Dual Water Systems in Northern Colorado

By

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In northern Colorado, the cost of water rights acquisition has risen dramatically over the past five years. Because of this dynamic, it has become economically feasible to retain the existing agricultural water rights with urban developments. Surface and ground water rights are often used to meet the landscape and outdoor water requirements of urbanization on land that was previously used for agricultural crop production.

A separate utility for outdoor water use, typically referred to as a dual water system, is developed to distribute the untreated water supply, or raw water, to individual residential lots, commercial lots and common open space. In many cases, the savings realized by a developer in reduced potable water right costs is less than the cost for developing the dual water system infrastructure.

This paper describes design considerations and solutions for dual water systems based upon completed projects in northern Colorado. Design issues to be discussed are water rights analysis, annual water requirements, water well water and surface water delivery constraints, storage requirements, determination of peak system flow, pump station and control requirements, distribution system hydraulic analysis, distribution system layout, coordination with other utilities, service connections for residential/commercial customers, system operation and maintenance. In addition, design considerations for drought management will be discussed.

Economic Feasibility

Many northern Colorado cities estimate that the typical single-family residential customer will use approximately ½ acre-ft of water per year for inside and outside use, with 45 to 55 percent of the annual water use going for outdoor use. This assumption is backed up by a three year, unpublished study by a small northern Colorado city where monthy water use was monitored for 100 residences with an average lot size of 7,000 square feet. Most northern Colorado water districts require the developer of residential and commercial properties to turn over appropriate raw water rights to them prior to gaining approval to build a development to ensure an adequate supply of potable water. For example, a northern Colorado city requires that 0.52 acre-ft of raw water rights be turned over per 8,000 square foot residential lot. At a cost to the developer of $11,500 per acre-foot for acceptable raw water rights, the cost for a single 8,000 square foot lot would be over $6,000.

Many cities have allowed developers to reduce the water rights dedication for residential lots, if a dual water system is installed for landscape irrigation use. The cost to install a dual water systems range from $1,500 to $3,500 per lot, depending on the lot size, density, and system design guidelines. A typical dual water system for a residential development with 8,000 square foot lots would cost between $2,000-$2,500 per lot.

Many cities have allowed the developer to reduce their potable water rights fees if a dual water system for landscape irrigation is installed. Since approximately half of the annual water use is for landscape irrigation use, some cities have allowed up to a 50 percent reduction in potable water rights acquisition fees. Using the previously cited example, with water rights costing $6,024 per lot, a reduction of $3,000 in water rights fees can be realized. Given typical dual water system infrastructure costs of $1,500 to $3,500 per lot, immediate savings can be realized.

Many times, the property being developed has existing agricultural water rights that have been historically excellent water rights, but cannot be transferred to a city to meet potable water dedication. Some water rights may be undesirable to a city simply due to the fact that the water cannot be delivered to a municipal potable water treatment plant. By using the existing agricultural water for outdoor water use in new residential developments, and assuming the city will reduce the potable water right dedication if a dual water system is installed, the existing rights maintain their value to the developer and the project.

In addition to initial cost savings, the long term operational cost to deliver raw irrigation water is lower than the cost of potable water and in some cases potable water treatment plant improvements can be delayed or even avoided.

Water Requirements

Annual irrigation water requirements for dual water systems are estimated based upon the same basic criteria as any irrigation system would be, namely plant material crop coefficient, reference evapotranspiration, effective rainfall, irrigation efficiency, and irrigated area. The irrigated area for a residential lot can be estimated by subtracting the footprint of the house, driveway, patio, shed, etc. from the gross lot area. Irrigated common open space areas can be determined directly from final development plans. Many times, final landscape plans are not available for commercial properties, and some judgment may be required to estimate the irrigated area. Depending upon local ordinances, commercial properties generally require 15 to 35 percent of the gross area to be irrigated. In instances where these assumptions must be made, clear documentation of all assumptions must be understood by all involved to make sure adequate water rights are procured.

Water Source

In northern Colorado, water for agricultural irrigation has been historically provided by shallow alluvial water wells or roughly 100 independent irrigation mutual companies. The ground water wells in the northern Colorado front range area are typically 40 to 100 ft deep. The State of Colorado Division of Natural Resources regulates the pumping of water from wells. A valid well permit and ground water augmentation plan must be in place to meet current Colorado laws. The mutual ditch companies deliver direct flow river water or stored reservoir water through a network of canals, reservoirs, ditches and laterals.

One advantage of ground water pumped from wells for landscape irrigation use is that it is generally available during the entire irrigation season. One negative of ground water is water quality. The water available from the shallow alluvial wells are typically high in total dissolved solids (TDS) which can result in staining of buildings and vehicles along with the build up of salts within the plant root zone. Some ground water may be unsuitable for some plants or turf sensitive to salts. A qualified laboratory should test water samples during preliminary or conceptual system design to determine the risk. Based upon the results, additional water may be required for the leaching of salts from the plant root zones, and planting and irrigation system recommendations may developed and given to the developer to prevent claims by home owners regarding staining of houses, vehicles, or loss of plant material due to the high mineral content of the ground water. Also, many of these wells are old and poorly constructed. A video survey of the existing water well and an 8 hour stepped-draw-down pump test is highly recommended prior design and installation of any distribution system pumping equipment. A video survey of the well is useful in determining the structural integrity of the well, as well as some indication as to the level of corrosion, incrustation, or plugging of the well screen. It is recommended that the pumping test be conducted during the winter or early spring months, which historically is the time of year where static water levels are at the lowest elevation.

The historical yield and delivery constraints of individual water rights to a specific site through any mutual ditch company should be thoroughly researched prior to design. For example, ditch water delivery to a project in Golden, Colorado only allows water to be diverted into a storage pond for 4 days of a 9-day period. Another project in Longmont, Colorado allowed water to be diverted from the ditch to an onsite storage pond as required without a set schedule. A typical mutual ditch company will deliver water from May through early September, which is somewhat less than the typical landscape irrigation season running from mid April thru the end of October. To make up for this water deficit during the early and late season, commonly referred to as “shoulder months”, potable water or well water is used. In other cases, homeowners must adjust to this shortened season and accept turf greening up later in the spring and going dormant earlier in the fall. In some cases, on-site storage can help extend ditch water to the end of October, but it is not useful in the early spring since irrigation water cannot be stored from one year to the next in onsite ponds per Colorado water laws.

The quality of water delivered by mutual ditch companies is generally excellent for plant growth. Compared to ground water, ditch water is generally much lower in salts, however, it can be high in organics. The organic loading of ditch water varies by ditch, and can vary greatly throughout the irrigation season. The organic loading of ditch water quality is generally at its highest during late summer. Mechanical components such as screens, filters, and pond aeration systems are required to protect the pumps and irrigation system components and reduce odor problems associated with stagnant ponds.

Storage Requirements

The amount of onsite storage required for a dual water system is a function of water delivery constraints, peak day irrigation evapotranspiration requirement, number and reliability of water sources, and the availability of land to construct a storage pond. Typically a storage pond with enough capacity to hold a 3-to 4-day demand of peak season irrigation water is recommended. A storage pond of this size allows for some unplanned down time in the delivery of water to the site, and to allows for a reasonable cushion in the delivery of water to the pond. In any case, on-site storage must be large enough to hold the minimum order allowed by the individual mutual ditch company. For example, many ditch companies require a minimum order of ½ CFS over a 24-hour period, which is approximately 1 acre-ft. The pond, at minimum, must have the capacity to receive this volume of water without overflowing. Having to a small pond may result in the pond going dry, or overflowing when filling due to the delivery constraints imposed by individual ditch companies. On the other hand, having a large pond may result in excessive installation costs due to the value of the land lost for development, the cost of excavation and possible liner installation.

In some instances where the water supply is highly reliable and available on demand, or where multiple sources of water are available, a pond with as little as one day of storage may be adequate. In planning a dual water system for a small town in northern Colorado, a pond with one day of peak season irrigation demand was recommended due to limited availability of land to build a pond, and the fact that 8 to 10 wells are used as sources of irrigation water. The likelihood of multiple wells failing at the same time is very small. The downside of a system with limited storage and multiple water sources is the need for more sophisticated management and controls, such as telemetry or SCADA systems, to efficiently manage the operation of the dual water system.

A pond may not be required at all for some systems utilizing only well water. In many cases the irrigated area for a typical development is much less than when the site was used for the production of agricultural crops. If the irrigated area is reduced, and the well was capable of meeting the irrigation requirements of most agricultural crops, the well may have the capacity to meet the instantaneous peak demand of the dual water system.

System Sizing

As with any irrigation system, the system capacity is based upon the irrigated area, irrigation system efficiency, peak season evapotranspiration, days of operation per week, and allowable daily irrigation window. The major difference between a dual water system to individual home sites and a large irrigation system for a golf course, is the number of irrigation system managers. In the case of a golf course irrigation system, for example, one irrigation manager is typically in charge of scheduling and operating the system. This scenario allows the pump station and mainline pipe be sized to operate at capacity for a given window of time, say 8 hours per day. A typical system demand over the course of a day is very predictable and represented by a relatively flat curve. The flow ramps up to full capacity over several minutes at the start of the irrigation window and runs at capacity until the demand drops off at the end of the irrigation window.

A dual water system for a typical 80-acre development in northern Colorado may have 200 to 400 individual lots, in addition to common open space areas. As a result, these systems must be designed to accommodate 200 to 400 individual water managers, most of whom are homeowners with little or no experience in operating or managing irrigation systems. One way to design and manage a dual water system is to impose tight irrigation watering windows for each lot. For example, group 1 lots would be only be allowed to operate their irrigation systems between the hours of 10 pm and 1 am, Monday, Wednesday, and Friday, group 2 lots would be allowed to operate their systems between 1 am and 4 am Monday, Wednesday, and Friday, and so on. While this approach to system design can reduce the installation cost of the dual water system and maximize pump station operating efficiency, it is generally more troublesome and difficult to manage. Many times the restrictions are not clearly presented by real estate agents, builders, or homeowners when they sell their houses. Over time, the rules and order can breakdown leading to an overall dissatisfaction with the dual water system by homeowners. The design of systems that require users to follow very narrow operating parameters are generally only successful in systems with a small number of lots or customers, such as a development with estate lots, and with a very strong and active homeowner's association in place.

Another approach is to design the system around current lawn watering restrictions imposed by water districts or municipalities where potable water is used for irrigation. It is common for most northern Colorado cities and water districts to encourage homeowners to irrigate every other day, or every third day. Using this as a basis for design, the dual water system would be designed to allow between one-half and one-third of the individual lot irrigation systems to operate on any given day. It is common to limit the flow from an individual tap to 10 GPM, the typical flow allowed by systems using potable water and a typical 5/8" or ¾" water meter. Sizing a dual water system to allow the simultaneous operation of ½ of all irrigation services in a typical development consisting of 7,000 square foot lots is very conservative, and probably will result in excessive pump station capacity and distribution pipe sizing.

Whichever method is used for estimating peak flow, the pump station and distribution system must be sized to accommodate the estimated peak flow. Hydraulic modeling software is very useful in analyzing pipe sizing within networks. Typically the distribution pipe is sized to keep velocities below 5 feet per second. In many instances dual water systems are installed in phases and some upsizing of pipe may be required to accommodate project phasing. The irrigation pump stations must be designed to provide consistent pressure over a wide variation in flow. Pump stations with variable frequency drives are typically specified.

A typical system pumping water from a storage pond will include an pond intake screen, intake pipe, wet well, multi-pump prefabricated pump station, automatic self cleaning filter. Generally, a two or three pump system is adequate. Three or four main pumps are provided on large systems, or where redundant pumps are required to meet specific owner demands.

Where possible, the existing diversion structure and headgate that has historically been in place to control the delivery of water for agricultural use can be maintained and kept in place for the dual water system. Many times however, the existing diversion does not work with the site layout, grading, etc. In these instances, a new diversion structure, headgate, water-measuring device, and diversion ditch or pipe may need to be designed and installed. In all cases, the design and construction of any new diversion structure, the mutual ditch company must approve water measuring devices or headgates. In some cases, pumps are required to lift water from the diversion structure to a storage pond. In general, the lift pumps must be capable of diverting water to the storage pond within the constraints required by the controlling ditch company. For example, the lift pumps designed to divert water for a project in Longmont are designed to pump 1 or 2 cubic feet per second, the same flows that historically had been diverted through the gravity diversion system. In this example, the water lifted from the ditch is measured through a water meter, installed downstream of the lift pumps.

Distribution System Layout

The layout of a dual water system distribution pipe must be coordinated with all other utilities, and must be installed within defined utility easements. Generally, the distribution pipe is either installed beneath the street, along with potable water and sanitary sewer, or installed in utility easements at the back or front of each lot. Irrigation service stub-outs should be located at the same relative location for ease of installation and coordination with the installation of other utilities. Figure 1 illustrates a typical irrigation service stub-out provided to individual lots.

Regardless of where the pipe is routed, the system must be installed to safeguard the public from the possibility of cross connections with the potable water system. Where dual water system distribution pipe is installed parallel to potable water pipes under streets, a minimum separation of 10 feet is often imposed between the two pipes. Where the non-potable system must cross the potable system it is preferred to install the non-potable pipe

12-inches to 18-inches below the potable pipe. Where it is necessary to install a non-potable pipe over the top of a potable pipe many cities require the non-potable pipe be encased in concrete for a distance of 5 to 10 feet in each direction from the point of crossing. At a minimum, the non-potable pipe shall be clearly marked with non-potable water warning tape. Some cities require that non-potable pipe be of a different color than the potable pipe. Purple pipe, which is primarily required for systems using reclaimed water (treated sewage effluent), is required by some water districts for dual water systems using raw irrigation water.

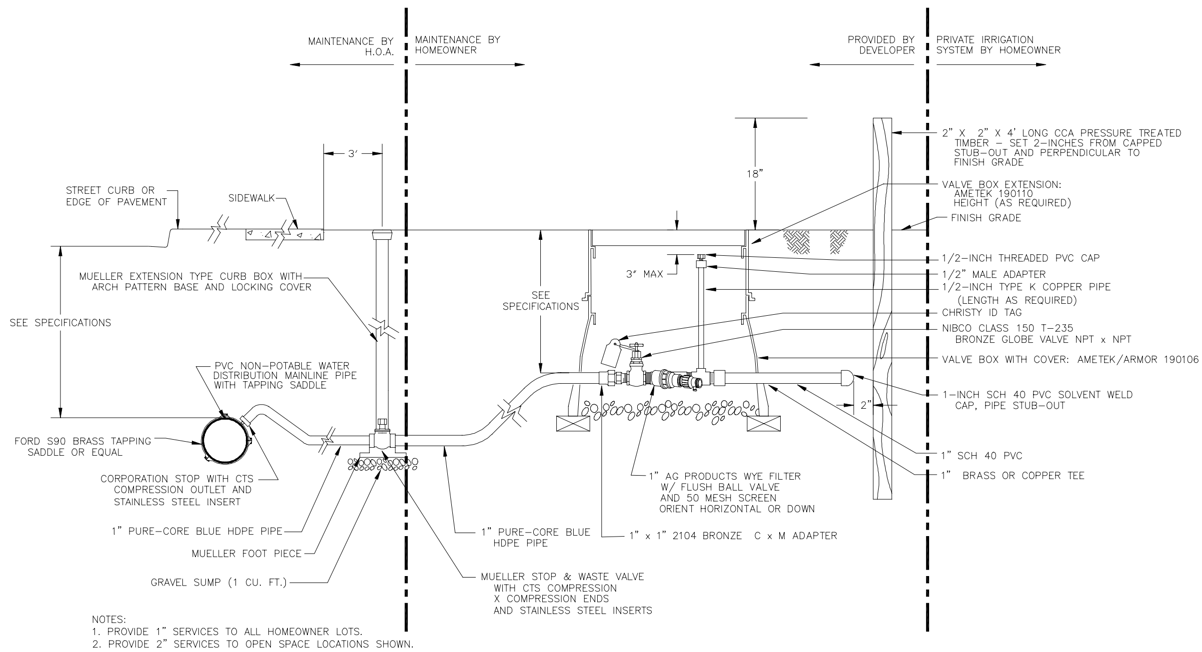

Figure 1
Typical Dual Water System Service

The installation of distribution pipe within a utility easement in the back of lots is generally less expensive, and easier to construct when compared to installing the distribution pipe under streets. Installing the pipe in the back of lots also minimizes places where the non-potable and potable pipe crossings can occur. Developments with extensive trail and open space areas, especially if the lots back up to the open space, are ideally suited for the installation of the distribution pipe in the back of lots. Access to service shut off valves and pipeline maintenance can generally occur within the open space, with little or no inconvenience to individual homeowners. For traditional developments, maintenance and service activities can be complicated since the pipe and irrigation service connections are located in backyards. Since most backyards are fenced and landscaped, annual maintenance and repair activities can become difficult.

The installation of dual water system distribution pipe under streets is generally more accessible for maintenance and service activities; however, the installation costs are generally higher than back of lot systems. Distribution pipe installed under streets are usually installed at a greater depth than backyard systems to avoid issues associated with the non-potable system crossing over the top of the potable pipes. Also, many cities require dual water systems to be constructed and installed to the same standards as potable water pipelines. Where dual water system distribution pipe is installed parallel to potable water pipes under streets, a minimum separation of 10 feet is often required between the two systems. Because of this, it is common to install the dual water system distribution piping above the sanitary sewer pipe, offset 1 to 2 feet. This allows for some economy in the installation of the dual water system since a common trench can be excavated for the sanitary sewer and dual water system pipes and services.

A majority of the systems installed in northern Colorado do not have meters at individual service connections. The advantages and disadvantages of meters is discussed for all projects, and most developers decide that the additional cost for individual meters and the ongoing maintenance cost for reading the meters and the associated costs for billing are not justified. Some HOA's charge homeowners a flat rate for irrigation water and include the cost for operation of the system with homeowner's monthly or annual dues. The provision of meters allows HOA's to charge homeowner's who waste water more. During drought conditions, the installation of meters also allows the HOA's to impose a stepped rate structure to financially penalize homeowners who use more water than allotted. The provision of meters can also reduce the potential for conflicts between homeowners over water use, particularly between the xeriscapers and the mushroom growers (those who water three times per day whether the turf needs it or not).

Other pipeline components, such as isolation valves, air relief valves, and blow off valves should be located in easily accessible locations and preferably not in back yards or locations with difficult or limited access. If possible, isolation valves should be located to allow the isolation of a small section of the distribution pipeline. An ideal system would allow the isolation of one block of distribution pipe without shutting down service to the rest of the system.

Adequate space must be provided for maintenance access to pump stations, well pumps, and other equipment. For systems using well water, adequate utility easements should be provided to allow for a replacement well to be constructed some time in the future.

System Management

On going management of each dual water system requires a competent maintenance contractor, and a cooperative homeowner's association. In many cases, the developer of the project maintains ownership and operation of dual water systems. The system is operated as a utility and offers an opportunity for ongoing revenue and profit, while at the same time reducing irrigation water costs for individual homeowners.

A clear line of responsibility and maintenance must be established between the HOA and the individual homeowners. As noted in Figure 1, the HOA is in control of the distribution pipe up to and including the main shut-off valve, typically a brass stop and waste valve. The homeowner is responsible for the system downstream of main service shut off valve. A separate hand-operated shut off valve, wye strainer, and winterization riser is provided in a separate box for the homeowner's use.

At the start of each season the HOA will typically start up the pump station, fill the distribution pipeline, and inspect the integrity of the system. Then each service will be turned on. Where problems are noted with individual systems, the hand-operated valve downstream of each main service shut-off valve should be closed and a note given to the homeowner about the nature of the problem. At the end of each season, each service should be shut off and the distribution and pumping system winterized as required. The HOA must clearly communicate with the homeowners prior to each of these activities.

One of the most important tasks of any maintenance contractor is the monitoring and management of the main water supply for the dual water system. If a well water source is used, the annual water use from each well must be documented. To make sure water use does not exceed the annual limit, monthly water use should be recorded and monitored. If excessive water is being used, the manager of the system must notify the HOA so conservation or water restrictions can be imposed to decrease water use.

If raw surface water is the dual water system source, the maintenance contractor must monitor the water levels in the storage ponds and order water through the ditch rider to be diverted into the storage pond. As noted above with ground water, the operator of the dual water system must know how much water has been used and how much water is available for use at any point during the irrigation season. This information is especially critical during drought years, just as we are currently experiencing in Northern Colorado. Some irrigation mutual companies are seeing record low yields this year, resulting in early shut down of ditch and canal systems. It should be noted that during this past year most northern Colorado cities and towns have imposed strict water conservation policies for irrigation systems using potable water, making dual water systems no more or less desirable than systems supplied with potable water during drought conditions.

The owners and/or managers of dual water systems must also determine how much to charge customers for raw water delivered to their homes or properties. The water rate must include the cost for electricity, pump station and distribution system maintenance and repairs, system management, and profit. In addition, a sinking fund should be set up to collect and save money for the eventual replacement or renovation of the entire dual water system.

Summary

Given the high value of water in northern Colorado, dual water systems are economically viable. By installing dual water utility in new developments, developers and cities can take advantage of the existing infrastructure of raw water canals, reservoirs, mutual irrigation companies, and ground water wells that previously supplied irrigation water for agricultural crop production. By using these resources, developers can benefit by reducing their costs for the procurement of potable water rights, and cities and/or potable water suppliers benefit by delaying or even avoiding expansion to their potable treatment facilities.

A well planned, designed, constructed, and managed dual water utility will ensure that cities, developers, homeowners, and HOA’s will all see long lasting benefits of using existing irrigation water resources with minimal inconvenience.