capabilities and Constraints

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Introduction

Throughout Nevada, water is a resource as precious as the minerals which first attracted settlers to the state over a hundred years ago. Nevada is one of the fastest growing states in the nation and one of the most arid. As a result, the Nevada Division of Water Resources (NDWR) faces immense challenges in effectively and equitably distributing water resources across the state to promote ample economic development opportunities and enhance quality of life. State water law indicates that water is a state resource and under certain conditions can be put to beneficial use in any basin throughout the state (NRS 533.025; 533.030; 534.020). Entities across the state face a myriad of technical, regulatory, and legal hurdles in the effort to secure water resources. One of the major hurdles is the practice of interbasin transfers. This is a contentious issue in rural regions who struggle in the face of urban regions to maintain and induce economic opportunities through the development of water resources. In addressing this issue the State Engineer has indicated he will consider the documented future demand for water to enable continued local economic development when considering applications to export water from one area to another (NRS 533.370(6)d). It is therefore in the best interests of rural counties to be proactive in their efforts to maintain the availability of, and to secure water resources necessary to meet future demands. To ensure that the State Engineer can effectively take into consideration future water resource requirements by rural entities, Nevada's rural local governments must be capable of developing forecasts of future water demand and providing the same to the Nevada State Engineer.

While many hydrographic basins within the Humboldt River Basin have permitted and decreed water rights and pending applications in excess of available groundwater yield some have groundwater yet available for application and appropriation. It is these basins which may become areas of interest by those seeking to develop and export water from the Humboldt River Basin. If HRBWA member counties are to ensure that adequate groundwater resources are available to meet future needs, it is imperative that said counties begin now to develop and maintain the capacity to defensibly project groundwater demand in coming years.

In its most basic application water demand forecasting is a function of socio-economic variables and water use trends. This is useful to the State Engineer who, in adjudicating basins throughout the state, must consider not only relative current impacts, but in addition the long-term economic and environmental impacts associated with the distribution of water resources (NRS 533.370). This report seeks to clarify the role water demand forecasting plays in the planning and decision making process of counties represented in the Humboldt River Basin Water Authority (HRBWA). To do so, regional water demand forecasting methodologies and regional population forecasting methodologies are discussed. This is important as long term forecasting is a difficult task and can be undertaken using variable data sources. This is to say that the socio-economic and land-use data instrumental to the design of water demand forecasts, as this report demonstrates, often comes from a variety of sources and subsequently has potential to produce varying results. Therefore, this report sheds light on methods regional entities have used to face forecasting challenges and is useful to the discourse of HRBWA

counties which must consider a) which method of water demand forecasting and which type of data will most accurately reflect the future water needs of HRBWA counties, and b) how should counties proceed to ensure the State Engineer receives vital information concerning future water demands. Furthermore, this report recognizes that counties represented in the HRBWA may already conduct water demand forecasting activities and/or have specific situations which will be best served through the individual counties development and maintenance of water demand forecasts.

Notably, this report places an emphasis on domestic and industrial water use. This is noteworthy considering the amount of water used for agricultural needs is generally far greater in rural regions than that used for municipal and industrial activities. However, given the likelihood that the agricultural base will remain constant or slightly decrease, it is in the best interests of counties to place special emphasis on securing water resources for municipal and industrial uses promoting economic growth and diversification.

Water Forecasting Methodologies

Water demand forecasting is a process achieved through several techniques and is typically used to predict future water requirements for uses including municipal and agriculture and for the planning of dams and reservoirs. The type of technique used depends on the breadth of the data needed, the general scope of the region for which the forecast is being conducted, and the resources available to the organization for which the forecast is being conducted. For all intensive purposes future water demand is derived from basic functions. For instance, municipal demand is generally projected using population size and the number of households, industrial demand is often based on number of employees, and agricultural demand commonly relies on crop type and irrigated acreage. These variables are then applied to basic formulas to estimate future demand.

The following description of prominent water demand forecasting techniques borrows heavily from material in the text *Water Resources Planning* (Dzurik, 1996).

Time Extrapolation:

> This technique only considers past water use records and extrapolates into the future using graphs and other mathematical methods.

Single-Coefficient Methods:

> This method is the most commonly used technique and estimates future water demand as a product of service area population and per capita water use.

Multiple Co-efficient Methods:

> This approach defines future water use as a function of two or more variables associated with water use. Regression equations are typically developed as the statistical technique for estimating the relevant coefficients.

Demand Models:

> Water demand models are a subcategory of the multi-coefficient method described above. The primary differences are that the price of water is included as an explanatory variable and some measure of personal income is often included.

Probabilistic Analysis

> Models using regression analysis to explain variations in water use also include the "error term" to account for unexplained variations. Probabilistic analysis includes not only independent variables to estimate future use but also a probability distribution of the estimate. (Dzurik, 165-167)

With these basic functions in mind it is useful to review the methodologies employed by individual entities in forecasting water demand needs.

Nevada Division of Water Resources: Nevada State Water Plan

The basic forecasting methodology in the Nevada State Water Plan (State of Nevada, 1999) is derived from a forecast of key socioeconomic variables multiplied by a water use factor or coefficient to produce a water withdrawal forecast. The state water plan addresses a variety of future water uses in its forecasting activities including municipal, agriculture, industrial, domestic, mining, and thermoelectric uses.

Of interest, the municipal and industrial water withdrawal forecasts are "based on resident population utilizing a public supply water system multiplied by a water use factor which is determined from historical conditions and trends.". Domestic water withdrawal forecasts are based on population and usage rates determined from historical trends. Lastly, agricultural water withdrawal forecasts in the Nevada State Water Plan are developed "using forecasts of county-unique irrigated acreage water use factors measured in acre feet per year.

California Department of Natural Resources: California Water Plan, Update 2005

Because of the influence of uncertain variables on water demand forecasts the California Department of Water Resources (DWR) has developed three narrative scenarios of future water demand in California to use for planning purposes. DWR uses the scenarios to test the functions of alternate management strategies under different future conditions. The *California Water Plan, Update 2005* (State of California, 2005) comments "Scenarios can help water planners to better understand the implications of uncertainty and to evaluate the performance of management strategies across more objectives."

Scenario 1 - Current Trends: Recent trends continue for the following: population growth and development patterns, agricultural and industrial production, environmental water dedication, and naturally occurring conservation (like plumbing code changes, natural replacement, actions water users implement on their own, etc.).

Scenario 2 - Less Resource Intensive: Recent trends for population growth, higher agricultural and industrial production, more environmental water dedication, and higher

naturally occurring conservation than Current Trends (but less than full implementation of all cost-effective conservation measures currently available).

Scenario 3 - More Resource Intensive: Higher population growth rate, higher agricultural and industrial production, no additional environmental water dedication (year 2000 level), and lower naturally occurring conservation than Current Trends. (Source)

Southern Nevada Water Authority: 2006 Water Resource Plan

The Southern Nevada Water Authority (SNWA) 2006 Water Resource Plan (SNWA, 2006) forecasts water demand through 2055. To optimize resource management the plan is organized into two planning horizons, near-term (2006-2016) and long-term (2017-2055). SNWA water demand forecasting is based on population projections as provided by the Center for Business and Economic Research at UNLV and expected levels of resource conservation.

Nye County, Nevada: Water Resources Plan

The methodology used to forecast water demand in the Nevada State Plan was mirrored in developing the water demand forecasts for the Nye County, Nevada Water Resources Plan (Buqo, 2004). There are however, significant differences in the results for several areas. Namely, municipal and industrial water use and agricultural use. This is the result of Nye County using data independent of the data used in the State Water Plan. This is discussed in greater length in a subsequent section of this document.

2004-2025 Washoe County Regional Water Management Plan

The 2004-2025 Washoe County Regional Water Management Plan (Regional Water Planning Commission, 2005) water demand projections are based on existing water commitments, projection of water demand through 2025, and the anticipated impact of water conservation potential on projection of future demand. The existing water commitments were obtained through the regions major water suppliers. The water demand projections were based on two models; the Market Forces Model and the Approved Land Use Model. The Market Forces Model is used for projections through 2025 and considers retail and wholesale demands, municipal demands from other water purveyors, and domestic wells. The Approved Land Use model is for long term projections beyond 2025 and uses the “increment of demand” as represented by vacant approved land uses to determine end-point water demand.

The impact of water conservation potential is based on the anticipation that metering un-metered accounts will create a reduction in future demand.

Local planners and decision makers, in consideration of water demand forecasts, must assess the availability of financial and data resources to be invested and utilized in water demand forecasts. Furthermore, counties must determine the goals they envision a water demand forecast meeting. In other words, questions such as is the data intended to provide the State Engineer with baseline water demand numbers or is it intended to develop concise management strategies based on varying conditions must be addressed? Lastly, local planners and local decision makers must consider what type of information will provide reliable and defensible results of future water demand. A thorough

assessment of these factors is pertinent to the development of sound and useful data.

State Population Forecasting

Population forecasts are a key contributing factor to municipal and industrial water demand forecasting and subsequently it is important that HRBWA members review population forecasting methodologies and their usefulness. Across the state water demand forecasts have utilized a number of varying techniques to forecast population and socio-economic data.

Nevada Division of Water Planning, Southern Nevada Water Authority, Washoe County
The Nevada Division of Water Planning, in developing the State Water Plan, generated and utilized a set of county and state population forecasts based on input received from the individual counties, input from the Nevada Department of Employment, Training, and Rehabilitation (DETR), and from the NDWP's best estimates. The SNWA, in the SNWA 2006 Water Resources Plan used data compiled by the Center for Business and Economic Research at UNLV. In producing the Washoe County Regional Water-Management Plan Washoe County utilized population projections from the Washoe County Consensus Forecasts 2003-2025. This forecast uses a number of "leading forecasts" including "DRI-WEFA, a national forecasting firm in Massachusetts that prepares national, state and county forecasts; NPA Data Services, Inc., a national forecasting firm in Arlington, VA that forecasts for every county in the United States as well as state and national forecasts; Truckee Meadows Water Authority's *Population and Employment Econometric Model*; and Woods and Poole, a national forecasting firm in Washington, DC that forecasts for every county in the United States, as well as state and national forecasts."

Nye County
Of specific interest is the population forecast used in the Nye County Water Resources Plan. In this plan, Nye County used a land use approach to forecasting population. The plan demonstrates the difficulties presented when population forecast for the same region and period of time are varied. This was noted to be the case for the forecasts which had been produced for Nye County. It is stated that the Nevada Division of Water Planning (Resources?) population forecasts, designed for the State Water Plan, suggests that the 2018 population will be 48% lower than what the state demographer forecasted. Furthermore, the Nye County 2018 population forecast is 17% less than the state demographer's forecasts. Nye County chose to use an alternate land based approach to population forecasting as opposed to the state demographers and NDWP's projections based on the variations between forecasts and with the understanding that long-term population projections can be "tenuous." In their population forecasts Nye County considered demographic assumptions based on planned and approved developments, proposed but yet unapproved developments and reasonably foreseeable developments.

Nevada State Demographer
The Nevada State Demographer is responsible for preparing forecasts for the state and counties and which must be used, by executive order of the governor, for all planning and budgeting functioning of state entities. The NDWP, in creating their individual

population forecasts, did so through agreement with the State Department of Taxation. (Nevada State Water Plan)

The Nevada 2005-2026 population projections were developed using the Regional Economic Models Incorporated (REMI) model. REMI is a comprehensive model made up of a broad scope of demographic and economic activity. The model is structural and includes cause and effect relationships. Several limitations to the model are cited by the State Demographer. First is a lack of historical data limiting the amount of information the model is constructed of. Second is the number of small Nevada counties with limited employees and employers. This results in missing information which the REMI must then estimate. Table 1 includes the draft 2005-2026 draft projections from the Nevada State Demographer.

Table 1. Draft 2005-2026 Population Estimates and Percent Population Change

	Elko	Eureka	Humboldt	Lander	Pershing
2005 Population	47,586	1,485	17,293	5,509	6,736
2026 Estimated Population	41,656	1,442	15,198	4,671	6,761
Total Difference	-5,930	-43	-2,095	-838	25
% Change	-12.5	-2.9	-12.11	-15.2	.4

Source: Nevada State Demographer, July 2007; http://www.nsbdc.org/what/data_statistics/demographer/pubs/docs/NV_2006_Projections.pdf

The official forecasts of population demand prepared by the Nevada State Demographer suggest declining population over the next three decades for all HRBWA member counties except Pershing, which shows almost no growth. Viewing the population estimates in Table 1, one might be tempted to conclude that counties within the Humboldt Basin can not justify a demand for water beyond that which exists today. In fact, it is possible that hearings before the Nevada State Engineer regarding proposals by municipalities within the Basin seeking additional water to support future demands may be met with opposition based on use of the Nevada State Demographers population projections which suggest municipal water demand in HRBWA member counties may actually decline in the future. This presents an interesting principal useful to county decision makers and planners. That is, how do planners negotiate between the varied results of long-term population forecasts when determining what information to be used in water demand forecasts? The questions raised by the previous sections on water forecasting methodologies are equally applicable here. Counties must assess the available financial and data resources which are available and determine how to apply these to meeting population forecasting goals based on the counties individual interests and needs. At a minimum, HRBWA counties may wish to consider annually reviewing the Nevada State Demographer population forecasts for accuracy. Further, HRBWA member

counties may find value in establishing and maintaining a local capability to develop annual population forecasts which better reflect local conditions and expectations.

County Water Demand Forecast Availability

Currently, Lander County is the only county represented in the HRBWA with a current water resources plan which includes water demand forecasting data. Elko County is in the process of preparing a comprehensive water plan which will include water demand forecasts. Other HRBWA counties have prepared a number of other relevant county documents which include socio-economic data vital to water demand forecasts.

Population forecasts for the Lander County water demand forecasts are derived from the State Demographers forecasts through a period of 1999-2030. From 1999-2030 the State Demographer forecasted a .34 percent growth rate. The plan also considers 2 percent and 3 percent growth scenarios for the 1999-2030 population. Population growth and water demand is forecasted for the individual communities of Battle Mountain, the Austin area, and Kingston. Community area population was forecasted under the assumption that the current ratio of community population would remain constant to the total county population over a 30-year period with the exception of the Battle Mountain service area which as a percent of the total population is expected to increase over the forecast period. (Lander County Water Plan). The plan includes the Nevada State Water Plan's county wide water demand forecasts for agricultural and mining water use. Water demand forecasts are included for Battle Mountain, the Austin area, and Kingston. No specific methodology is cited for the water demand forecasts that appear in the plan though they appear to be made up of a basic function using the forecasted population growth and assumptions of the average acre-feet per year used by an individual. The Battle Mountain area forecast uses a greater acre-foot per year user average than the Austin area or the Kingston area. This proportional increase is based on the assumption that there will be service area expansion near the I-80 corridor. Water demand forecasts are included for the period of 1999-2030 (Lander County Water Plan).

Elko County is currently in the process of preparing a comprehensive water plan. The plan will likely be available in Summer of 2007 and will include water demand forecast.

Eureka, Humboldt and Pershing counties do not have current water plans with water demand forecasts. They do, as is the case for Elko and Lander counties posses a number of planning documents and information available and useful in compiling data for water demand forecasts. This includes county and community master plans, land-use plans, and economic development strategies. As mentioned previously, many key elements to water demand forecasting are forecasts related to socio-economic variables including population forecasts. The basis for this type of data is generally an integral part of community planning documents.

Furthermore, all counties represented in the HRBWA do have accesses to specific water demand data through the Nevada State Water plan; currently the most comprehensive water demand forecasts for the HRBWA region. This being said, the State Water Plan,

for individualized planning purposes through the year 2020, is not current and has not been maintained. The State Water Plan' official year of release was 1999 and included individualized county forecasting data through the year 2020.

The Nevada State Water Plan considers in its forecasts 14 water uses listed as:

By Public Supply:
Total Municipal and Industrial (M&I) Water Withdrawals

By Water Use Type:
Total Water Withdrawals
- Total Domestic (Residential) Water Withdrawals
  - Domestic Public Supply Withdrawals
  - Domestic Self-Supplied Withdrawals
- Commercial and Industrial Water Withdrawals
- Thermoelectric Water Withdrawals
- M&I Public Use and Loss
- Total Mining Water Withdrawals
  - Mine Processing (Consumptive) Withdrawals
  - Mine Dewatering (Non-Consumptive) Withdrawals
- Total Agricultural Water Withdrawals
  - Irrigation Withdrawals
  - Livestock (Including Fisheries and Hatcheries) Withdrawals

This is notably a comprehensive list of water uses which the State has forecasted for the individual HRBWA counties and can be extremely useful in many regards. However, as Nye County noted in creating their individual forecasts, the sources for the State population data and its usefulness to individual local situations must be considered. HRBWA counties must assess if there are any factors which were not considered or given enough consideration in the State Water Plan and the likelihood that these varied elements would lead to varied yet defensible water demand forecasts.

Other Factors for County Consideration in Preparing Water Demand Forecasts

In addition to the generally accepted methods and data for developing water demand forecasts described above, HRBWA counties may wish to consider the following additional factors:

- number of unimproved parcels
- acres of undeveloped irrigable farmland
- water demand associated with any targeted industries.

Number of Unimproved Parcels
As shown in Table 2, a large number of unimproved parcels exist in HRBWA member counties. If one assumes at least one dwelling unit per parcel and one acre-foot per dwelling unit, water demand associated with domestic uses for all of the unimproved

parcels in the five-county area alone would total at least 48,465 acre-feet of water. It is reasonable to assume and should be a defensible position to take that at least one acre-foot of water (enough for one residence) should be available for each unimproved parcel in each county.

Table 2. Unimproved Parcels in HRBWA Member Counties, As of May 2007

County	Number of Unimproved Parcels
Elko	28,443
Eureka	2,125
Humboldt	4,118
Lander	6,419
Pershing	7,360

Source: Contact with Elko, Eureka, Humboldt and Pershing county assessors May 1-10, 2007 and Lander County Assessor July 16, 2007.

Acres of Undeveloped Irrigable Farmland

Based upon Natural Resources Conservation Service (NRCS) soil surveys it should be possible to determine how many acres of currently unused irrigated cropland, pasture and other farmland (i.e. orchards) exist within each HRBWA member county. Each acre of undeveloped irrigable farmland could be assumed to require anywhere from 3 to 4.5 acre feet of water. Given the rate of conversion of irrigable farmland to non-agricultural development and the growing demand for food products in the western United States, it is reasonable to assume the development of new areas of irrigated cropland will be required in the future.

Water Demand Associated with Targeted Industries

County-based or regional economic development organizations often undertake initiatives to identify those industries for which the local geographic area represents a comparative advantage to other locals and said industries are often encouraged to expand or relocate to areas offering said comparative locational advantages. The I-80 corridor through the Humboldt River Basin and its intersection with major north-south highways has been recognized as a region for which a variety of industries may find a locational advantage. The water requirements of these “target industries” should be considered in HRBWA forecasts of future water demand.

Concluding Observations

In light of the scramble for water resources throughout Nevada, HRBWA member counties must be proactive in working to secure future water resources. This is especially pertinent given the growth the state is experiencing and the uncertainties associated with environmental conditions and climate irregularities. Water demand forecasting is a technique employed for planning in a wide variety of regions and provides a number of benefits to entities which choose to employ it. There should be little question that water

demand forecasting serves a very useful function in planning purposes and for aiding future economic development initiatives in arid regions such as northern Nevada.

Across Nevada various methods have been used to forecast population and water demand trends. This demonstrates that there are many variables to be considered in conducting said forecasts. Individual entities should assess whether there are local conditions which are not reflected in the state water forecasts and the state demographer's population forecasts. Furthermore, local decision makers must assess if the data available is relevant and current.

As mentioned earlier, though not all counties have water plans there are other data sources available such as master plans and land-use plans which have relevant information that can be factored into a water demand forecast. Counties should consider, given the individual resources available, what methodologies would be best employed for their purposes, goals, and the scope of time and information their forecast would cover. All HRBWA member counties are encouraged to develop and maintain a program of preparing annual water demand forecasts.

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