Libby Dam Water Supply Forecast Update

Joel Fenolio, P.E.
Seattle District, Corps of Engineers
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US Army Corps of Engineers
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Libby Dam Forecast Update – Why?

		2011 - March Forecast of April – August Water Supply Forecast				2012 - March Forecast of April – August Water Supply Forecast			
Variable	Month(s)	Observed Value	Percent of Average	Regression Coefficient	Marginal Runoff (KAF)	Observed Value	Percent of Average	Regression Coefficient	Marginal Runoff (KAF)
		A		B	=A*B	A		B	=A*B
QBO	∑Jan:Mar	**-52.68**		**-10.2**	**539**	**29.67**	**0%**	**-10.2**	**-303**
Eureka, MT	∑Oct:Feb Prcp	5.74 in	115%	70.2	403	4.30 in	86%	68.6	295
Libby 1 NE RS, MT	∑Oct:Feb Prcp	10.60 in	117%	52.0	551	8.65 in	95%	51.5	446
West Glacier, MT	∑Oct:Feb Prcp	19.21 in	133%	33.6	645	13.23 in	92%	33.7	446
Fernie, BC	∑Oct:Feb Prcp	27.14 in	107%	10.8	294	14.78 in	58%	11.5	170
Floe Lake, BC	1-Mar SWE	24.53 in	106%	5.8	141	26.87 in	116%	6.4	172
Sunshine Village, AB	1-Mar SWE	18.16 in	98%	15.9	288	20.20 in	109%	17.8	360
East Creek, BC	1-Mar SWE	29.82 in	104%	5.0	151	29.23 in	102%	4.8	139
Stahl Peak, MT	1-Mar SWE	37.20 in	128%	15.9	590	27.60 in	95%	15.2	421
Gardiner Creek, AB	1-Mar SWE	25.48 in	140%	14.7	374	17.24 in	95%	13.2	227
Three Isle Lake, AB	1-Mar SWE	14.42 in	94%	24.6	355	17.20 in	112%	26.1	449
Lost Creek S., AB	1-Mar SWE	18.06 in	94%	15.4	278	26.65 in	138%	14.7	392
Morrissey Ridge, BC	1-Mar SWE	22.74 in	100%	18.5	420	20.08 in	88%	18.6	374
Hawkins Lake, MT	1-Mar SWE	26.00 in	129%	23.3	605	25.20 in	125%	22.8	575
Intercept		1.00		1,476	1476	1.00		1,473	1473
				2011 1-Mar Forecast (KAF) =	**7111**			**2012 1-Mar Forecast (KAF) =**	**5635**

Need to Update Cont'd

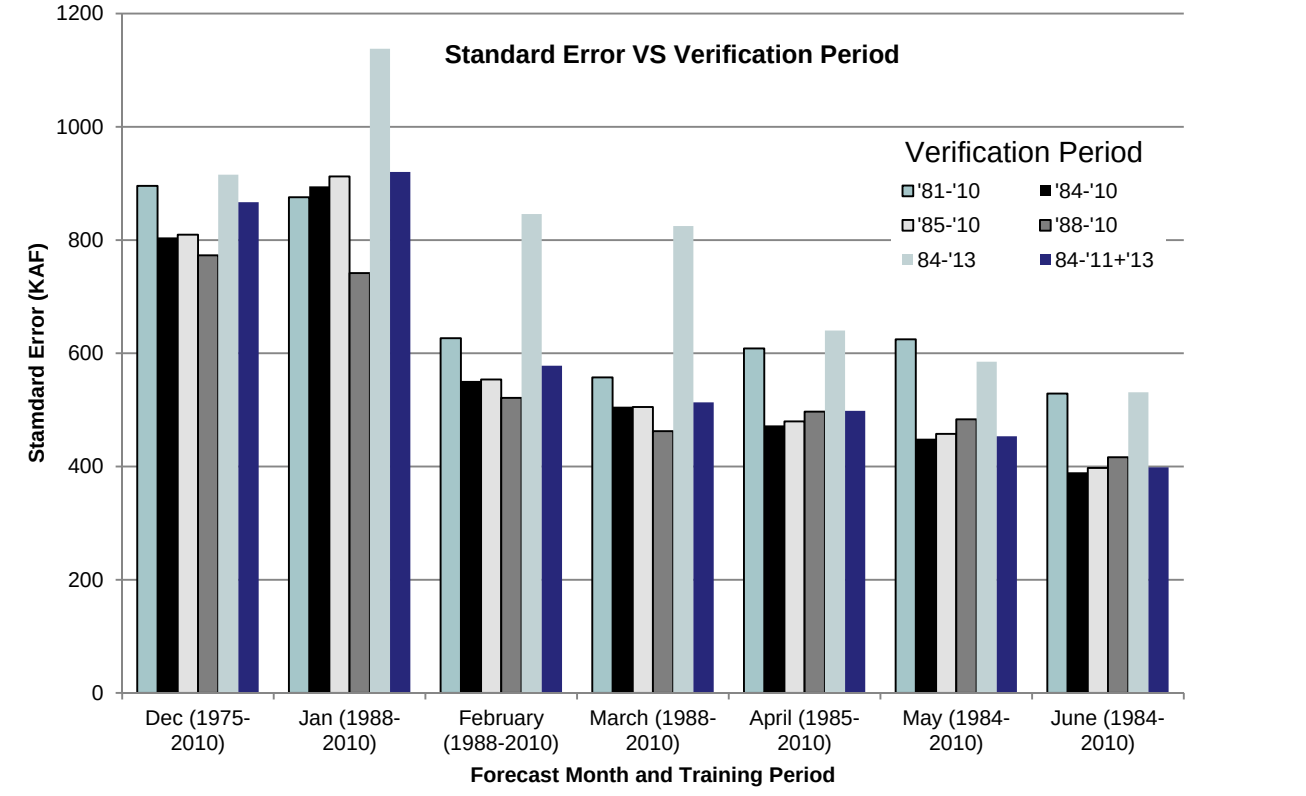
Regression Variables		Forecast Issue Date							
	Training Period	1975-2010	1975-2010	1988-2010	1988-2010	1988-2010	1985-2010	1984-2010	1984-2010
Type	VarName	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
CLX	SOI	JunJul	JunJul						
	QBO	JFM	JFM	JFM	JFM	JFM	JFM	JFM	JFM
	PNA						ONDJ	ONDJ	ONDJ
PPT	Eureka, MT	Oct	ON	OND	ONDJ	ONDJF			
	Libby 1NE RS, MT	Oct	ON	OND	ONDJ	ONDJF			
	West Glacier, MT	Oct	ON	OND	ONDJ	ONDJF	DJFM	JFMA	JFMAM
	Fernie, BC	Oct	ON	OND	ONDJ	ONDJF	DJFM	JFMA	JFMAM
SWE	Floe Lake, BC			1-Jan	1-Feb	1-Mar			
	Sunshine Village, AB			1-Jan	1-Feb	1-Mar	1-Apr	1-May	
	East Creek, BC			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
	Stahl Peak, MT			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
	Gardiner Creek, AB			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
	Three Isle Lake, AB			1-Jan	1-Feb	1-Mar	1-Apr		
	Lost Creek South, AB			1-Jan	1-Feb	1-Mar			
	Morrissey Ridge, BC			1-Jan	1-Feb	1-Mar			
	Hawkins Lake, MT			1-Jan	1-Feb	1-Mar			
Depen-dent	Libby Inflow (in KAF)	AprAug	AprAug	AprAug	AprAug	AprAug	AprAug	MayAug	JunAug

Goals

- To develop forecast equations that are consistent and use measurable physical estimators.
- The only climatic variables considered will be those with a fully explained connection to the Kootenai Basin hydrology or show no deterioration of the forecast.
- Eliminate the November first of month forecast.
- Minimize Errors – maximum, standard, and/or regression error.
- Enhance geographic coverage of the snow stations.
- Improved forecast performance.

Training Period

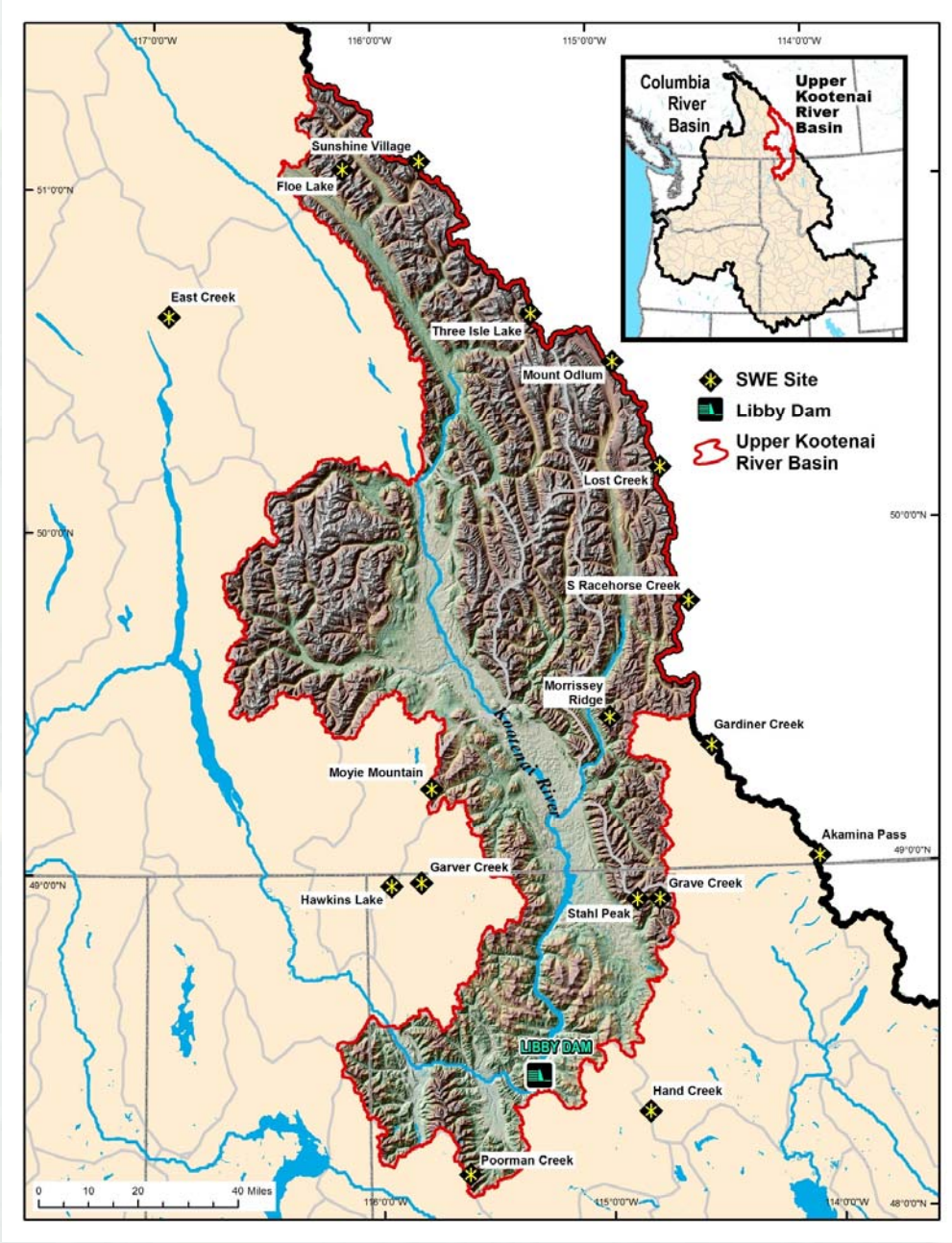
- Previous forecast used a variety of training periods for different month's forecast.



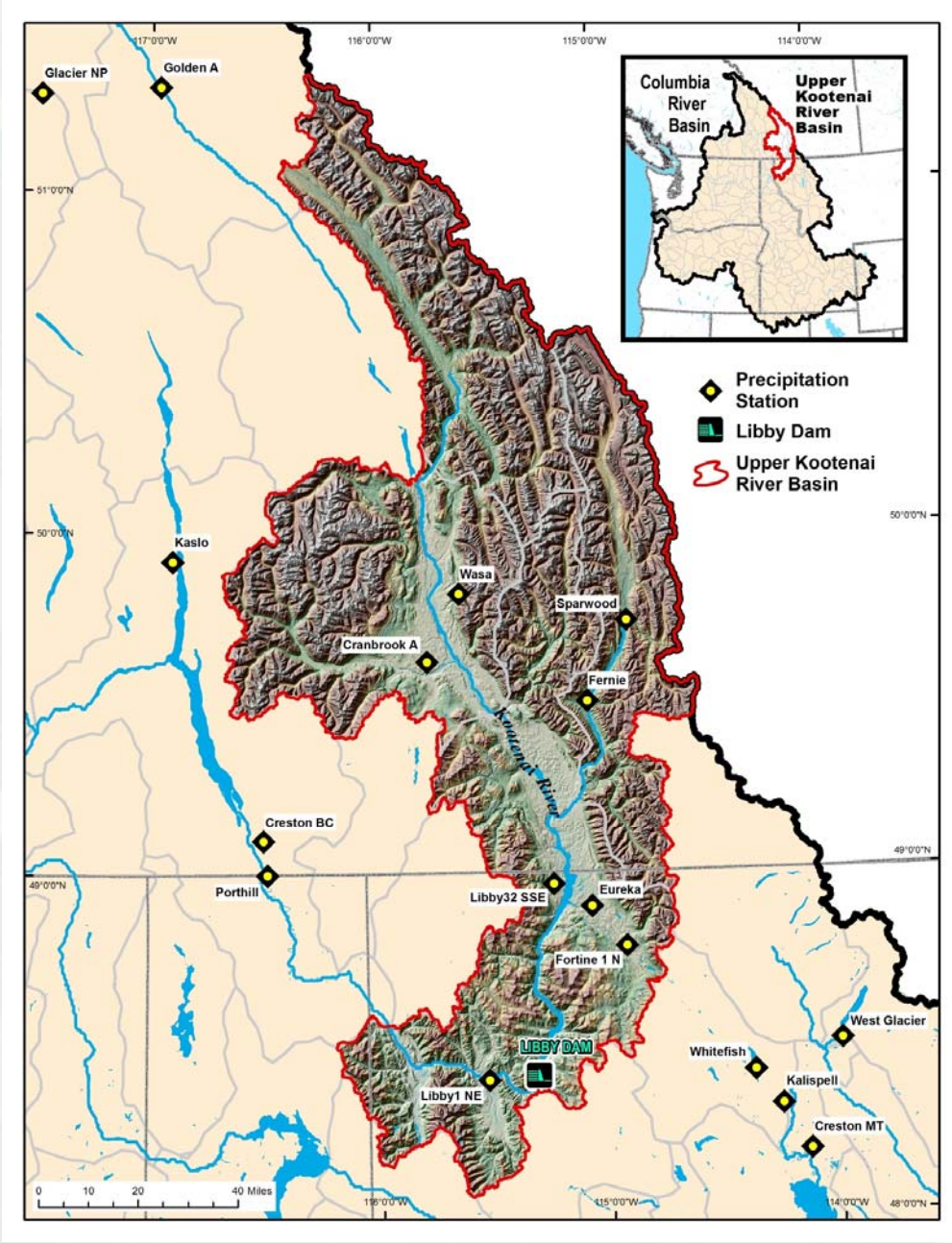
Period of Record

- 1984-2013 was chosen for this update.
  - Maximizes Alberta sites and the 1975* – 2013 Inflow set
  - Minimizes data extension
  - Month to month consistency

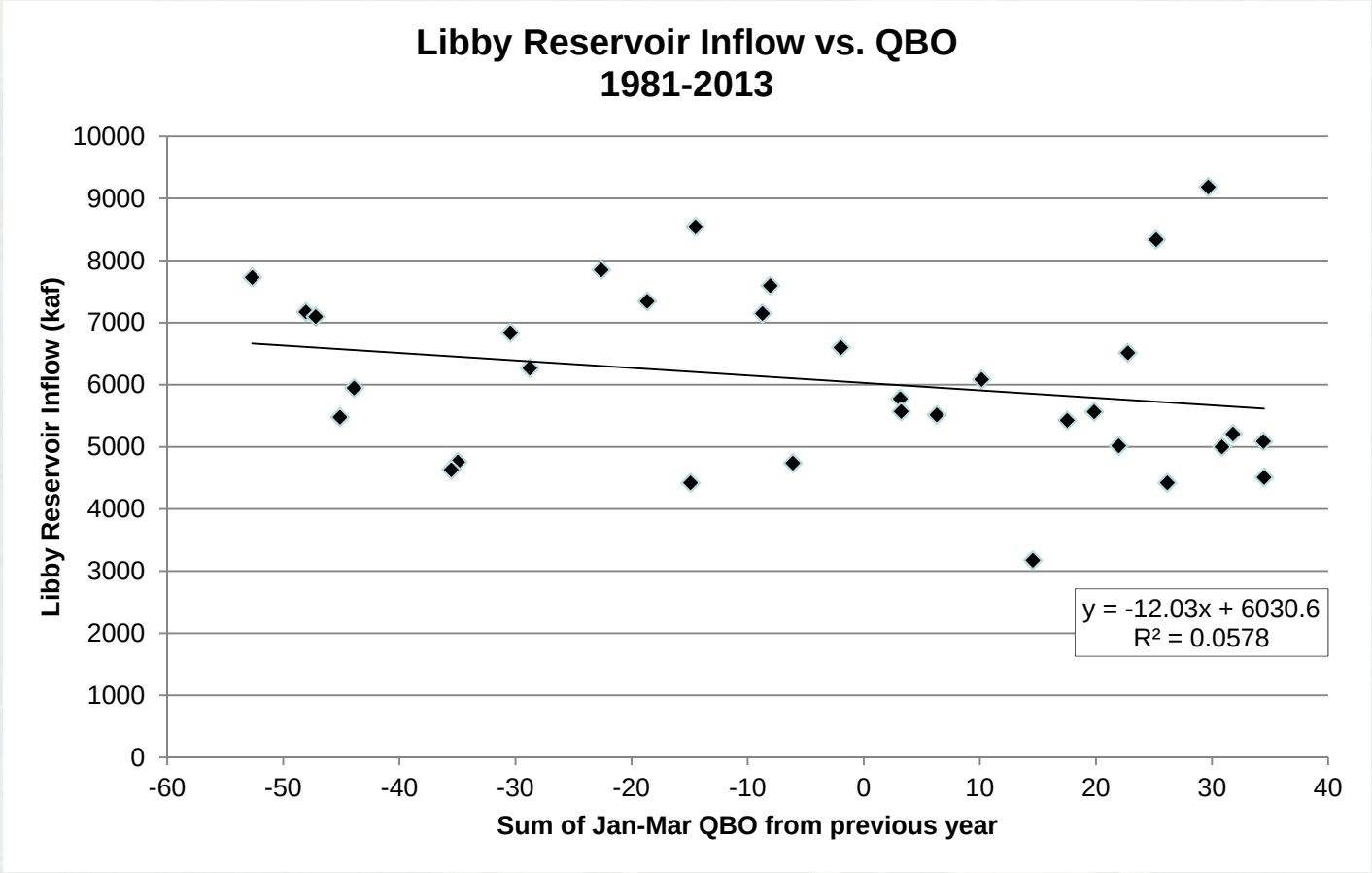
SWE Stations



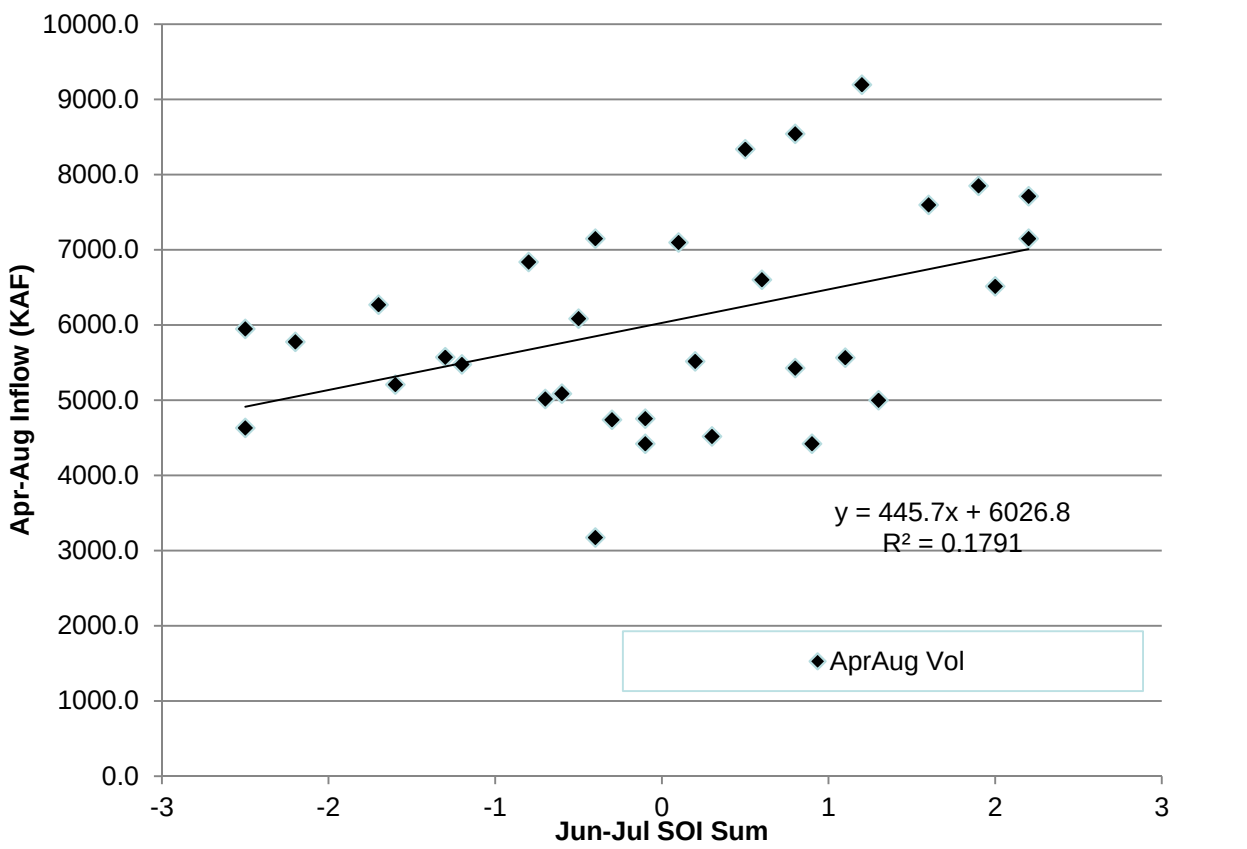
Precip Selection



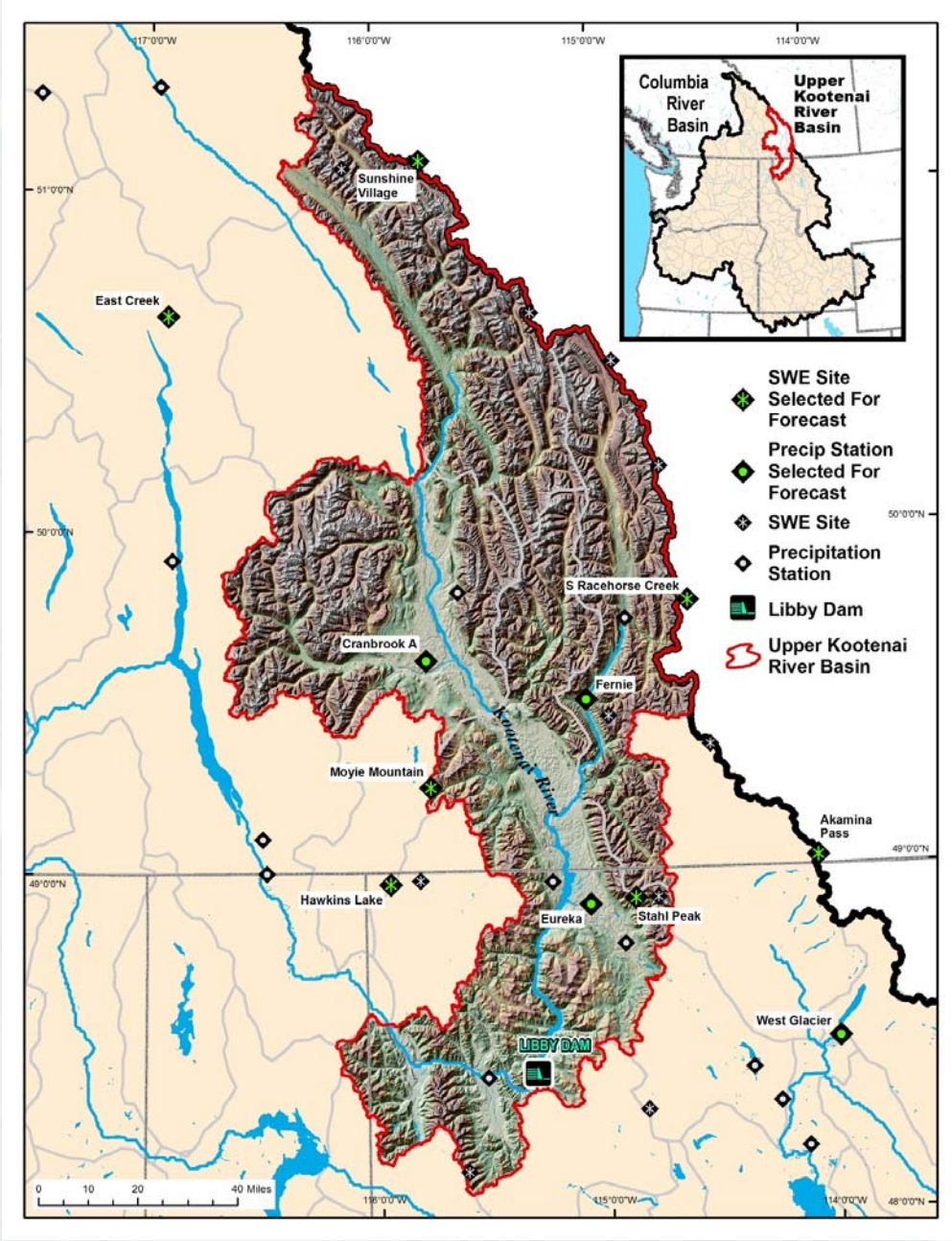
Climatic Variables - QBO



Climatic Variables - SOI



Stations Selected



Selected Variables for Final Equations
1984-2013 Training Period

Regression Variables		Forecast Issue Date						
Type	VarName	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
CLX	SOI	JunJul	JunJul					
PPT	Cranbrook AP, BC	Oct-Nov	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Apr	Oct-May	Oct-Jun
	Eureka, MT	Oct-Nov	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Apr	Oct-May	Oct-Jun
	Fernie, BC	Oct-Nov	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Apr	Oct-May	Oct-Jun
	West Glacier, MT	Oct-Nov	Oct-Dec	Oct-Jan	Oct-Feb	Oct-Apr	Oct-May	Oct-Jun
SWE	Akamina Pass, AB			1-Feb	1-Mar	1-Apr	1-May	1-Jun
	East Creek, BC			1-Feb	1-Mar	1-Apr	1-May	1-Jun
	Hawkins Lake, MT			1-Feb	1-Mar	1-Apr	1-May	1-Jun
	Moyie Mountain, BC		1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
	Stahl Peak, MT		1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
	Sunshine Village, AB		1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
	South Racehorse Creek, AB		1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Depen-dent	Libby Inflow (in KAF)	AprAug	AprAug	AprAug	AprAug	AprAug	MayAug	JunAug

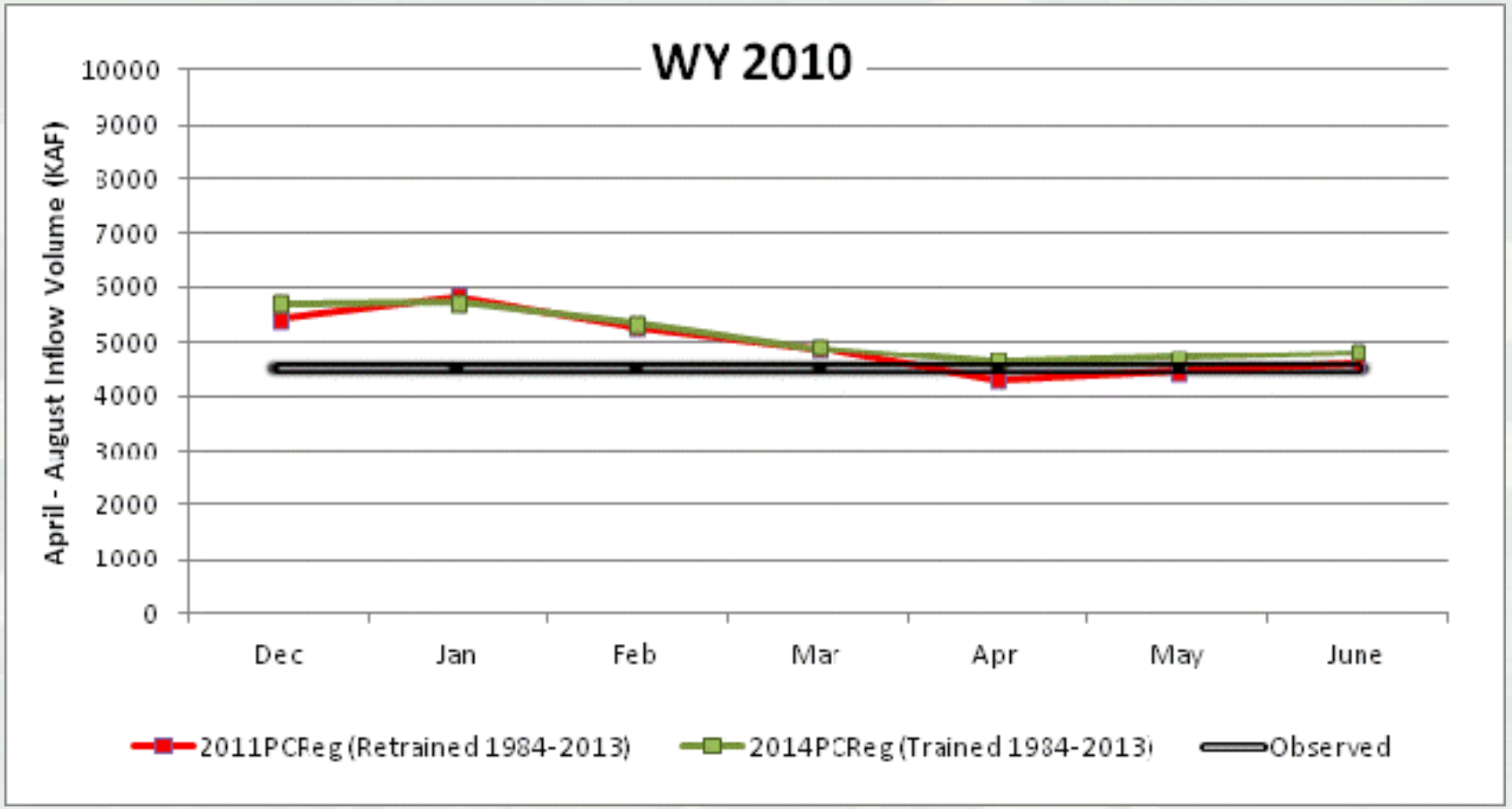
Selected Variables for Final Equations
1984-2013 Training Period

Regression Variables		Forecast Issue Date						
Type	Variable Name	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
CLX	SOI	133.38	95.28					
PPT	Cranbrook AP, BC	8.79	4.58	2.84	2.73	2.99	2.80	2.03
	Eureka, MT	267.66	141.74	78.47	65.87	68.52	57.45	37.66
	Fernie, BC	1.95	1.20	0.72	0.63	0.71	0.61	0.50
	West Glacier, MT	105.96	58.42	30.95	28.51	29.47	28.04	22.46
SWE	Akamina Pass, AB			1.27	1.04	0.72	0.55	0.68
	East Creek, BC			0.75	0.65	0.73	0.57	0.43
	Hawkins Lake, MT			30.61	24.33	22.43	17.30	10.09
	Moyie Mountain, BC		1.59	1.48	1.27	1.21	0.91	0.85
	Stahl Peak, MT		34.63	22.99	19.11	19.70	16.74	10.31
	Sunshine Village, AB		2.14	1.47	1.26	1.43	1.26	0.62
	South Racehorse Creek, AB			1.53	1.40	1.35	0.83	0.64
-	Constant (in KAF)	3704	2724	1291	1142	70.54	408	977
Depen-dent	Libby Inflow (in KAF)							

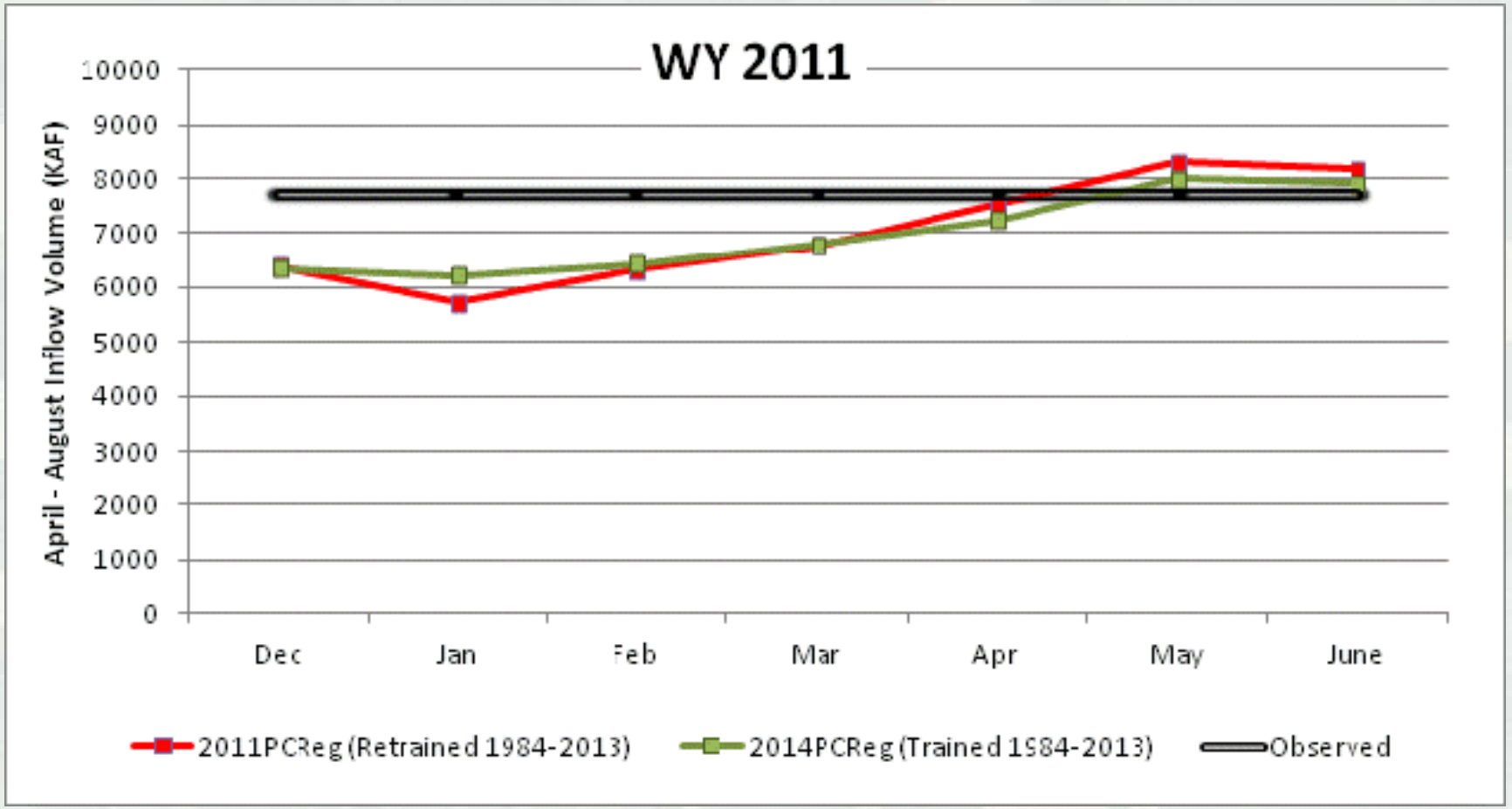
2011 vs. 2014 Forecast Comparison

Statistic	Forecast	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
CVSE	2011PCReg	1091	1239	922	899	671	633	586
	2014PCReg	1077	1087	875	836	620	611	618
Std Error	2011PCReg	1044	1168	886	859	634	596	527
	2014PCReg	1025	1040	832	792	575	572	575
R^2	2011PCReg	0.499	0.373	0.640	0.661	0.815	0.814	0.812
	2014PCReg	0.518	0.503	0.682	0.712	0.848	0.829	0.769
Maximum Error	2011PCReg	3326	3386	3050	3069	2043	1971	2130
	2014PCReg	2747	3216	2642	2676	1272	1415	2020

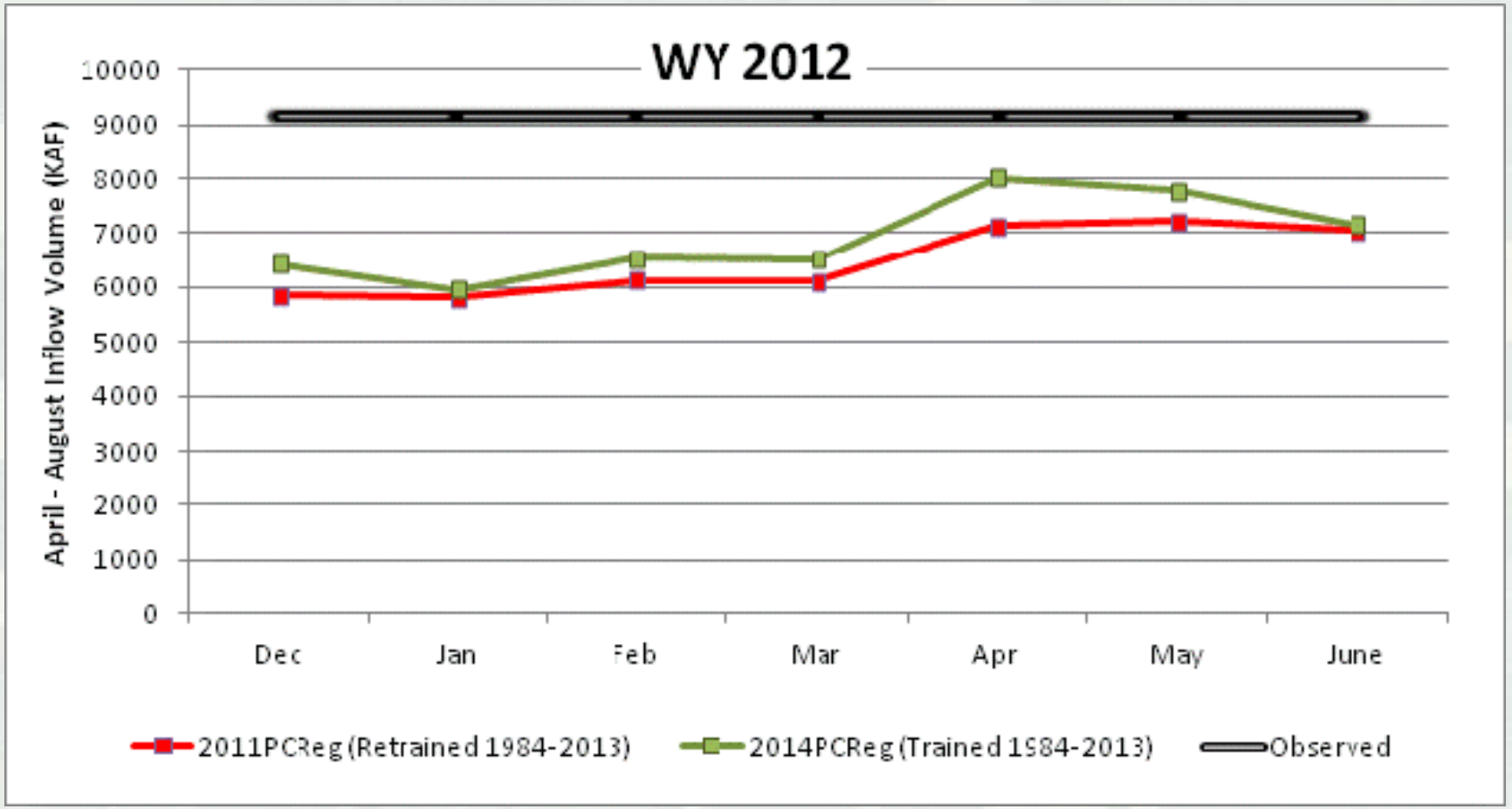
Example 2010 – Dry year



Example 2011 – Wet year, snow



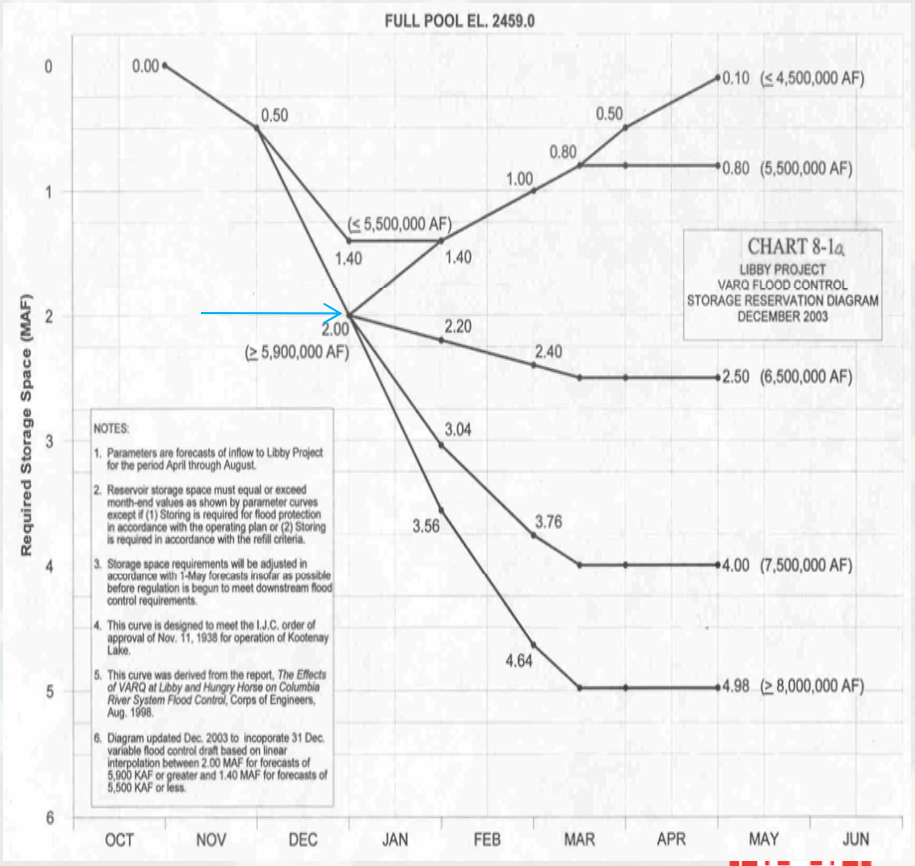
Example 2012 – Wet year, snow/rain



December Draft

Libby Dam SRD

- If the forecast is >= 5900 KAF target 2411 ft (2.0 MAF of Space)
- If the forecast is <= 5500 KAF target 2426.7 ft (relax to 1.4 MAF or 600 KAF)
- If the forecast is between 5500 KAF and 5900 KAF relax draft by interpolating between 600 and 0 kaf



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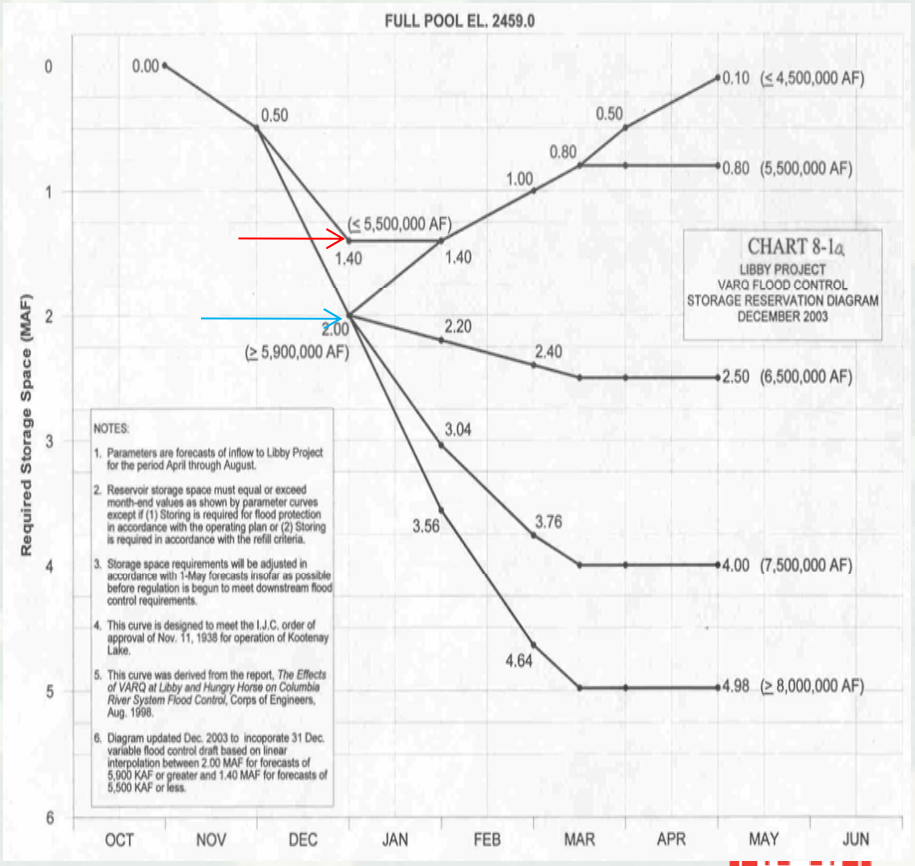

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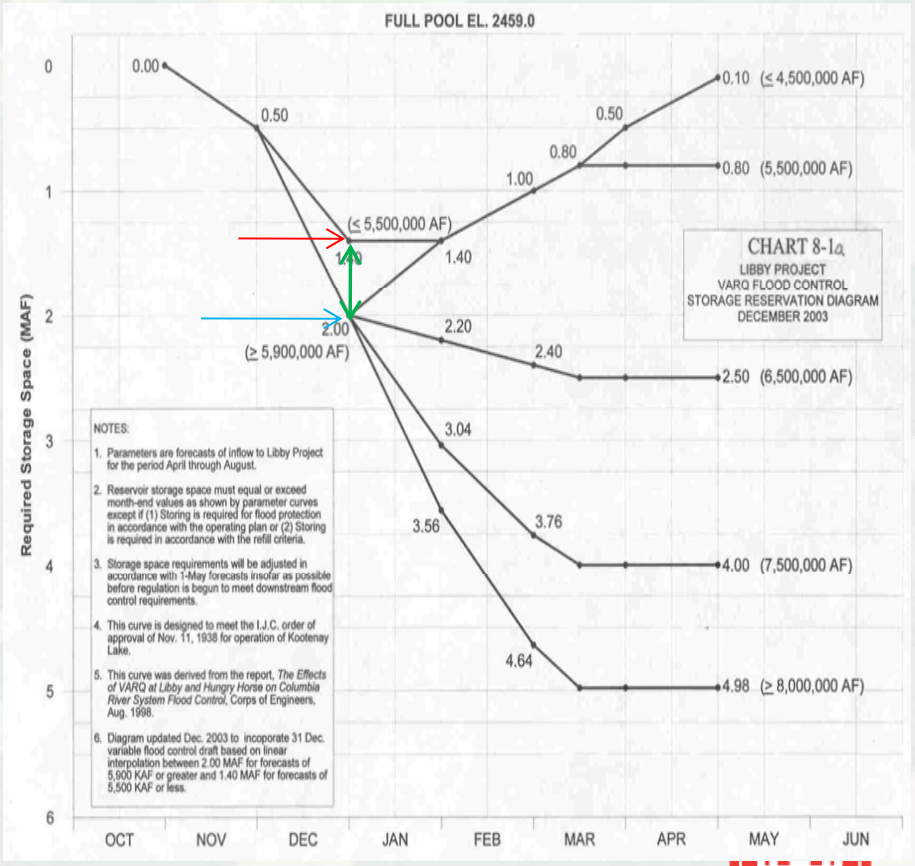

Probability of Relaxation 2004 vs 2010 Equation

	Year Forecast Retrained		
Percent Year of years there was:	2004	2010	2014
No Relaxation	80%	47%	60%
At Least Partial Relaxation	20%	53%	40%
Full Relaxation	15%	41%	28%

History of December Drafts since 2002

		Act Forcast (KAF)	FRM Target (ft)	Current Frcst (KAF)	FRM Target (ft)	Observed Vol (KAF)
	2003	6526	2411.0	4339	2426.6	5017
	2004	6954	2411.0	6071	2411.0	4740
2004 Equations	2005	6178	2411.0	5693	2419.1	5572
	2006	6248	2411.0	6479	2411.0	6601
	2007	7746	2411.0	7384	2411.0	6839
	2008	6385	2411.0	5353	2426.6	5517
	2009	5937	2411.0	5167	2426.6	4421
	2010	6558	2411.0	5695	2419.0	4510
2010/11 Equations	2011	6262	2411.0	6351	2411.0	7729
	2012	5876	2412.0	6439	2411.0	9186
	2013	6238	2411.0	6739	2411.0	7173
	2014	5502	2426.0	5446	2426.6	6672
	2015	6903	2411.0	6903	2411.0	4255
	2016	?	?			

Questions