The Confluence® Model

Presentation to Modeling and Forecasting Working Group

January 21, 2015

Introductions

- Presenter:
  - Gary Fiske
- Working Group
- Water Department staff

Objective: Penetrate the Black Box

- What Confluence is (and what it's not)
- How Confluence fits into Santa Cruz water resources planning
- Key model input assumptions
- How Confluence simulates actual system operations
- What we can learn from Confluence outputs

Agenda

- PowerPoint presentation
- Q&A
- Break
- Inside Confluence
- Q&A

Confluence History and Context

- Roots in power planning
- Designed specifically for water resources planning
- Has been applied to a variety of system types & sizes
- Used to help address many issues in Santa Cruz

Confluence: What it is and isn't

Confluence is:

- Planning model
- Simulation tool

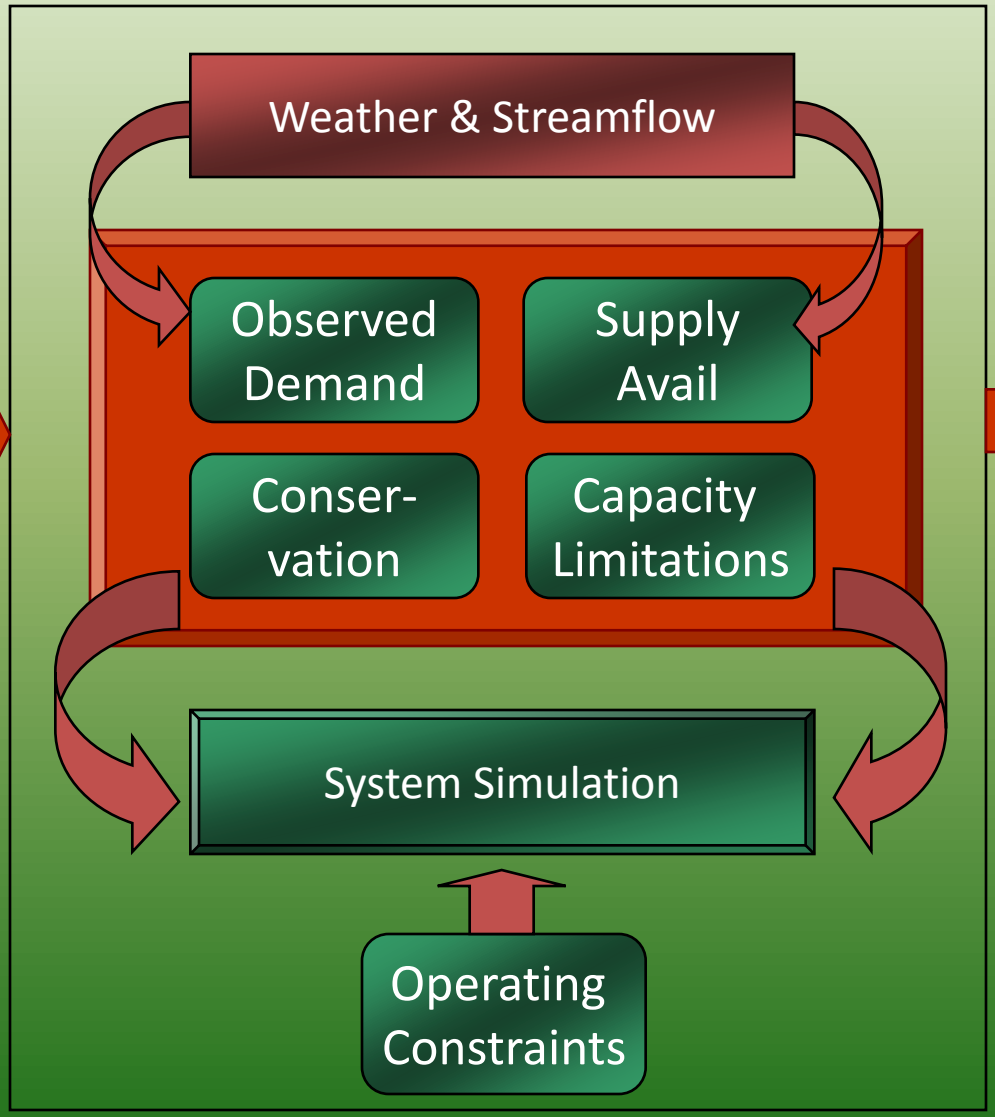
Confluence can compare scenarios

Confluence isn't:

- Operations model
- Optimization tool

Confluence can't find the "best" scenario

Confluence® Model Structure



Inputs

- Demands
- System structure
- Supplies
- Conservation
- Facilities
- System operations
- Simulation Parameters

Outputs

- Reliability
- Costs & rates
- Demands
- Supply utilization
- Lake operations
- Conservation savings
- Transmission loadings
- Scenario comparisons
- Diagnostic reports

Confluence Inputs

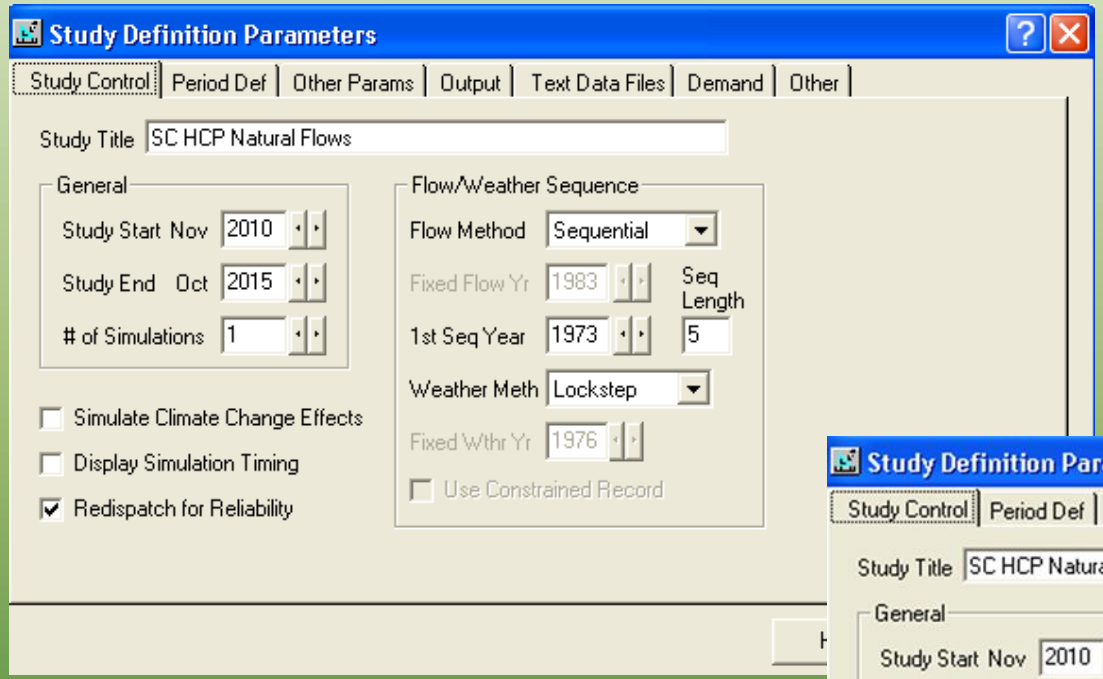
Confluence input assumptions have been continually updated since the IWP to better simulate actual system operations

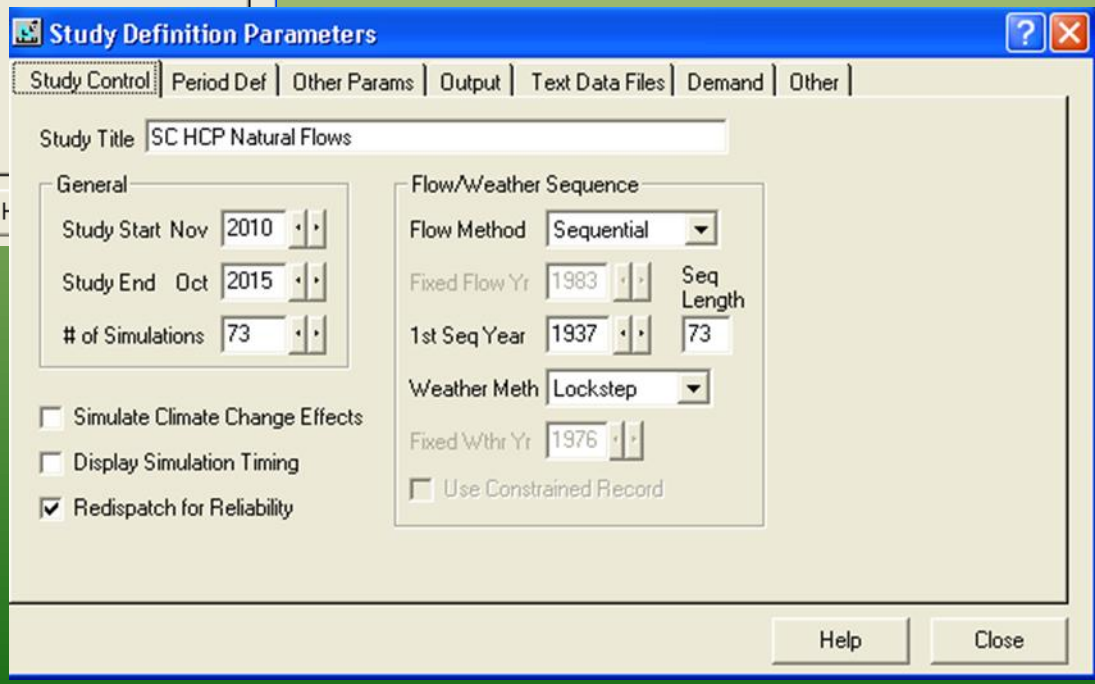
Key Changes in Modeling Assumptions in Last Year

Modeling Parameter	Previous	Current
Demand Shape (Percent of annual demand in peak season)	64%	59%
Annual Loch Lomond Withdrawal Limit	3,200 AF	No limit
N Coast Annual Ag Demands (mg)	81.4	40
Tait Street Flow Buffer (cfs)	0	0.5
Tait Street Well Capacity (cfs)	1.78	1.29 peak 0.78 off-peak

Study Definition:

Forecast Years, Flows, Weather





Two Ways of Defining the Study

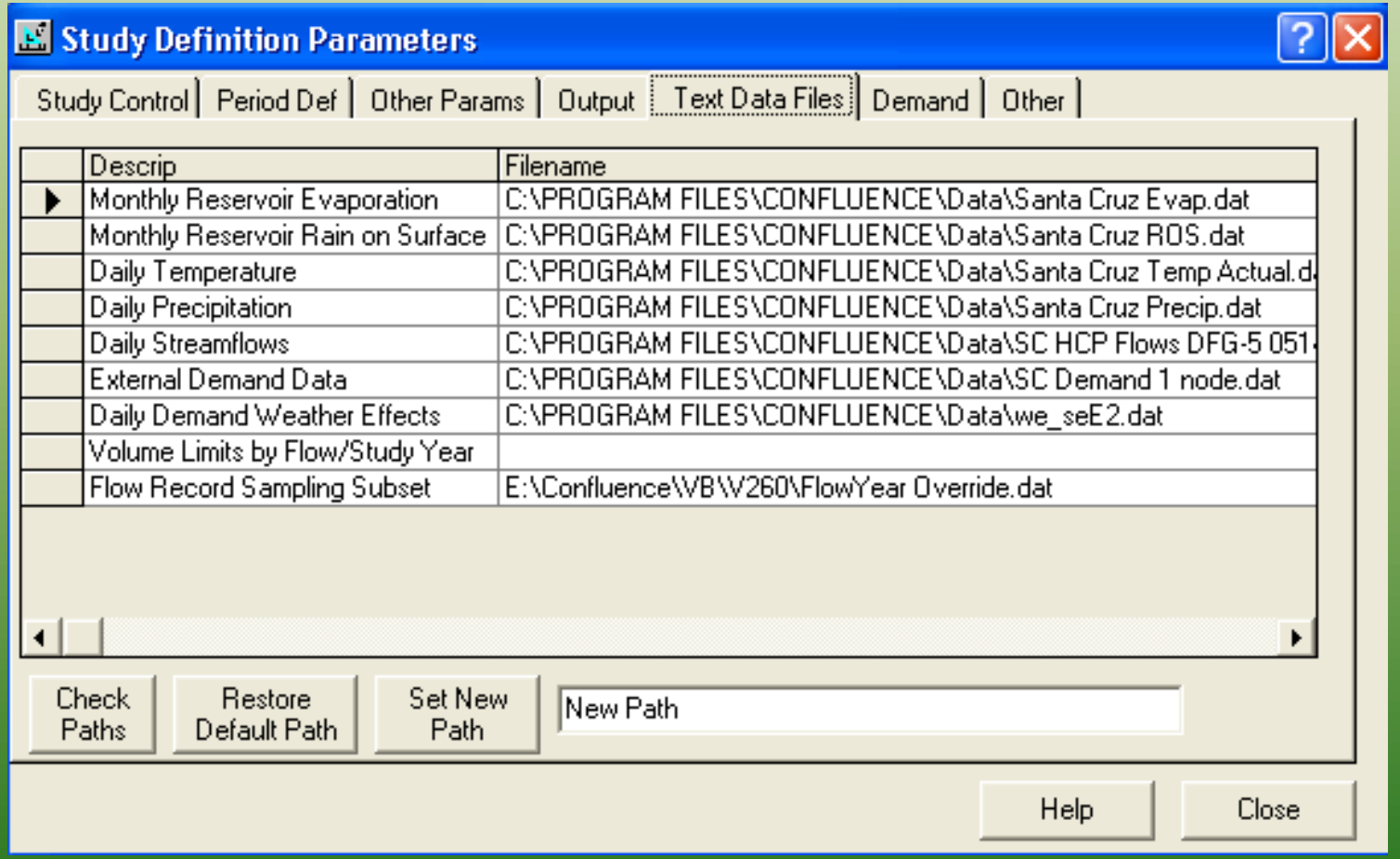
Drought Year

Fcst Year	Hydro Years
	Sim 1
2011	1973
2012	1974
2013	1975
2014	1976
2015	1977

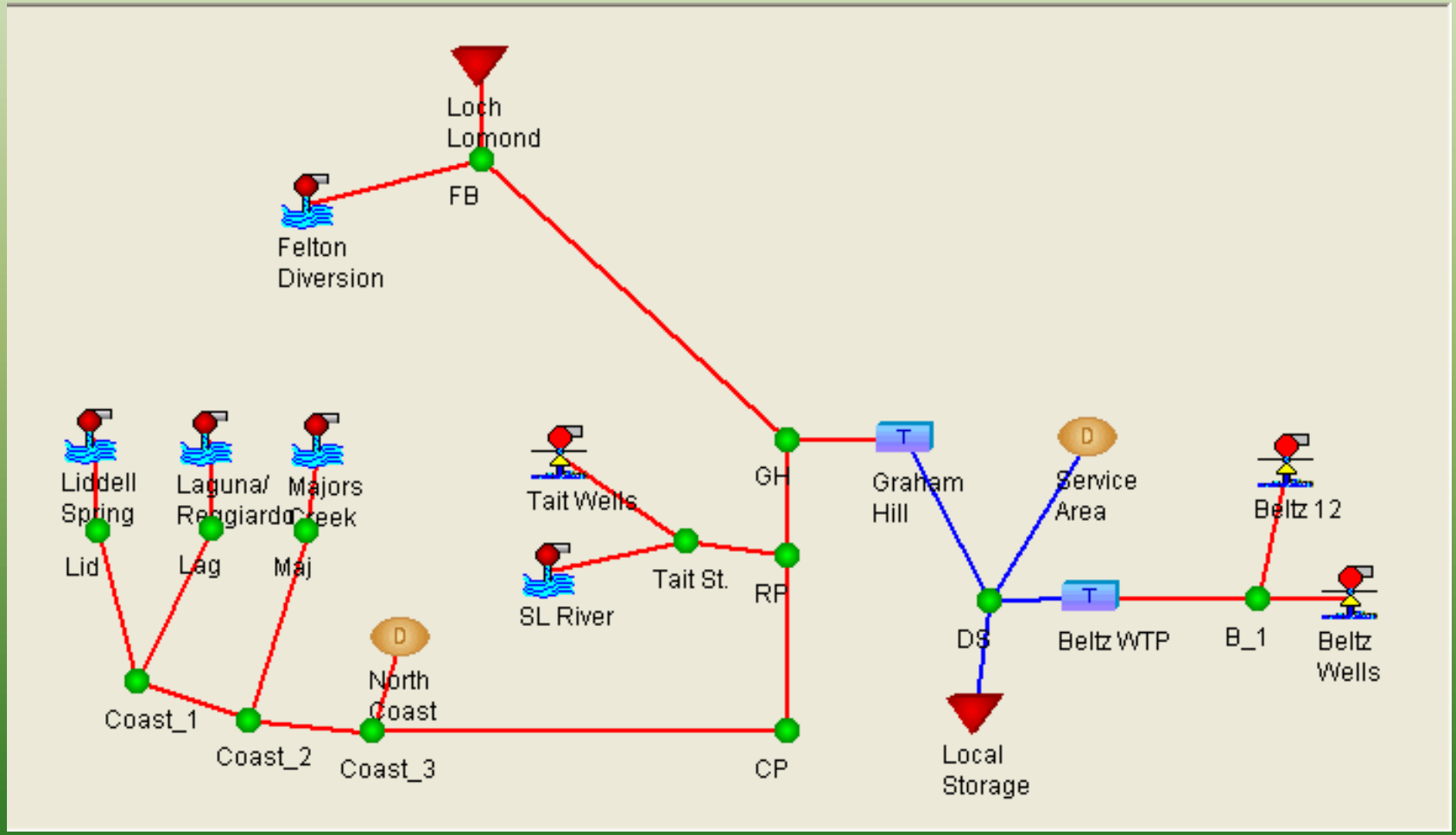
All Years

Fcst Year	Hydro Years					
	Sim 1	Sim 2	Sim 3	. . .	Sim 72	Sim 73
2011	1937	1938	1939		2008	2009
2012	1938	1939	1940		2009	1937
2013	1939	1940	1941		1937	1938
2014	1940	1941	1942		1938	1939
2015	1941	1942	1943		1939	1940

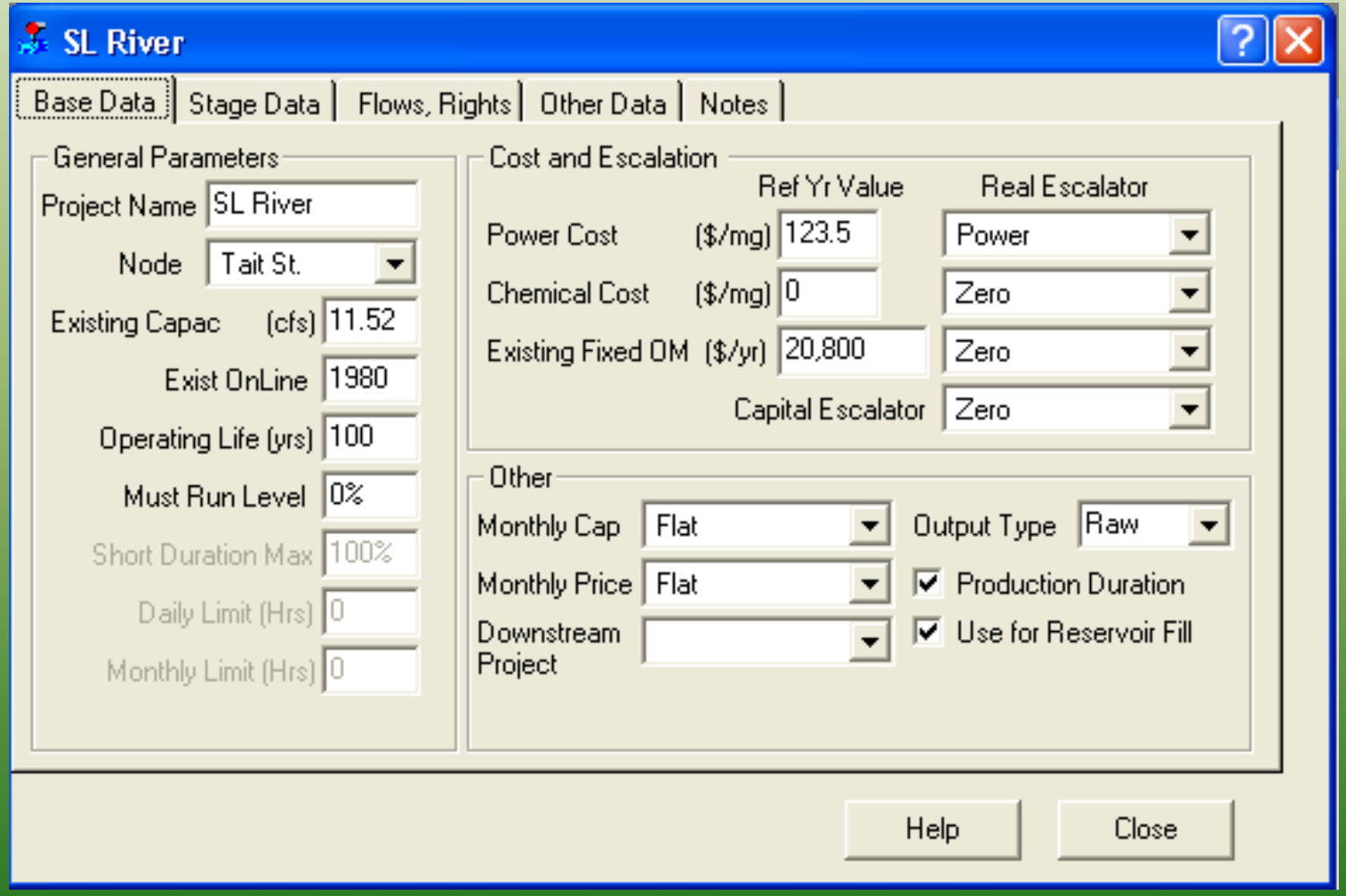
Study Definition (cont'd):
Text file linkages



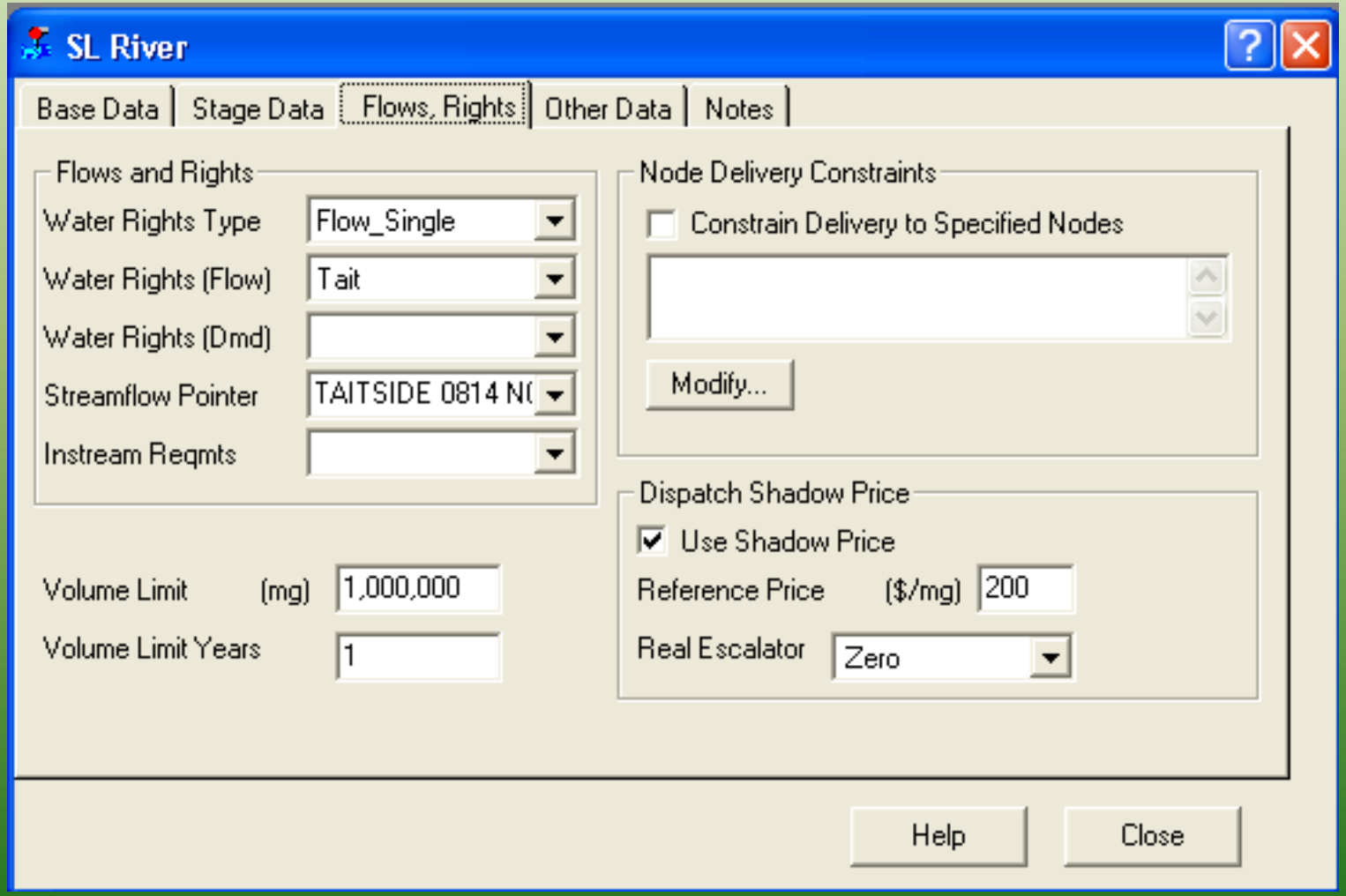
Interactive Data Map



Defining Supply Sources



Defining System Components: Shadow Prices and Pointers



Source Dispatch is Driven by Shadow Prices

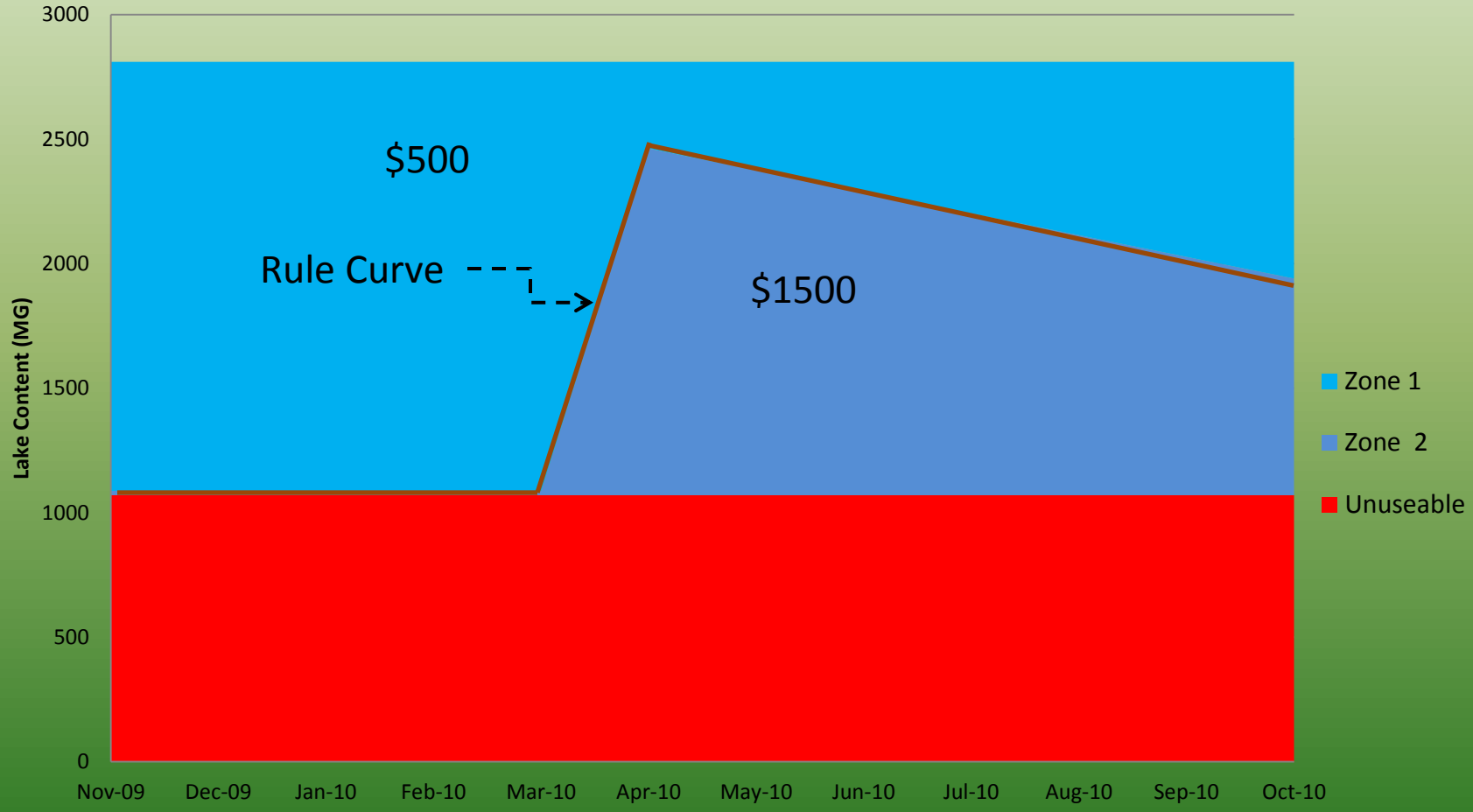
Source	Shadow Price
Liddell	$5
Laguna	$5
Majors	$10
Tait Street Diversion	$200
Tait Street Wells	$210
Beltz Wells	$300
Beltz 12	$301
Loch Lomond	$500/$1500

Operating the Lake

- Lake drawdown must be regulated to ensure that lake doesn't run dry midway through summer season
- Model does that through shadow prices

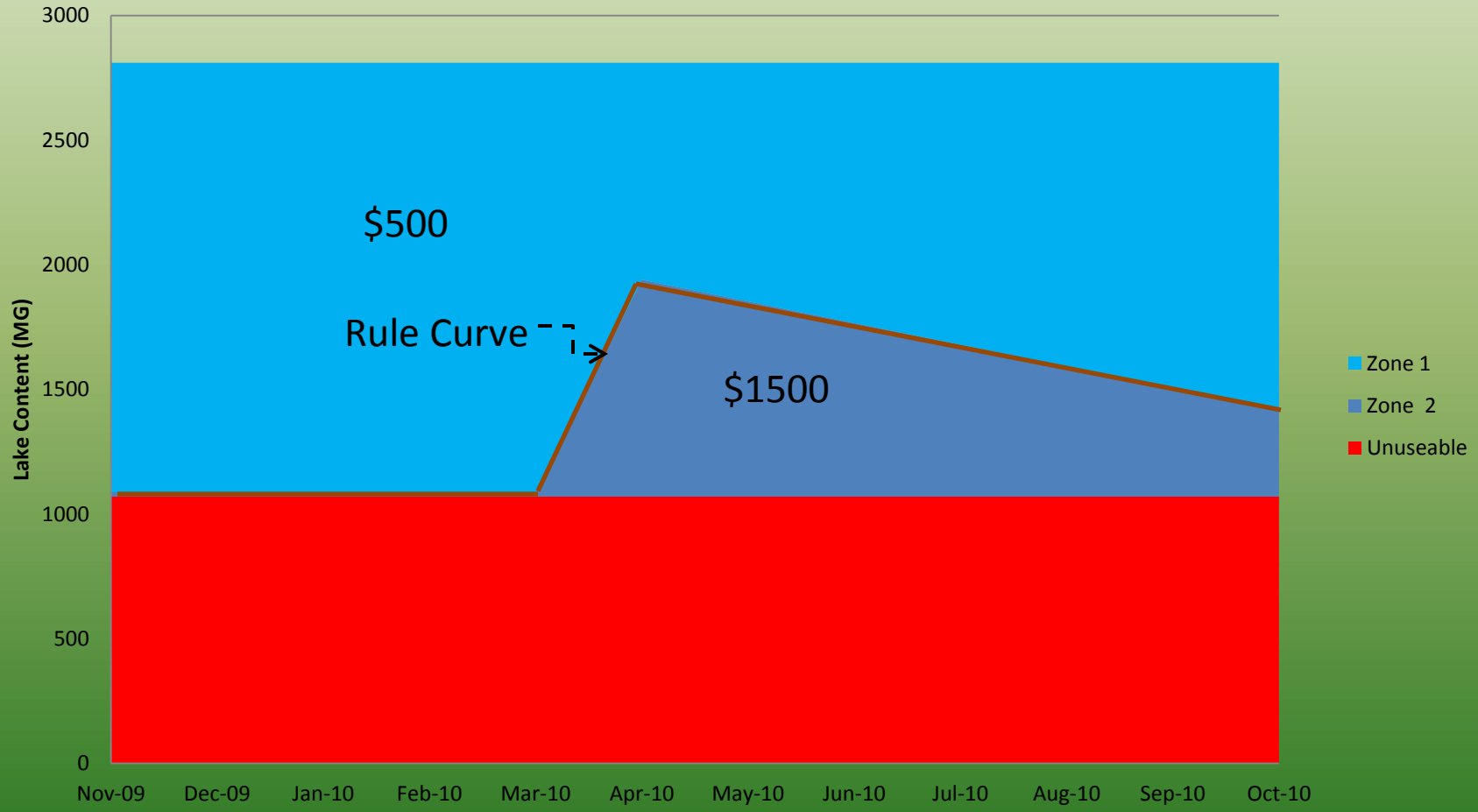
Reservoir Zones and Shadow Prices

Alternative 1



Reservoir Zones and Shadow Prices

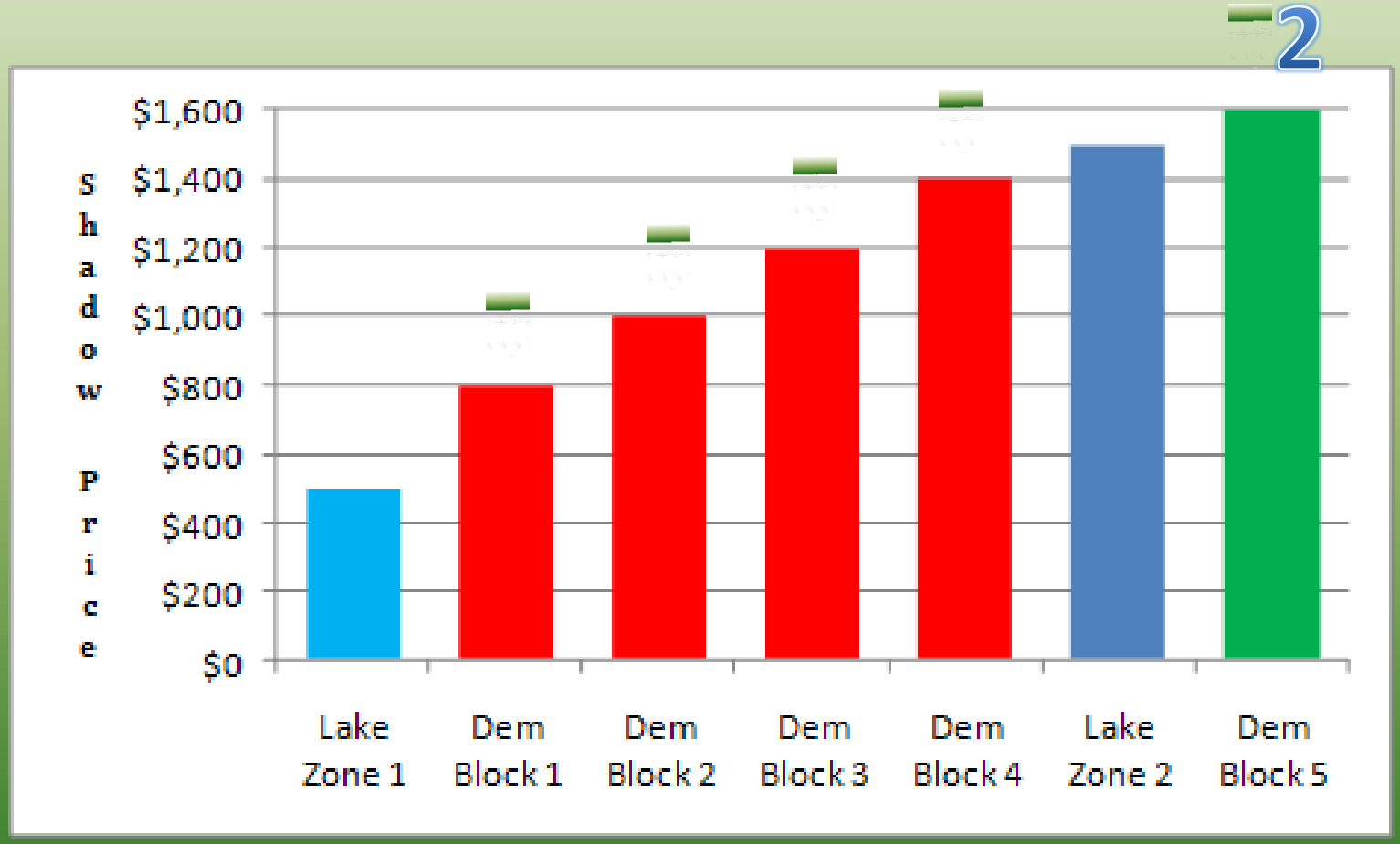
Alternative 2



Shadow Prices of Unserved Demand Blocks

Block	Shadow Price
1	$800
2	$1000
3	$1200
4	$1400
5	$1600

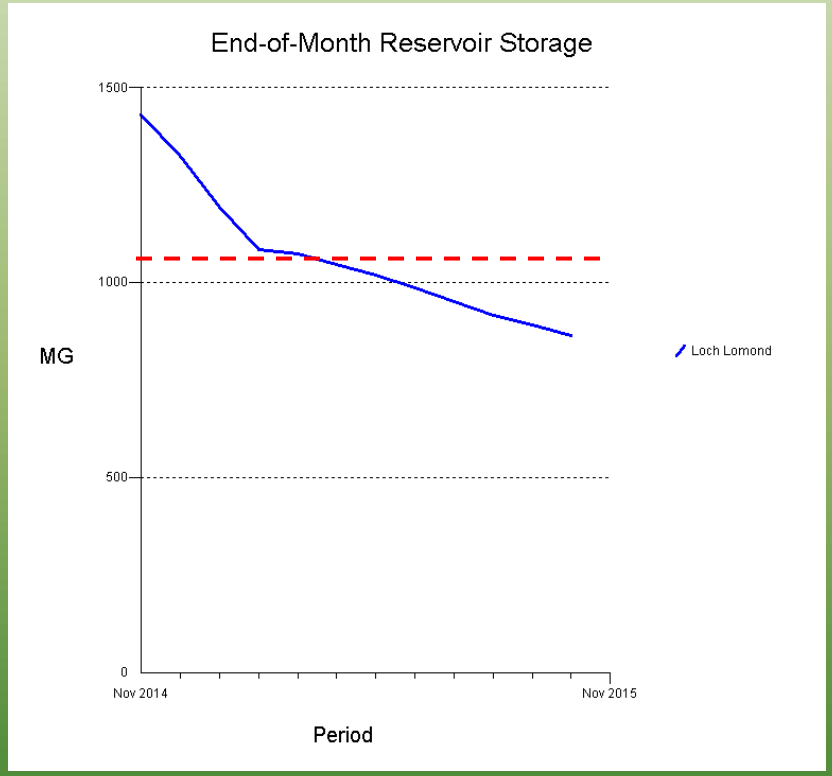
Regulation of Lake Drawdown: An Illustration

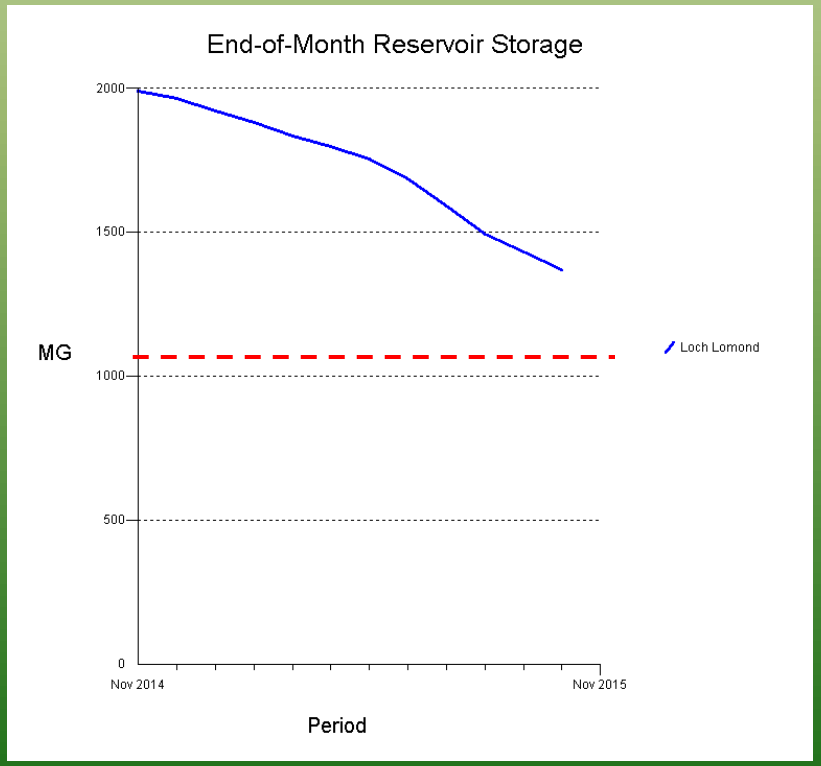


How to Set Rule Curve/USD Blocks?

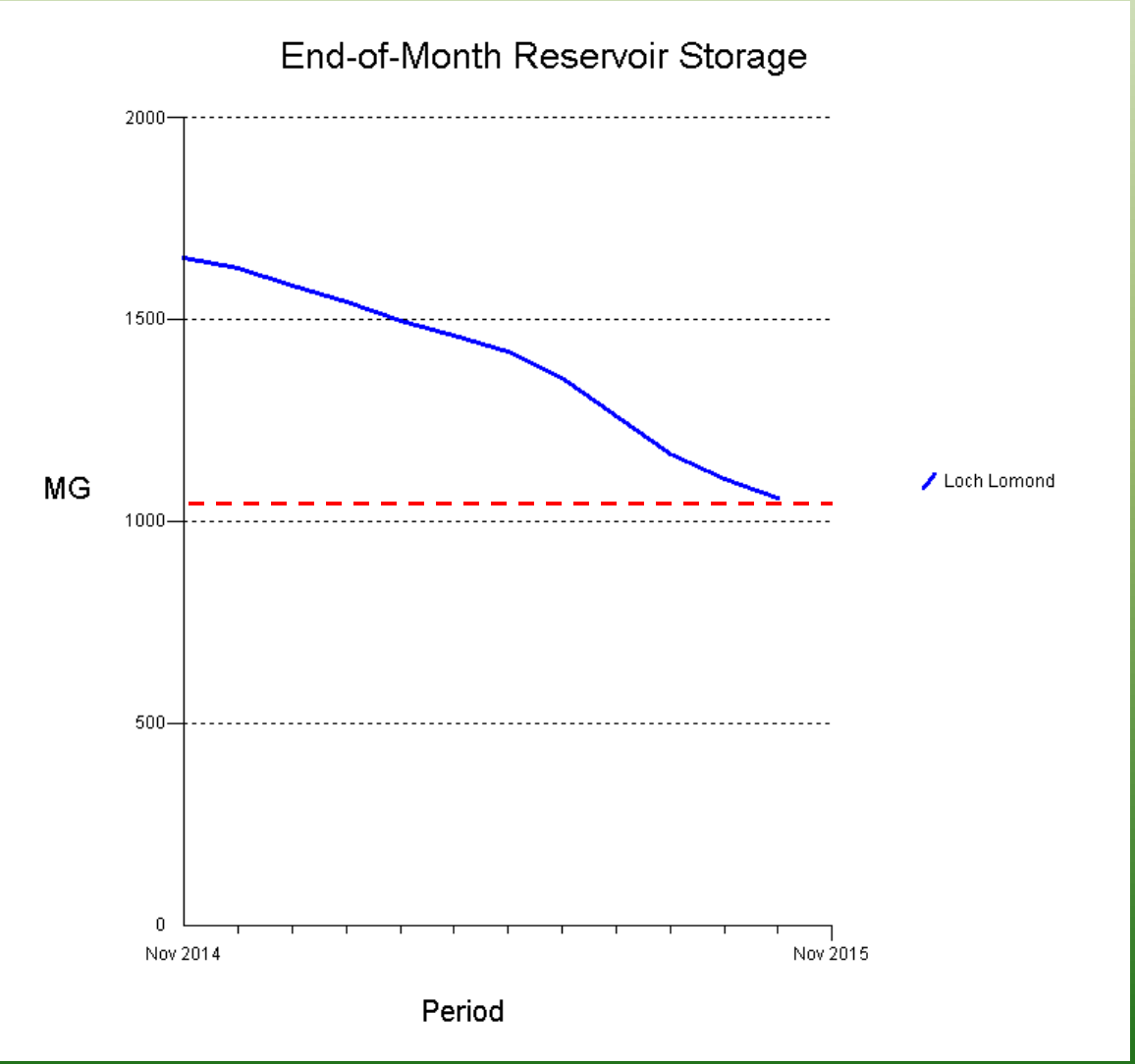
- “Smooth landing”: Use all usable storage by end of dry season in extremely dry year
- Usable storage is based on a 1 billion gallon “insurance policy”

Two Things We Don't Want to Happen in Extremely Dry Year



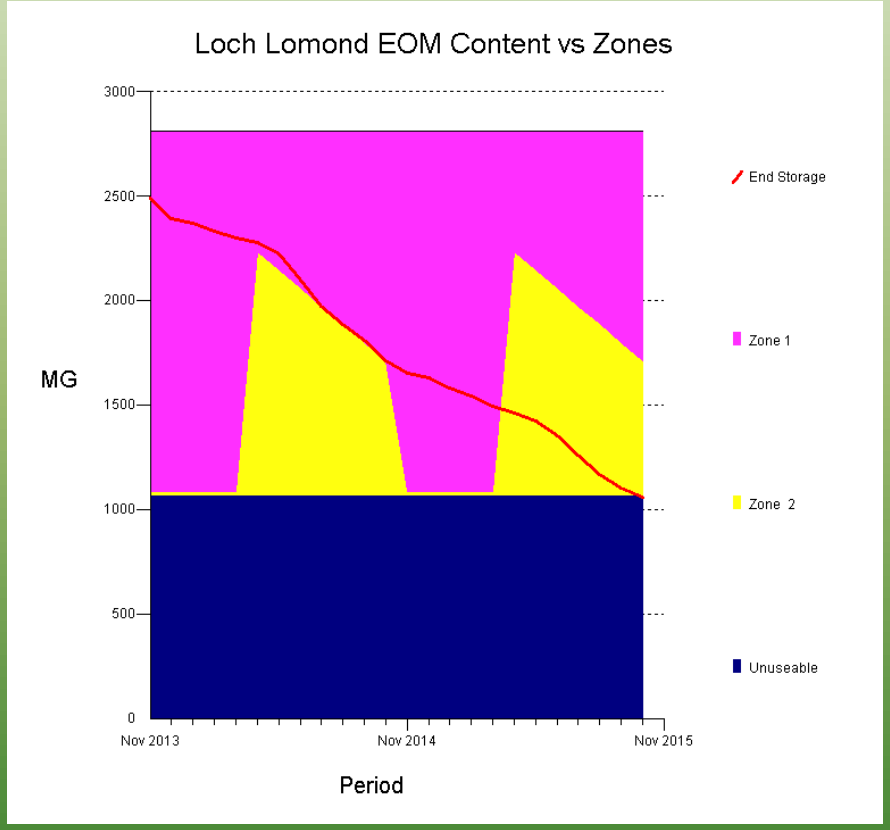


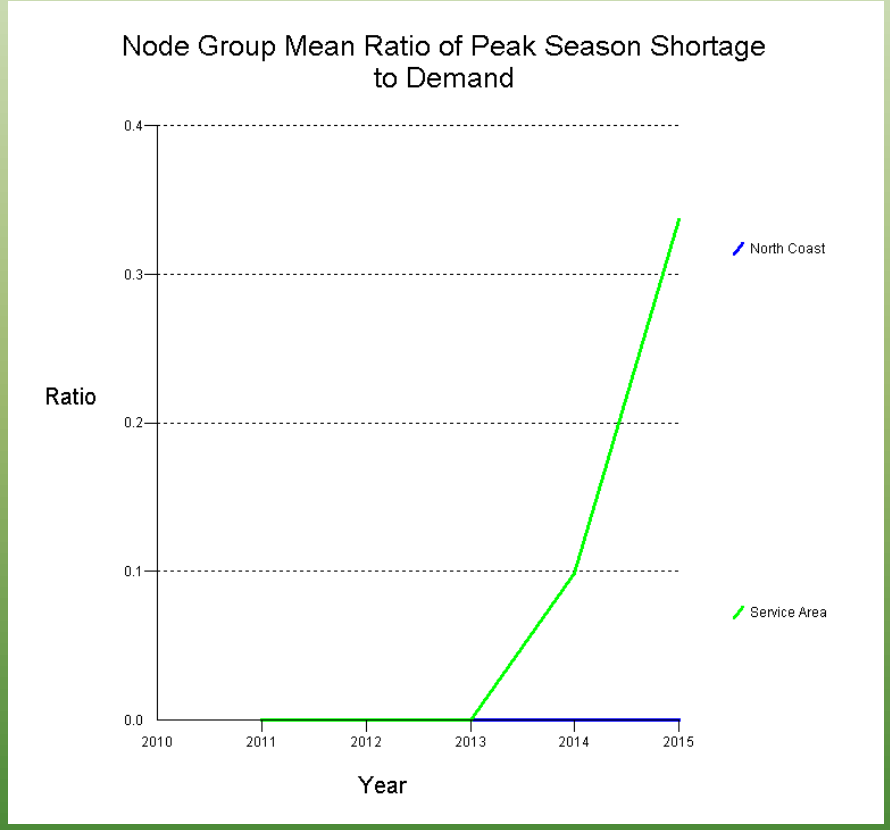
What We Do Want to Happen in That Extreme Drought Year



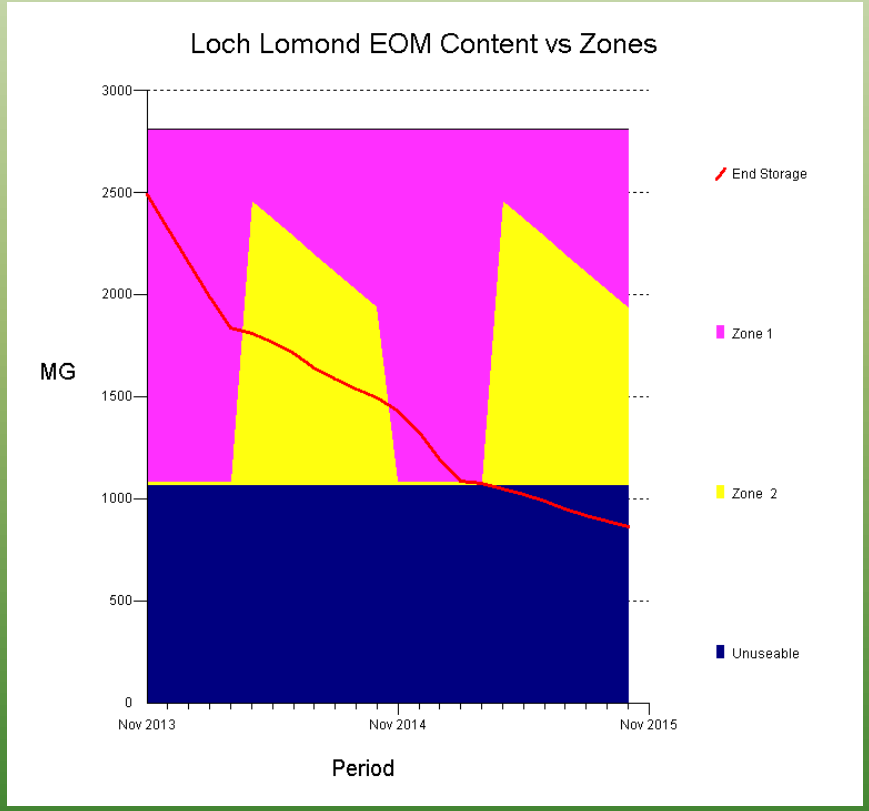
What Happens in a 1976-77 Event?

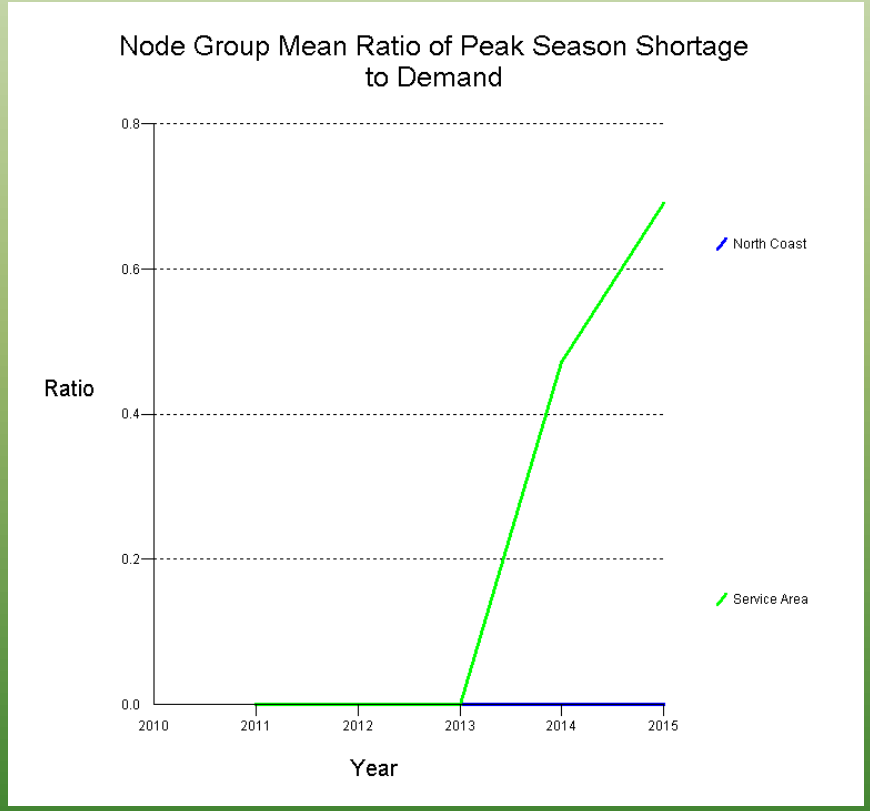
(With City Proposed HCP Flows)





What Happens in a 1976-77 Event?
(with DFG-5 HCP Flows)

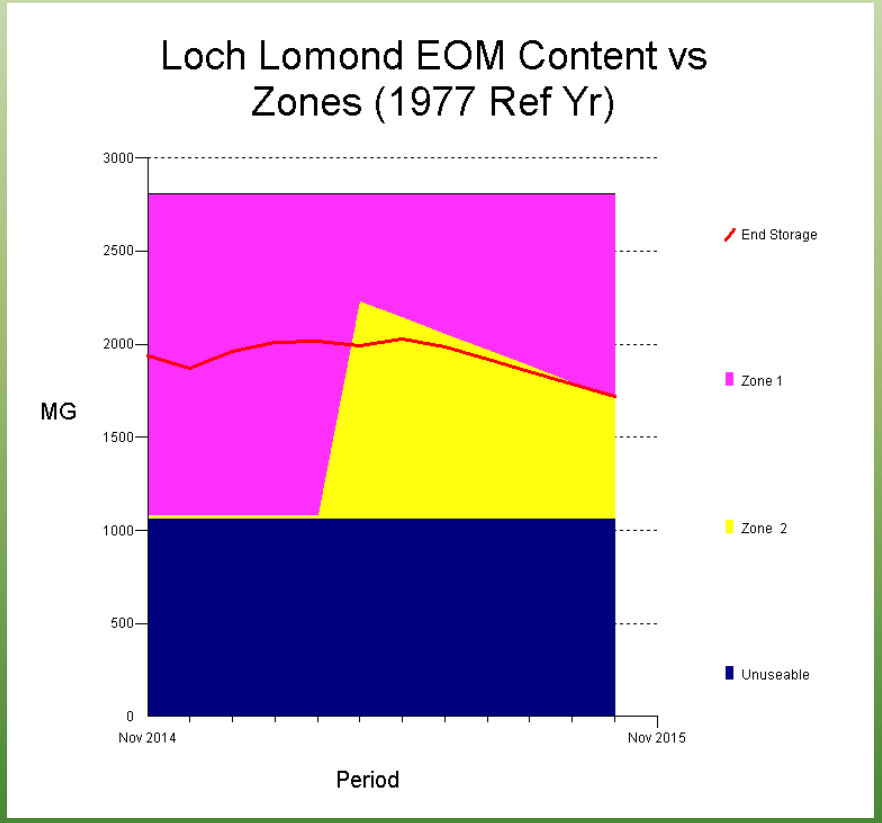


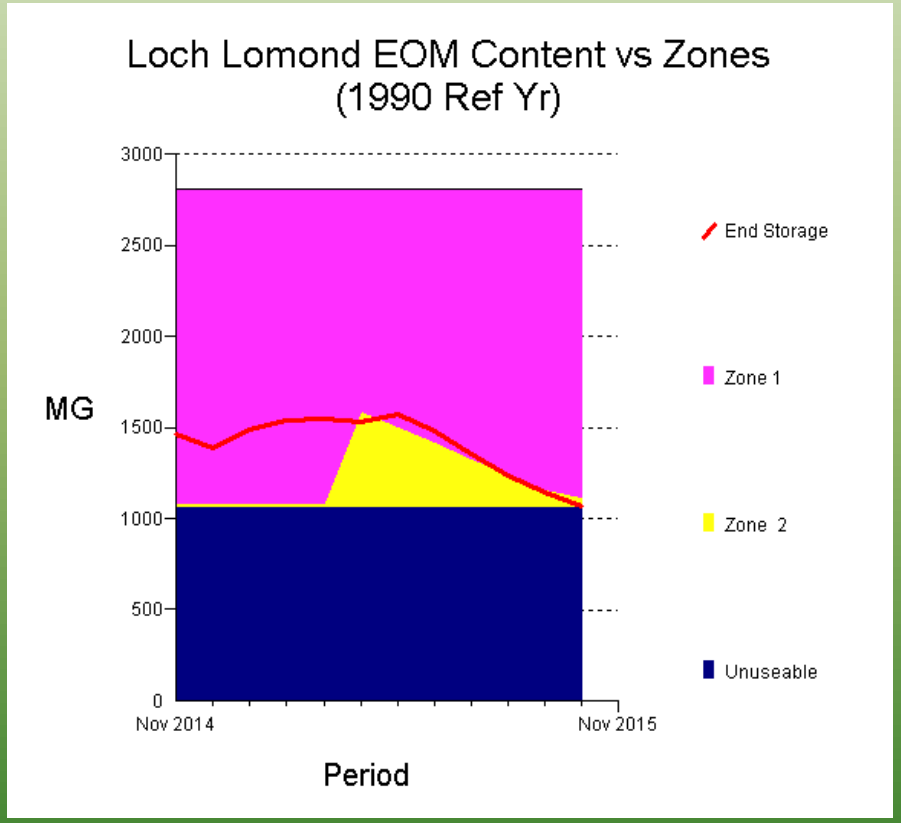


We Distinguish Between 1976-77 Event and Other Years

- Under most historical water conditions, rule curves/USD blocks based on 1990 drought year.
- For 1976-1977 event, rule curves/USD blocks based on 1977.

Two Ways to Operate Lake in 1990





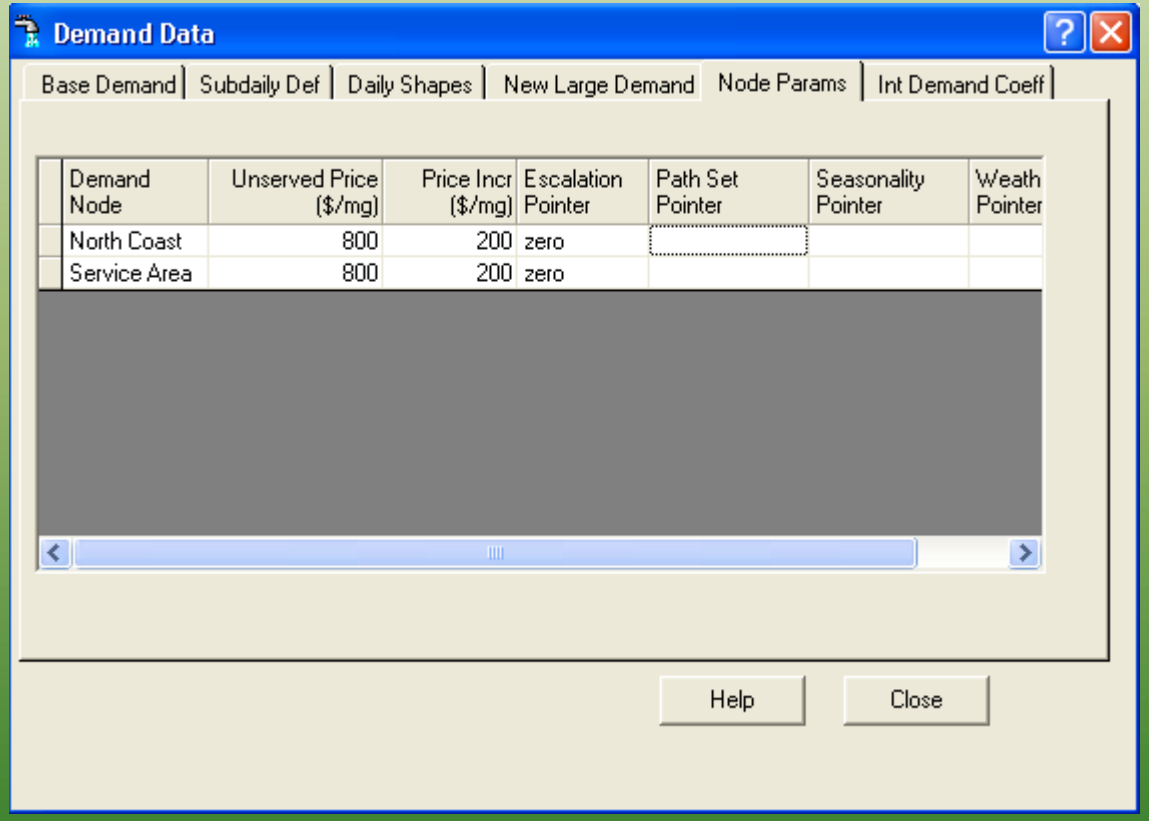
System Demand

- Demand = Volume customers would consume with no city-imposed curtailment.
- Demand ≠ Usage during curtailment.
- Curtailment is what we want to avoid.

Modeling of Peak-Season vs. Off-Peak Season Demand

- Peak-Season (May-Oct): Daily per-capita demand determined by temperature and precipitation
  - Calibrated to add up to total seasonal demand
- Off-Peak-Season (Nov-Apr): Seasonal demand allocated to months. No weather-dependency

Defining Unserved Demand Shadow Prices (for 5 blocks)

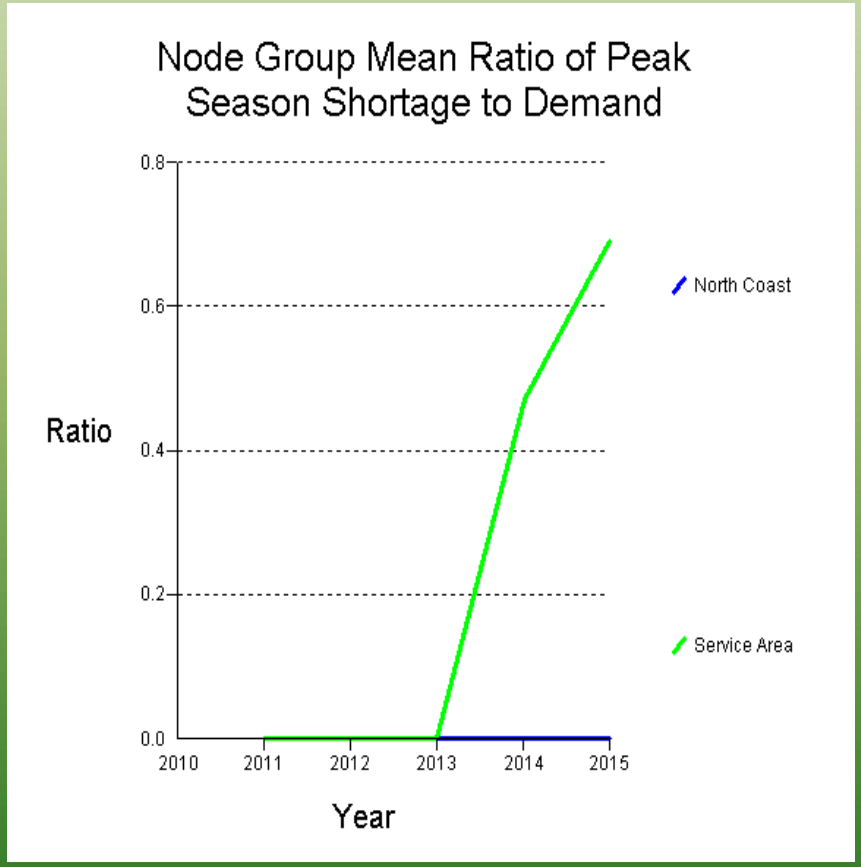


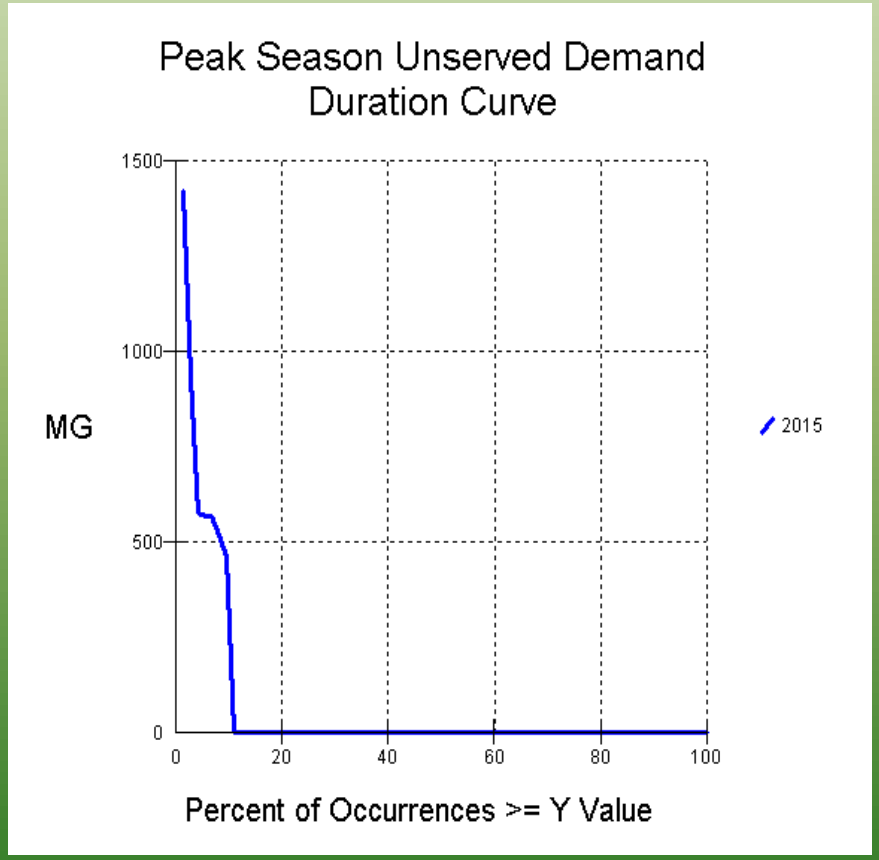
Confluence Outputs

Types of Output

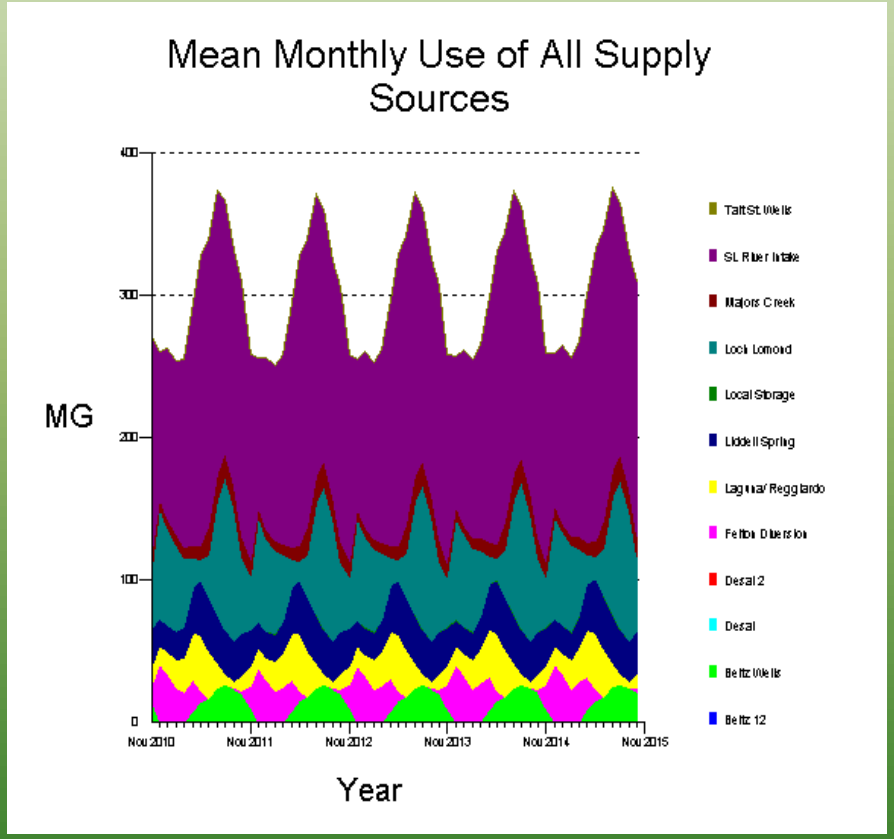
- Confluence charts (Data easily exported)
- Detail/Diagnostic text files (Data easily exported)
- Excel tables/charts from exported data

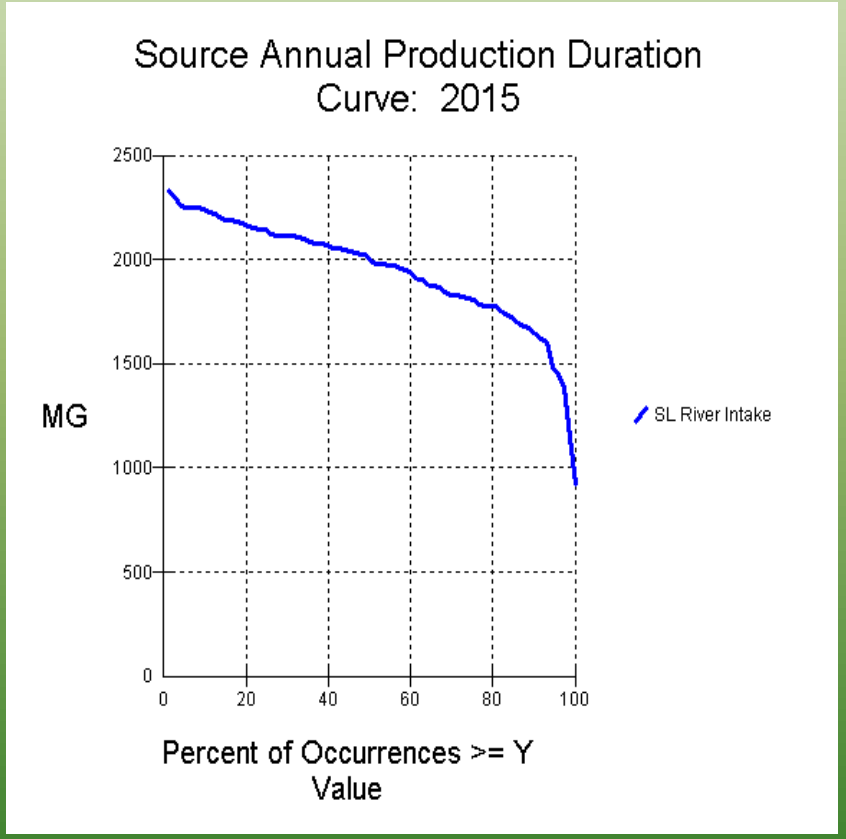
Sample Confluence Charts: Water Supply Reliability



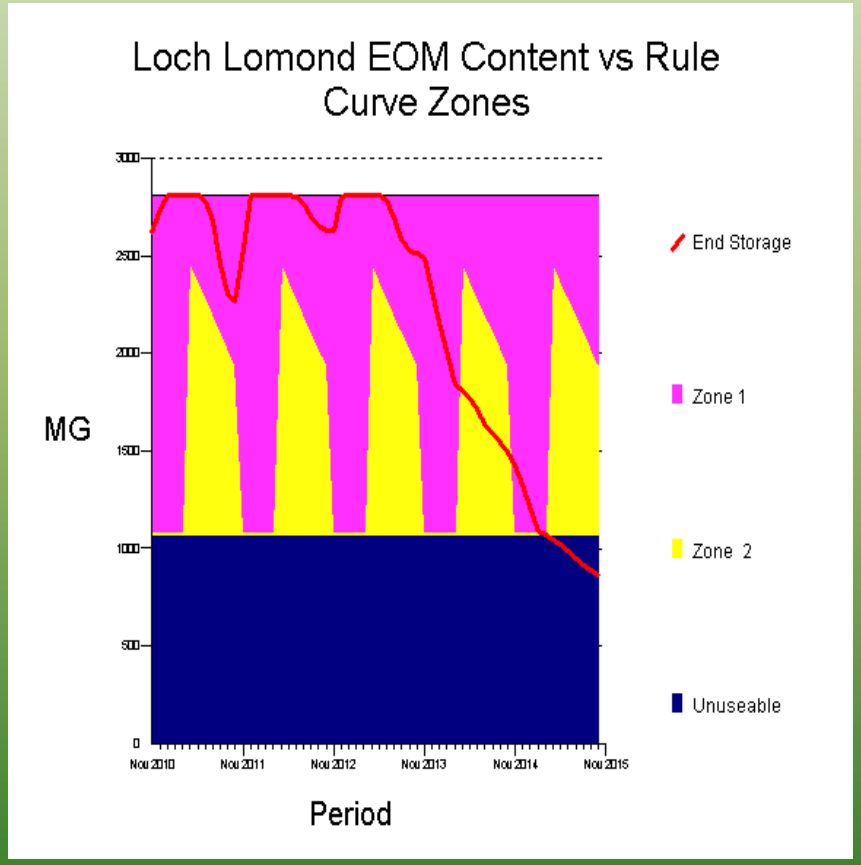


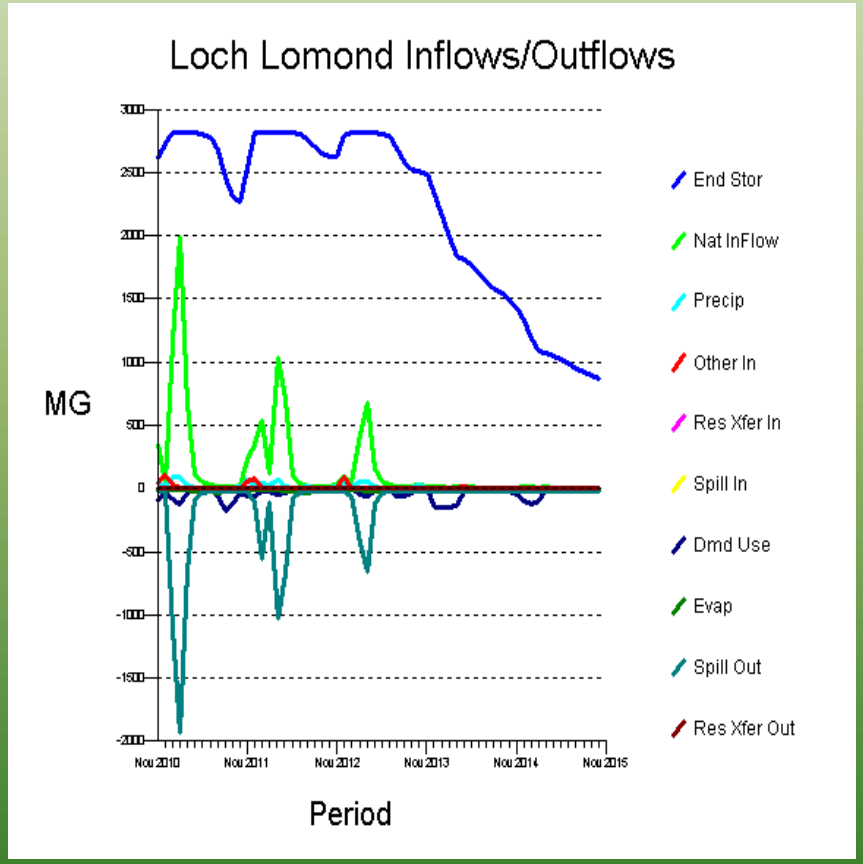
Sample Confluence Charts: Source Production



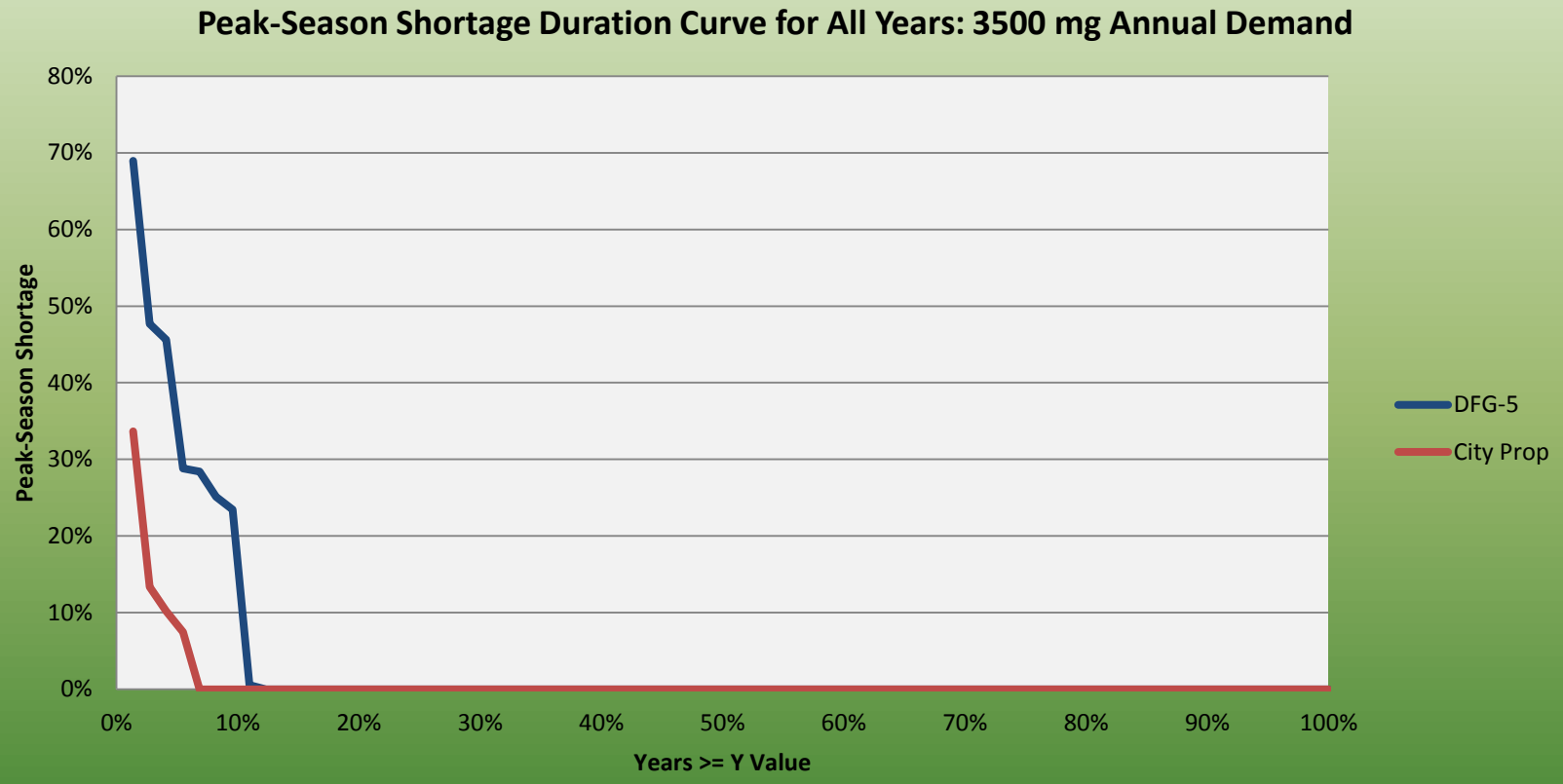


Sample Confluence Charts: Lake Operations

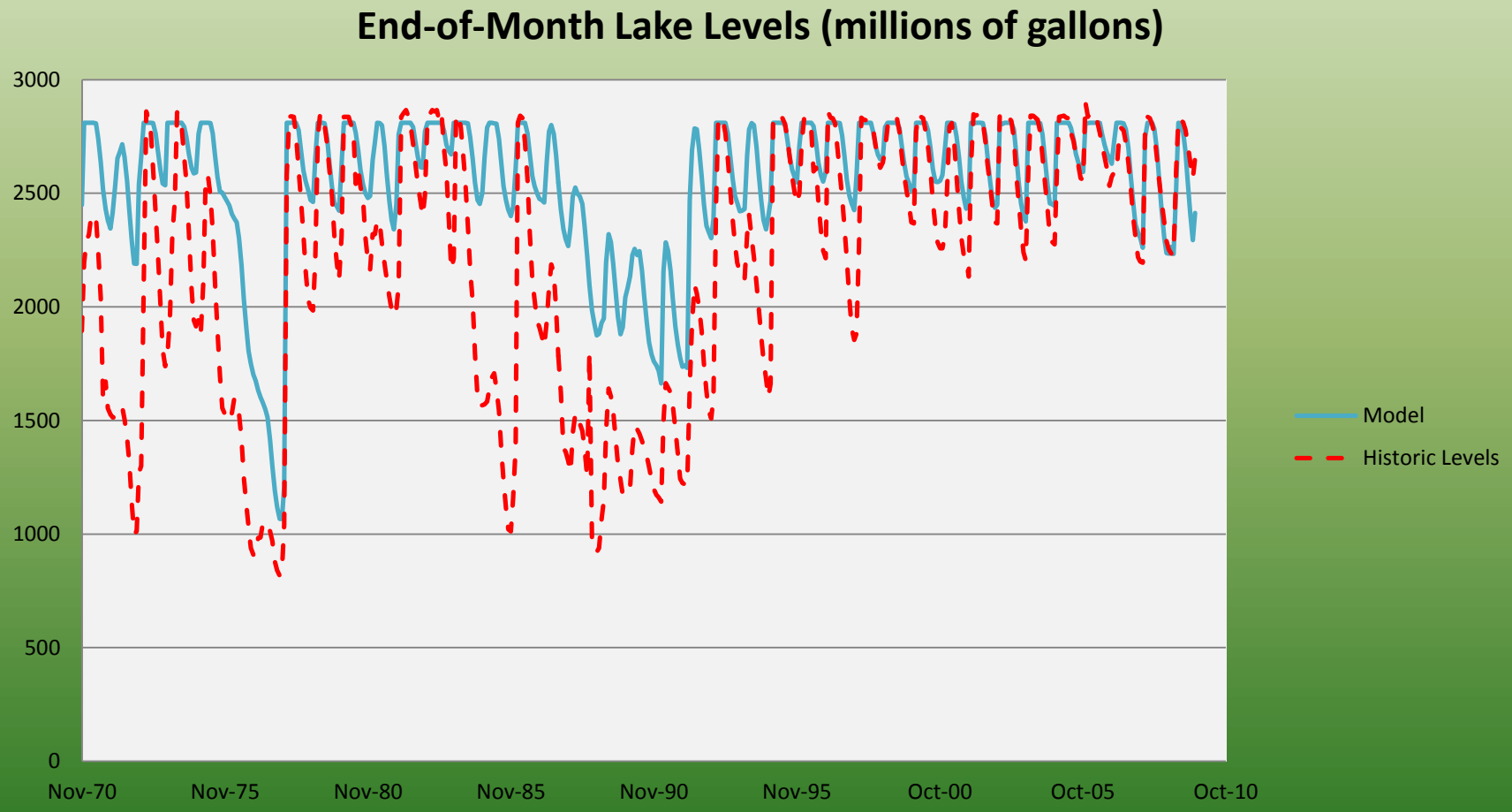




Sample Excel Chart Using Imported Confluence Data: Peak-Season Shortage Duration Curve Comparison



Sample Excel Chart: Comparison of Modeled and Historical Lake Operations



Sample Excel Table: Shortage Profile Comparison

PROFILE:	PROBABILITY OF:					Worst-Year Peak-Season Shortage
	0% Peak-Season Shortage	1-10% Peak-Season Shortage	10-20% Peak-Season Shortage	20-30% Peak-Season Shortage	> 30% Peak-Season Shortage	
IWP Adopted	49-52 in 59 (83-88%)	6-9 in 59 (10-15%)	1 in 59 (2%)	0	0	15%
City Proposal	69 in 73 (95%)	1 in 73 (1%)	2 in 73 (3%)	0	1 in 73 (1%)	34%
DFG-5	65 in 73 (89%)	1 in 73 (1%)	0	4 in 73 (5%)	3 in 73 (4%)	69%

Sample Excel Table:
Average Monthly Source Production

		Beltz				Desal				Felton				Laguna				Liddell				Loch Lomond				Majors				SL River @ Tait St			
		Beltz	Beltz	Beltz	Beltz	Desal	Desal	Desal	Desal	Felton	Felton	Felton	Felton	aguna	aguna	aguna	aguna	Liddel	Liddel	Liddel	Liddel	Loch	Loch	Loch	Loch	Majors	Majors	Majors	Majors	SL	SL	SL	SL
		Av	Med	Max	Min	Av	Med	Max	Min	Av	Med	Max	Min	Av	Med	Max	Min	Av	Med	Max	Min	Av	Med	Max	Min	Av	Med	Max	Min	Av	Med	Max	Min
		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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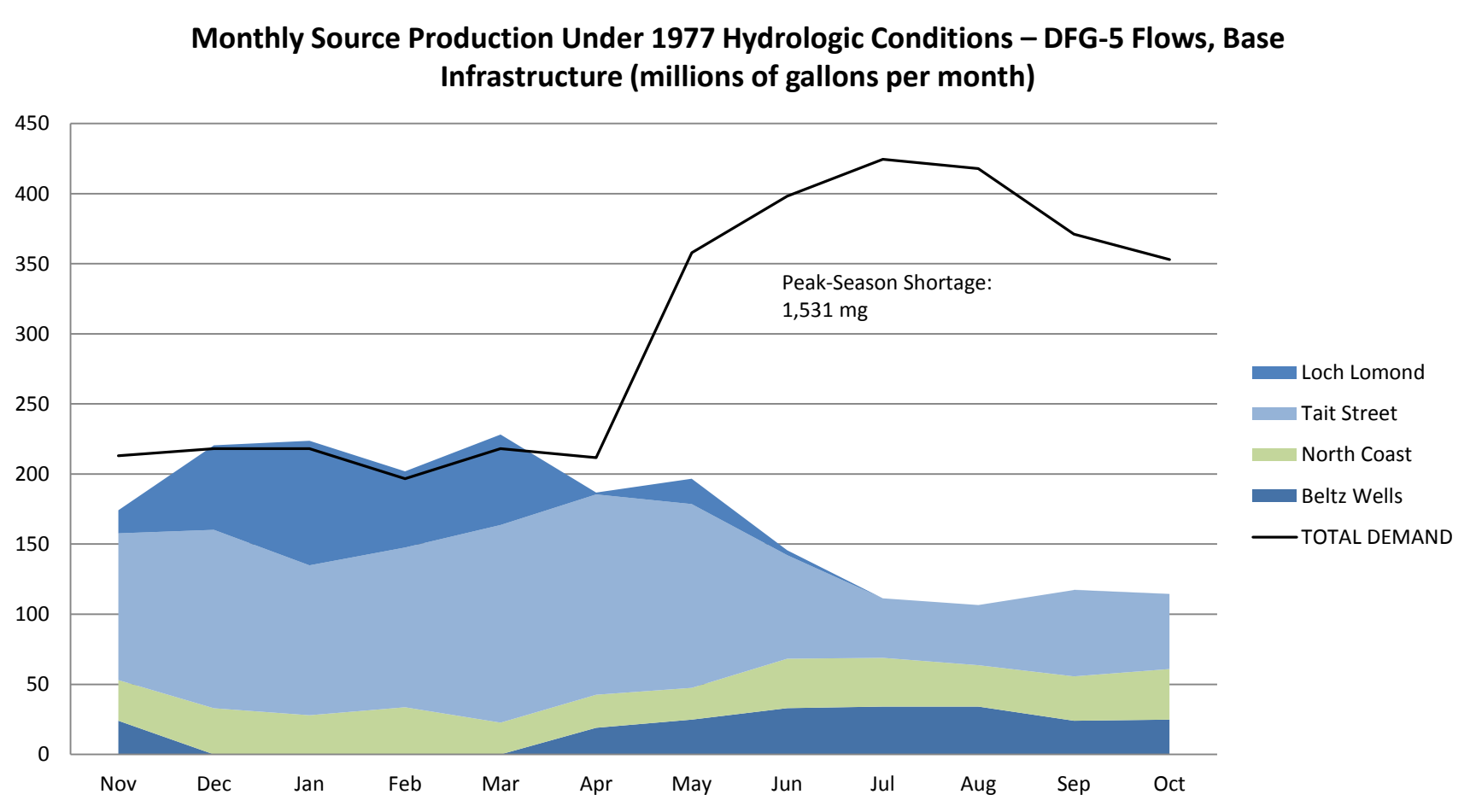
Aug	Crit Dry	34	34	34	34	0	0	0	0	0	0	0	0	3	0	12	0	31	30	39	28	101	110	177	0	11	9	21	5	169	171	226	92
	Dry	25	25	25	25	0	0	0	0	0	0	0	0	5	3	16	0	32	30	37	28	97	101	136	61	12	11	16	9	205	208	231	162
	Normal	25	25	25	25	0	0	0	0	0	0	0	0	8	7	25	1	28	33	35	15	101	75	245	47	13	12	29	6	207	230	231	96
	Wet	25	25	25	24	0	0	0	0	0	0	0	0	30	31	52	12	33	33	43	22	42	34	125	8	29	31	31	23	225	231	231	177
	All	26	25	34	19	0	0	0	0	0	0	0	0	15	9	69	0	31	30	43	15	79	74	245	0	18	15	31	5	207	228	231	92
Sep	Crit Dry	24	24	24	23	0	0	0	0	0	0	0	0	3	1	13	0	30	29	37	27	86	96	153	0	11	9	19	8	161	160	211	119
	Dry	24	24	24	24	0	0	0	0	0	0	0	0	3	1	12	0	31	31	34	27	72	69	117	34	11	11	14	9	197	201	223	159
	Normal	23	24	24	18	0	0	0	0	3	0	34	0	7	4	24	1	27	28	36	18	76	55	151	31	13	11	26	8	200	219	223	132
	Wet	22	23	24	15	0	0	0	0	0	0	0	0	24	22	42	10	31	31	41	23	32	29	60	3	27	28	30	21	217	223	223	205
	All	23	24	24	13	0	0	0	0	0	0	34	0	12	8	45	0	29	29	41	18	64	57	162	0	17	14	30	5	197	209	223	118
Oct	Crit Dry	22	25	25	15	0	0	0	0	6	0	55	0	5	0	21	0	32	31	37	30	39	39	96	0	12	10	22	9	192	203	223	131
	Dry	22	23	25	15	0	0	0	0	0	0	0	0	9	8	27	1	33	33	38	31	30	25	64	2	12	12	19	10	210	217	231	151
	Normal	20	21	25	9	0	0	0	0	9	0	97	0	19	16	49	6	31	33	36	20	29	18	88	4	13	12	25	6	214	223	231	175
	Wet	11	12	19	2	0	0	0	0	2	0	24	0	38	38	54	27	30	28	39	23	12	4	70	0	23	24	31	8	215	217	229	172
	All	19	21	25	1	0	0	0	0	3	0	97	0	17	14	54	0	29	30	39	18	34	19	143	0	16	14	31	4	203	214	231	114
ANNUAL AVERAGE	Crit Dry	195				0				282				90				352				592				145				2135			
	Dry	161				0				239				137				346				542				140				2227			
	Normal	142				0				133				250				346				578				138				2145			
	Wet	107				0				86				531				372				449				194				1977			
	All	144				0				152				298				349				546				158				2086			
PEAK-SEASON AVERAGE	Crit Dry	178				0				19				20				189				380				73				1144			
	Dry	140				0				11				48				196				338				84				1287			
	Normal	128				0				20				99				194				336				88				1278			
	Wet	93				0				3				279				220				123				157				1276			
	All	128				0				9				136				198				279				106				1253			

Sample Excel Chart: Demand-Production Comparison



Questions

Then Inside Confluence . . .