Decision Tool Development Exercise

“When to Start ASR Recovery?”

Peace River Manasota Regional Water Supply Authority

June 26, 2013

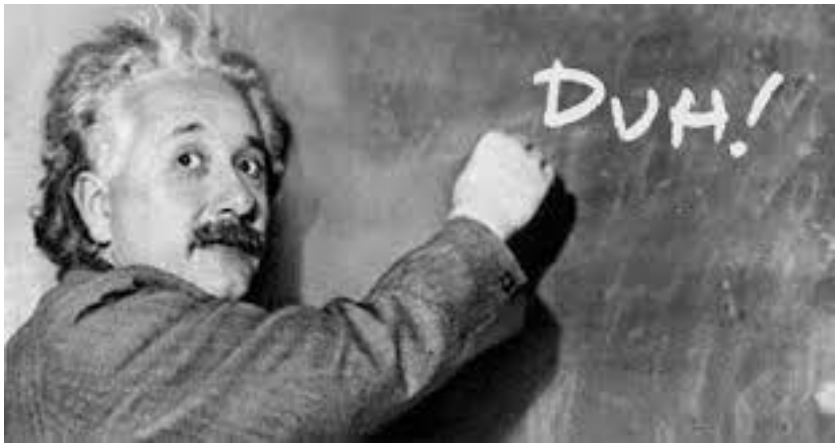
Outline

- The Value of Decision Tools
- Focusing Efforts on a Central Question: “When to Start ASR Recovery?”
- Development of the Decision Tool
- Choosing Variables and Scaling According to Importance
- Organizational Factors
- Where to Go from Here?

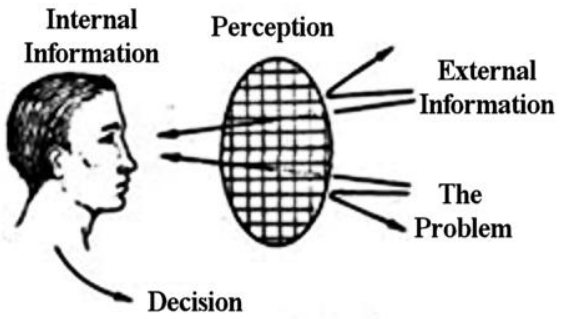
The Value of Decision Tools

Water Managers Making Ad Hoc Decisions

With Decision Tools Water Managers can Feel More Like



- **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)



- **Decision Tools:**
  - Reduce subjectivity and error which can creep in from decision makers
  - Decision Tools can insure the right data is:
    - considered
    - valued/weighted appropriately
    - placed into the proper context

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

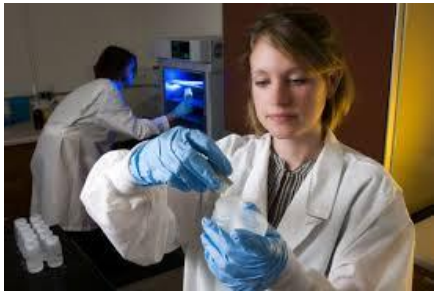
- Difficulty in developing a decision tool increases proportionally to the number of questions and variable interdependencies (i.e. OROP)
- For this first attempt, we Chose one Big Picture Question, "When to Start ASR Recovery?"

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

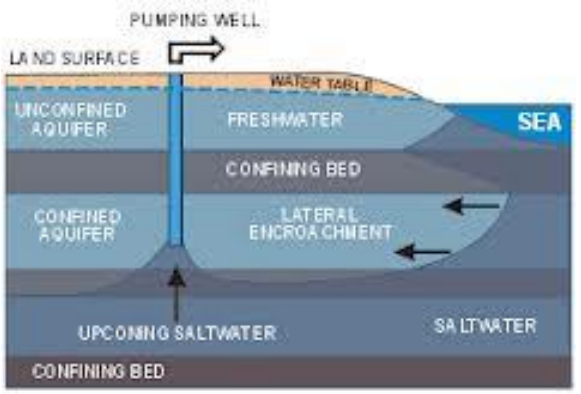


If ASR Recovery is Started **Too Late**:

- 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

A = raw water reserves
< 1 BG = 1.00
1-2 BG = 0.75
2-3 BG = 0.50
3-4 BG = 0.25
4-5 BG = 0.00
5–6 BG = -0.10
> 6 BG = -0.20

B = month
January = 0.00
February = 0.08
March = 0.12
April = 0.25
May = 0.25
June= 0.12
July = -0.15
August = -0.25
September = -0.25
October = -0.10
November = 0.00
December = -0.05

C = ASR reserves
0-1 BG = 0.20
1-2 BG = 0.12
2-3 BG = 0.08
> 3BG = 0.10

D = Keetch Byram Index for watershed
0–100 = -0.10
100-200 = -0.05
200-300 = 0.00
300-400 = 0.03
400-500 = 0.08
500-600 = 0.10
600-700 = 0.12
> 700 = 0.15

E = USGS river flow at Arcadia (cfs)
< 75 = 0.35
75–130 = 0.25
130-300 = 0.15
300-600 = 0.05
600–1,000 = 0.00
1,000-3,000= -0.15
> 3,000 = -0.30

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

Some variables are more important than others

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

Top 3 variables count for 60% of our index

Choosing Variables and Scaling According to Importance

Table 1

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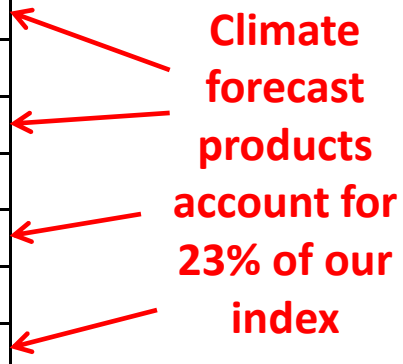
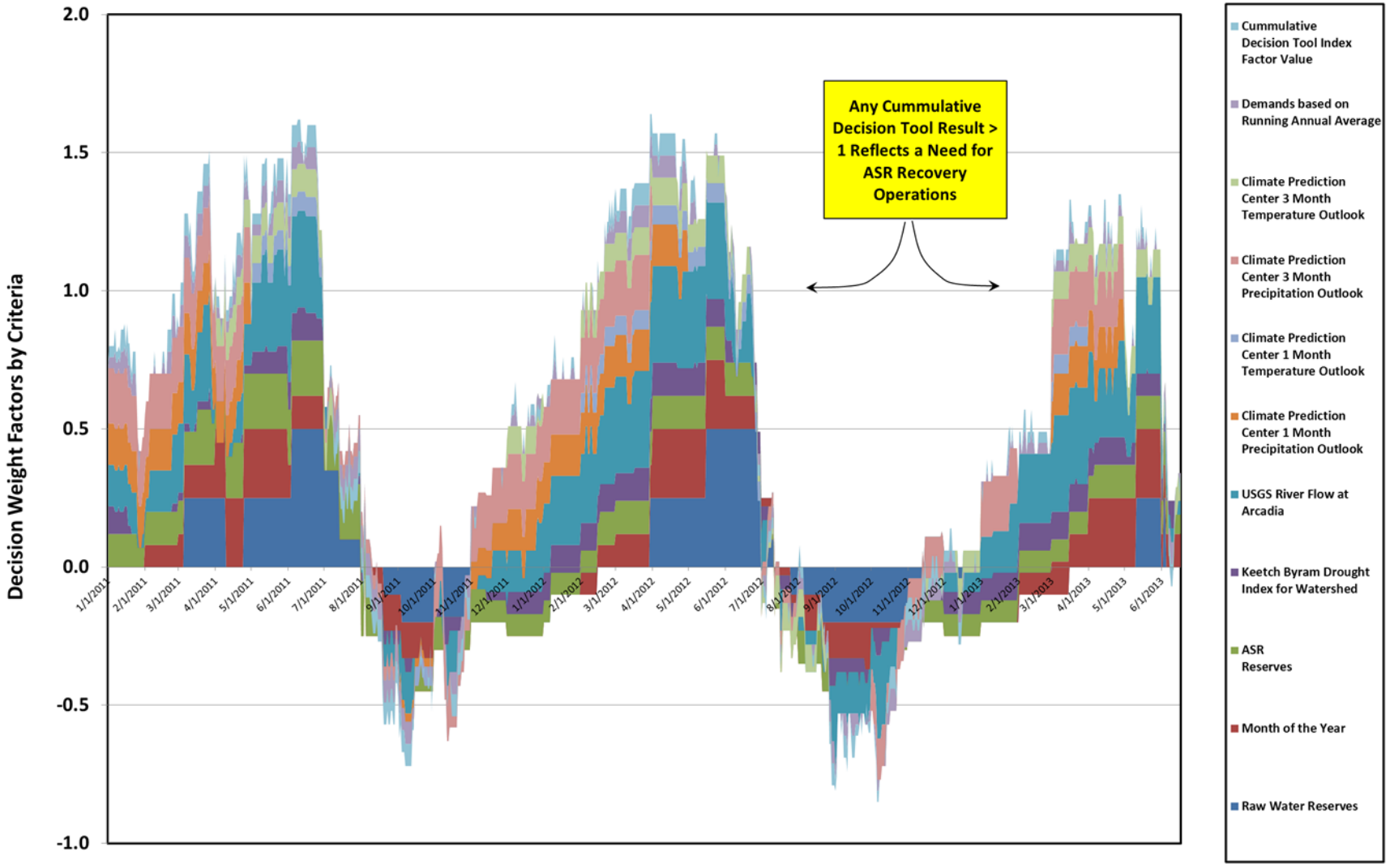
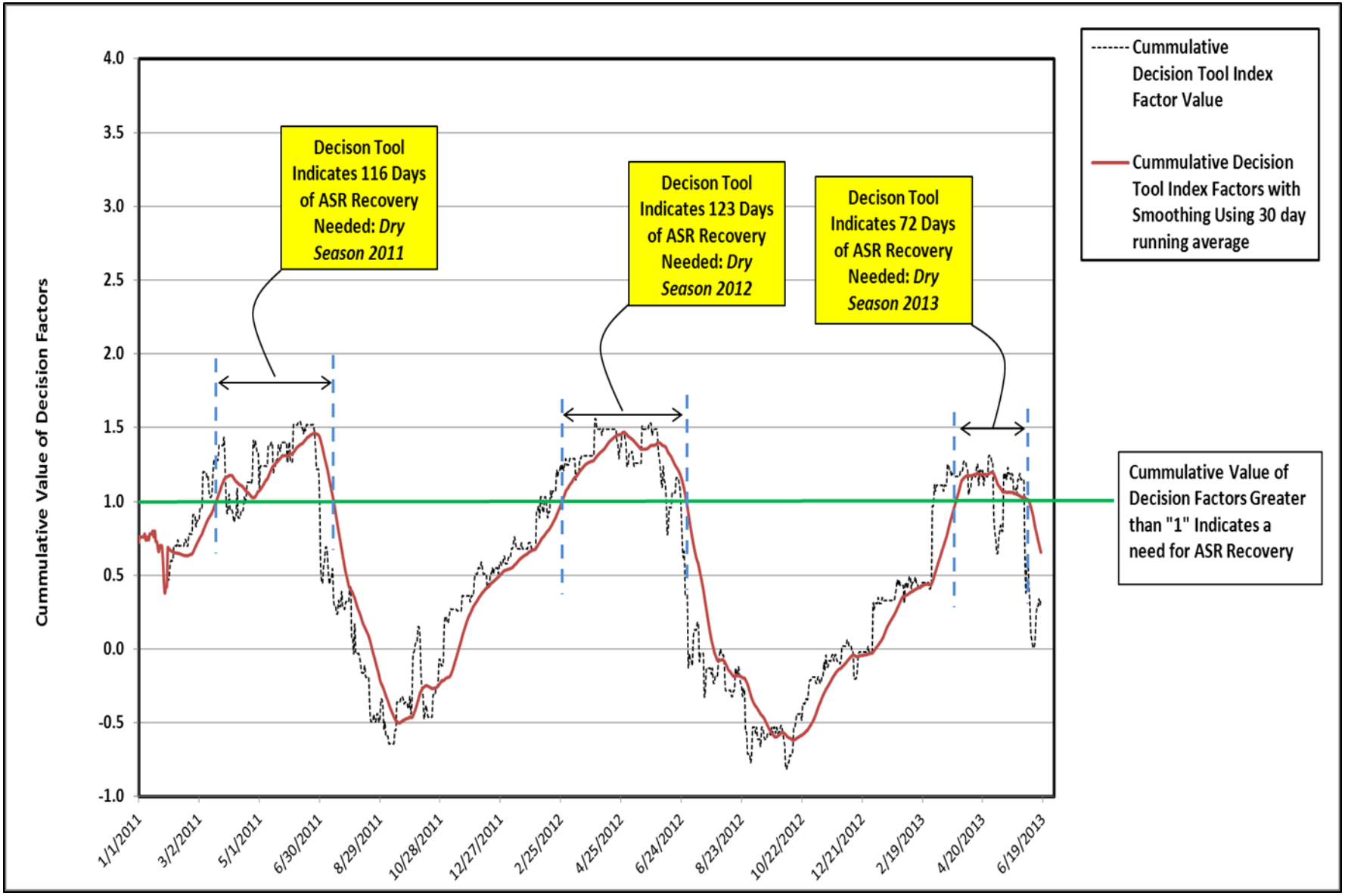
Rank	Variable	Range of Values
1	Raw Water Reserves	1.20
2	River Flow	0.65
3	Month	0.50
4	3 Month Precip Forecast	0.35
5	KBDI	0.25
6	1 Month Precip Forecast	0.25
7	ASR Reserves	0.20
8	3 Month Temp Forecast	0.18
9	Demands	0.16
10	1 Month Temp Forecast	0.12

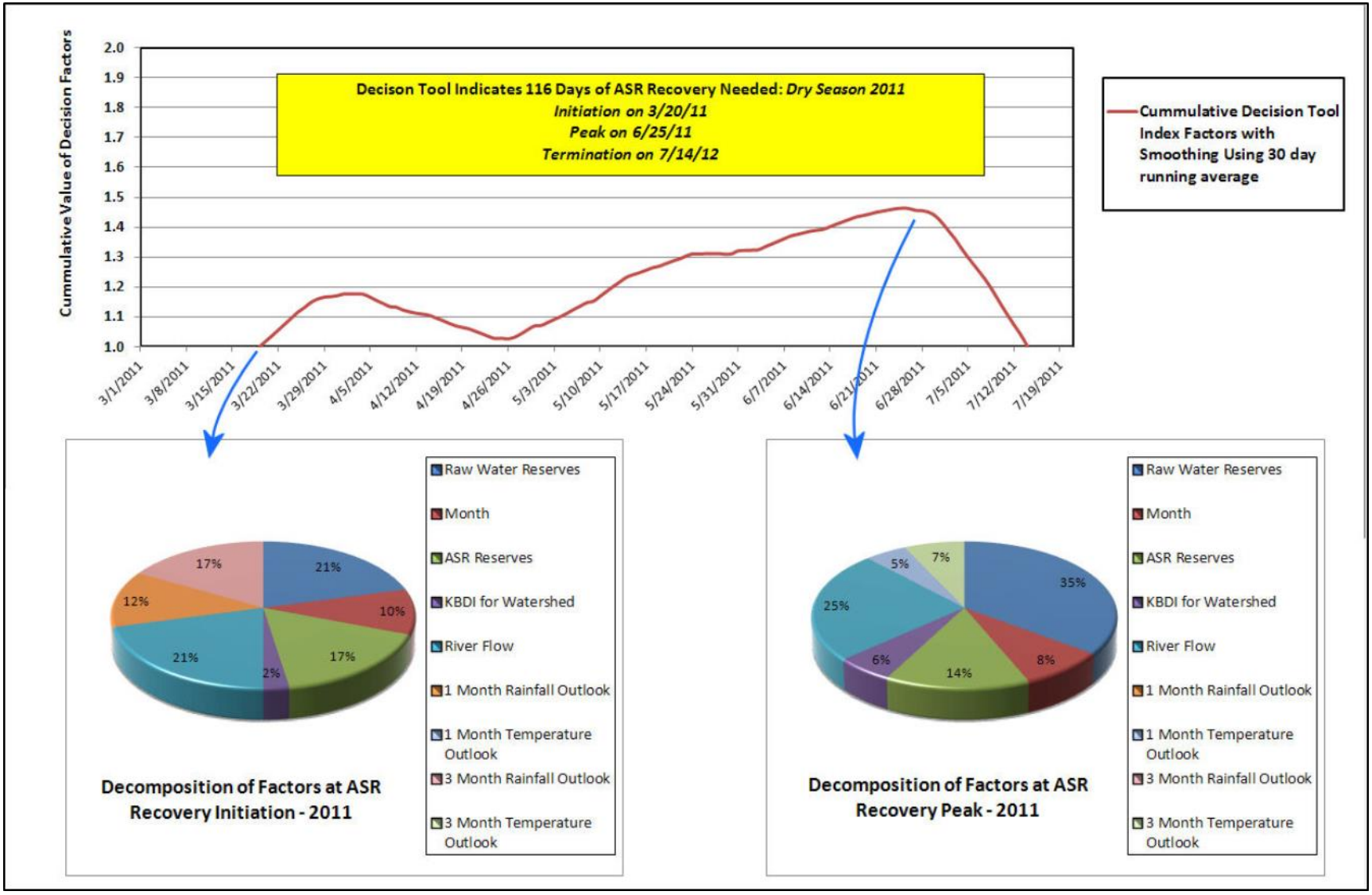


	A		B		C		D		E		F		G		H		I		J					
	Raw Water Reserves		Month of the Year		ASR Reserves		Keetch Byram Drought Index for Watershed		USGS River Flow at Arcadia		Climate Prediction Center 1 Month Precipitation Outlook		Climate Prediction Center 1 Month Temperature Outlook		Climate Prediction Center 3 Month Precipitation Outlook		Climate Prediction Center 3 Month Temperature Outlook		Demands based on Running Annual Average				Cummulative Decision Tool Index Factor Value	Cummulative Decision Tool Index Factors with Smoothing Using 30 day running 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	Demands (MGD)	Demands as a Percent of RAA	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	-0.08	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																				
Date			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
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
1/1/2011
3/2/2011
5/1/2011
6/30/2011
8/29/2011
10/28/2011
12/27/2011
2/25/2012
4/25/2012
6/24/2012
8/23/2012
10/22/2012
12/21/2012
2/19/2013
4/20/2013
6/19/2013
Decison Tool Indicates 116 Days of ASR Recovery Needed: Dry Season 2011
Decison Tool Indicates 123 Days of ASR Recovery Needed: Dry Season 2012
Decison Tool Indicates 72 Days of ASR Recovery Needed: Dry Season 2013
Cummulative Decision Tool Index Factor Value
Cummulative 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


Cummulative Value of Decision Factors
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
Decison Tool Indicates 116 Days of ASR Recovery Needed: Dry Season 2011
Initiation on 3/20/11
Peak on 6/25/11
Termination on 7/14/12
Cummulative Decision Tool Index Factors with Smoothing Using 30 day running average
3/1/2011
3/8/2011
3/15/2011
3/22/2011
3/29/2011
4/5/2011
4/12/2011
4/19/2011
4/26/2011
5/3/2011
5/10/2011
5/17/2011
5/24/2011
5/31/2011
6/7/2011
6/14/2011
6/21/2011
6/28/2011
7/5/2011
7/12/2011
7/19/2011
21%
10%
17%
2%
21%
12%
17%
Raw Water Reserves
Month
ASR Reserves
KBDI for Watershed
River Flow
1 Month Rainfall Outlook
1 Month Temperature Outlook
3 Month Rainfall Outlook
3 Month Temperature Outlook
Decomposition of Factors at ASR Recovery Initiation - 2011
35%
8%
14%
6%
25%
5%
7%
Raw Water Reserves
Month
ASR Reserves
KBDI for Watershed
River Flow
1 Month Rainfall Outlook
1 Month Temperature Outlook
3 Month Rainfall Outlook
3 Month Temperature Outlook
Decomposition of Factors at ASR Recovery Peak - 2011

Organizational Factors

- ASR is no longer controlled by construction permits
  - don't have to pump every spring anymore unless we need to
- Recurring annual decision
  - we put ourselves at a great disadvantage if we answer it wrongly
- Global trend towards greater use of information
  - Pressure from customers to explain our decisions
  - Political pressure to make smart, defensible decisions
- Small utility
  - less bureaucracy = fewer layers of resistance to overcome
- Important Internal Stakeholders
  - Former Tampa Bay Water employees familiar with advantages of OROP
  - Long association with Florida Water and Climate Alliance

Next Steps

- Extend the “hindcast” back to 2009 when our new reservoir came online
- Daily vs. monthly climate forecast products
- Testing/tweaking variable weighting to prevent false signals
- ?
- ?
- ?