Selection of a Reuse Factor for the Portfolio Tool Planning Exercise
Metro Roundtable

1. Purpose of this Paper

This paper provides background information on municipal water reuse, examples of water reuse by Metro Roundtable member utilities and describes how the Metro Roundtable's reuse factor was selected for the Portfolio Tool planning exercise. The Metro Roundtable prepared a companion paper titled "Metro Roundtable Conservation Strategy" that was used in selecting future conservation levels in the Portfolio Tool planning exercise.

The Portfolio Tool was developed by the Colorado Water Conservation Board for an exercise by the basin roundtables to consider various methods or portfolios for meeting future municipal water supply needs. Each basin roundtable has been directed to produce a set of portfolios using the Tool.

To develop a portfolio, the user of the Tool needs to specify an amount of a hypothetical new supply to develop for meeting municipal water needs. The new supply would come from developing new water sources or from purchasing agricultural water rights. Both of these sources of water are assumed to be reusable. The Tool user then specifies the additional amount of supply that could be gained from successively reusing the new supply. This amount is input into the Tool as a **percentage of additional supply from the reuse of the new supply.*** We refer to this as the **reuse factor** in this paper.

Here is an example to explain how the reuse factor is defined.

> Assume development of 100,000 acre-feet per year of new supply. If the new supply can be reused with a 50% reuse factor, that means an additional 50,000 acre-feet per year of supply would be available through the reuse of the new supply. The 50,000 acre-feet is the **cumulative amount of supply derived from all reuses after the first use** of the 100,000 acre-feet. The total supply would be the first use of 100,000 acre-feet

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plus the additional amount of supply from reuse of 50,000 acre-feet for a total supply of 150,000 acre-feet per year.

It should be noted that the reuse factors presented here are calculated at the water treatment plant. In order to calculate the reuse factor starting at the source of water, rather than at the water treatment plant, one should apply the system losses from the source of water to the treatment plant which could include reservoir evaporation and river transit losses.

Disclaimer. This paper does not estimate reuse capabilities in other basins, leaving that planning consideration for the local roundtables. It is important to note that the Portfolio Tool is a simplistic tool developed for a high level state-wide planning process by volunteer citizen groups. Information from the Tool is not necessarily applicable at the regional or water utility level or for professional water planning. The information in this paper and the information from the Tool are not suitable for use in regulatory and legal processes. Reuse factor information in this paper is for a general, hypothetical supply project. Actual reuse factors will vary depending on the specifics of individual water utilities and their water rights, infrastructure, projects, and other circumstances.

2. Background Information

Reuse rights. Water right decrees determine whether water can be reused. Municipal water right decrees older than about 30 years usually do not allow reuse. For instance, many of Denver Water's east slope decrees do not allow reuse. Water right decrees that transferred water from agricultural to municipal uses usually allowed reuse of a portion of the transferred water. Likewise, most transbasin decrees allow reuse, as do most recent municipal decrees. Also, non-tributary groundwater can be reused. For this Portfolio Tool planning exercise, it was assumed that all the water available from the hypothetical new supply project would be fully reusable.

Sources of Reusable Water. The largest source of reusable water is the water discharged from wastewater treatment or reclamation plants after the water has been used for various purposes in the potable municipal water systems.

An additional source of reuse water is from Lawn Irrigation Return Flows (LIRFs). This is water that is not consumed by lawns or plants being irrigated or lost to evaporation during irrigation application. This water flows back to the river on the surface or, over a longer period of time, through groundwater. Similar to reusable effluent, the amount of LIRFs that can be reused is dependent on the water rights used in the municipal system.

Reusable water that is returned to the river from wastewater reclamation plants and from LIRFs are collectively referred to as "reusable return flows" in this paper. The amount of the return flows that can be reused depends upon the water rights used in the municipal system. In general, if, for example, 30% of the water rights being used by a utility are reusable, then 30% of the return flows can be reused.

Method for Reusing Water. Metro basin providers have developed many different ways to reuse their water in an effort to make the most efficient use of their resources.

A primary means of reuse is to operate a river exchange. Generally in a river exchange water is diverted from a river at an upstream municipal intake in trade for reusable return flows provided to the river at a downstream location. Usually the exchange is a one-for-one trade in the amount of water. Reusable return flows can also be recaptured and stored for later release to operate a river exchange. There are several limitations on river exchanges: a major one being the amount of river water that is available for upstream diversion. There are several water right administration conditions that must be met including no injury of intervening water rights. Water quality considerations can also limit river exchanges.

Reusable return flows can also be used in augmentation plans for augmenting out-of-priority tributary wells that are used to irrigate parks, golf courses, and other green spaces. In some cases it is legal to lease reusable return flows to other municipal users or to farmers.

Reusable return flows can be used to pay "return flow obligations" associated with agricultural transfers, which, in effect, enlarges the amount of transferred agricultural water that can be used for potable purposes. Reusable return flows can be captured, treated, and delivered for non-drinking water uses and for drinking water uses.

Greywater use may become another way to stretch water supplies. This paper did not address greywater use because of the many legal constraints and issues that need to be addressed.

Reuse Limitations. Using simple theoretical calculations of the amount of water consumed in each use of water and assuming there are no other losses or limitations in the ability to successively use the water until nothing is left, it appears that the reuse factor should be well over 100%. However, as explained in section 3 below, the experiences of water providers in the Metro Roundtable show that the actual reuse factor is much lower. Below is a general outline of technical factors that can limit the reuse of water. There are additional social, economic, and legal factors that are not listed.

- Water right decrees – please see above for an explanation of these limitations.
- River conditions – please see above for an explanation of these limitations.
- Infrastructure capacities – facility sizes can limit the amount of reusable return flows that can be captured, stored, released, treated, or used.
- Losses within water supply systems, consumptive use of water, and losses within the wastewater collection and treatment systems all reduce the amount of available reusable return flows. Below are examples:
    - River transit losses – Reusable return flows are often transported in rivers. Examples are from an upstream reservoir to the river intake for a water treatment plant, and from the wastewater discharge to a storage area or downstream point of diversion. The State Engineer's Office assesses the river transit losses.
    - Reservoir seepage and evaporation.
    - Losses from river diversion systems and from leaks in pipes that transport water to water treatment plants.
    - Water treatment plant losses.
    - Water distribution system losses and leaks.
    - Consumptive use by customers – this is the water consumed by customers for various purposes. Most indoor uses do not consume more than about 5 to 10% of the supply. Outdoor landscaping uses consume a much greater percentage of the water, and some industrial uses can consume all of the water.
    - Wastewater collection and treatment losses.
    - Losses in ditches, pipes, and gravel pits that collect and store reusable return flows.
    - Non-potable and potable treatment and distribution system losses.
- Supply and demand timing. The timing of supply of reusable return flows does not always match up with potential uses. For instance, flows of reusable return flows from wastewater reclamation plants can be fairly high, as a percentage of water produced by the water utility, in the winter time because most winter uses are indoor and those uses consume only a small amount of the water. Without additional capture, storage, and delivery facilities, full reuse of return flows that are discharged from wastewater reclamation plants in the winter may not be possible.
- Water quality requirements. Water from reuse projects may need to be blended with higher quality water before it can be used for drinking water. The lack of high quality blending water can limit reuse of lower quality supplies. Membrane filtration and reserve osmosis treatment is sometimes used for drinking water reuse. Brine is a byproduct of this type of treatment which has environmental disposal concerns. Also,

water quality standards such as temperature or total nitrogen can result in the need for wastewater reclamation utilities to implement treatment technologies that result in significantly higher consumptive use than typical advanced or tertiary treatment. For example, total nitrogen stream standards that require membrane filtration or reverse osmosis treatment can result in a loss of up to 20% of the treated water.

Below is a list of other technical factors that would tend to reduce reuse capabilities. This paper did not attempt to determine the effects of these other limitations. Therefore, this paper may over-estimate reuse capabilities.

- Conservation methods affect reusable return flows. Metro Roundtable feels that it is important to refine the Portfolio Tool to account for the relationship between conservation and reuse.
- Drought restrictions also reduce wastewater flows and decrease reuse potential.
- A warmer and/or drier climate could substantially reduce supplies and increase water use which affect reuse capabilities. Also, climate change could significantly affect the ability to operate river exchanges.
- If the hypothetical new supply comes from the Colorado River, compact curtailment could reduce supplies and the reuse of those supplies.

For the Metro Roundtable water providers, most of the river flow available for use in river exchanges has been appropriated or will be in the near future. Therefore, most future reuse will require capturing, treating, and delivering the reusable returns. This makes future reuse much more expensive and requires much more energy use than the current reuse that is done through river exchanges.

3. <u>Examples of Current Reuse in by Metro Roundtable Utilities</u>

Aurora Water Current Reuse. Aurora Water currently reuses water by river exchange, through the Prairie Waters Project (PWP), and through the Sand Creek Reclamation Facility for landscape irrigation.

Factors that influence AW's reuse potential include:

- Contractual obligations. (AW must deliver return flows to entities with whom it has a contractual commitment, some of which are in perpetuity.)
- Reusable water. (Approximately 90% of AW's portfolio is decreed as fully reusable.)

- Indirect reuse. (AW reuses return flows by exchange, which is limited due to water availability and river call.)
- Water quality (because of AW's commitment to meet high quality drinking water standards, the amount of reuse water captured by PWP is limited due to blending water constraints related to higher total dissolved solids [TDS] levels with PWP water).
- Service area. (PWP water is currently only delivered to one of three water treatment plants limiting the service area that can receive PWP water.)
- System losses.
- River losses. (The PWP captures Aurora's return flows downstream of the point of discharge.)

Given these factors, **AW's reuse factor is currently 30%**, i.e., for every unit of water at the treatment plant, AW is able to meet another 0.3 units of demand from reuse. As explained below, AW expects its reuse factor for new fully consumable supplies to be higher than 30%.

Denver Water Current Reuse. Roughly one quarter of DW's supplies are currently reusable, most of which come from the Blue River diverted through the Roberts Tunnel. (Most of the water diverted through the Moffat Tunnel is legally not reusable by contract. And, most of the South Platte water is not reusable). DW's primary means for reusing water is through river exchanges. River exchange amounts vary widely depending on the amount of reusable water in the system, the amount of river flow available for exchange, water use patterns, water rights administration conditions, etc. River exchanges are limited in dry years because of lack of available river flow to divert and in wet years by not having senior downstream calling rights with which to exchange water. Water is also reused through augmentation plans and water leases. Denver Water is building gravel pit storage downstream of wastewater return flow points to store reusable water for times when river exchanges can be made. Denver Water is also building a water recycling plant to reuse water for irrigation and industrial uses.

Over the past 10 years, Denver Water's **reuse factor** for its Blue River water has averaged **roughly 30%.** This factor will increase as the gravel pits and the recycle plant are built out. Denver Water is in the process of quantifying LIRFs which will also increase the factor.

Centennial Water and Sanitation District Current Reuse. Centennial Water and Sanitation District's (CWSD) water source portfolio includes river water rights with decrees that allow reuse, non-tributary rights from mining rights, and non-tributary groundwater which is essentially fully reusable. Non-potable reuse is practiced with treated wastewater effluent applied to golf course and park irrigated areas. Wastewater discharged below Chatfield Reservoir may be recaptured at times through alluvial wells downstream, and also through exchanges and an augmentation plan. Reusable water in these operations may also be exchanged to storage and subsequently delivered to optimize reuse and recapture potential.

The recapture and reuse of water is relatively efficient for CWSD because the return flow recapture operation occurs within a short distance. However, losses through the water treatment and distribution system reduce the efficiency, along with the limitations mentioned earlier.

For the period 1996-2011, CWSD has been able to maximize the reuse of its reusable water discharged from our wastewater reclamation plant. This rate of recovery is highly dependent upon having adequate supplies of reusable water available in the non-irrigation season.

City of Thornton Reuse. Much of the City of Thornton's water supply is associated with transferred agricultural water rights. As such, much of Thornton's available reusable effluent is used for payment of "return flow obligations" associated with the transfers. Reusable effluent is also used to operate river exchanges to Thornton's water supply diversion points on the South Platte River and Clear Creek, and to augment well pumping and lake evaporation in the City. Thornton is developing additional facilities to capture, store, and release reusable effluent that can't be reused on a real-time basis as it is discharged from the wastewater reclamation facility. Finally, reusable effluent is used to meet certain contractual obligations. Thornton uses its Lawn Irrigation Return Flows in generally the same manner as reusable effluent, though the timing and location of LIRFs are different than reusable effluent. **Thornton's current reuse factor is approximately 40%**, and the City expects that to remain somewhat constant as new supplies are added, since Thornton is concurrently developing facilities to promote the reuse of the new supplies.

4. <u>Estimation of Reuse Factors for New Supplies</u>

Metro Roundtable providers analyzed the amount of reuse they would expect from a new water supply project. It is expected that ongoing reuse efforts will fully develop the potential for river exchanges to municipal intakes in and above the Denver Metro area. Therefore, to reuse water from a hypothetical new supply project, most providers would need to use facilities much like those in the Prairie Waters Project which would need to be built downstream of the wastewater plants in the Denver Metro area to capture, transport, and treat the water for potable uses in the metro area.

Because of the long distances (in many cases over 30 miles) and the amount of elevation gain (in many cases over 1000 feet) required to pump and transport water combined with the advanced treatment needed, this type of reuse project would cost hundreds of millions of dollars to well over a billion dollars depending on the size of the hypothetical supply project.

It should be noted that the reuse factors presented here are calculated at the water treatment plant. In order to calculate reuse factor starting at the source of water, rather than at the water treatment plant, one should apply the system losses from the source of water to the treatment plant which could include reservoir evaporation and river transit losses.

Aurora Water Analysis. In order to calculate AW's reuse factor for new supply sources, the following assumptions were made:

- Future indirect reuse by exchange is highly limited.
- All new supply is fully reusable to extinction.
- Expansions to the capacity of Prairie Waters Project have been completed.
- Improvements have been made to allow PWP water to be delivered to a greater portion of Aurora's demand.
- Blending of recaptured water is still required to meet water quality goals.

Under these assumptions, the **reuse factor for new supply sources is calculated to be 50%**. The true reuse potential for new supply sources will depend on many system-specific factors, with the major drivers for AW being blending requirements to maintain water quality goals and other infrastructure upgrades. The true reuse potential could be more or less than the reuse factor predicted. However, the true reuse potential is representative of AW's current system and is based on reasonable assumptions about future system improvements and operations.

Denver Water Analysis. Denver Water performed an analysis that considered the following limitations, losses, and factors to determine an estimate of a reuse factor for new supplies.

- 58% of the water discharged from water treatment is used indoor and 82% returns to the river at wastewater treatment discharge points.
- 42% of the water discharged from water treatment plants is used outdoors and about 4% returns to the river from reusable lawn irrigation return flows.
- 3 to 6% transit loss from wastewater discharge to downstream diversion point.

River transport and storage losses from the new supply were not accounted for. It was assumed the new supply is the amount available at the water treatment plant. Losses were not factored in from the downstream diversion through the transport, treatment, and delivery into the potable water system. Evaporative losses from storage were not accounted for. The consumptive use in recycling water through a non-potable system was not considered. About 80% of the water treated and delivered to DW's non-potable recycle plant is consumed, leaving about 20% available for subsequent reuse. Perfect operations were assumed, with no adjustments for operational problems and limitations. It also assumed that facilities would be sized to capture, store, transport, and deliver the full amount of reusable supply. This may not prove to be an economical decision.

Based on a simple analysis of the information above combined with some exercises in system modeling, it was estimated that for each acre-foot of new supply that could be used and then recycled through a Prairie Waters type system, a range of about 0.5 to 0.8 acre-feet of additional demand could be supplied through multiple recycling of the new supply. After adjusting for the losses and limitations mentioned in the preceding paragraph, it is expected the **reuse factor would be about 50%** . The actual amount is expected to be lower when the additional losses and operation considerations described above are accounted for. A more detailed analysis would be needed for water utility planning.

Centennial Water and Sanitation District Analysis. When the recapture of raw water diverted from the river is considered on an annual basis, and considering the various losses in the total system (which can be in the range of 15-30%), the **overall reuse factor of 50% should be appropriate for new sources.**

City of Thornton Analysis. Thornton performed an analysis that considered the City's operations, water rights, and facilities to determine an estimate of a reuse factor.

- On an average annual basis, for every one acre-foot of fully consumable water used in Thornton's system, approximately 0.56 acre-feet of reusable water is generated as reusable return flow.
- On an average annual basis, for every one acre-foot of available reusable return flow, the City can generate approximately 0.54 acre-feet of yield through the payment of return flows and by operating exchanges.
- Through repeated reuse of supplies, Thornton can generate approximately 1.4 acre-feet of yield from an initial supply of 1 acre-foot of fully consumable water, resulting in an **overall reuse factor of approximately 40%.**

6) <u>Selected Reuse Factor for the Portfolio Tool</u>

The analysis above results in a reuse factor in the range of about **40 to 50%.** The Metro Roundtable **chose to use a 50% reuse factor.***

This analysis considered only four of the many water providers in the Metro Basin. As noted above, this estimate may be high for several reasons. Because this is a high level planning effort, we did not feel a more detailed analysis to address these issues was warranted or within the resources of the roundtable to conduct. As explained in the disclaimer, results will vary for individual water utilities and their projects. The Metro Basin made no attempt to estimate or plan for reuse capabilities in other basins, leaving that decision to the individual basins.

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