Memorandum

To: Matt Moore —South Washington Watershed District Administrator
From: Mark Doneux, Bob Fossum, Wendy Griffin, and Karen Kill —Washington SWCD
Date: February 22, 2002
Re: SWWD 2001 Monitoring: MS1, MS2, Powers, 100th Street Station, Fox Run, Tamarack Rd, Armstrong Lake, Lake Gages, & Observation Wells

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At the request of the South Washington Watershed District (SWWD), the Washington Soil and Water Conservation District (SWCD) conducted stream monitoring at two existing stream monitoring stations (MS1 and MS2), monitored at a new stream monitoring station (Powers), monitored at a developing stream monitoring station (100th Street—Cottage Grove), monitored two stormwater sites (Fox Run and Tamarack Road), monitored Armstrong Lake, installed and read eight lake staff gages, and monitored seven groundwater observation wells. The following report summarizes our methods and results for monitoring conducted from January 1 - December 31, 2001. This report and the accompanying data will also be provided in an electronic format.

Stream Sites: MS1, MS2, Powers & 100th Street

Continuous stage and velocity measurements were taken every 15 minutes at MS1 from March 28 – November 6, 2001, at MS2 from March 8–November 6, 2001, and at Powers from March 20-November 8, 2001. Precipitation data was also continuously collected at each of these sites during the same time period. The 100th Street site was a grab sampling site with no automated recorders (Figure 1).

Staff gages were installed and read at each site. Field stage measurements were taken in the outflow culverts. Temperature, dissolved oxygen, and transparency tube measurements were also taken. Flow weighted storm event samples, storm event grab samples were collected, as well as baseflow composite and grab samples. The samples were analyzed at the Metropolitan Council Lab.

Level to flow rating curves were developed at all stream sites except MS2. When the area-velocity probe was covered with debris, erroneous velocity and discharge readings were given. There were also some periods when discharge data was not collected due to technical difficulties. In most of these circumstances, reliable level data was still collected (either with an Isco area-velocity meter or Global Water EZ Level Logger) and was applied to the individual rating curve equation to calculate discharge.

There was no field developed level to flow rating curve at MS2 due to the culvert design, which made field flow measurements difficult with a Marsh-McBirney Flo-Mate. Therefore, to supplement missing or erroneous discharge data, rating curves were developed using reliable level and discharge data to present a more complete record of discharge.

The 100th Street site will benefit greatly from an area-velocity probe in 2002 due to the large affect of tail waters. Although field level to flow rating curve measurements were taken, there was little correlation found between level and flow especially during the flooding in spring 2001.

Figure 1. SWWD Monitoring Locations

MS1 (I94)

The hydrograph for the MS1 site shows flows between March 28 – November 6, 2001 (Figure 2). Total discharge during this period was 16,751,692 cf or 385 acre-ft. There was no measurable baseflow found at MS1. The peak discharge—77.3 cfs, was on April 22nd from daily precipitation of 3.74 inches. This was also the highest daily rainfall recorded at MS1. To supplement the rainfall data, daily rainfall data from the State Climatology Office high-density network was used. The closest rainfall monitoring location, T28N R21W S6, was within one mile of MS1.

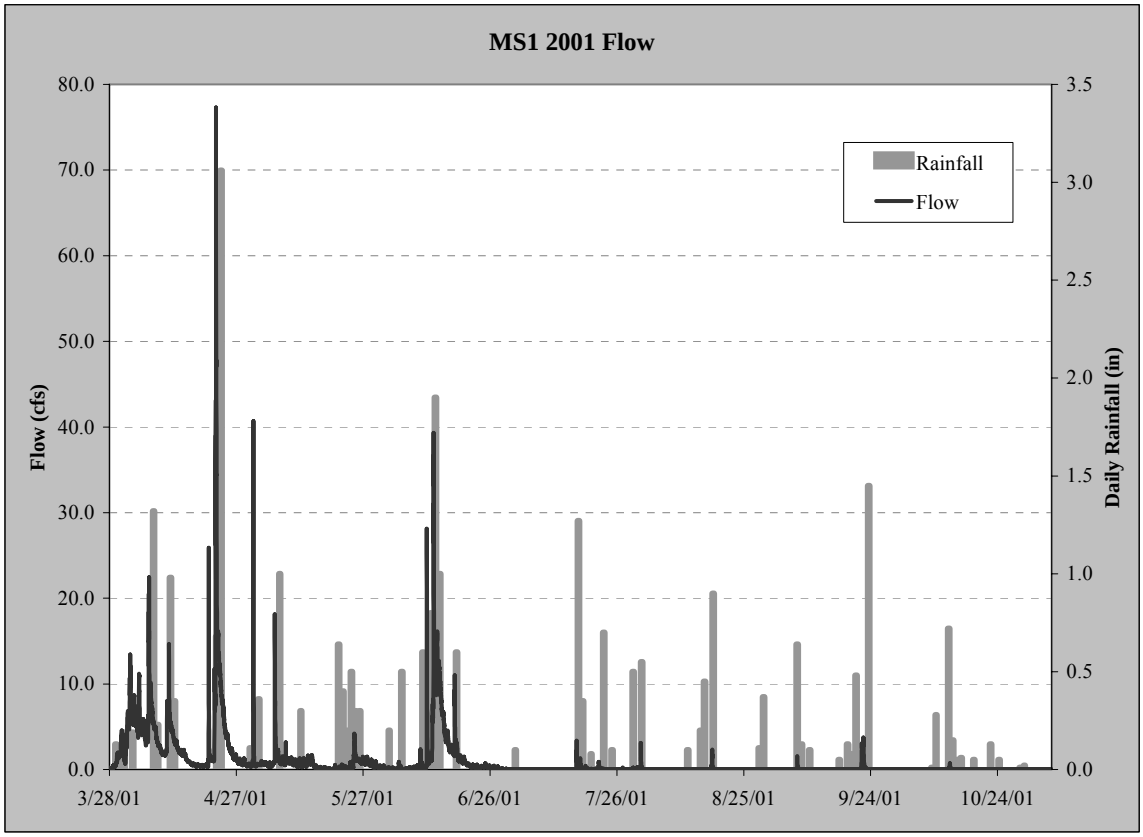


Figure 2. MS1 2001 Continuous Flow and Daily Rainfall

Grab samples and flow weighted automatic water quality samples were taken at the MS1 site. The total suspended solids (TSS), total Kjeldahl nitrogen (TKN), and total phosphorus (TP) results from all collected samples are listed in Table 1. The highest TSS, TKN, and TP concentrations were all from storm composite samples taken on June 11, 2001. The average baseflow concentrations were TSS—6.6 mg/L, TKN—1.04 mg/L, and TP—0.16 mg/L.

Table 1. MS1 2001 Sample Chemistry Results

Sample Type	Start Date & Time	End Date & Time	Total Suspended Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)
Snowmelt Grab	3/21/01 14:00	NA	~13	0.85	0.46
Snowmelt Grab	3/29/01 14:00	NA	83	2.00	0.60
Snowmelt Grab	4/3/01 14:50	NA	36	1.70	0.22
Snowmelt Grab	4/4/01 12:30	NA	23	1.10	0.29
Snowmelt Grab	4/4/01 12:30	NA	42	1.80	0.26
Storm Grab	4/12/01 9:10	NA	21	1.00	0.15
Storm Grab	4/23/01 14:39	NA	48	1.10	0.14
Base Composite	4/27/01 13:34	4/30/01 10:06	~3	0.43	~0.02
Storm Composite	5/3/01 13:22	5/4/01 13:04	<2	0.44	~0.04
Storm Composite	5/6/01 19:30	5/6/01 19:30	606	2.30	1.10
Storm Grab	5/22/01 13:30	NA	88	0.85	0.19
Storm Composite	5/22/01 13:54	5/22/01 19:18	27	1.40	0.22
Storm Grab	6/6/01 12:00	NA	16	0.59	0.07
Storm Composite	6/11/01 18:18	6/11/01 20:16	1440	5.20	2.40
Storm Composite	6/13/01 15:40	6/14/01 6:52	86	1.50	0.28
Storm Composite	6/18/01 15:00	6/19/01 22:30	8	0.75	0.11
Quality Control	6/29/01 12:40	NA	~4	NA	~0.02
Base Grab	6/29/01 12:40	NA	~2	0.30	0.10
Base Grab	7/18/01 11:15	NA	15	2.40	0.35
Storm Grab	8/1/01 15:15	NA	50	1.10	0.21
Storm Composite	8/18/01 5:26	8/18/01 6:46		1.50	0.59

Sampling data yielded detects for metals and other species of nitrogen during a few storm event samples and in one base grab sample. Of the parameters sampled (copper, nickel, lead, zinc, cadmium, chromium, and ammonia), copper, lead, zinc, cadmium and ammonia exceeded the MPCA Rule 7050 Water Quality Chronic Standard. Samples which exceeded the MPCA Chronic Standard are in bold in Table 2. Copper, lead and zinc exceeded the MPCA Rule 7050 Water Quality Maximum Standard. Samples that exceeded the MPCA Maximum Standard are in bold and underlined. The highest metal concentrations were from the June 11, 2001, storm composite sample.

Table 2. MS1 Chemical Parameters Which Exceeded MPCA Water Quality Standards

Sample Type	Start Date/Time	End Date/Time	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Ammonia Nitrogen (mg/L)
Snowmelt Grab	3/21/01 14:00	NA	**0.0096**	**0.0027**	0.0178	<0.0001	**0.10**
Snowmelt Grab	3/29/01 14:00	NA	**0.0142**	**0.0055**	0.0450	0.0002	**0.53**
Snowmelt Grab	4/3/01 14:50	NA	0.0044	0.0010	0.0088	<0.0001	**0.69**
Snowmelt Grab	4/4/01 12:30	NA	NA	NA	NA	NA	**0.70**
Snowmelt Grab	4/4/01 12:30	NA	NA	NA	NA	NA	**0.63**
Storm Grab	4/12/01 9:10	NA	0.0023	<0.0005	0.0059	<0.0001	**0.19**
Storm Grab	4/23/01 14:39	NA	0.0029	0.0009	0.0073	0.0006	*NA*
Base Composite	4/27/01 13:34	4/30/01 10:06	0.0024	<0.0005	0.0044	0.0002	<0.02
Storm Composite	5/3/01 13:22	5/4/01 13:04	**0.0070**	<0.0005	0.0052	0.0002	<0.02
Storm Composite	5/6/01 19:30	5/6/01 19:30	**0.0266**	**0.0224**	**0.071**	**0.0008**	<0.02
Storm Grab	5/22/01 13:30	NA	NA	NA	NA	NA	<0.02
Storm Composite	5/22/01 13:54	5/22/01 19:18	**0.0084**	**0.0015**	0.0152	0.0002	<0.02
Storm Grab	6/6/01 12:00	NA	0.0020	<0.0005	0.0058	<0.0001	<0.02
Storm Composite	**6/11/01 18:18**	**6/11/01 20:16**	**0.0600**	**0.0670**	**0.1560**	**0.0010**	**0.17**
Storm Composite	6/13/01 15:40	6/14/01 6:52	**0.0076**	**0.0037**	0.0169	**0.0009**	**0.09**
Storm Composite	6/18/01 15:00	6/19/01 22:30	0.0029	<0.0005	0.0034	0.0005	~0.04
Quality Control	6/29/01 12:40	NA	NA	NA	NA	NA	<0.02
Base Grab	6/29/01 12:40	NA	0.0026	<0.0005	0.0036	<0.0001	**~0.05**

Base Grab	7/18/01 11:15	NA	**0.0096**	0.0008	0.0103	<0.0001	**0.41**
Storm Grab	8/1/01 15:15	NA	**0.0076**	**0.0027**	0.0145	<0.0001	~0.02
Storm Composite	8/18/01 5:26	8/18/01 6:46	**0.0167**	**0.0068**	0.0360	0.0006	~0.03
Chronic Standard			**0.0064**	**0.0013**	**0.0590**	**0.00066**	**0.04**
# of Exceedences/# of Samples			10/17	8/17	2/17	3/17	10/20
Maximum Standard			**0.0092**	**0.0340**	**0.0650**	**0.01500**	**No Standard**
# of Exceedences/# of Samples			6/17	1/17	2/17	0/17	NA

MS2 (Bailey)

The hydrograph for the MS2 site shows flow between March 8 – November 6, 2001(Figure 3). Total discharge during this period was 29,936,276 cf or 687 acre-ft. Baseflow at MS2 ranged from 0.03 to 0.1 cfs. The highest flow—9.5 cfs occurred on June 16, 2001, from a very intense rainfall of 0.21 in. The highest daily rainfall—3.06 inches, was on April 23, 2001, yielding a flow of 8.7 cfs. Supplemental daily rainfall data was used from the State Climatology Office high-density network at the closest monitoring location, T28N R21W S6, which is within six miles of MS2.

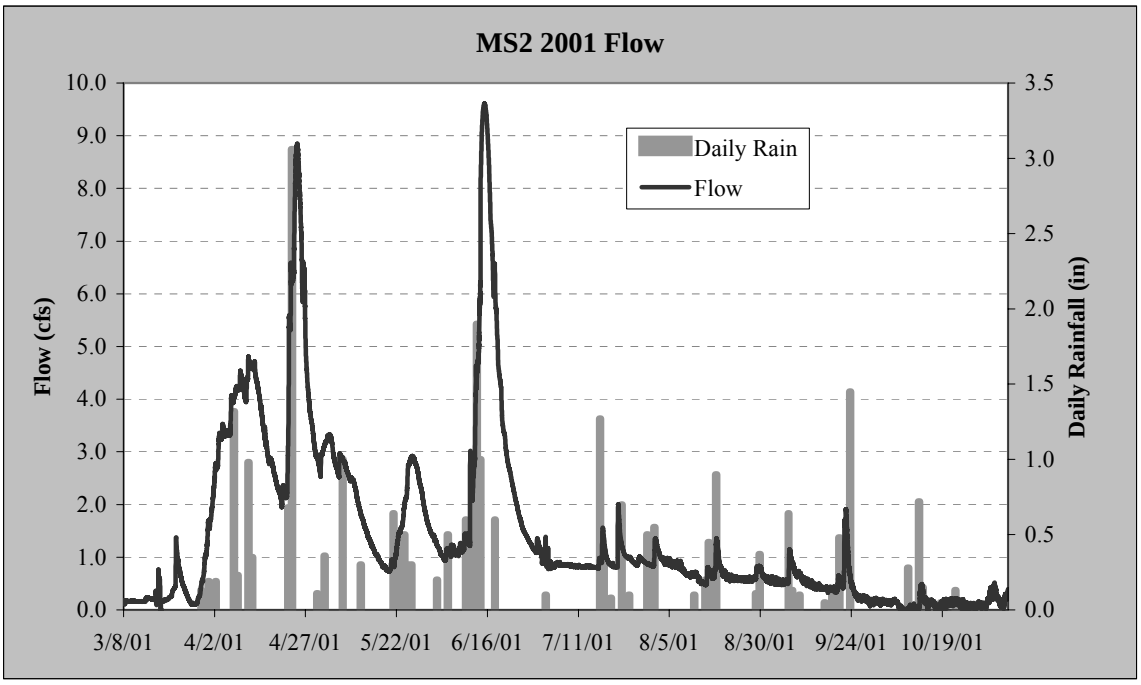


Figure 3. MS2 2001 Continuous Flow and Daily Rainfall

Grab samples and flow weighted automatic samples were taken at the MS2 site. The TSS, TKN, and TP results from all collected samples are listed in Table 3. The highest TSS result of 1470 mg/L was from the June 6, 2001 storm grab sample. TKN results had a small range—0.81 to 3.3 mg/L. The highest TKN result was from the March 23, 2001, snowmelt grab sample. The highest TP results was from a base composite on April 27-29, 2001. However, that result was extremely high (8.4 mg/L) in comparison to all other results (0.02 to 0.44 mg/L) and is thought to be a lab error. The next highest TP result was 0.44 mg/L on March 23, 2001, from a snowmelt grab. The average base sample results, excluding the April 27-29, 2001, TP sample, were TSS—21.3 mg/L, TKN—1.44 mg/L, and TP—0.15 mg/L.

Table 3. MS2 2001 Sample Chemistry Results

Sample Type	Start Date & Time	End Date & Time	Total Suspended Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)
Snowmelt Grab	3/23/01 13:15	NA	13	3.3	0.44
Snowmelt Grab	3/29/01 14:30	NA	~9	2.6	0.42
Snowmelt Grab	4/4/01 14:15	NA	8	2.4	0.22
Storm Grab	4/12/01 10:35	NA	~8	1.3	0.16
Storm Grab	4/23/01 15:25	NA	16	1.3	0.1
Base Composite	4/27/01 11:45	4/29/01 10:30	8	1.4	8.4
Storm Composite	5/3/01 13:10	5/4/01 11:55		1.5	0.17
Storm Grab	5/22/01 16:20	NA	8	0.99	0.07
Storm Composite	5/23/01 5:10	5/24/01 13:55	42	1.2	0.13
Storm Grab	6/6/01 13:45	NA	1470	1.2	0.05
Storm Composite	6/11/01 20:10	6/13/01 14:10	29	1.1	0.13
Storm Composite	6/13/01 15:10	6/14/01 21:40	9	0.9	0.07
Storm Grab	6/21/01 12:40	NA	8	0.9	0.1
Quality Control	6/29/01 13:50	NA	~2		~0.02
Base Grab	6/29/01 13:50	NA	8	0.81	0.1
Base Grab	7/16/01 14:00	NA	10	0.93	0.07
Base Grab	7/18/01 12:35	NA	11	0.95	0.08
Storm Composite	8/1/01 15:25	8/2/01 14:40	39	2	0.2
Base Composite	8/13/01 11:25	8/14/01 11:10	34	1.4	0.16
Storm Composite	8/18/01 8:00	8/19/01 21:00		2.1	0.19
Base Composite	8/28/01 15:40	8/29/01 8:30	41	2.2	0.27
Base Composite	9/18/01 13:30	9/20/01 12:15	37	2.4	0.22
Storm Composite	9/22/01 17:30	9/24/01 0:30	35	2	0.21

Sampling data yielded very few detects for metals and other species of nitrogen. Of the parameters sampled (copper, nickel, lead, zinc, cadmium, chromium, and ammonia), only copper, chromium and ammonia exceeded the MPCA Rule 7050 Water Quality Chronic Standard. Samples which exceeded the MPCA Chronic Standard are bolded in Table 4. Only copper exceeded the MPCA Rule 7050 Water Quality Maximum Standard. Samples that exceeded the MPCA Maximum Standard are bolded and underlined.

Table 4. MS2 Chemical Parameters Which Exceeded MPCA Water Quality Standards

Sample Type	Start Date/Time	End Date/Time	Copper (mg/L)	Chromium (mg/L)	Ammonia Nitrogen (mg/L)
Snowmelt Grab	3/23/01 13:15	NA	**0.0070**	**0.0007**	**1.53**
Snowmelt Grab	3/29/01 14:30	NA	**0.0073**	0.0006	**1.07**
Snowmelt Grab	4/4/01 14:15	NA	NA	NA	**0.75**
Storm Grab	4/12/01 10:35	NA	0.0040	0.0005	**0.22**
Storm Grab	4/23/01 15:25	NA	0.0030	0.0005	NA
Base Composite	4/27/01 11:45	4/29/01 10:30	**0.0123**	0.0005	**0.08**
Storm Composite	5/3/01 13:10	5/4/01 11:55	0.0059	**0.0011**	NA
Storm Grab	5/22/01 16:20	NA	NA	NA	**~0.06**
Storm Composite	5/23/01 5:10	5/24/01 13:55	0.0042	**0.0012**	**0.11**
Storm Grab	6/6/01 13:45	NA	0.0024	<0.0005	<0.02
Storm Composite	6/11/01 20:10	6/13/01 14:10	0.0058	**0.0010**	**~0.05**
Storm Composite	6/13/01 15:10	6/14/01 21:40	0.0057	<0.0005	**0.07**
Storm Grab	6/21/01 12:40	NA	0.0024	<0.0005	<0.02
Quality Control	6/29/01 13:50	NA	NA	NA	~0.03
Base Grab	6/29/01 13:50	NA	0.0025	<0.0005	<0.02
Base Grab	7/16/01 14:00	NA	0.0020	<0.0005	<0.02
Base Grab	7/18/01 12:35	NA	0.0022	<0.0005	<0.02
Storm Composite	8/1/01 15:25	8/2/01 14:40	0.0060	0.0006	<0.02
Base Composite	8/13/01 11:25	8/14/01 11:10	0.0030	<0.0005	<0.02

Storm Composite	8/18/01 8:00	8/19/01 21:00	0.0038	<0.0005	**0.28**
Base Composite	8/28/01 15:40	8/29/01 8:30	0.0037	0.0005	<0.02
Base Composite	9/18/01 13:30	9/20/01 12:15	0.0033	<0.0005	~0.02
Storm Composite	9/22/01 17:30	9/24/01 0:30	0.0053	<0.0005	**0.11**
Chronic Standard			**0.0064**	**0.00066**	**0.04**
# of Exceedences/# of Samples			3/20	4/20	11/21
Maximum Standard			**0.0092**	**0.015**	**No Standard**
# of Exceedences/# of Samples			1/20	0/20	NA

Powers Lake Northeast Tributary

The hydrograph for the Powers site shows flow between March 20 – November 8, 2001 (Figure 4). The total discharge for this period was 12,249,152 cf or 281 acre-ft. The highest recorded flow was 9.88 cfs on April 22nd. This high flow was due to snowmelt. Baseflow at Powers was approximately 0.14 ft and 0.06 cfs. To supplement the rainfall data, daily rainfall data was used from the State Climatology Office high-density network at the closest monitoring location, T28N R21W S6, which is within four miles of the Powers monitoring station.

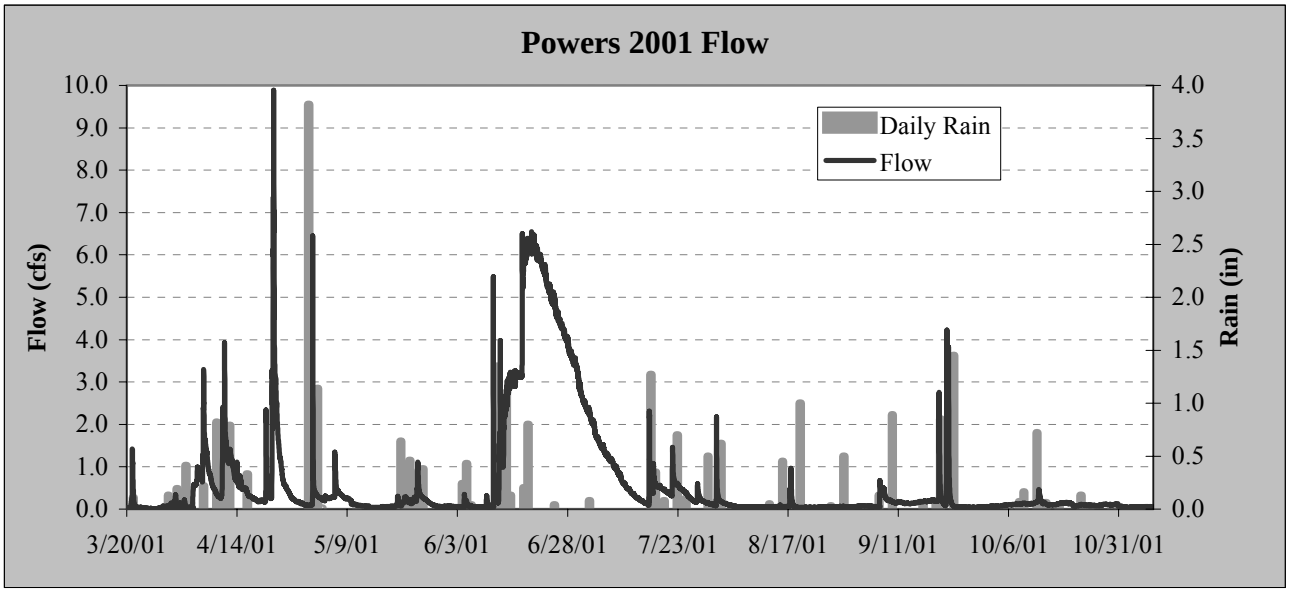


Figure 4. Powers 2001 Continuous Flow and Daily Rainfall

Grab samples and flow weighted automatic samples were taken at the Powers site. The TSS, TKN, and TP results from all collected samples are listed in Table 5. The highest TSS &TKN results, 200 mg/L and 1.6 mg/L respectively, were from samples taken on June 11, 2001. The TP result (0.38 mg/L) was also high on June 11, 2001; however, the highest TP result (0.42 mg/L) was from the sample taken on April 4, 2001. The average base sample results were TSS of 12.4 mg/L, TKN of 0.47 mg/L, and TP of 0.06 mg/L.

Table 5. Powers 2001 Sample Chemistry Results

Sample Type	Start Date & Time	End Date & Time	Total Suspended Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)
Snowmelt Grab	3/21/01 14:36	NA	105	NA	~0.36
Snowmelt Grab	3/23/00 14:00	NA	NA	0.57	0.27
Snowmelt Grab	4/4/01 13:50	NA	82	0.96	0.42
Storm Grab	4/12/01 10:12	NA	14	1.20	0.17
Storm Grab	4/23/01 15:04	NA	17	1.10	0.10
Base Grab	5/4/01 13:45	NA	~2	0.45	~0.02
Storm Composite	5/17/01 10:28	5/21/01 9:20	10	0.30	0.06
Storm Composite	5/22/01 14:50	5/23/01 1:22	~6	0.55	0.09
Storm Grab	6/6/01 12:40	NA	~4	0.31	~0.03
Storm Composite	6/11/01 17:29	6/11/01 19:21	200	1.60	0.38
Storm Composite	6/13/01 16:55	6/14/01 6:14	32	0.68	0.16
Storm Composite	6/18/01 7:26	6/18/01 15:26	173	1.20	0.36
Base Composite	6/18/01 16:12	6/19/01 9:49	11	0.84	0.09
Quality Control	6/29/01 13:30	NA	~4	NA	NA
Base Grab	6/29/01 13:30	NA	~2	NA	<0.01
Base Composite	7/13/01 13:42	7/16/01 11:20	15	NA	0.06
Storm Composite	7/17/01 3:11	7/18/01 5:53	84	NA	0.24
Storm Composite	8/1/01 8:10	8/1/01 11:49	69	1.60	0.22
Base Composite	8/13/01 10:15	8/14/01 10:09	8	0.29	~0.03
Storm Composite	8/17/01 22:27	8/18/01 1:33	73	1.20	0.30
Base Composite	8/28/01 14:30	8/29/01 8:07	14	0.42	0.07
Base Composite	9/18/01 12:16	9/20/01 10:57	35	0.34	0.15

Only one sample was taken for metals and other species of nitrogen, including copper, nickel, lead, cadmium, chromium, zinc, and ammonia, on June 6, 2001. Sampling data yielded low or no detects for metals and other species of nitrogen. None of the parameters exceeded the MPCA Rule 7050 Water Quality Chronic or Maximum Standards.

Table 6. Powers Chemical Parameters Sampled

Date	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Zinc (mg/L)	Ammonia Nitrogen (mg/L)
6/6/01	0.0022	0.0028	<0.0005	<0.0001	<0.0005	0.0044	<0.02
Chronic Standard	**0.0064**	**0.088**	**0.0013**	**0.00066**	**0.117**	**0.059**	**0.04**
Maximum Standard	**0.0092**	**0.789**	**0.0340**	**0.015**	**0.984**	**0.065**	**No Standard**

100th Street (Cottage Grove)

The 100th Street site was monitored from March 21 – November 14, 2001. A staff gage was installed and read at the site. Field stage measurements were taken in the outflow culvert (Figure 5). Temperature, dissolved oxygen, and transparency tube measurements were also taken. Nine storm grab samples and seven baseflow grab samples were collected and brought to the Metropolitan Council Lab for analysis, including a two fecal coliform tests. No samples were taken for metals and other species of nitrogen. A few of the chemical parameter results from the samples are listed in Table 7.

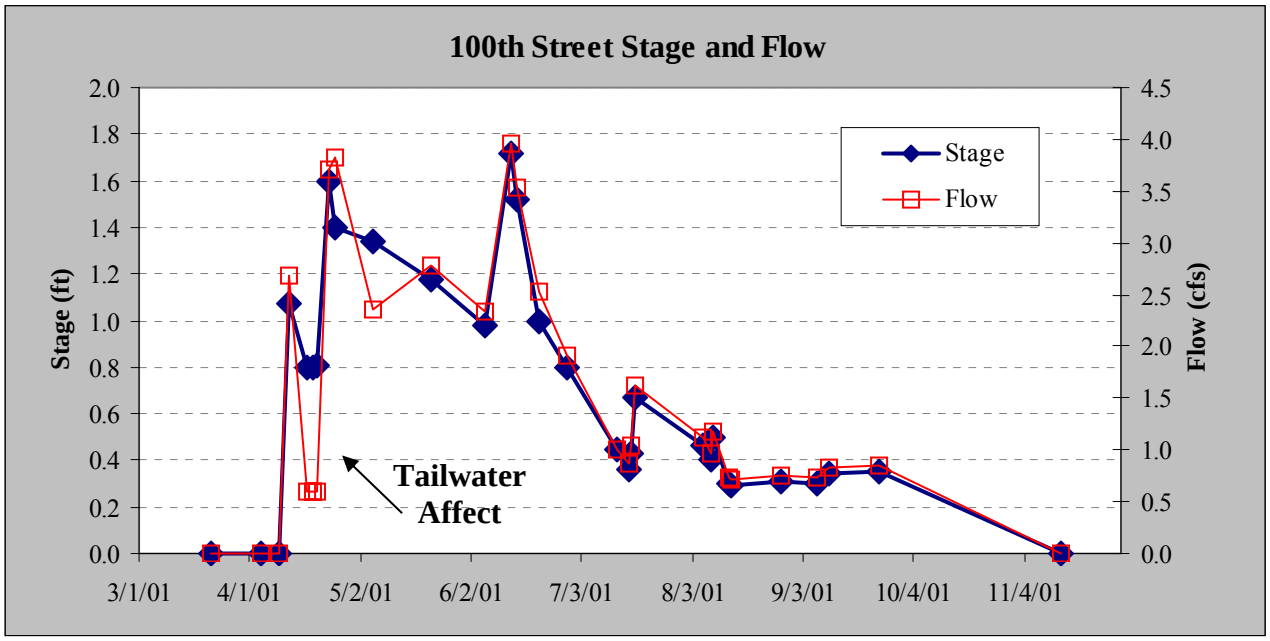


Figure 5. 2001 100th Street Culvert Stage(ft) and Flow (cfs)

Table 7. 100th Street 2001 Sample Chemistry Results

Sample Type	Date/Time	Fecal Coliform (#/100 mL)	Total Suspended Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)
Storm Grab	4/12/01 10:54	NA	NA	1.00	0.08
Storm Grab	4/23/01 15:50	NA	22	1.20	0.11
Storm Grab	5/7/01 12:45	NA	9	0.88	0.07
Storm Grab	5/22/01 16:45	44	4	0.59	0.06
Storm Grab	6/6/01 14:50	NA	<2	0.48	<0.01
Storm Grab	6/13/01 15:10	240	6	0.65	0.07
Storm Grab	6/15/01 14:20	NA	NA	0.52	0.07
Base Grab	6/29/01 14:36	NA	<2	<0.20	0.03
Base Grab	7/16/01 14:15	NA	2	0.43	0.07
Storm Grab	7/18/01 13:15	NA	2	<0.20	0.02
Base Grab	8/6/01 14:00	NA	2	0.32	0.03
Base Grab	8/14/01 12:35	NA	2	0.45	0.03
Base Grab	8/28/01 11:15	NA	3	0.38	0.04
Storm Grab	9/7/01 10:25	NA	2	0.36	0.06
Base Grab	9/10/01 12:00	NA	2	0.38	0.04
Base Grab	9/24/01 10:40	NA	3	NA	NA

Stormwater Sites

Fox Run

The hydrograph for the Fox Run stormwater site shows flow between March 23– November 6, 2001 (Figure 6). The total discharge for this period was 715,260 cf or 16 acre-ft. The highest recorded flow was 4.93 cfs on June 13th. This high flow was due to two days rainfall of 2.38 inches. However, there is missing data from April 15-May 29, 2001 and August 29-September 5, 2001, due to equipment failure. There was heavy rainfall during the period in April-May and would greatly increase the total discharge for the sampling season. It is believed that the highest flow, although unrecorded, would have occurred after the April 30th rainfall of 3.8 inches. There was only a small rain event on August 30th and would not greatly influence the total discharge levels. There was no baseflow at this site. There was no precipitation gage at this site. Daily rainfall data was used from the State Climatology Office high-density network at the closest monitoring location, T28N R21W S6, which is within four miles of the monitoring station. No chemistry data was collected at this site.

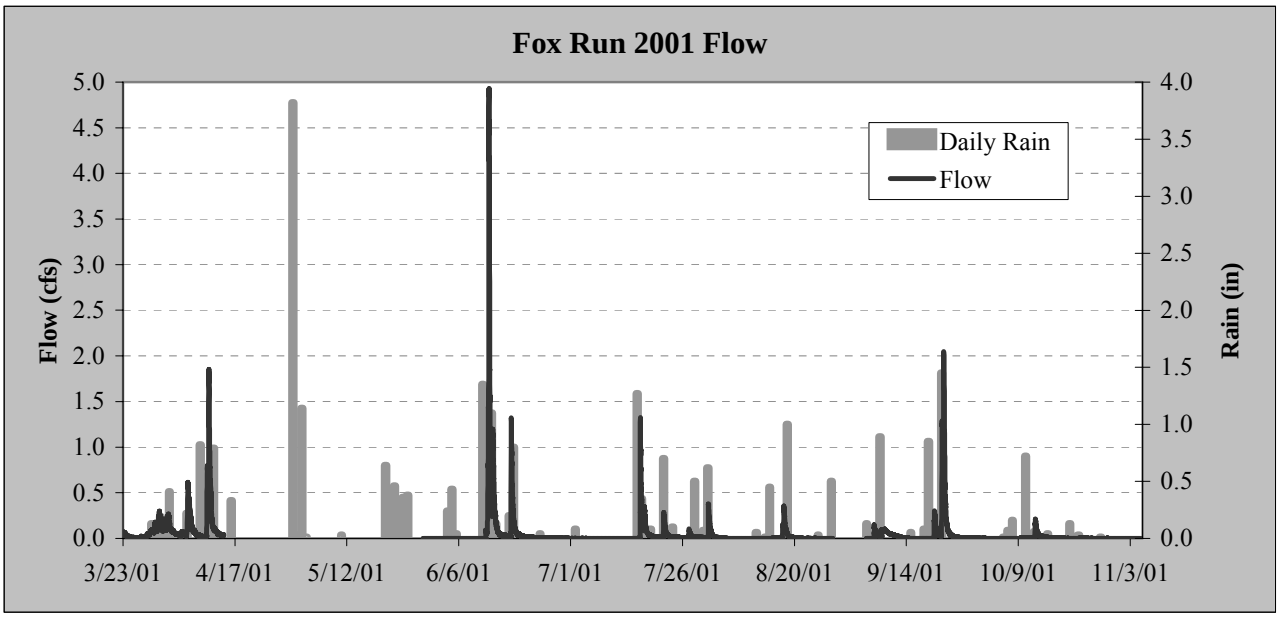


Figure 6. Fox Run 2001 Continuous Flow and Daily Rainfall

Tamarack Road

The hydrograph for the Tamarack Rd stormwater site shows flow between March 26 – November 6, 2001 (Figure 7). The total discharge for this period was 1,559,059 cf or 36 acre-ft. However, there is missing data from April 15-May 29, 2001 and September 18-October 2, 2001, due to equipment failure. There was heavy rainfall during this period and would greatly increase the total discharge for the sampling season. The highest recorded flow was 48.5 cfs on June 11th. This high flow was due to rainfall of at least 1.4 inches. It is believed that the highest flow, although unrecorded, would have occurred after the April 30th rainfall of 3.8 inches. There was no baseflow at the Tamarack Rd stormwater site. There was no precipitation gage at this site. Daily rainfall data was used from the State Climatology Office high-density network at the closest monitoring location, T28N R21W S6, which is within four miles of the monitoring station. No chemistry data was collected at this site.

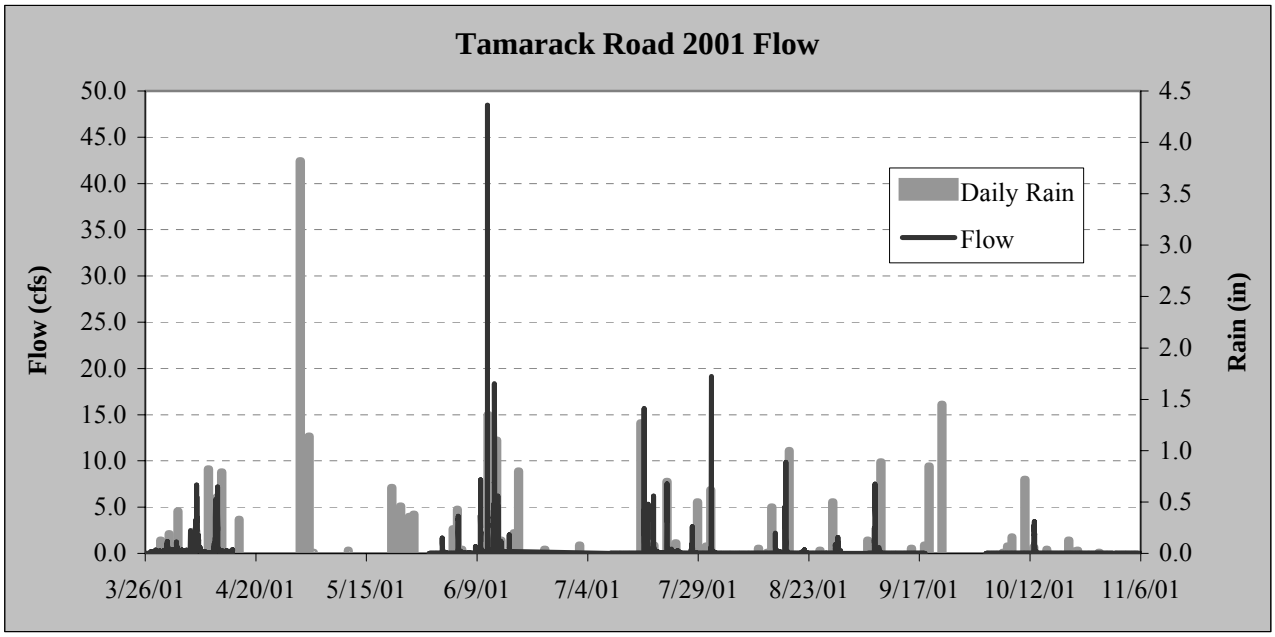


Figure 7. Tamarack Rd 2001 Continuous Flow and Daily Rainfall

Armstrong Lake

Vital Statistics:

DNR ID #: 82-0116
LOCATION: $NW^{1/4}$ Section 33 T29N-R21W
MUNICIPALITY: City of Lake Elmo
LAKE SIZE: 28.1 acres (North—7.3 acres, South—20.8 acres)
ORDINARY HIGH WATER MARK: 1019.1 ft

Armstrong Lake was monitored from May 2 to October 10, 2001, in accordance with the Metropolitan Council Citizen-Assisted Monitoring Program (CAMP). Monitoring consisted of 14 biweekly lake gage readings and samplings of Secchi disk, surface total phosphorus, surface total Kjeldahl nitrogen, and surface chlorophyll-a. In addition, a temperature and dissolved oxygen profile was taken during each sampling round and the CAMP data sheet was completed. The samples were analyzed by the Metropolitan Council Lab.

Table 9 gives the 2001 high, low, and average lake levels. Individual lake level readings are shown in Figure 8. Table 10 gives the 2001 monitoring results. Armstrong showed better water quality in 2001 than 2000. The lake received an average lake grade of a C in 2001, compared to a D+ for 2000. Table 11 shows the lake grade and trophic status.

Figure 9-Figure 11 compare the lake chemistry data and Secchi disk readings. There was a weak negative relationship between Secchi and total phosphorous: as Secchi readings increased, TP decreased. There was no correlation between Secchi and total Kjeldahl nitrogen. There was a weak negative relationship between Secchi and chlorophyll a: as Secchi readings increased, CLA decreased. There was no correlation between total

phosphorous and total Kjeldahl nitrogen. There was a weak positive relationship between chlorophyll a and total Kjeldahl nitrogen: as CLA increased, TKN increased. The strongest correlation (R^2=0.46) was the positive relationship between chlorophyll a and total phosphorus: as CLA increased, TP increased (Table 8).

Table 8. Lake Parameter Relationships

	Secchi	CLA	TP	TKN
Secchi		↑ ↓	↑ ↓	-----
CLA	↑ ↓		↑ ↑	↑ ↑
TP	↑ ↓	↑ ↑		-----
TKN	-----	↑ ↑	-----	

Table 9. Armstrong 2001 Lake Level

	High	High Date	Low	Low Date	Average
Lake Level (ft)	1018.88	4/19/01	1017.74	9/11/01	1018.29

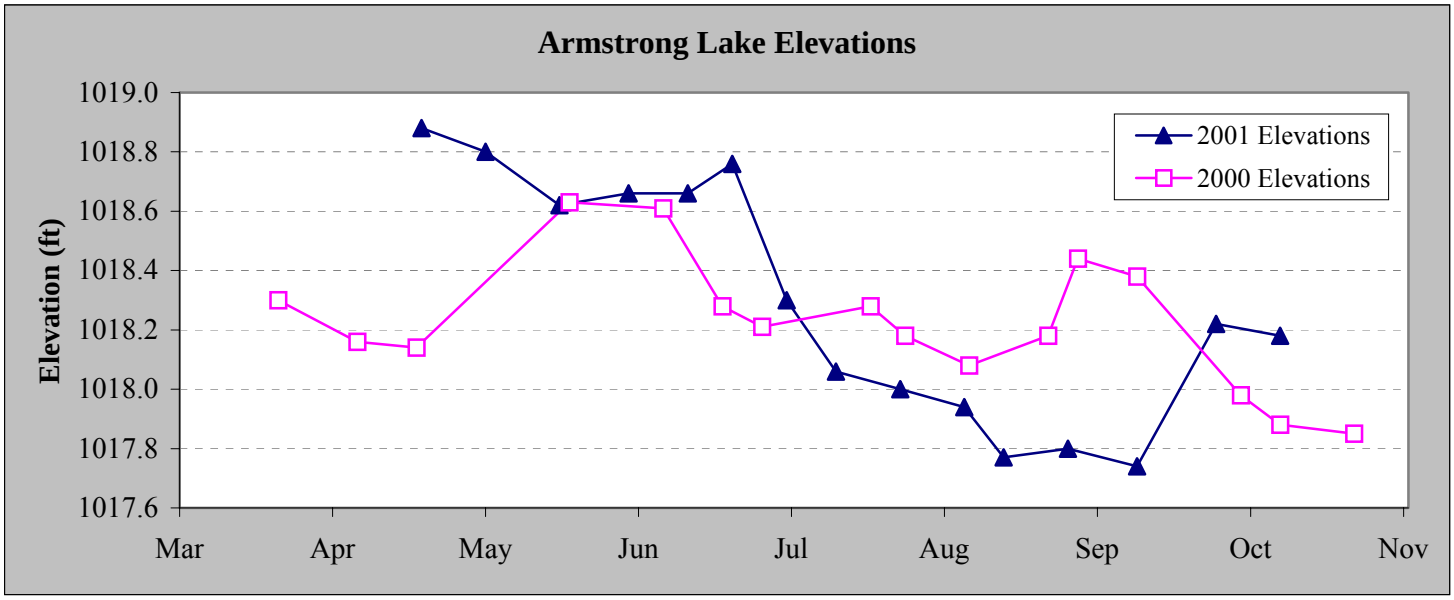


Figure 8. Armstrong Lake Elevations 2000-01

Table 10. Armstrong Lake 2001 Monitoring Results

Date	Surface Total Phosphorus (mg/L)	Surface Total Kjeldahl Nitrogen (mg/L)	Chlorophyll-a (ug/L)	Secchi Disk (m)	Surface Dissolved Oxygen (mg/L)	Surface Temperature (C)
5/2/01	0.08	0.20	33.0	0.92	9.20	18.3
5/17/01	0.11	1.50	31.0	0.76	6.70	21.2
5/31/01	0.07	1.00	20.0	0.61	17.09	20.7
6/12/01	0.06	1.30	14.0	1.22	8.38	22.3
6/21/01	0.11	1.10	22.0	0.61	7.48	22.3
7/2/01	0.08	0.92	22.0	0.76	5.27	20.2
7/12/01	0.06	0.94	13.0	0.76	8.74	25.8
7/25/01	0.10	1.00	31.0	0.76	8.46	26.3
8/7/01	0.07	1.30	42.0	0.92	3.92	28.2
8/15/01	0.05	1.40	21.0	0.92	5.55	20.7
8/28/01	0.06	1.20	16.0	0.92	10.65	27.5
9/12/01	0.04	1.20	4.70	0.76	12.48	19.1
9/27/01	0.06	1.20	4.60	0.92	NA	13.4
10/10/01	0.06	1.20	9.10	1.07	8.55	12.7
2001 Averages	**0.07**	**1.10**	**20.2**	**0.85**	**8.65**	**21.3**

Table 11. Armstrong Lake Water Quality Summary

	Trophic Status (2000 Average)	Lake Grade (2000 Average)	Trophic Status (2001 Average)	Lake Grade (2001 Average)
Total Phosphorus (mg/L)	Eutrophic	C	Hypereutrophic	D
Chlorophyll-a (ug/L)	Eutrophic	C	Eutrophic	B
Secchi disk (ft)	Hypereutrophic	F	Eutrophic	D
Overall	Hypereutrophic	D+	Eutrophic	C

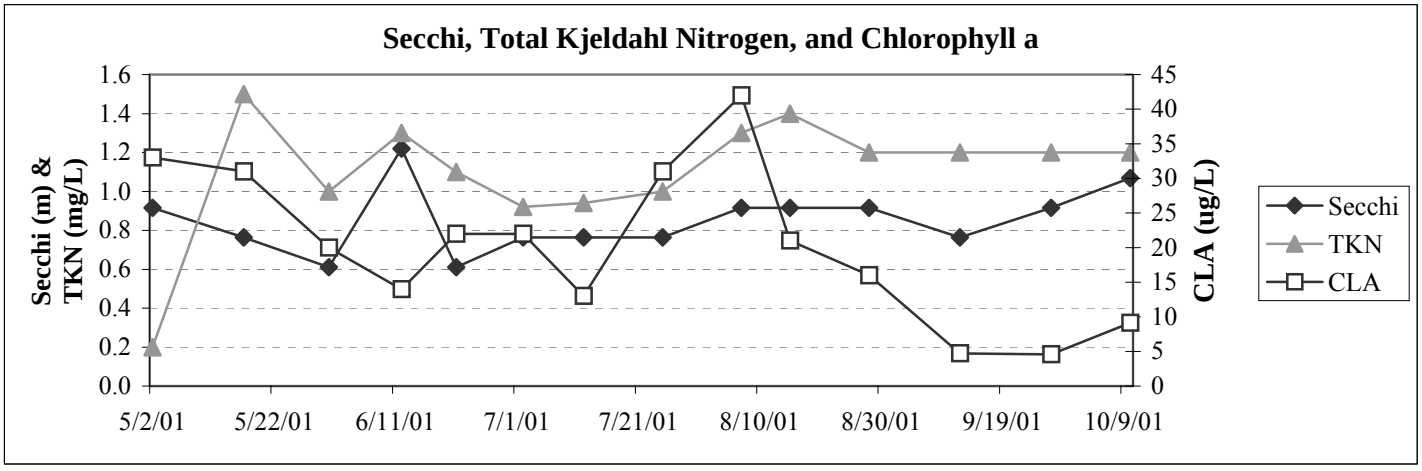


Figure 9. Secchi, Total Kjeldahl Nitrogen and Chlorophyll-a

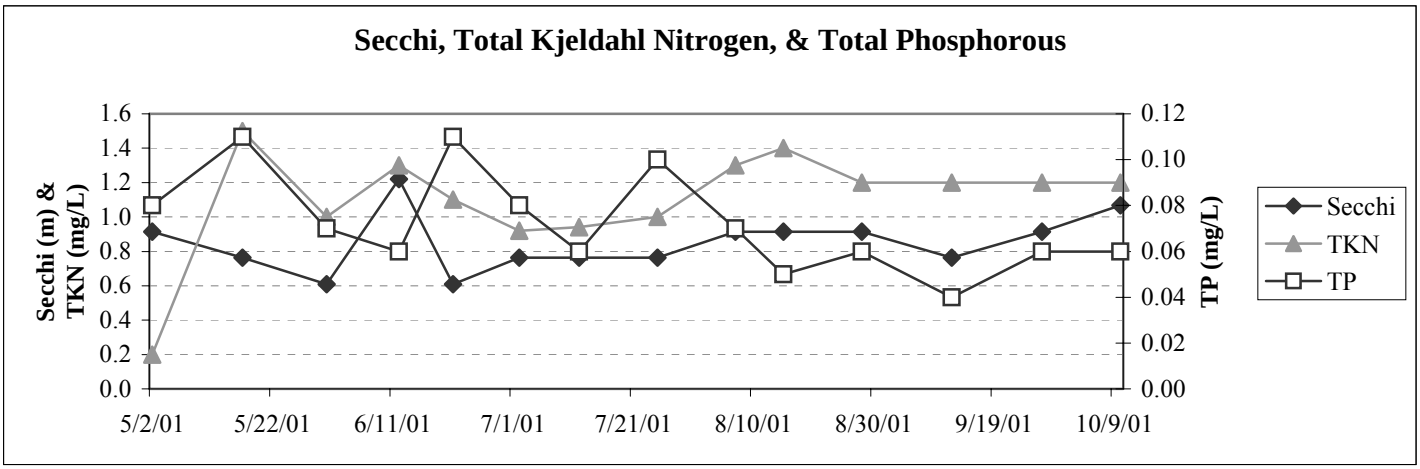


Figure 10. Secchi, Total Kjeldahl Nitrogen, and Total Phosphorus

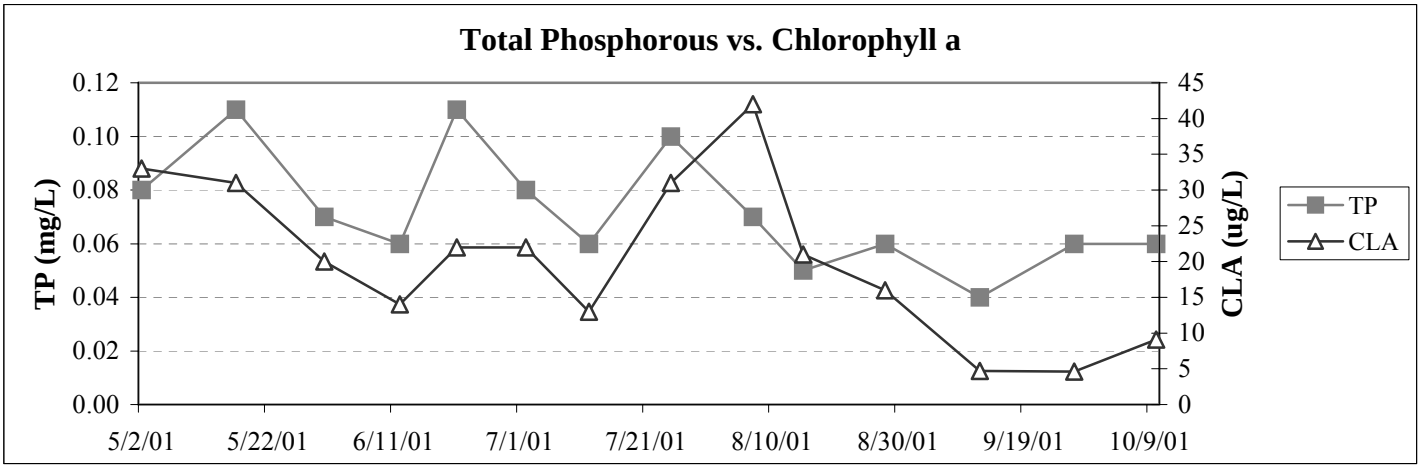


Figure 11. Total Phosphorous and Chlorophyll *a*

Table 12 lists the dissolved oxygen and temperature profiles. The maximum depth was between 1 and 2 meters. No thermocline was present in the lake. The surface dissolved oxygen and surface temperatures are shown in Figure 12.

Table 12. Dissolved Oxygen and Temperature Profiles

	5/2/01		5/17/01		5/31/01		6/12/01		6/21/01		7/2/01		7/12/01	
Depth (m)	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**
surface	9.20	18.3	6.70	21.2	17.09	20.7	8.38	22.3	7.48	22.3	5.27	20.2	8.74	25.8
1	8.99	18.3	4.40	21.0	17.48	20.6	8.87	21.7	2.32	21.0	4.33	20.3	0.39	24.2
2	0.41	18.1	4.97	21.0			9.37	20.8	1.32	20.8	3.82	20.4		

	7/25/01		8/7/01		8/15/01		8/28/01		9/12/01		9/27/01		10/10/01	
Depth (m)	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**
surface	8.46	26.3	3.92	28.2	5.55	20.7	10.65	27.5	12.48	19.1	NA	13.4	8.55	12.7
1	0.87	23.6	1.53	28.0	0.19	21.0	0.68	23.1	12.00	19.0	NA	13.4	8.98	12.5
2	0.48	23.3	1.49	28.0	0.13	21.0	0.61	22.9					7.13	11.6

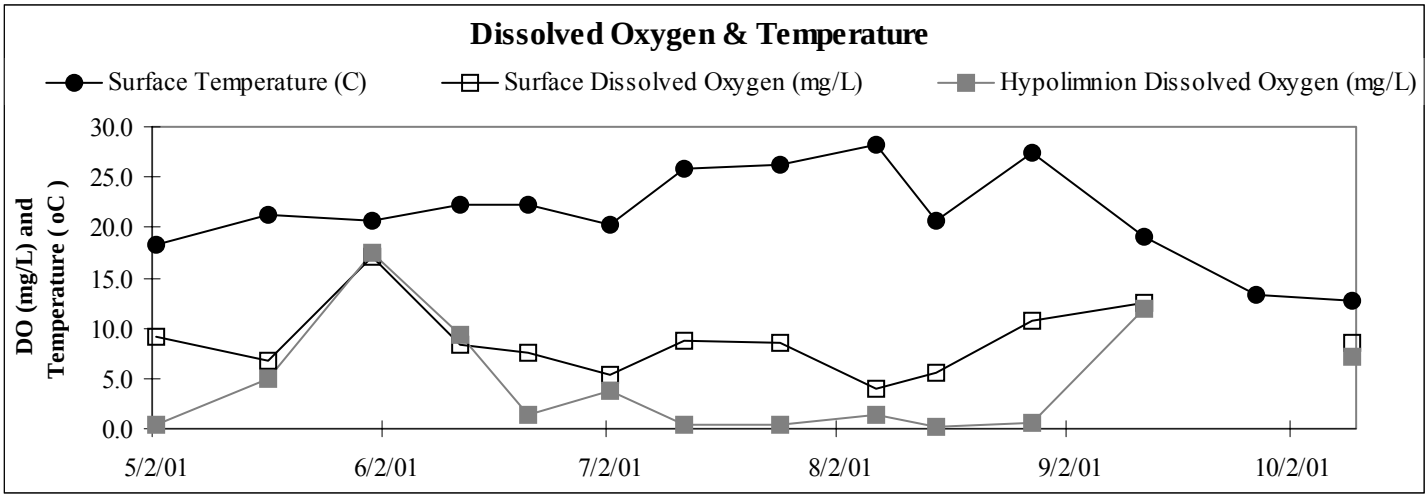


Figure 12. Surface Dissolved Oxygen and Surface Temperatures

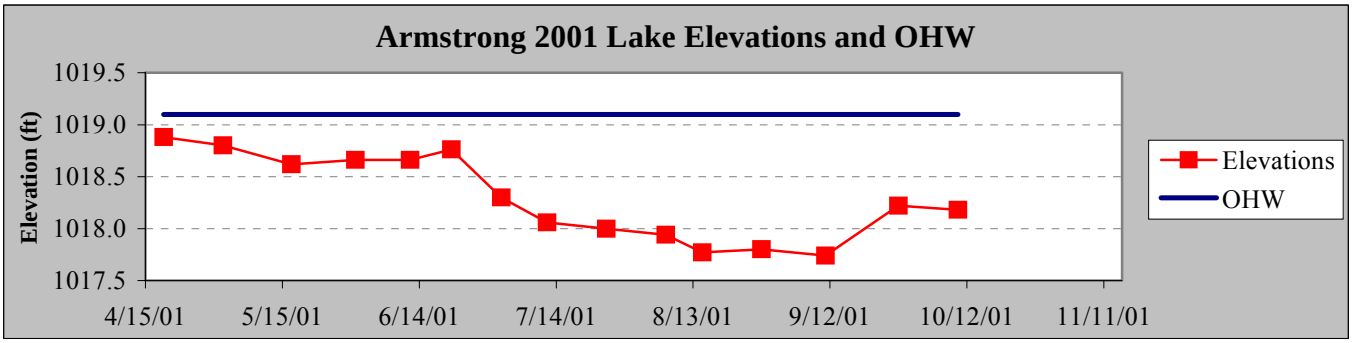
Lake Gages

Lake gages were read biweekly on eight lakes in SWWD from April 19-November 1, 2001. Table 13 lists the high, low, range and average elevations for each lake monitored in 2001. Figure 13a-h shows the fluctuation in elevation for each lake monitored in 2001.

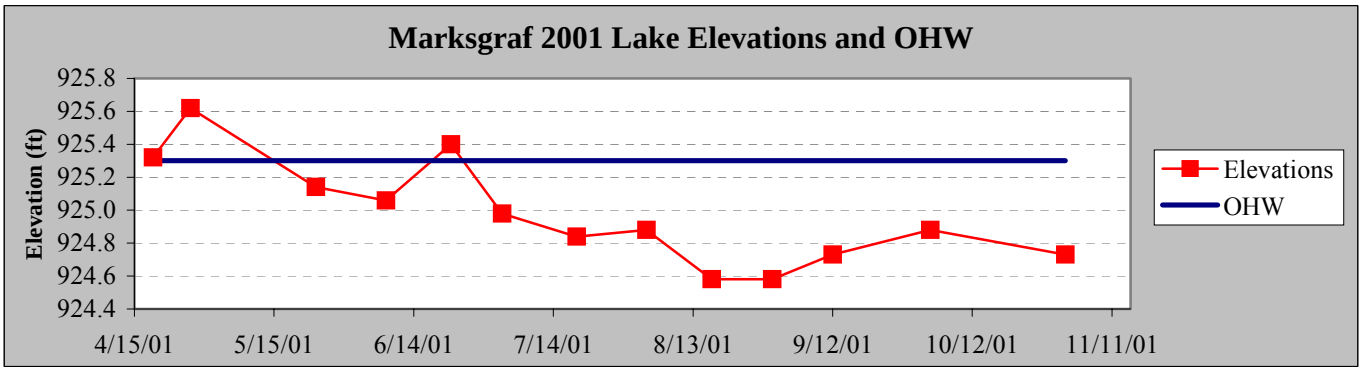
Table 13. SWWD 2001 Lake Gage Readings

Lake Name	DNR ID#	Dates Monitored	# Readings	High Reading (ft) Date	Low Reading (ft) Date	Range (ft)	Average Elevation (ft)	OHW (ft)
Cottage Grove Ravine Park	82-0087	4/19/01 – 9/24/01	12	772.02 6/15/01	771.31 4/19/01	0.71	771.51	770.70
Marksgraf	82-0089	4/19/01 – 11/1/01	13	925.62 4/27/01	924.58 8/30/01	1.04	924.98	925.30
Wilmes	82-0090	4/19/01 – 11/1/01	13	903.90 4/27/01	901.39 11/1/01	2.51	902.40	902.60
Powers	82-0092	4/19/01 – 10/3/01	10	887.56 6/18/01	884.96 4/19/01	2.60	886.60	891.30
Colby	82-0094	4/19/01 – 11/1/01	13	891.96 6/15/01	890.00 9/10/01	1.96	890.60	891.80
Bailey	82-0456	4/19/01 – 11/1/01	12	874.44 4/27/01	868.97 4/19/01	5.47	872.27	NA
Armstrong	82-0116	4/19/01- 10/10/01	15	1018.88 4/19/01	1017.74 9/11/01	1.14	1018.25	1019.10
Vandeberg	82-0084	4/19/01 – 11/1/01	13	839.37 6/15/01	838.28 11/1/01	1.09	838.83	NA

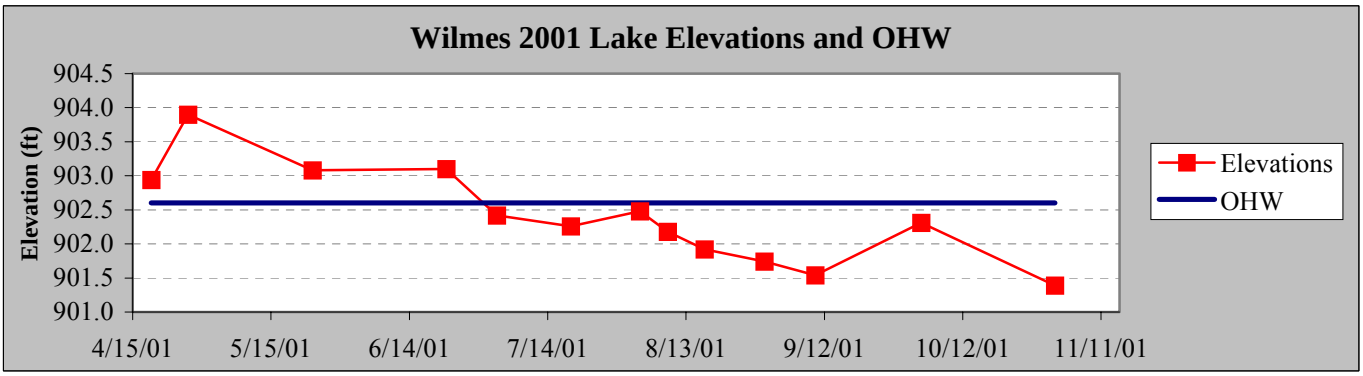
Figure 13a-h. SWWD 2001 Lake Elevations



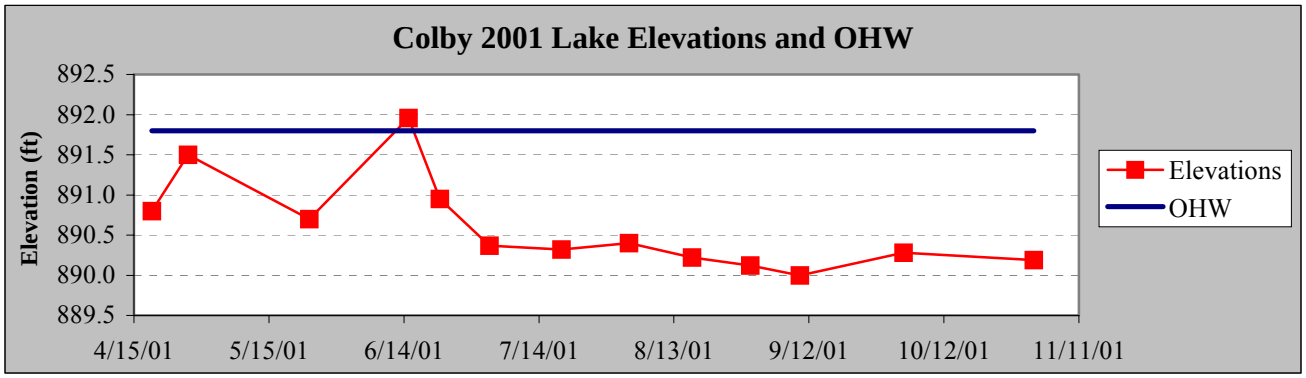
a. Armstrong Lake Elevations and Ordinary High Water (OHW)



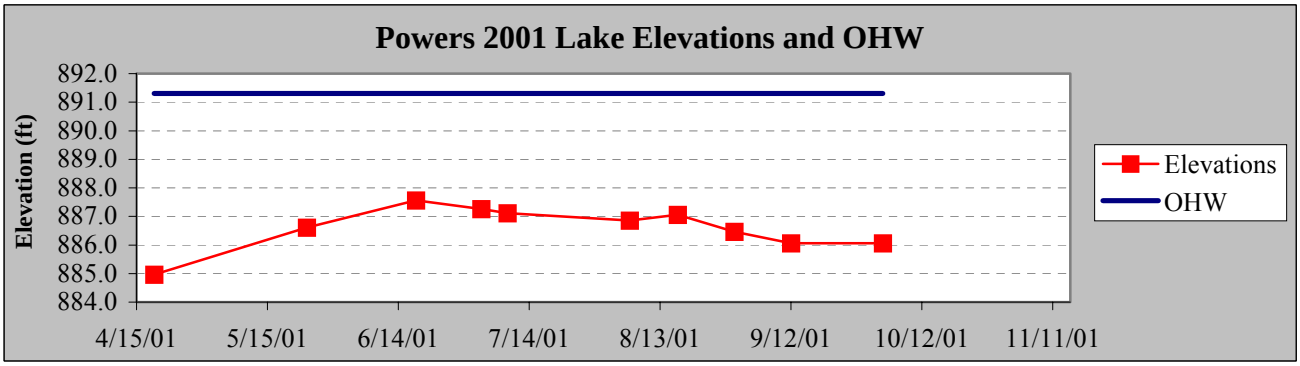
b. Marksgraf Lake Elevations and Ordinary High Water (OHW)



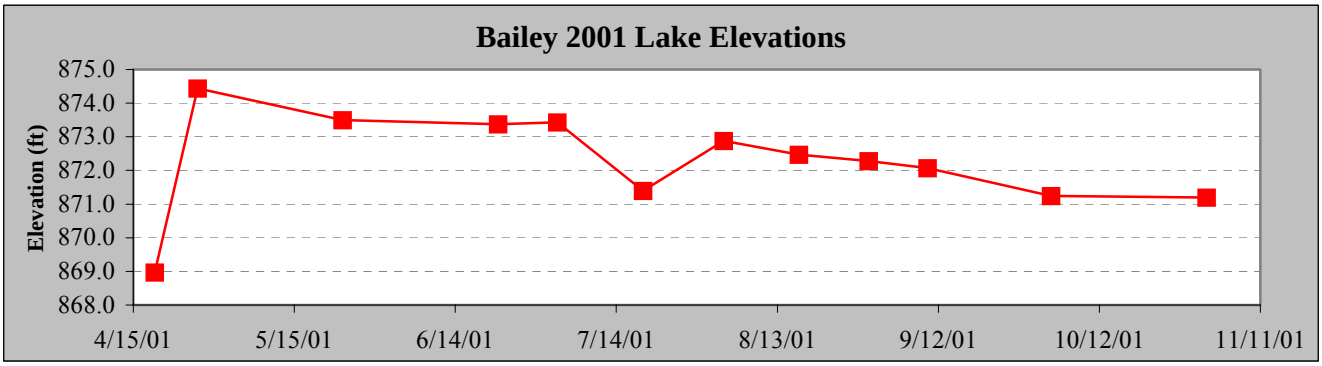
c. Wilmes Lake Elevations and Ordinary High Water (OHW)



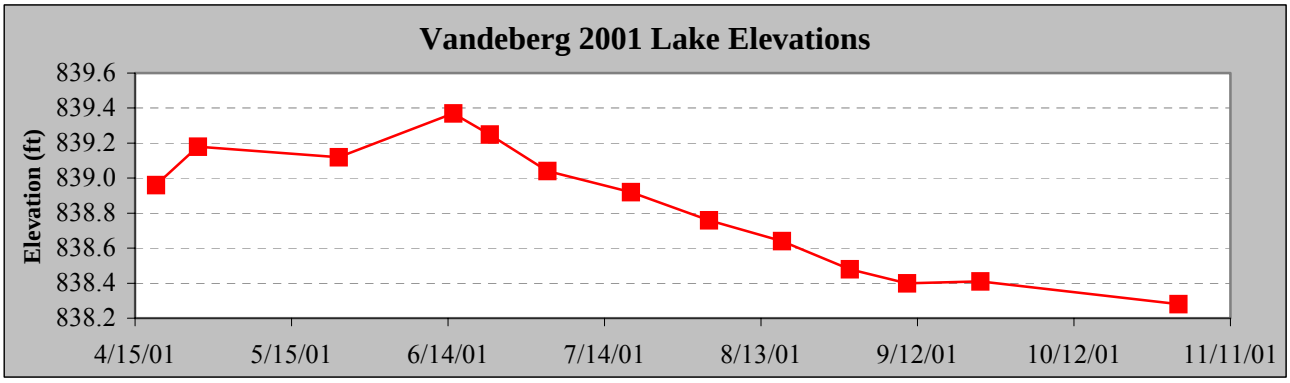
d. Colby Lake Elevations and Ordinary High Water (OHW)



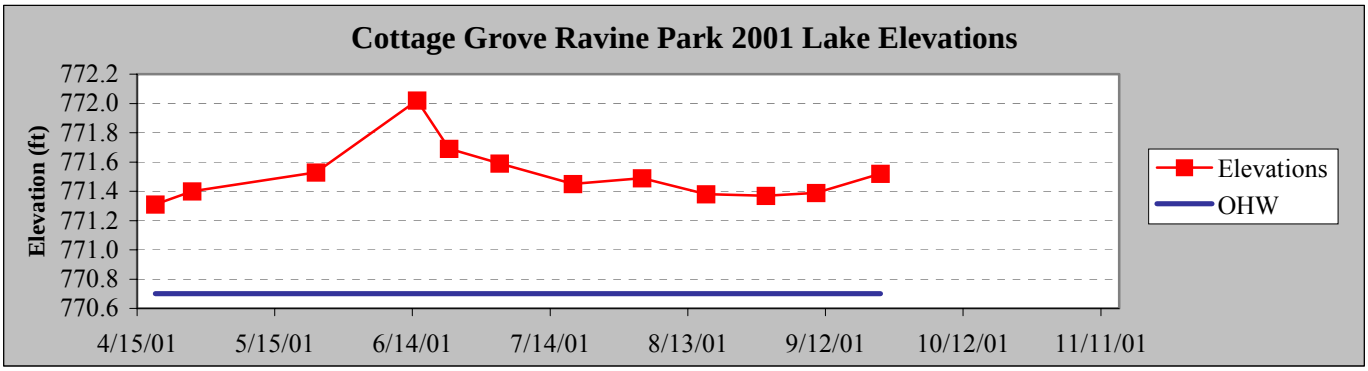
e. Powers Lake Elevations and Ordinary High Water (OHW)



f. Bailey Lake Elevations



g. Vandeberg Lake Elevations



h. Cottage Grove Ravine Park Lake Elevations and Ordinary High Water (OHW)

Observation Wells

Six observation wells were monitored ten times from March 28-December 17, 2001. Table 14 shows the high, low, range and average depth from land surface to groundwater during the 2001 monitoring.
Figure 14 shows the fluctuation of the groundwater elevations for each well during the 2001 monitoring. The groundwater table was highest (less distance to groundwater surface) in June and July. Washington SWCD staff attempted to monitor a seventh observation well (616494) on each of the dates listed in Table 14; however, on all occasions, the well was locked and therefore not read.

Table 14. SWWD 2001 Observation Well Elevations

Well #	Dates Monitored	# Readings	Surface Elevation (ft)	Lowest Reading (ft) Date	Highest Reading (ft) Date	Range (ft)	Average Depth to Water Surface (ft)
545602	3/28/01 – 12/17/01	10	904.39	832.34 4/18/01	835.2 9/28/01	2.86	834.19
545603	3/28/01 – 12/17/01	10	906.42	846.71 3/28/01	859.97 7/30/01	13.26	855.27
545604	3/28/01 – 12/17/01	10	886.60	842.55 3/28/01	852.90 6/25/01	10.35	849.89
616493	3/28/01 – 12/17/01	10	917.32	837.67 3/28/01	852.80 6/25/01	15.13	844.83
616497	3/28/01 – 12/17/01	10	920.34	868.96 4/18/01	890.23 6/25/01	21.27	871.16
616498	3/28/01 – 12/17/01	10	913.55	862.10 4/18/01	890.15 6/25/01	28.05	865.76

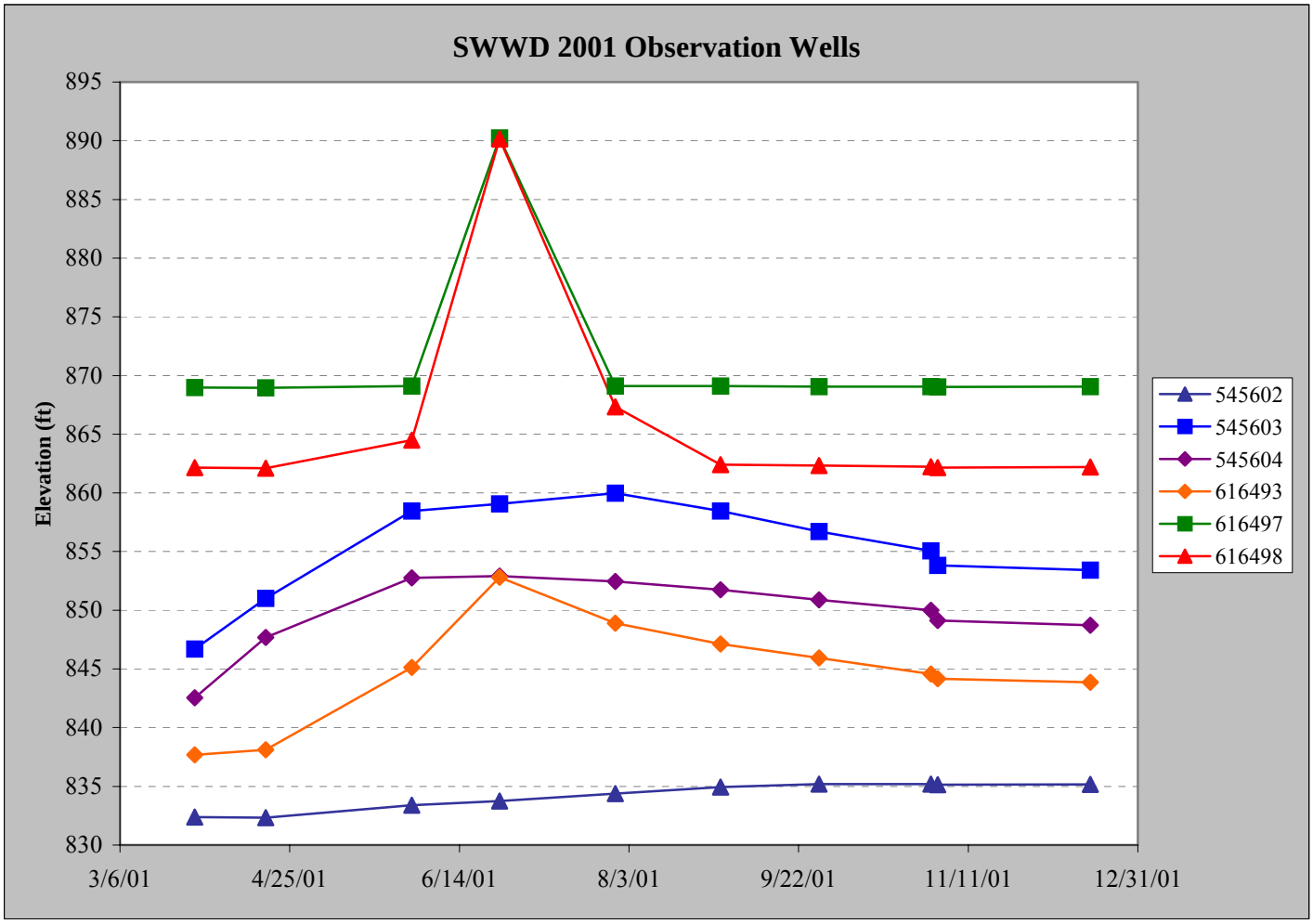


Figure 14. SWWD 2001 Observation Well Elevations