

Synthesis of Diverse Data in Developing a Decision Tool for Initiating Recovery from an Aquifer Storage and Recovery System

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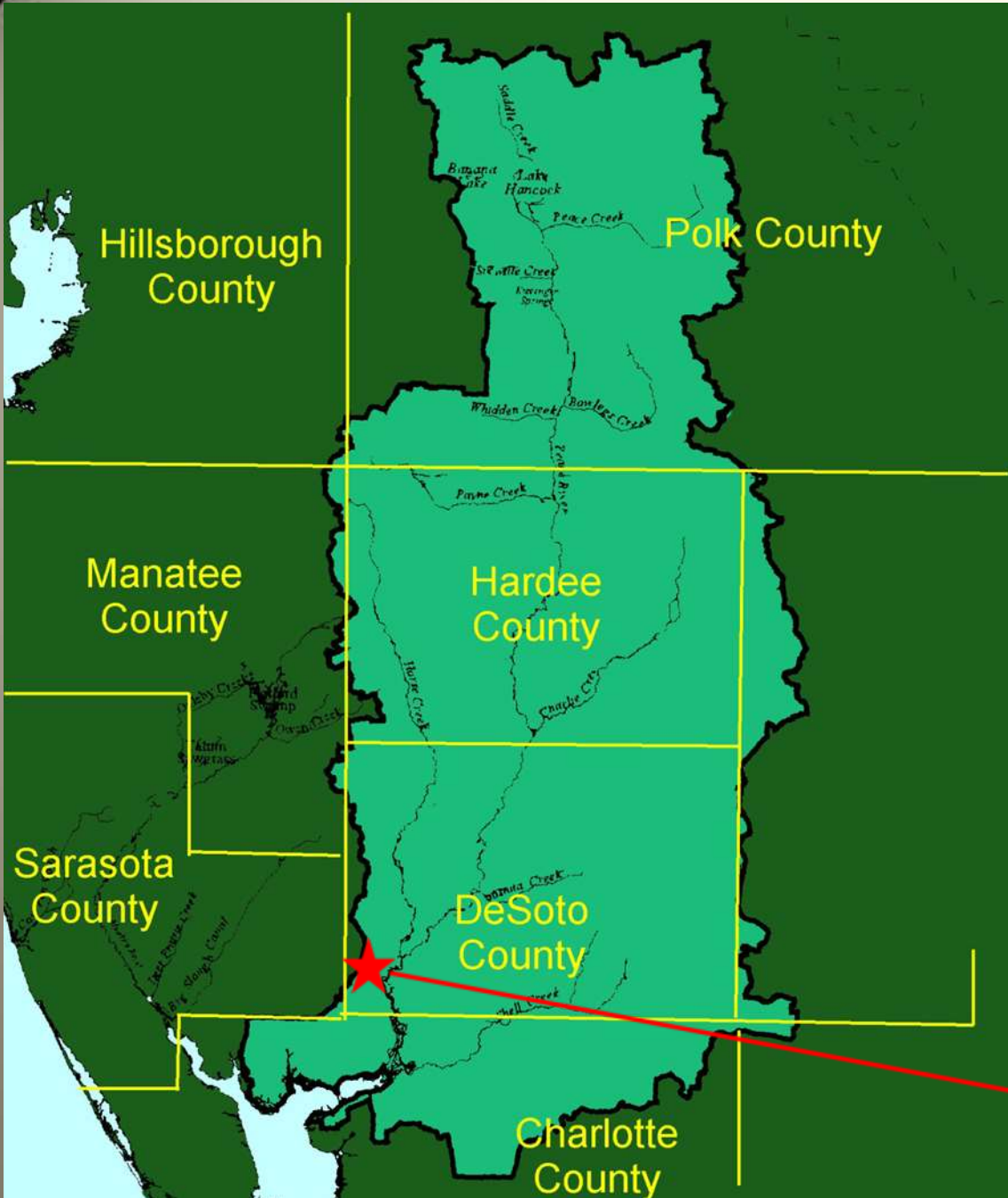
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**Peace River
Watershed
is 2,350
square miles**

**Peace River
Facility**

The Peace River's Flow is Highly Seasonal in Nature

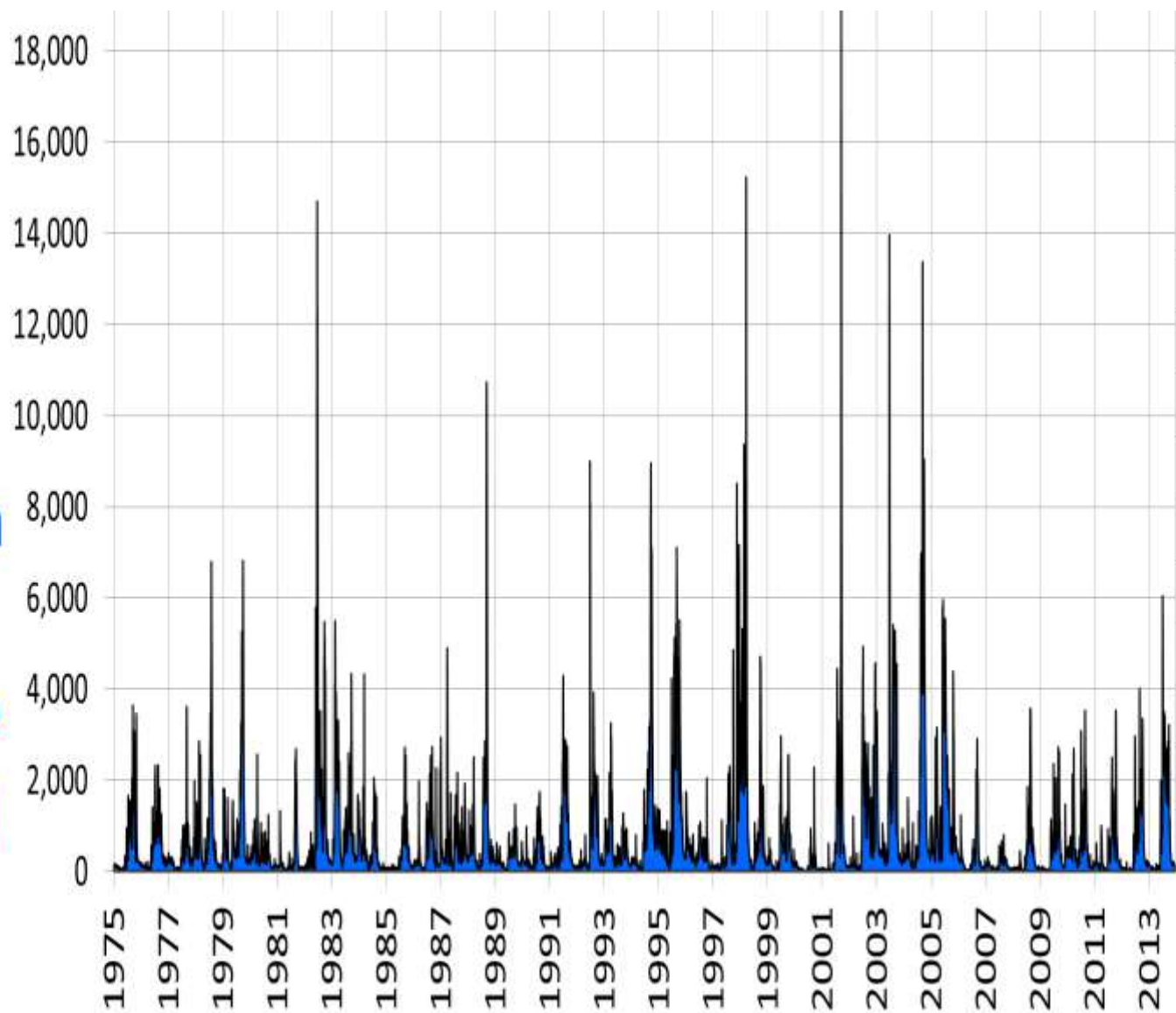



Dry Season

Wet Season 



Total
Stream
Flow
in Blue
(MGD)

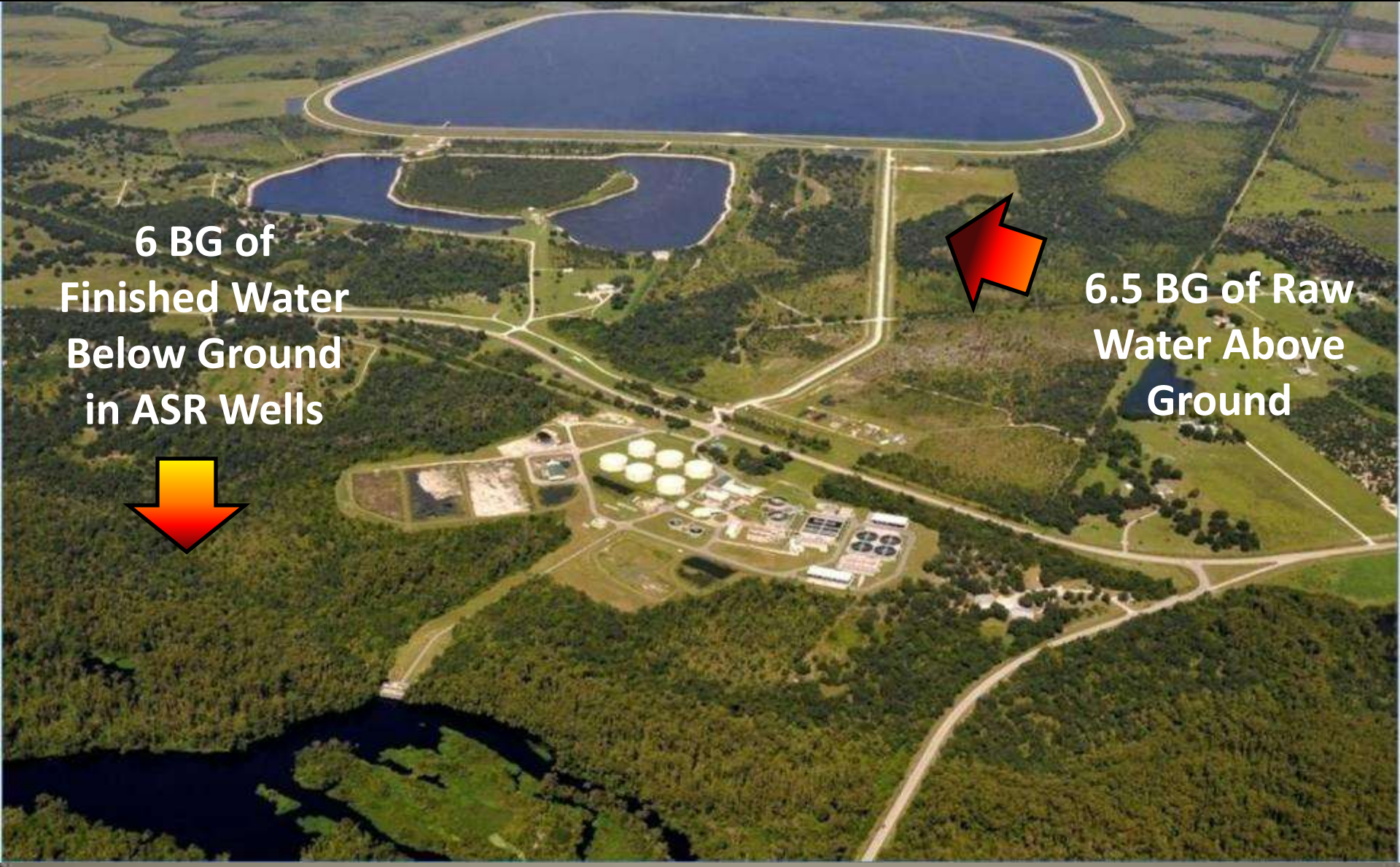


Storage is the Key to Resiliency for this System which Serves 300,000 in SW Florida

6 BG of
Finished Water
Below Ground
in ASR Wells



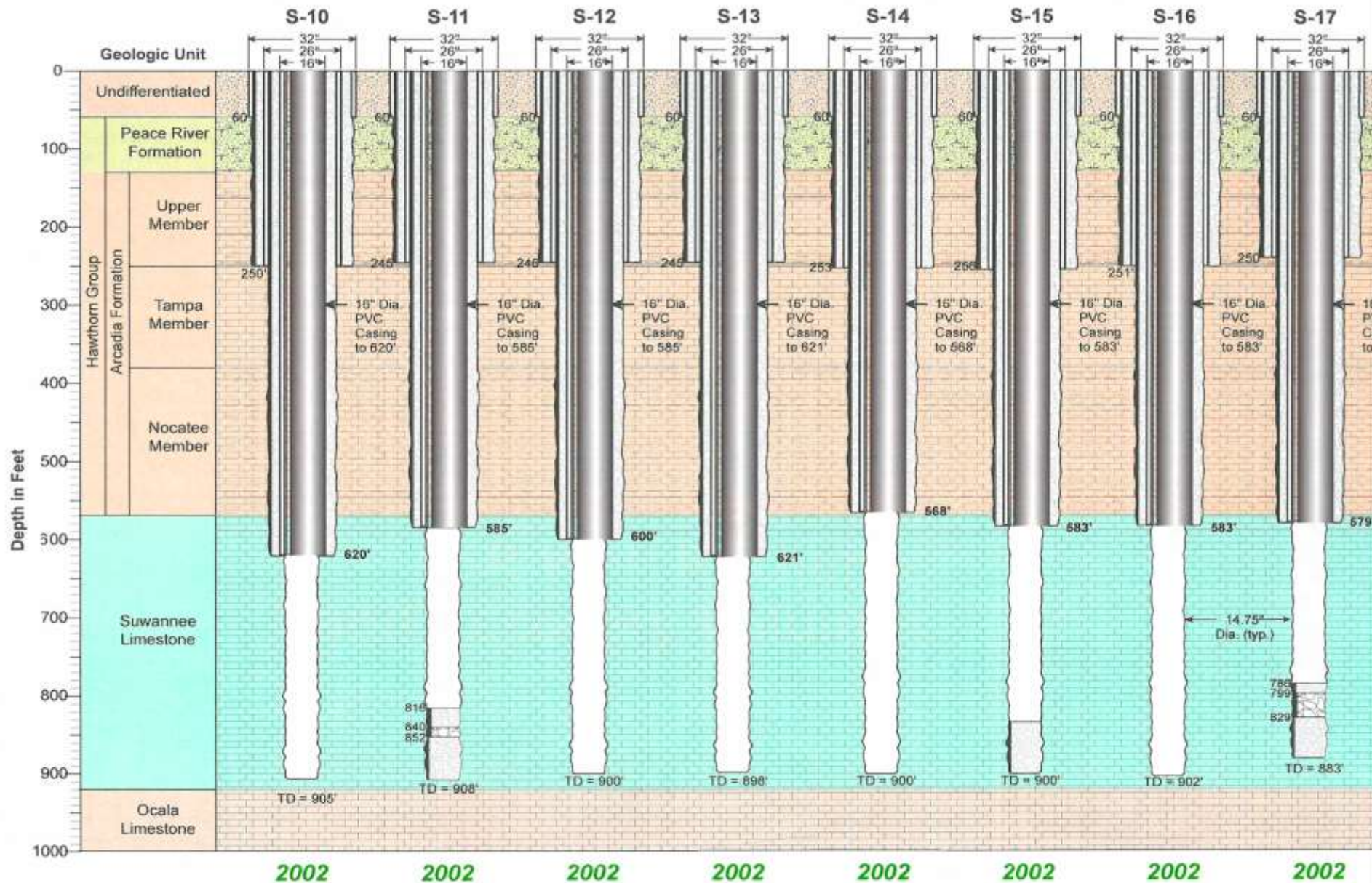
6.5 BG of Raw
Water Above
Ground



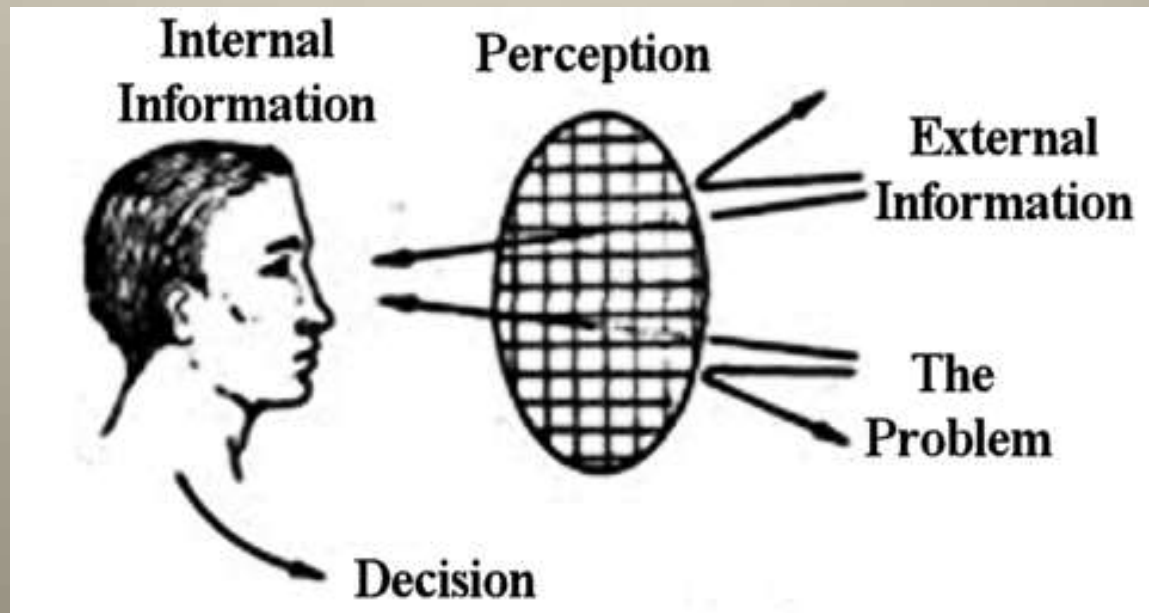


The Authority has one of the largest Aquifer Storage and Recovery (ASR) systems in the US with 21 wells and a capacity of 6 Billion Gallons

Cross Section of ASR Wells



- **Water Management Decisions involve:**
 - Processing great amounts of external data
 - Judgment synthesized from managers' understanding of external data and internal factors (past experiences, personality & emotions)



Focusing Efforts on a Central Question: “When to Start ASR Recovery?”

- Difficulty in developing a decision tool increases proportionally to the number of questions and variable interdependencies
- For this exercise, we Chose one Big Picture Question, that we struggle with annually
“When to Start ASR Recovery?”

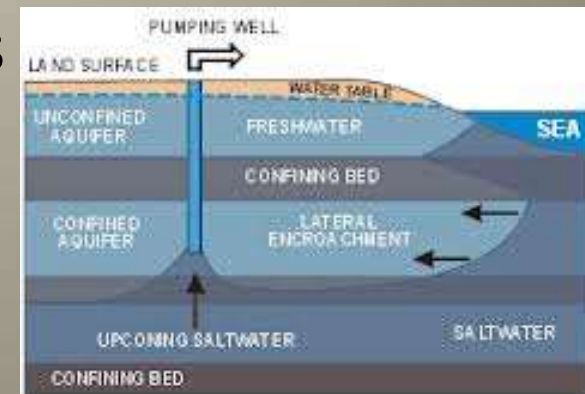
If ASR Recovery is Started Too Soon:

- Costs rise because ASR Water is treated twice, once before it is placed underground and upon recovery to remove arsenic
- “Clear” water in the reservoirs can contribute to algal blooms
- ASR Recovered water has higher TDS, too much can lead to water quality concerns

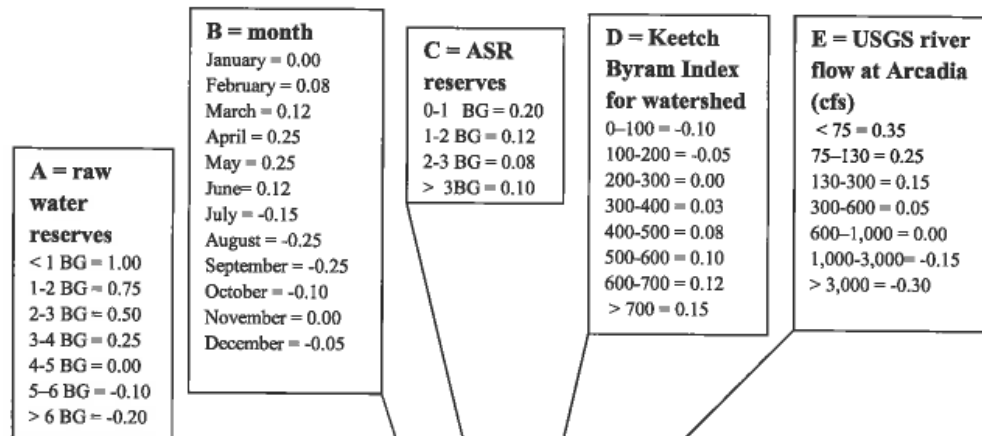


If ASR Recovery is Started Too Late:

- Less “good” quality water in the reservoirs to blend away effects of higher TDS ASR water
- Greater risk of running short = watering restrictions
- Having to pull too hard on the wells increases upconing from lower, higher salinity formations



Development of the Decision Tool



ASR Recovery Initiation Decision: $F(A+B+C+D+E+F+G+H+I+J) = X$

where:

if $0 < X < 1$, the decision is "No"

if $X > 1$, the decision is "Yes"

F = CPC 1 Month Precip Outlook
 Above Normal = -0.10
 Normal/EC = 0.00
 Below Normal = 0.15

G = CPC 1 Month Temp Outlook
 Above Normal = 0.07
 Normal/EC = 0.00
 Below Normal = -0.05

H = CPC 3 Month Precip Outlook
 Above Normal = -0.15
 Normal/EC = 0.00
 Below Normal = 0.20

I = CPC 3 Month Temp Outlook
 Above Normal = 0.10
 Normal/EC = 0.00
 Below Normal = -0.08

J = Demands
 < 90% RAA = -0.08
 90 - 95% RAA = -0.04
 95 - 105% RAA = 0.00
 105 - 110% RAA = 0.04
 > 110% RAA = 0.08



Choosing Variables and Scaling According to Importance

Table 1

Decision Tool Variables In Order of Decreasing Importance

Rank	Variable	Range of Values
1	Raw Water Reserves	1.20
2	River Flow	0.65
3	Month	0.50
4	3 Month Precip Forecast	0.35
5	KBDI	0.25
6	1 Month Precip Forecast	0.25
7	ASR Reserves	0.20
8	3 Month Temp Forecast	0.18
9	Demands	0.16
10	1 Month Temp Forecast	0.12

Some variables are more important than others

Top 3 variables count for 60% of our index

Choosing Variables and Scaling According to Importance

Table 1

Decision Tool Variables In Order of Decreasing Importance

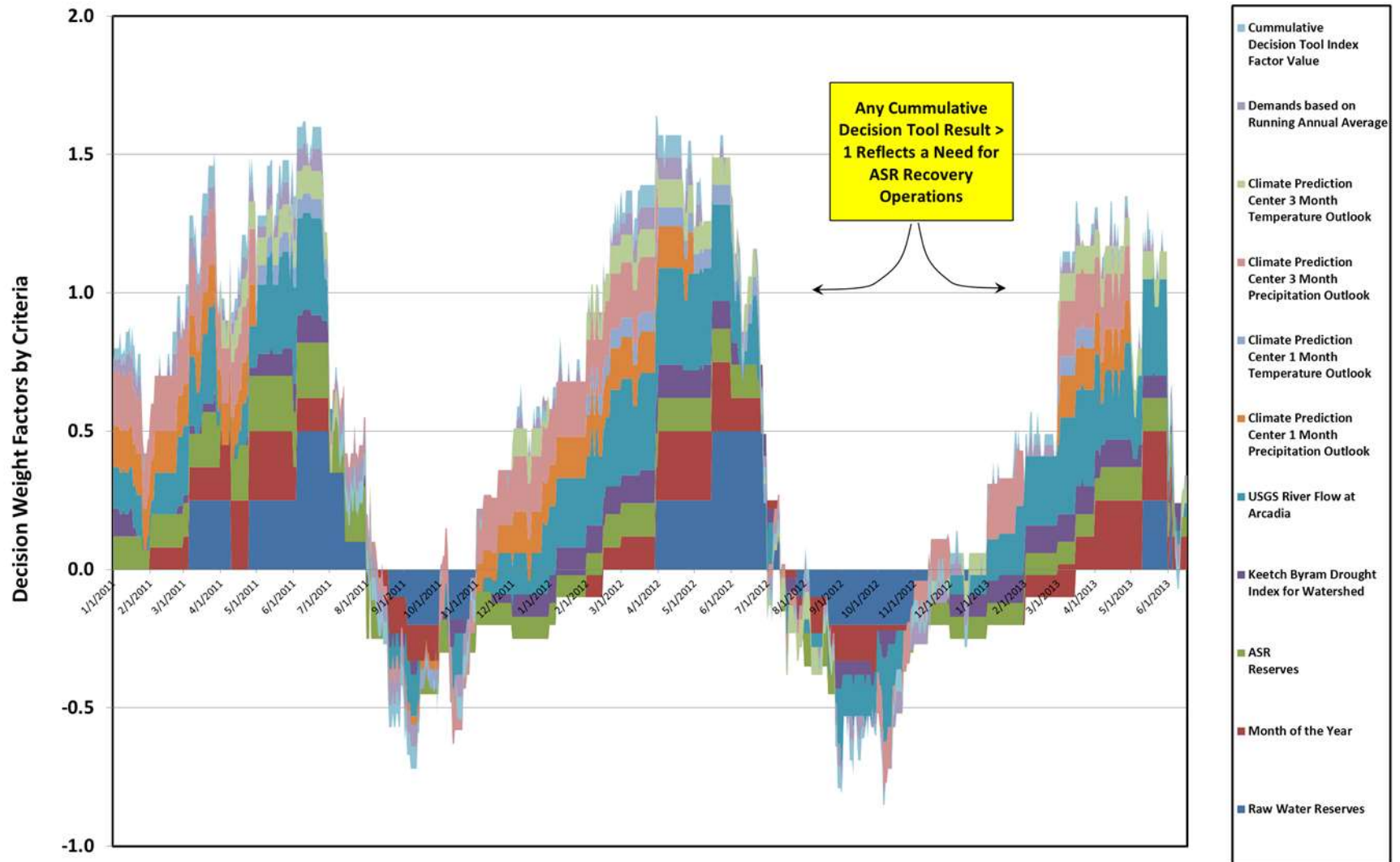
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8	3 Month Temp Forecast	0.18
9	Demands	0.16
10	1 Month Temp Forecast	0.12

**Climate
forecast
products
account for
23% of our
index**

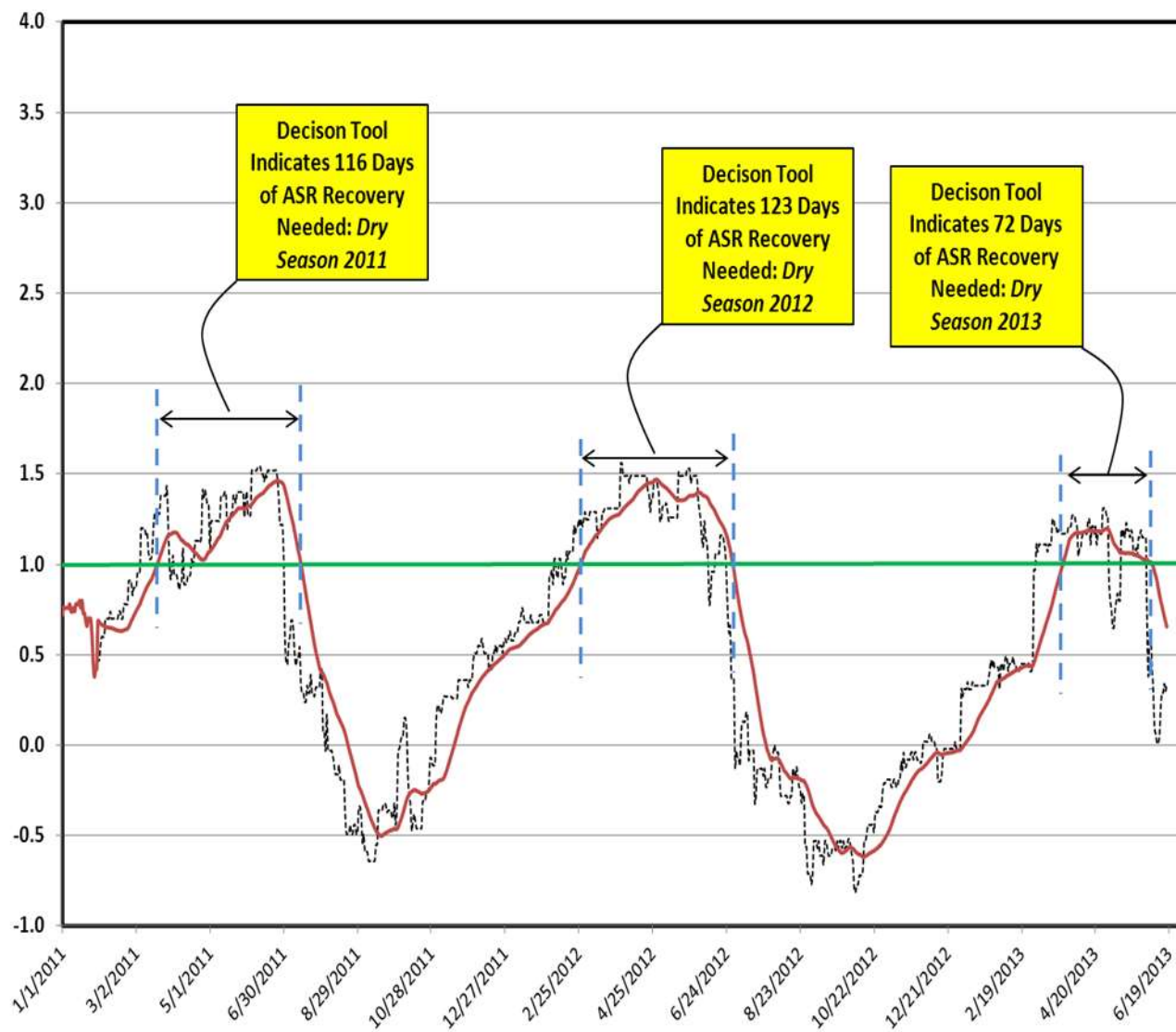


Date	A		B		C		D		E		F		G		H		I		J			Cumulative Decision Tool Index Factor Value	Cumulative Decision Tool Index Factors with Smoothing Using 30 day running average
	Raw Water Reserves		Month of the Year		ASR Reserves		Keetch Byram Drought Index for Watershed		USGS River Flow at Arcadia		Climate Prediction Center 1 Month Precipitation Outlook		Climate Prediction Center 1 Month Temperature Outlook		Climate Prediction Center 3 Month Precipitation Outlook		Climate Prediction Center 3 Month Temperature Outlook		Demands based on Running Annual Average				
	Reserves (BG)	Factor	Month	Factor	Reserves (BG)	Factor	Value	Factor	Flow (cfs)	Factor	Prediction	Factor	Prediction	Factor	Prediction	Factor	Prediction	Factor	Range (% of Running Annual Average)		Factor		
	< 1	1.00	Jan	0.00	0 - 1 BG	0.20	0 - 100 = -0.20	-0.10	<75	0.35	Above Normal	-0.10	Above Normal	0.07	Above Normal	-0.15	Above Normal	0.10	< 90% RAA		-0.08		
	1 - 2	0.75	Feb	0.08	1 - 2 BG	0.12	100 - 200 = 0.00	-0.05	75 - 130	0.25	Normal/Equal Chance	0.00	Normal/Equal Chance	0.00	Normal/Equal Chance	0.00	Normal/Equal Chance	0.00	90 - 95% RAA		-0.04		
	2 - 3	0.50	Mar	0.12	2 - 3 BG	0.08	200 - 300 = 0.00	0.00	130 - 300	0.15	Below Normal	0.15	Below Normal	-0.05	Below Normal	0.20	Below Normal	-0.05	95 - 105% RAA		0.00		
3 - 4	0.25	Apr	0.25	> 3 BG	0.00	300 - 400 = 0.00	0.03	300 - 600	0.05									105 - 110% RAA		0.04			
4 - 5	0.00	May	0.25			400 - 500 = 0.00	0.08	600 - 1,000	0.00									> 110% RAA		0.08			
5 - 6	-0.10	Jun	0.12			500 - 600 = 0.00	0.10	1,000 - 3,000	-0.15														
> 6	-0.20	Jul	-0.15			600 - 700 = 0.00	0.12	> 3,000	-0.30														
		Aug	-0.25			> 700	0.15																
		Sep	-0.25																				
		Oct	-0.10																				
		Nov	0.00																				
		Dec	-0.05																				
1/1/2011	4.436	0.00	Jan-11	0.00	1.424	0.12	540	0.10	181	0.15	B	0.15	N	0.00	B	0.20	N	0.00	23.205	104%	0.00	0.72	0.72
1/2/2011	4.424	0.00	Jan-11	0.00	1.424	0.12	542	0.10	175	0.15	B	0.15	N	0.00	B	0.20	N	0.00	23.386	105%	0.04	0.76	0.76
1/3/2011	4.403	0.00	Jan-11	0.00	1.424	0.12	545	0.10	165	0.15	B	0.15	N	0.00	B	0.20	N	0.00	23.657	106%	0.04	0.76	0.76
1/4/2011	4.361	0.00	Jan-11	0.00	1.424	0.12	546	0.10	155	0.15	B	0.15	N	0.00	B	0.20	N	0.00	23.53	106%	0.04	0.76	0.76
1/5/2011	4.354	0.00	Jan-11	0.00	1.420	0.12	548	0.10	146	0.15	B	0.15	N	0.00	B	0.20	N	0.00	23.974	108%	0.04	0.76	0.76
1/6/2011	4.344	0.00	Jan-11	0.00	1.415	0.12	507	0.10	159	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.288	109%	0.04	0.76	0.76
1/7/2011	4.338	0.00	Jan-11	0.00	1.408	0.12	496	0.08	187	0.15	B	0.15	N	0.00	B	0.20	N	0.00	25.157	113%	0.08	0.78	0.78
1/8/2011	4.309	0.00	Jan-11	0.00	1.402	0.12	497	0.08	225	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.129	108%	0.04	0.74	0.74
1/9/2011	4.299	0.00	Jan-11	0.00	1.396	0.12	499	0.08	205	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.132	108%	0.04	0.74	0.74
1/10/2011	4.290	0.00	Jan-11	0.00	1.390	0.12	501	0.10	182	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.132	108%	0.04	0.76	0.76
1/11/2011	4.290	0.00	Jan-11	0.00	1.384	0.12	497	0.08	168	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.41	110%	0.04	0.74	0.74
1/12/2011	4.279	0.00	Jan-11	0.00	1.378	0.12	498	0.08	159	0.15	B	0.15	N	0.00	B	0.20	N	0.00	25.684	115%	0.08	0.78	0.78
1/13/2011	4.263	0.00	Jan-11	0.00	1.373	0.12	499	0.08	158	0.15	B	0.15	N	0.00	B	0.20	N	0.00	25.169	113%	0.08	0.78	0.78
1/14/2011	4.252	0.00	Jan-11	0.00	1.367	0.12	499	0.08	149	0.15	B	0.15	N	0.00	B	0.20	N	0.00	25.135	113%	0.08	0.78	0.78
1/15/2011	4.240	0.00	Jan-11	0.00	1.361	0.12	500	0.10	143	0.15	B	0.15	N	0.00	B	0.20	N	0.00	25.416	114%	0.08	0.80	0.80
1/16/2011	4.226	0.00	Jan-11	0.00	1.356	0.12	502	0.10	136	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.452	110%	0.04	0.76	0.76
1/17/2011	4.218	0.00	Jan-11	0.00	1.350	0.12	504	0.10	136	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.609	110%	0.08	0.80	0.80
1/18/2011	4.198	0.00	Jan-11	0.00	1.344	0.12	373	0.03	139	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.833	111%	0.08	0.73	0.73
1/19/2011	4.188	0.00	Jan-11	0.00	1.338	0.12	364	0.03	178	0.15	B	0.15	N	0.00	B	0.20	N	0.00	24.74	111%	0.08	0.73	0.73
1/20/2011	4.164	0.00	Jan-11	0.00	1.332	0.12	369	0.03	211	0.15	B	0.15	N	0.00	B	0.20	N	0.00	23.872	107%	0.04	0.69	0.69
1/21/2011	4.162	0.00	Jan-11	0.00	1.326	0.12	296	0.00	208	0.15	B	0.15	N	0.00	B	0.20	N	0.00	23.764	106%	0.04	0.66	0.66
1/22/2011	4.158	0.00	Jan-11	0.00	1.320	0.12	275	0.00	222	0.15	B	0.15	N	0.00	B	0.20	N	0.00	25.041	112%	0.08	0.70	0.70
1/23/2011	4.148	0.00	Jan-11	0.00	1.314	0.12	277	0.00	267	0.15	B	0.15	N	0.00	B	0.20	N	0.00	25.772	115%	0.08	0.70	0.70
1/24/2011	4.126	0.00	Jan-11	0.00	1.308	0.12	279	0.00	257	0.15	B	0.15	N	0.00	B	0.20	N	0.00	25.449	114%	0.08	0.70	0.70
1/25/2011	4.126	0.00	Jan-11	0.00	1.302	0.12	284	0.00	259	0.15	B	0.15	N	0.00	B	0.20	N	0.00	23.294	104%	0.00	0.62	0.62
1/26/2011	4.184	0.00	Jan-11	0.00	1.298	0.12	164	-0.05	400	0.05	B	0.15	N	0.00	B	0.20	N	0.00	22.973	103%	0.00	0.47	0.47
1/27/2011	4.180	0.00	Jan-11	0.00	1.292	0.12	169	-0.05	735	0.00	B	0.15	N	0.00	B	0.20	N	0.00	20.291	91%	-0.04	0.38	0.38
1/28/2011	4.172	0.00	Jan-11	0.00	1.286	0.12	171	-0.05	760	0.00	B	0.15	N	0.00	B	0.20	N	0.00	21.495	96%	0.00	0.42	0.42
1/29/2011	4.217	0.00	Jan-11	0.00	1.280	0.12	175	-0.05	630	0.00	B	0.15	N	0.00	B	0.20	N	0.00	22.931	103%	0.00	0.42	0.42
1/30/2011	4.237	0.00	Jan-11	0.00	1.274	0.12	180	-0.05	530	0.05	B	0.15	N	0.00	B	0.20	N	0.00	21.96	98%	0.00	0.47	0.69
1/31/2011	4.287	0.00	Jan-11	0.00	1.268	0.12	185	-0.05	466	0.05	B	0.15	N	0.00	B	0.20	N	0.00	21.3	95%	0.00	0.47	0.68
2/1/2011	4.293	0.00	Feb-11	0.08	1.262	0.12	192	-0.05	415	0.05	B	0.15	N	0.00	B	0.20	N	0.00	21.608	97%	0.00	0.55	0.67
2/2/2011	4.311	0.00	Feb-11	0.08	1.257	0.12	200	0.00	374	0.05	B	0.15	N	0.00	B	0.20	N	0.00	22.577	101%	0.00	0.60	0.67
2/3/2011	4.315	0.00	Feb-11	0.08	1.251	0.12	208	0.00	338	0.05	B	0.15	N	0.00	B	0.20	N	0.00	21.997	98%	0.00	0.60	0.66
2/4/2011	4.325	0.00	Feb-11	0.08	1.245	0.12	215	0.00	314	0.05	B	0.15	N	0.00	B	0.20	N	0.00	21.689	97%	0.00	0.60	0.66
2/5/2011	4.340	0.00	Feb-11	0.08	1.239	0.12	223	0.00	297	0.15	B	0.15	N	0.00	B	0.20	N	0.00	22.34	100%	0.00	0.70	0.66
2/6/2011	4.323	0.00	Feb-11	0.08	1.233	0.12	230	0.00	280	0.15	B	0.15	N	0.00	B	0.20	N	0.00	21.837	98%	0.00	0.70	0.65
2/7/2011	4.345	0.00	Feb-11	0.08	1.227	0.12	225	0.00	267	0.15	B	0.15	N	0.00	B	0.20	N	0.00	21.688	97%	0.00	0.70	0.65
2/8/2011	4.334	0.00	Feb-11	0.08	1.221	0.12	219	0.00	262	0.15	B	0.15	N	0.00	B	0.20	N	0.00	22.355	100%	0.00	0.70	0.65

Individual Decision Tool Weight Components



Cummulative Value of Decision Factors



Decision Tool
Indicates 116 Days
of ASR Recovery
Needed: Dry
Season 2011

Decision Tool
Indicates 123 Days
of ASR Recovery
Needed: Dry
Season 2012

Decision Tool
Indicates 72 Days
of ASR Recovery
Needed: Dry
Season 2013

----- Cumulative
Decision Tool Index
Factor Value

— Cumulative Decision
Tool Index Factors with
Smoothing Using 30 day
running average

Cummulative Value of
Decision Factors Greater
than "1" Indicates a
need for ASR Recovery

In Summation

- **Recurring annual decision** every Feb - May
- **Stakes are High** - we could put ourselves at great disadvantage if we “miss” with our decisions
- **This is the Information Age** - data is readily available
- **Responsibility** to be good stewards and make resource decisions in thoughtful and deliberative manner
- **Political pressure** to exercise science and make defensible decisions

The End