City of Louisville

COLORADO • SINCE 1878

Drought Management Plan

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City of Louisville Public Works Department

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Introduction

The purpose of this plan is to provide operating guidelines regarding drought management strategies that are specific to the City of Louisville. Inputs to the drought management plan included: 1) a review of the City's current water/storage supplies and total municipal water demands; 2) Louisville's water conservation efforts; 3) historical drought data in the South Boulder Creek drainage basin; and 4) the parameters involved with the City's "design drought" as described in the City's 2016 Water Management Plan.

The City's drought management goal is to supply water demands within specified parameters and risks (design drought) at a reasonable cost. This plan outlines responses for these specified conditions and further describes responses for future droughts more severe than the design drought.

Using this information, a drought plan was developed identifying four drought stages with accompanying response strategies. The plan was designed as a management tool for use in conjunction with other City-wide inputs and "real-time" hydrological statistics. It is not intended to be the sole criteria used in Louisville's drought response strategies because other considerations, as listed below, are also important for determining the appropriate City drought response:

- Precipitation forecasts
- Availability of storage space
- Carryover storage
- Available water right volumetric limits
- Highly variable runoff
- The uniqueness associated with each historical drought
- Surrounding communities and media response
- Economic distributions
- Environmental considerations

City Water Supplies

The City's water supplies include forty-four surface rights located on South Boulder Creek, three reservoirs (Marshall, Harper, Louisville), Colorado-Big Thompson Project ("C-BT") water supplies and Windy Gap Project supplies (occurring in the near future). These combined water rights are the water/storage supplies owned and operated by Louisville that are affected during drought conditions.

South Boulder Creek

Marshall Lake

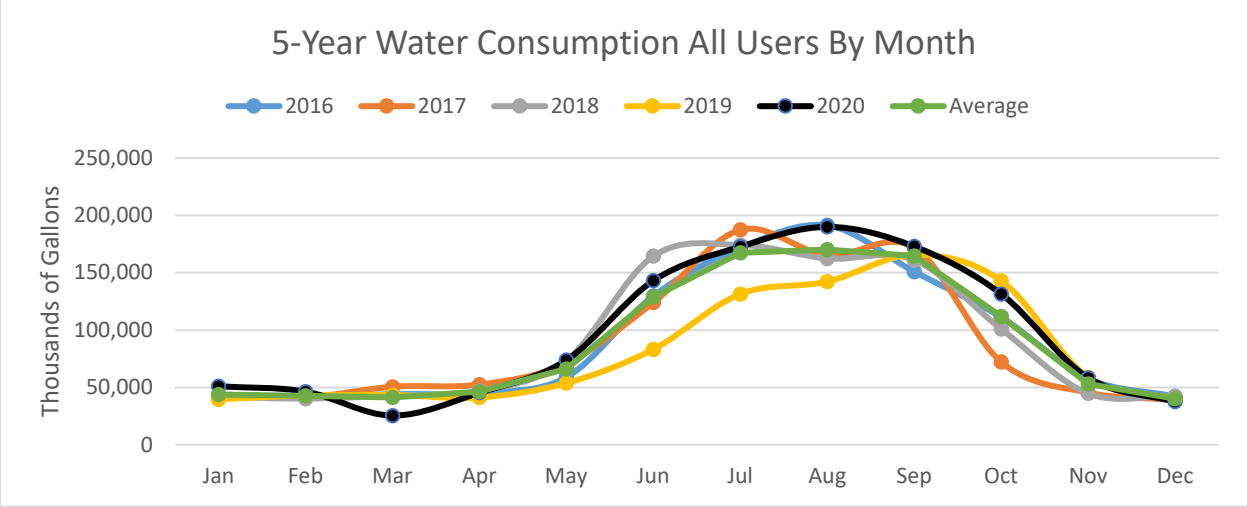
Alva Adams Tunnel (C-BT)

City Water Demands

The City's water demand fluctuates annually, however the water use patterns are generally predictable: historically approximately one-half of the City's total water demand is related to outdoor use (lawn irrigation) while the other half is used for indoor domestic, industrial, and commercial purposes.

The City's water demand for the past five years (2016-2020) was reviewed in preparation of this plan and is shown in Chart 1 below:

Chart 1
5-Year Monthly Water Consumption

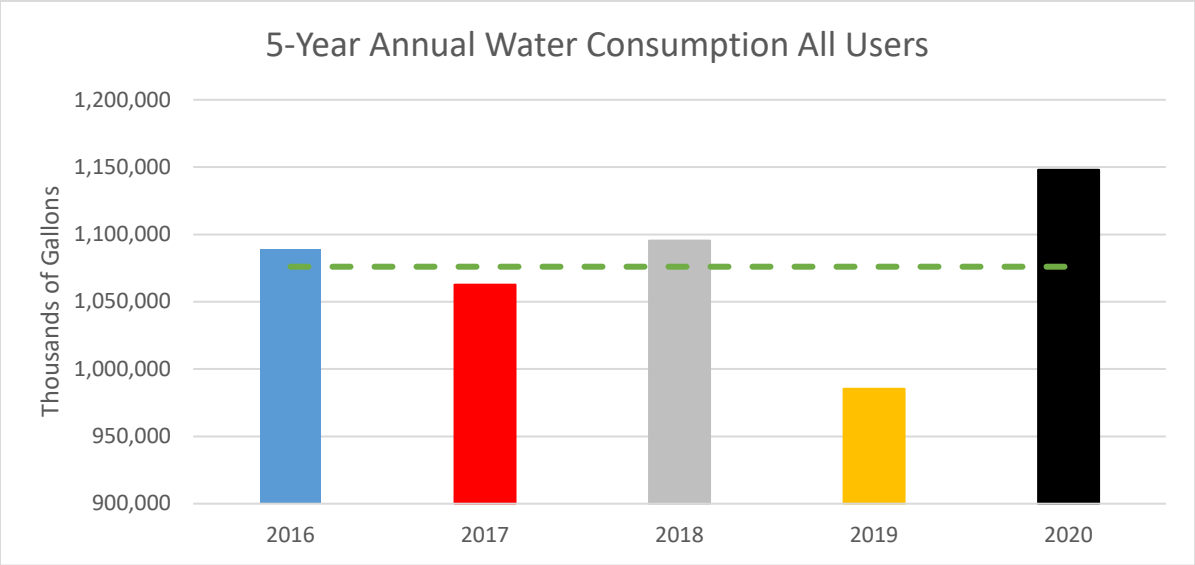


The average monthly water demand during the winter months is typically between 40-50 million gallons or approximately 1.3 to 1.7 million gallons per day. By contrast the average monthly water demand during the peak summer months is typically between 160-170 million gallons or approximately 5.3 to 5.7 million gallons per day. This shows that there is an average multiple of

four times when comparing winter to summer month demand. This also demonstrates the significant impact of irrigation requirements.

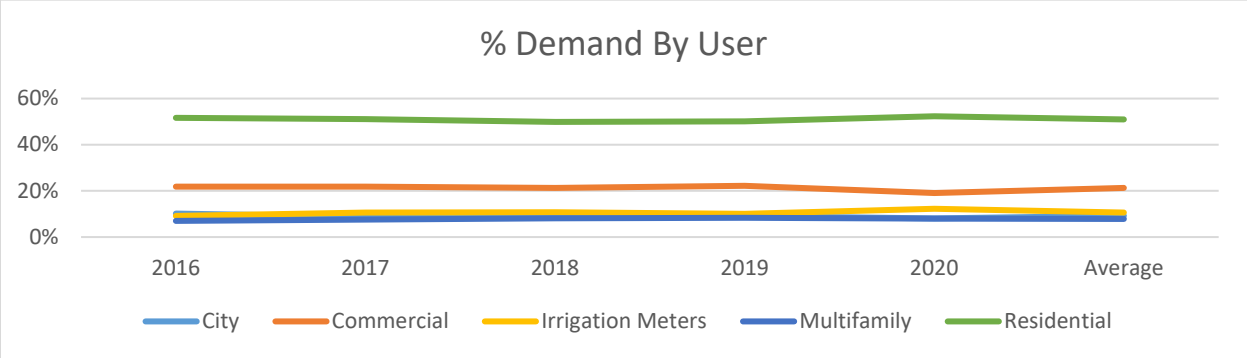
Annual water demand for the past five years averages approximately 1 billion gallons as shown in Chart 2 below:

Chart 2
5-Year Annual Water Consumption



Additionally water demand by user type was reviewed as shown in Chart 3 below:

Chart 3
Water Consumption By User Type



The consumption by user type has been consistent for the last several years with residential users accounting for the majority of the annual water demand with an average of 51% of the total usage. Commercial users account for an average of 21%, dedicated irrigation meters at 11%, City facilities at 9%, and multifamily housing at 8%.

Climate Change

Data from various studies, including the September 2016 Rocky Mountain Climate Organization's publication: Future Climate Change Extremes in Boulder County, indicate that droughts will become more frequent and severe due to predicted climate change. Precipitation patterns will also shift from less snow to more rainfall. This will subsequently alter the historical runoff patterns of South Boulder Creek, resulting in the peak runoff period to occur earlier in the spring. With this change in runoff timing and amounts, water right administration will also be affected.

It is anticipated that climate change impacts will occur over a period of years/decades. Therefore, it is reasonable to assume that responses to these impacts will be developed in advance and subsequently implemented to reduce future vulnerability. It is not anticipated that Louisville will be a single player regarding climate change impacts within the South Boulder Creek basin, but rather will collaborate and coordinate with other regional water providers to address common issues.

Drought Definition

The City is defined to be operating within drought conditions at times that available water supplies, over multiple years, are significantly less than average-year supplies. The severity, length and magnitude of a drought cannot be easily recognized in its initial stages. The severity of a drought also depends on the vulnerability of affected water users. Realistically, the magnitude of a drought period can be determined only after it has occurred. Therefore, the difficulty of defining a drought is a real-time issue. For example, a one-year time period is not usually considered a drought by Louisville's standards (see Louisville's Water Master Plan) but a two-year duration is the basis for the City's design drought. Therefore, the amount of time in which to identify and/or project drought conditions is limited, creating unique management challenges for the City's staff and policy makers.

General Guidelines

The City's 2016 Water Management Plan identified the 1963-1965 drought on South Boulder Creek as the "design drought" used to develop various water operations and management strategies. The analysis highlighted several factors unique to Louisville's water resources: 1) drought period of 1-3 years; 2) limited amount of time to react to drought conditions; 3) water

storage limitations; 4) firm annual yield supply; and 5) the need to develop updated drought response strategies.

The key factor in assessing drought actions for Louisville is associated with the drawdown of City-wide storage levels during the first two years of any given drought. The City currently utilizes and plans for a two-year storage buffer available for the design drought periods. During the first year of the design drought, water storage levels are drawn below average end-of-water year (November 15th) recorded levels. During the second year, the City is reliant on: 1) its reservoir and C-BT carryover from the previous year and; 2) the amount of water diverted from South Boulder Creek. From the design-drought analysis, Louisville would only implement drought response strategies once a drought has begun and is already in its second year. As a result, according to the analytics, the City would implement restriction only after the drought has begun, with no actions necessary prior to the drought's onset. At that point, storage levels have decreased sufficiently to indicate that City-wide water demand reductions are necessary.

While these analytics are helpful, the fundamental problem to determine the timing of drought responses is knowing the depth of severity on a real-time basis. Reserving response strategies until the second year of a drought can expose the City to greater supply shortages as a result of the uncertainty in estimating whether any single dry period represents the design drought criteria. Any given drought could be longer or shorter in duration and severity than the design drought, with no reliable "prediction" indicator to provide management insight. Therefore, the design drought analytics should be in combination with the other factors. For example, due to the extreme hydrological conditions in 2002, Louisville implemented watering restrictions during the first year of the drought, rather than risk further storage level drops in Marshall Lake.

Implementing Drought Management Restrictions

A critical component to properly manage the City's water resources during drought periods is to identify the appropriate time to implement the Drought Plan responses. Implementing the drought plan too early results in supplies exceeding demands, negating the need for outdoor water restrictions. Contrarily, implementing restrictions too slowly results in a significantly below average drawdown of City-wide storage levels, reducing carry-over supplies for subsequent use if drought conditions continue.

The time of year in which drought management restriction are determined will depend on a variety of hydrological factors: winter snowpack within the South Boulder Creek, projected C-BT's west slope deliveries, Marshall Lake carry-over storage supplies, and the City's water usage. At times snowpack and/or runoff levels are significantly below average within the South Boulder Creek drainage (e.g. 2002), it is reasonable to anticipate water restrictions during April-October. However, at times when snowpack levels are only marginally below average, timing the drought responses becomes more difficult. Historically, during times of low spring snowpack within the basin, the City relied more heavily and earlier on C-BT supplies prior to implementing outdoor

watering restrictions. By doing so, the City prevented the need to impose drought restrictions too early in the summer's irrigation season but risked the need to implement the same restrictions later in the summer (July-August) or the following spring.

Drought Indicators

To address the impacts of a drought, historical empirical data is reviewed to develop a set of accurate indicators to assist in the following management issues:

- Determine whether water shortages are likely to occur (the onset of a drought)
- Determine the actual severity of the drought and the accompanying drought response strategy
- Determine the length of time needed to recover from a drought event

The data used for such an analysis included:

1. Snowpack readings: February 1 - May 1 of each year (Note: Snotel stations at Eldora, University Camp and Berthoud Pass are the nearest sites, but because of geographical differences these sites can only be used as a general representative of runoff rates in the South Boulder Creek basin.)
2. Reservoir levels as of April 1- May 1 of each year
3. Estimated raw water treatment plant demands from May 1 - October 31, based on historical data and trends, i.e. annual monthly historical data, 5-year running average, or 5-year monthly maximum volume.

This information is combined to develop the City's major drought indicator: the Water Supply Index ("WSI"). The WSI is a predictive tool for the City's annual water supply and, subsequently, assessing the probability of an anticipated drought. The WSI is a predictive tool that utilizes numerical input to assess water supplies and demands for any given runoff season. The WSI calculation is as follows:

WSI = Supply/Demand, or more specifically:

WSI=Carryover (last) + SBC Direct Water Rights + Northern Water (C-BT and/or Windy Gap) + Marshall Reservoir Storage / City Demand - Carry over (next)

Whereby:

Carryover (last) - volume of water in the City's storage system carried over from the previous year.

SBC Direct Water Rights - projected total diversions from South Boulder Creek in the current year. Prior to the spring runoff period, projected flows are based using the historical streamflow records and relationships between snowpack levels and subsequent runoff rates and volumes. (Northern Colorado Water Conservancy District ("Northern") provides runoff projections by basin starting early in the year.)

Northern Water - actual and projected water available for Colorado-Big Thompson and Windy Gap allocations. Louisville's portion of C-BT storage is the maximum amount of projected available water stored in Granby, Carter and Horsetooth Reservoirs during the ensuing May-June period, times the ratio of Louisville's CBT units divided by the total number of C-BT units in the CBT Project, plus the net amount of any CBT water that Louisville carried over in the CBT system.

Historically, the "Winter Quota" is initially set in November at 0.5 acre foot per unit of C-BT owned and supplemental additions to the quota occur in April, with possible adjustments later in the summer depending on storage availability. The Final Quota is usually set between 0.5 and 1 depending on the need of the supplemental supply and the amount of storage volume within the C-BT project.

If storage is drawn down from previous year's levels, then the Winter Quota is reset based on availability of water: 70% if runoff into the CBT system is 75% of average or greater next spring and 50% if runoff into the CBT system is 100% of average or greater. This inverse relationship is typical of supplemental water supplies whereby water is stored in wet years and reallocated during dry periods.

Upon completion of the Windy Gap Firming Project, Northern water supplies will also include Windy Gap supplies. Estimated completion is expected in 2024.

Marshall Reservoir - actual and projected City stored water in Marshall Reservoir for the current year.

Demand - estimated City water uses for current year (5-year running average).

Carryover (next) - amount of estimated carryover requirements for the following year(s) to address a multiple year drought.

The WSI indicates the expected amount of water shortage (if any) by comparing anticipated supplies with "average" annual demands. From the results of the City's Water Management Plan, the critical period for water supply projections is March-May. This is the time of year at which: 1) the City's reservoirs are near their lowest levels; 2) direct diversions of the City's South Boulder Creek water rights are still limited; and 3) reliable snowpack data is available. Given this information, the base work to assess potential drought implications can be developed for the upcoming irrigation season.

Caution is required in using the WSI as the sole indicator of a drought. The WSI incorporates water supply and demand components used for managing drought conditions, but other factors

must also be considered: annual snowpack/runoff statistics, monthly rainfall amounts, daily maximum temperatures, and the City's monthly water use patterns. A rapid increase/decrease in one of these factors will cause the WSI to fluctuate during any given month. Therefore, updating and recalculating the WSI on a regular (weekly, monthly) basis is recommended.

From a practical accounting perspective, a rule-of-thumb goal for each upcoming "water year" is to have the following storage account levels by November 1st of each year:

Marshall Reservoir	1,100 acre feet
Harper Reservoir	750 acre feet
Louisville Reservoir	200 acre feet
C-BT Deliveries	1,000 acre feet
	3,050 acre feet

Drought Determination and Stages

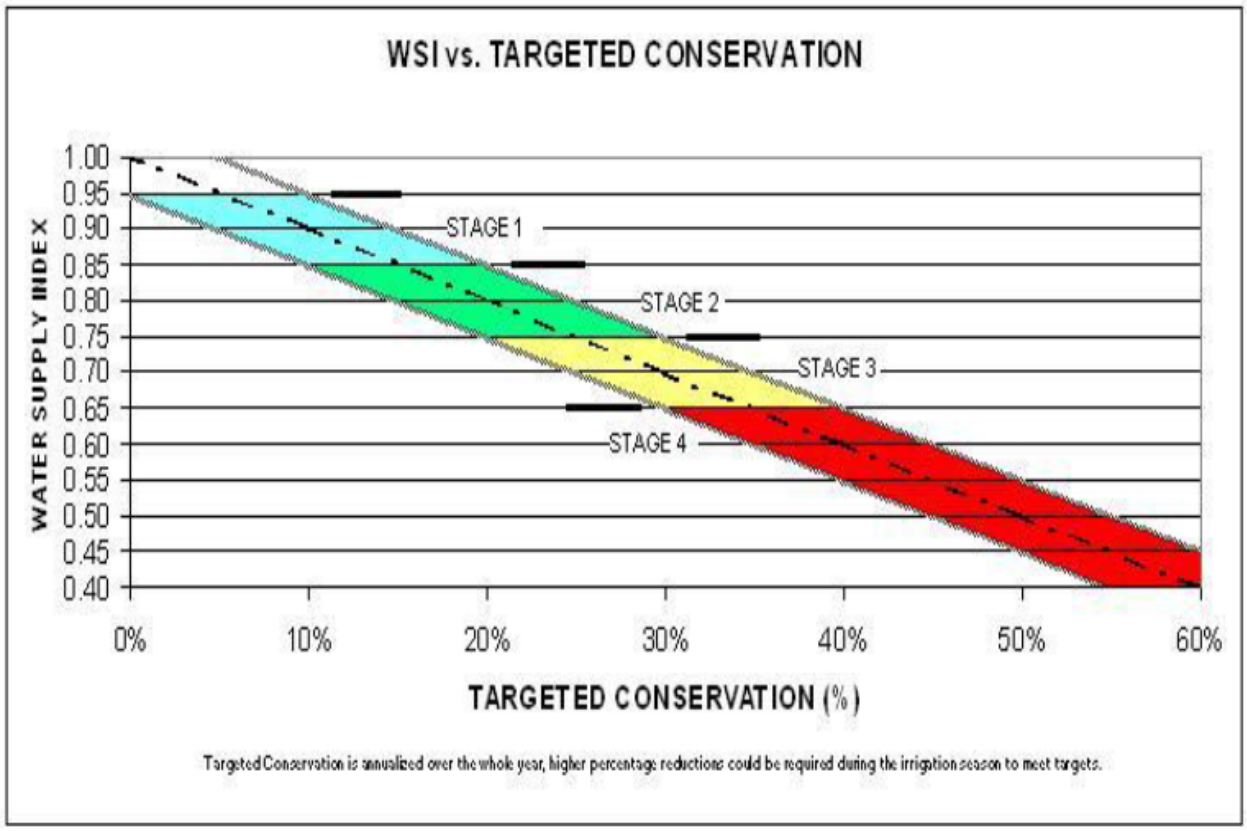
The WSI is used to determine the potential severity of a water shortage during drought conditions. If the WSI is below 1.0, the index predicts a water shortage. A WSI of 0.95 - 0.85 indicates a "Stage 1" level drought and a 10% supply shortage, initiating a series of accompanying drought response strategies: A WSI of 0.85 - 0.75 indicates a "Stage 2" drought stage and a shortage of 20%; an index of 0.75 - 0.65 is a "Stage 3" drought level with a 30% reductions in water supplies; and a WSI less than 0.65 indicates a severe "Stage 4" management level and a water shortage of 40% or greater. (Note: Previous modeling indicates that these later stages rarely occur. Within the historical period of 2000-2015, Stage 2 was implemented once during the 2002 drought. Stages 3 and 4 conditions did not occur within the designated study period.)

For example: A WSI of 1.0 in April indicates that the City's projected water supplies are available to sufficiently meet the upcoming year's summer season demands (with proper long term carry over reserves). A value greater than 1.0 indicates an excess of water supplies; a value less than 1.0 indicates a shortage.

Table 1
Drought Stage Description

Drought Stage	Available Water Supply Reduction
Stage 1	10%
Stage 2	20%
Stage 3	30%
Stage 4	40%

Chart 4
WSI vs. Water Supply Reduction



Drought Response Strategies

Methods to reduce City-wide water demands are typically separated into four general categories:

1. Operational alternatives: City-wide residential and commercial watering restrictions, pipeline repairs, and water use restrictions for parks, ball fields, and street medians
2. Economic impacts: revise rate structures and water pricing, enforce restrictions and penalties.
3. Outreach program that include: public education and notices, and landscaping restrictions.
4. Infrastructure upgrades: modify/improve the water system by metering, pressure reduction, flow controllers, and increase reuse and recycling;

For each drought stage, a set of predetermined response strategies has been developed, as shown in Table 2.

Reducing City-wide Demand

This Drought Management Plan's primary focus involved the reduction of water usage consistent with the severity of the drought event. Each drought stage is associated with a set of management strategies designed to reduce City-wide water demands. Drought stage strategies/actions specifically developed for Louisville focus on effectively reducing demand levels during the summer months by restricting outdoor water use. These restrictions provide the most significant reductions. However, in longer duration droughts, additional year-round responses may also be necessary (no outdoor watering or "hand" watering only) to conserve the maximum amount of stored water in the City's reservoir system.

Indoor water savings can also be achieved through the installation of water conserving devices. However, this would be part of the City's ongoing water conservations efforts rather than a management response to a specific drought period.

Rate Structures and Pricing

The City may implement a structured water rate surcharge during droughts to reduce demands and maintain the financial viability of the utility. In those instances, surcharges may be applied to water uses not considered necessary for basic needs and consumption. The pricing structure is designed to reduce residential and commercial use and is considered only a temporary option until such time the City's water supplies increase to average levels following the drought. It is anticipated that surcharge rates will be used in conjunction with other drought management strategies and will be included in the City's public awareness/outreach efforts. Surcharges will be assessed with the severity of the drought and may increase as drought stages increase over time.

It has been shown in other Front Range communities that drought surcharges alone, without accompanying mandatory restrictions, may not reduce demands in a timely manner. The benefit of surcharges on City-wide water demand levels is delayed because of implementation, administration, and public awareness considerations. For Louisville, this delayed effect limits the usefulness of implementing surcharges. Once drought conditions are identified, the "lead" time for implementation of drought management strategies is limited. Prolonged reaction time between implementation and effect is not consistent with the City's drought management goals. Additionally, many municipalities have indicated that surcharge amounts need to represent a significant increase in rates to achieve the desired level of public participation. This type of strategy, with a rapid water rate increase, often has political implications involving public notification and awareness. Given these considerations, the concept of utilizing drought surcharges should be combined with other, more immediate, response strategies and used in combination with an aggressive public outreach program.

Public Information and Participation

During all drought events, the City will strive to be a resource for its residential, commercial, industrial, and irrigation customers. The level of effort in education, public outreach, incentive programs, etc. will be commensurate with the severity of the drought, public response and needed reductions.

A good communication effort can significantly improve public acceptance and therefore actual water savings targeted by the drought plan. During a drought, it is important to frequently convey information to the public regarding what is happening, why it is happening, and the impact to individuals.

The drought management plan should be highly visible within the community. Aspects of a visible program include feedback on how well conservation measures are working, frequent reports on whether water supplies are more or less plentiful than predicted, and sharing of the concerns or problems residents are experiencing as part of the plan. Public involvement includes providing the proper information regarding the need and implementation of any given drought stage response. However, it is likely that as the drought becomes longer and more severe, that communication frequency and the quantity of information disseminated may increase. The following activities are anticipated to be needed at increasing levels of effort during and as a drought increases in severity.

- Keeping City Council apprised on the status of the drought, drought strategies implemented and their effects.
- Identify the frequency and type of information disseminated on a routine basis. As a minimum, release a monthly updated appraisal of the drought condition.
- Designate a spokesperson to coordinate internal communication protocol and coordinate with the City's Communications division for public/media contact.
- Provide data indicating effects and results of implemented drought management strategies.
- Emphasize that drought management is additional to ongoing water conservation efforts.
- Provide utility customers with tips, information and links to other available resources for achieving different levels of conservation.

Dissemination of critical information can be achieved through: 1) notices mailed with the customer's billing statements; 2) notices in the public media; 3) notices on the City's web page; and 4) public meetings and outreach.

Commercial and industrial customers in Louisville, excluding multi-family accounts, have different water use patterns than residential customers. As a result, significant water reductions may have severe financial consequences for manufacturing and industrial users. Therefore, these customers may need additional flexibility to achieve the desired reductions. However,

commercial and industrial users must demonstrate the essential water needs of their commercial enterprise, quantify the amount of water needed monthly, and provide a sustainable management strategy so that overall water consumption will be reduced while drought conditions persist.

Drought response and measures will strive to insure that inconvenience, discomfort, and sacrifice is shared in an equal manner across all customers. It is important to acknowledge conservation may not be exactly equal by customer class but is done to reflect the values of the community by utilizing water in a way that is important to the total community. This equity concept would address the relative value of water used by individual residents for landscaping purposes compared to community facility uses such as golf courses, parks, and pools and similar facilities.

Staffing and Resources

As a drought develops it is likely that additional resources will be needed to implement the various components of a Drought Management Plan. This will likely occur during times when revenue is declining because of an anticipated watering reduction. It is also expected that existing staff will be assigned temporary drought responsibilities in order for the various actions to be undertaken in a reasonable time frame. Temporary reassignment of staff or the procurement of additional staff resources to deal with the drought will be utilized in order to:

- Implement the desired communication and public relations program for given level of drought.
- Prioritize staff assignments to include assisting residents with private irrigation system leak detection, irrigation system operations, and other drought related activities.
- Developing “exception” criteria to deal with hardships and health and safety issues.
- Consistency and leadership role on City water usage.
- Coordination and consistency of information (i.e. Finance Department for utility billing, Parks and Recreation Department on park usage and impact, Public Works personnel at the water treatment plant and Administration).
- Increase funding to the water conversation program and utilize outside agencies to assist with response efforts.

Table 2
Drought Stage-Response Summary

Response	**Stage 1 Moderate** (WSI: 0.95-0.85 Target Reduction 10%)	**Stage 2 Serious** (WSI: 0.85-0.75 Target Reduction 20%)	**Stage 3 Severe** (WSI: 0.75-0.65 Target Reduction 30%)	**Stage 4 Extreme** (WSI: ≤ 0.65 Target Reduction 40%)
Landscaping: grass & gardens (automatic systems)	Voluntary watering schedule (3 days/week, 6pm to 10am)	Mandatory watering schedule (2 days/week, 6pm to 10am)	No watering allowed	No watering allowed
New Lawn Installation (sod and seed)	Best management practices/No waste of water	Mandatory watering schedule (2 days/week, 6pm to 10am)	No watering allowed	No watering allowed
Trees, shrubs and perennials beds (non-automatic systems)	Hand watering (6pm to 10am)	Hand watering (6pm to 10am)	Hand watering (once per week)	Hand watering (once per month)
High use/traffic areas (parks, athletic fields and golf courses)	Best management practices/No waste of water	Best management practices/No waste of water	Implement water budget	No watering allowed (reuse considered)
Construction water, Hydrant permits and New Taps	Best management practices/No waste of water	No waste of water, permits rescinded for violations.	No waste of water, permits rescinded for violations. Surcharges applies	Not allowed
Water features (fountains, ponds, waterfalls, swimming pools, etc.)	Best management practices/No waste of water	Voluntary restriction on use	No features that sprays water into the air. No single-family residential pools filling	No filling of water features
Car washing	With buckets or shutoff nozzles	With buckets or shutoff nozzles	Commercial car washes only	Not allowed
Washing impermeable surfaces	Best management practices/No waste of water	Use dry cleanup methods prior to washing.	Use dry cleanup methods prior to washing. Health and safety issues only	Use dry cleanup methods prior to washing. Health and safety issues only

Water rate surcharges (Residential and Some Commercial - combined use meters)	None	Blocks 4 & 5	Blocks 3-5	Blocks 2-5, may terminate water service for extreme waste of water offenders
Irrigation-only meters	Blocks 4 & 5	All Blocks	Terminate water service	Terminate water service
Commercial and Multi-Family with separate irrigation meters	None	None	None	Blocks 4 & 5

Summary

This drought management planning process focused on reducing City-wide demand. This is most effectively done in the summer with irrigation reductions. However, outdoor watering restrictions need to be consistently implemented at times they are determined to be season long actions (as a minimum). Public perception is important to obtain for compliance with watering restrictions. Inconsistency and/or "false alarms" associated with the timing of watering restrictions erodes public confidence. Generally, a high level of consistency can be achieved by assessing the City's water supplies by May 1 (or earlier) of each year. For example, during the first year of the design drought period used in this study, watering restrictions would be unlikely. However, by May 1 of the second drought year, indicators (snowpack/runoff predictions, Marshall Lake carryover storage, recorded City demands, and projected C-BT deliveries) are anticipated to indicate the need and level of watering restrictions to match estimated water supplies.

Additional Drought Responses

The following list of alternatives have been developed as potential drought related actions that warrant future consideration and addition to the City's Drought Management Plan.

Interruptible Supplies - The term "interruptible supply" is used to describe an arrangement where Louisville would acquire or leverage existing South Boulder Creek water rights specifically for use during droughts. Conversely, during wetter periods or times of excess, these shares would be leased to irrigators for agricultural uses. The long term sustainability of agricultural uses in and around Boulder County may provide favorable conditions in the development of this type of water supply. This arrangement would require specific legal action within water court to authorize this type of usage.

Recharge Facilities - Future recharge pond(s) may be used as an additional water resource for the City when replacement obligations attributable to Louisville's water rights. Excess return flow credits discharged from the wastewater treatment plant or junior water rights could be used as a source. Delayed return flows from the pond(s) could accrue to the calling rights, thereby satisfying the City's legal return flow obligations. Challenges related to the planning and construction of any potential recharge facility are: site location, property costs, limited seasonal water supply and use, and required water court actions. Additionally, infrastructure will likely be required to deliver water to the facility, which may require agreements with landowners and ditch companies. Any of these issues may cause this alternative to become cost prohibitive. Nevertheless, there are compelling reasons to further investigate the feasibility of recharge pond(s), most notably the ability to recapture excess return flow credits to be used directly or leased/traded during drought conditions that otherwise would be unclaimed by the City.

Cooperative Agreements - Cooperation and collaboration with other Water District 6 water users was identified in the Master Plan as an effective method to increase water yield to the City. For example, Lafayette owns a variety of water rights decreed for diversion at the Louisville Pipeline intake. As a result, this water is legally available for use by Louisville with the approval of Lafayette. Additionally, Louisville and Lafayette (and the Farmers Reservoir and Irrigation Company) have also cooperatively operated the "Borrowing Program" during the winter months on South Boulder Creek that allows for more efficient use of the City's storage rights. Cooperative administration with other users on South Boulder Creek has historically allowed the City to optimize its water rights. This cooperative administration requires advanced planning between the stakeholders and the District 6 water commissioner and regular, reliable "real-time" communication to ensure all parties are protected. This planning process has led to the concept of a regional drought management "team." The team would consist of Water District 6 water users and state officials to implement and coordinate the various drought management strategies throughout Boulder County and the South Boulder Creek drainage area.

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