FLORIDA WATER AND CLIMATE ALLIANCE WORKSHOP

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Workshop Handout, Kevin Morris
SESSION 4: *Use of Seasonal Climate Forecasts - Practical applicability from the user perspective*

DRAFT

Peace River Manasota Regional Water Supply Authority

Decision Processes Related to Water Supply Management Choices

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This DRAFT was developed as an exercise to explore and demonstrate application of Decision Science Methods to framing and articulating utility management decisions employing a widely varied pool of historic data observations coupled with scientific forecast products. It grew out of partner discussions in the FloridaWCA NOAA Project 2: Use of seasonal climate forecasts to minimize short-term operational risks for water supply and ecosystem restoration, exploring the application of seasonal scale data using probabilistic forecasts in operations planning and *decision support system.*

Elements of Decision Science in Utility Decision Making

Peace River Manasota Regional Water Supply Authority

Question: "*When to Initiate ASR Well Recovery?*"

Developed as an exercise to demonstrate application of Decision Science Methods to framing and articulating utility management decisions employing a widely varied pool of historic data observations coupled with scientific forecast products

Reservoir No. 2 - constructed in 2009 holds 6.3 Billion Gallons

One of the earliest ASR Wells in Florida, designated "S-2" installed in 1985

June 2013

The Peace River Manasota Regional Water Supply Authority

The Peace River Manasota Regional Water Supply Authority (Authority) is a wholesale water provider located in Southwest Florida between the cities of Tampa and Fort Myers. The Authority was formed in 1982 and is comprised of Charlotte, DeSoto, Manatee and Sarasota Counties. The Authority currently (2013) provides approximately 26 million gallons per day of potable water to approximately 300,000 citizens in Charlotte, DeSoto and Sarasota Counties as well as the City of North Port.

The Authority has 45 total employees and a senior management team comprised of six individuals. Similar to most organizations of this size and smaller, the lean staffing structure does not allow for a great deal of specialization and so senior staff must assume a diverse range of duties. Significant permitting efforts, engineering design and studies are often outsourced to consultants.

Utility Planning and the Role of Decision Science

Utility planning and management requires a great deal of judgment and intuitive reasoning. Utilities are entrusted to provide vital public services and the consequences of poor decisions can have widespread negative impact to the community. Poor decisions can stem from lack of information, poor understanding of the information and human factors. Leaders who are reckless or overconfident can make poor decisions as well as leaders who are too timid or overly conservative. Mistakes in judgment stemming from human factors can result from a lack of experience, embedded biases for previous experiences or the inability to adequately process wide ranging, complex sources of information. One of the dangers of our rapidly evolving technological world is the risk of being inundated by data forces us to ask “which data to use and which to ignore?”. Decision science broadly describes a process of activities which help organizations methodically and objectively collect information, assimilate the data and yield guidance to leaders. Decision tools help to promote better decision making by creating a framework which insures important data is gathered, weighed and considered in the proper context. Decision tools act as a hedge against the risk of poor decisions and promote greater confidence in the decision process.

This paper describes the application of decision science in helping to manage the Authority’s water supply capabilities. A myriad of operational and planning decisions must be made by utilities on a daily basis. Many decisions are nuanced, complex and require significant and wide ranging sources of information. For this example, the authors chose to focus on using decision science to answer a single important question for the Authority, “When to Initiate ASR Recovery?”. This question is currently answered by the Authority management team through consideration of dry season scenarios based on projected river flow. However, since no entity produces projected river flow forecasts for the Peace River, the projected hydrographs used in these scenarios are developed by staff using historic flow records from previous years and guesswork. The approach developed in this paper blends current water supply and environmental conditions with water demand projection scenarios and predictive climatological forecast products to bolster the methodology and reduce elements of subjectivity in deciding when to initiate ASR recovery.

The complexity of decision tools available to utilities can vary greatly based upon the capabilities and expertise of the organization and how complex the variables are within the decision matrix. Complex, sophisticated computer models such as that in use by Tampa Bay Water (OROP) to optimize their operational matrix are greatly evolved compared to what is being attempted here. This meager attempt simply defines an approach to answer a single but very important question to this organization – "When to initiate ASR Recovery". It does not attempt to dictate which ASR wells or wellfields to run and at what rates they should be operated at. The formulation of each organization's decision tools will vary according to their unique mix of assets, access to data, staff skill level and the ability to frame the questions. The authors hope the framework described here and the outcomes presented may serve to be useful to other utilities currently lacking a definitive framework for their water supply decisions.

The Authority's Water Resources

The Authority's water supply is derived from the Peace River, which drains a 1,367 square mile drainage basin which begins with the headwaters in Polk County near the geographic center of the peninsula and discharges to tide at Charlotte Harbor 106 miles to the southwest. The hydrologic cycle of the Peace River reflects a degree of seasonal dependence with flows (measured at the USGS gauge station at Arcadia) as high as 40,000 cfs during the rainy season and below 40 cfs during the dry season.

The Authority is the only permitted user withdrawing water from the Peace River. Entities further northward in the drainage basin have expressed sporadic interest in withdrawals, however, the viability of the river as a reliable source diminishes the further northward one travels. In fact, it is not uncommon during extremely low flow periods for karst features within the riverbed to intercept most if not all of the river flow in these regions (see Figure 1).

The Peace River, unencumbered by dams or salinity barriers, runs freely to tide, in fact, just a few miles from Charlotte Harbor, the flow at the Authority's intake is tidally influenced. Low river flow periods or strong storms can actually push brackish water to the intake location. Use of river water is, therefore, greatly dependent upon the ability to seasonally capture water when it is available. The Authority harvests seasonal high flows from the river by diverting it from the river to off-stream storage components.

Figure 1. Peace River Sinkhole in 2001, *taken by Sam Stone*

The river diversion pump station has a permitted capacity of 120 MGD. The off-stream storage components include 21 aquifer storage and recovery (ASR) wells and two off-stream reservoirs. The off-stream reservoirs comprise 6.5 billion gallons of storage. The ASR wells, permitted to receive potable water, store water in a permeable zone between 600 and 1,000 feet below ground surface and can store an estimated 6 billion gallons. This water is withdrawn during drought periods and helps sustain the region.

Strategy Critical to Surface Water Systems

Water utilities face myriad decisions as they navigate the continuum of water supply scenarios over time. Water demands, water supply conditions and climatological forecasts are three major factors which play a part in how utilities formulate their strategy but there many variables and considerations within each of these areas which come into play. Although relevant to all water systems, these concerns are especially critical for riverine surface water systems which are greatly reliant upon seasonal rainfall in some portion of a watershed to generate stream flow. Further, the criticality of seasonal flow becomes a more acute concern when there is no dam to hold back and retain runoff but it must be captured in real time as it flows past.

One common method for arriving at considered decisions is through using the *OODA Loop,* which stands for "***O****bserve,* ***O****rient,* ***D****ecide* and ***A****ct"* which is illustrated in Figure 2. One of the central strengths of the OODA Loop is the fact that it represents a cycle of circumspective strategy reformulation as past decisions undergo constant assessment using new data. This decision process is especially suitable to water utility management since customer demands and surface water hydrology conditions often change significantly in short periods of time in response to rainfall events. Thus, the continuous strategy reformulation effort embedded within this approach is well suited to the Authority and the decision tool will be formulated using daily data.

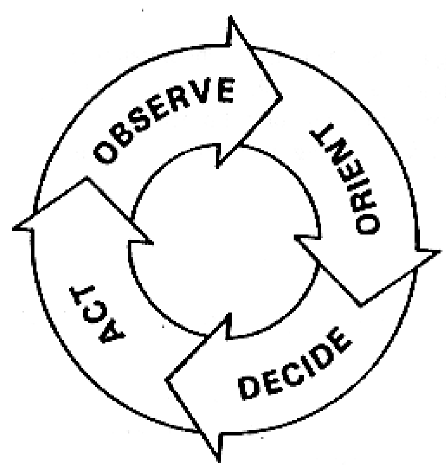

Figure 2. The command and control process: The OODA loop.

Defining the Question

The first step when developing a decision tool is to define and frame the central question(s) being explored. For the Authority, with two sources of water supply reserves (off-stream reservoirs and ASR), most of the uncertainty revolves around when to tap into or to augment the ASR reserves. There are occasionally years where abundant river flow is available every month and ASR recovery is not needed. However, most years the dry period between February and July calls for ASR system recovery. The primary decision the Authority is concerned with in managing ASR recovery operations is "When to

Commence ASR Recovery?". Supplemental decisions including what flow rate to target, which wells(fields) to use are also important but are subservient to the main decision to start ASR Recovery.

Overview of ASR

ASR reserves are an extremely important part of the Authority's water supply portfolio. The Authority maintains 21 ASR wells which can collectively store up to 6 billion gallons, nearly half of all potential reserves. However, the rate at which water can be accessed is limited by well capacities, piping infrastructure and permit restrictions to about 18 MGD. Most of the Authority's ASR wells are installed into the Suwannee formation, a zone of permeable rock located 600 – 1,100 feet below land surface with native salinity levels of about 1,100 mg/L, more than twice the drinking water standard of 500 mg/L.

Water stored in ASR wells can degrade due to mixing with native water, dissolution of naturally occurring minerals and turbidity which forms from the incomplete oxidation of sulfide. So, although it is originally injected as potable water, the water must be retreated upon its removal from the ground. ASR water withdrawn is discharged to the reservoir(s) where it blends with raw water originally diverted from the river and eventually undergoes treatment a second time at the Peace River Facility. The treatment processes in use at the Peace River Facility do not remove dissolved inorganic salts, so extended ASR recovery operations where the recovered water approaches background TDS levels of 1,100 mg/L can pose a challenge to maintaining finished water quality.

<u>What Happens if Recovery is Started too Soon?</u>

ASR recovery water is low in color and as it is recovered and pumped into the surface water reservoirs, these reservoirs gradually become more clear. As the high color level of stored water diminishes, light transmittance increases and the risk of algal blooms increases. Algal blooms are undesirable because they can impart an off-taste and undesirable odors to the water supply which become difficult to remove later during treatment. This concern, coupled with the expected increase in salinity, makes it prudent to commence ASR recovery early enough so that great volumes of raw water remain to mitigate expected quality impacts.

<u>What Happens if ASR Recovery is Started Too Late?</u>

The maximum rate ASR water can be withdrawn from the wells is about 18 MGD. Customer demands often reach 30 MGD during the dry season, far more than the ASR system can deliver by itself. So to maximize use of the volume contained within the ASR, it must be committed early so that it can run longer, thereby maximizing offset of raw water usage. But there are other considerations as well, If the decision to initiate ASR recovery is delayed too long, not only is there less raw water to buffer TDS effects, but it increases the likelihood of running short of supply and triggers the need to pump at higher rates. However, higher recovery rates cause severe well drawdown which accelerates deterioration in water quality. This deterioration in quality comes mostly from "worm-holing" of water from outside the zone of influence back to the borehole along the path of least resistance rather than from within the "bubble" of stored water proximate to the well. Another risk of high pumping rates for extended periods is up-coning from lower, higher salinity formations through cracks in the confining layer.

The optimal strategy seems to be to commit to ASR recovery sooner rather than later which accommodates a more moderate pumping rate which leads to a combination of improved yield and better water quality.

Decision Variables

The decision to initiate ASR recovery must consider many factors which can be expressed as variables. The authors developed a list of ten (10) variables which could affect the decision to start ASR recovery. To program these as inputs into a decision tool, one approach is to quantify and weight the variables in dynamic manner. For example, some factors will change with time as the dry season wanes and summer rains become more of a certainty. The general form of an equation to consider these various factors which play into making the decision to initiate ASR recovery can be developed in a zero order summation equation as shown in Figure 3 and as follows:

ASR Recovery Initiation Decision*:* $\boldsymbol{F}$(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"

The variables in this case pertain to following inputs and values:

A = raw water reserves *in billions of gallons (BG)*

< 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 of the year

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 = -1.00
October = -0.10

November = 0.00
December = -0.05

C = ASR reserves

0-1 BG = 0.20
1-2 BG = 0.12
2-3BG = 0.08
> 3BG = 0.00

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

F = Climate Prediction Center 1 Month Precipitation Outlook

Above Normal = -0.10
Normal/Equal Chance = 0.00
Below Normal = 0.15

G = Climate Prediction Center 1 Month Temperature Outlook

Above Normal = 0.07
Normal/Equal Chance = 0.00
Below Normal = -0.05

H = Climate Prediction Center 3 Month Precipitation Outlook

Above Normal = -0.15
Normal/Equal Chance = 0.00
Below Normal = 0.20

I = Climate Prediction Center 3 Month Temperature Outlook

Above Normal = 0.10
Normal/Equal Chance = 0.00
Below Normal = -0.08

J = Demands *based on running annual average (RAA)*
< 90% RAA = -0.08
90 – 95% RAA = -0.04
95 – 105% RAA = 0.00
105– 110% RAA = 0.04
> 110% RAA = 0.08

These weighting factors have been empirically developed by Authority and continue under consideration. At the present time, the range of values from high to low reflects the relative importance of the various factors. Ranking them in order of decreasing influence to the composite result we would find the results in Table 1.

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

As these figures demonstrate the most important variable is Raw Water Reserves, followed by River Flow and then Month. These three variables comprise the potential to exert up to 60% of the total impact on the decision tool result. The least important variable listed is the 1 Month Temperature Forecast with a total absolute range of 0.12, or just 3% of the potential swing.

Creating a Spreadsheet for the Decision Tool

Excel is an adequate platform for this rudimentary decision tool with each day reflected as a different row. The timeframe under consideration in this exercise is approximately is 2.5 years; from January 2011 to June 2013. The climatological forecasts are only updated monthly, so they have been assumed constant for the entire target month. Figure 4 presents a screen capture of the spreadsheet model developed for this exercise.

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

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

ASR Recovery Initiation Decision: $\boldsymbol{F}$(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

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

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

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Figure 3 – ASR Recovery Decision Tool Equation

	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		
	< 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															Demands (MGD)	Demands as a Percent of RAA	Factor		
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

Figure 4 – Screenshot of Spreadsheet

Results - Discussion

Figure 5 presents a graph of the decision criteria factor results over the study period with each individual variable identified. The seasonal aspects of the chart is quite evident with wet seasons resulting in low to negative scores and dry season scores peaking above one. The changing magnitude of the variables can be readily seen as the dry season transitions into wet season and vice versa.

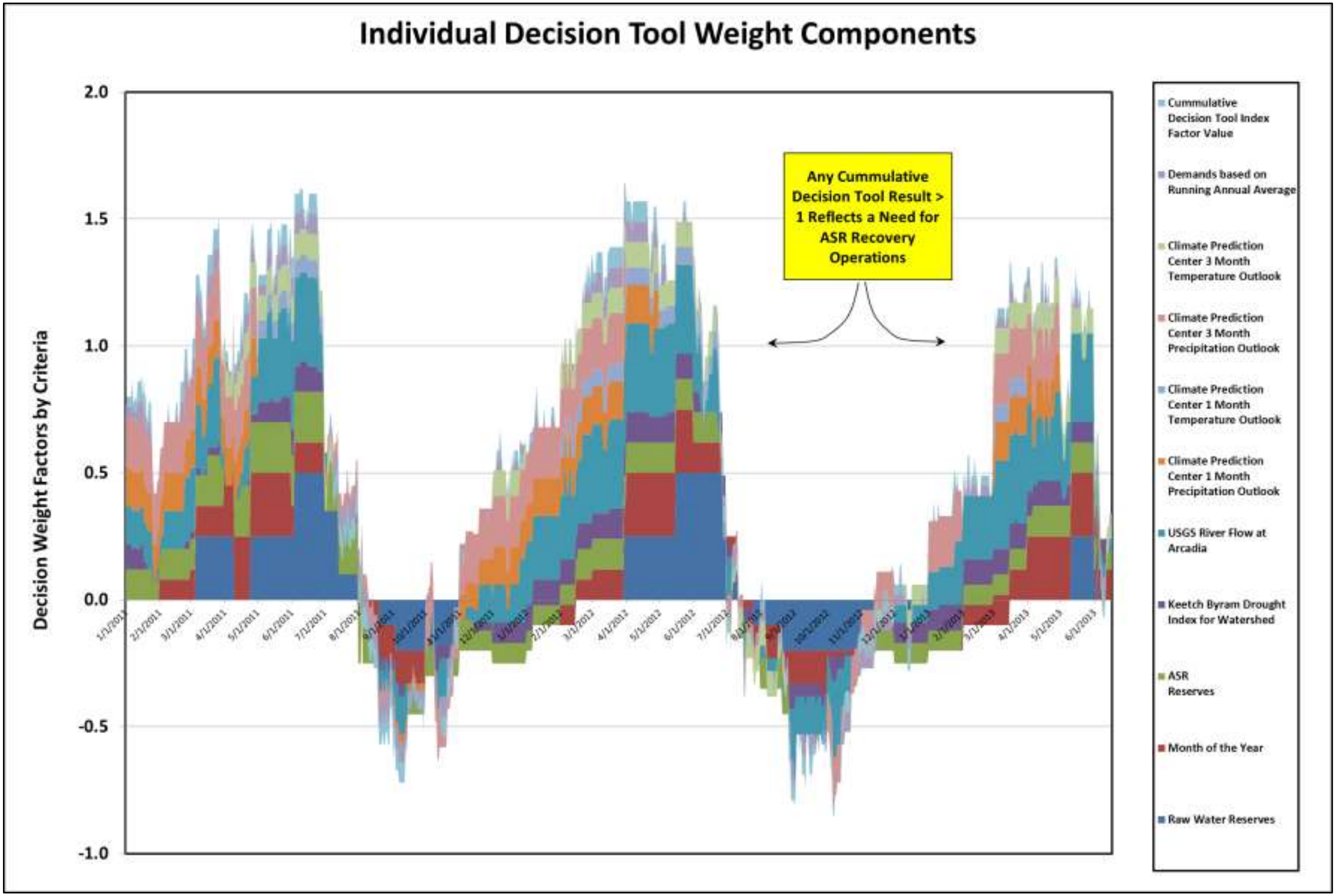
Recall that the criteria for determining if ASR Recovery should be initiated was a cumulative decision tool value greater than unity. Figure 6 reflects just the graphing of the cumulative score along with a smoothing factor derived by calculating a running 30 day average of the cumulative score. The smoothing factor convention is useful to moderate abrupt changes in the index caused by temporal events such as a rainfall event or a change in one of the monthly climatological forecast products. However, smoothing does delay recognition of changes which can be important. The chart reflects that ASR recovery would have been recommended for each of the past 3 dry seasons for periods ranging from 72 to 123 days.

Figures 7, 8 and 9 present graphs of the 2011, 2012 and 2013 dry seasons, respectively, along with pie charts to reflect how the index was composed at the start and peak of each indicated recovery period. Comparison of these results with actual recovery operations is not fruitful – until recently (May 2013) the Authority was operating most its ASR wells under a construction permit which compelled annual exercise of the wells in order to gather data to support research goals of various regulatory agencies. This means that ASR Recovery was preordained at the commencement of each dry season regardless of whether water was needed to meet public supply. However, this past May, the Authority was successful at securing transfer of all its ASR wells to operational status. This means that going forward ASR wells will only be operated when water is needed from them. Thus, this exercise was timely; a decision tool will be very helpful in deciding how to approach ASR Recovery in the spring of 2014.

Conclusions and Recommendations

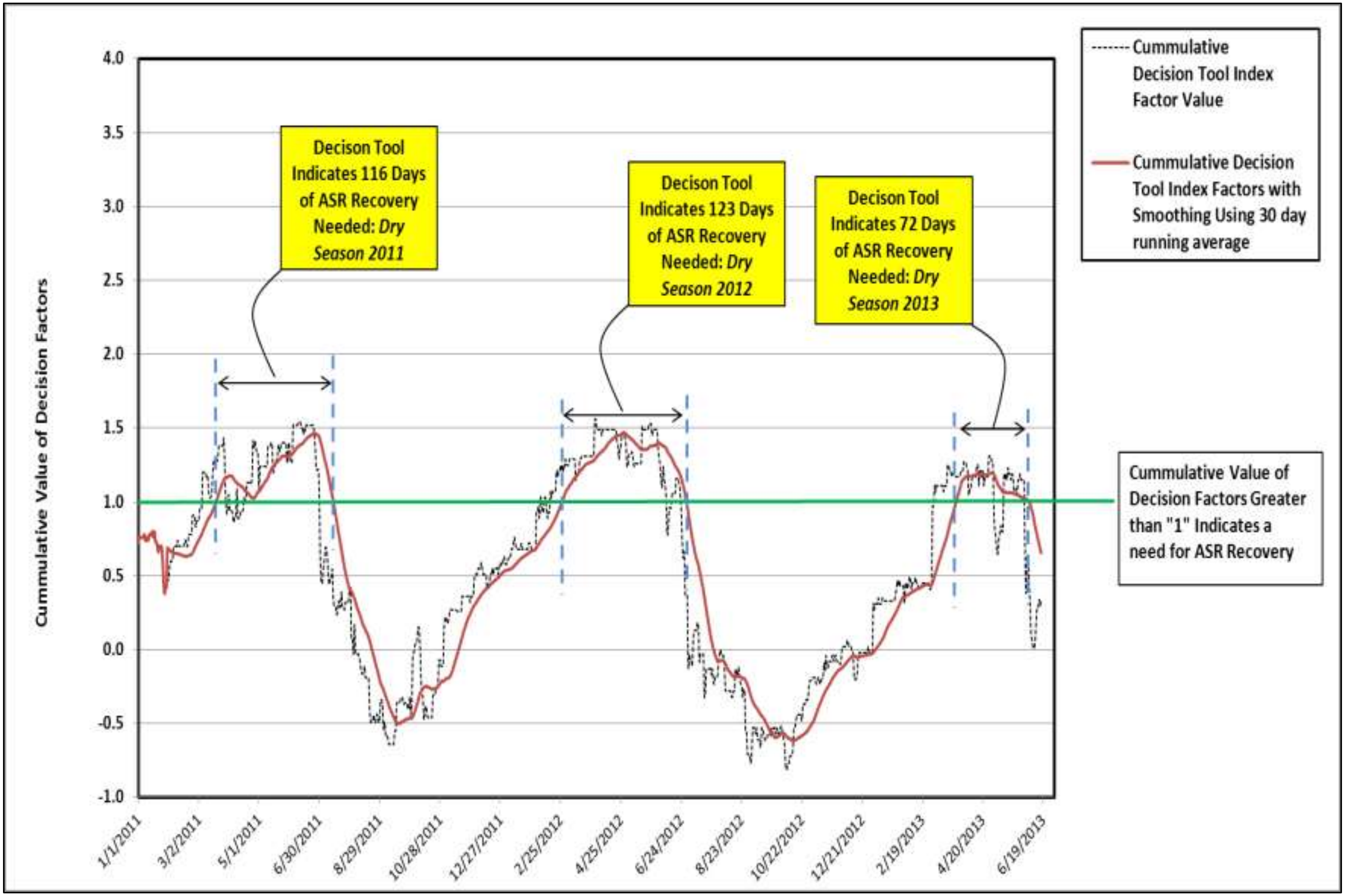
This exercise demonstrated the incorporation of climatological forecast products in developing utility operational decisions. The OODA loop which incorporates frequent strategy reconsideration was built into the model by developing a platform using daily data so that conditions are constantly undergoing revision and review. The framework was developed utilizing ten variables in an attempt to capture relevant factors. Additional work will be undertaken to fine tune variable weighting for the Authority going forward. Additionally, more detailed weather forecast data sets (such as FISH50) might offer the potential to use daily climatological products instead of the monthly product used in this version as well as products specifically constructed for peninsular Florida rather than national forecast models.

One appeal of this process was its development on a platform as ubiquitous as Excel requiring no specialized training and it could offer promise to other utilities considering similar questions. Although limited in its ability for application to complex, sophisticated systems, the approach works quite well for questions which can be adequately articulated and for which dependent variables are known.



Individual Decision Tool Weight Components
Decision Weight Factors by Criteria
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Any Cummulative Decision Tool Result > 1 Reflects a Need for ASR Recovery Operations
Cummulative Decision Tool Index Factor Value
Demands based on Running Annual Average
Climate Prediction Center 3 Month Temperature Outlook
Climate Prediction Center 3 Month Precipitation Outlook
Climate Prediction Center 1 Month Temperature Outlook
Climate Prediction Center 1 Month Precipitation Outlook
USGS River Flow at Arcadia
Keetch Byram Drought Index for Watershed
ASR Reserves
Month of the Year
Raw Water Reserves

Figure 5 – Individual Variable Contributions to ASR Recovery Decision Tool



Florida Water and Climate Alliance Workshop #9, June 26, 2013 - handout
Kevin Morris, Peace River Manasota Regional Water Authority

Figure 6 – Cumulative ASR Recovery Decision Tool Values

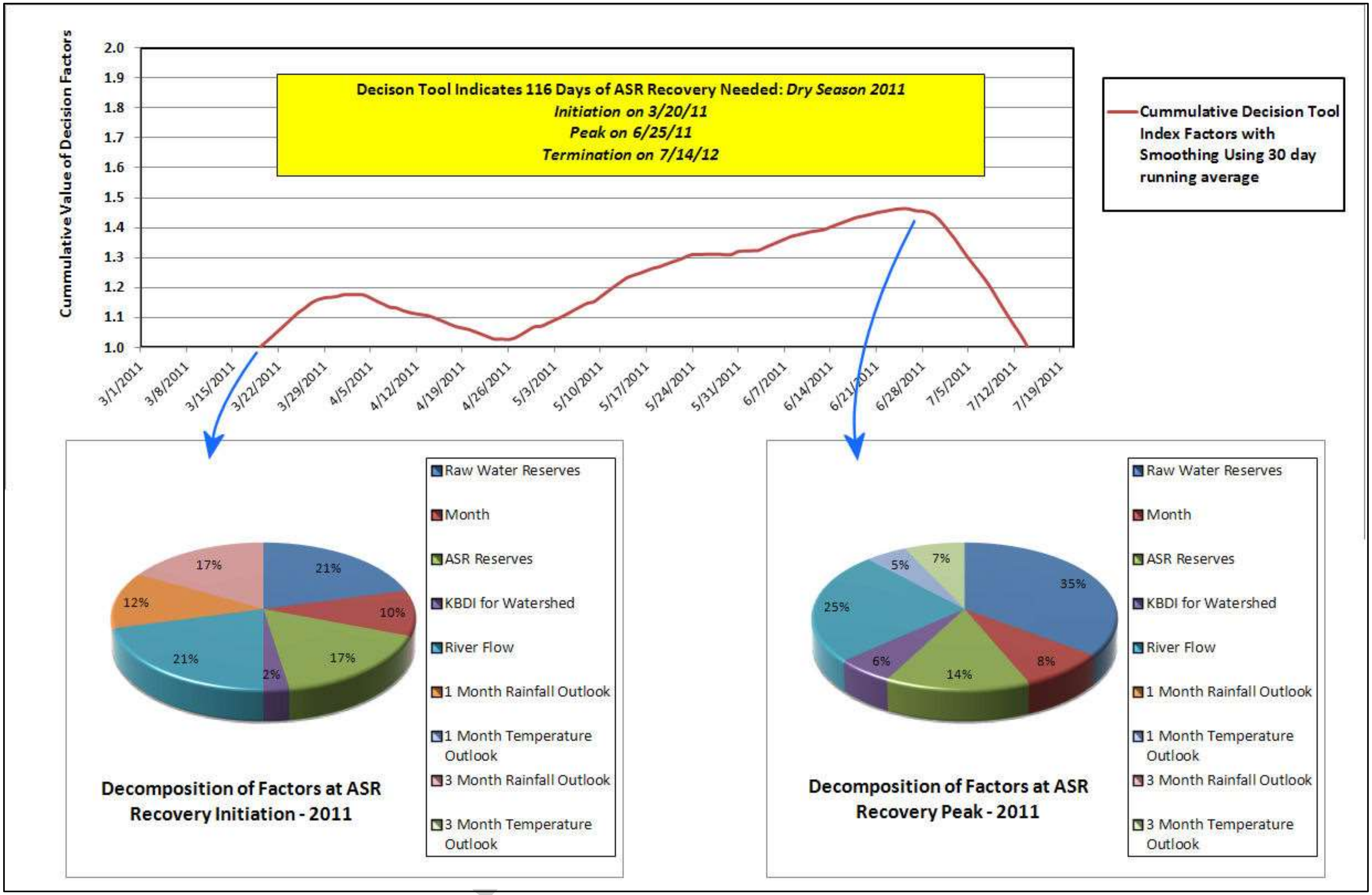


Figure 7 – Year 2011 ASR Recovery Decision Tool Values Analyzed

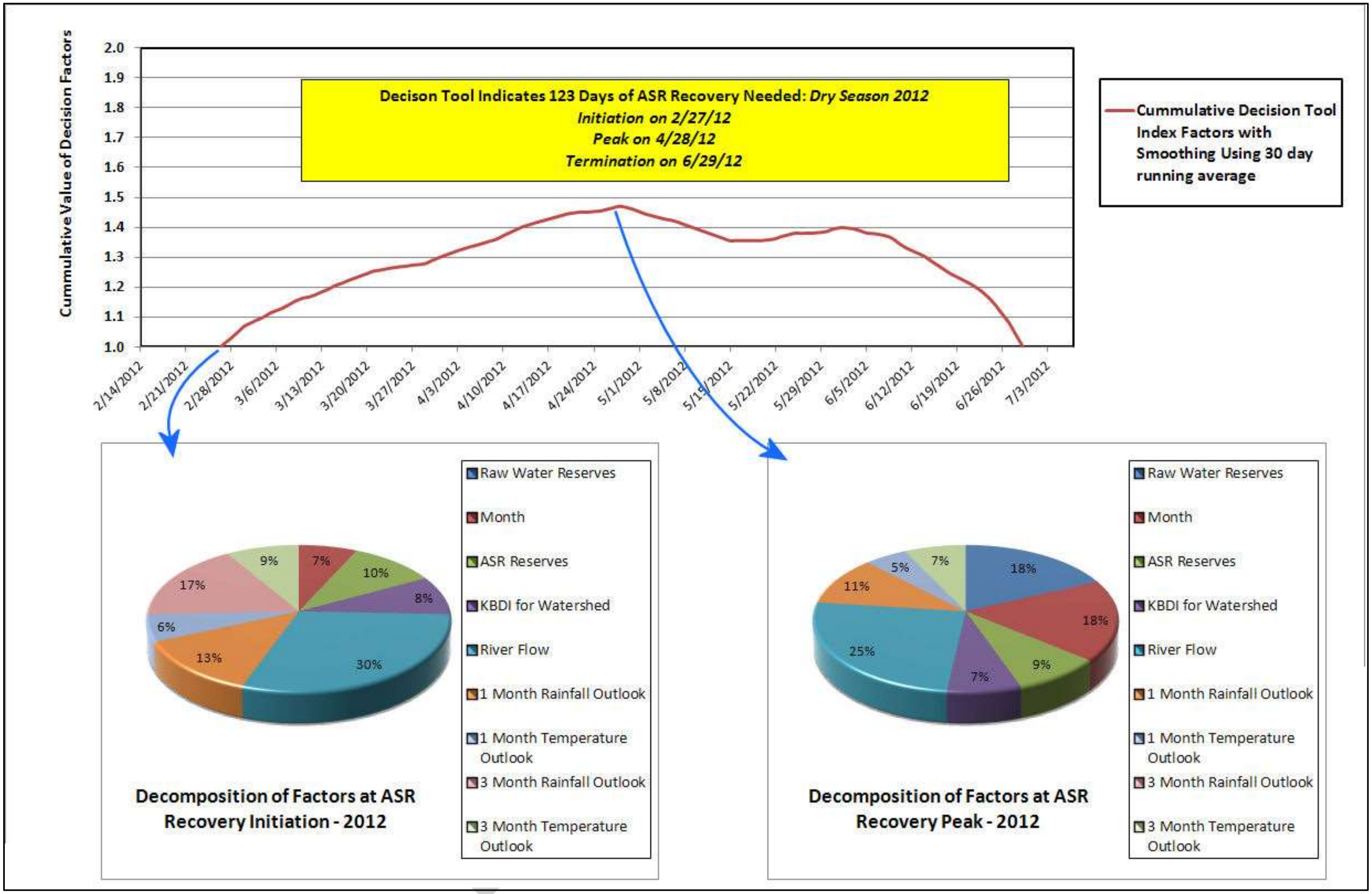


Figure 7 – Year 2012 ASR Recovery Decision Tool Values Analyzed

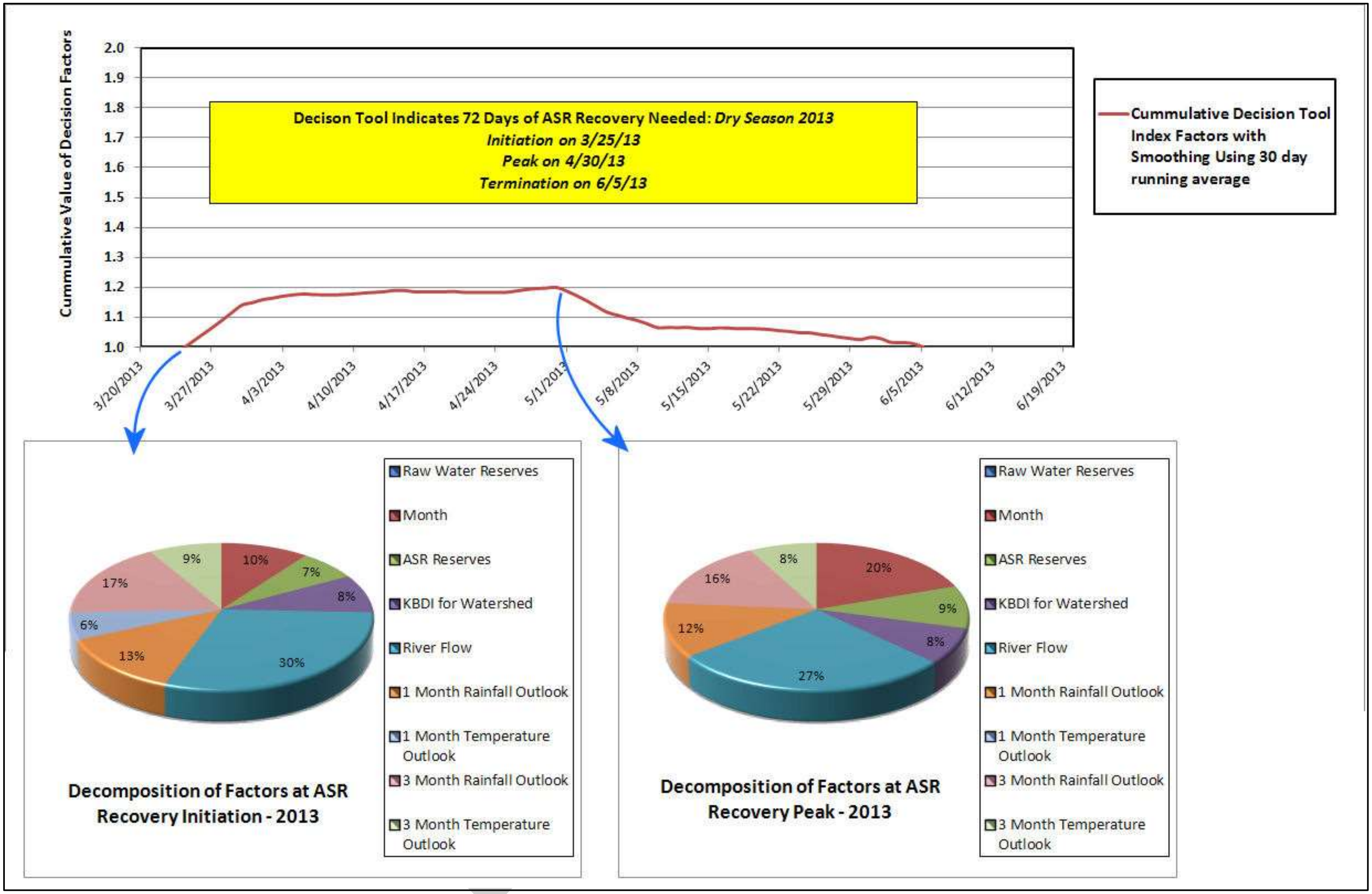


Figure 8 – Year 2013 ASR Recovery Decision Tool Values Analyzed