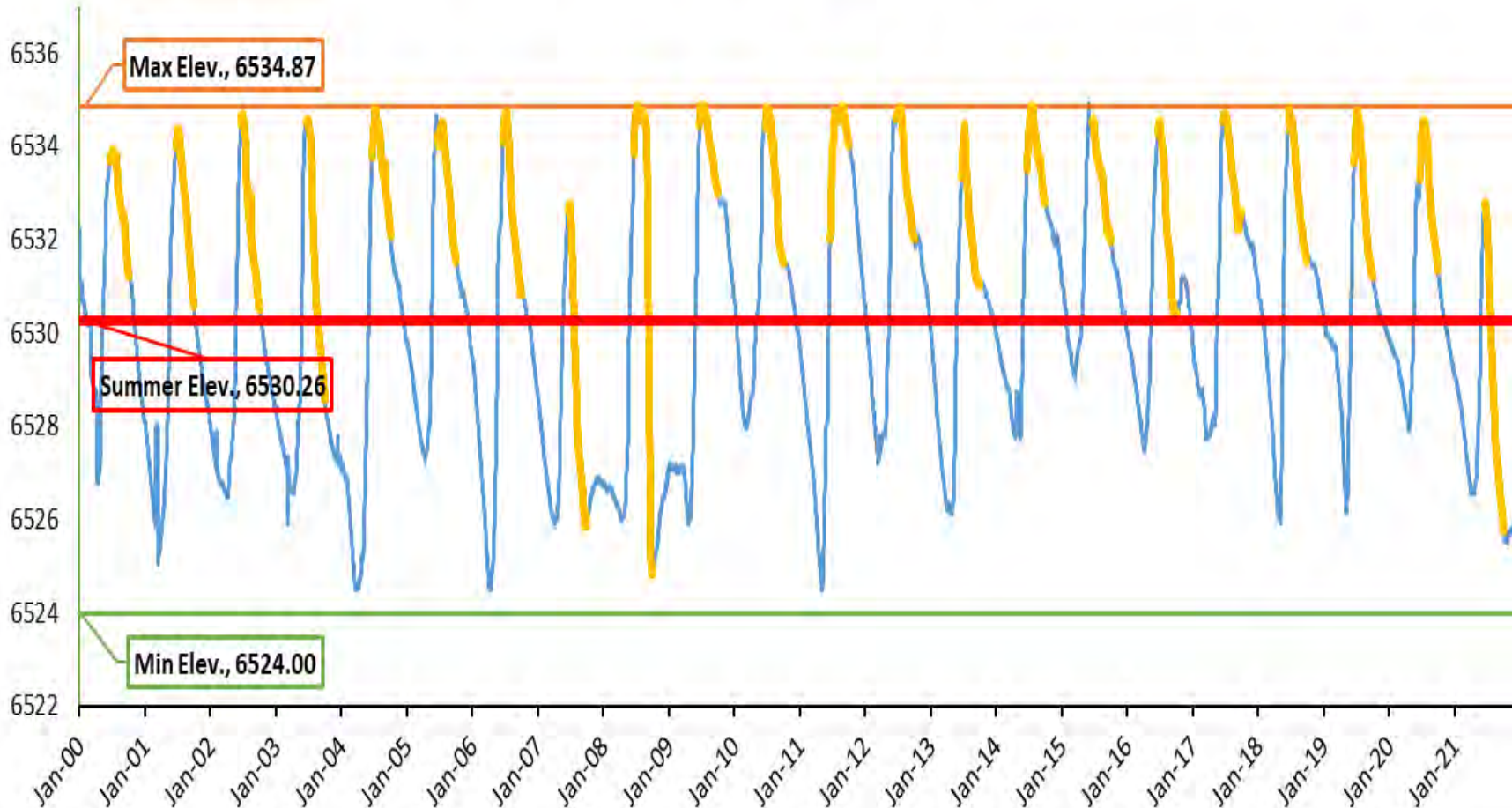


NorthWestern[®] Energy

Delivering a Bright Future

Madison-Hebgen: Stakeholder Engagement
November 30, 2022

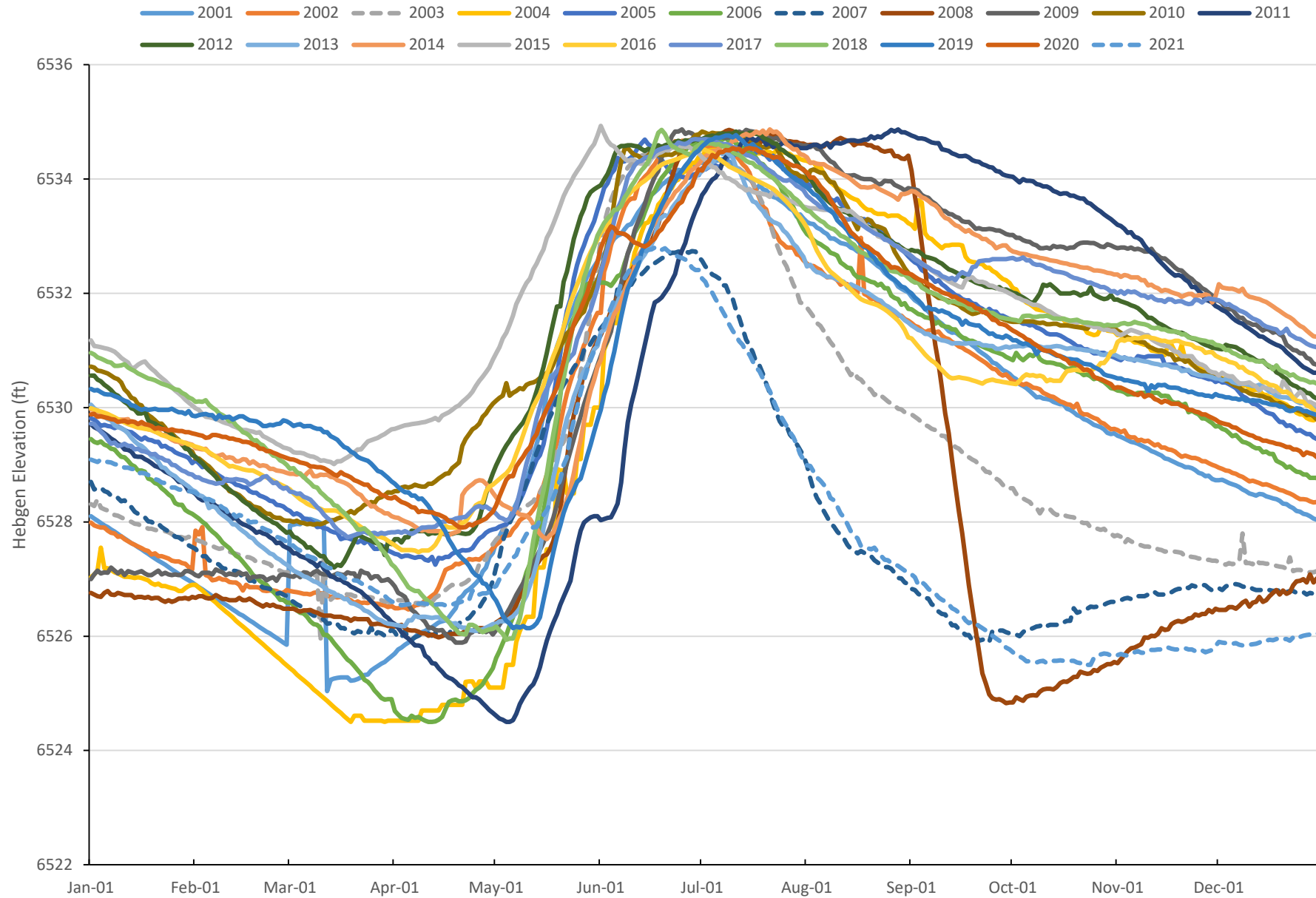
Hebgen Lake Elvation 2000-2021



- Dropped below summer recreation elevation in:
 - 2003
 - 2007
 - 2008*
 - 2021
- *2008 draft was due to failure of intake stop log resulting in uncontrolled releases

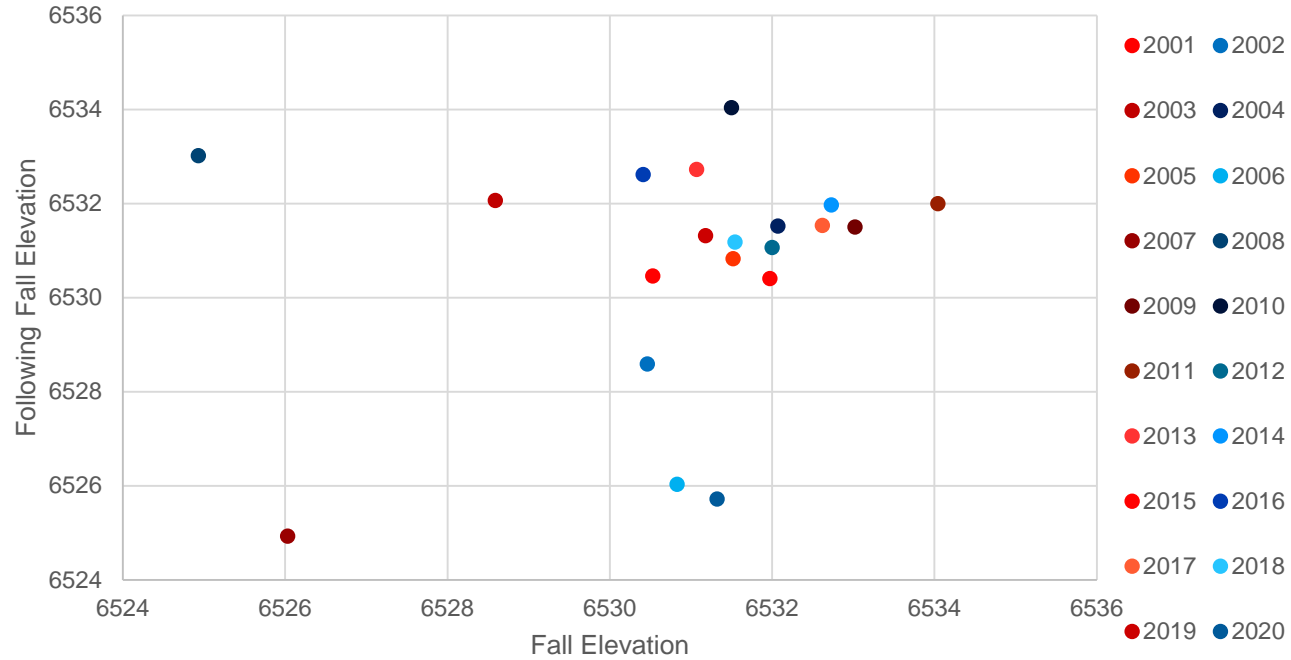


Hebgen Reservoir Elevations

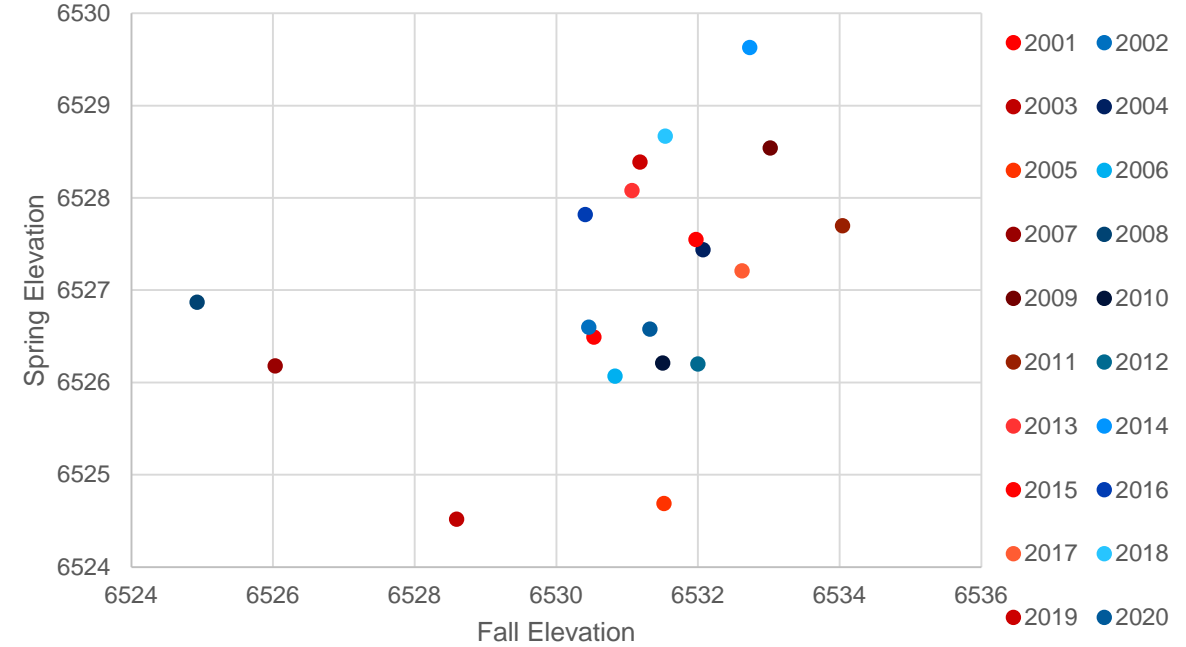




Oct 1 Elevation (Year) vs. Following Oct 1 Elevation

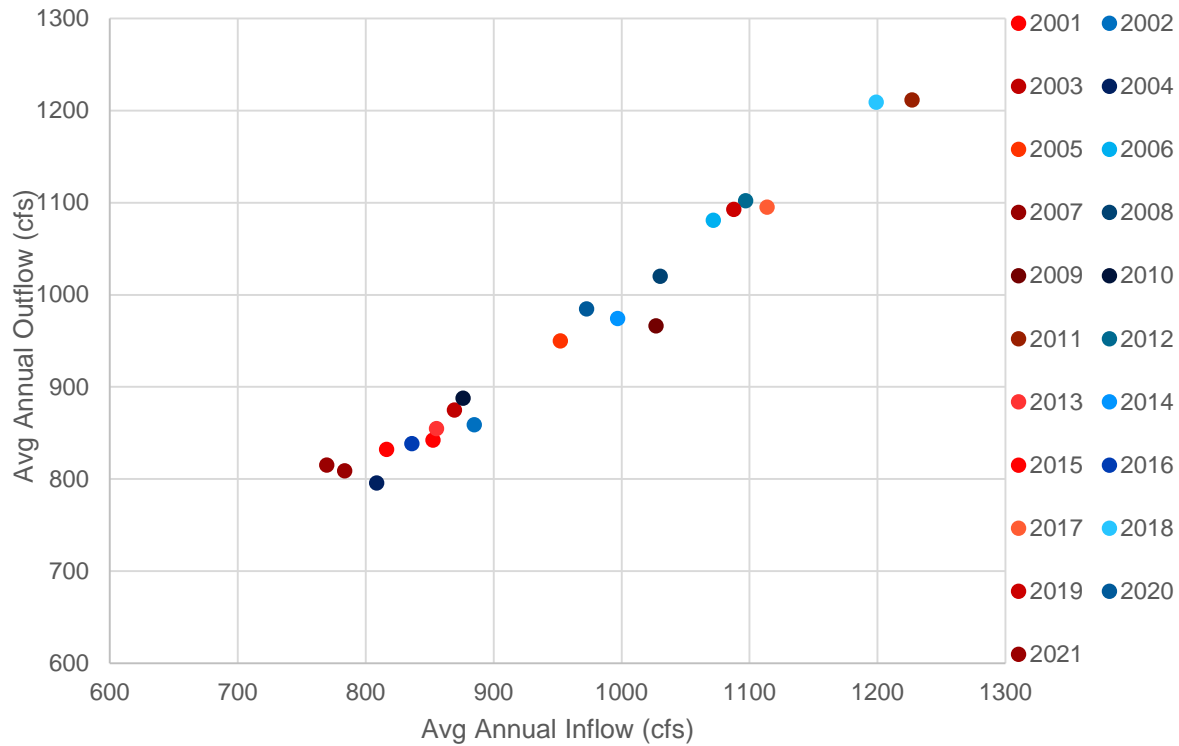


Oct 1 Elevation (Year) vs. Following Apr 1 Elevation

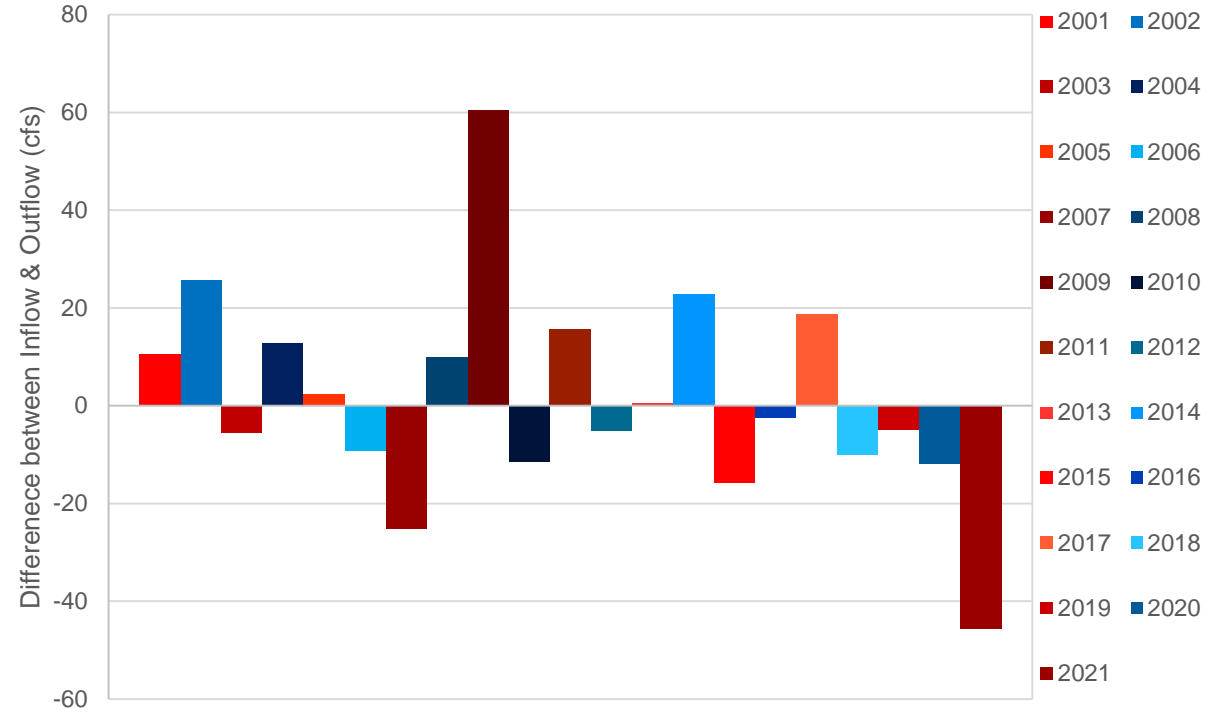




Inflow vs. Outflow

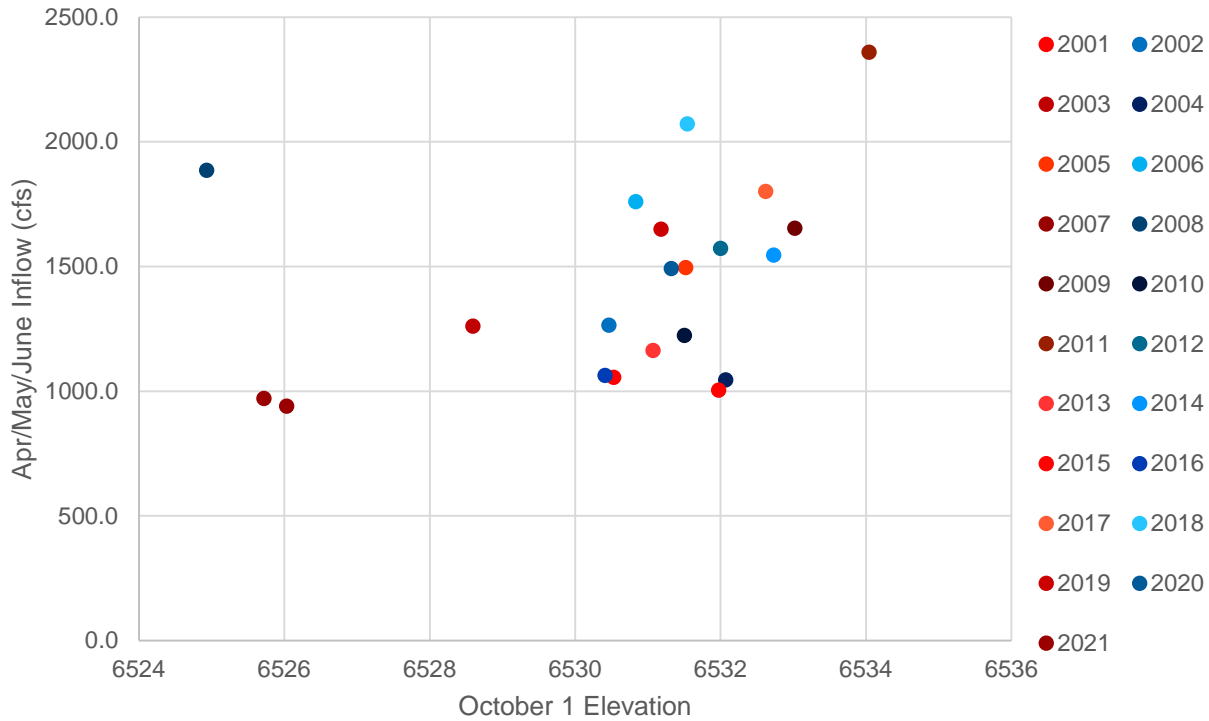


Mean Inflow Minus Mean Outflow

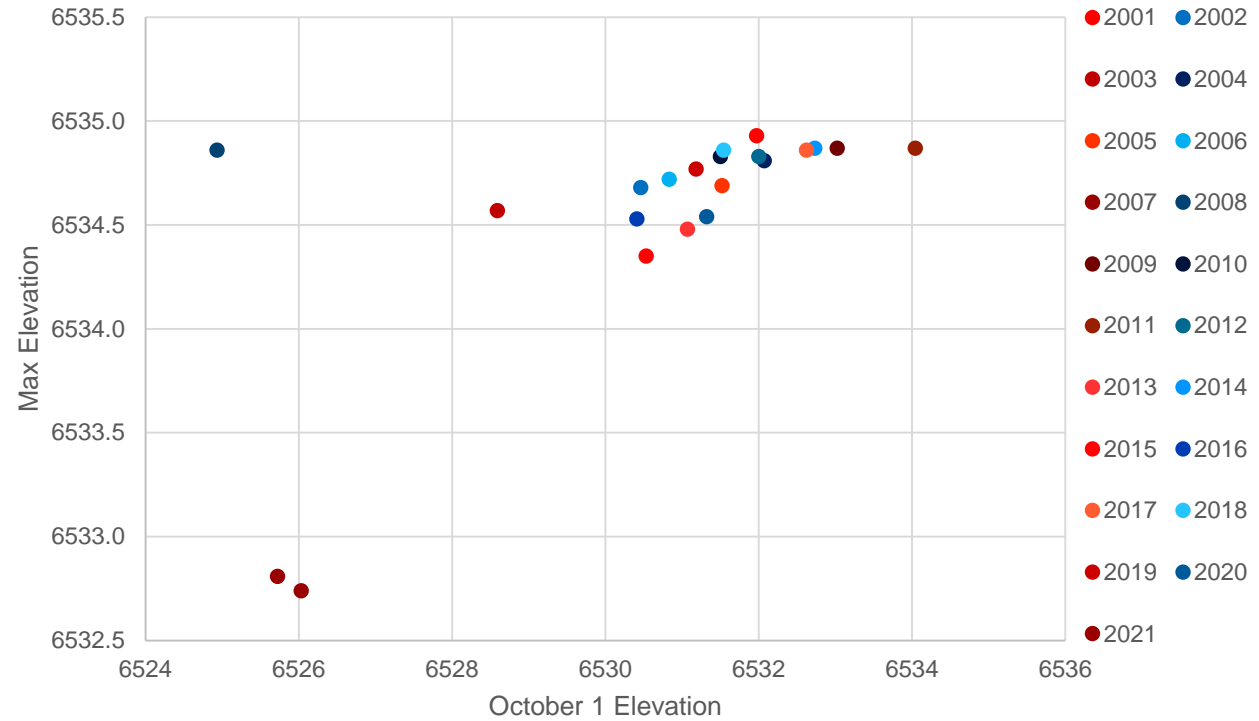




Apr/May/June Inflow vs. Oct 1 Elevation

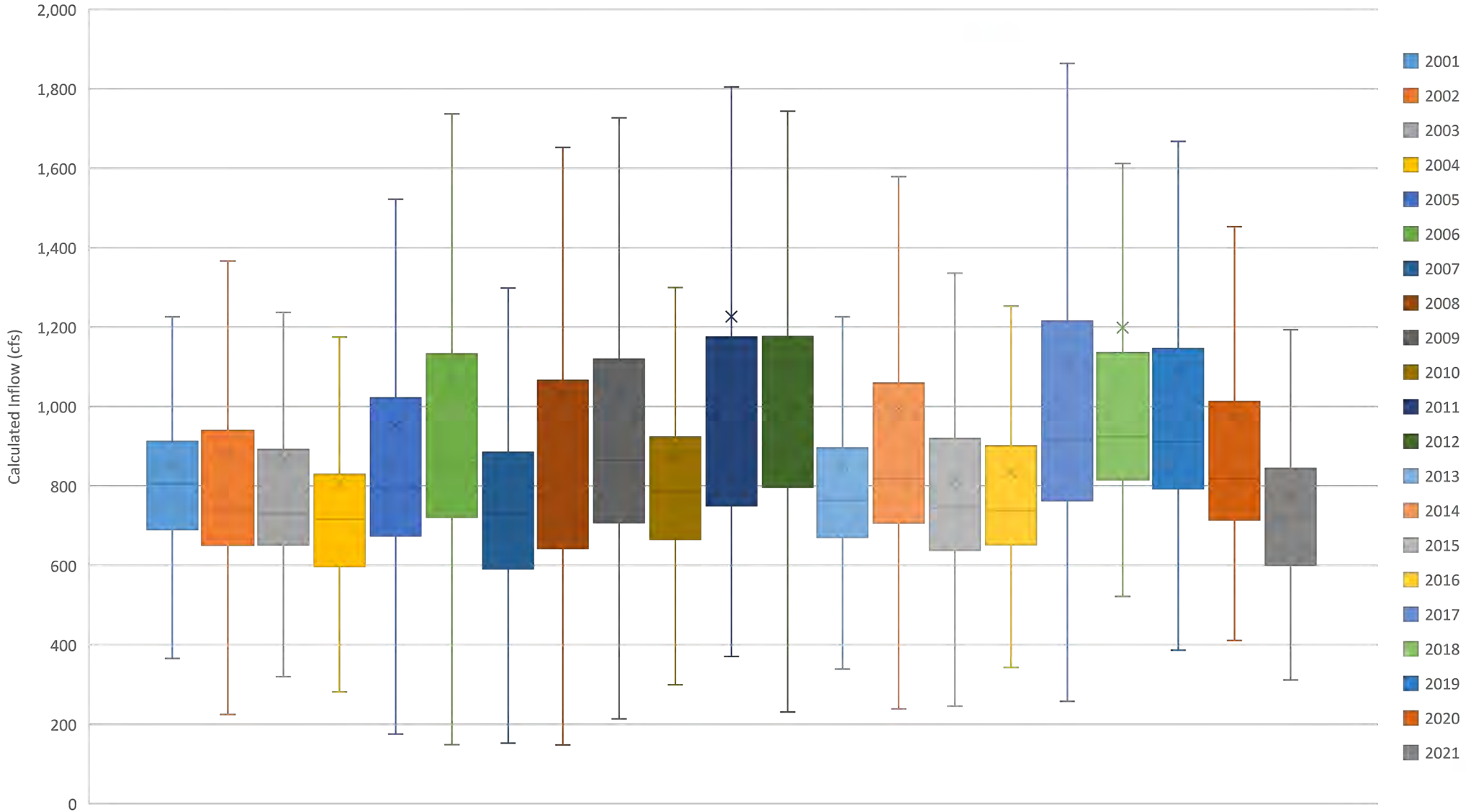


Max Elevation vs. Oct 1 Elevation





Calculated Inflows to Hebgen

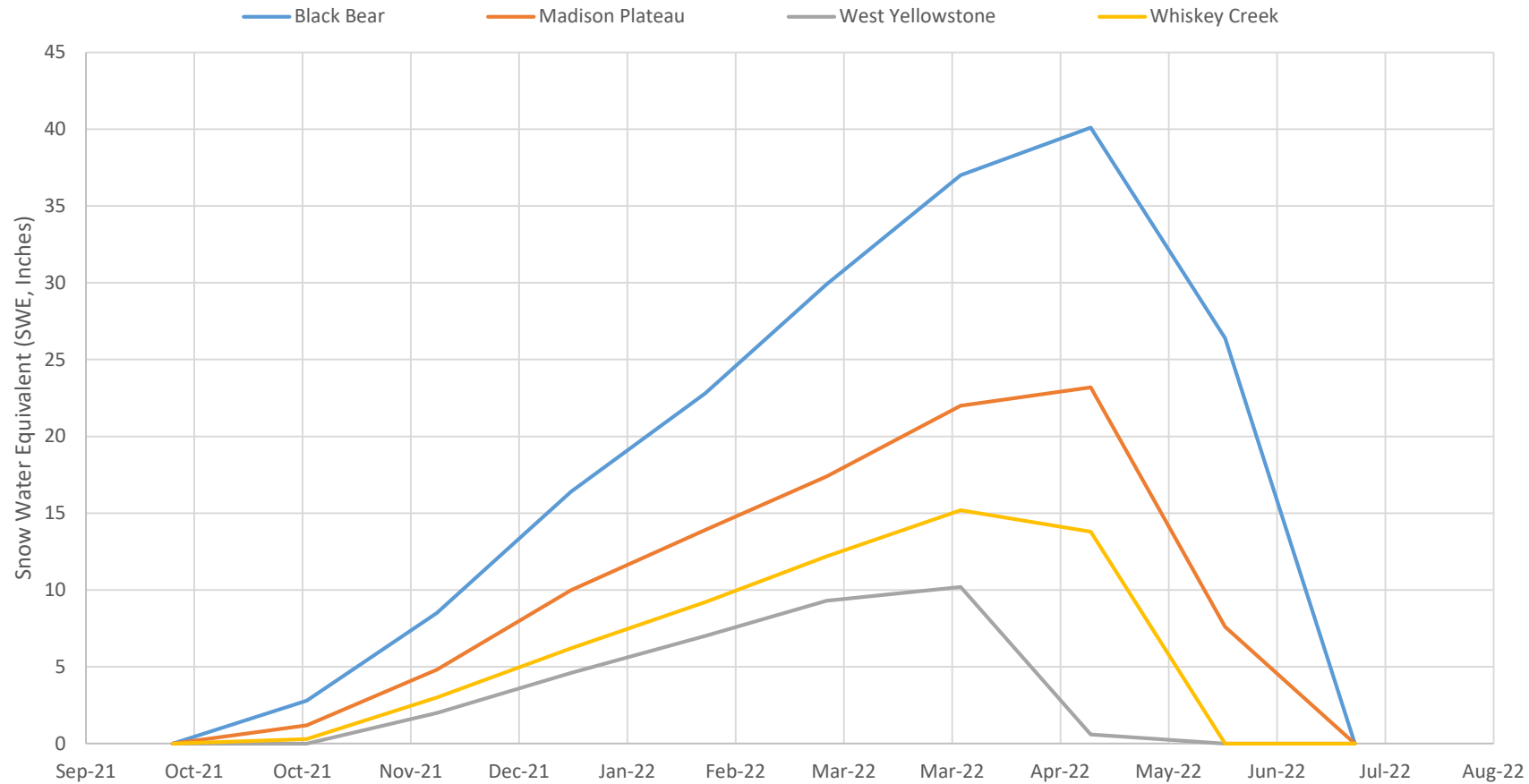


	Parameter	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
I N F L O W	Min	171	76	212	121	175	149	153	148	214	109	371	185	146	239	246	246	258	522	387	411	312
	5%	495	482	493	394	509	517	383	465	505	397	568	649	541	505	471	530	588	687	644	578	457
	25%	691	652	652	597	675	722	592	643	708	666	751	798	671	707	639	653	764	816	794	715	601
	Annual Mean	853	885	869	809	952	1072	784	1030	1027	876	1227	1097	855	997	816	836	1114	1199	1088	973	769
	Annual Median	806	739	730	717	796	860	731	809	866	787	910	909	766	819	747	738	915	925	912	820	719
	75%	912	940	892	830	1022	1133	885	1066	1119	923	1175	1177	896	1059	920	901	1215	1136	1146	1013	844
	95%	1457	1873	1689	1674	2080	2458	1479	2745	2227	1808	3349	2193	1614	2309	1390	1630	2622	3173	2362	2042	1349
	Max	2840	5287	3923	3884	3570	4298	2579	3773	3036	3590	5456	3697	2882	4497	2359	1995	3591	4285	3085	3092	2822
	Jul/Aug/Sept Avg	664	677	655	740	780	825	614	867	852	696	1174	855	691	838	697	619	906	949	904	779	615
	July Avg	714	754	691	826	877	912	632	1119	973	722	1627	964	730	863	712	650	1012	1068	991	884	609
	Aug Avg	638	618	631	690	757	767	588	759	835	691	968	802	654	842	692	589	806	917	836	741	659
	Sept Avg	641	656	644	701	705	794	622	716	744	673	918	798	689	809	687	620	901	859	883	711	572
Apr/May/June Avg	1056	1265	1261	1046	1496	1760	940	1886	1654	1223	2360	1573	1164	1546	1005	1063	1802	2073	1650	1492	971	

O U T F L O W	Min	498	577	591	394	757	776	342	582	708	563	838	890	350	680	494	508	804	919	767	560	248
	5%	533	767	755	467	834	929	433	665	763	606	880	909	430	706	552	656	821	922	895	808	444
	25%	669	783	769	747	854	970	640	698	773	755	963	1003	749	817	749	722	931	997	911	889	665
	Annual Mean	842	859	875	796	950	1081	809	1020	966	888	1211	1102	855	974	832	838	1095	1209	1092	984	815
	Annual Median	892	850	831	866	885	1019	787	699	923	872	1096	1070	836	891	835	860	1019	1106	1003	936	815
	75%	948	860	889	898	973	1077	953	961	1087	976	1186	1136	984	1012	885	902	1190	1302	1208	1029	883
	95%	1042	1055	1184	978	1429	1543	1336	3015	1399	1138	2282	1479	1135	1730	1039	1043	1681	2061	1658	1290	1211
	Max	1140	2072	1784	1166	2123	2399	1772	3330	1636	2606	3044	2122	1662	1990	2078	1519	1882	2562	1894	2648	1357
	Jul/Aug/Sept Avg	918	954	1052	892	951	1083	1028	1491	972	916	1139	1043	893	943	868	900	1053	1160	1129	972	1024
	July Avg	924	1168	1258	845	873	1225	1304	1128	1002	879	1422	1092	1030	829	907	940	1197	1298	1117	892	1232
	Aug Avg	902	837	999	925	1028	1051	992	854	991	1019	915	1079	866	981	862	979	1039	1170	1220	1110	1014
	Sept Avg	929	856	893	905	950	970	780	2526	922	848	1079	955	778	1022	834	776	918	1007	1048	913	820
	Apr/May/June Avg	680	945	996	610	1083	1277	790	1347	1102	943	1730	1234	760	1154	823	773	1435	1604	1187	1110	831
Apr/May/June Avg Inflow-Outflow	376	320	265	436	413	483	150	540	551	281	629	339	404	391	182	290	367	469	463	383	140	



Median SNOTEL SWE 1991-2020





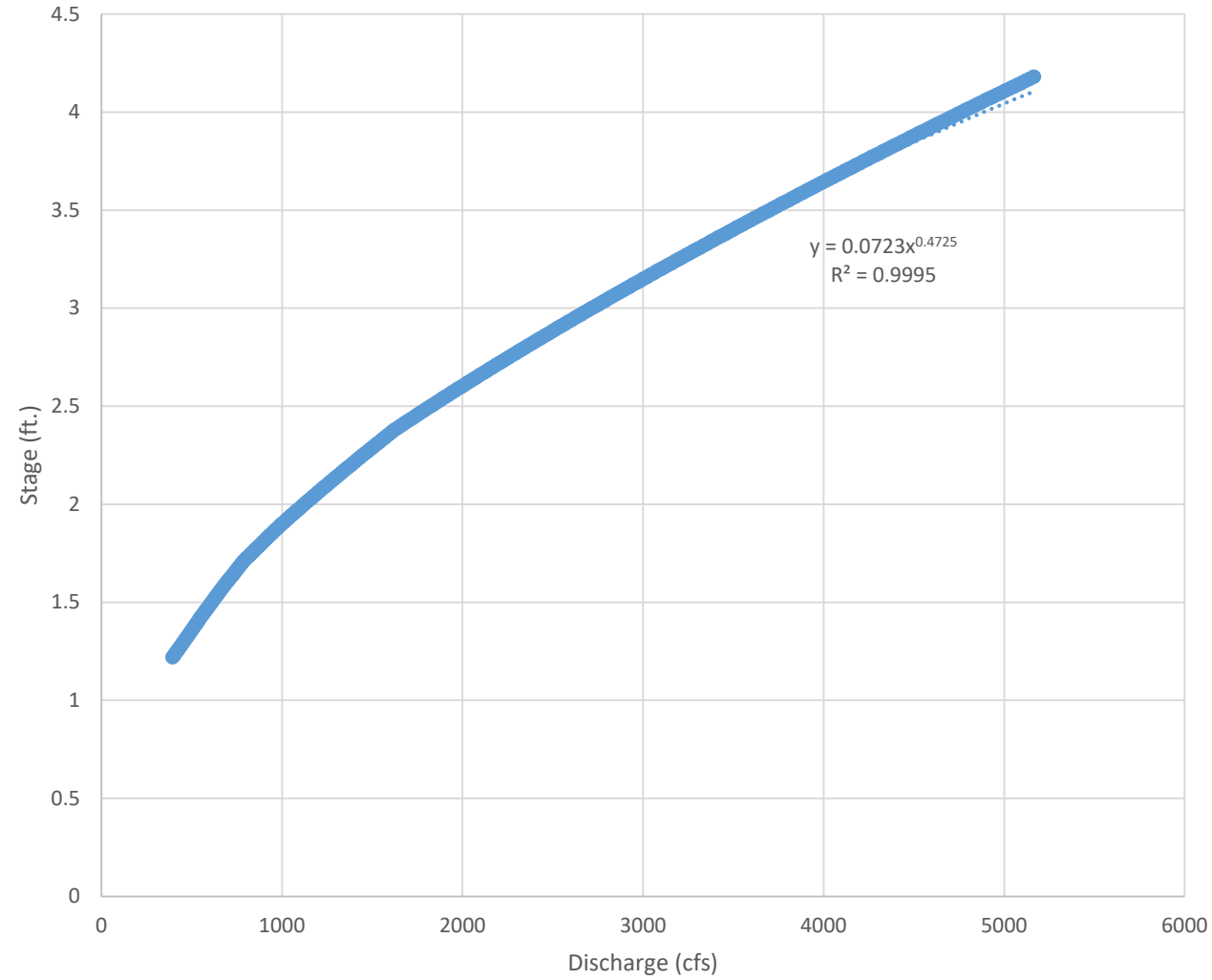
PERIOD OF USE	MAX FLOW (CFS)
OCTOBER 1 through OCTOBER 1	537.60
OCTOBER 2 through OCTOBER 4	512.55
OCTOBER 5 through OCTOBER 15	439.18
OCTOBER 16 through OCTOBER 19	431.62
OCTOBER 20 through OCTOBER 24	422.05
OCTOBER 25 through OCTOBER 31	367.00
NOVEMBER 1 through NOVEMBER 1	352.00
NOVEMBER 2 through NOVEMBER 4	351.97
NOVEMBER 5 through DECEMBER 31	0.03
JANUARY 1 through MARCH 14	0.03
MARCH 15 through MARCH 30	2.26

** 48 unquantified stock watering rights operate at some point during this period, many allowing diversions

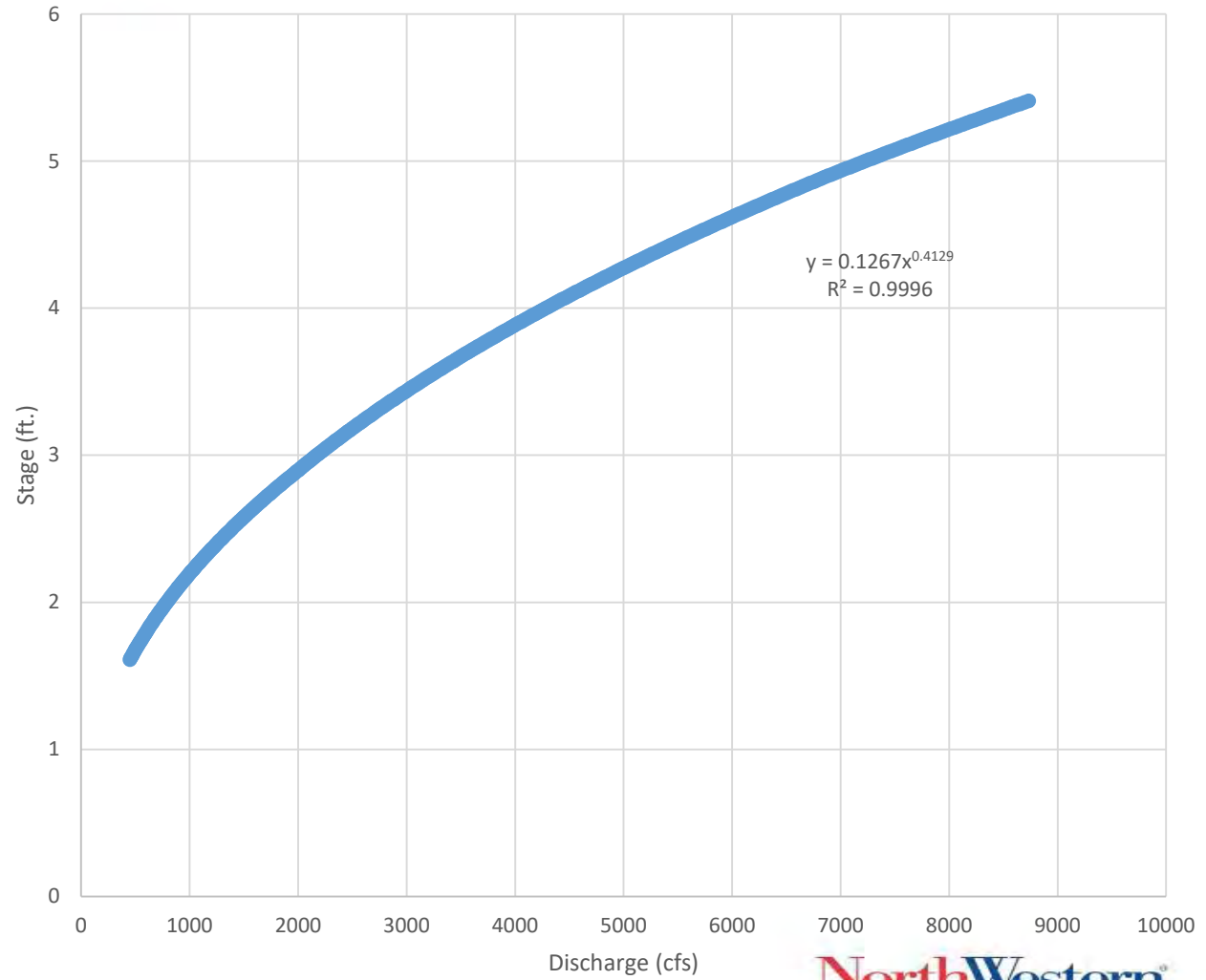
	<u>Instream Flows</u>	Above WF	Below WF
MONTANA, STATE OF DEPT OF FISH WILDLIFE & PARKS	OCTOBER 1 through DECEMBER 31	502.5	1050
	JANUARY 1 through MARCH 30	502.5	1050



Kirby USGS Gage Rating



Varney USGS Gage Rating





USGS Gage Ratings

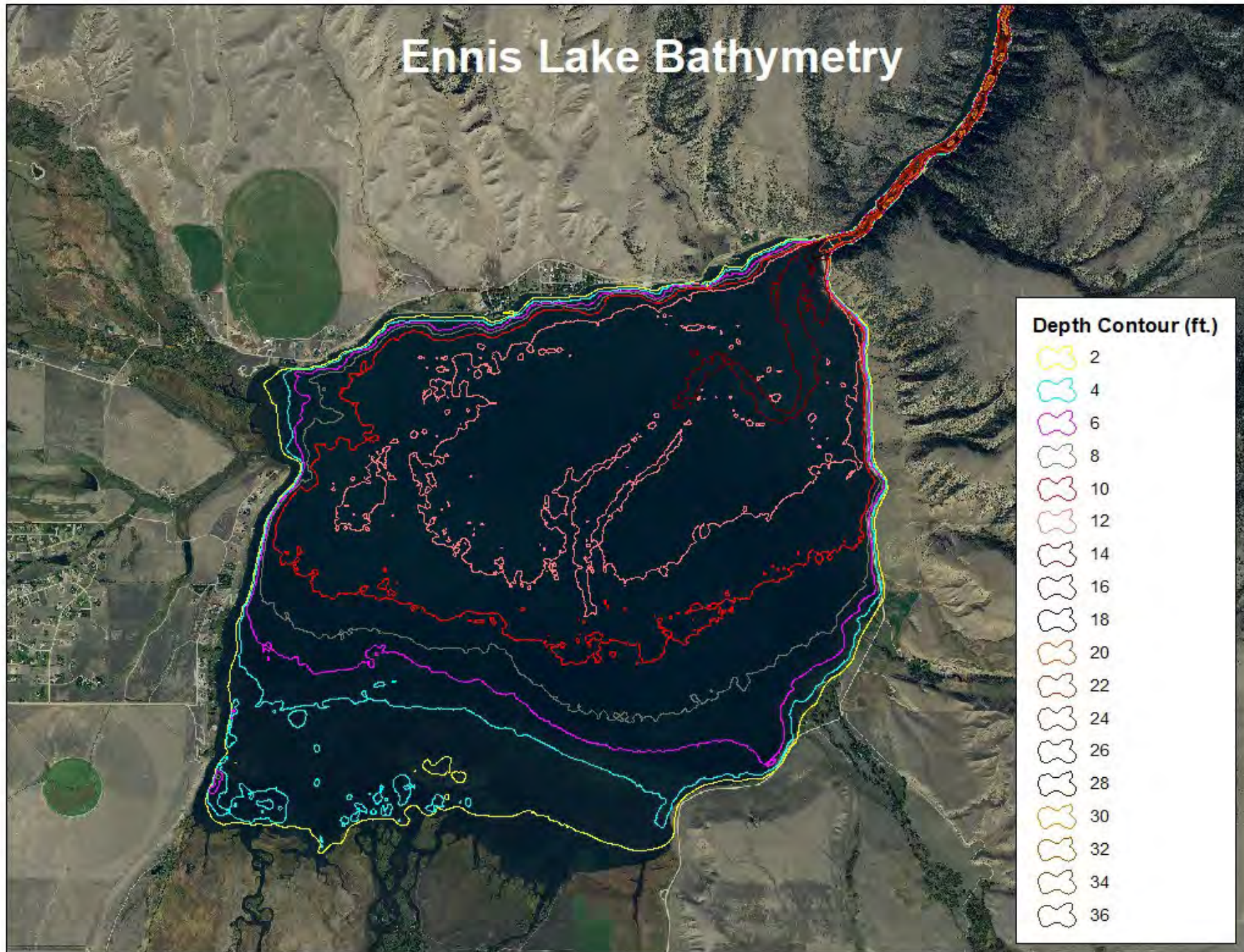
calculated

USGS Gage	Discharge (cfs)	Stage (ft.)	50 CFS Change (ft.)	Cummulative Change (ft.)
H e b g e n	600	1.30	0	0
	500	1.18	0.12	0.12
	400	1.04	0.13	0.25
	350	0.97	0.07	0.33
	300	0.89	0.08	0.40
	250	0.81	0.08	0.49
K i r y b	650	1.54	0	0.00
	600	1.49	0.06	0.06
	550	1.43	0.06	0.12
	500	1.36	0.06	0.18
V a e r y n	750	1.95	0.00	0.00
	700	1.89	0.05	0.05
	650	1.84	0.06	0.11
	600	1.78	0.06	0.17
M c A t l e r i s	1150	1.90	0.00	0.00
	1100	1.84	0.06	0.06
	1050	1.78	0.06	0.13
	1000	1.71	0.06	0.19
	950	1.65	0.06	0.25
	900	1.58	0.07	0.32

from rating
table

USGS Gage	Discharge (cfs)	Stage (ft.)	50 CFS Change (ft.)	Cummulative Change (ft.)
H e b g e n	601.92	1.37	0	0
	503.41	1.23	0.14	0.14
	399.02	1.06	0.17	0.31
	350.12	0.97	0.09	0.40
	300.67	0.87	0.10	0.50
	251.91	0.76	0.11	0.61
K i r y b	650.99	1.55	0	0.00
	602.98	1.49	0.06	0.06
	547.44	1.42	0.07	0.13
	501.95	1.36	0.06	0.19
V a e r y n	749.34	1.96	0.00	0.00
	701.13	1.91	0.05	0.05
	654.7	1.86	0.05	0.10
	601.33	1.8	0.06	0.16
M c A t l e r i s	1147.77	1.88	0.00	0.00
	1101.25	1.81	0.07	0.07
	1048.66	1.73	0.08	0.15
	1003.18	1.66	0.07	0.22
	951.81	1.58	0.08	0.30
	901.12	1.5	0.08	0.38

Ennis Lake Bathymetry



- Elevation savings at Hebgen Lake if deviations were imposed .
- Fall trigger 182 days (Oct1 through Mar31)
- Assumes 675 inflow 710 outflow

Madison Deviation		Hebgen Lake Elevation (ft)										
		6534	6533	6532	6531	6530	6529	6528	6527	6526	6525	6524
Madison Outflow (cfs)	1050	1.40	1.43	1.48	1.53	1.58	1.62	1.65	1.66	1.68	1.69	1.71
	1000	0	2.83	2.90	2.99	3.09	3.18	3.25	3.29	3.33	3.35	3.39
	950	0	0	0	4.39	4.52	4.65	4.74	4.86	4.94	4.99	5.05

Kirby Deviation		Hebgen Lake Elevation (ft)										
		6534	6533	6532	6531	6530	6529	6528	6527	6526	6525	6524
Kirby Outflow	575	0.70	0.72	0.75	0.77	0.80	0.82	0.83	0.83	0.84	0.85	0.86
	550	1.40	1.43	1.48	1.53	1.58	1.62	1.65	1.66	1.68	1.69	1.71



- Elevation savings at Hebgen Lake if Kirby deviation were imposed
- Spring trigger 91 days (Apr1 through Jun30)
- Assumes 1040 inflow 608 outflow

Madison Deviation		Hebgen Lake Elevation (ft)						
		6530	6529	6528	6527	6526	6525	6524
Madison Outflow (cfs)	1050	0	0	0	0.70	0.71	0.72	0.75
	1000	0	0	0	0	1.40	1.43	1.47
	950	0	0	0	0	2.10	2.13	2.19

Kirby Deviation		Hebgen Lake Elevation (ft)						
		6530	6529	6528	6527	6526	6525	6524
Kirby Outflow (cfs)	575	0	0	0.35	0.35	0.36	0.36	0.37
	550	0	0	0	0.70	0.71	0.72	0.75

Hebgen Water Savings with 5% Hourly Upward Ramp Rate

		End outflow									
cfs		700	800	900	1000	1100	1200	1300	1400	1500	1600
Start Outflow	300	0.50	0.72	0.84	0.91	1.06	1.40	1.59	1.81	1.81	2.04
	400	0.32	0.54	0.67	0.81	0.96	1.12	1.20	1.40	1.40	1.85
	500	0.25	0.36	0.53	0.68	0.83	1.01	1.19	1.19	1.40	1.50
	600	0.07	0.30	0.42	0.57	0.64	0.81	1.00	1.00	1.21	1.42
	700	0.00	0.09	0.21	0.35	0.50	0.56	0.75	0.94	0.95	1.17
	800	0.00	0.00	0.10	0.24	0.39	0.56	0.76	0.76	0.86	1.08
	900	0.00	0.00	0.00	0.11	0.27	0.45	0.45	0.63	0.85	0.96
	1000	0.00	0.00	0.00	0.00	0.12	0.12	0.30	0.50	0.71	0.71
	1100	0.00	0.00	0.00	0.00	0.00	0.11	0.08	0.33	0.54	0.55



- Did not run the winter water savings because Hebgen elevation was not warranting a fall trigger
- Ran using Kirby's deviation

Spring 2020-2021					
Normal Operations			Spring Deviation		
Apr1-Jun30			Apr1-Jun30		
Normal Operations	Start Elev.	6526.75	550 Kirby Deviation	Start Elev.	6526.75
	Inflow	1084		Inflow	1084
	Outflow	685		Outflow	685
	End Elev.	6532.97		End Elev.	6533.67
			Spring Ramp Up		
			Hebgen Hourly 5% Ramp Rate	Start Elev.	6533.67
				Start Outflow	380
				End Outflow	1000
				End Elev.	6534.67



- The table below shows the difference between normal operations and the 950 deviation at Madison
- Based off of the winter timeframe (182 days)

Winter 2021-2022					
Oct-Mar31			Oct-Mar31		
Normal Operations	Start Elev.	6525.72	950 Madison	Start Elev.	6525.72
	Inflow	675		Inflow	675
	Outflow	709		Outflow	709
	End Elev.	6524.57		End Elev.	6529.53



Water Savings at Heb. With No Upward Ramp Rate in Madison Bypass	
Hebgen Elev. (ft)	Water Savings (ft)
6525	0.32
6526	0.31
6527	0.30
6528	0.29
6529	0.28
6530	0.27
6531	0.26
6532	0.25
6533	0.24
6534	0.24
6534.84	0.23