

Memorandum

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist)

The Beaver Dam Lake Management District treated 278 acres of Beaver Dam Lake with 2,4-D in 2014 to attain the District goal of reducing Eurasian watermilfoil (EWM) to no more than ten percent of the littoral zone area while minimizing harm to native aquatic plants (Table 1). Herbicide residue samples were collected from sites within each treatment area at intervals of approximately 0.04, 0.16, 1, 2, 3, 5, 7, 12, 19, and 26 days after treatment (DAT). Whole lake point intercept plant surveys were completed July 12 through 16 and October 10 through 12. All plants were surveyed in July. Only invasive species (i.e., Eurasian watermilfoil and curly-leaf pondweed) were surveyed in October.

Table 1 2014 EWM Treatment Plan

Treatment Area	Acres Treated	Treatment Date	2,4-D Concentration Applied to Each Treatment Area (ppm)	Expected Whole Lake/Bay Concentration of 2,4-D (ppm)
West Lake Basins				
West Lake	65.12	6/24/2014	4	0.3
Williams Bay	15.95	6/17/2014	4	0.3
Rabbit Island Bay	12.97	6/11/2014	4	0.3
Library Lake	1.89	5/22/2014	4	0.3
East Lake Basins				
Norwegian Bay	37.90	6/3/2014	0.6	0.6
East Lake	33.83	6/6/2014	4	0.6
City Bay	102.17	6/9/2014	0.6	0.6
Cemetery Bay	8.08	6/10/2014	2	0.3

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 2
Project: 49030011.14
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The purpose of this memorandum is to present the results of the 2014 herbicide treatment program to control Eurasian watermilfoil (EWM) in Beaver Dam Lake. This memorandum discusses (1) results of the 2014 herbicide residue monitoring program and (2) changes in EWM frequency and extent between 2013 and 2014. The memorandum first discusses lake-wide treatment results and then discusses results from the eight treatment areas: West Lake, Williams Bay, Rabbit Island Bay, Library Lake, Norwegian Bay, East Lake, City Bay, and Cemetery Bay. The eight treatment areas differed in herbicide dose and/or expected post-treatment bay-wide herbicide concentration. Results of the herbicide residue monitoring program are included in the discussion of results from the eight treatment areas.

EWM frequency in this memorandum is the percent of sample points up to the 25-foot depth containing EWM. The 2014 District goal was to attain a lake-wide EWM frequency of 10 percent or less.

1.0 2014 EWM Treatment Results

1.1 Lake-Wide Treatment Results

The July 2014 aquatic plant survey results indicate the herbicide treatment reduced EWM frequency by nearly an order of magnitude, from 19 percent in the fall of 2013 to 2 percent during July of 2014 (Figure 1). EWM expanded in coverage more than four-fold between summer and fall and occurred at a frequency of 9 percent during October of 2014. The net effect of the 2014 treatment was a reduction of EWM frequency by about half between the fall of 2013 and the fall of 2014. The 2014 District EWM frequency goal of 10 percent or less was met in 2014 (Figure 1).

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 3
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

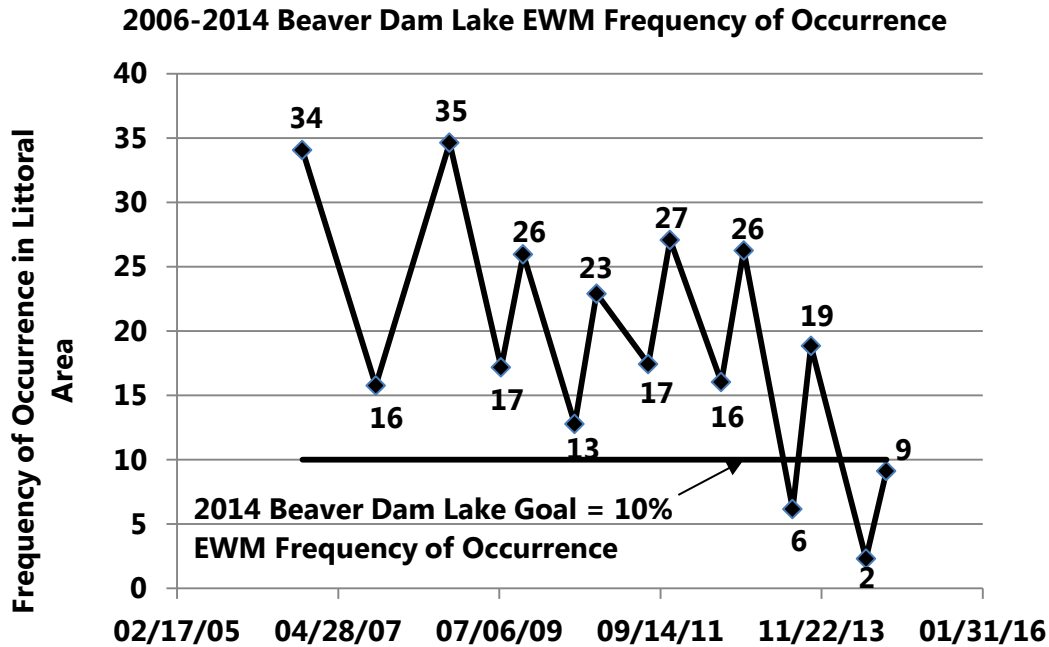


Figure 1 2006-2014 Beaver Dam Lake Frequency of Occurrence in Littoral Area

The 2014 herbicide treatment reduced EWM extent by more than an order of magnitude, from 122 acres in the fall of 2013 to 10 acres in July of 2014 (Figure 2). EWM expanded in coverage more than six-fold between summer and fall and occurred in 67 acres during October of 2014. Hence, the net effect of the 2014 treatment was a reduction in EWM extent by nearly half between the fall of 2013 and the fall of 2014.

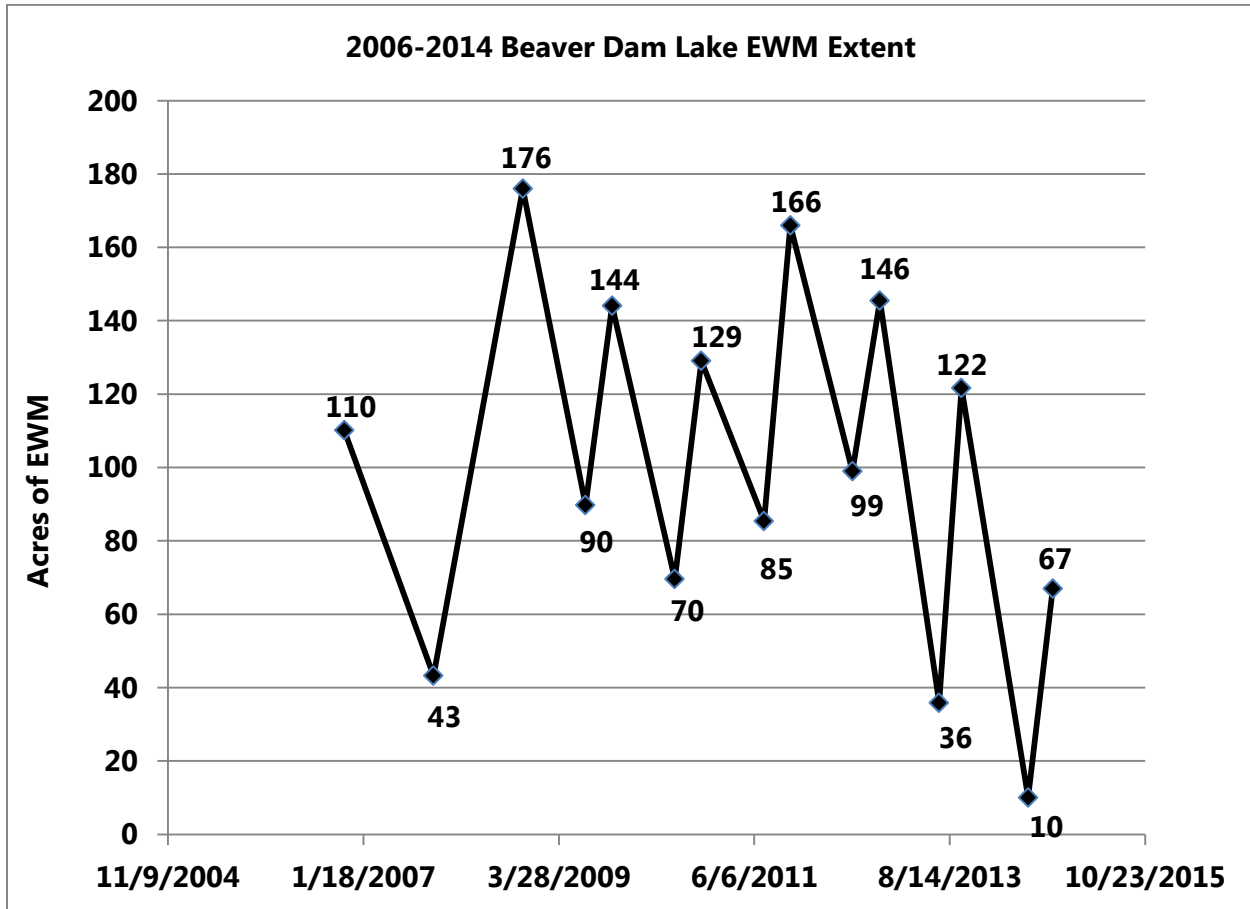


Figure 2 2006-2014 Beaver Dam Lake EWM Acreage

1.2 Results from the Eight Treatment Areas

Herbicide residue results and changes in EWM are discussed for each of the eight treatment areas.

Herbicide residue sample locations are shown in Figures 3 and 4. Changes in EWM in the eight treatment areas were determined in two ways – changes in frequency (Table 2) and changes in extent (Table 3).

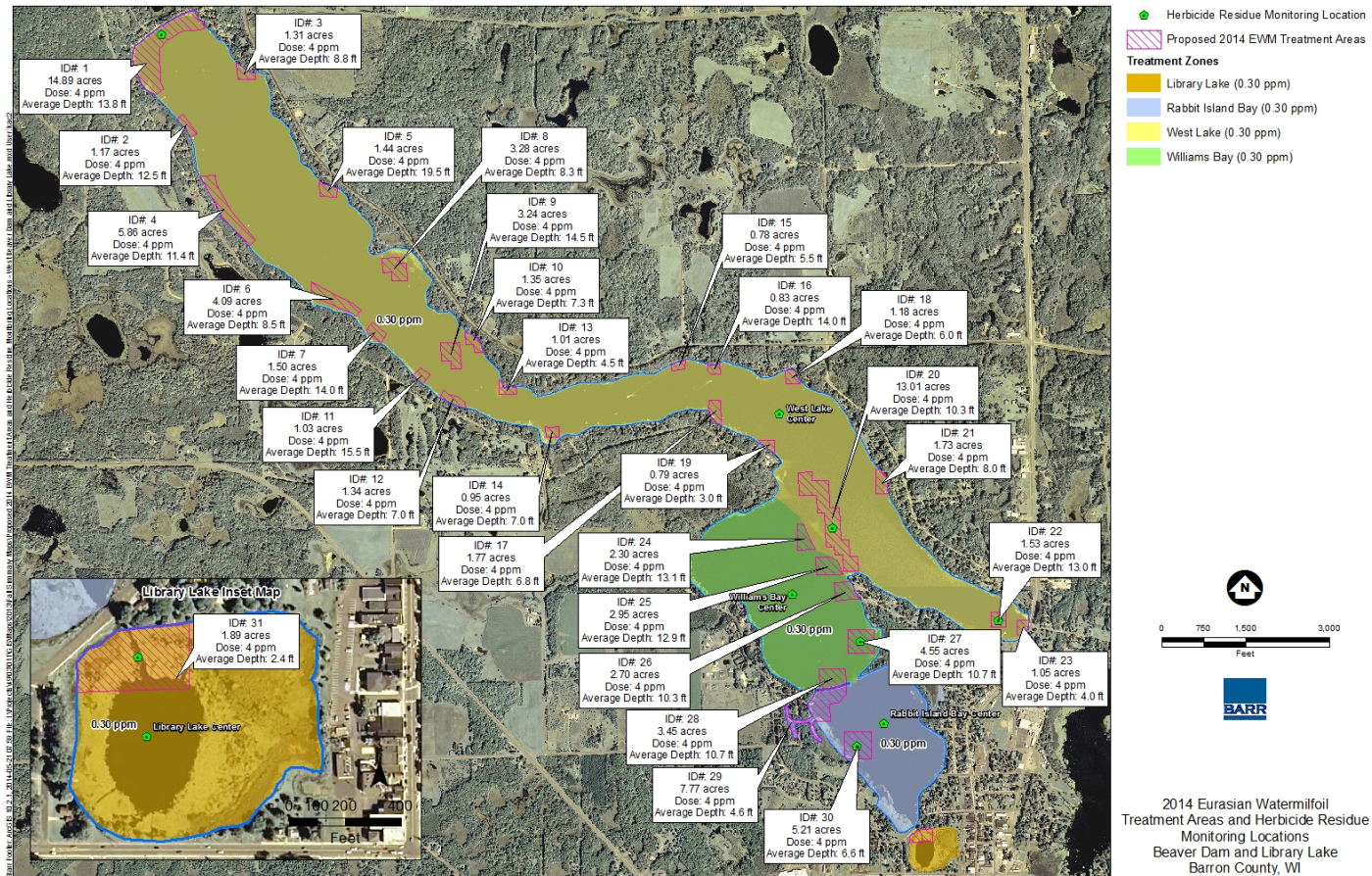


Figure 3 2014 Beaver Dam Lake Eurasian Watermilfoil Treatment Areas and Herbicide Residue Monitoring Locations: West Lake

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 6
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

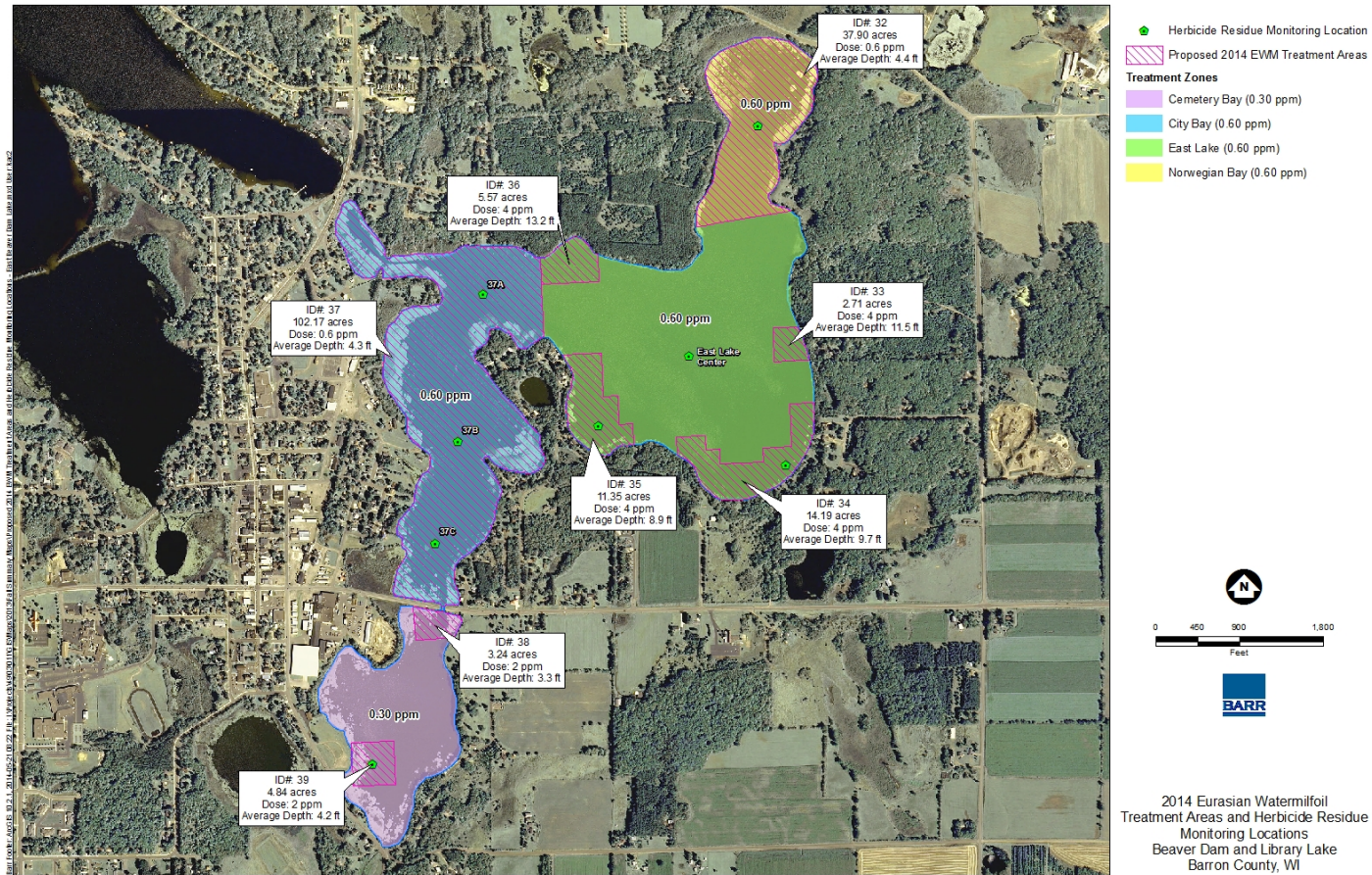


Figure 4 2014 Beaver Dam Lake Eurasian Watermilfoil Treatment Areas and Herbicide Residue Monitoring Locations: East Lake

Table 2. 2006-2014 Beaver Dam Lake EWM Frequency of Occurrence

Location	% of sample points up to 25 foot depth with Eurasian watermilfoil, including visuals																	
	Nov-06	Nov-07	Nov-08	Jul-09	Nov-09	Jul-10	Nov-10	Jul-11	Nov-11	Jun-12	Jul-12	Nov-12	May-13	Jun-13	Jul-13	Oct-13	Jul-14	Oct-14
West Lake	18.77	11.07	21.19	14.84	13.33	10.59	13.61	7.35	10.18	N/A	8.64	14.15	N/A		6.69	17.31	5.50	11.52
Williams Bay	13.33	28.05	23.81	16.98	11.01	3.85	12.15	9.80	10.19	N/A	3.85	15.96	N/A		0.96	6.36	0.00	9.43
Rabbit Island Bay	39.39	28.72	30.10	18.49	20.54	12.82	26.79	10.17	17.86	0.00	1.67	11.43			0.85	3.33	1.68	5.00
Library Lake	73.33	61.97	47.30	5.04	2.60	0.72	7.41	0.00	0.00	N/A	2.88	1.79	N/A	N/A	0.00	0.72	0.00	1.44
East Lake	5.13	0.00	13.38	14.00	27.86	22.70	27.54	28.78	33.79	N/A	17.57	27.86	N/A	N/A	2.88	19.73	0.73	2.10
City Bay	59.12	7.74	72.84	32.78	62.13	21.67	55.93	54.40	70.39	8.89	48.07	58.90	46.93	0.00	21.67	46.11	1.67	9.44
Norwegian Bay	28.57	16.39	52.46	39.71	80.00	33.82	28.36	11.76	51.52	13.24	54.41	72.13	39.71	0.00	7.35	58.82	4.41	44.12
Cemetery Bay	41.10	0.00	40.00	0.00	6.82	0.00	10.23	3.37	47.73	N/A	0.00	18.39	N/A	3.37	0.00	2.25	0.00	1.14

 Limited areas surveyed - not the whole lake/bay area
 Rabbit Island Bay channels surveyed and a small area near the Eagle Point Boat Launch was surveyed.

Table 3. 2006-2014 EWM Extent in Beaver Dam Lake

Treatment Area	Acreage of EWM (based on plant surveys)																	
	Fall 2006	Fall 2007	Fall 2008	July 2009	Fall 2009	July 2010	Fall 2010	July 2011	Fall 2011	June 2012	July 2012	Fall 2012	May 2013	June 2013	July 2013	October 2013	July 2014	October 2014
East Lake	0.00	0.00	9.34	8.14	19.37	14.13	17.48	17.18	23.93	N/A	11.33	19.98	N/A	N/A	1.18	15.72	0.33	0.90
City Bay	60.25	3.94	68.06	27.89	61.62	20.11	54.01	47.97	73.66	7.65	48.76	55.75	50.85	0.00	20.70	49.01	0.79	7.26
Cemetery Bay	10.90	0.00	17.80	0.00	1.81	0.00	3.97	0.86	21.32	N/A	0	7.17	N/A	0.75	0.00	0.51	0.00	0.26
Norwegian Bay	3.64	4.75	18.12	8.65	28.23	12.09	9.61	1.99	19.67	3.36	21.21	26.91	15.16	0.00	2.19	23.37	1.10	17.89
West Lake	25.27	11.36	33.19	24.59	19.67	15.80	25.15	8.65	14.78	N/A	15.31	23.11	N/A	3.15	10.05	29.13	7.23	29.94
Rabbit Island Bay	5.80	12.36	13.21	10.57	8.51	6.26	11.47	4.22	8.01	0	0.51	5.64	0	N/A	0.38	1.45	0.61	3.11
Williams Bay	3.63	10.23	12.64	9.48	4.80	1.15	6.68	4.57	4.65	N/A	1.68	6.92	N/A	0.26	0.33	2.46	0.00	7.45
Library Lake	0.66	0.59	3.62	0.40	0.09	0.04	0.72	0.00	0.00	N/A	0.2	0.04	N/A	N/A	0.00	0.06	0.00	0.14
East Lake Total:	74.79	8.69	113.32	44.68	111.03	46.33	85.07	67.99	138.58	N/A	81.30	109.81	N/A	N/A	24.07	88.60	2.22	26.31
West Lake Total:	35.36	34.54	62.66	45.04	33.07	23.25	44.02	17.44	27.44	N/A	17.70	35.70	N/A	N/A	10.76	33.10	7.84	40.64
Beaver Dam Lake Total	110.15	43.23	175.98	89.72	144.10	69.58	129.09	85.43	166.02	N/A	99.00	145.51	N/A	N/A	35.88	121.70	10.06	66.96

1.2.1 West Lake – West Lake treatment included 23 spot treatments with target concentrations of 4,000 µg/L ae, which were calculated to result in a bay wide target concentration of 300 µg/L assuming dissipation throughout the bay (Figure 5). Herbicide application occurred on June 24.

Concentrations of 2,4-D in water samples from the monitored treatment areas ranged from 1,600 µg/L ae to 1,700 µg/L ae at 0.04 Days after Treatment (DAT) and from 71 µg/L ae to 1,700 µg/L ae at 1 DAT (Figure 5). Concentrations of 2,4-D in water samples from the lake’s center, which was not treated, ranged from 25 µg/L ae to 230 µg/L ae at 0.04 to 1 DAT (Figure 5). The mean lake wide concentration in samples collected from 0.04 to 7 DAT was 463 µg/L ae compared to the target lake wide concentration of 300 µg/L ae. Site 1 at the northwest end of the lake was able to attain and sustain a 2,4-D concentration of at least 300 µg/L ae for 7 days (Figure 5). Concentrations at Sites 20 and 22 were less than 300 µg/L ae by 1 or 2 DAT (Figure 5). The untreated center location did not attain a 2,4-D concentration of 300 µg/L ae (Figure 5).

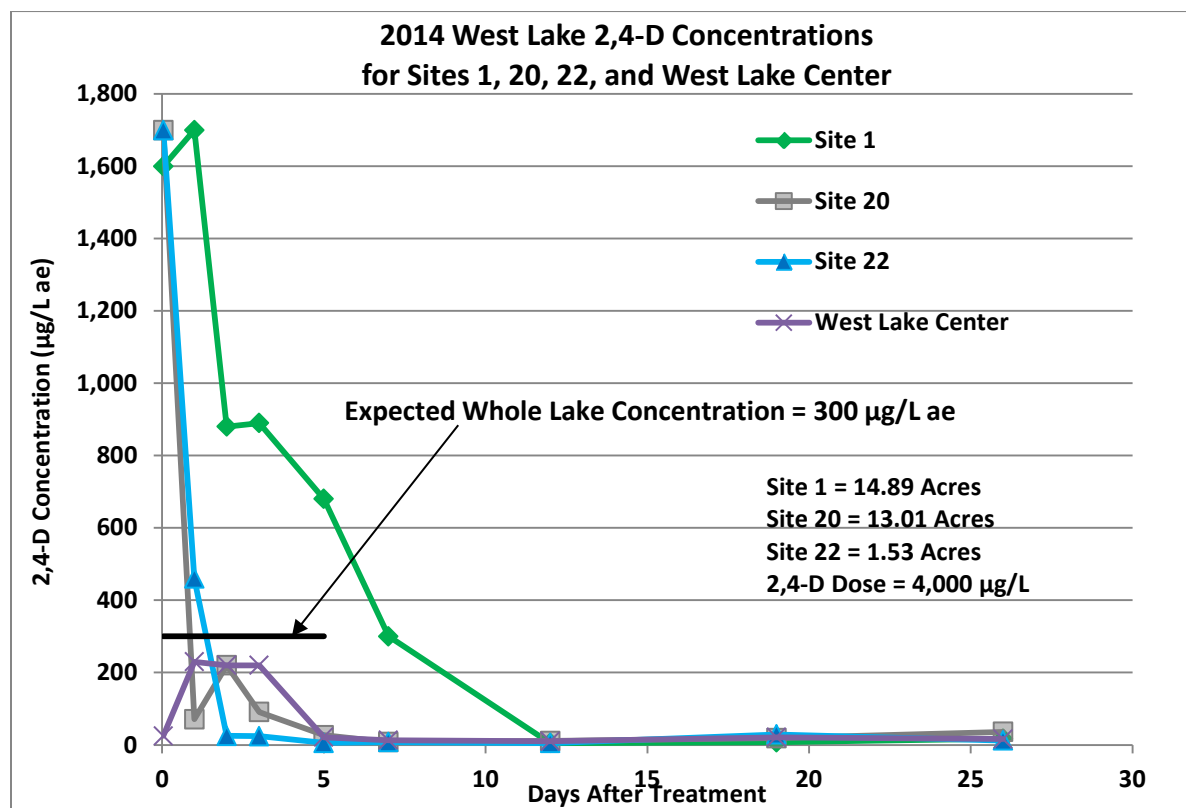


Figure 5 2014 West Lake 2,4-D Concentrations for Sites 1, 20, 22, and West Lake Center

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 9
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

The 2014 herbicide treatment reduced EWM frequency by about two thirds (i.e., from 17 percent in fall of 2013 to 6 percent in July of 2014) and reduced EWM extent by more than three quarters (i.e., from 29 acres in fall of 2013 to 7 acres in July of 2014) (Figures 6 and 7). However, during the summer to fall period, EWM expanded in coverage, doubling EWM frequency of occurrence (i.e., from 6 percent July of 2014 to 12 percent in fall of 2014) and more than quadrupling EWM extent (i.e., from 7 acres in July of 2014 to 30 acres in fall of 2014) (Figures 6 and 7). EWM beds adjacent to deep water were burned by the herbicide, but not killed. These beds reestablished and were dense, monotypic, canopied beds in fall. These EWM beds provided opportunity for boat traffic to shred and spread EWM.



in

West Lake EWM beds adjacent to deep water were burned by the herbicide treatment, but not killed (pictured above).

Although EWM in the northwestern area of the lake had the 2,4-D dose and contact time needed to attain lasting control, EWM in other areas of the lake did not have the 2,4-D dose and contact time needed to attain lasting control of EWM. Not surprising, EWM control in the northwestern area of West Lake was better than other areas of West Lake. The data indicate a higher 2,4-D dose may be needed to attain the dose and contact time needed for lake-wide EWM control.

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 10
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

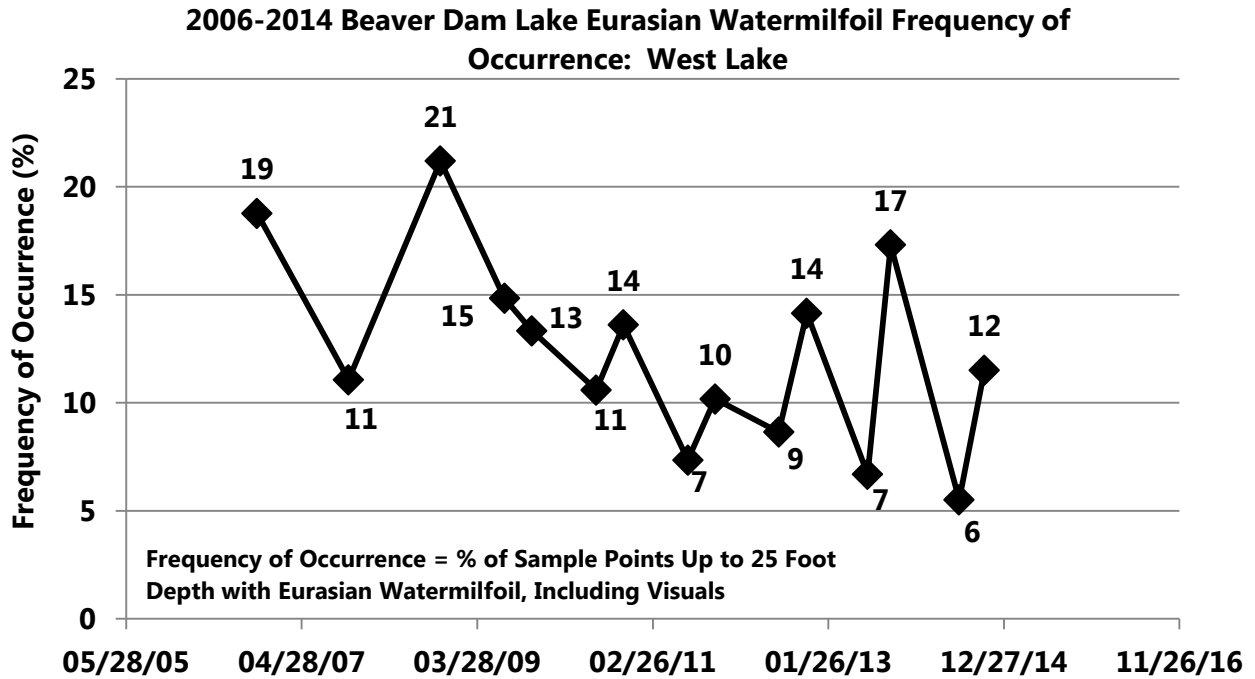


Figure 6 2006-2014 Beaver Dam Lake Frequency of Occurrence in Littoral Area: West Lake

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 11
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

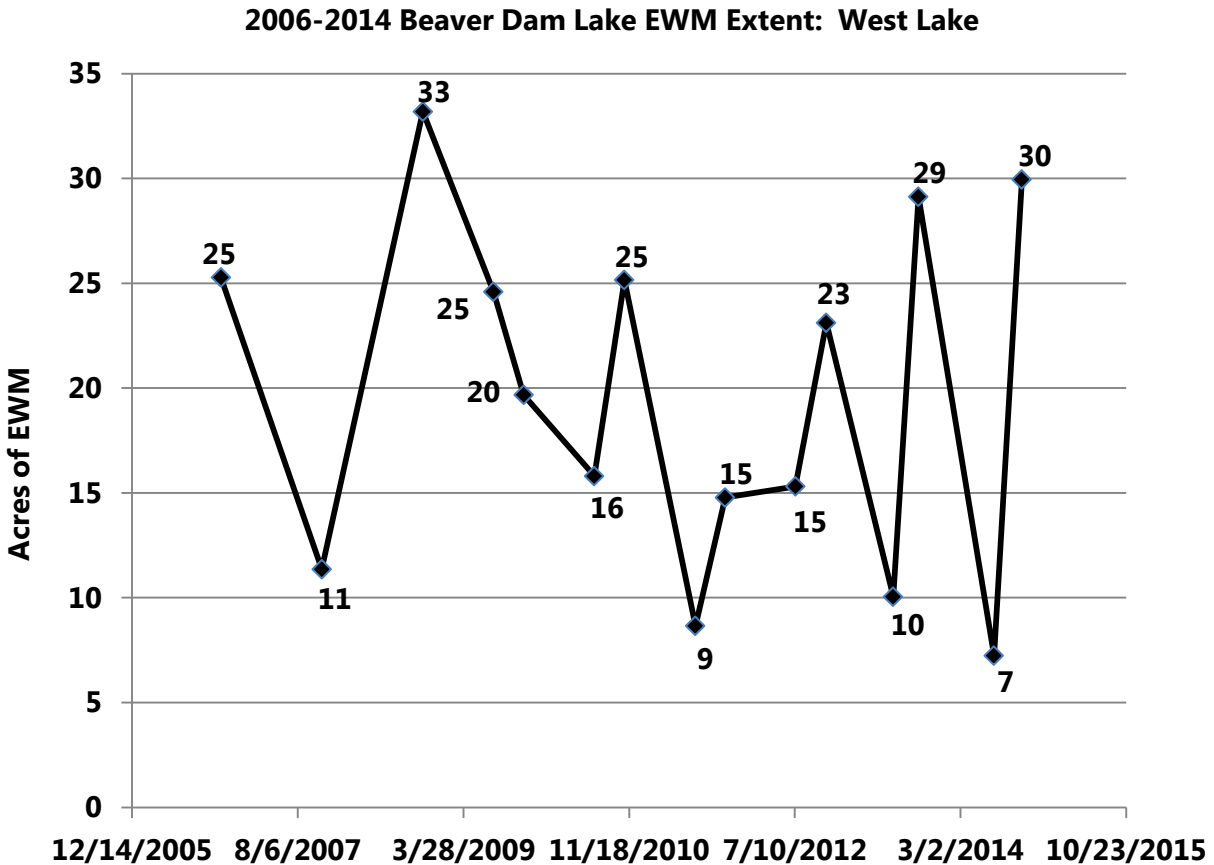


Figure 7 2006-2014 Beaver Dam Lake EWM Acreage: West Lake

1.2.2 Williams Bay - Williams Bay treatment included 5 spot treatments with target concentrations of 4,000 µg/L ae, which were calculated to result in a bay wide target concentration of 300 µg/L assuming dissipation throughout the bay. Herbicide application occurred on June 17.

Concentrations of 2,4-D in water samples from the monitored treatment area ranged from 570 µg/L to 1,700 µg/L ae at 0.04 to 1 DAT (Figure 8). Concentrations of 2,4-D in water samples from the lake's center, which was not treated, ranged from 160 µg/L ae to 210 µg/L ae at 0.04 to 1 DAT (Figure 8). The mean lake wide concentration in samples collected from 0.04 to 7 DAT was 310 µg/L ae compared to the

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 12
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

target lake wide concentration of 300 µg/L ae (Figure 8). The treatment area was able to attain and sustain a 2,4-D concentration of at least 300 µg/L ae for 3 days.

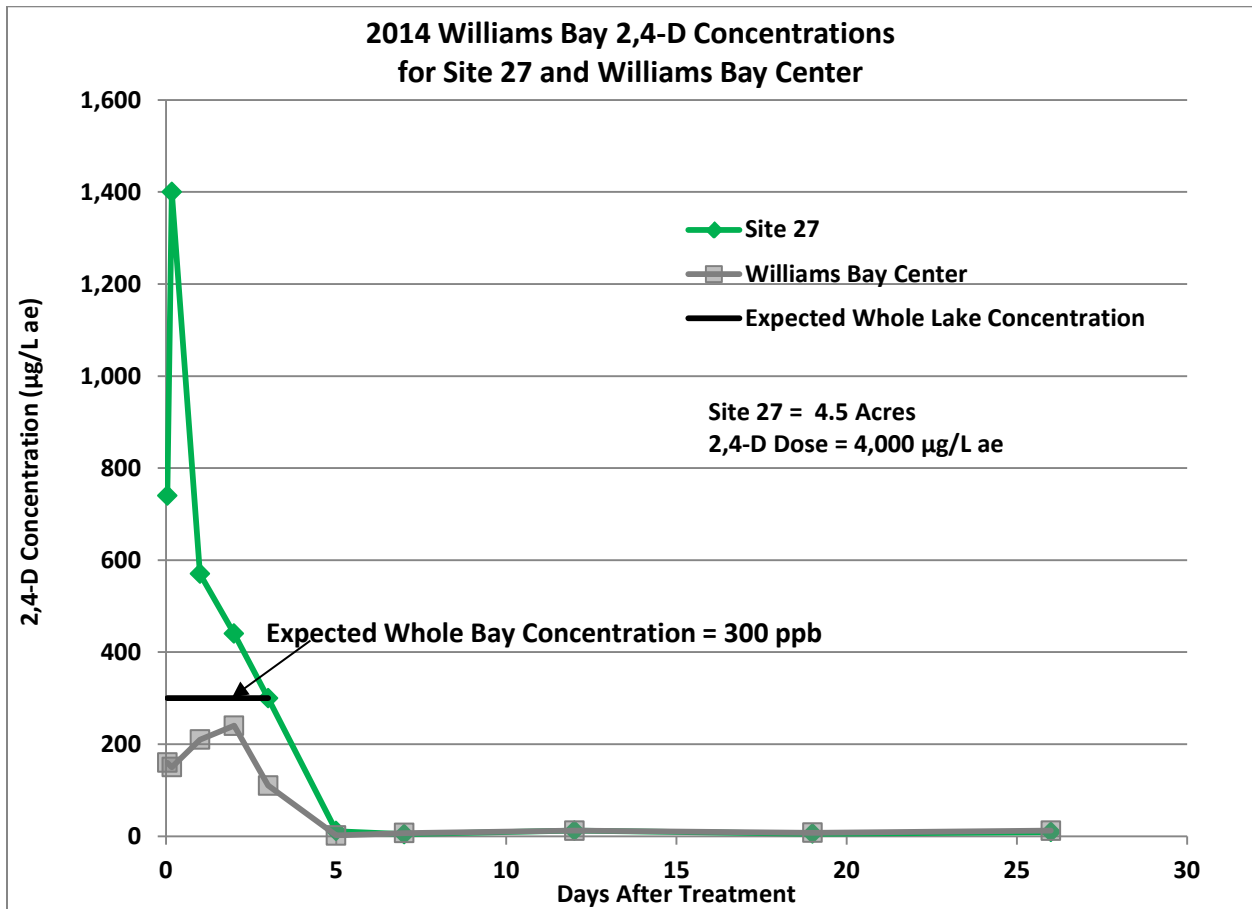


Figure 8 2014 Williams Bay 2,4-D Concentrations for Site 27 and Williams Bay Center

In fall of 2013, EWM frequency and extent in Williams Bay were 6 percent and 2 acres, respectively (Figures 9 and 10). After the 2014 herbicide treatment, EWM was not observed in Williams Bay during the July plant survey (Figures 9 and 10). However, in late summer a lake resident observed wind and wave action from a strong north wind moving EWM fragments from the Eagle Point boat landing area into Williams Bay. In fall of 2014, EWM frequency in Williams Bay was 9 percent and EWM extent was 7 acres (Figures 9 and 10). The locations where EWM was found in the fall of 2014 corresponded with

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 13
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

locations where EWM fragments were deposited by wind and wave action during late summer. The data indicate a higher herbicide dose is needed in both Williams Bay and adjacent West Lake to effectively control EWM in the Eagle Point Boat landing area. Unless controlled, EWM in this high traffic area spreads to other areas, including Williams Bay.

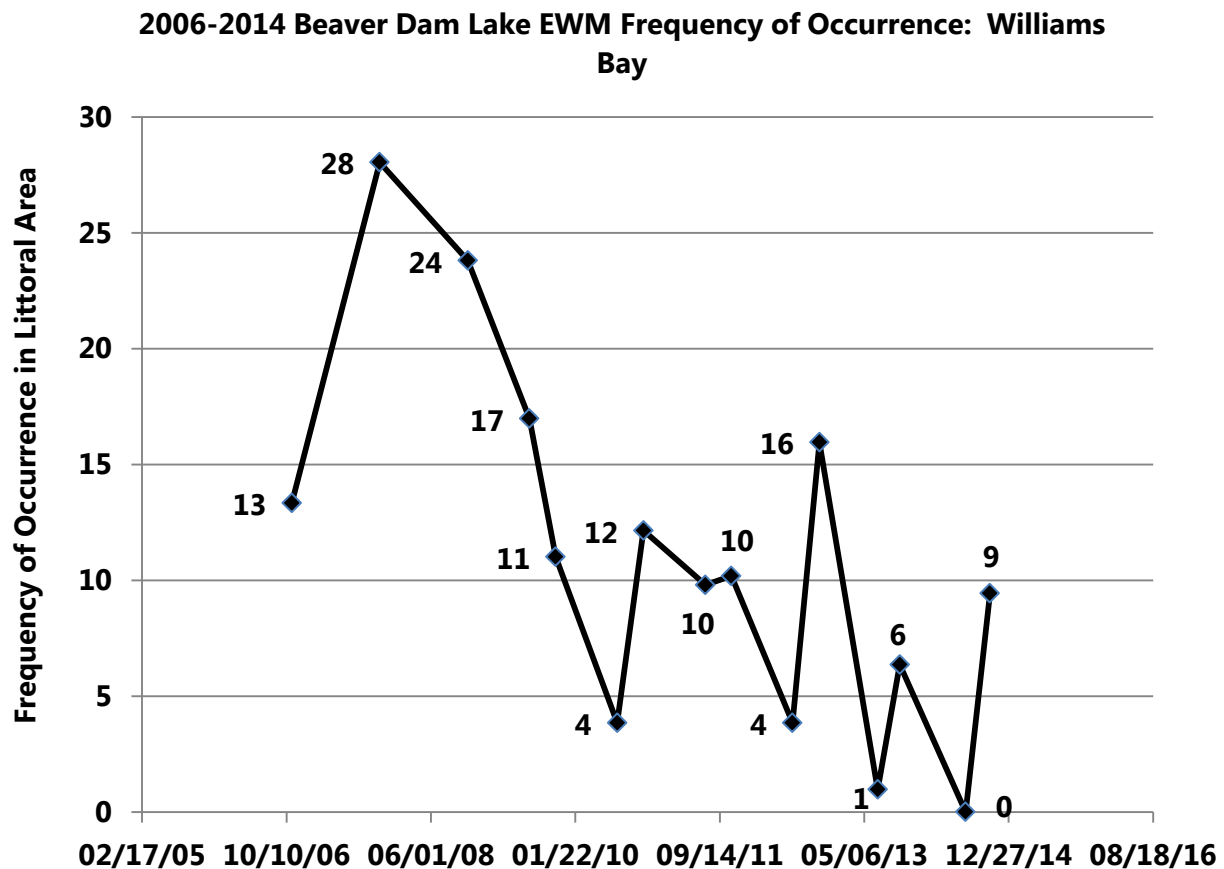


Figure 9 2006-2014 Beaver Dam Lake Frequency of Occurrence in Littoral Area: Williams Bay

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 14
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

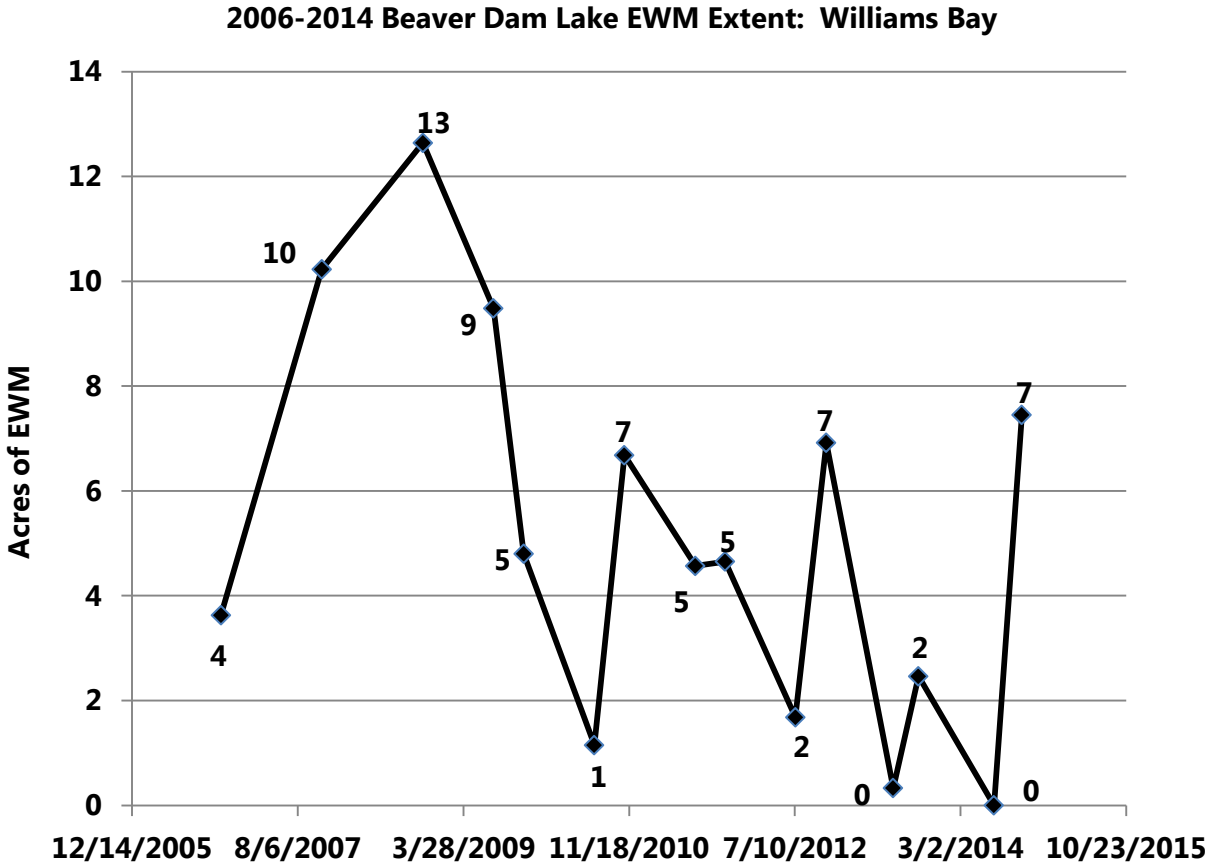


Figure 10 2006-2014 Beaver Dam Lake EWM Acreage: Williams Bay

1.2.3 Rabbit Island Bay – Rabbit Island Bay treatment included two spot treatments with target concentrations of 4,000 µg/L ae, which were calculated to result in a bay wide target concentration of 300 µg/L assuming dissipation throughout the bay (Figure 11). Herbicide application occurred on June 11.

Concentrations of 2,4-D in water samples from a monitored treatment area ranged from 680 µg/L ae to 1,400 µg/L ae at 0.04 to 1 DAT (Figure 11). Concentrations of 2,4-D in water samples from the bay’s center, which was not treated, ranged from 16 µg/L ae to 390 µg/L ae at 0.04 to 1 DAT (Figure 11). The mean lake wide concentration in samples collected from 0.04 to 7 DAT was 476 µg/L ae compared to the

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 15
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

target lake wide concentration of 300 µg/L ae (Figure 11). The treatment area was able to attain and sustain a 2,4-D concentration of at least 300 µg/L ae for 7 days.

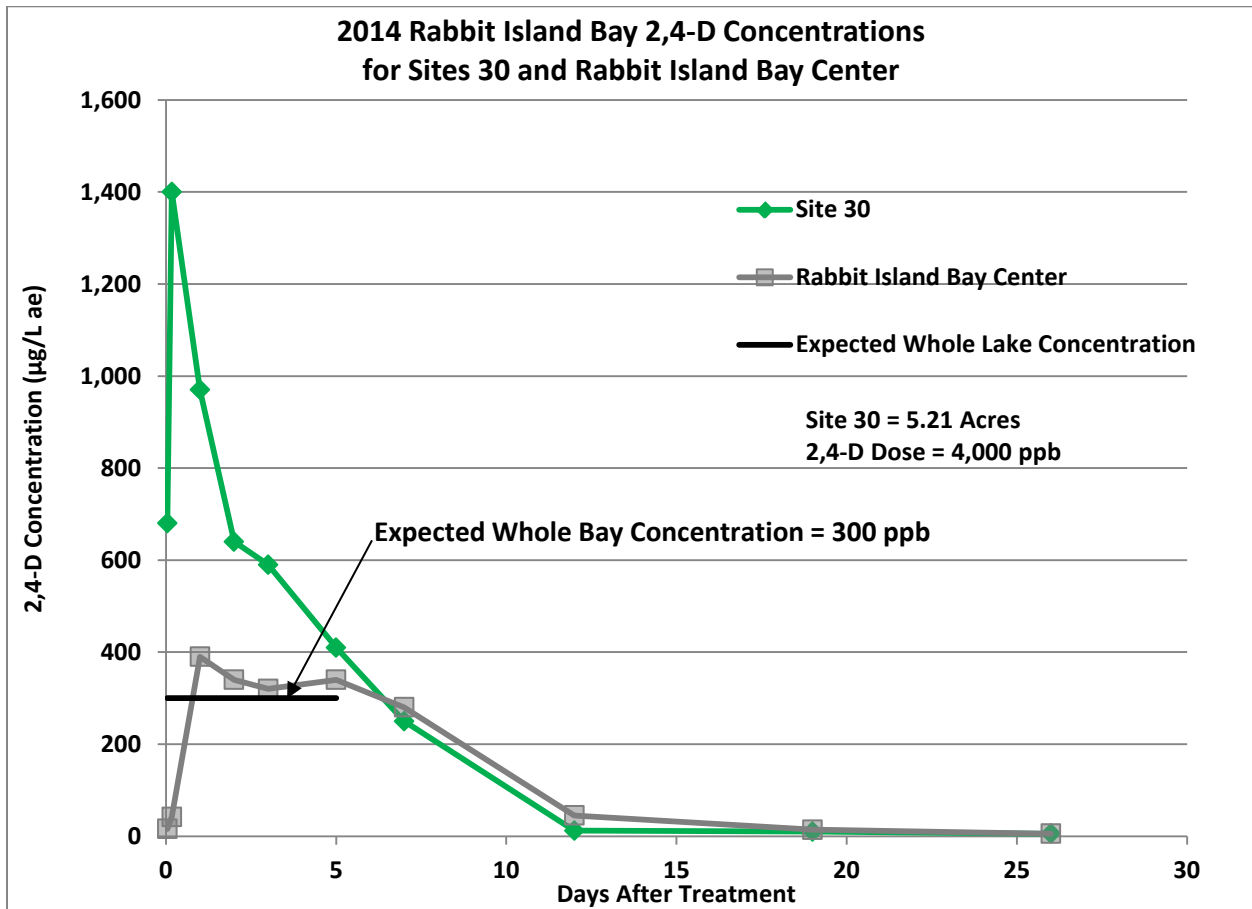


Figure 11 2014 Rabbit Island Bay 2,4-D Concentrations for Site 30 and Rabbit Island Bay Center

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 16
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

The 2014 herbicide treatment reduced EWM frequency in Rabbit Island Bay from 3 percent during the fall of 2013 to 2 percent during July of 2014 (Figure 12). EWM extent was reduced by about half, from 1.4 acres in the fall of 2013 to 0.6 acres during July of 2014 (Figure 13). While EWM remained at relatively low levels from summer to fall, an increase in EWM frequency and extent were observed during the fall survey. EWM frequency increased from 2 percent in July to 5 percent in fall (Figure 12). EWM extent increased from 0.6 acres in July to 3.1 acres in fall (Figure 13). In fall, EWM was present in low density in both the Plum Street and Terrace Drive channels and was scattered just northeast of the Terrace Drive Channel entrance on the bay's west side – clusters of plants were nearing canopy (i.e., nearing the surface.

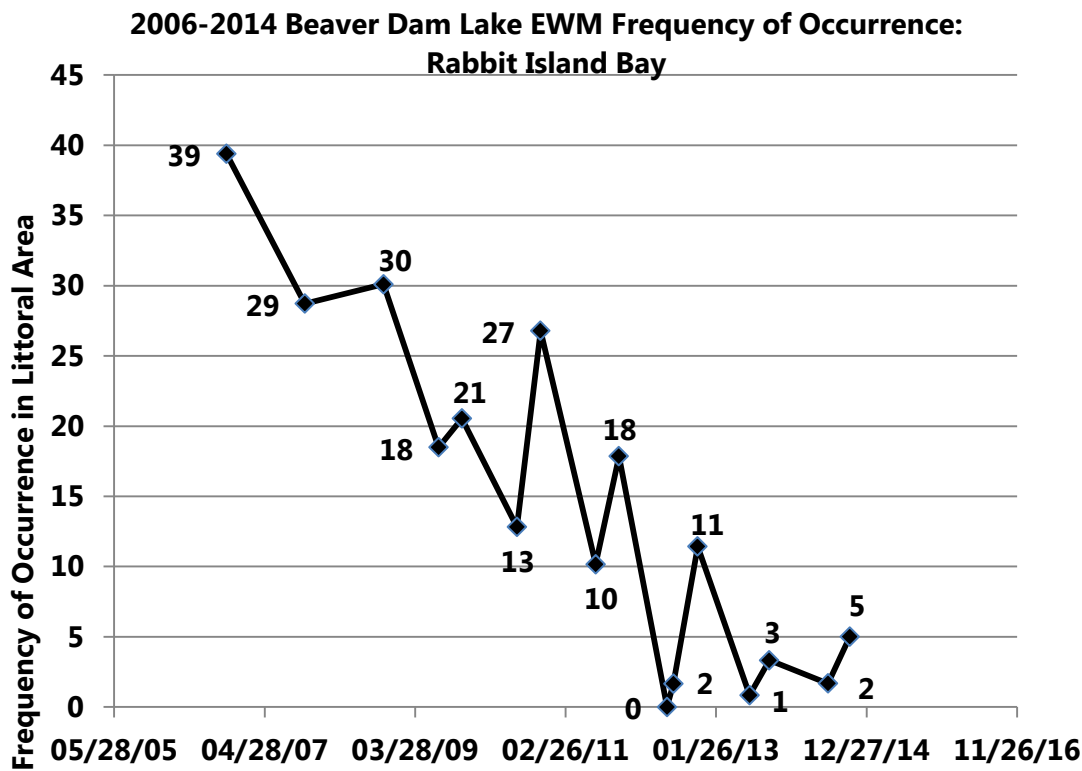


Figure 12 2006-2014 Beaver Dam Lake Frequency of Occurrence in Littoral Area: Rabbit Island Bay

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 17
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

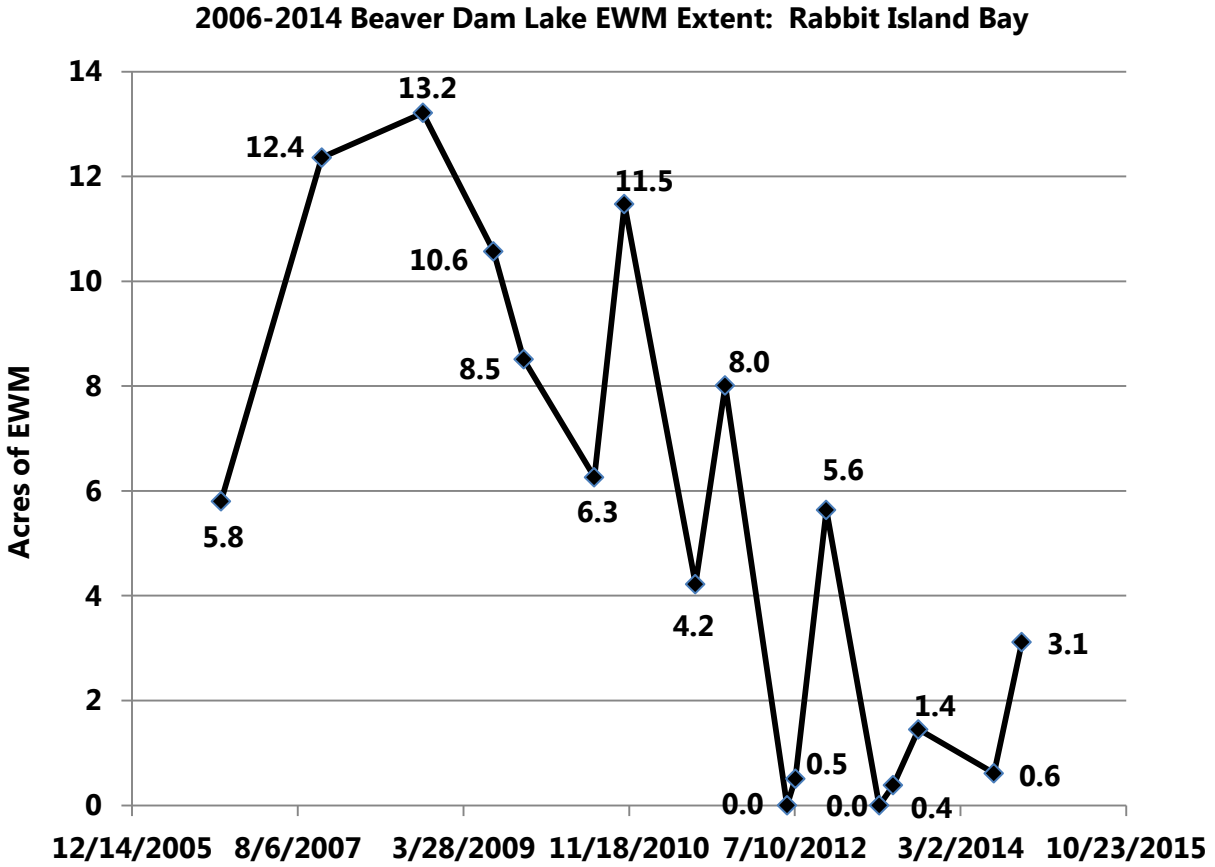


Figure 13 2006-2014 Beaver Dam Lake EWM Acreage: Rabbit Island Bay

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 18
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

The low levels of EWM consistently observed in Rabbit Island Bay during the past couple of years show the EWM reduction attained since 2006 has been sustained. EWM frequency in 2006 was 39 percent compared with 5 percent in 2014 (Figure 12). EWM extent in Rabbit Island Bay has declined from a high of 13.2 acres in fall of 2008 to 3.1 acres in fall of 2014 (Figure 13). The District considers the present reduction successful. However, continued herbicide treatments are needed to reduce EWM to even lower levels so as to attain the lake-wide goal of a 7 percent frequency of occurrence.

1.2.4 **Library Lake** - Library Lake treatment included one spot treatment with a target concentration of 4,000 $\mu\text{g/L ae}$, which was calculated to result in a bay wide target concentration of 300 $\mu\text{g/L}$ assuming dissipation throughout the bay (Figure 14). Herbicide application occurred on May 22.

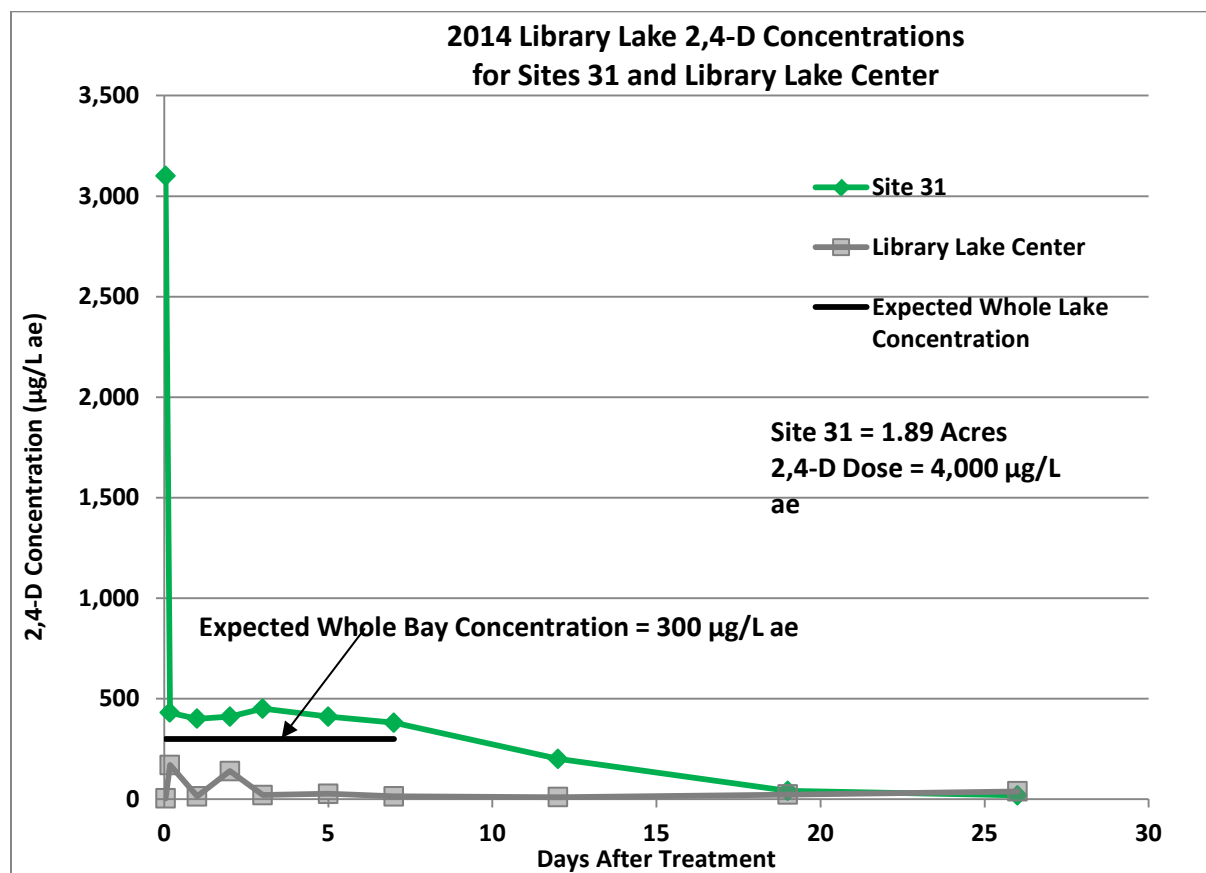


Figure 14 2014 Library Lake 2,4-D Concentrations for Site 31 and Library Lake Center

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 19
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

Concentrations of 2,4-D in water samples from the monitored treatment area ranged from 400 µg/L ae to 3,100 µg/L ae at 0.04 to 1 DAT (Figure 14). Concentrations of 2,4-D in water samples from the bay's center, which was not treated, ranged from 3.9 µg/L ae to 170 µg/L ae at 0.04 to 1 DAT (Figure 14). The mean lake wide concentration in samples collected from 0.04 to 7 DAT was 426 µg/L ae compared to the target lake wide concentration of 300 µg/L ae. The treatment area was able to attain and sustain a 2,4-D concentration of at least 300 µg/L ae for 7 days.

In fall of 2013, EWM was found at a frequency of less than 1 percent and an extent of 0.06 acres (Figures 15 and 16). After the 2014 herbicide treatment, EWM was not observed in Library Lake during the July plant survey (Figures 15 and 16). However, during the fall survey, a handful of EWM plants were observed in the channel leading out of the lake. The EWM frequency and extent during fall of 2014 were 1 percent and 0.1 acres, respectively (Figures 15 and 16).

The low levels of EWM consistently observed in Library Lake during the past few years indicate the EWM reduction attained since 2006 has been sustained. EWM frequency in fall of 2006 was 73 percent compared with 1 percent in fall 2014 (Figure 15). EWM extent in Library Lake has declined from a high of 3.62 acres in fall of 2008 to 0.14 acres in fall of 2014 (Figure 16). The District considers the present reduction successful. However, continued herbicide treatments are needed to reduce EWM to even lower levels so as to attain the lake-wide goal of a 7 percent frequency of occurrence.

1.25 Cemetery Bay – Cemetery Bay treatment included two spot treatments with target concentrations of 4,000 µg/L ae, which were calculated to result in a bay wide target concentration of 300 µg/L assuming dissipation throughout the bay (Figure 17). Herbicide application occurred on June 10.

Concentrations of 2,4-D in water samples from the monitored treatment area ranged from 320 µg/L ae to 430 µg/L ae at 0.04 to 1 DAT (Figure 17). The mean concentration in samples collected from 0.04 to 7 DAT was 343 µg/L ae compared to the target lake wide concentration of 300 µg/L ae. The treatment area was able to attain and sustain a 2,4-D concentration of at least 300 µg/L ae for 5 days (Figure 17).

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 20
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

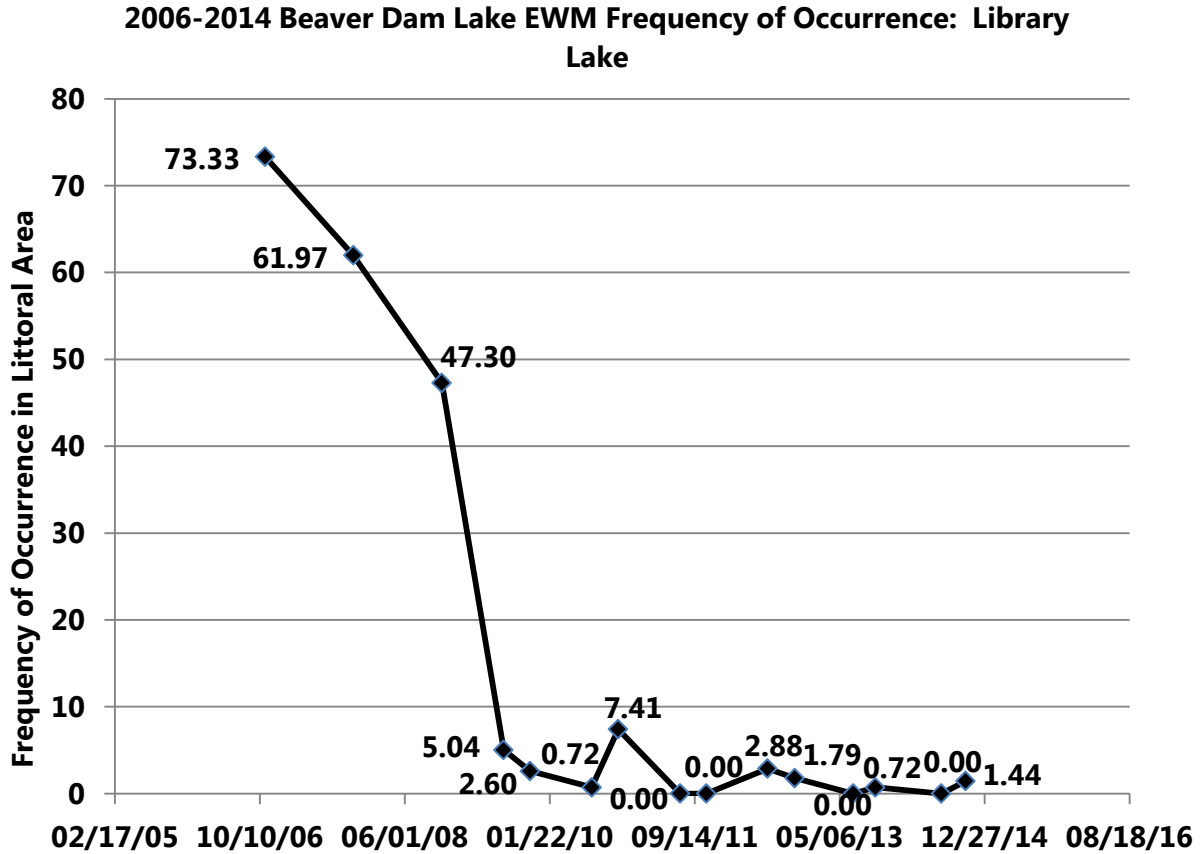


Figure 15 2006-2014 Beaver Dam Lake Frequency of Occurrence in Littoral Area: Library Lake

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 21
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

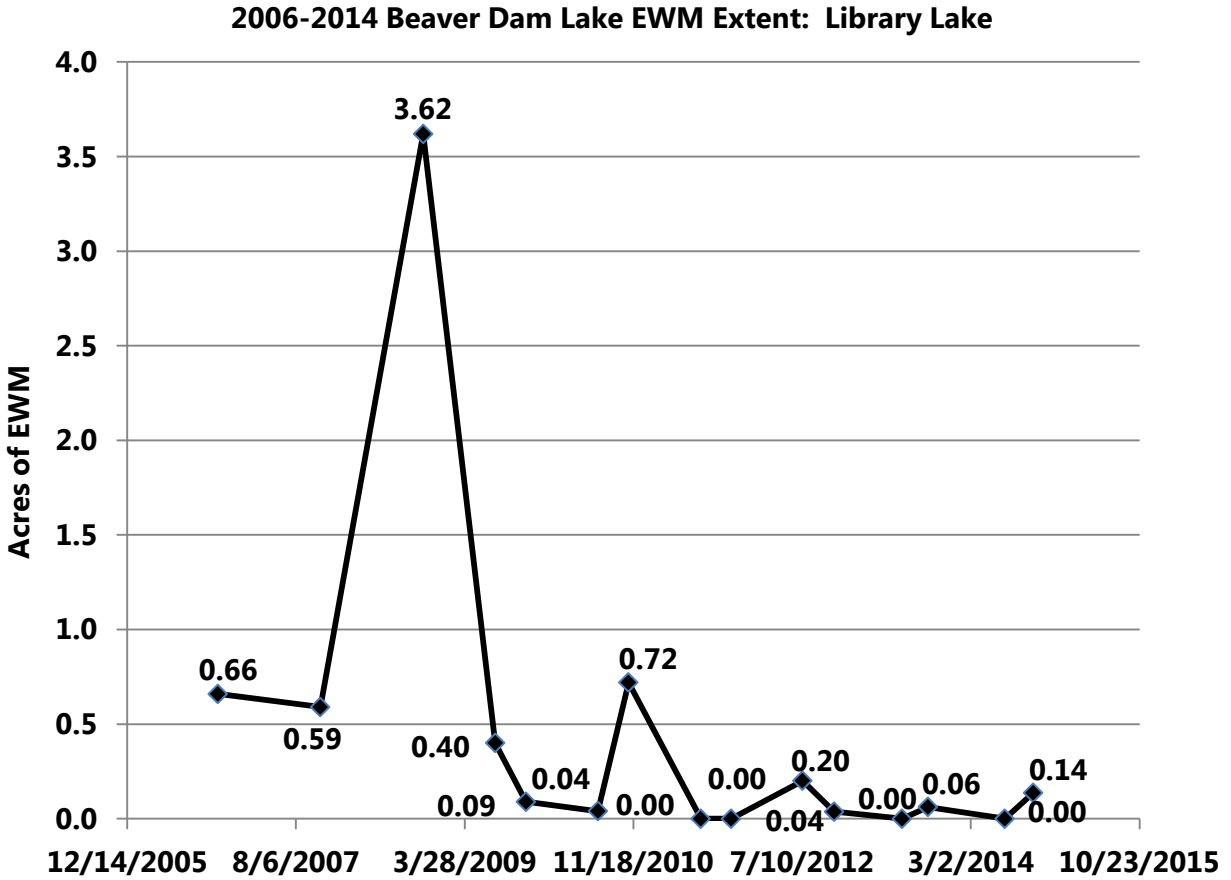


Figure 16 2006-2014 Beaver Dam Lake EWM Acreage: Library Lake

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 22
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

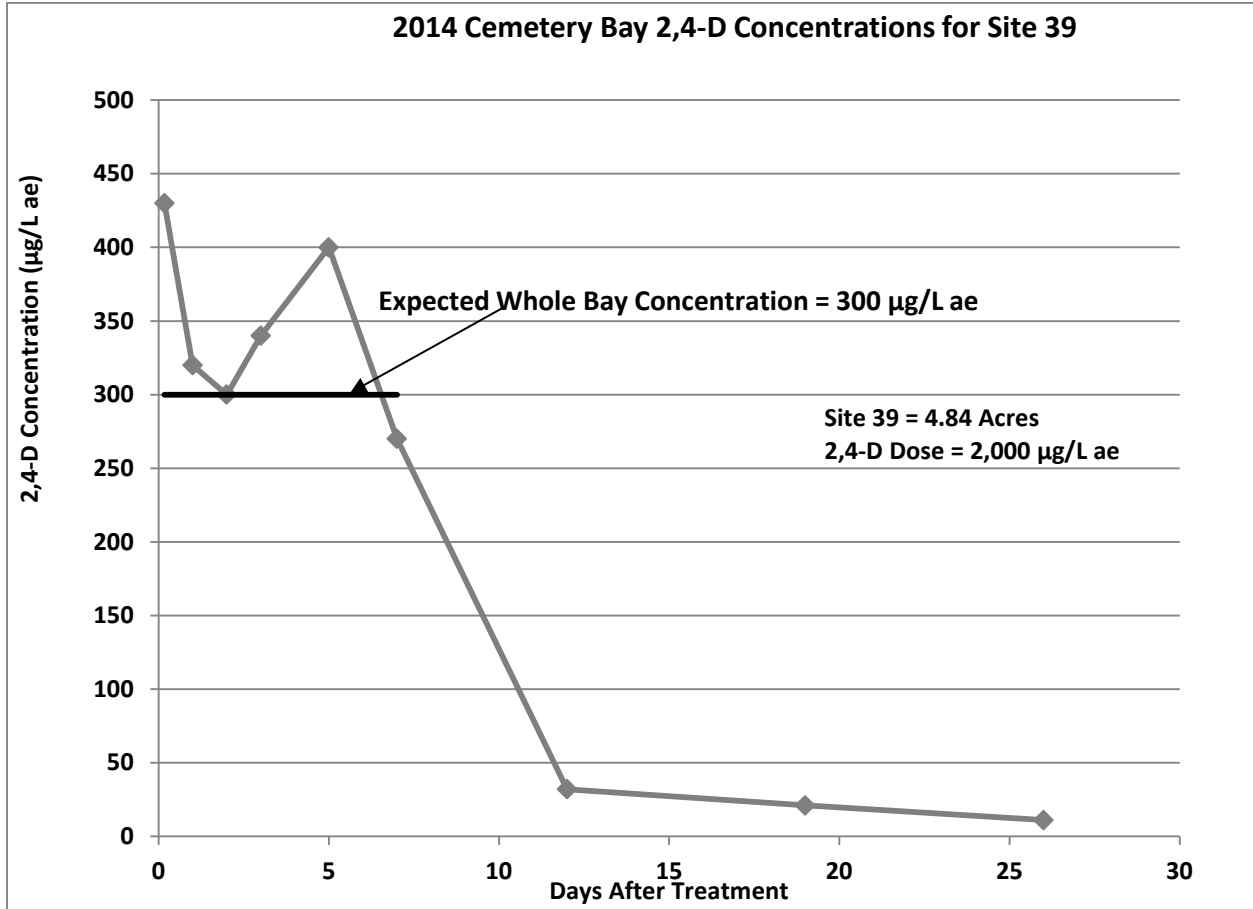


Figure 17 2014 Cemetery Bay 2,4-D Concentrations for Site 39

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 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 23
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

The 2014 herbicide treatment reduced EWM frequency in Cemetery Bay from 2 percent during the fall of 2013 to 0 percent (not observed) during July of 2014 (Figure 18). EWM extent was reduced from 0.5 acres in the fall of 2013 to 0 acres (not observed) during July of 2014 (Figure 19). In fall, a few widely scattered EWM plants were observed near the inlet from City Bay. In fall of 2014, EWM frequency was 1 percent and extent was 0.3 acres (Figures 18 and 19).

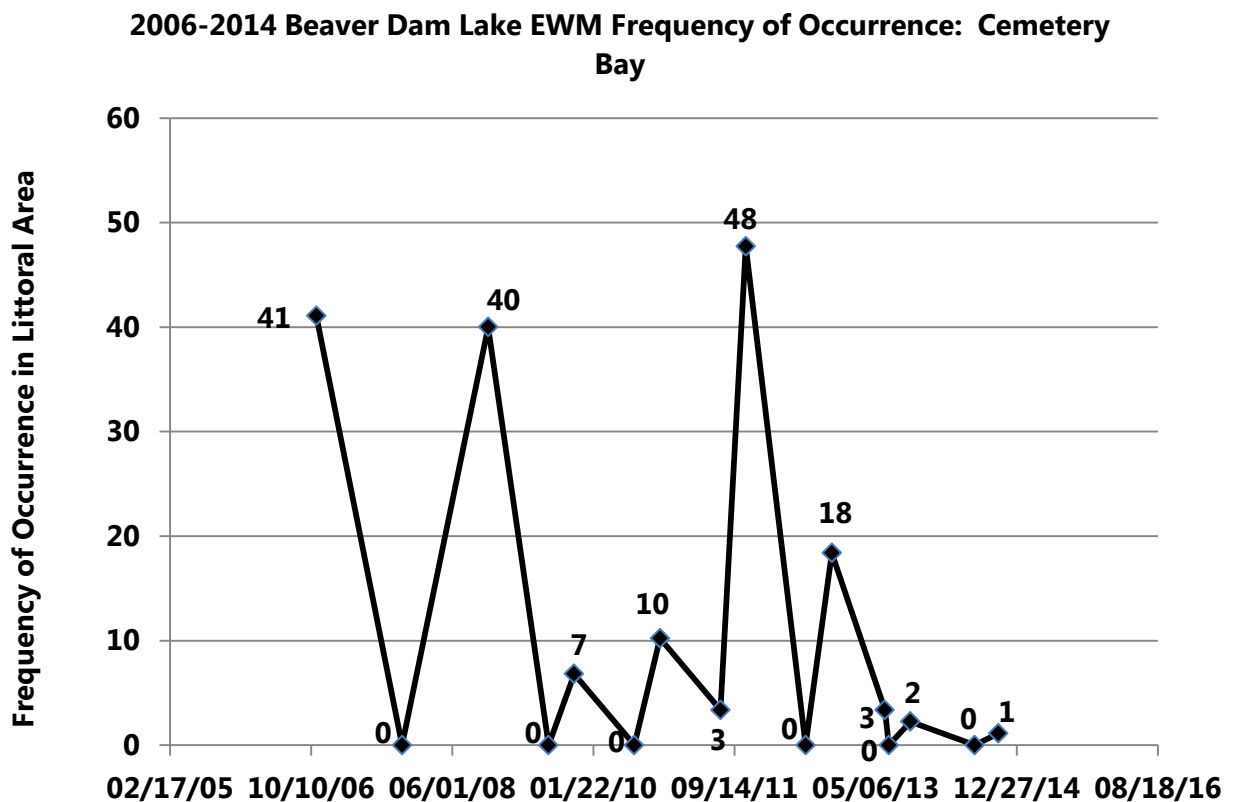


Figure 18 2006-2014 Beaver Dam Lake Frequency of Occurrence in Littoral Area: Cemetery Bay

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 24
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

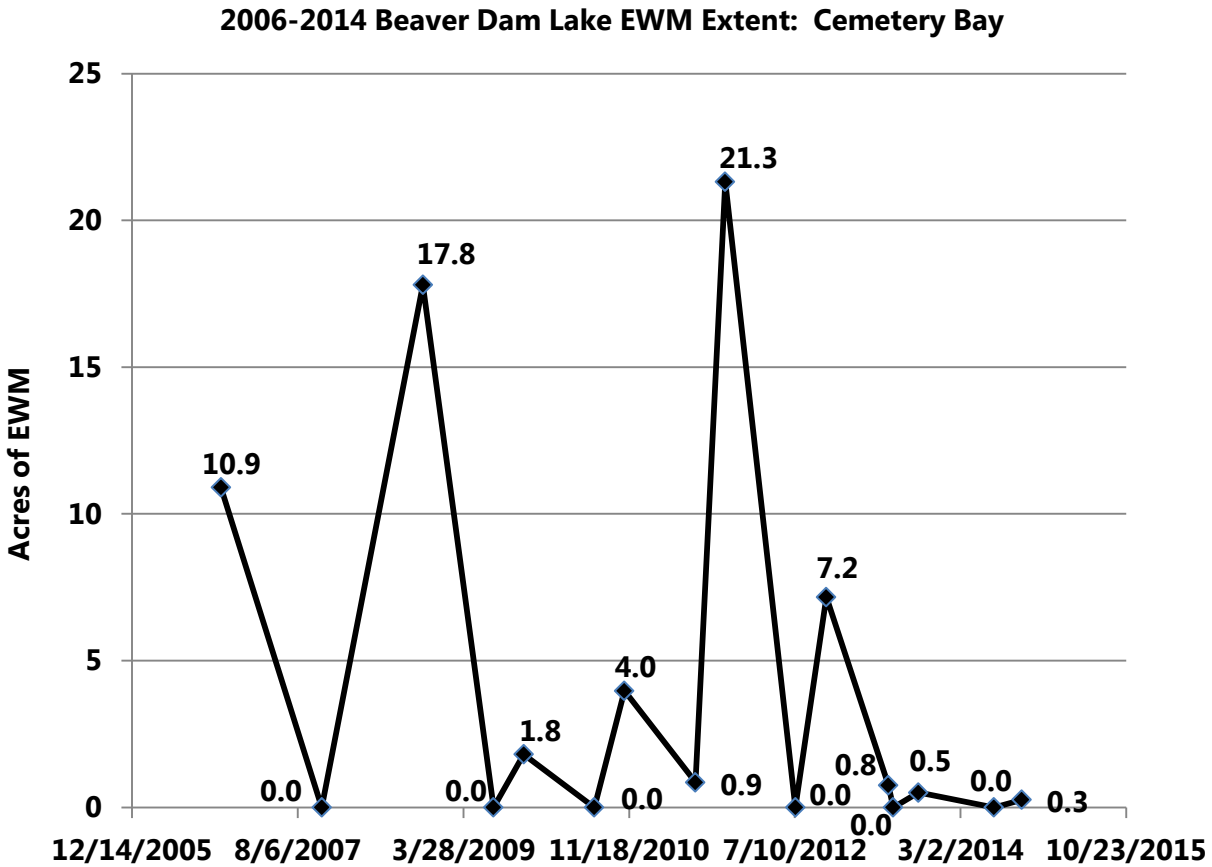


Figure 19 2006-2014 Beaver Dam Lake EWM Acreage: Cemetery Bay

The low levels of EWM consistently observed in Cemetery Bay during the past couple of years indicate the EWM reduction attained since 2011 has been sustained. EWM frequency in fall of 2011 was 48 percent compared with 1 percent in fall of 2014 (Figure 18). EWM extent in Cemetery Bay has declined from 21.3 acres in fall of 2011 to 0.3 acres in fall of 2014 (Figure 19). The District considers the present reduction successful. However, continued herbicide treatments are needed to reduce EWM to even lower levels so as to attain the lake-wide goal of a 7 percent frequency of occurrence.

1.26 City Bay - City Bay was a whole bay 2,4-D treatment with a bay wide target concentration of 600 µg/L ae. Herbicide application occurred on June 9.

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 25
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

Concentrations of 2,4-D in water samples from the monitored treatment areas ranged from 150 µg/L to 1,200 µg/L ae at 0.04 to 1 DAT (Figure 20). The mean lake wide concentration in samples collected from 0.04 to 7 DAT was 538 µg/L ae compared to the target lake wide concentration of 600 µg/L ae (Figure 20). Although all sample locations attained a 2,4-D concentration of at least 600 µg/L ae, none of the three locations sustained this concentration for at least three consecutive days (Figure 20). 2,4-D concentrations at all locations declined to 130 to 230 µg/L ae within 1 to 2 DAT and then increased to at least 600 µg/L ae for a day or two before declining again (Figure 20). The data indicate a higher 2,4-D dose may be needed to attain the dose and contact time needed for lake-wide EWM control.

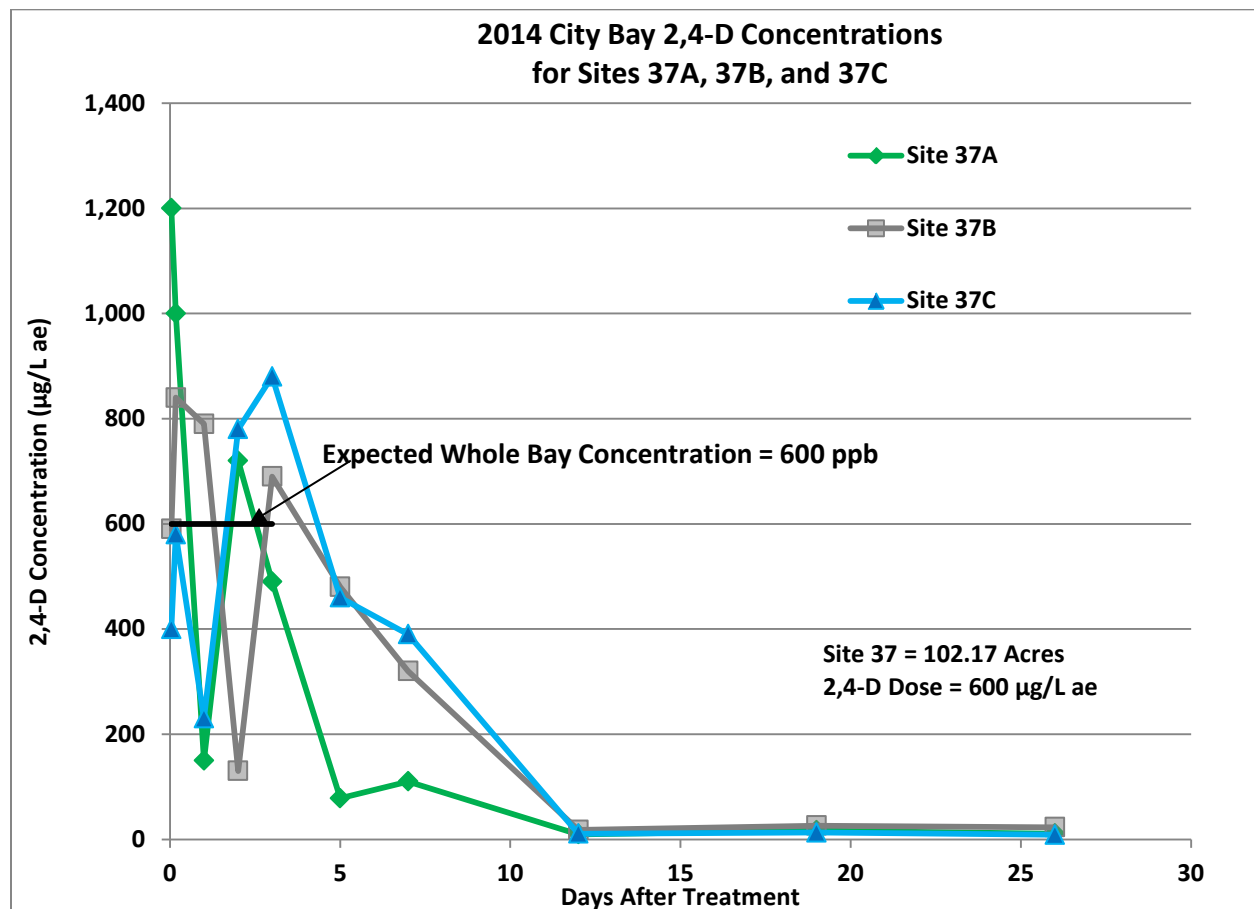


Figure 20 2014 City Bay 2,4-D Concentrations for Sites 37A, 37B, and 37C

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 26
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

The 2014 herbicide treatment reduced EWM frequency in City Bay from 46 percent during the fall of 2013 to 2 percent during July of 2014 (Figure 21). EWM extent was reduced from 49 acres in the fall of 2013 to 0.8 acres during July of 2014 (Figure 22). However, because EWM did not have the 2,4-D dose and contact time needed to attain lasting EWM control, EWM increased in both frequency and extent between summer and fall. In fall of 2014, EWM had reoccupied most of the areas where it had been observed in fall of 2013, although it was **much less dense** and had **recolonized a smaller area**. In fall of 2014, the western shoreline was rapidly filling in with EWM and most of the EWM was nearly canopied. In addition, patchy growths of EWM were observed along the eastern shoreline. It appeared that the eastern shoreline was headed back to solid EWM plants. EWM frequency increased from 2 percent in July to 9 percent in fall (Figure 21). EWM extent increased from 0.8 acres in July to 7 acres in fall (Figure 22). The data indicate a higher 2,4-D dose may be needed to attain the dose and contact time needed for bay-wide EWM control.

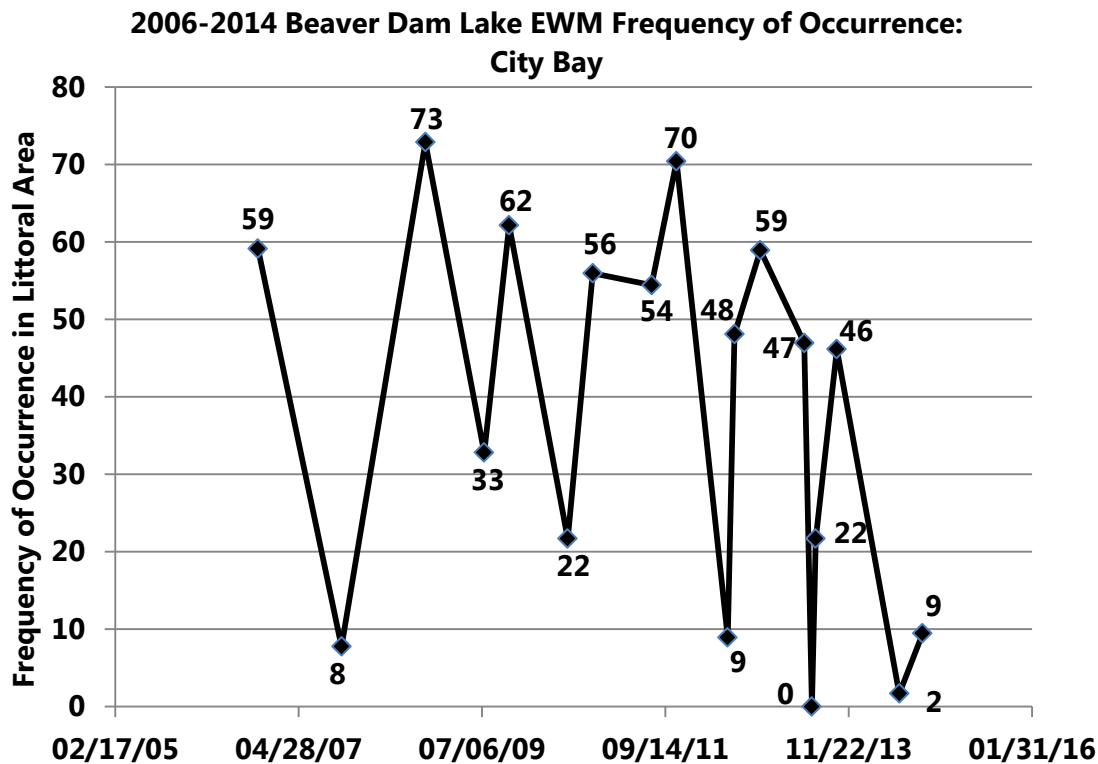


Figure 21 2006-2014 Beaver Dam Lake Frequency of Occurrence in Littoral Area: City Bay

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 27
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

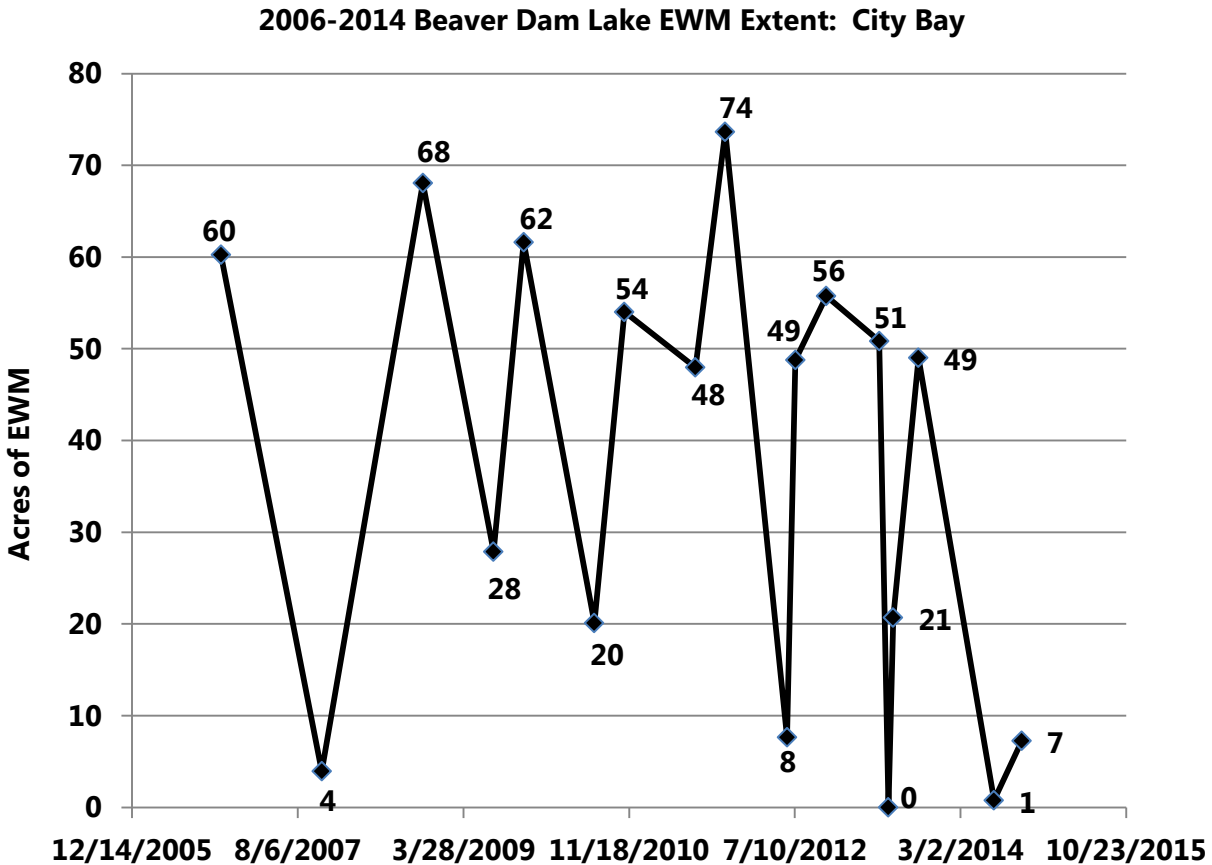


Figure 22 2006-2014 Beaver Dam Lake EWM Acreage: City Bay

1.27 East Lake - East Lake treatment included four spot treatments with target concentrations of 4,000 µg/L ae, which was calculated to result in a bay wide target concentration of 600 µg/L assuming dissipation throughout the bay (Figure 23). Herbicide application occurred on June 6.

Concentrations of 2,4-D in water samples from monitored treatment areas ranged from 490 µg/L ae to 4,400 µg/L ae at 0.04 to 1 DAT compared to the target concentration of 4,000 µg/L ae (Figure 23). Concentrations of 2,4-D in water samples from the bay’s center, which was not treated, ranged from 240 µg/L ae to 720 µg/L ae at 0.04 to 1 DAT (Figure 11). The mean lake wide concentration in samples collected from 0.04 to 7 DAT was 1,043µg/L ae compared with a target bay wide concentration of 600

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 28
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

µg/L ae. The treatment area was able to attain and sustain a 2,4-D concentration of at least 600 µg/L ae for at least 7 days.

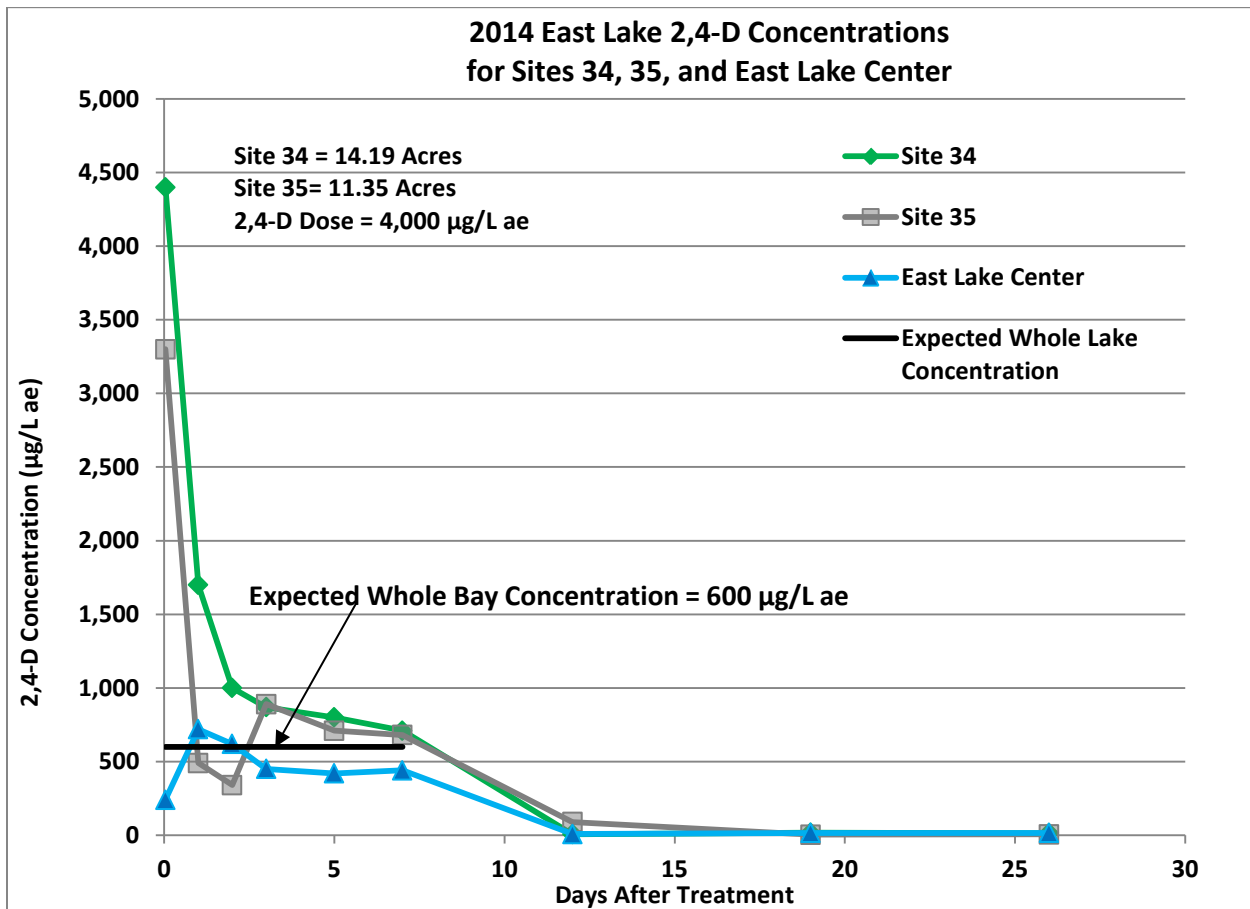


Figure 23 2014 East Lake 2,4-D Concentrations for Sites 34, 35, and East Lake Center

The 2014 herbicide treatment reduced EWM frequency in East Lake from 20 percent during the fall of 2013 to 1 percent during July of 2014 (Figure 24). EWM extent was reduced from 16 acres in the fall of 2013 to 0.3 acres during July of 2014 (Figure 25). The herbicide treatment attained lasting EWM control and the only significant EWM observed during fall was a bed located in the area between East Lake and City Bay. This bed was growing and expanding rapidly in fall. The southeast bay of the lake, an area in which EWM has persisted in previous years, noted less than a handful of plants in fall of 2014. EWM

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 29
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

frequency in East Lake remained low during summer through fall, only increasing from 1 percent in July to 2 percent in fall (Figure 24). EWM extent also remained low during summer through fall, only increasing from 0.3 acres in July to 0.9 acres in fall (Figure 25). The District considers the present reduction successful. However, continued herbicide treatments are needed to reduce EWM to even lower levels so as to attain the lake-wide goal of a 7 percent frequency of occurrence.

2006-2014 Beaver Dam Lake EWM Frequency of Occurrence: East Lake

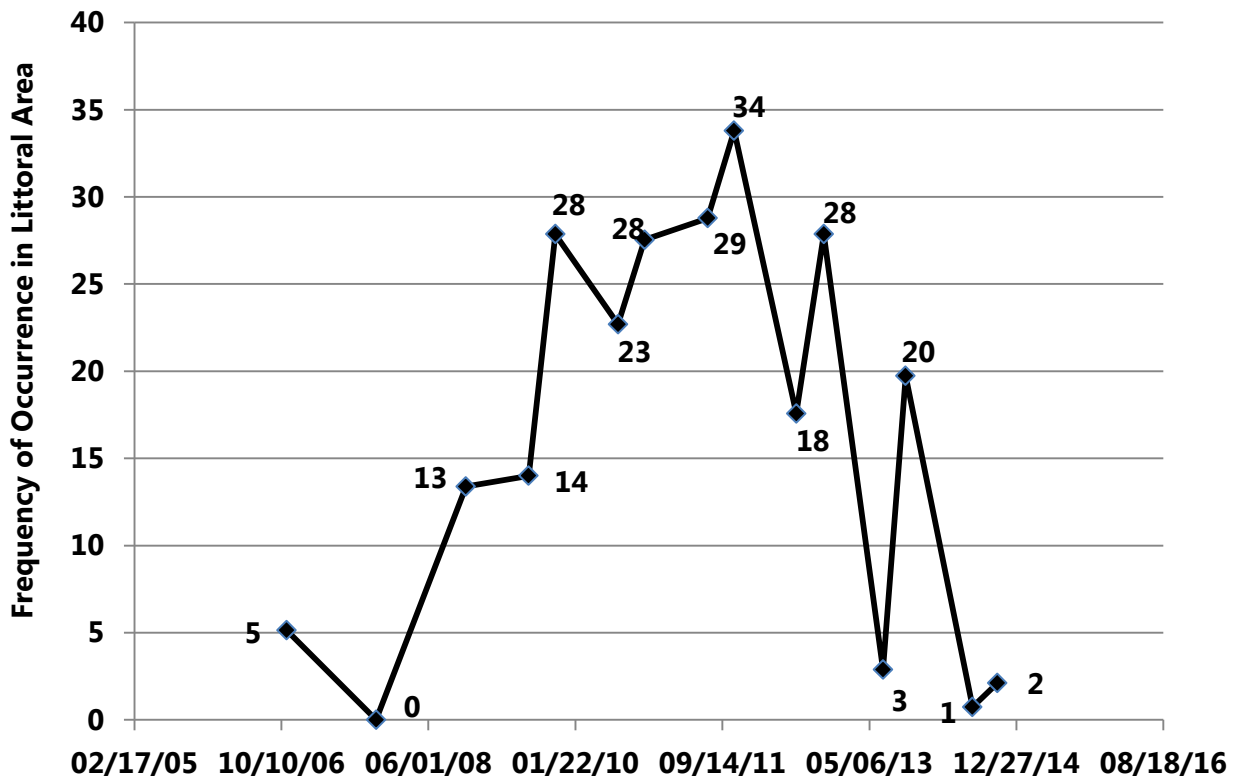


Figure 24 2006-2014 Beaver Dam Lake Frequency of Occurrence in Littoral Area: East Lake

2006-2014 Beaver Dam Lake EWM Extent: East Lake

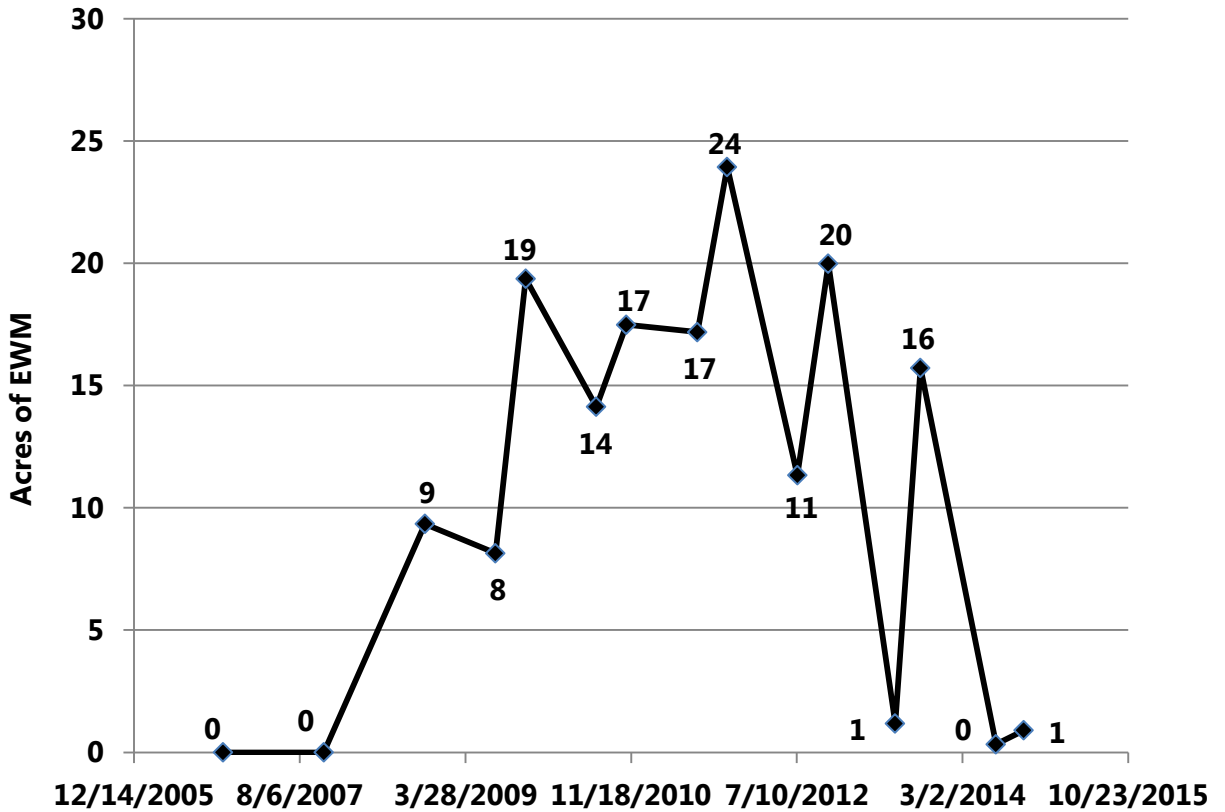


Figure 25 2006-2014 Beaver Dam Lake EWM Acreage: East Lake

1.27 Norwegian Bay – Norwegian Bay was a whole bay 2,4-D treatment with a bay wide target concentration of 600 µg/L ae. Herbicide application occurred on June 3.

Concentrations of 2,4-D in water samples from the monitored treatment areas ranged from 88 µg/L to 290 µg/L ae at 0.04 to 1 DAT (Figure 26). The mean lake wide concentration in samples collected from 0.04 to 7 DAT was 178 µg/L ae compared to the target lake wide target concentration of 600 µg/L ae (Figure 26). The low concentrations of herbicide observed in Norwegian Bay may be a result of dilution by inflow waters from the bay’s inlet. The data indicate a higher 2,4-D dose may be needed to attain the dose and contact time needed for bay-wide EWM control.

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 31
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

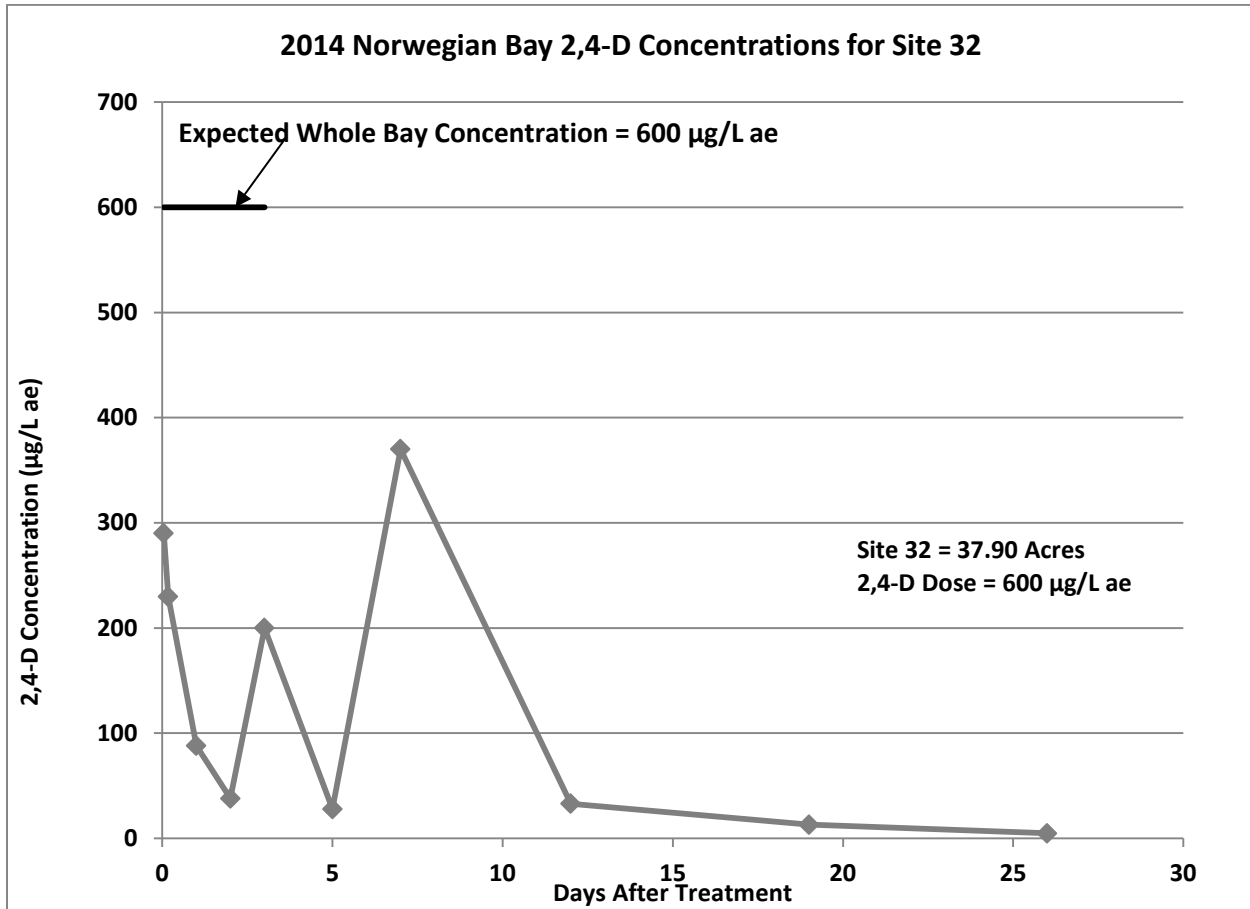


Figure 26 2014 Norwegian Bay 2,4-D Concentrations for Site 32

The 2014 herbicide treatment reduced EWM frequency in Norwegian Bay from 59 percent during the fall of 2013 to 4 percent during July of 2014 (Figure 27). EWM extent was reduced from 23 acres in the fall of 2013 to 1 acre during July of 2014 (Figure 28). However, EWM increased in both frequency and extent between summer and fall. In fall of 2014, the north end of the bay had nearly continuous low density EWM. Plants often had large gaps between them and were only sporadically canopied. However, EWM was rapidly filling in from both the eastern and western shorelines as you headed south out of the bay.

EWM frequency increased more than an order of magnitude, from 4 percent in July to 44 percent in fall (Figure 27). EWM extent also increased more than an order of magnitude, from 1 acre in July to 18 acres

To: Beaver Dam Lake Management District (Board of Commissioners)
 From: Barr Engineering Company (Meg Rattei)
 Subject: 2014 EWM Treatment Results
 Date: December 2, 2014
 Page: 33
 Project: 49030011.14
 c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

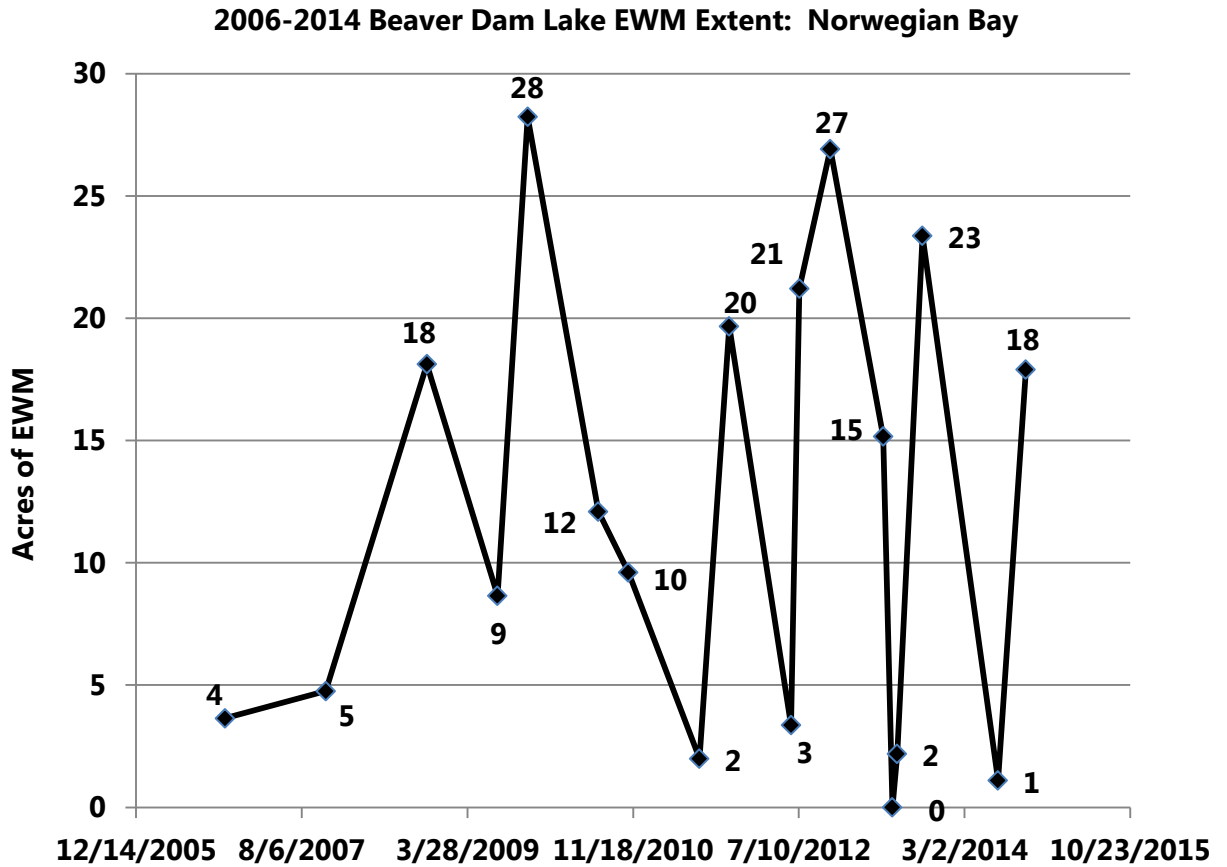


Figure 27 2006-2014 Beaver Dam Lake EWM Acreage: Norwegian Bay

2.0 Summary and Recommendations

The 2014 EWM frequency and extent were at the lowest levels observed since monitoring began in 2006. EWM frequency has declined from a high of 35 percent in the fall of 2008 to 9 percent in fall of 2014. EWM extent has declined from a high of 176 acres in fall of 2008 to 67 acres in fall of 2014. The 2014 herbicide treatment attained the District EWM goal of a frequency of 10 percent or less. Because the goal was attained and the District felt that additional EWM reductions were possible, the Beaver Dam Lake Management District changed the goal to 7 percent at its November 20, 2014 Board meeting.

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 34
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

The 2014 treatment results indicate a strong correlation between lasting EWM control and sustaining the target concentration of herbicide for at least 3 days after treatment. Rabbit Island Bay, Library Lake, Cemetery Bay, and East Lake attained and sustained the target bay-wide 2,4-D concentration for at least 3 days and also both attained and sustained EWM control through fall. The target concentration of 300 µg/L ae was attained for a week in the Library Lake and for 5 days in Cemetery Bay and Rabbit Island Bay. The target concentration of 600 µg/L ae was attained for a week in East Lake. Summer EWM frequency of occurrence in the four bays ranged from 0 to 2 percent and summer EWM extent ranged from 0 to 0.6 acres. Despite increases in EWM frequency and extent between summer and fall, EWM remained at low levels. Fall EWM frequency of occurrence ranged from 1 to 5 percent and fall EWM extent ranged from 0.1 to 3.1 acres.

EWM increases between summer and fall in West Lake, Norwegian Bay, and City Bay were correlated with a failure to attain and sustain the target concentration of herbicide for at least 3 days after treatment.

In West Lake, the treatment area in the northwest area of the lake attained and sustained a target concentration of 300 µg/L ae for a week and lasting EWM control was attained in this area of the lake. However, treatment areas near the Eagle Point Boat landing and in the southeast area of the lake only sustained the target concentration of 300 µg/L ae for a day or two. EWM increased in both frequency and extent between summer and fall in these areas of the lake. The EWM beds in these areas provided ample opportunity for boat traffic to shred and spread EWM. Heavy boat traffic in the area of Eagle Point Landing caused the spread of EWM to adjacent Williams Bay. Herbicide residue data from Williams Bay indicated treatment areas attained and sustained the 2,4-D target concentration of 300 µg/L ae for 3 days after treatment and EWM was not observed in Williams Bay during July. However, in late summer a lake resident observed wind and wave action from a strong north wind moving EWM fragments from the Eagle Point boat landing area into Williams Bay. In fall of 2014, EWM frequency in Williams Bay was 9 percent and EWM extent was 7 acres (Figures 9 and 10). The locations where EWM was found in the fall of 2014 corresponded with locations where EWM fragments were deposited by wind and wave action during late summer. These data indicate a higher herbicide dose is needed in West Lake and Williams Bay to attain lasting control of EWM in the Eagle Point Boat landing area.

To: Beaver Dam Lake Management District (Board of Commissioners)
From: Barr Engineering Company (Meg Rattei)
Subject: 2014 EWM Treatment Results
Date: December 2, 2014
Page: 35
Project: 49030011.14
c: Kevin Kretsch (Lake Restoration, Inc.), Alex Smith (WDNR), Mark Sundeen (WDNR), and John Skogerboe (Research Scientist working with WDNR)

In City Bay, the bay-wide target 2,4-D concentration of 600 µg/L ae was attained, but was only sustained for a day or two. In Norwegian Bay, the target bay-wide 2,4-D concentration of 600 µg/L ae was never attained, probably due to dilution from inflowing waters from the bay's inlet. In both bays, EWM recolonized between summer and fall and was observed at a higher frequency and extent than the bays in which the target bay-wide concentration was both attained and sustained for at least 3 days.

In July, EWM frequency in West Lake, Williams Bay, City Bay, and Norwegian Bay ranged from 0 to 6 percent and EWM extent ranged from 0 to 7 acres. In fall, EWM frequency in these four bays ranged from 9 to 44 percent and EWM extent ranged from 7 to 30 acres. The data clearly show the necessity of increasing the herbicide dose in these four treatment areas so that the target bay-wide 2,4-D concentration is both attained and sustained for at least 3 days. In addition, the data suggests that closing the inlet to Norwegian Bay for about a week after treatment would help prevent dilution of the herbicide from inflowing waters and sustain the target bay-wide 2,4-D concentration in this bay for a minimum of 3 days.