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Managing Water in the West

Bighorn Lake Forecasting

Long-Term Issues Group Meeting

Crown Plaza Hotel
Billings, Montana

May 21, 2008

U.S. Department of the Interior
Bureau of Reclamation

Outline

- Deriving Bureau of Reclamation forecast
- Utilization of other forecasts
  - NRCS / National Weather Service
  - Corps of Engineers
- Final Bureau of Reclamation Forecast
- Interpreting the Forecast

Data Used to Develop Seasonal Forecasts

- NRCS Snow Data
- NWS Precipitation Data
- Antecedent Conditions
  - (October – December Inflows)
- Actual Historic Inflows
  - April - July

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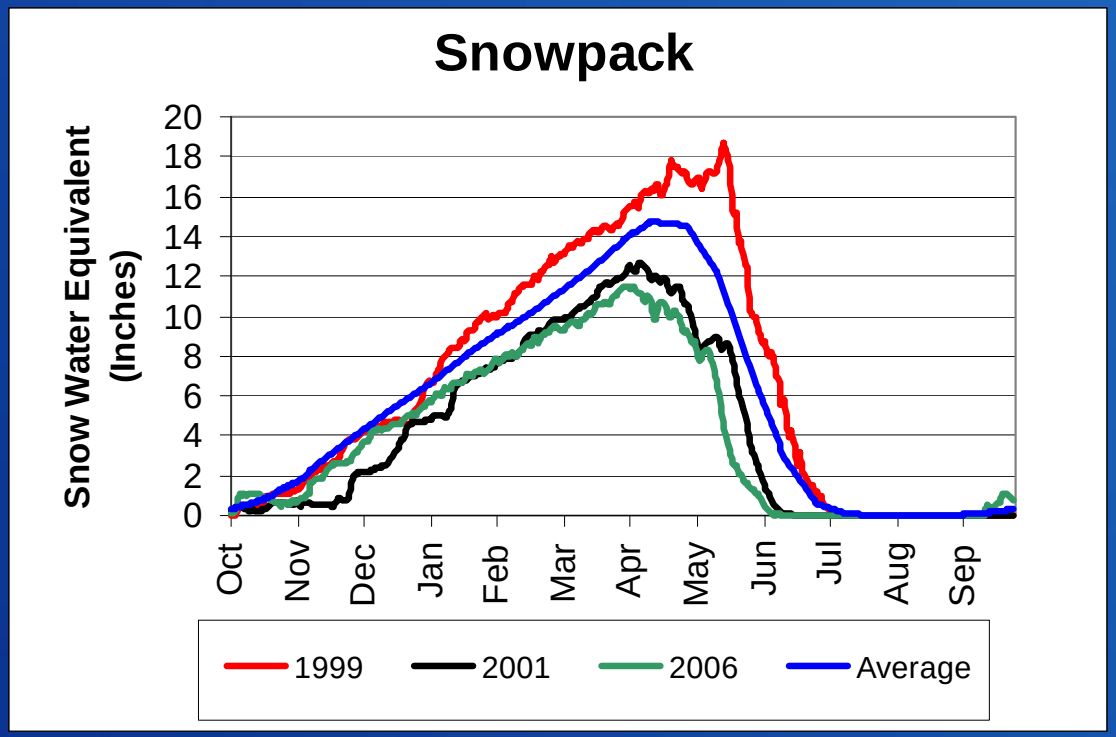
NRCS Snowtel Site



Burgess Junction
Hansen Sawmill
Shell Creek
Hobbs Park
Kirwin
Marquette
Parkers Peak

Sucker Creek
Bone Springs Divide
Burroughs Creek
Little Warm
Blackwater
Sylvan Lake

Bald Mountain
Sylvan Road
South Pass
Togwottee Pass
Evening Star
Sylvan Lake

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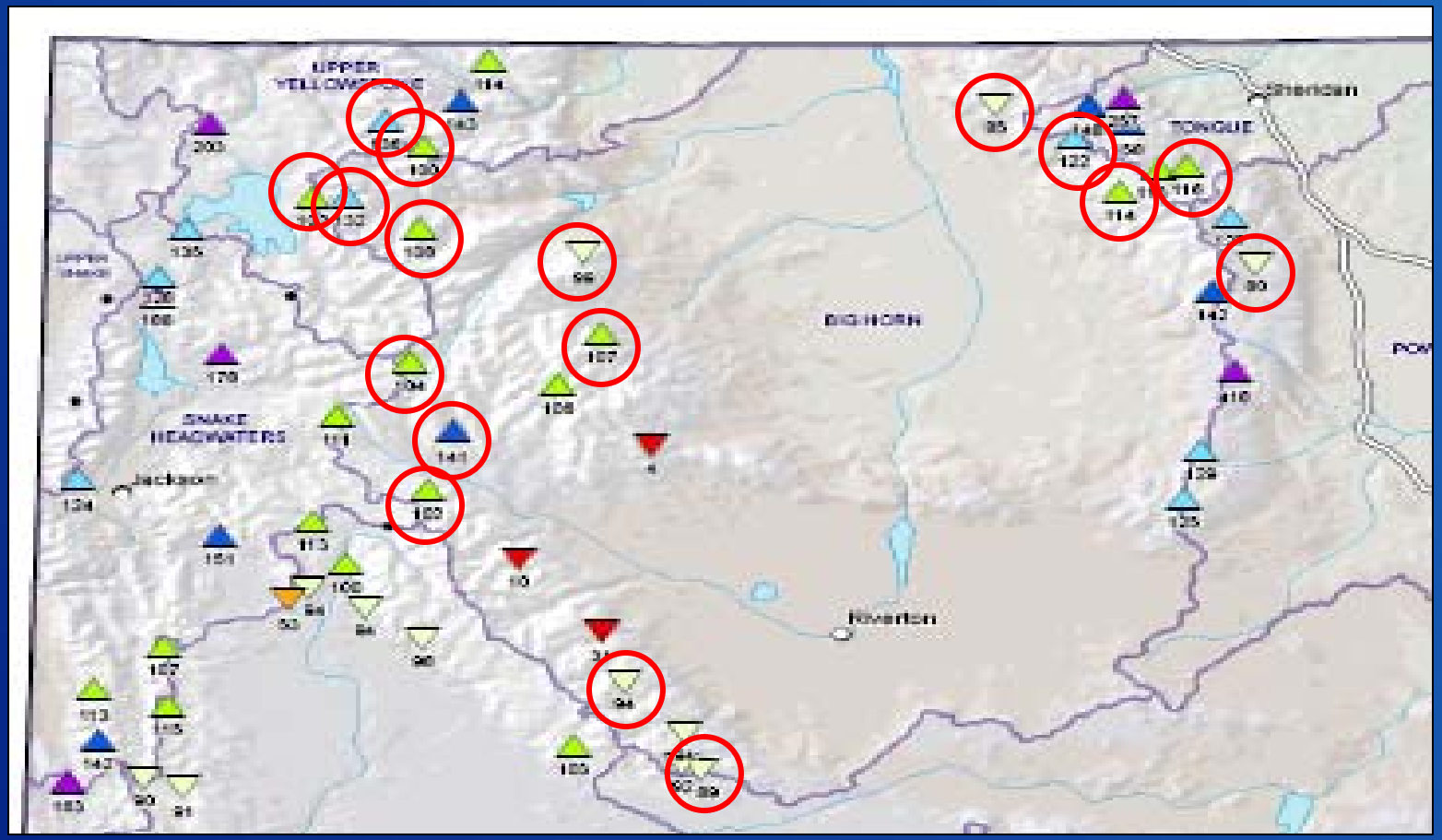
Snowtel Sites



Sites Used in Forecasts, and in Daily Monitoring of Snowpack

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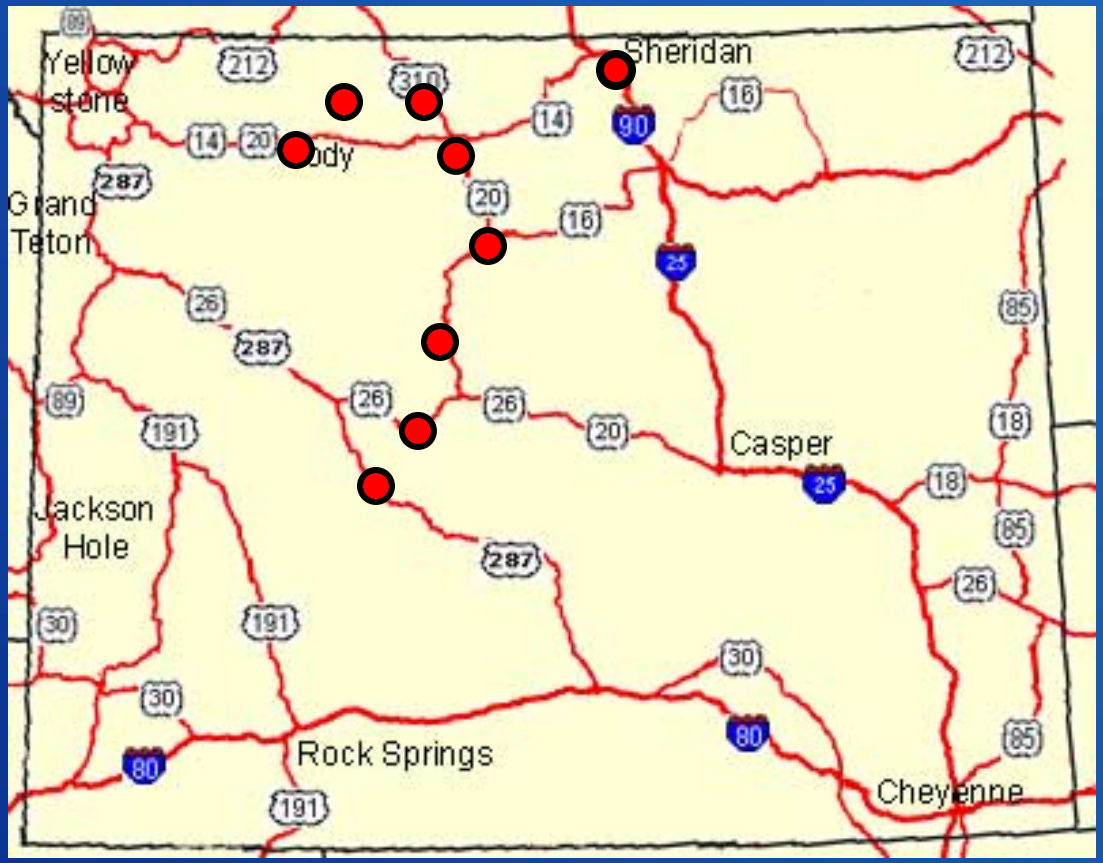
Precipitation Stations

- Powell
- Basin
- Cody
- Lovell
- Worland
- Thermopolis
- Sheridan
- Lander
- Riverton



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Antecedent Conditions

- **Natural Inflows from the previous months, and current Inflows are looked at when determining the equations we use to predict spring runoff.**

- **Typically the period from October – December provides the best correlation to predict future runoff.**

Forecast

- **Linear Regression is used to derive the forecasting equations.**

- **Independent Variables**
  - **Snow Station Data**
  - **Precipitation Station Data**
  - **Fall Inflows**

- **Dependent Variable**
  - **April-July spring flows**

Forecast Development

- **Linear Regression is used to evaluate all of the variables to come up with an equation that best matches the Actual Historic Inflows.**

- **The derived equation for the Equal Chance Forecast will come out something like the examples below.**

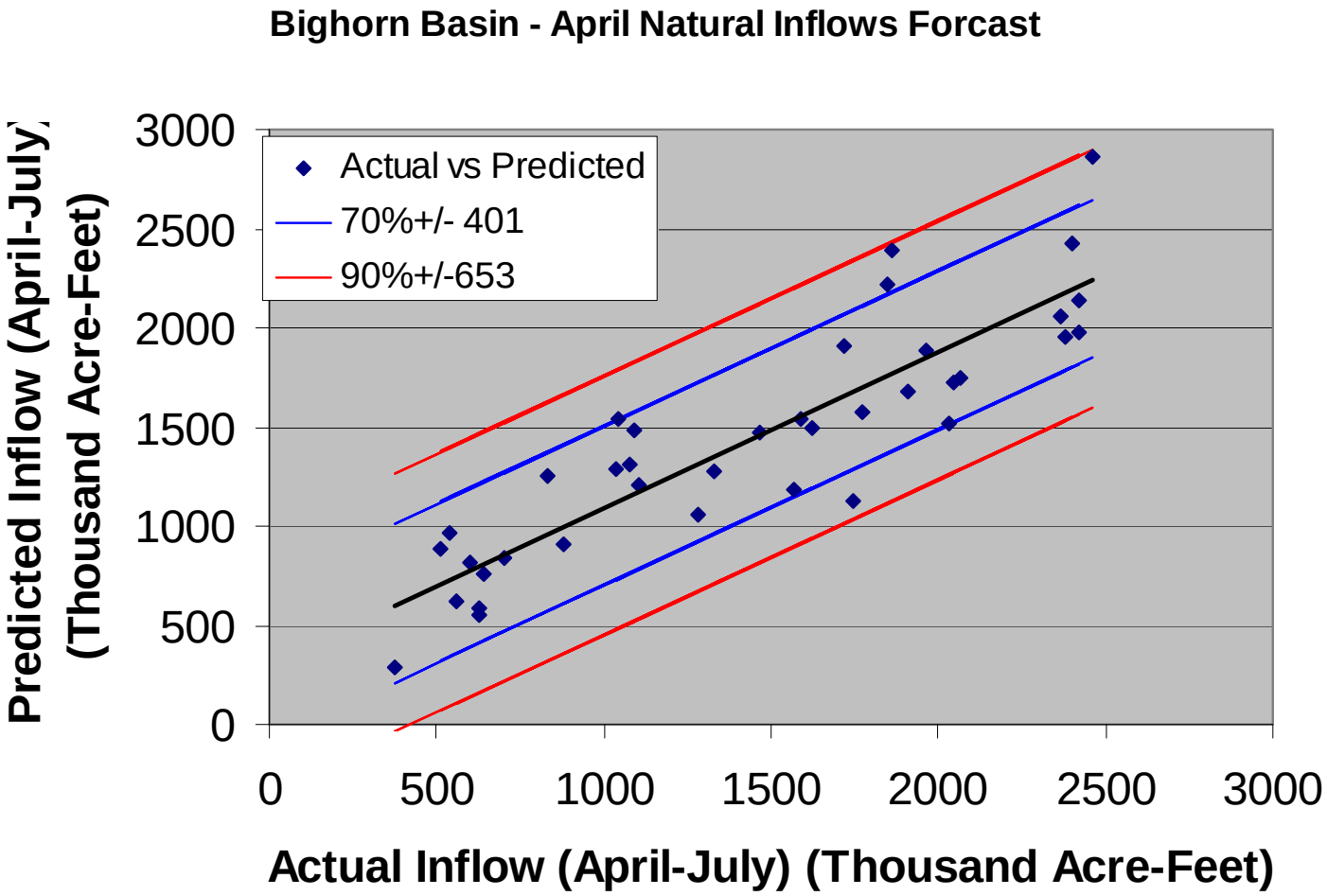
R = 0.92 (coefficient of multiple correlation)

Inflow = 27.0(Snow) +10.9(Precip.) +2.7(IN) -624.8

R = 0.89 (coefficient of multiple correlation)

Inflow = 81.99(S1) - 60.85(S2) + 7.7(S3)+38.23(S4) +72.81(S5) +36.49(P1) - 68.23(P2) +103.56(P3) +16.33(P4) +19.92(P5) +45.26(P6) +43.11(P7) -22.25(P8) -20.57(P9) +43.72(P10) -1191.04

Statistical Evaluation



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Interpreting Water Supply Forecasts

- **90 Percent Chance of Exceedance Forecast-** There is a 90 percent chance that the actual stream flow volume will exceed this forecast value, and there is a 10 percent chance that the actual stream flow volume will be less than this forecast value.

- **70 Percent Chance of Exceedance Forecast-** There is a 70 percent chance that the actual stream flow volume will exceed this forecast value, and there is a 30 percent chance the actual stream flow volume will be less than this forecast volume.

- **50 Percent Chance of Exceedance Forecast-** There is a 50 percent chance that the actual stream flow volume will exceed this forecast value, and a 50 percent chance that the actual forecast will be less than this forecast value. Generally, this forecast is the middle of the range of possible stream flow volumes that can be produced given current conditions.

- **30 Percent Chance of Exceedance Forecast-** There is a 30 percent chance that the actual stream flow volume will exceed this forecast value, and there is a 70 percent chance that the actual stream flow volume will be less than this forecast value.

- **10 Percent Chance of Exceedance Forecast-** There is a 10 percent chance that the actual stream flow volume will exceed this forecast value, and a 90 percent chance that the actual stream flow will be less than this forecast.

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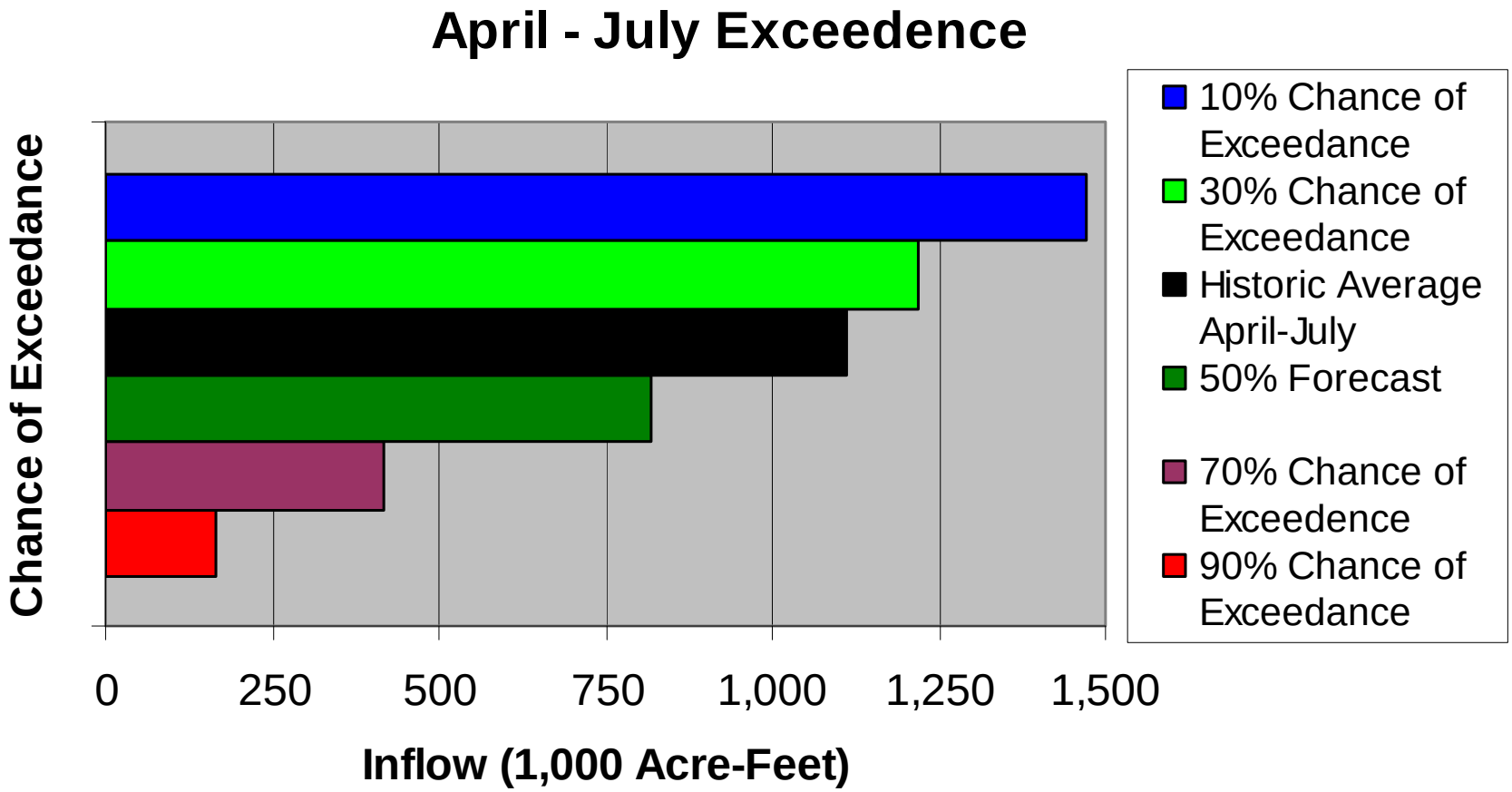
Forecast Exceedance Levels



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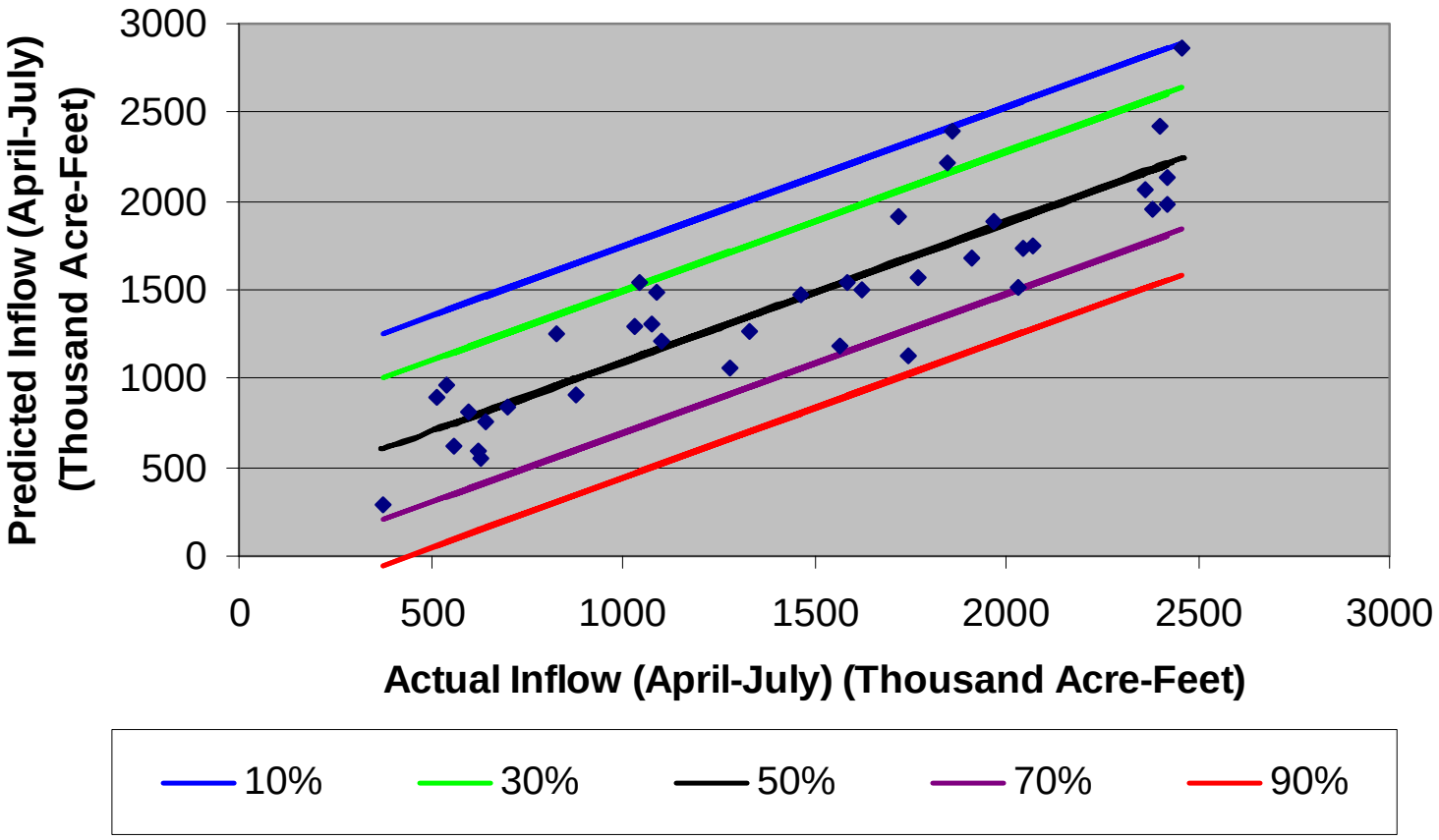
Forecast Exceedance Levels



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Distribution of Inflow Forecast

05/20/2008	Bighorn Lake Inflow Most Probable Plan					
	MONTH USED FOR FORECAST					
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Forecasted May 1 (May-Jul) Runoff Value					**786.6**	
Jan	128.9	153.6	154.0	134.5	143.7	
Feb	119.6	153.9	154.5	127.4	140.1	
March	147.2	189.0	189.7	156.7	172.2	
April	132.9	175.5	176.3	142.6	158.4	
May	199.7	258.1	259.2	212.9	234.7	
June	255.6	398.1	400.7	287.9	340.9	
July	155.6	248.2	249.9	176.6	211.1	
Aug	121.2	169.5	170.3	132.1	150.1	
Sept	152.7	198.5	199.3	163.0	180.1	
Oct	161.0	205.0	205.8	170.9	187.3	
Nov	128.6	172.1	172.9	138.4	154.6	
Dec	109.5	153.8	154.5	119.5	136.0	

Variability on Forecasts

- Spring precipitation accounting for 30-35% of the April-July runoff
- Weather conditions
  - Precipitation (rain and/or snow)
  - Temperatures
- Irrigation demands or withdrawals
- Soil moisture conditions
- High elevation snow versus low elevation snow
- Upstream reservoir and river operations

Daily Operations Worksheet

21-May-08 11:25 AM

BIGHORN LAKE (YELLOWTAIL) PROJECTED STORAGE CONTENTS

Date	Gains	Boysen Release	Buff. Bill Release	Calculated Inflow*	Outflow			Content	Elevation	Conservation Space		Flood Pool Space		
					Canal	River	Total			Feet to Fill	Acre-Feet to Fill	Feet Occupied	Acre-Feet Occupied	% Occupied
05/20/08	1,693	1,110	1,840	4,642	341	1,490	1,831	810,455	3611.1	28.9	259,574	0.0	0	0.0
05/21/08	2,500	1,140	1,800	5,449	400	1,500	1,900	817,495	3612.2	27.8	252,534	0.0	0	0.0
05/22/08	3,125	1,140	1,800	6,065	400	1,500	1,900	825,756	3613.4	26.6	244,273	0.0	0	0.0
05/23/08	3,906	1,140	1,800	6,846	400	1,500	1,900	835,567	3614.8	25.2	234,462	0.0	0	0.0
05/24/08	4,883	1,140	1,800	7,823	400	1,500	1,900	847,315	3616.4	23.6	222,714	0.0	0	0.0
05/25/08	6,104	1,140	1,800	9,044	400	1,500	1,900	861,483	3618.4	21.6	208,546	0.0	0	0.0
05/26/08	6,714	1,140	1,800	9,654	400	1,500	1,900	876,863	3620.4	19.6	193,166	0.0	0	0.0
05/27/08	7,385	1,140	1,800	10,325	400	1,500	1,900	893,574	3622.5	17.5	176,455	0.0	0	0.0
05/28/08	8,124	1,140	1,800	11,064	400	1,500	1,900	911,750	3624.7	15.3	158,279	0.0	0	0.0
05/29/08	8,936	1,140	1,800	11,876	400	1,500	1,900	931,538	3626.9	13.1	138,491	0.0	0	0.0
05/30/08	9,383	1,140	1,800	12,323	400	1,500	1,900	952,211	3629.2	10.8	117,818	0.0	0	0.0
05/31/08	9,195	1,140	1,800	12,135	400	1,500	1,900	972,513	3631.3	8.7	97,516	0.0	0	0.0
06/01/08	9,011	1,140	1,800	11,951	400	1,500	1,900	992,449	3633.2	6.8	77,580	0.0	0	0.0
06/02/08	8,831	1,140	1,800	11,771	400	1,500	1,900	1,012,029	3635.0	5.0	58,000	0.0	0	0.0
06/03/08	8,655	1,230	2,300	11,595	400	1,500	1,900	1,031,258	3636.7	3.3	38,771	0.0	0	0.0
06/04/08	8,481	1,230	2,300	12,011	400	1,500	1,900	1,051,313	3638.4	1.6	18,716	0.0	0	0.0
06/05/08	8,312	1,230	2,300	11,842	400	1,500	1,900	1,071,033	3640.0	0.0	0	0.0	1,004	0.4
06/06/08	8,146	1,230	2,300	11,676	400	1,500	1,900	1,090,422	3641.5	0.0	0	-1.5	20,393	7.9
06/07/08	7,983	1,230	2,300	11,513	400	1,500	1,900	1,109,489	3643.0	0.0	0	-3.0	39,460	15.3
06/08/08	7,823	1,230	2,300	11,353	400	1,500	1,900	1,128,238	3644.3	0.0	0	-4.3	58,209	22.5
06/09/08	7,588	1,230	2,300	11,118	400	1,500	1,900	1,146,523	3645.6	0.0	0	-5.6	76,494	29.6
06/10/08	7,361	1,230	2,300	10,891	400	1,750	2,150	1,163,860	3646.8	0.0	0	-6.8	93,831	36.3
06/11/08	7,140	1,230	2,300	10,670	400	1,750	2,150	1,180,759	3647.9	0.0	0	-7.9	110,730	42.9
06/12/08	6,926	1,230	2,300	10,456	400	1,750	2,150	1,197,233	3649.0	0.0	0	-9.0	127,204	49.2
06/13/08	6,579	1,230	2,300	10,109	400	1,750	2,150	1,213,020	3650.0	0.0	0	-10.0	142,991	55.4
06/14/08	6,250	1,230	2,300	9,780	400	1,750	2,150	1,228,154	3650.9	0.0	0	-10.9	158,125	61.2
06/15/08	5,938	1,230	2,300	9,468	400	1,750	2,150	1,242,669	3651.8	0.0	0	-11.8	172,640	66.8
06/16/08	5,641	1,230	2,300	9,171	400	1,750	2,150	1,256,595	3652.7	0.0	0	-12.7	186,566	72.2
06/17/08	5,359	1,230	2,300	8,889	400	1,750	2,150	1,269,962	3653.5	0.0	0	-13.5	199,933	77.4
06/18/08	5,091	1,230	2,300	8,621	400	1,750	2,150	1,282,797	3654.3	0.0	0	-14.3	212,768	82.4
06/19/08	4,836	1,230	2,300	8,366	400	1,750	2,150	1,295,127	3655.0	0.0	0	-15.0	225,098	87.1
06/20/08	4,595	1,230	2,300	8,125	400	1,750	2,150	1,306,977	3655.7	0.0	0	-15.7	236,948	91.7
May 1-20	(6,346)	36,602	57,451	87,707	11,843	64,212	73,028							
May 21-31	139,348	24,873	39,273	203,512	8,727	32,727	41,455							
Total May	133,003	61,474	96,724	291,219	20,570	96,939	114,483							
Total Ave. cfs	2163	1000	1626	4894	346	1629	1924							
WrkSht TOTALS	418,117	73,309	128,529	618,803	24,595	97,686	122,281							

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Post Runoff Season Forecast

- **Analyze actual April-July runoff**
- **Compare to Previous Records**
  - **Actual Inflows**
  - **Precipitation**
  - **Snow Water Content**
- **Forecast future inflows using from previous years of similar characteristics.**