Preliminary Draft
Santa Cruz Water Supply Advisory Committee
Agreements and Recommendations

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Article I. Executive Summary

To be developed

Article II. Preamble

Section 2.01 Committee Charge

The Committee's purpose is to explore, through an iterative, fact-based process, the City's water profile, including supply, demand and future risks; analyze potential solutions to deliver a safe, adequate, reliable, affordable and environmentally sustainable water supply and develop recommendations for City Council consideration.

Section 2.02 Committee Membership

The following individuals were appointed to the Water Supply Advisory Committee to represent the interests listed:

Community Interest	**Representative**
Business Organization (Think Local First)	Peter Beckmann
City Resident	Doug Engfer
Santa Cruz Water Commission	David Green Baskin
Water Customer (Non-City Resident)	Suzanne Holt
City Resident	Dana Jacobson
City Resident	Charlie Keutmann
Santa Cruz Desal Alternatives	Rick Longinotti
Environmental Organization (Surfrider Foundation)	Sarah Mansergh
Business Organization (Santa Cruz Chamber of Commerce)	Mark Mesiti-Miller
Environmental Organization (Coastal Watershed Council)	Greg Pepping
Santa Cruz Sustainable Water Coalition	Mike Rotkin
Business Organization (Santa Cruz County Business Council)	Sid Slatter
City Resident	Erica Stanojevic
Santa Cruz Water Commission	David Stearns
Santa Cruz Water Department (ex officio)	Rosemary Menard

Section 2.03 Committee Agreement about Decision-Making

The Committee's decision-making processes will differ from the Council or City Commissions in that it is intended to reach consensus through a collaborative process. Therefore, the Committee will use this hierarchy of decision tools:

i. The preferred decision tool is for the Committee to arrive at a "sense of the meeting."
ii. Consensus is highly desirable.
iii. Informal voting may only be used to explore the decision space.
iv. Formal voting may be used as a fallback when consensus fails as long as there is consensus that a vote should take place. The voting shall be by a supermajority of 10.

Section 2.04 General Context and Framing Issues

(a) Uncertainty Issues and Planning in the Face of Uncertainty and Complexity

The most important element of a problem solving process is defining the problem. Yet one of the characteristics of complexity is that even the problem is difficult to define. This is true of Santa Cruz's water planning.

Like all long range planning, water supply planning must deal with the realities of an uncertain future. In a historical context, water supply planning uncertainties have included the normal sources of variability:

- weather and its impacts on supply;
- demand increases in the future due to growth and development;
- demand decreases resulting from changing plumbing codes, technologies, demographics, or consumer behaviors (conservation); and
- potential supply decreases due to regulatory requirements to release water to support threatened or endangered fish species.

Today, uncertainties related to impacts of climate change must be added to this list.

During the first phase of the WSAC's work, the Committee was presented information about a variety of decision tools that the technical and facilitation teams believed could be useful in the Committee's work. The Committee chose to develop four basic tools:

- Scenario planning, including portfolio development,
- Risk analysis and risk management
- Criteria based evaluation of alternatives and portfolios using a Multi-Criteria Decision Support tool (MCDS), and
- Triple-bottom line analysis.

A Committee explored or applied all of these tools as it did its work. The Adaptation Strategy described in more detail in Section 3.18 later in this document exists largely as a result of the Committee's efforts to create a plan that would be able to respond if not seamlessly then at least with reasonable capability to the new information that will emerge and the potential changes in our understanding of circumstances that may occur over time.

Section 2.05 Overview of Committee Process

The Committee's process was divided into three phases: a reconnaissance phase where the Committee learned about the water system and its issues and identified a broad range of alternatives approaches for addressing the system reliability issues; an analysis phase where more detailed information about supply, demand, the supply shortfall, and the alternative approaches to solving the problem were explored in some detail; and an agreements phase where the Committee developed the agreements and recommendations that they conveyed to the City Council. The process has been iterative without stark boundaries between the phases but with a steadily increasing level of understanding of the issues, drivers, opportunities and constraints that the Committee was dealing with.

The Committee's process has been supported by a technical team that brought a diverse range of skills, experience and expertise to the tasks the Committee defined. In addition, the Committee was professionally facilitated by a team of individuals experienced in collaborative problem solving and multi-party negotiations.

Article III. Agreements

Section 3.01 Introduction

This Article summarizes the work the Committee did in several major topic areas that were key to developing their understanding of the issues and their recommendations to the Council. In each of the sections that follow, the issue is described, the work the Committee did on that issue is summarized, any agreement that the Committee reached about that topic is presented and the key assumptions are articulated.

The analysis, assumptions and agreements presented in this section create the foundation for the Committee's recommendations to the City Council presented in Article IV.

Section 3.02 Background

The Water Supply Advisory Committee's Analysis Phase work program was designed around the use of scenario planning to explore and evaluate a range of alternatives. This status report of WSAC work during calendar year 2015 summarizes the basic work to date and provides an overview of the products developed to support the Committee's work. Several additional documents are attached to this status report as appendices to provide more detailed information where such information was thought to be relevant and potentially of interest.

The key ingredients of scenario planning include:

- Problem definition
    - Forecasts of current and future water demand;
    - Analyses of supply available to meet current and future water demand; and
    - Identification of probable and plausible challenges that will need to be addressed in the future; in this case these include a probable requirement for releasing water for fish flows and plausible impacts of climate change.
- Solution development
    - A range of demand management and supply augmentation alternatives that can be combined in various portfolios to meet the supply demand gap; and
    - Evaluation criteria to use in considering the portfolios created.

This staff report will provide a high level summary of the Committee's progress in their work through the scenario planning phase and, where relevant, links will be provided to more detailed information, typically found in materials developed for committee meetings. In addition, comprehensive information about the Committee's work is available through its website: www.santacruzwatersupply.com.

Section 3.03 Preliminary Problem Definition

Over the many years that Santa Cruz has been studying ways to improve the reliability of its water supply, the problem has been defined in a variety of ways that were relevant at the time.

Today, it is fair to say that the fundamental cause of the Santa Cruz water system's reliability problem is the inability to store sufficient volumes of available winter flows for use in the driest years and/or the lack of a supply that does not depend on those flows. At least one of these is needed to ensure an adequate and dependable supply during water years classified as critically dry and, to some degree, dry.

Section 3.04 Historical Context – The Challenge of Variability

Figures 1 and 2 show two versions of local, historical information for water years (October 1 to September 30) classified into water-year types. These are familiar figures to many, but the purpose of including them up front is to emphasize two issues:

- Figure 1 shows the data sorted chronologically. This view underlines the significant variability of the data.
- Figure 2 sorts the data into year types, showing the number of years that have historically fallen into each year type. As will be discussed later in this section, a plausible impact of climate change on Santa Cruz's water supply would be an increase, perhaps significantly, in the fraction of dry and critically dry years that Santa Cruz will experience, thereby exacerbating the reliability issues the system currently faces.

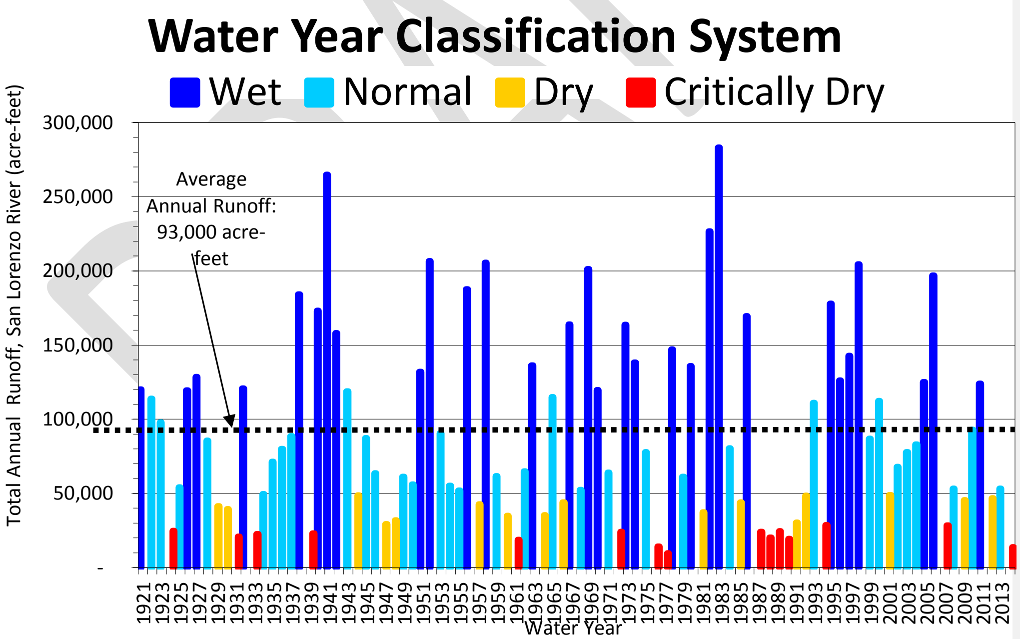


Figure 1: Water Year Classification System – Chronological Presentation

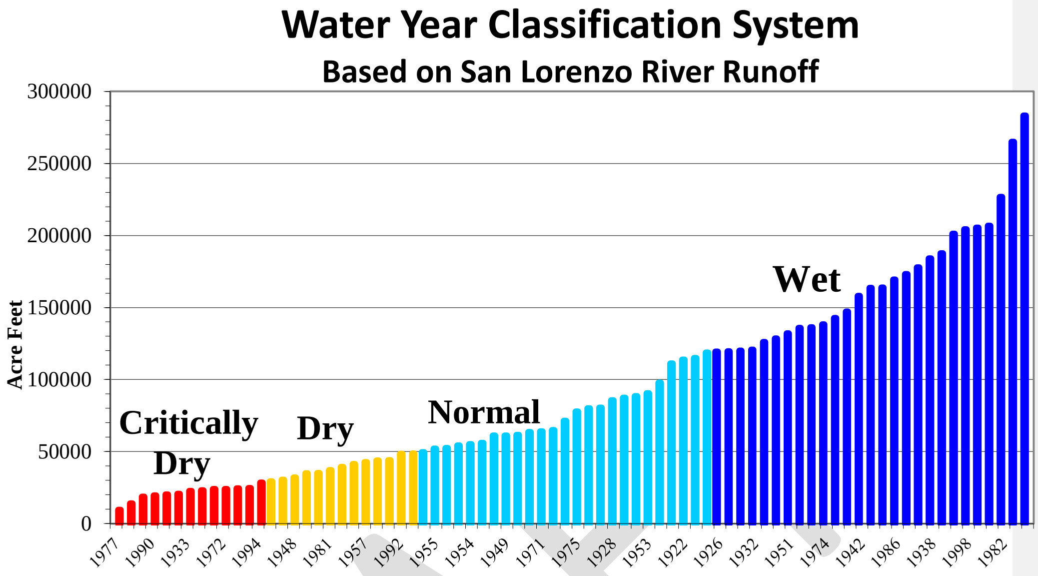


Figure 2: Water Year Classification System -- Year Type Presentation

Section 3.05 Forecast of Current and Future Water Demand

(a) Water Supply and Growth – the City General Plan

At its August 1, 2014 meeting, the Water Supply Advisory Committee agreed that using water scarcity to change the assumptions about the City's future growth and development, as laid out in the 2010 Council adopted General Plan was not part of the Committee's decision space. In making this agreement, the Committee recognized that there are several growth issues that are within the Committee's purview including, for example, the potential impacts of growth on water demand for the period after that covered by the General Plan.

The Committee also acknowledged the requirements in the California Urban Water Management Planning Act (Water Code Section 10631) requiring that "… The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier and shall be in five-year increments to 20 years or as far as data is available."

(b) Water Supply and Growth – UCSC Future Demands

Significant work has been done to update the water demand forecast used in the 2010 Urban Water Management Plan. This demand forecast incorporates the changes in population and development that were part of the City's General Plan update as well as whatever up to date information was available at the time for the Water Department's outside-city service area.

The forecast of future UCSC demand is based on a linear projection of the university's buildout demand in its 2005 LRDP, assuming two alternative buildout dates. In both cases, buildout demand is 349 MGY. In the lower bound forecast, buildout occurs in 2050. In the upper bound forecast it occurs in 2035. The primary forecast is the midpoint between the lower and upper bound forecasts. The forecast of UCSC demand is given in Table ES-3. The primary forecast almost exactly replicates a forecast based on projected enrollment and average rates of water use per student.[1]

Table 1 – Primary, High and Low Projections for University Growth

	2013*	2020	2025	2030	2035
Low	182	186	213	240	268
Primary	182	196	234	271	308
High	182	207	254	302	349

Notes
*Actual per Water Department billing records.

(c) Interim Demand Forecast – February to April 2015

An interim demand forecast was developed by working from the demand forecast used in the 2010 Urban Water Management Plan. The 2010 Urban Water Management Plan demand forecast incorporates the changes in population and development that were part of the City's General Plan update as well as whatever up to date information was available at the time for the Water Department's outside-city service area at the time. This interim forecast was intended to be used by the Committee in developing its supply-demand gap until the econometric model was completed.

Working from the 2010 forecast, the interim forecast incorporated a number of key changes including:

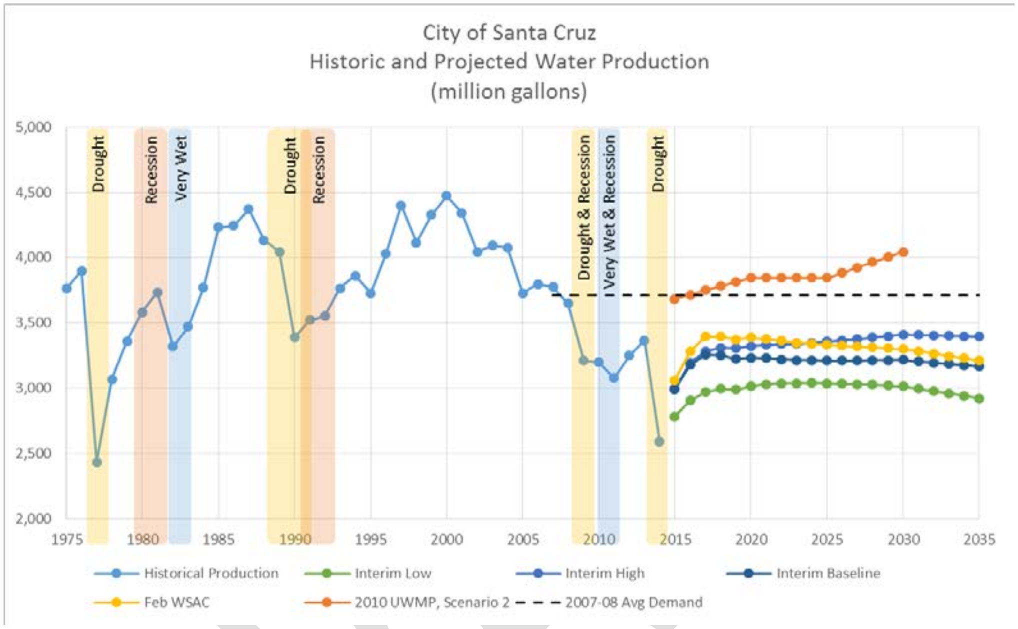
- incorporating effects of existing, ongoing water conservation programs,
- integrating the expected impacts of changes in the State's building and plumbing codes that will affect future water use in both existing and new construction,
- adding into the forecast the effects of price increases on water use,
- explicitly accounting for the impacts of weather on demands, and
- retaining the University's projection of its ultimate build-out demand but extending its time for completion.

The result was a forecast for current and future demand that looks substantially different from the 2010 Urban Water Management Plan forecast. Most notably, the revised forecast is no longer showing an increase in water demand during the coming 20 years.

[1] The enrollment-based approach yields a 2035 demand of 304 MG, which differs from the primary forecast by less than 2%.

Figure 3 below portrays the interim demand forecast and incorporates the changes described above as well as the revisions to the University's growth projections described above.

Figure 3 – April 2015 Interim Demand Forecast with High and Low Forecasts



(d) Econometric Demand Forecast – July to September 2015

The forecast of future water demand is a foundational component to any water utility of its future needs for water supply. In recent years the historical patterns of water demand have been upended by a variety of factors, including the cumulative effects of tighter efficiency standards for appliances and plumbing fixtures, greater investment in conservation, a significant uptick in water rates, an equally significant downturn in economic activity during the Great Recession, and on-going drought. These events have resulted in even more uncertainty than usual regarding future water demand and have placed even greater importance on sorting out the effect each has had on demand in recent years as well as how they are likely to affect demand going forward.

One of the first requests made by the WSAC was for the Water Department to update the demand forecast to reflect current information on water usage and to account for effects of conservation, water rates, and other factors expected to impact the future demand for water.

(e) Statistical Models of Average Demand

Econometric demand forecasting develops statistically-based models of average water demand. A demand forecasts was developed based on these models covering the period 2020-2035 and incorporating empirical relationships between water use and key explanatory variables, including season, weather, water rates, household income, employment, conservation, and drought restrictions. The approach builds on similar models of water demand developed for the California Urban Water Conservation Council (Western Policy Research, 2011), Bay Area Water Supply and Conservation Agency (Western Policy Research, 2014), California Water Services Company (A&N Technical Services, 2014, M.Cubed 2015), and Contra Costa Water District (M.Cubed 2014).

The statistical models of demand were estimated using historical data on class water use, weather, water price, household income, conservation, and other economic variables driving water demand. The monthly models of average water demand are combined with service and housing growth forecasts to predict future water demands. The average demand models explain 90 to 99% of the observed variation in historical average use over the 14 year estimation period.

The forecasts of average demand by customer class are summarized in Table 2. The forecasts include adjustments for future effects of plumbing codes and the City's baseline conservation program[2] and are predicated on average weather and normal economic conditions.

Table 2 -- Forecasted Average Demand by Customer Class (CCF/Year)

YEAR		2013	2020		2025		2030		2035	
	Per	Actual [1/]	Forecast	CI	Forecast	CI	Forecast	CI	Forecast	CI
Single Family	Housing Unit	87	86	± 3	83	± 3	80	± 4	78	± 4
Multi Family	Housing Unit	53	56	± 2	52	± 2	50	± 2	49	± 3
Business	Service	405	400	± 12	389	± 12	382	± 13	377	± 13
Municipal	Service	388	296	± 26	290	± 27	283	± 29	277	± 30
Irrigation	Service	365	286	± 28	271	± 28	257	± 28	244	± 28
Golf	Acre	990	671	± 130	641	± 134	606	± 137	593	± 144

1/ Actual use, unadjusted for weather or economy. Stage 1 drought water use restrictions in effect May - Dec.

CI = 95% confidence interval.

(f) Industrial Demand

Because of their unique characteristics, industrial demand was forecasted separately from the other customer categories. In the case of industrial demand, there is a strong relationship between Santa Cruz County manufacturing employment and aggregate industrial water use. This relationship is used to generate the industrial demand forecast shown in Table 3 below.

[2] The baseline conservation program level is Program A in the City's forthcoming water conservation master plan.

Table 3 – Industrial Demand Forecast

	2013 1/	2020	2025	2030	2035
Mfg Employment Forecast 2/		5,900	6,200	6,400	6,500
Industrial Water Demand (MG)					
Low	56	56	58	59	60
Primary	56	57	59	61	62
High	56	57	60	63	64

Notes
1/ Actual per Water Department billing records.
2/ Caltrans Economic Forecast for Santa Cruz County.

(g) Population, Housing, and Non-Residential Connection Forecasts

Forecasts of population, housing units, and non-residential connections are anchored to AMBAG's 2014 Regional Growth Forecast (AMBAG 2014). Projected growth in single- and multi-family housing units are shown in Table 4 and projected growth in non-residential services (excluding industrial and UCSC) are summarized in Table 5.[3]

Table 4 -- Forecast of Occupied Housing Units

	2014 1/	2020	2025	2030	2035
Inside-City					
Single Family	12,246	12,534	12,780	13,030	13,246
Multi Family	9,583	10,958	11,398	12,106	12,679
Subtotal	21,829	23,492	24,177	25,136	25,925
Outside-City					
Single Family	6,743	6,922	7,074	7,230	7,390
Multi Family	7,901	7,910	8,033	8,310	8,495
Subtotal	14,644	14,832	15,107	15,540	15,884
Service Area					
Single Family	18,989	19,456	19,854	20,260	20,636
Multi Family	17,484	18,868	19,431	20,416	21,174
Total	36,473	38,324	39,284	40,676	41,809

Notes
1/ Actual per Water Department billing records.

[3] The decrease in forecasted golf acreage is due to the intention of Pasatiempo golf course to shift to non-City sources of irrigation water.

Table 5 -- Forecast of Non-Residential Services and City-Irrigated Golf Acreage

	2013 [1/]	2020	2025	2030	2035
Business [2/]	1,889	1,948	1,971	2,008	2,055
Municipal [3/]	218	218	218	218	218
Irrigation [4/]	452	651	723	845	951
Golf					
Delaveaga	79	79	79	79	79
Pasatiempo	68	40	30	20	20
Total Golf	146	119	109	99	99

Notes
1/ Actual per Water Department billing records.
2/ Based on ratio of business to residential demand.
3/ No expected growth in number of municipal services.
4/ Based on historical rate of gain in irrigation services per gain in multi-family and business services.

(h) Demand Forecasts

The primary forecast of system demand is provided in Tables 6. Under the primary forecast, total system demand is expected to remain stable at about 3,400 MGY over the forecast period, despite a 13 percent increase in population over the same period. Per capita water use is projected to go from 93 gallons per day in 2020 to 84 gallons per day in 2035, a decrease of approximately 10 percent.

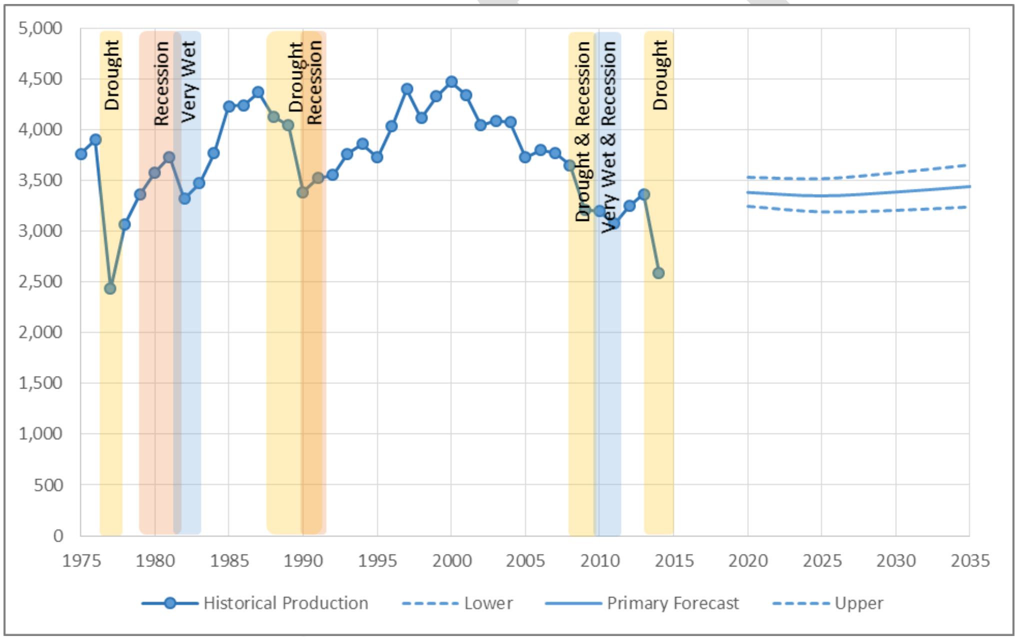
Table 1 -- Primary Forecast of Class Demands and System Production

YEAR		2020	2025	2030	2035
		Forecast	Forecast	Forecast	Forecast
Service Units	**Units**				
SFR	Housing Units	19,456	19,854	20,260	20,636
MFR	Housing Units	18,867	19,430	20,416	21,174
BUS	Services	1,948	1,971	2,008	2,055
IND	NA	NA	NA	NA	NA
MUN	Services	218	218	218	218
IRR	Services	651	723	845	951
GOLF	Acres	119	109	99	99
UC	NA	NA	NA	NA	NA
Avg Demand	**Units**				
SFR	CCF	86	83	80	78
MFR	CCF	56	52	50	49
BUS	CCF	400	389	382	377
IND	NA	NA	NA	NA	NA
MUN	CCF	296	290	283	277
IRR	CCF	286	271	257	244
GOLF	CCF	671	641	606	593
UC	NA	NA	NA	NA	NA
Annual Demand	**Units**				
SFR	MG	1,256	1,228	1,208	1,196
MFR	MG	792	759	766	775
BUS	MG	583	573	575	580
IND	MG	57	59	61	62
MUN	MG	48	47	46	45
IRR	MG	139	147	163	174
GOLF	MG	60	52	45	44
UC	MG	196	234	271	308
Total Demand	**MG**	**3,131**	**3,099**	**3,134**	**3,184**
MISC/LOSS	MG	254	251	254	258
Total Production	**MG**	**3,385**	**3,351**	**3,388**	**3,442**
Rounded	**MG**	**3,400**	**3,400**	**3,400**	**3,400**

Forecasted demands are significantly lower than the 2010 UWMP forecast. The primary reasons for this are that the 2010 UWMP forecast (1) did not include adjustments for the future effects of passive and active conservation and higher water rates on future water use and (2) assumed higher UCSC demand.

Figure 4 shows a comparison of historical production and the primary, lower, and upper bound forecasts. It is interesting to see how historical production has been influenced by weather and economic events. The forecast does not exhibit a similar degree of variability because it is based on average weather and normal economic conditions. In other words, it is a forecast of *expected future demand*. Realized future demand will certainly not be smooth like the forecast. It will vary about the expected value depending on year-to-year variation in future weather and economic conditions. The forecast, however, provides the baseline around which this variability is likely to occur.

Figure 4 – Historical and Forecast Production in Millions of Gallons



Appendices: February 2015 Tech Memo; April 2015 Tech Memo; July 2015 Tech Memo and/or Final Report

(i) Committee Agreement(s)

At its July 23, 2015 meeting, the Water Supply Advisory Committee Agreed to use the econometric demand forecast as presented by David Mitchell of M.Cubed Consulting at this meeting.

(j) List of Key Assumptions for Econometric Demand Forecast

- Plumbing and Building Code changes incorporated into the forecast
- Existing water conservation program continues
- Etc.

Comment [RM1]: Need additional items here

Section 3.06 Analysis of Supply Available to Meet Current and Projected Future Water Demand

The projected change in demand has had an immediate and important impact on the analysis of the adequacy of current supply to meet demand. Essentially the projected stabilization and longer term reduction in demand would allow the water system to fully meet customer demand, under natural (unconstrained) flow conditions, even in historically worst case conditions such as the 1976-1977drought.

City staff and members of the technical team have discussed this result and recognize that modeled results based on historic hydrological information may underestimate the real-world likelihood of curtailments being implemented. This is because water managers making decisions in the late winter and spring of one water year may act more conservatively than the model to conserve storage in light of the uncertainty about the coming months and the next water year will bring. In fact, this reality is behind City staff's recommendation for implementing Stage 3 water restrictions in the spring of 2015.

The key assumption of using natural flow conditions is an important one. Natural flows mean no externally driven constraints on the City's ability to withdraw water from its existing sources, except for those associated with the City's water rights. The likelihood of this condition being the case in the future is low. The more likely case is that the City's ability to withdraw water from its supply sources will be affected by both the need to release water for fish flows (to meet the federal and state requirements for the protection of threatened and endangered coho salmon and steelhead trout,) and the impact climate change will have on available resources resulting in changed hydrology and increased likelihood of extended droughts. The implications of both of these factors on the City's future supply are discussed in more detail in the next sections.

(a) Future Challenges – Fish Flow Releases

The City has not yet finalized a flow agreement with state and federal fishery agencies. Two flow regimes have been identified and are being used by the WSAC to assess water supply reliability implications. The lower bound flow regime is called "City Proposal" and the upper bound flow regime is called "DFG-5." Both result in less water available for diversion than the natural flows discussed above and both have different impacts on the long-term availability of water to meet City needs.

(b) Potential implications of Fish Flow Releases on the Frequency and Severity of Water Shortages

Comment [RM2]: Tables here will be updated to reflect the revised demand forecast

Tables 7 and Table 8 respectively show the forecasted peak-season shortage profiles in 2020 and 2035.

Table 7 -- 2020 Shortage Profiles[4,5]

FLOWS	2020 Shortage Profiles					Worst-Year Peak-Season Shortage
	Likelihood of Peak-Season Shortages					
	0%	<15%	15%-25%	25%-50%	>50%	
	0	<300 mg	300-500 mg	500-1000 mg	>1000 mg	
Natural	100%	0%	0%	0%	0%	0%
City Prop	92%	7%	0%	1%	0%	32%
DFG-5	90%	1%	4%	3%	1%	68%

Table 8 -- 2035 Shortage Profiles

FLOWS	2035 Shortage Profiles					Worst-Year Peak-Season Shortage
	Likelihood of Peak-Season Shortages					
	0%	<15%	15%-25%	25%-50%	>50%	
	0	<285 mg	285-475 mg	475-950 mg	>950 mg	
Natural	100%	0%	0%	0%	0%	0%
City Prop	97%	1%	0%	1%	0%	26%
DFG-5	90%	1%	4%	3%	1%	65%

(c) Committee Agreements on Fish Flow Releases

The Committee discussed this information and agreed that the following conclusions can be drawn from these profiles:

- With unconstrained natural flows, there are no shortages of any magnitude under any hydrologic condition. Since we saw above that there are no expected shortages under worst-year conditions, this is not surprising.
- As expected, the DFG-5 profile is worse (i.e. results in a higher likelihood of larger shortages) than the profile for City Proposed flows. For example, in both forecast years,

[4] Note that the totals in any row may not add to 100% due to rounding.
[5] The data in Tables 1 and 2 was developed for the February version of the demand forecast and have not been adjusted to reflect the changes incorporated and reflected in the April forecast shown in Figure 1. Thus the results here are slightly overstated as the April demand forecast is slightly lower than the February one.

there is about an 8% likelihood (6 out of 73 years) of a peak-season shortage larger than 15% under DFG-5. This compares to around 1% (1 out of 73 years) under the City Proposal.

- Even under the most stringent flow regime (DFG-5), there are no expected shortages in 90% of historic hydrologic conditions. Without taking into account the possible impacts of climate change, the City's supply reliability challenges have been and will continue to be in the driest years.

- While similar, the 2035 profiles are slightly more favorable than the 2020 profiles due to the somewhat lower forecast demand that results from the ongoing implementation of demand management programs and the impacts of changes in plumbing and building codes.

- The key conclusion is that under baseline conditions, and assuming that future hydrology looks like the historic record, the City would have sufficient supply to serve its demands in the absence of any HCP flow restrictions. Under either of the proposals, the City faces peak-season shortages in the driest hydrologic conditions. In those driest years, those shortages can be significant, around 600 million gallons under City-Proposed flows and close to 1.4 billion gallons under DFG-5 flows.

(d) Key Assumptions about Fish Flow Releases

Fish flow assumptions used in the WSAC process are based on two key data sets:

- The City's 2012 flow proposal to state and federal agencies for flow releases for the San Lorenzo River and Laguna and Marjors creeks and Liddell Springs (City Proposal); and
- The September 2012 response received from the (then) California Department of Game suggesting modifications to the City Proposal (DFG-5).

Both fish flow regimes are designed to address flow requirements needed to maintain habitat for endangered coho salmon and threatened steelhead trout during their various fresh water life-stages. Both flow regimes are indexed to the amount of water available using a modified version of the year class type shown in Figures 1 and 2, which divides years into five rather than four categories and specifically links flow releases for a coming month to the year class type for the amount of water in the system in the previous month.

The ultimate resolution of fish flow requirements for the City's sources of supply will be the result of the City's negotiations with state and federal fishery agencies. Negotiated flows will be the foundation of a habitat conservation plan for the City's water system. At the completion of the environmental review of the habitat conservation plan, the City will receive a long term permit, called an Incidental Take Permit (and a state version), that will give the City an ability to plan for and operate its water system with long term certainty.

(e) Potential Impacts of Climate Change

The second potentially significant factor to impact the City's current water system is climate change. With California in the throes of a deep multi-year drought, some would say that the City's water system has already been experiencing the impacts of climate change. For example, with the exception of the summer of 2011, the City has imposed some form of water restrictions on its customers every year since 2009. And this year's second consecutive year of rationing is entirely unprecedented.

The Water Supply Advisory Committee explored the impacts on future water supply reliability of two potential manifestations of climate change:

- Longer and more severe extended droughts; and
- Changes in ongoing hydrologic patterns.

(f) Extended Droughts

As the Committee began to delve into the issue of climate change, the Technical Team conducted a brief literature search to frame the discussion. A summary of information related to drought is provided here to help frame the issue.

Recent evaluations of paleoclimate records and future climate model projections indicate that longer droughts have occurred in the past and are likely to occur again within the next century. In this section we review paleoclimate and climate change projection studies relevant to drought planning in California and the Santa Cruz region. Several publications, including some very recent ones, compare modern climate observations to historical records and to future climate projections.

Fritts (1991) shows that droughts in the Santa Cruz region were frequently much longer than three to eight years. Paleoclimate reconstruction for the California valleys show that precipitation from the 17th century until the 20th century was consistently below average 20th-century values, with long periods of relative drought and short periods of high rainfall. These data show that cycles of below-average precipitation have commonly lasted from 30 to 75 years (Fritts, 1991)[6].

Other paleoclimate analyses, summarized in Fritts (1991), have concluded:

- "The variability of precipitation was reconstructed to have been higher in the past three centuries than in the present" (p. 7).
- "Lower variability occurred in twentieth-century precipitation. Reconstructions of this kind should be used to extend the baseline information on past climatic variations so

[6] Fritts, H.C. 1991. *Reconstructing Large-Scale Climatic Patterns from Tree-Ring Data: A Diagnostic Analysis*. University of Arizona Press, Tucson, AZ.

> that projections for the future include a more realistic estimate of natural climatic variability than is available from the short instrumental record" (p. 8).

A recent publication by Cook et al. (2015)[7] compares paleoclimate drought records with future predicted conditions based on climate change models. Using tree ring data and current climate models, the authors found that drought conditions in the coming century are likely to be as bad as or worse than the most severe historical droughts in the region, with severe dry periods lasting several decades (20–30 years). In some cases, winter precipitation may increase, but gains in water during that period will most likely be lost due to hotter, drier summers and greater evaporation.

Other recent studies linking climate change, precipitation changes, and drought conditions have found that warming temperatures greatly increase drought risks in California (Diffenbaugh et al., 2015)[8].

The historic hydrologic record on which all of the prior analyses of Santa Cruz water supplies are based only goes back to 1937. This record therefore cannot adequately capture the kind of historic variability found in these paleoclimate studies and by extension the conditions the City might face under future conditions of climate change. The WSAC technical team created an extended-drought planning sequence that represents a discrete plausible future event that can help guide water resource planning in Santa Cruz. Building on examples from utilities around the state, the Santa Cruz extended drought planning sequence combines and places back to back the City's two worst drought sequences: 76-77 and 87-92. This eight year drought sequence is worse than anything in the historic hydrologic record, but is intended to represent what might be experienced under climate change. It was combined with each of the fish flow proposals discussed above and evaluated for the frequency and severity of the shortages that would be produced. Table 9 summarizes these results.

[7] Cook, B.I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st century drought risk in the American southwest and central plains. *Science Advances* 1(1):e1400082. doi: 10.1126/sciadv.1400082

[8] Diffenbaugh, N.S., D.L. Swain, and D. Touma. 2015. Anthropogenic warming has increased drought risk in California. *PNAS.* doi: 10.1073/pnas.1422385112.

Table 9. Extended drought peak-season shortage statistics

	City Proposal	DFG-5
Total 8-year (mg)	**702**	**5,108**
Average	**4%**	**32%**
Maximum	**32%**	**67%**
Minimum	**0%**	**6%**
Years > 20%	**1**	**6**

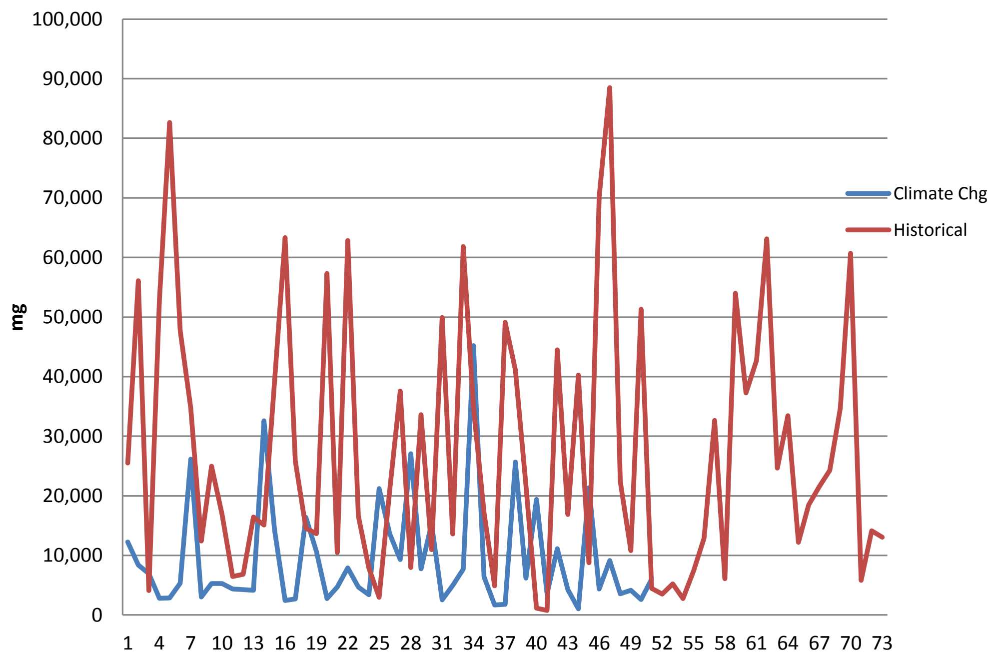
(g) Changes in Ongoing Hydrology

Across hundreds of modeling runs that have been done to evaluate Santa Cruz water supplies, beginning with the 2003 Integrated Water Plan, the essential characteristics of the historic hydrologic flow record have remained constant. The worst drought event was 1976–1977. The 1987–1992 period represented another major drought. And it was clear which years in the record were very wet and which were exceptionally dry.

This strong foundation on which to plan and operate no longer applies when analyzing how the system will respond to potential changed hydrology driven by climate change. The essence of analyzing this type of climate change is the assumption that future weather and stream flows will not be the same as the past.

To analyze the plausible impact of climate change, a new 51 year flow record has been produced by working with hydrologic conditions that would occur in a selected global climate model and downscaling those conditions to Santa Cruz's sources and local conditions. In the resulting flow projection, there is no longer a 1976–1977 worst-case drought benchmark or a 1987–1992 sequence. As is illustrated in Figure 5 for City proposed HCP flows at Big Trees, the distribution of flows is completely different from that of the historic record.

Figure 5 -- Comparison of annual flows at Big Trees: City proposal.



While the worst years in the climate change scenario are no worse than the driest historic years, the overall pattern is a considerably drier one, which might be expected to result in a higher fraction of years in which there is insufficient water to meet the needs of both Santa Cruz water customers and fisheries.

(h) Committee Agreements on Climate Change

On April 30, 2015, the WSAC agreed that the Climate (hydrologic) Change and Extended Drought scenarios provide plausible parameters to use in its water system planning and that this analysis provides a useful point of depart for its scenario planning work.

(i) Key Assumptions about Climate Change

Content to be added

Section 3.07 How Climate Change Affects the Modeling:

As shown in Figures 6 and 7, climate change increases the likelihood of larger shortages.

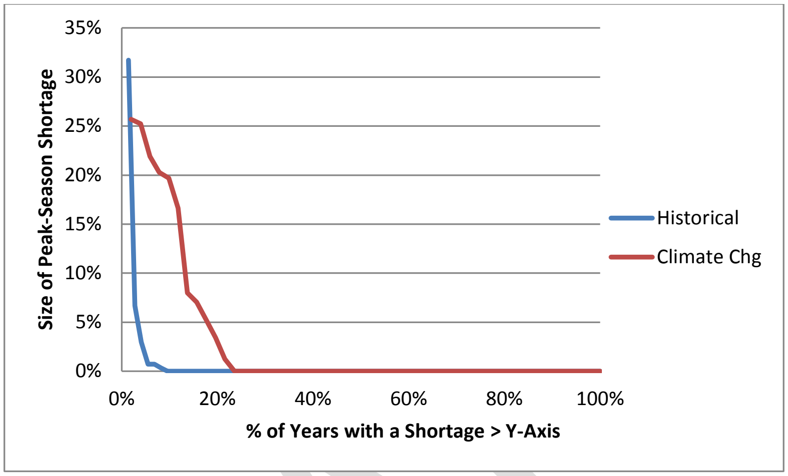
(a) City Proposed Flows

Figure 6 compares the peak-season shortage duration curves for City Proposed flows with and without climate change.

Figure 6 -- Peak-season shortage duration curves with and without climate change:

City Proposed Flows

Comment [RM3]: Replace with figure based on revised demand forecast.



The differences between the two curves are immediately noticeable:

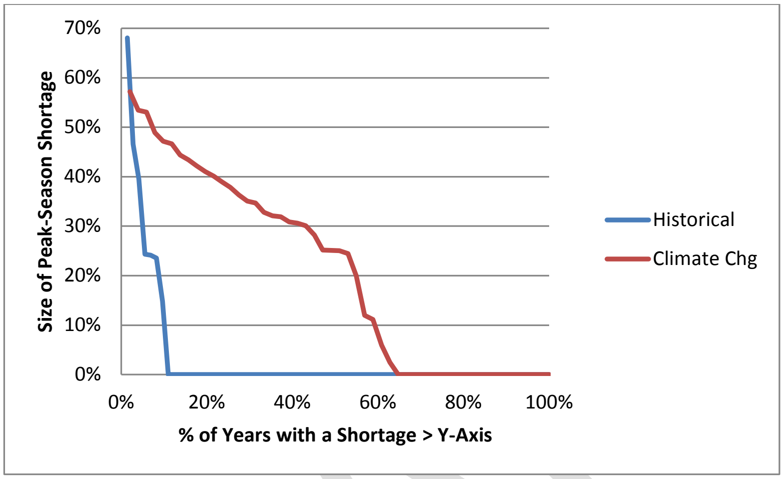
- Climate change shifts the curve upward and to the right, meaning there is an increased likelihood of larger shortages. Whereas with historic flows, there is a small chance (< 10%) of any shortage at all, this rises to more than 20% with climate change. The probability of a shortage greater than 20% increases from about 1% with historic flows to about 8% with climate change.

(b) DFG-5 Flows

Comment [RM4]: Replace with figures for revised demand forecast

Figure 7 shows the same system reliability comparisons for DFG-5 flows.

Figure 7 -- Peak-season shortage duration curves with and without climate change: DFG-5 flows.



While the types of impacts are similar, their magnitudes with DFG-5 are much increased. For example, under more than 60% of hydrologic conditions, there will be a peak-season shortage. In fact, a shortage exceeding 25% can be expected in just over half the years.

The foregoing results are consistent with the flow patterns of Figure 4, and highlight the importance of considering climate change as Santa Cruz plans for its water supply future. Even under the City's proposed HCP flows, which represent the potential lowest impact to Santa Cruz's water supply, water customers would have to contend with frequent shortages under this climate change scenario. If the outcome of the HCP negotiations are closer to the California Department of Fish and Wildlife's (CDFW's) DFG-5 proposal, the frequency and magnitude of shortages becomes much more onerous.

Thus with climate change, the City's water future will look qualitatively different. With historical flows, while there is a real possibility of large peak-season shortages, these are generally confined to the driest years with the large majority of conditions having no shortages. This is clearly not the case with climate change. Instead, significant shortages can be expected in many years. With DFG-5 flows, large shortages can be expected in the majority of years. The pattern of water availability to customers will be markedly altered.

Section 3.08 Problem Statement

Section 3.01 begins with a brief statement about the nature of Santa Cruz's water supply problem that was based on conventional wisdom and past studies and analyses. The analysis described in Sections 3.04 through 3.07 deconstructs and then reconstructs that conventional wisdom to quantify the supply-demand gap and to include the potential impacts of fish flow releases and climate change of the size and characteristics of the Santa Cruz's water supply reliability issue. A concise statement of Santa Cruz's water supply reliability problem based on this analysis and that the WSAC recommendations are designed to address is as follows:

> *Santa Cruz's water supply reliability issue is the result of having only a marginally adequate amount of storage to serve demand during dry and critically dry years when the system's reservoir doesn't fill completely. Both expected requirements for fish flow releases and anticipated impacts of climate change will turn a marginally adequate situation into a seriously inadequate one in the coming years.*
>
> *Santa Cruz's lack of storage makes it particularly vulnerable to multi-year droughts. The key management strategy for dealing with this vulnerability is to very conservatively manage available storage. This strategy typically results in regular calls for annual curtailments of demand that may lead to modest, significant, or even critical requirements for reduction. In addition the Santa Cruz supply lacks diversity, thereby further increasing the system's vulnerability to drought conditions.*
>
> *To close the gap between available supply and demand and establish a reasonable level of reliability for Santa Cruz's water service customers, the Water Supply Advisory Committee adopted a goal of creating 3 billion gallons of additional storage to be used during multi-year droughts or the equivalent of about 1.1 billion gallons of new supply capacity from a source other than the City's existing sources.*

Comment [RM5]: This needs a committee agreement

Comment [RM6]: Need Gary to review this.

Section 3.09 Data Driven Decision Making

(a) Evaluation Criteria

Criteria that enable us to distinguish among potential solutions are essential for effective problem solving. Understanding how various alternatives or portfolios of alternatives rate against those criteria is at the heart of the problem solving process. The development of the multi-criteria decision support (MCDS) model provided a focal point for the definition of criteria, subcriteria, and rating scales. A key purpose of using this approach is to support data-driven decision making.

The Council's charge to the Committee emphasizes the importance of data-driven decision making. The goal of developing and using a MCDS tool is not to produce an outcome by "pouring in the ingredients, turning the crank and having the answer come out."

No analytical tool can (or should) completely replace the judgment and careful weighing and balancing of values, uncertainties, and risks in this kind of decision-making. Rather the goal of using such a tool is to help develop information in a form that decision-makers can effectively and efficiently use as they make their decisions.

An additional benefit is that the careful thought that goes in to the creation of the MCDS tool creates many opportunities to talk about values and interests that are important to address as the collaborative problem solving process proceeds. Creating the MCDS model required the WSAC to identify important criteria and subcriteria, define what is meant by those criteria, and create rating scales that appropriately measure what is important to Committee members related to the criteria identified.

Table 10 provides a list of the evaluation criteria used by the Committee in the MCDS evaluation it conducted in the Spring of 2015. In addition to using these criteria in that formal evaluation, these criteria were used more informally through much of the Committee's work during the Spring and Summer of 2015 as they worked together to identify and evaluate portfolios of measures to improve the reliability of Santa Cruz's water supply.

Appendix XX provides the detailed criteria the Committee used in its MCDS modeling and portfolio building exercises conducted in the Spring and Summer of 2015.

Table 10 WSAC Evaluation Criteria

Criterion	Questions
1. Technical Feasibility	How likely is each Plan to be technically successful? For Plan B, consider the technical feasibility at the time the plan would actually start
2. Time Required to Demonstrate Technical Feasibility	How much time is required to demonstrate whether a Plan is technically feasible? When rating Plan B, start from the time Plan B actually begins.
3. Time Required to Full Scale Production	What is the time required to full scale production? For all Plans, start the clock when the Plan is permitted, has all needed rights and property ownership issues resolved and is ready to proceed.
4. Adaptive Flexibility (includes Scalability)	What benefits in terms of adaptive flexibility is each Plan likely to contribute in the face of external conditions such as climate change, demand levels or streamflow requirements?
5. Supply Reliability	How likely would each Plan be to improve the reliability of the Santa Cruz water system in the face of different operating conditions such as turbidity, low flows, etc.?
6. Supply Diversity (Portfolio Level Only)	How does the Portfolio affect the diversity of Santa Cruz water supply portfolio?
7. Energy Profile	How much energy does each Plan require? Units are megawatts of energy per million gallons produced, mw/mg expressed as weighted average by Plan.
8. Environmental Profile	What is the environmental profile of each Plan? Note: this criterion covers a range of issues and a diversity of Plans. This is a great place to provide details about your rating using the comment button.
9. Regulatory Feasibility	How easy or difficult would the regulatory approval process be for these Plans?
10. Legal Feasibility	How easily and within what time period are these Plans likely to obtain the necessary rights in the form needed? When considering a Plan B that would start after a trigger, start the clock at the point at which the trigger actually occurs.
11. Administrative Feasibility	To what degree do each of the Plans require cooperation, collaboration, financial participation, and/or intergovernmental agreements to succeed? How likely is it that these can be obtained?
12. Potential for Grants or Special Low Interest Loans for Engineering and/or Construction	What is the potential for these Plans to qualify for grants and/or special low interest loans?
13. Political Feasibility	What level of political support is each Plan approach likely to have? When rating Plan B, take into account the impacts of additional time and the (hypothetical) failure of Plan A would have on Santa Cruz's political landscape.
14. Cost Metrics	How much do each of these Plans cost? Metric is annualized unit cost in dollars per million gallons, $/mg.

Section 3.10 Identifying and Evaluating Solutions

The WSAC used an iterative approach to identify and evaluate alternative approaches to improving the reliability of the Santa Cruz water supply. Their efforts began with their work in the summer and fall of 2014 to identify a full range of demand management and water supply options for consideration. Since then, the WSAC, City staff and the technical team supporting the WSAC have invested considerable resources in developing and fleshing out demand management and supplemental water supply and infrastructure addition and operating change options to develop more specific planning level information for use in evaluating alternatives.

In this section, the Committee's iterative approach to identifying and evaluating alternatives for improving the reliability of the Santa Cruz water supply is presented.

(a) Alternatives Identification: Our Water, Our Future – The Santa Cruz Water Supply Convention

During the community discussions of the desal DEIR, a common criticism was that the City hadn't adequately evaluated other alternatives during the decades of water supply planning that preceded the selection of desal in the Integrated Water Planning process in early 2000s/ A key element of the Council's reset decision was the desire to look in more detail at alternatives to desal while not excluding desal from further consideration.

As the Committee got underway in the spring of 2014, it was clear that a handful of very engaged citizens had ideas they wanted to share with the Committee regarding how to improve the reliability of the Santa Cruz water system. The challenge was to make sure that others who might have ideas to share would have the opportunity to do so as well.

In June, the WSAC decided to include in its Reconnaissance phase an event that would engage the broader public by inviting those with strategies, alternatives, or ideas for improving water supply reliability to submit their proposals. The goal was to ensure that citizen and community-based ideas, as well as those provided by the technical team and other outside experts, were considered as possible strategies to improve water supply reliability in the Santa Cruz water system.

By late July, the Committee was starting to receive suggested approaches to improving the reliability of the Santa Cruz water supply. Submissions covered a wide range of topics including:

- enhancing conservation efforts
- landscaping improvements
- expanding rainwater catchments and grey water systems
- incentivizing conservation through pricing structures

- revisiting old strategies such as exchanging highly treated wastewater for irrigation water used for north coast agriculture
- developing recycled water facilities and systems
- more groundwater development
- aquifer storage and recovery
- on-stream and off-stream storage projects
- desalination using a variety of existing and new approaches and technologies for both the desalination process and the energy issues related to desalination.

In August those submitting ideas in the first round were invited to further develop their proposals for submission to the WSAC and for public review for an event called "*Our Water, Our Future – the Santa Cruz Water Supply Convention*."

Our Water, Our Future, the Santa Cruz Water Supply Convention was held from 11 a.m. to 9 p.m. on Thursday, October 16 at the Civic Auditorium. More than 40 ideas were presented in poster session presentations set up around the hall. Brief presentations by the submitters were provided at noon and at 6:00 p.m. and attendees were invited and encouraged to visit the poster presentations of strategies, ideas, and alternatives and to interact with the submitters.

Approximately 350 people attended the convention, and attendees included most of the members of the WSAC, members of the City Council, and many staff members of the Water Department. WSAC members practiced rating and ranking the proposals using four criteria: effectiveness, environmental impact, community impact, and practicability.

Following the conclusion of the *Our Water, Our Future* event, the Committee has continued to accept ideas and alternatives for addressing the issues that have been identified. The most recent proposal, a project for storing water in Hanson Quarry, was received in early January 2015. During Recon especially, the Committee's purpose in keeping the door open is to ensure that the arbitrary exercise of a deadline does not keep a great idea from being considered.

(b) Selected Alternatives

Between the Committee's October and November meetings, WSAC members provided their technical consultant, Stratus Consulting, with their input on the alternatives identified in the Water Supply Convention that they were most interested in considering further. Stratus' job was to select a dozen or so alternatives that were representative of a broad range of approaches that the Committee would use in testing the decision model. Alternatives not selected as part of this effort were not eliminated from further consideration, just not selected for further evaluation in the Recon phase of the Committee's work.

Twelve alternatives were selected by Stratus and approved by the Committee at their November meeting. The alternatives selected were:

- WaterSmart Software Implementation
- Landscaping Revisions, Rainwater Capture and Grey Water Reuse
- Water Neutral Development
- North Coast Off Stream Storage
- The Lochquifer Alternative
- Expanded Treatment Capacity on San Lorenzo River
- Ranney Collectors on San Lorenzo River
- Reuse for Agriculture
- Aquifer Restoration
- Potable Water Reuse
- Reverse Osmosis Desalination
- Forward Osmosis Desalination

The varied and often incomplete nature of the information provided by those proposing many of the alternatives submitted in the Water Supply Convention has proven to be a challenge for the Committee, City staff, and the technical team. Almost immediately following the November Committee meeting, information and assumptions about the selected alternatives were needed to support the Committee's use of the Recon MCDS model. To facilitate this timing, City staff made a variety of assumptions to fill in data gaps and used this information to provide default ratings for the alternatives and scenarios in the MCDS model. Still there is was a critical need to develop reasonably accurate technical details to support further analysis.

(c) Consolidated Alternatives

From the more than 80 suggestions and proposals presented by community interests, project proponents, and City staff during the October 16, 2014 Water Supply Convention, the technical team created 20 Consolidated Alternatives.

"Consolidated Alternatives" are alternative created from groups of Water Convention Alternatives with similar concepts and attributes. Consolidated Alternatives were created for a range of options and approaches such as additional demand management activities, approaches to improving storage for available system flows in the winter, to developing climate independent sources using purified recycled water.

Insert something from earlier consolidated alternatives work and include something in the appendix about this.

Section 3.11 Scenario Planning

Scenario planning is a tool often used to facilitate planning in the face of uncertainty. A goal of scenario planning is to explore a range of futures that are different from what would occur if current trends continue, but not so unlikely as to be a waste of time. One way to maximize the benefits of scenario planning is to create scenarios based on what are called "deep drivers of change." For Santa Cruz, the obvious deep drivers of change are climate change and fish flows.

Scenario planning isn't intended to result in the selection of a preferred scenario to pursue but to explore and get a better understanding of the degree to which key uncertainties such as climate change could affect the problem we need to solve or the outcomes we might be able to achieve. The "best" solutions are those that address conditions in multiple scenarios.

Throughout the Recon phase of its work, the Committee used simple scenario planning to explore a range of potential water futures. For example, different scenarios were created to explore how the community's water supply needs would be affected by the need to release water for fish, the implications of climate change, and potential changes to the local economy that would make Santa Cruz a place where people could both live and work.

During the first half of 2015, the technical team worked to develop consistent information about Consolidated Alternatives so that the Committee could use them as building blocks in the two rounds of scenario planning. Among the most important information emerging from this technical analysis was the result of system simulation modeling using the Confluence model.[9] These simulations concluded that two broad approaches have the potential of completely addressing the City's water supply challenges:

- Harvesting and storage of winter flows. This is the case even with current water rights, DFG-5 instream flows, and climate change. To achieve these benefits, the "virtual reservoir" used in the analysis would have to become real, i.e. suitable infrastructure improvements and institutional arrangements would have to be made to have a place to reliably store at least 3 billion gallons of water and be able to recover a sufficient portion of that storage. This would require increasing the capacities of various current infrastructure.
- Developing a drought-proof supply (i.e. one that is insulated from year-to-year variability in weather and streamflow). Examples of such a supply include desalination and use of highly-treated recycled water. These alternatives would also require development and improvement of infrastructure.

The first round of scenario planning occurred during the March meeting. In this effort, Committee members broke into small groups, with each group working on one of three scenarios:

- Changed hydrology that results from City proposed flows;
- Changed hydrology that results from DFG-5 flows; and
- DFG-5 flows and a potential extended drought that is a plausible event under future climate change conditions.

[9] See Appendix XY for a description of the Confluence model and its use in the WSAC process.

Following several hours of work in their small groups, Committee members presented the demand management and water supply improvement measures they had created to address the conditions described in their scenario. These groups of measures are called portfolios.

Two key themes emerged from this work:

- Committee members created water supply portfolios which included additional investments in demand management; and
- Each of the groups gravitated to some form of winter flow capture and storage as a key strategy for meeting future water supply needs for Santa Cruz. One group acknowledged the potential need for a supplemental supply to help get the aquifer storage program going before it could be completely filled by available winter flows, and chose to fill that potential gap with recycled water.

Round two of scenario planning occurred at the Committee's April/May meeting and included two scenarios:

- DFG-5 flows with extended drought,
- DFG-5 flows with climate change.

Two working groups of Committee members were assigned to each scenario. Again, winter flow harvest was the centerpiece of each group's solution to the scenario they were given, and again, purified recycled water played a role if and as needed as a back-up resource.

Section 3.12 Portfolio Development and Evaluation

Starting in May 2015, the Committee began exploring and building portfolios of measures to close the supply-demand gap. Portfolios were typically made up of combinations of demand management and supply augmentation strategies that often included projects or approaches for improving the performance of the existing water system, particularly as it relates to its ability to capture and store winter flows.

One goal of portfolio building was to provide opportunities for Committee members explore the risks and uncertainties associated with various combinations of measures. Another was for Committee members to work with each other to create portfolios that met their common interests using interest based bargaining techniques. And a third was to give Committee members a very hands on way to engage with the information about the technical aspects of various approaches.

Especially with respect to the last goal, Committee members have received, processed, and asked for clarification of and additional information about just about every aspect of water system operation, technical and financial assumptions and build a substantial base of knowledge upon which to create their recommendations. The diversity of Committee member backgrounds and interests has been a significant asset to the group as it has done this important work and they have learned from each other as well as from the Technical Team and City staff participating in their work. In addition, these hands on approaches have created an unparalleled opportunity for Committee members to learn about, and learn to respect their individual perspectives and interests, which is an invaluable asset to any collaborative problem solving process.

Section 3.13 Issues of Risks and Uncertainties

At the Committee's June meeting, Committee members worked with a set of four different staff-created water supply portfolios that have at their center some form of winter water harvest. In addition to a winter water harvest approach provided as a "Plan A," each portfolio contained a proposed "Plan B" and a "trigger" that would define the conditions for moving from Plan A to Plan B. The task was to consider the risks and uncertainties related to the various approaches, and the addition of a Plan B and a trigger was designed to get the Committee members thinking about and working with ideas related to "what ifs."

The four portfolios developed were:

- Plan A: In lieu recharge of regional aquifers by providing excess flows to Soquel Creek and Scotts Valley to meet their demand, thereby allowing them to rest their wells. Additional infrastructure or operating rule changes were added to extend the season during which in lieu recharge could be provided, thereby increasing the rate of recharge. The ultimate goal would be for groundwater to come back to Santa Cruz from regional aquifers when Santa Cruz needs it. Plan B: Purified recycled water piped back to and mixed with Loch Lomond supplies (a technique called indirect potable reuse or IPR).

- Plan A: Active recharge of regional aquifers using injection wells (a technique called Aquifer Storage and Recovery, or ASR). The ultimate goal would be for groundwater to come back to Santa Cruz from regional aquifers when Santa Cruz needs it. Using ASR could replenish the aquifers at a higher rate, and thereby accelerate the timeline when this source would fully meet Santa Cruz's needs. Plan B: Purified recycled water piped to and mixed with North Coast and San Lorenzo River supplies, retreated at Graham Hill Water Treatment Plant and delivered to customers (a technique called direct potable reuse, or DPR).

- Plan A: ASR along with using purified recycled water to create a sea water barrier along the coast to manage and impede salt water intrusion. The ultimate goal would be for groundwater to come back to Santa Cruz from regional aquifers when Santa Cruz needs it. Creating a salt water intrusion barrier would accelerate the timeline when this source would fully meet Santa Cruz's needs. Should the ASR program ultimately completely solve Santa Cruz's problem, the stranded assets in this plan would be a complete advanced treatment plant for producing purified recycled water and related infrastructure. Plan B: Converting the purified recycled water plant producing water for the salt water intrusion barrier to a source of water for DPR use.

- Plan A: ASR coupled with desalinated water from the proposed DeepWater Desal plant at Moss Landing. The ultimate goal would be for groundwater to come back to Santa Cruz from regional aquifers when Santa Cruz needs it. Creating a supplemental source of potable water could result in a combined ASR and in lieu recharge strategy that would accelerate the restoration of regional aquifers, making the timeline when this source would fully meet Santa Cruz's needs shorter. Should the ASR program ultimately completely solve Santa Cruz's problem, the stranded assets in this plan would be a share of a regional desalination facility that might be sold to another party and a pipeline that might be repurposed for a different use. Plan: DeepWater Desal.

None of these portfolios was designed to be the best one. Rather, they were designed to be purposefully different from each other so that the Committee could explore the risks and uncertainties associated with different approaches. It was not part of the goal of the Committee's June meeting to select one of the portfolios that have been developed as the preferred approach.

The focus on risks and uncertainties associated with the performance of these portfolios is an important one. At the level of analysis and information currently available, it is inevitable that there will be questions about actual performance of various approaches.

Section 3.14 Committee Member Portfolio Building

Between the July and August meetings (2015) Committee members worked independently or in teams to prepare portfolios that addressed the supply demand gap.

One portfolio was created by David Baskin, Peter Beckmann, Sue Holt, Charlie Keutmann and David Stearns. This portfolio was designed to effectively cover the "gap" and, in the long term, would go further than by providing the capacity to supply water even if events occurred such as a wildfire around Loch Lomond.

A second portfolio was created by Greg Pepping, Rick Longinotti, Mark Mesiti-Miller and Sid Slatter. This portfolio proposed a combination of a hybrid of In-Lieu and Aquifer Storage and Recovery (ASR) with direct potable reuse. This group reached consensus on the component parts and found that they disagreed as to whether, to ensure success, it would be necessary to implement the parts of the proposal sequentially or concurrently. This proposal provides for concurrent implementation, and Rick Longinotti developed a separate proposal (described below) that proposed a sequential implementation.

A third portfolio was developed by Rick Longinotti in consultation with Erica Stanojevic and members of Desal Alternatives. As noted above, this proposal scales down the in-lieu to operate initially within the capacity of the existing system, thus avoiding significant upgrade costs for modifications to the Graham Hill Water Treatment Plant. Ongoing monitoring of the response of the aquifer would provide the information needed to determine whether to maintain the level of effort or scale up as necessary.

A fourth portfolio was developed by Sarah Mansergh. This proposal shows an approach that portrays a lower level of urgency for moving forward than some of the other portfolios. The portfolio is also designed to seek and achieve multiple benefits through regional partnerships focused on restoring regional aquifers.

The fifth portfolio was developed by Erica Stanojevic. This proposal combines the storage capacity of Loch Lomond with the aquifer. By starting the project immediately and sorting out our water rights, security will be increased and we could achieve 3BG in storage by 2020.

All of these portfolios incorporated demand management.

(a) Agreements Emerging from Committee Discussions Following Presentation of Portfolios

In the discussion that followed the following agreements were articulated:

- The Committee has developed consensus that the environmental benefits of fish restoration is an important value and that the supply-demand gap should reflect a commitment to releasing flows to support restoration of threatened and endangered fish species. (The specifics of the DFG-5 flow proposal are not agreed to, as the Committee wants the City to work with the agencies to define the final flow proposal.)
- The Committee has developed consensus that there are substantial benefits from pursuing regional solutions for Santa Cruz's water supply issues and that regional solutions should be pursued if at all possible.
- The Committee has developed consensus that energy requirements for any new water supply augmentation project should be met with power from renewable sources.
- The Committee has developed strong agreement that groundwater storage strategies implemented by in lieu (passive recharge) and aquifer storage and recovery (ASR) (active recharge) are preferred and there is great optimism that they will be successful.
- The Committee has developed consensus that their direction be focused on policy versus prescriptive level detail.
- The Committee has developed consensus that the plan they develop and recommend to the City Council will include an adaptation or change management

Section 3.15 Alternatives that Emerged as Key Strategies to Consider

As the Committee worked through its first several meeting of Phase 2, information developed by the WSAC Technical Team identified challenges with some of the alternatives, for example, building surface water storage reservoirs in old quarries underlain by Karst formation geology. Other alternatives emerged as being more feasible and began to appear consistently as measures included in scenario planning results. By late spring the Committee had defined a set of alternatives and approaches that became their focus. Each area is described briefly below.

(a) Demand Management

During much of the Committee's work a program known as "C recommended" (Crec) was a focus of the conversation around what additional demand management activities should be pursued by the City. Crec is a combination of water conservation measures identified during the development of an updated Water Conservation Master Plan in a process that began in 2013 but was still underway in the spring and summer of 2014.

As the Committee gained a better understanding of the nature of the reliability problem Santa Cruz faces, it began to look at whether and how well the measures combined into Program Crec focused on peak season demand. In the spring of 2015, the Committee formed a Peak Season Demand Management Working group of members to look at strategies for improving the focus of the future Demand Management program on peak season reductions.

The Working Group developed and presented some strategies focusing on peak season demand management. When their results were received, the Working Group had proposed that the City set a goal of reducing peak season demand by an additional 150 mgy using a variety of strategies. This proposal raised a concern about the potential for double counting demand management savings due to the significant impact of price elasticity in reducing future demand.

Table 11 below, lays out the impact of price response on future water demand.

Table 11 – Peak Season Savings Due to Price Response

Peak (May-Oct) Demand Without Price Response, MG

	SFR	MFR	BUS	MUN	IRR	GOLF	TOTAL
2020	750	386	372	39	123	58	**1,728**
2025	763	375	373	39	138	52	**1,739**
2030	778	383	381	39	162	46	**1,790**
2035	798	393	393	39	184	46	**1,854**

Peak (May-Oct) Demand With Price Response, MG

	SFR	MFR	BUS	MUN	IRR	GOLF	TOTAL
2020	705	364	348	35	93	52	**1,598**
2025	703	347	342	35	104	45	**1,575**
2030	702	347	341	34	111	37	**1,572**
2035	703	347	342	33	119	35	**1,580**

Peak (May-Oct) Savings from Price Response, MG

	SFR	MFR	BUS	MUN	IRR	GOLF	TOTAL	% Savings
2020	46	22	23	4	30	5	**131**	**8%**
2025	60	28	31	5	34	7	**164**	**9%**
2030	76	36	40	6	51	9	**218**	**12%**
2035	95	46	51	7	65	11	**274**	**15%**

The price elasticity used to produce these numbers was based on the measured impact of price on the demand of various customer groups in Santa Cruz between 2000 and 2013. These elasticities were integrated into the econometric demand forecast presented to the Committee in July of 2015.

The double counting of savings concern was that with an estimated 274 mgy of peak season demand reduction due to price, and an estimated 170 mgy from Program Crec, it seemed highly unlikely that an additional 150 mgy that was not somehow already in one of these other numbers was likely to be real and attainable.

Comment [RM7]: Update this figure and this section based on 9-4-15 Demand Management Memo.

(b) Committee Agreement about Demand Management

Insert summary and agreement about this topic (as a result of the September 10-11 meeting) here.

(c) Key Assumptions about Demand Management

(d) Infrastructure Constraints

As it the case with all water systems, the City of Santa Cruz water system's operation is constrained by a number of infrastructure limitations. Chief among these is the inability of the Graham Hill Water Treatment Plant to efficiently treat waters with turbidities over about 15 nephelometric turbidity units[10](NTU). Additional infrastructure constraints involve the limited hydraulic capacity and pressure constraints of the existing pipeline between the Felton Booster Station and Loch Lomond. A more minor constraint that could further improve performance once the pipeline between Felton and Loch Lomond is replaced is the capacity of the existing Felton pumps.

In the recently completed Water Transfer and Water Exchanges Report (April 2015 – give specific title and reference info), the Graham Hill Water Treatment Plant turbidity constraint was identified as a potentially significant barrier to the idea of capturing and using winter flows for passive and active recharge of regional groundwater basins. That report laid out a phased implementation of in lieu (passive) recharge that would not require addressing the treatment plant constraints in the initial phase. The report also showed described various infrastructure improvements to both Graham Hill Water Treatment Plant and the Tait Street Diversion that would be required as more winter water deliveries to Soquel Creek and Scotts Valley is ramped up to allow them to rest their wells.

During the WSAC process the issue of infrastructure constraints was given considerable attention, and a range of possible approaches to addressing these problems was discussed. In the "State of the Water System Report" provided to the Committee at its April/May meeting, City staff provided a high level overview of the deferred maintenance and major rehabilitation and replacement issues the system has and laid out a conceptual framework for a 15 year Capital Improvement Program (CIP) to tackle these issues. The CIP includes projects to address some of the infrastructure constraints, for example the need for a replacement pipeline from Felton to Loch Lomond, but not others, for example the upgrade to the water treatment plant to allow it to treat higher turbidity water. The rationale for including the pipeline is that it is needed to improve system operation whether or not a winter harvest option is pursued. The water treatment plant upgrade, on the other hand, is a project that is directly related to selection of a water supply augmentation strategy. Including it in a long term CIP prior to the Committee having completed its work would not be appropriate.

(e) Committee Agreements about Infrastructure Constraints

tbd

(f) Key Assumptions about Infrastructure Constraints

tbd

(g) Operational Constraints

The Santa Cruz water system uses a variety of operating rules and practices to guide its daily operation. The purpose of operating rules developed by utilities is to provide straight-forward

[10] nephelometric turbidity units (NTU) is a measure of water clarity that is used in drinking water treatment and safe drinking water regulations.

and reasonable parameters for both operating the system and for modeling system performance.

Most of the City's operating rules and practices have developed over time based on experience and often the perspective that avoiding real and potential problems is simpler than dealing with their real or potential consequences after the fact. Some of the key operating constraints have been incorporated into the Confluence Model to help insure that system modeling results reasonably represent reality.

During the WSAC process considerable analysis focused on operating rules and constraints that have a significant impact on the ability of the existing water system to provide water either during the peak season or in the winter. For the former, the key constraint is the existing operating rule curve for Loch Lomond drawdown. For the latter, constraints on taking first flush water and dealing with turbidity level over 15 NTU, for either treatment at the Graham Hill Water Treatment Plant or to send to Loch Lomond to store in years when winter precipitation is not expected to fill this critical reservoir, were the key constraints.

During the WSAC process the Committee, the Technical Team and City staff explored all of the key constraints and a number of recommendations for change and further evaluation were developed. Of those evaluating two particular operating constraints stand out: the rule curve used to operate Loch Lomond, and the first flush constraint for sending water from Felton to Loch Lomond.

The existing Loch Lomond rule curve is designed to keep about a billion gallons of water in the reservoir as drought supply for a potential third year of drought conditions. When modeling the system, the Confluence Model will run the system to ensure that the on October 31st of the second year of a drought, the reservoir still has one billion gallons remaining in storage. This constraint could potentially be relaxed in the event the City has additional storage, and this was the focus of much of the discussion on this topic.

The first flush constraint is designed to allow a sufficient quantity of water to bypass the City's Felton Diversion on the San Lorenzo River to avoid introducing large quantities of nutrients and pathogens into Loch Lomond. In critically dry years the quantity of water needed to meet the first flush criterion, 48 hours at 100 cubic feet per second or greater, may never be achieved. If this criterion can be relaxed without threatening Loch Lomond's water quality or ecosystem health, the additional water diverted to Loch Lomond during dry years could have significant benefits in reducing the size of worst year shortages.

The complexity of Loch Lomond's ecosystem and the need to be conservative in not creating a problem that would likely to be time-consuming and expensive to solve. Still the potential supply enhancing benefits of changing this constraint makes it worthwhile to seriously explore this matter over the coming years.

(h) Committee Agreement on Operating Constraints

To be added

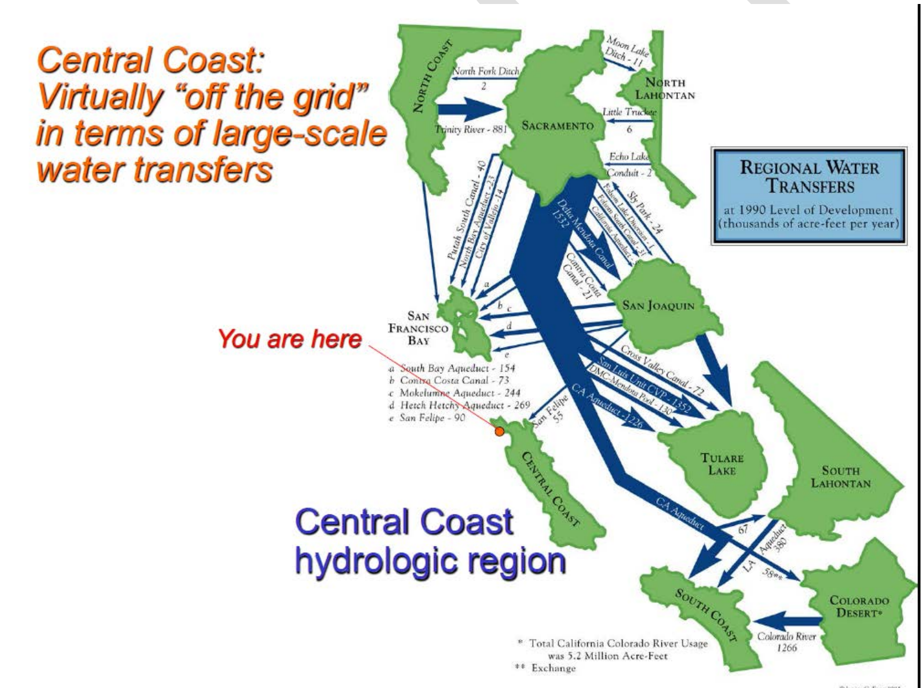
(i) Key Assumptions on Operating Constraints

To be added

(j) Supply Development

As described earlier, the Committee considered a wide range of supply augmentation alternatives during its deliberations. Figure 8 tells a story that Committee members became very familiar with: Santa Cruz's options for developing additional supply are limited to options that are local.

Figure 8 – California Regional Water Transfers[11]



Section 3.16 Alternatives Considered but Not Pursued at this Time

To be added following Committee discussion of this matter at the 9-10/11-15 meeting

[11] Figure courtesy of UCSC Professor Andrew Fisher

Section 3.17 Agreement on solution (approach, content, to be reflected as pull outs that move into the consolidated recommendations)

Section 3.18 Adaptive Management Strategies for Dealing with Risks and Uncertainties

Section 3.19 Decision Making and Roles and Responsibilities

Article IV. Recommendations

Section 4.01 Portfolio elements (Plan A and Plan B, C, D…)

Section 4.02 Adaptive Management Strategy and Plan

Section 4.03 Implementation Policy Direction

Section 4.04 Implementation Performance Measures

Section 4.05 Implementation Plan and Timeline

Article V. Additional Remarks/Recommendations

Article VI. List of Appendices