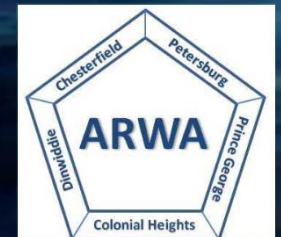


Evaluation of ARWA Capacity Expansion Options

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Casey Caldwell

September 25, 2014

Advancing the Management
of Water Resources



5 Options

- 18 Inch Raise of Lake Chesdin
- Offsite Storage, 5 BG Usable Storage
- Offsite Storage, 7 BG Usable Storage
- Raised Dam Plus 5 BG Offsite Storage
- Raised Dam Plus 7 BG Offsite Storage

Raised Dam Scenario

- Raise Chesdin dam by 18 inches
 - Total storage increased from 9.3 to 11.2 BG
- All storage triggers and recreational drawdown metrics are based on increased storage from raised dam, e.g.
 - May Stage 1 drought trigger is 85% of 9.3 BG storage now based on 85% of the increased storage of 11.2 BG
 - 2 ft recreational drawdown metric is now 156.7 ft (157.2' current dam + 1.5' raise - 2' drawdown)

Offline Storage Assumptions

- Offline storage has 5 BG usable storage, 118 acre surface area at full pool
 - Also analyze 7 BG offline storage
- Pump from Chesdin into offline storage when Chesdin storage $\geq 95\%$
 - Max pumping rate = the lesser of 100 mgd or 10% of the unregulated inflow less demand
- Pump from offline storage to demand when Chesdin storage \leq Stage 1 trigger
 - Max pumping rate = $\frac{1}{2}$ of demand

Assumptions for Combined Scenarios

- Raise Chesdin dam by 18 inches
 - Total storage increased from 9.3 to 11.2 BG
- Pump from Chesdin into offline storage when Chesdin storage $\geq 95\%$
 - Max pumping rate = the lesser of 100 mgd or 10% of the unregulated inflow less demand
- Pump from offline storage to demand when Chesdin storage \leq Stage 1 trigger
 - Max pumping rate = $\frac{1}{2}$ of demand
- All storage triggers and recreational drawdown metrics are based on increased storage from raised dam, e.g.
 - 95% offline refill trigger is 95% of the increased storage of 11.2 BG
 - 2 ft recreational drawdown metric is now 156.7 ft (157.2' current dam + 1.5' raise - 2' drawdown)

Reliable Service Level

“The reliable service level is a planning figure that represents the annual average demand above which a water provider will need additional capacity to avoid violating the specified reserve or the acceptable frequency of invoking its drought management plan.”

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Reserve = 60 days

Acceptable Frequency

- Voluntary 1 in 5 years
- Mandatory 1 in 25 years
- Emergency 1 in 84 years

Reliable Service Level – In Practice

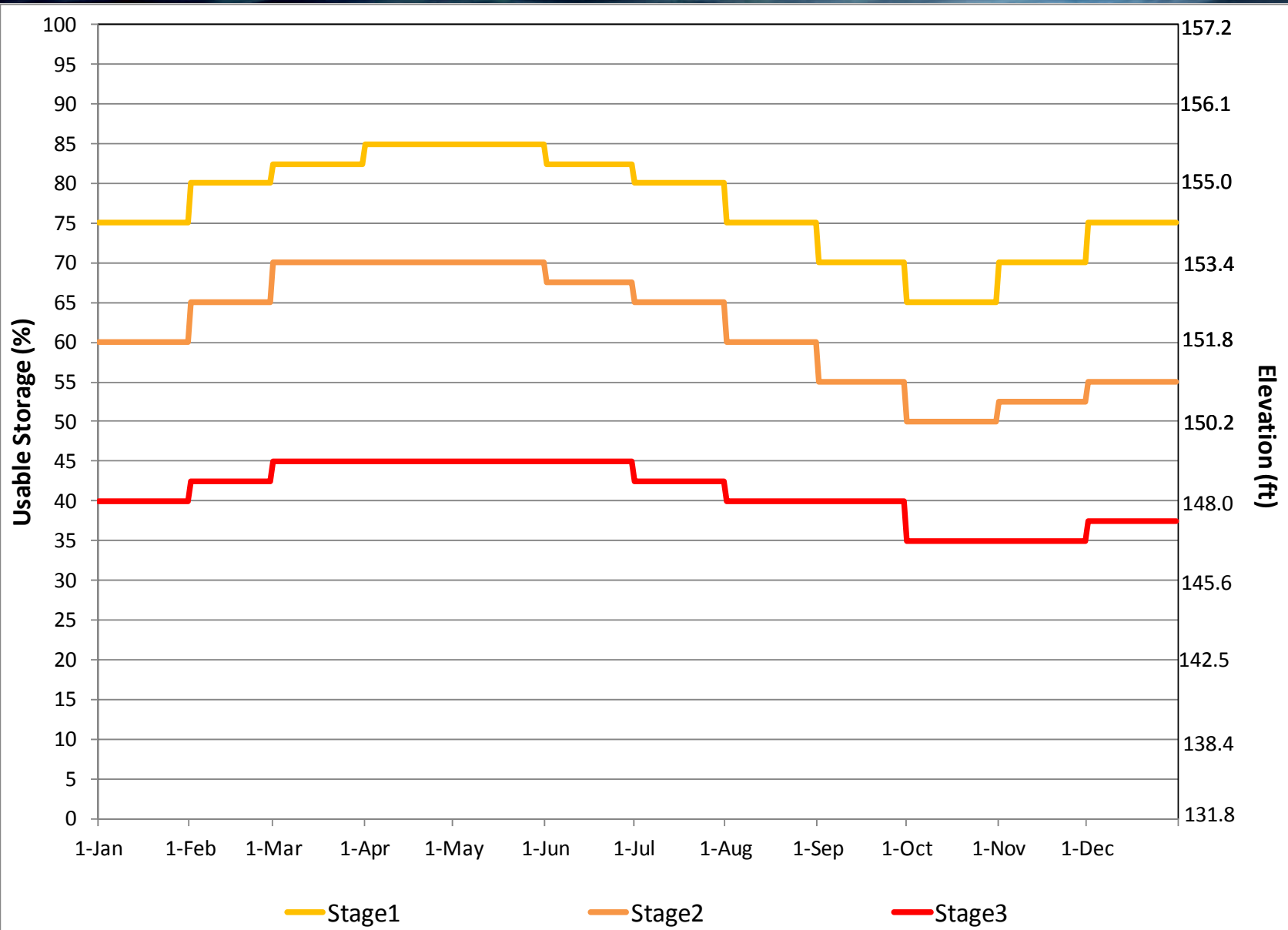
- The reliable service level demand is not satisfied in years in which the drought management plan is invoked

Reliable Service Level – In Practice

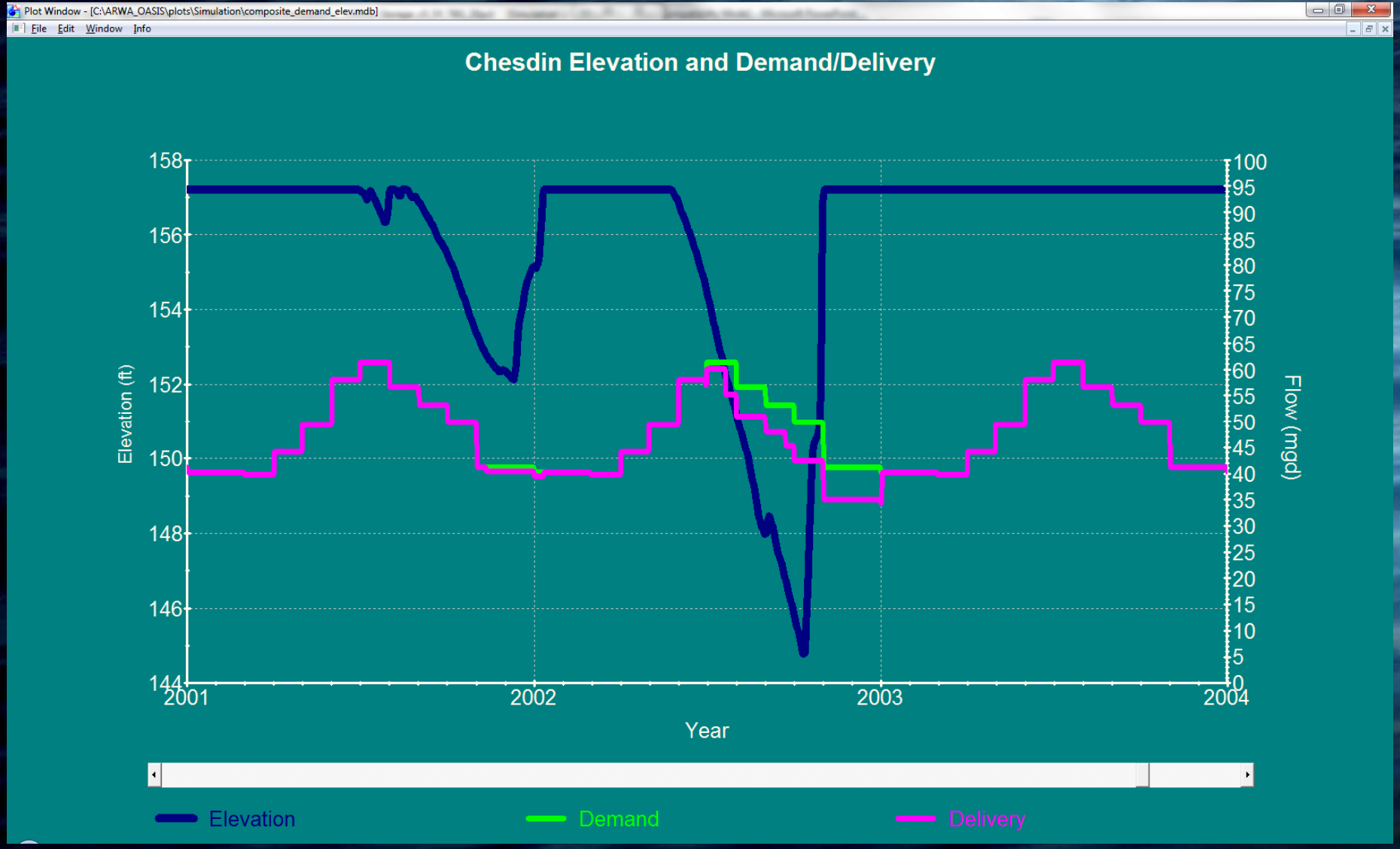
- The reliable service level demand is not satisfied in years in which the drought management plan is invoked

An example

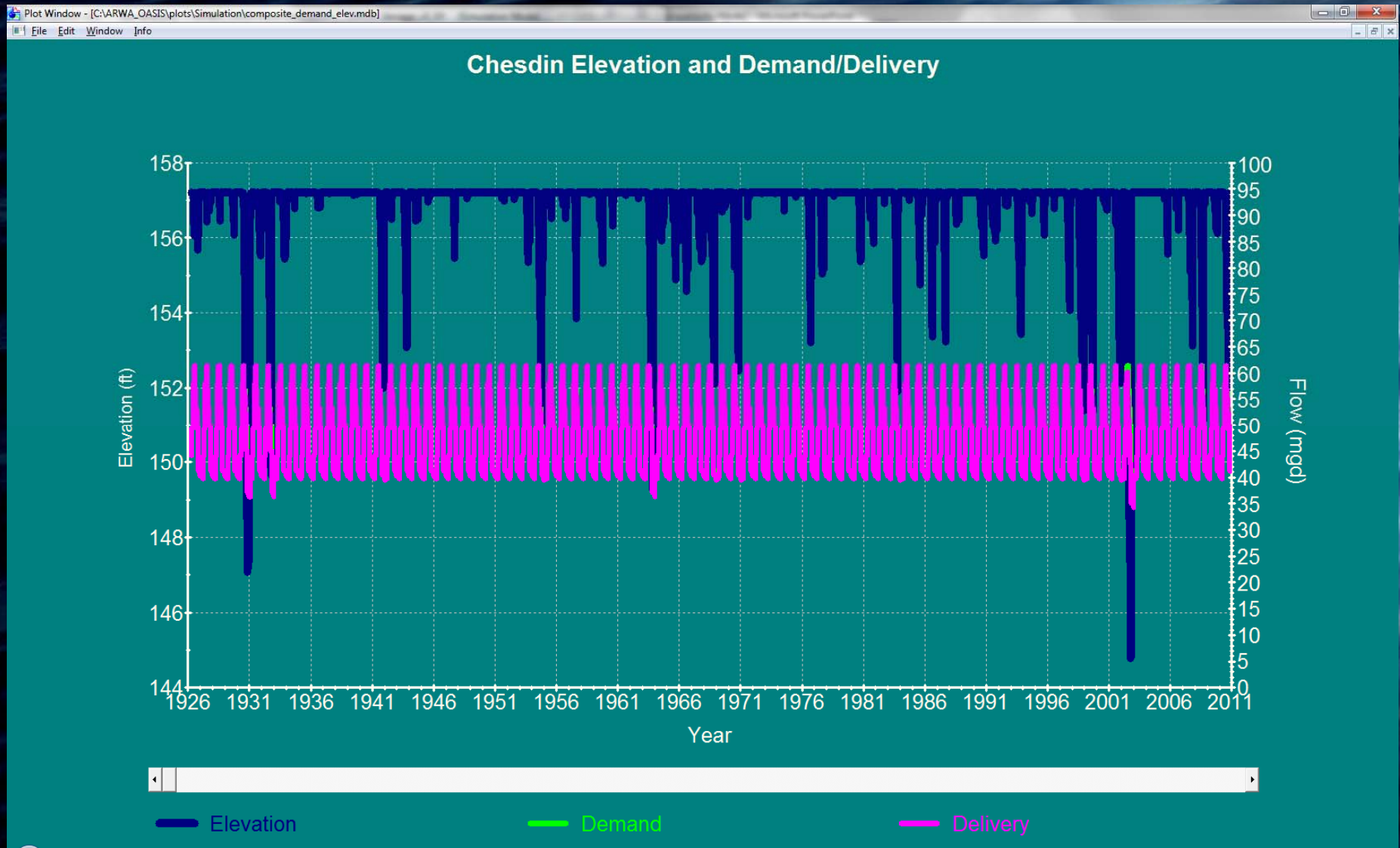
Current Permit Drought Triggers



Elevation, Demand and Delivery – 2030 Demand



Elevation, Demand and Delivery – 2030 Demand



Performance Metrics – 2030 Demand

Drought Plan	Trigger	Current Permit	Current Permit w/ Chesdin Raised 18"***	With Offsite Storage			
				5 BG Storage Alone	7 BG Storage Alone	5 BG Storage w/ Chesdin Raised	7 BG Storage w/ Chesdin Raised
Frequency *	Stage 1 (Voluntary)	1 in 5 yrs					
	Stage 2 (Mandatory)	1 in 21 yrs					
	Stage 3 (Emergency)	1 in 84 yrs					
Median Duration (min-max)	Stage 1 (Voluntary)	62 days (12-186)					
	Stage 2 (Mandatory)	118 days (67-165)					
	Stage 3 (Emergency)	102 days (102-102)	n/a				
Drawdown**		Current Permit	Current Permit w/ Chesdin Raised 18"	5 BG Storage Alone	7 BG Storage Alone	5 BG Storage w/ Chesdin Raised	7 BG Storage w/ Chesdin Raised
Frequency	Rec > 2 ft	1 in 3.5 yrs					
	Rec > 4 ft	1 in 9 yrs					
	Mig > 3.5 ft, 45+ days	1 in 17 yrs					
Median Duration (min-max)	Rec > 2 ft	27 days (2-98)					
	Rec > 4 ft	26 days (5-80)					
	Mig > 3.5 ft	35 days (6-91)					
Preserves 60-day supply?		No (55 days)					
Pumping frequency from offline storage to WTP		n/a					
Avg. # days pumping Chesdin to offline		n/a					
Avg. # days pumping at full capacity Chesdin to offline		n/a					
Reliable Service Level (mgd)		67					

Red = goal not met, yellow = within 1 event of goal, green = goal met.

* Counting drought events lasting 10 or more days

** Recreation statistics are for May 15 – Sep 30,

** Out-Migration statistics are for Sep 1 – Nov 30

*** Recreational drawdown metrics for raised dam

scenarios based on the raised normal pool elevation

Performance Metrics – 2030 Demand

Drought Plan	Trigger	Current Permit	Current Permit w/ Chesdin Raised 18"***	With Offsite Storage			
				5 BG Storage Alone	7 BG Storage Alone	5 BG Storage w/ Chesdin Raised	7 BG Storage w/ Chesdin Raised
Frequency *	Stage 1 (Voluntary)	1 in 5 yrs	1 in 7 yrs				
	Stage 2 (Mandatory)	1 in 21 yrs	1 in 42 yrs				
	Stage 3 (Emergency)	1 in 84 yrs	< 1 in 84 yrs				
Median Duration (min-max)	Stage 1 (Voluntary)	62 days (12-186)	68 days (11-186)				
	Stage 2 (Mandatory)	118 days (67-165)	127 days (110-144)				
	Stage 3 (Emergency)	102 days (102-102)	n/a				
Drawdown**		Current Permit	Current Permit w/ Chesdin Raised 18"	5 BG Storage Alone	7 BG Storage Alone	5 BG Storage w/ Chesdin Raised	7 BG Storage w/ Chesdin Raised
Frequency	Rec > 2 ft	1 in 3.5 yrs	1 in 6 yrs				
	Rec > 4 ft	1 in 9 yrs	1 in 17 yrs				
	Mig > 3.5 ft, 45+ days	1 in 17 yrs	1 in 42 yrs				
Median Duration (min-max)	Rec > 2 ft	27 days (2-98)	29 days (5-87)				
	Rec > 4 ft	26 days (5-80)	15 days (1-63)				
	Mig > 3.5 ft	35 days (6-91)	40 days (11-64)				
Preserves 60-day supply?		No (55 days)	Yes (89 days)				
Pumping frequency from offline storage to WTP		n/a	n/a				
Avg. # days pumping Chesdin to offline		n/a	n/a				
Avg. # days pumping at full capacity Chesdin to offline		n/a	n/a				
Reliable Service Level (mgd)		67	82				

Red = goal not met, yellow = within 1 event of goal, green = goal met.

* Counting drought events lasting 10 or more days

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*** Recreational drawdown metrics for raised dam

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Performance Metrics – 2030 Demand

Drought Plan	Trigger	Current Permit	Current Permit w/ Chesdin Raised 18"***	With Offsite Storage			
				5 BG Storage Alone	7 BG Storage Alone	5 BG Storage w/ Chesdin Raised	7 BG Storage w/ Chesdin Raised
Frequency *	Stage 1 (Voluntary)	1 in 5 yrs	1 in 7 yrs	1 in 5 yrs	1 in 5 yrs		
	Stage 2 (Mandatory)	1 in 21 yrs	1 in 42 yrs	< 1 in 84 yrs	< 1 in 84 yrs		
	Stage 3 (Emergency)	1 in 84 yrs	< 1 in 84 yrs	< 1 in 84 yrs	< 1 in 84 yrs		
Median Duration (min-max)	Stage 1 (Voluntary)	62 days (12-186)	68 days (11-186)	61 days (12-145)	61 days (12-145)		
	Stage 2 (Mandatory)	118 days (67-165)	127 days (110-144)	n/a	n/a		
	Stage 3 (Emergency)	102 days (102-102)	n/a	n/a	n/a		
Drawdown**		Current Permit	Current Permit w/ Chesdin Raised 18"	5 BG Storage Alone	7 BG Storage Alone	5 BG Storage w/ Chesdin Raised	7 BG Storage w/ Chesdin Raised
Frequency	Rec > 2 ft	1 in 3.5 yrs	1 in 6 yrs	1 in 3.5 yrs	1 in 3.5 yrs		
	Rec > 4 ft	1 in 9 yrs	1 in 17 yrs	1 in 9 yrs	1 in 9 yrs		
	Mig > 3.5 ft, 45+ days	1 in 17 yrs	1 in 42 yrs	1 in 21 yrs	1 in 21 yrs		
Median Duration (min-max)	Rec > 2 ft	27 days (2-98)	29 days (5-87)	27 days (2-98)	27 days (2-98)		
	Rec > 4 ft	26 days (5-80)	15 days (1-63)	17 days (4-62)	17 days (4-62)		
	Mig > 3.5 ft	35 days (6-91)	40 days (11-64)	35 days (5-91)	35 days (5-91)		
Preserves 60-day supply?		No (55 days)	Yes (89 days)	Yes (98 days)	Yes (98 days)		
Pumping frequency from offline storage to WTP		n/a	n/a	1 in 5 yrs	1 in 5 yrs		
Avg. # days pumping Chesdin to offline		n/a	n/a	20 (max = 74)	20 (max = 74)		
Avg. # days pumping at full capacity Chesdin to offline		n/a	n/a	5 (max = 24)	5 (max = 24)		
Reliable Service Level (mgd)		67	82	80	87		

Red = goal not met, yellow = within 1 event of goal, green = goal met.

* Counting drought events lasting 10 or more days

** Recreation statistics are for May 15 – Sep 30,

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*** Recreational drawdown metrics for raised dam

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Performance Metrics – 2030 Demand

Drought Plan	Trigger	Current Permit	Current Permit w/ Chesdin Raised 18"***	With Offsite Storage			
				5 BG Storage Alone	7 BG Storage Alone	5 BG Storage w/ Chesdin Raised	7 BG Storage w/ Chesdin Raised
Frequency *	Stage 1 (Voluntary)	1 in 5 yrs	1 in 7 yrs	1 in 5 yrs	1 in 5 yrs	1 in 8 yrs	1 in 8 yrs
	Stage 2 (Mandatory)	1 in 21 yrs	1 in 42 yrs	< 1 in 84 yrs	< 1 in 84 yrs	< 1 in 84 yrs	< 1 in 84 yrs
	Stage 3 (Emergency)	1 in 84 yrs	< 1 in 84 yrs	< 1 in 84 yrs	< 1 in 84 yrs	< 1 in 84 yrs	< 1 in 84 yrs
Median Duration (min-max)	Stage 1 (Voluntary)	62 days (12-186)	68 days (11-186)	61 days (12-145)	61 days (12-145)	63 days (18-140)	63 days (18-140)
	Stage 2 (Mandatory)	118 days (67-165)	127 days (110-144)	n/a	n/a	n/a	n/a
	Stage 3 (Emergency)	102 days (102-102)	n/a	n/a	n/a	n/a	n/a
Drawdown**		Current Permit	Current Permit w/ Chesdin Raised 18"	5 BG Storage Alone	7 BG Storage Alone	5 BG Storage w/ Chesdin Raised	7 BG Storage w/ Chesdin Raised
Frequency	Rec > 2 ft	1 in 3.5 yrs	1 in 6 yrs	1 in 3.5 yrs	1 in 3.5 yrs	1 in 6 yrs	1 in 6 yrs
	Rec > 4 ft	1 in 9 yrs	1 in 17 yrs	1 in 9 yrs	1 in 9 yrs	1 in 42 yrs	1 in 42 yrs
	Mig > 3.5 ft, 45+ days	1 in 17 yrs	1 in 42 yrs	1 in 21 yrs	1 in 21 yrs	< 1 in 84 yrs	< 1 in 84 yrs
Median Duration (min-max)	Rec > 2 ft	27 days (2-98)	29 days (5-87)	27 days (2-98)	27 days (2-98)	28 days (5-86)	28 days (5-86)
	Rec > 4 ft	26 days (5-80)	15 days (1-63)	17 days (4-62)	17 days (4-62)	6 days (2-10)	6 days (2-10)
	Mig > 3.5 ft	35 days (6-91)	40 days (11-64)	35 days (5-91)	35 days (5-91)	n/a	n/a
Preserves 60-day supply?		No (55 days)	Yes (89 days)	Yes (98 days)	Yes (98 days)	Yes (125 days)	Yes (125 days)
Pumping frequency from offline storage to WTP		n/a	n/a	1 in 5 yrs	1 in 5 yrs	1 in 7 yrs	1 in 7 yrs
Avg. # days pumping Chesdin to offline		n/a	n/a	20 (max = 74)	20 (max = 74)	22 (max = 61)	22 (max = 61)
Avg. # days pumping at full capacity Chesdin to offline		n/a	n/a	5 (max = 24)	5 (max = 24)	5 (max = 21)	5 (max = 21)
Reliable Service Level (mgd)		67	82	80	87	90	96

Red = goal not met, yellow = within 1 event of goal, green = goal met.

* Counting drought events lasting 10 or more days

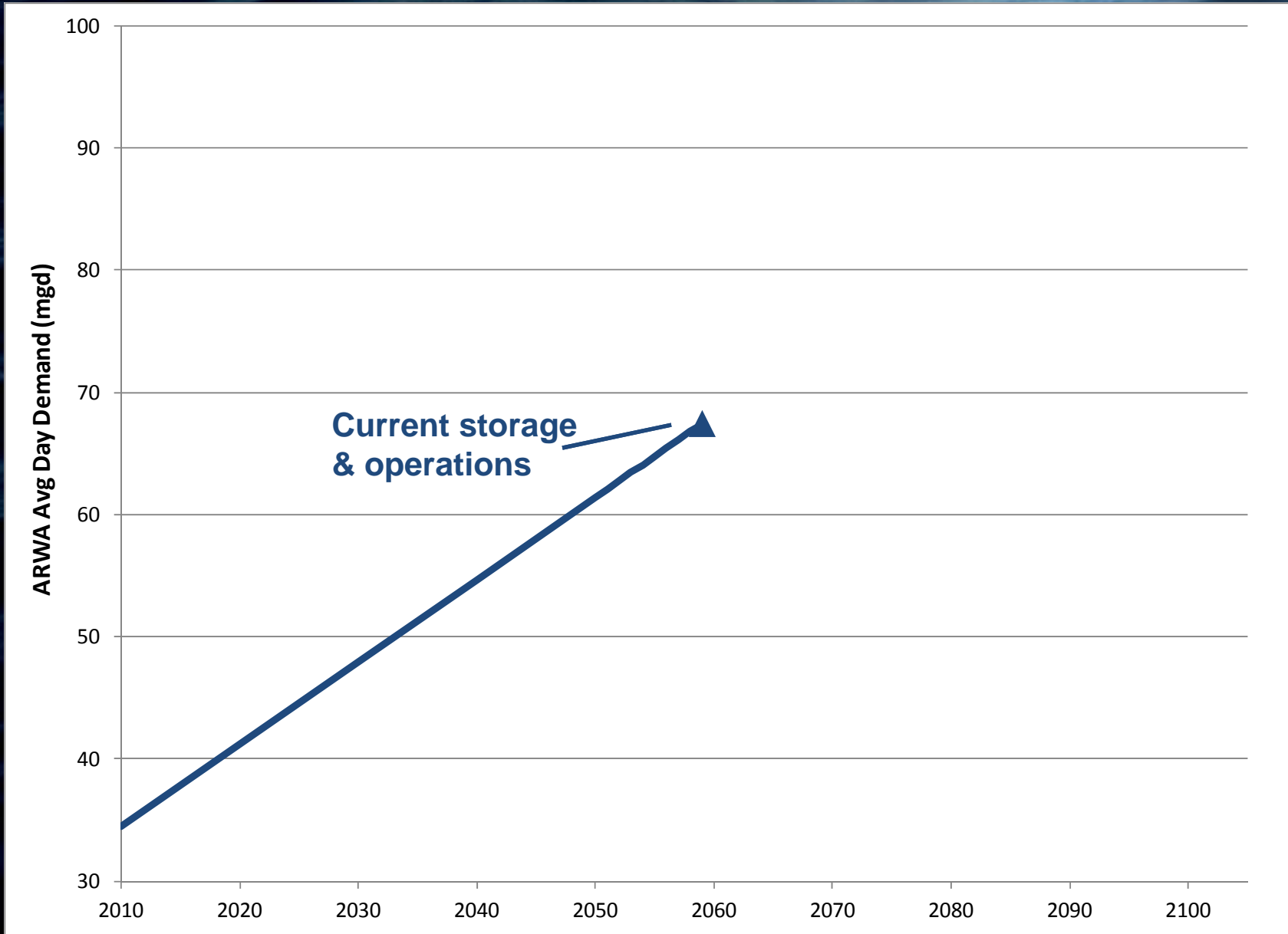
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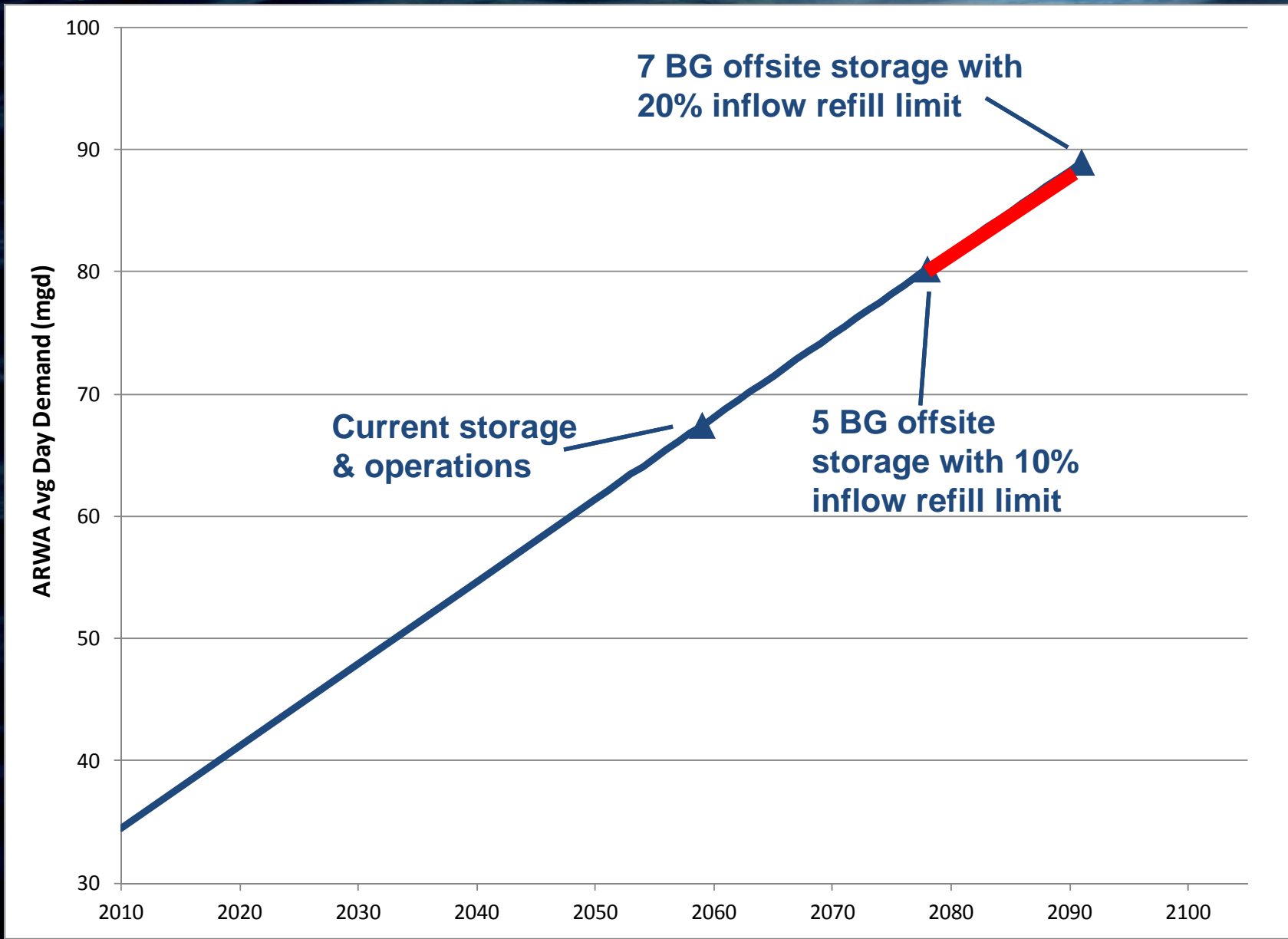
scenarios based on the raised normal pool elevation

ARWA Demand and Supply Options



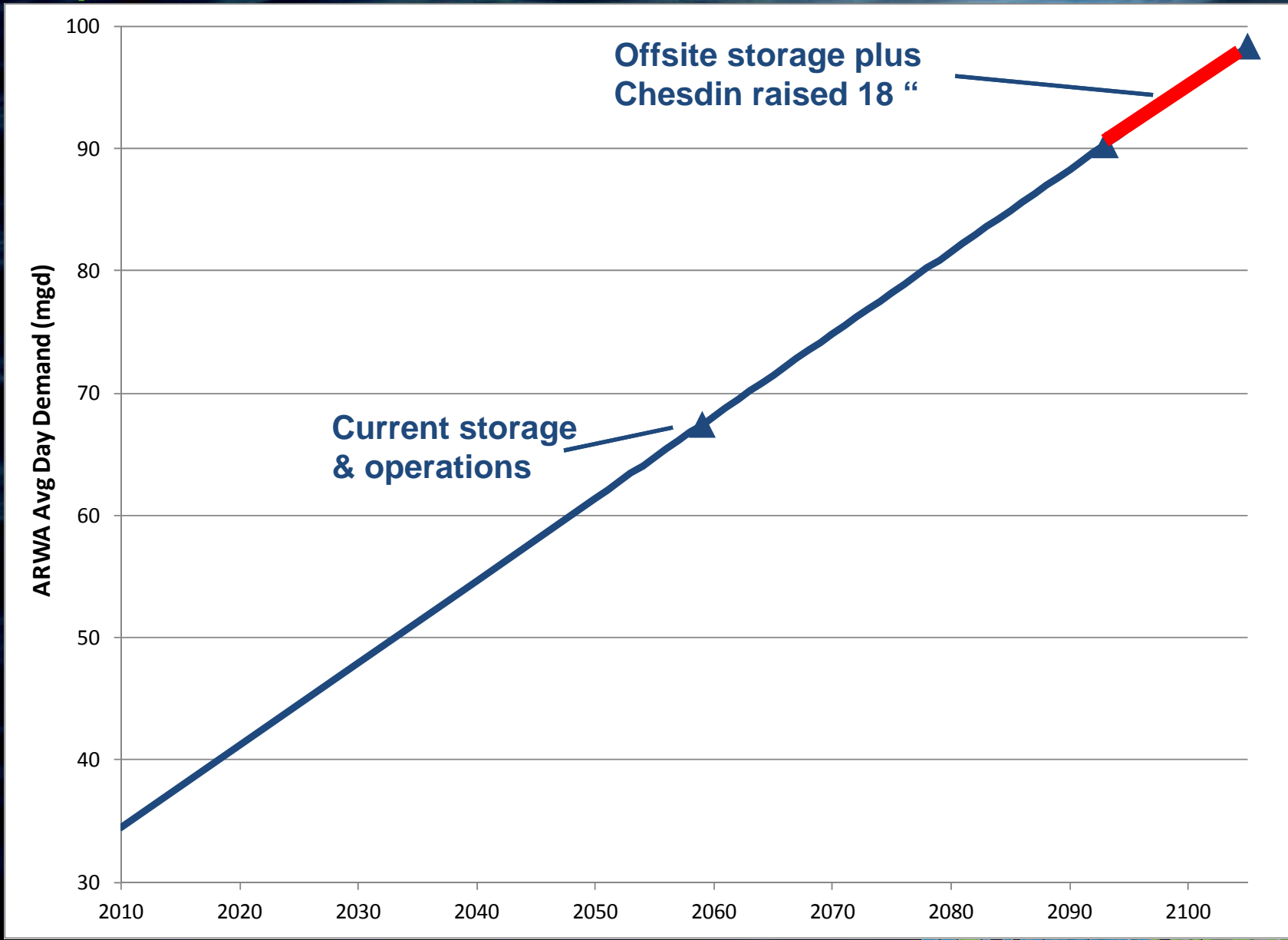
ARWA Demand and Supply Options

Impact of all alternatives



ARWA Demand and Supply Options

Impact of all alternatives



DEQ and DGIF Response

- Met with DEQ September 12
 - Approach is reasonable
 - No action needed prior to the end of current permit (2028)
- Met with DGIF September 23
 - 10 % pumping protocol is OK
 - Might allow additional withdrawal if flows are above over bankfull (somewhere between 3500 and 14000 cfs)
 - Increase in capacity *may* trigger a review of downstream release protocol



Questions?