



## **Chapter 4**

### **Multi-Barrier Approach Decision Criteria**

This chapter describes the criteria developed as part of a structured K-T<sup>®</sup> decision analysis model used to rank BRWTF multi-barrier water delivery alternatives. This set of decision criteria forms the basis of a fair and balanced evaluation of BRWTF multi-barrier water delivery alternatives. City staff developed decision model criteria in 5 categories including finished water quality, source water, treatment operations, risk, and environmental and public acceptance.

A set of preliminary decision model performance criteria was presented to City staff by B&V in a workshop held on August 16, 2006. Over the next several months, an ad hoc City staff committee (BRWTF Multi-Barrier Project Working Group) representing drinking water quality, water resources, operations, and senior management functions refined the preliminary decision model performance criteria through a series of scheduled meetings and informal communications. Based on the collective expertise and experience of the Project Working Group members, the set of decision model performance criteria ultimately chosen was reviewed and finalized in a workshop held on December 14, 2006.

#### **A. Mandatory MUST Criteria**

As described in Chapter 1, performance criteria in K-T<sup>®</sup> decision analysis are classified either as MUST criteria that each candidate problem solution must absolutely satisfy in order to be included in the decision process, or WANT criteria that are desirable but not mandatory for each candidate problem solution to satisfy. Two MUST decision criteria were developed by the Project Working Group.

##### **1. Regulatory Compliance**

For a candidate decision model alternative to be considered as an acceptable BRWTF multi-barrier water delivery approach it must be capable of continuously meeting all enforceable USEPA and CDPHE drinking water



regulations and standards. This MUST criterion assumes that BRWTF will be adequately maintained and operated in accordance with its design specifications. Furthermore, this MUST criterion assumes that only raw water delivered through BFC, pumped from Boulder Reservoir, or conveyed directly from Carter Lake through a dedicated pipeline will be utilized at BRWTF.

## **2. Water Rights Portfolio Yield**

Each candidate BRWTF multi-barrier water delivery alternative must be capable of maintaining the current expected yield of the City's water rights portfolio and must not reduce the current level of flexibility in selecting drinking water sources from its water rights portfolio.

## **B. Desirable WANT Criteria**

The Project Working Group developed 28 decision model performance criteria in five categories including finished water quality, source water, treatment operations, risk, and environmental and public acceptance, as listed in the following sections. These criteria are satisfied by the BRWTF multi-barrier water delivery alternatives outlined in Chapter 5 to varying degrees.



### 1. Finished Water Quality Criteria

Finished water quality WANT criteria related to each of the contaminant barrier categories detailed in Chapter 3 were incorporated including pathogens, disinfection by-products, organic micropollutants, manganese, taste and odor, and inorganic contaminants, as listed in Table 4-1.

<b>Table 4-1</b>	
<b>Finished Water Quality Criteria for BRWTF Multi-Barrier Water Delivery Alternatives</b>	
<b>Criteria</b>	<b>Comments</b>
Pathogens	What are the recent trends in microbial water quality in BFC, Boulder Reservoir, and Carter Lake? How likely are acute pathogenic contamination events in these raw water sources? Are barriers sufficient to prevent pathogens from passing through BRWTF at levels that could jeopardize public health?
Disinfection Byproducts	Which DBPs will be formed and at what levels? Can source water as well as treatment controls be used to minimize DBP formation?
Organic Micro-Pollutants	How significant is the potential risk of organic chemical contamination during source water conveyance or storage? To what extent can treatment processes mitigate acute or chronic organic chemical contamination?
Manganese	What is the extent and duration of seasonal manganese mobilization? Can source water as well as treatment controls be used to limit manganese concentrations?
Taste and Odor	What is the extent and duration of seasonal taste and odor episodes associated with algal blooms or manganese mobilization? Can source water as well as treatment controls be used to minimize objectionable tastes and odors?
Inorganic Contaminants	What is the potential for inorganic contamination during source water conveyance or storage? Can source water as well as treatment controls be used to mitigate inorganic contamination?



**2. Source Water Portfolio Criteria**

Decision model performance criteria related to management of the City's source water portfolio were identified, as listed in Table 4-2.

<b>Table 4-2</b>	
<b>Source Water Portfolio Criteria for BRWTF Water Delivery Alternatives</b>	
<b>Criteria</b>	<b>Comments</b>
Source Water Quality Consistency	What is the extent of seasonal and short-term source water quality fluctuation to BRWTF? Do these fluctuations impact treatment at BRWTF and for how long?
Water Rights Yield	What is the availability of raw water for direct use? Is the ability to manage stored reservoir water throughout the year and during droughts maximized? Can water rights yield be increased through enhanced water management or capacity of facilities?
Portfolio Flexibility	How many options are available for delivering raw water to BRWTF? How difficult is it to switch water sources in response to changing conditions? Are there seasonal limitations on use of raw water sources?
Availability of Raw Water Delivery Facilities	What is the expected reliability of infrastructure for raw water delivery to BRWTF? What are the capacity limitations of these delivery methods? Are their restrictions on the use of water delivery infrastructure due to external factors that affect operations or water quality?



### 3. Water Treatment and Operations Criteria

Decision model performance criteria related to water treatment and BRWTF operations were identified, as listed in Table 4-3.

<b>Table 4-3</b>	
<b>Water Treatment and Operations Criteria for BRWTF Water Delivery Alternatives</b>	
<b>Criteria</b>	<b>Comments</b>
Worker Safety	What types and amounts of treatment or cleaning chemicals that staff will be exposed to? What are the durations of these exposures? Will staff be exposed to high voltage electrical shock hazards? Are physically intensive maintenance procedures such as cleaning intake grates required?
Process Flexibility	What is the maturity and robustness of treatment technologies? Is the number of treatment process technologies required to provide required contaminant barriers minimized?
Process Reliability	Is raw water delivered with consistent quality and flow? Can consistent year-round treatment be provided with minimal process failure?
Process Redundancy	Are multiple barriers provided for contaminant categories of concern? Is back-up capability provided for critical treatment operations?
Maintenance	Can all maintenance be performed by City staff or will an outside contractor be required? Will routine replacement of consumable items such as lamps or membranes be required?
Staffing	What are the levels of staffing and supervision required? What levels of expertise and certification are required?
Residuals Processing	What are the quantities and characteristics of residuals produced by new treatment processes? Will residuals disposal require special environmental permitting?



#### 4. Risk Criteria

Decision model performance criteria associated with risk of source water contamination, adverse impact of additional regulatory requirements on BRWTF operations, infrastructure vulnerability, and chemical usage and delivery were identified, as listed in Table 4-4.

<b>Table 4-4</b>	
<b>Risk Criteria for BRWTF Water Delivery Alternatives</b>	
<b>Criteria</b>	<b>Comments</b>
Acute Contamination	What is the potential for acute or “slug-loading” of contaminants that could disrupt or disable water delivery from BRWTF either temporarily or long term? Is there potential for undetected breakthrough of these contaminants?
Chronic Contamination	What is the risk associated with non-point contaminant sources in BRWTF raw water supplies that could pose a threat to public health? Are these contaminants difficult to remove or inactivate through treatment?
Adaptability to Change	What is the risk to public health associated with potential near- and long-term source water quality degradation? What is the potential for future regulatory non-compliance?
Infrastructure Vulnerability	What is the likelihood that damage to infrastructure could impede conveyance or treatment of the potable water supply?
Consumable Delivery/Usage	Are there consumables such as process specific chemicals, membranes, or lamps that would impede treatment or public health protection if delivery was interrupted? To what extent are alternate sources of these critical treatment consumables available?



**5. Environmental and Public Acceptance Criteria**

Decision model performance criteria associated with environmental and public acceptance issues specific to BRWTF were identified, as listed in Table 4-5.

<b>Table 4-5</b>	
<b>Environmental and Public Acceptance Criteria for BRWTF Water Delivery Alternatives</b>	
<b>Criteria</b>	<b>Comments</b>
Adjacent Land Use Compatibility	Are there critical wildlife habitats, archeologically sensitive, or historically significant lands adjacent to conveyance structures? What impact might adjacent agricultural, industrial, commercial, recreational, and residential tracts have on conveyance?
Finished Water Uniformity	How uniform is finished water quality across the distribution system? Does finished water from BRWTF meet City water quality goals?
Construction	What are the land area footprint and associated restoration requirements? Will extensive underground excavation and associated materials handling be required?
Consumer Confidence	What is the level of consumer confidence with finished water delivered from BRWTF?
Permitting	Are there sensitive environmental or public acceptance issues that would make required permitting difficult? What measures are available to mitigate these concerns?
Energy Requirements	What are the operational energy requirements and what are their secondary environmental effects? Is there potential for renewable energy generation?