Appendix K

Combined Watershed Loading and Lake Water Quality Response Model

- **Model Input – Phosphorus Sources**
- **Lake Response Model Equations**
- **Watershed Loading and Lake Response Model Calibration Factors**
- **Model Calibration**
- **Lake Response Curves – Benchmark Conditions**
- **Water Quality Modeling – Benchmark Conditions**
- **Model Run for Benchmark Conditions (2004)**
- **Model Run for Wet Conditions (2003)**
- **Model Run for Dry Conditions (2006)**

Model Input – Phosphorus Sources

Unit Area Loading - Land Use

Land Use	TP UAL [kg/ha/yr]	TP UAL [lb/acre/yr]
Cropland	0.38	**0.34**
Forest	0.075	**0.07**
Grassland	0.169	**0.15**
Developed – High Density	1.5	**1.34**
Developed – Med Density	1.15	**1.03**
Developed – Low Density	0.91	**0.81**
Golf Course	0.91	**0.81**
Sand & Gravel Mining	0	-
Wetlands	0	**-0.02**

Livestock Load

Animal Unit [AU]	Production Rate of P in Manure as P[lb/AU/d]
Beef Cattle	0.097
Beef Calves	0.055
Dairy Cattle	0.17
Dairy Calves	0.055
Horses	0.029
Chickens	0.011
Sheep	0.0087
Goats	0.0097
European Red Deer	0.0055
Llamas	0.0055
Dogs	0.0000275

Septic System Load

Estimated ISTS phosphorus discharge rate [lb/ISTS/year]	1.08

	Septic System Load		Internal Load
Lake	Estimated # of Lakeshore Residences	Phosphorus for Lakeshore Residences [lbs/yr]	Lake Internal Load [TP lbs/yr]
Lendt Lake	--n/a--	--n/a--	--n/a--
Moody Lake	8	**8.6**	**490**
Third Lake	15	**16.2**	--n/a--
Sea Lake	--n/a--	--n/a--	--n/a--
Bone Lake	78	**84.1**	**165**
Nielsen Lake	--n/a--	--n/a--	--n/a--
Birch Lake	4	**4.3**	**18**
School Lake	7	**7.5**	**46**
Little Comfort Lake	15	**16.2**	**56**
Clear Lake	--n/a--	--n/a--	--n/a--
Twin Lake	--n/a--	--n/a--	--n/a--
Cranberry Lake	--n/a--	--n/a--	--n/a--
Elwell Lake	--n/a--	--n/a--	--n/a--
Sylvan Lake	67	**72.3**	**17**
Shields Lake	-	**0**	**76**
Forest Lake (East Basin)	-	**0**	**251**
Forest Lake (Middle Basin)	-	**0**	**97**
Forest Lake (West Basin)	-	**0**	**73**
Heims Lake	--n/a--	--n/a--	--n/a--
Shallow Pond	--n/a--	--n/a--	--n/a--
Comfort Lake	91	**98.1**	**223**
First Lake	--n/a--	--n/a--	--n/a--
Second Lake	--n/a--	--n/a--	--n/a--
Scandia - Lake West of Sch	--n/a--	--n/a--	--n/a--

Atmospheric Load

	2004	2003	2006
	Baseline Conditions	Wet Conditions	Dry Conditions
Precipitation P Deposition [lb/ac/yr]	0.1081	0.1328	0.0837
Dry P Deposition [lb/ac/yr]	0.025	0.025	0.025
Total [lb/ac/yr]	**0.1331**	**0.1578**	**0.1087**

Influent Groundwater Load

MPCA's median concentration of TP [ug/L] for surficial quaternary aquifers	**56**

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Lake Response Model Equations

Canfield & Bachmann (1981)
Phosphorus sedimentation model

$$TP = \frac{L}{z(\sigma + \rho)}$$

TP = Total Phophorus [mg/m^3]
L = Annual Phosphorus Loading per unit of Lake Surface Area [mg/m^2/yr]
z = Mean Depth of Lake [m]
σ = phosphorus sedimentation coefficient [year^{-1}]
ρ = hydraulic flushing rate [year^{-1}] = Q/V
Q = surface outflow from lake's subwatershed [ac-ft/yr]
V = lake's volume [ac-ft]

$$\sigma = 0.162\left(\frac{L}{z}\right)^{0.458}$$

Natural Lake Model	
a =	0.162
b =	0.458

$$\sigma = 0.114\left(\frac{L}{z}\right)^{0.589}$$

Artifical Lake Model
0.114
0.589

MINLEAP - Chlorphyll-a → **Equation Re-written**
Wilson & Walker (1989)

$$Chla = CF \times 10^{\left(1.46\,Log_{10}(TP)-1.09\right)}$$

MINLEAP paper equation 3	
a =	1.46
b =	-1.09

$$Chla = CF \times 0.08 \times TP^{1.46}$$

a =	**0.08**
b =	**1.46**

Chla = Chlorphyll-a [ug/L]
TP = Total Phophorus [ug/L]

MINLEAP - Secchi Depth → **Equation Re-written**
Wilson & Walker (1989)

$$SD = CF \times 10^{\left(-0.57\,Log_{10}(Chla)+0.87\right)}$$

MINLEAP paper equation 4	
a =	-0.57
b =	0.87

$$SD = CF \times 7.41 \times Chla^{-0.57}$$

a =	**7.41**
b =	**(0.57)**

Chla = Chlorphyll-a [ug/L]
SD = Secchi Depth [m]

MINLEAP - Secchi Depth (direct calculation) → **Equation Re-written**

MINLEAP paper equation 3 & 4

$$SD = CF \times 31.0 \times TP^{-0.83}$$

a =	**31.00**
b =	**(0.83)**

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Watershed Loading and Lake Response Model Calibration Factors

Unit Area Loading - Land Use

Land Use	CF UAL
Cropland	1.00
Forest	1.00
Grassland	1.00
Developed – High Density	1.00
Developed – Med Density	1.00
Developed – Low Density	1.00
Golf Course	1.00
Sand & Gravel Mining	1.00
Wetlands	1.00

Livestock Load

Livestock TP Load delivery percentage	**4%**

Annual TP Loading Calibration Factors

	Runoff	Livestock	Total Load Calibration Increment
Benchmark Conditions (2004)	1.0	1.0	1.0
Wet Conditions (2003)	**1.6**	**1.6**	1.0
Dry Conditions (2006)	**0.8**	**0.8**	1.0

Calibration Factors by Lake

Lake	UAL CF	Livestock CF	Internal Load CF	Chl-a Calibration Parameter	Chl-a Empirical Model Coefficient	Chl-a Empirical Model Exponent	Secchi Calibration Parameter	Secchi Empirical Model Coefficient	Secchi Empirical Model Exponent	CB Calibration Factor	Ratio of Corrected FWMC / Summer TP	Watershed Load Increment	Total Load Calibration Increment
Lendt Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.84**		
Moody Lake	1.00	1.00	**0.75**	**0.37**	0.08	1.46	**0.88**	7.41	(0.57)	**1.20**	**0.84**		
Third Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.84**		
Sea Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.84**		
Bone Lake	1.00	1.00	**0.80**	1.00	0.08	1.46	1.00	7.41	(0.57)	**1.20**	**0.78**		
Nielsen Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.84**		
Birch Lake	1.00	1.00	1.00	**0.35**	0.08	1.46	**2.30**	31.00	(0.83)	**1.20**	**0.84**		**250**
School Lake	1.00	1.00	1.00	1.00	0.08	1.46	1.00	7.41	(0.57)	**1.10**	**0.84**		
Little Comfort Lake	1.00	1.00	1.00	**0.43**	0.08	1.46	**1.30**	7.41	(0.57)	1.00	**0.84**	**314.0**	
Clear Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.83**		
Twin Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.83**		
Cranberry Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.83**		
Elwell Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.83**		
Sylvan Lake	1.00	1.00	1.00	**0.60**	0.08	1.46	**1.20**	7.41	(0.57)	**1.40**	**0.84**		**-240**
Shields Lake	1.00	1.00	1.00	**0.20**	0.08	1.46	**1.50**	7.41	(0.57)	1.00	**0.73**		**837**
Forest Lake (East Basin)	1.00	1.00	1.00	1.00	0.08	1.46	1.00	7.41	(0.57)	**1.20**	**0.83**		0.0
Forest Lake (Middle Basin)	1.00	1.00	1.00	1.00	0.08	1.46	1.00	7.41	(0.57)	**1.30**	**0.83**		
Forest Lake (West Basin)	1.00	1.00	1.00	1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.83**		
Heims Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**1.03**		
Shallow Pond	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	**3.30**	**1.03**		
Comfort Lake	1.00	1.00	**0.60**	1.00	0.08	1.46	1.00	7.41	(0.57)	**1.20**	**1.03**	0.0	**-200**
First Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.78**		
Second Lake	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.78**		
Scandia - Lake West of School	1.00	1.00		1.00	0.08	1.46	1.00	7.41	(0.57)	1.00	**0.78**		

Special Conditions

Lake	UAL CF	Livestock CF	Internal Load CF	Chl-a Calibration Parameter	Chl-a Empirical Model Coefficient	Chl-a Empirical Model Exponent	Secchi Calibration Parameter	Secchi Empirical Model Coefficient	Secchi Empirical Model Exponent	CB Calibration Factor	Ratio of Corrected FWMC / Summer TP	Watershed Load Increment	Total Load Calibration Increment
2006 Shallow Pond										**1.80**			
Birch Lake							2.30	31.00	(0.83)				

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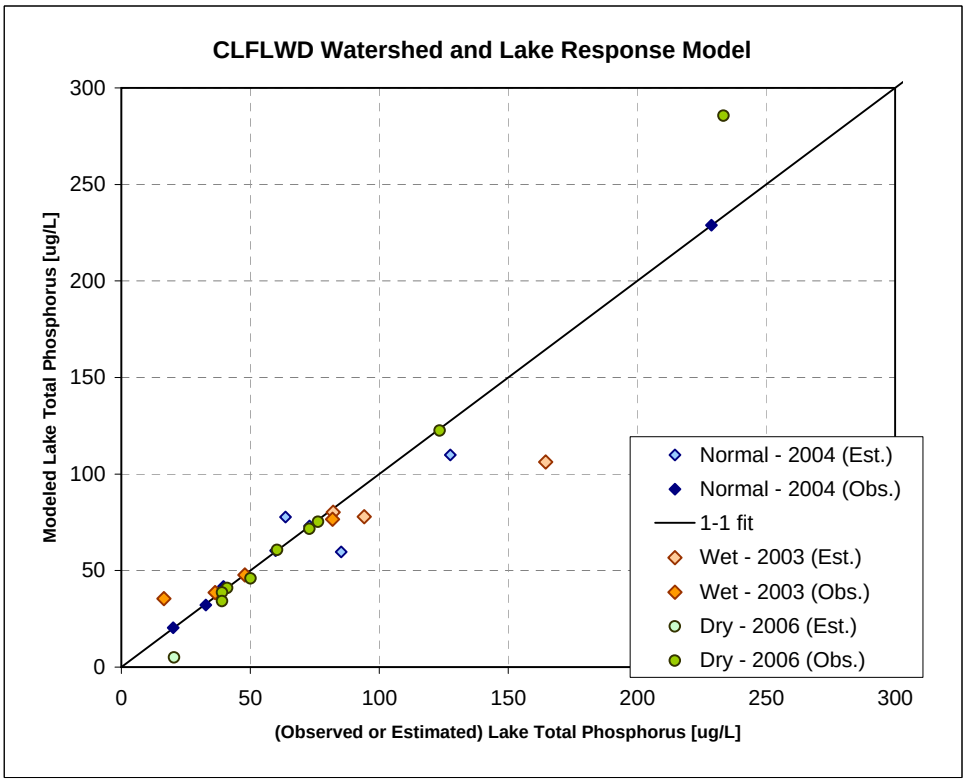
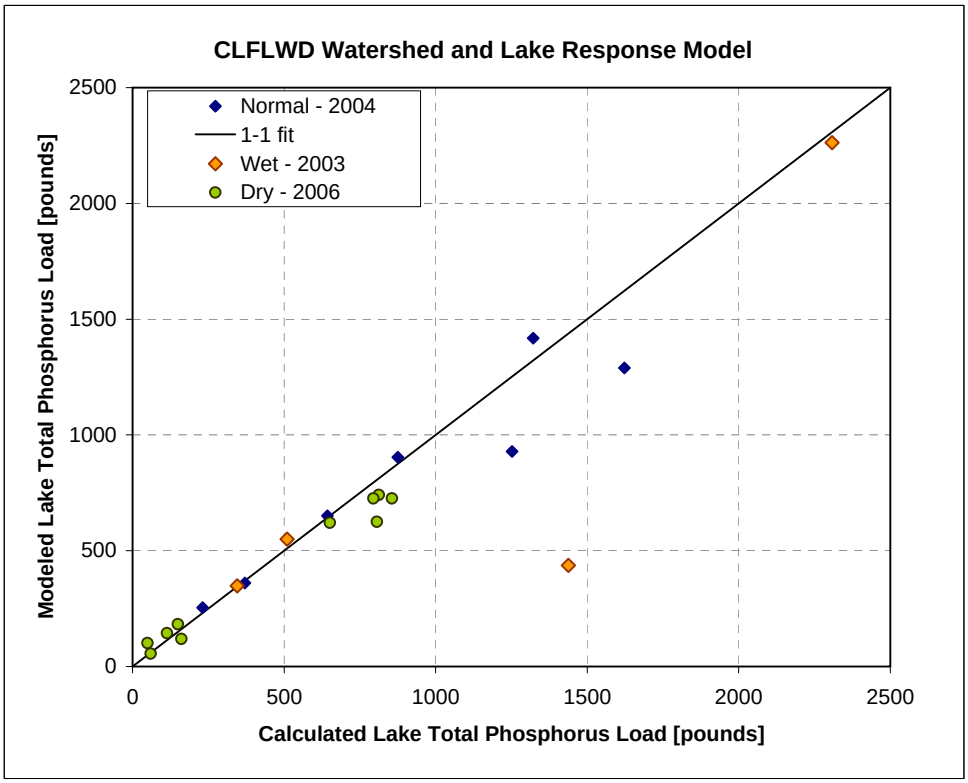
Model Calibration





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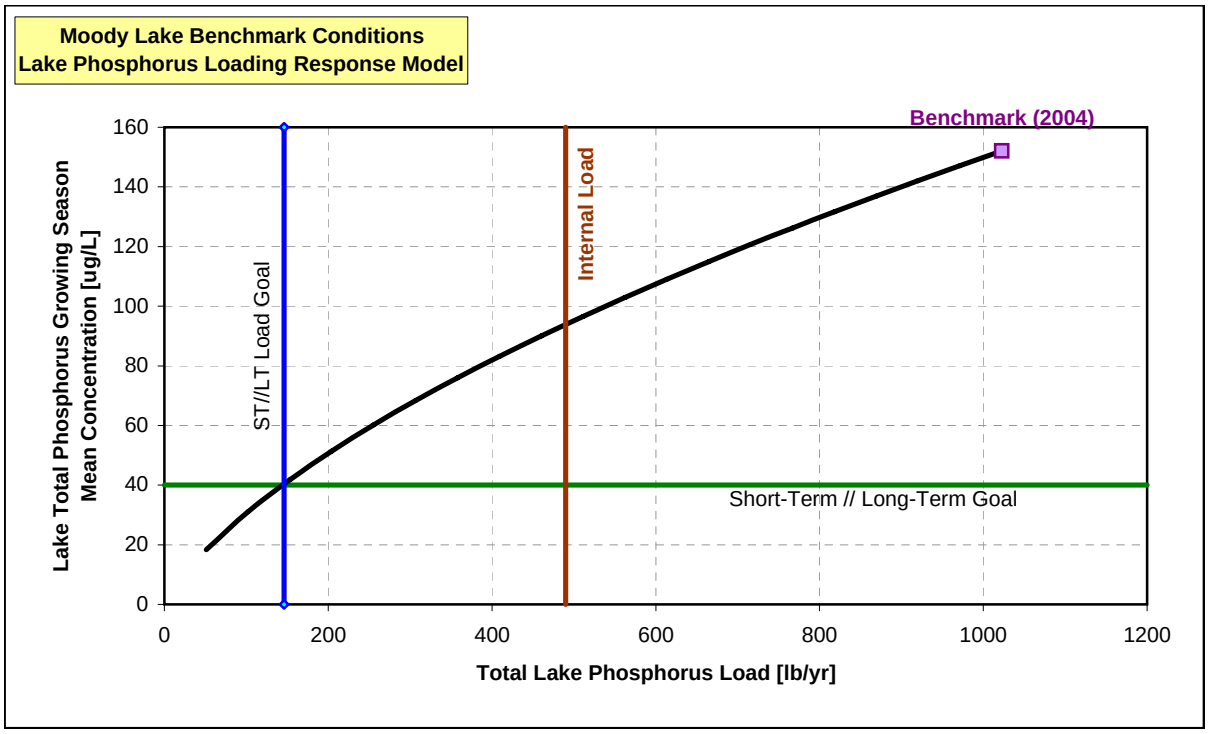
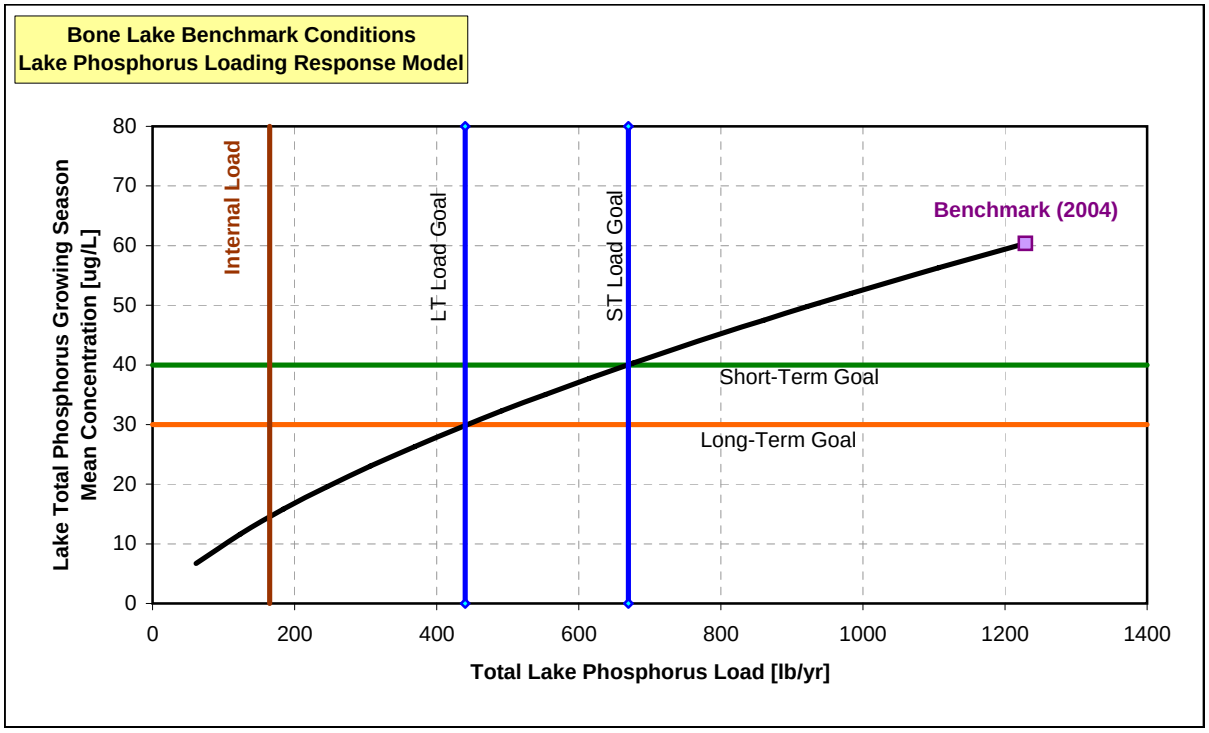
Lake Response Curves – Benchmark Conditions

Legend:
Black - Modeled Lake Response to Load Reductions
Brown - Internal Load
Green - Lake Total Phosphorus Goal (MPCA Std.)
Orange - Lake Total Phosphorus Goal Proposed in Project RFP
Purple - Non-Degradation Goal
Blue - Load Required to Meet Goals





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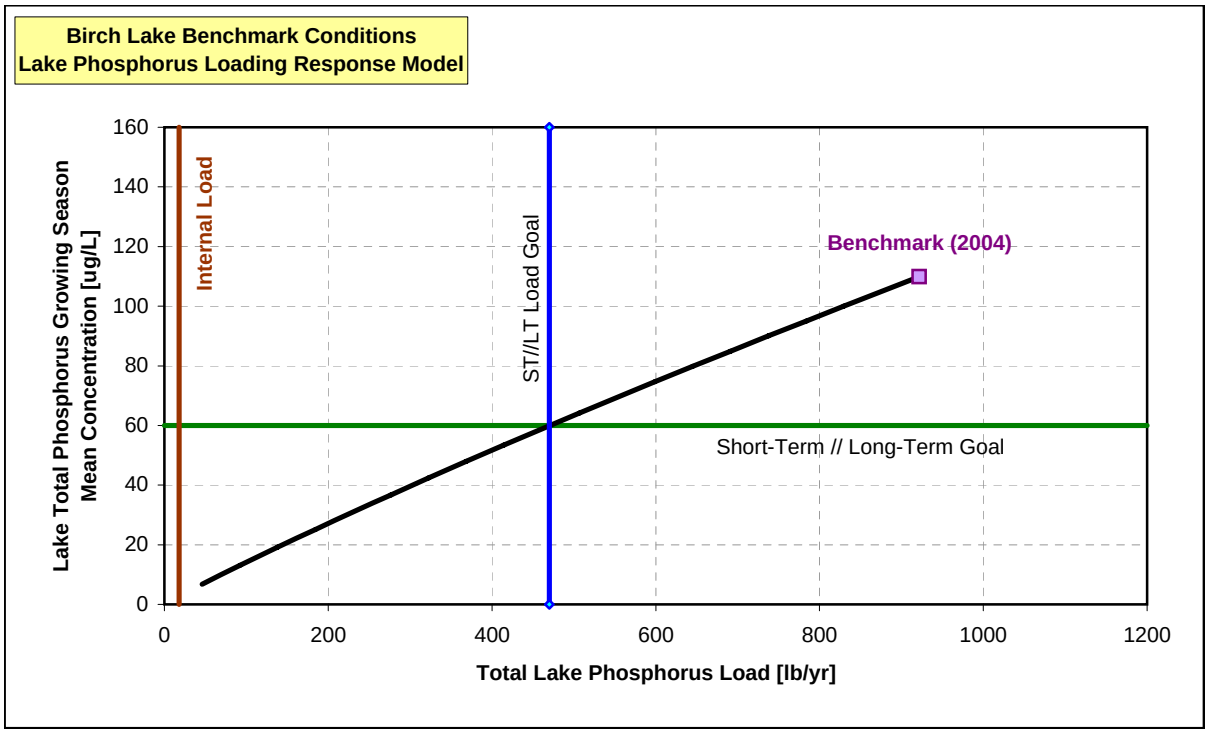

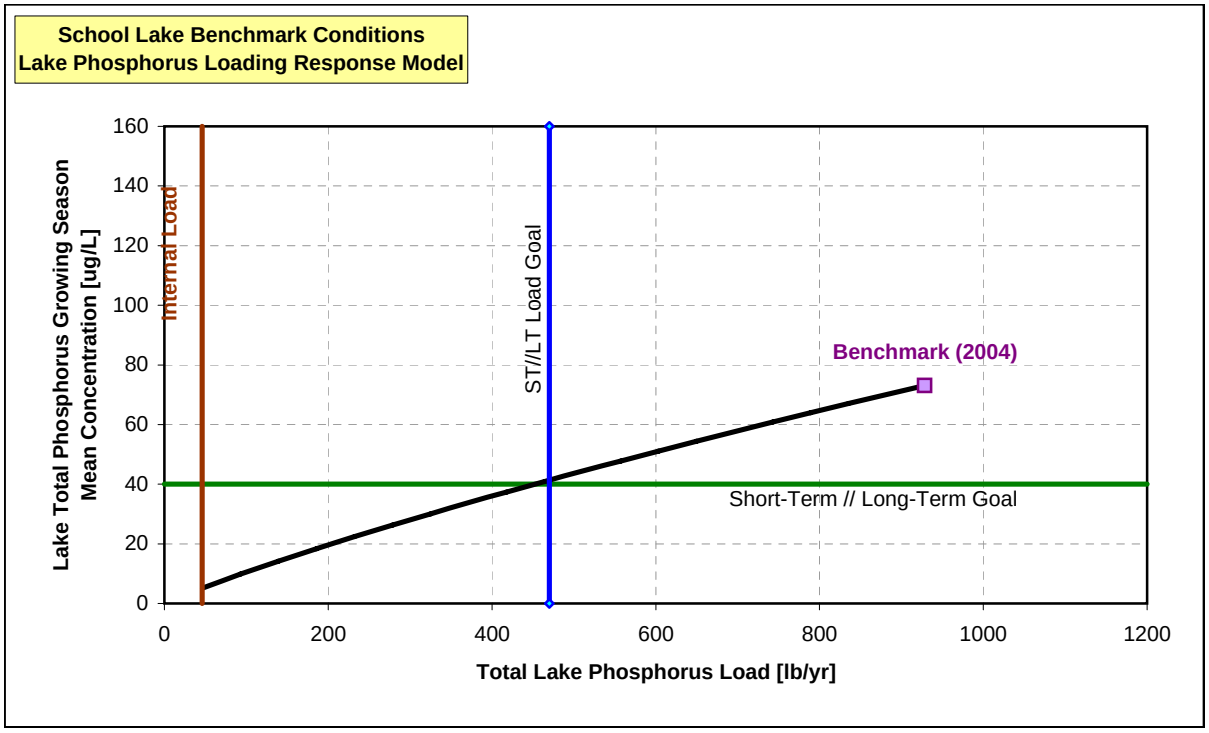

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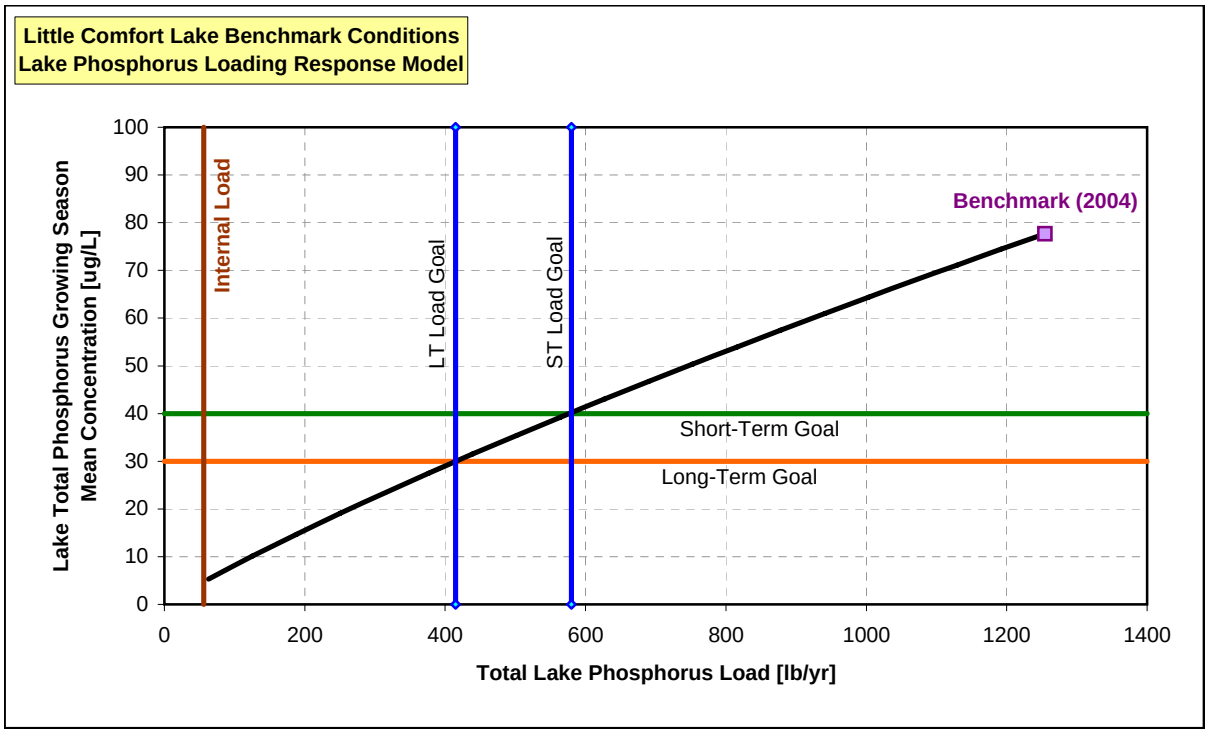

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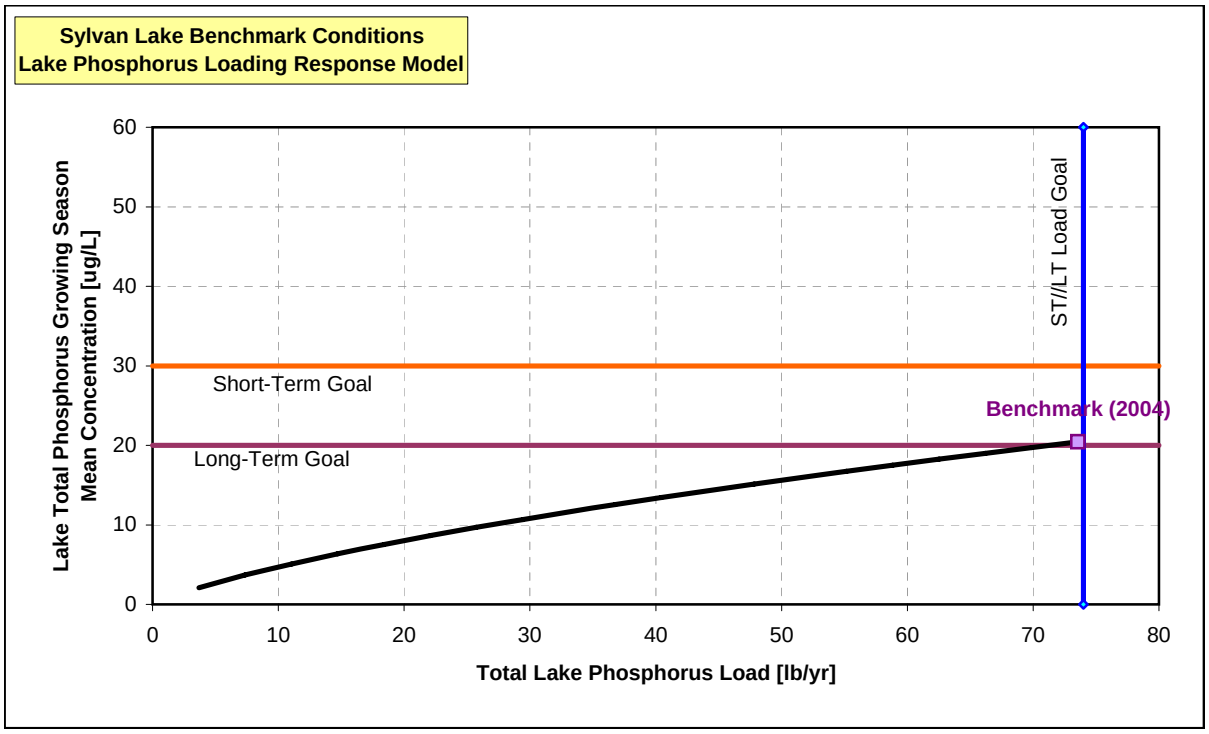

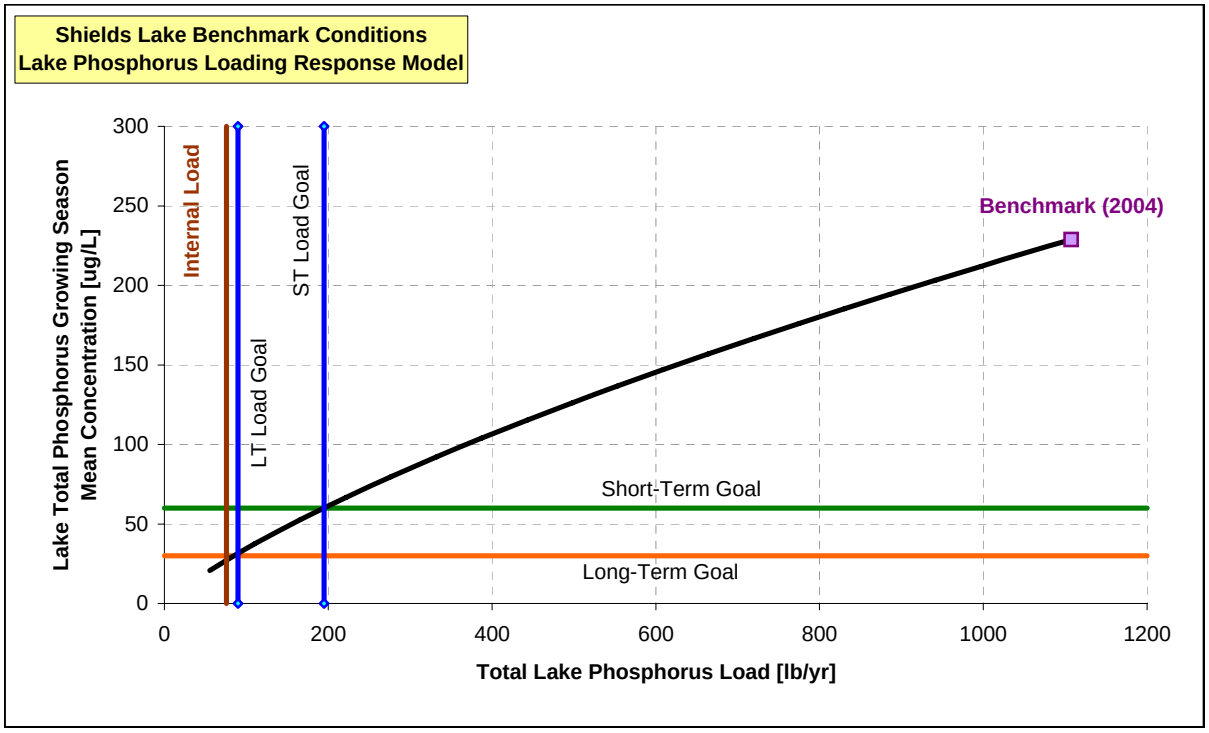

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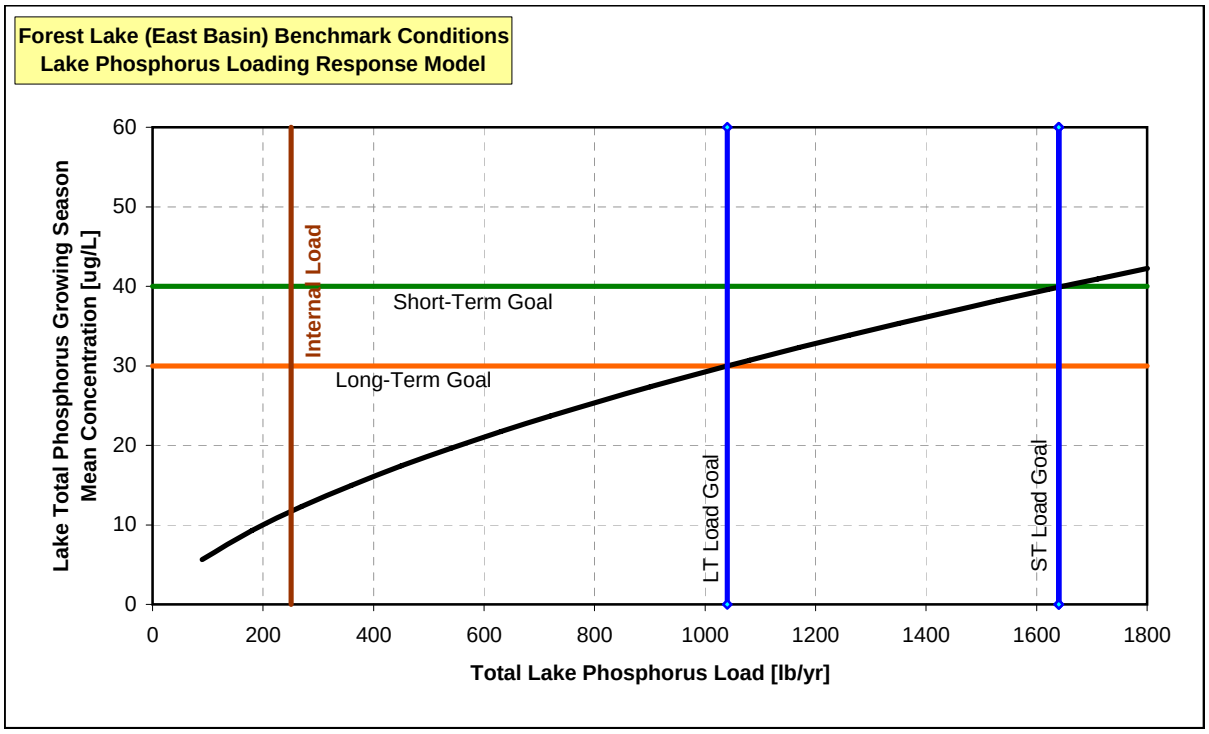

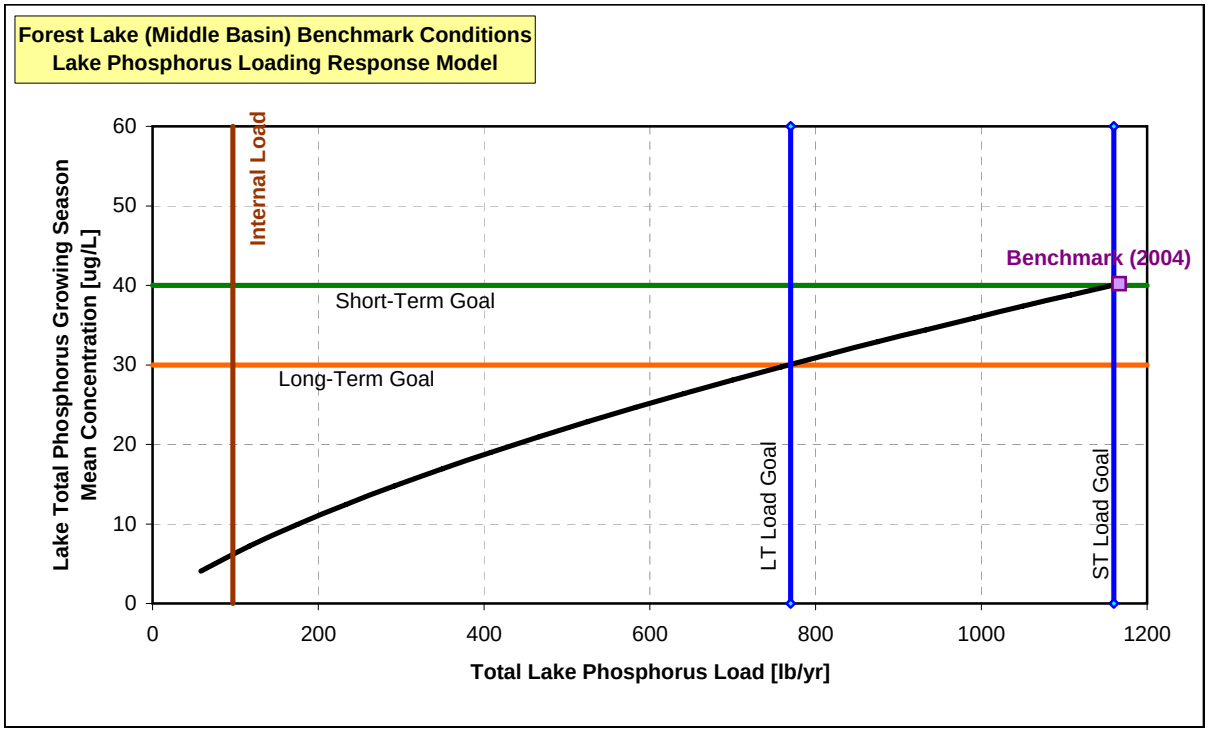

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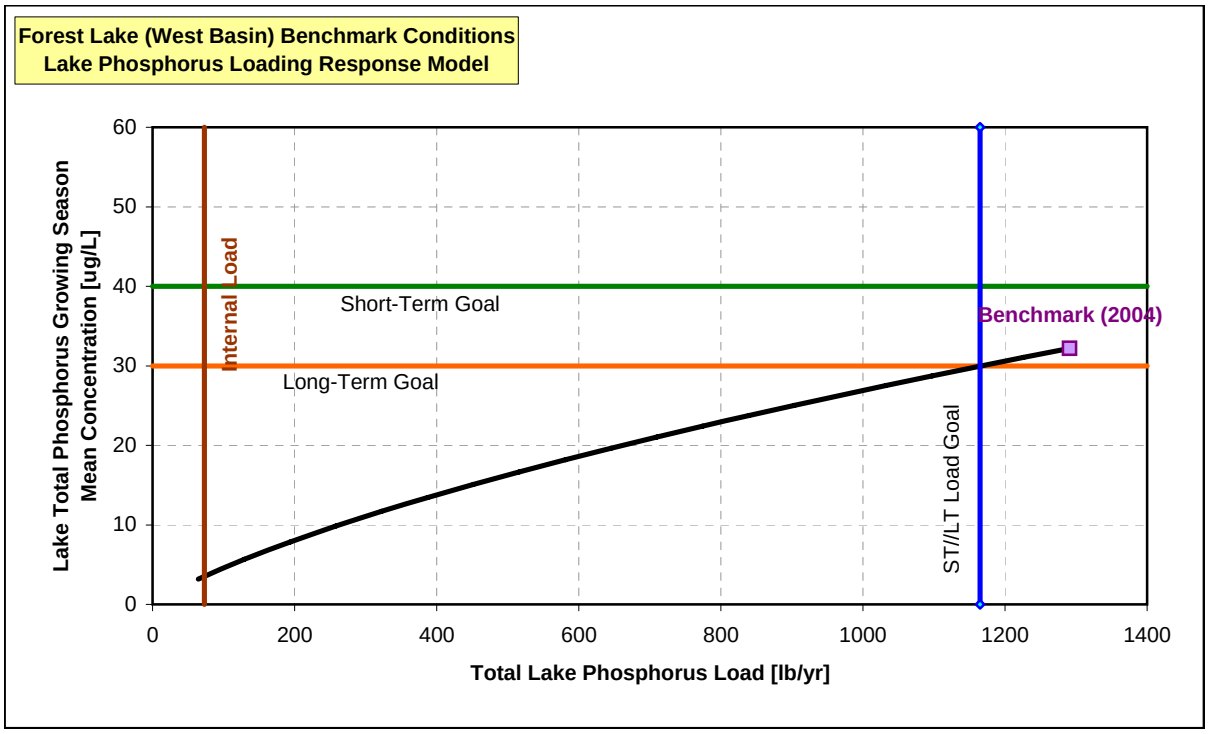
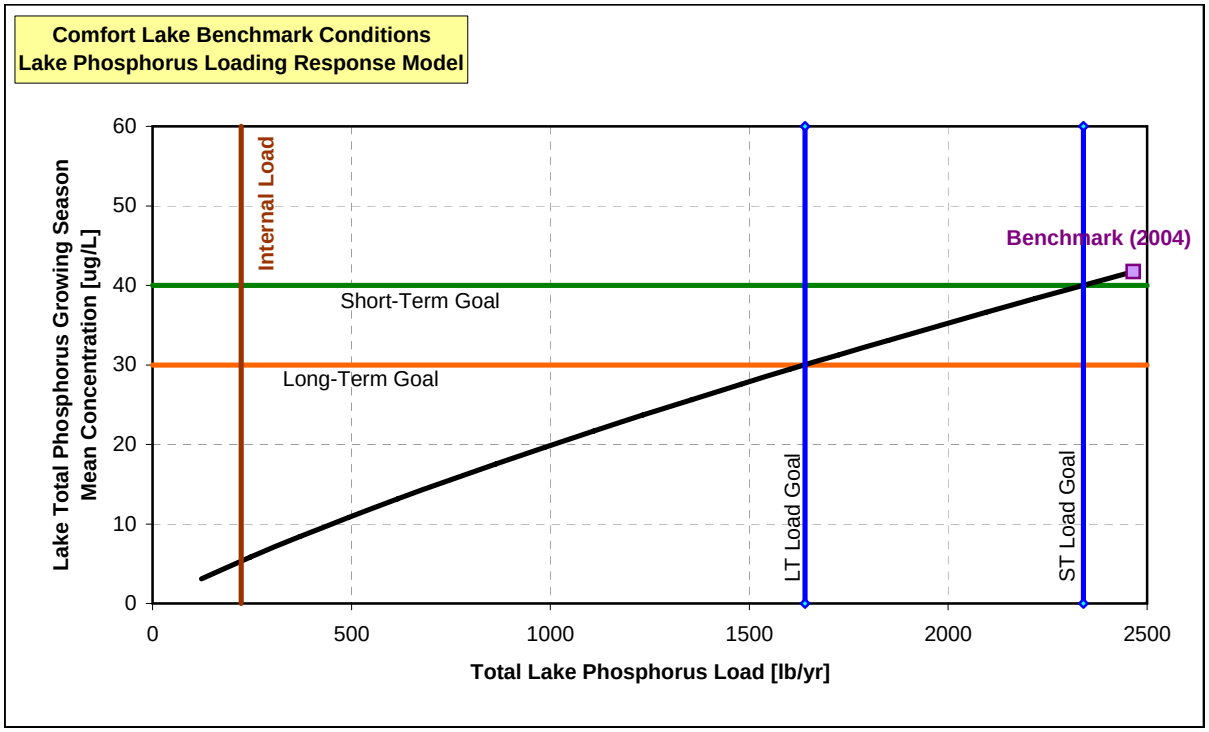
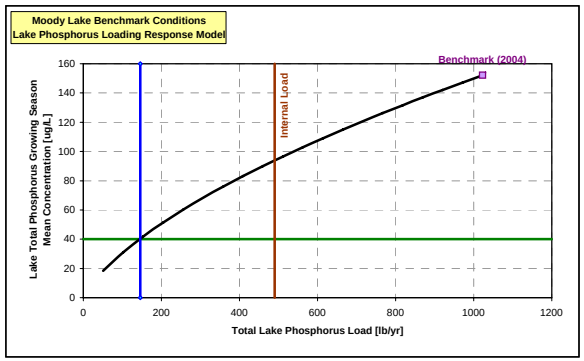
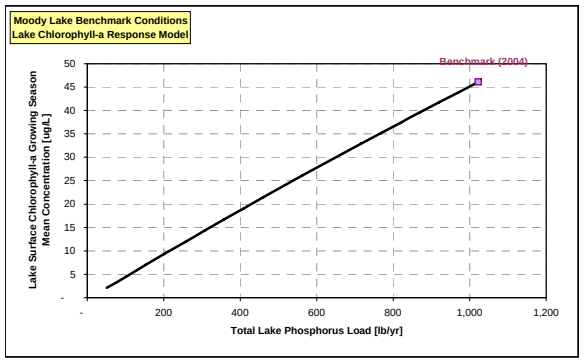
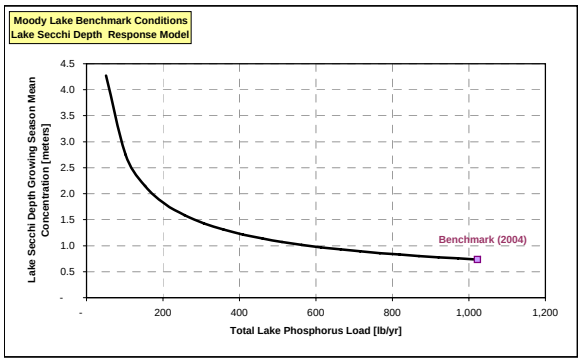


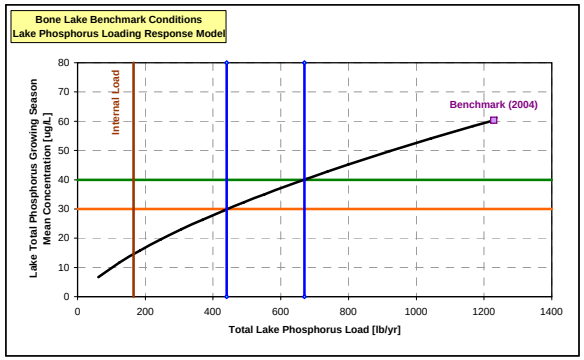


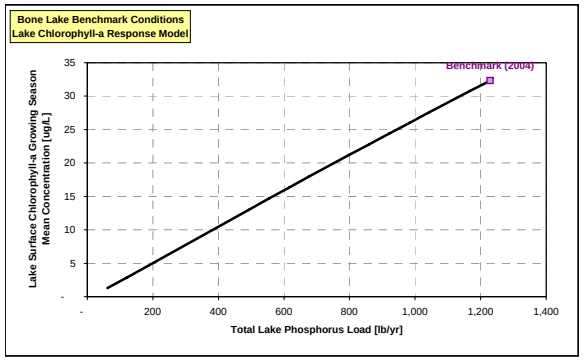
Water Quality Modeling – Benchmark Conditions

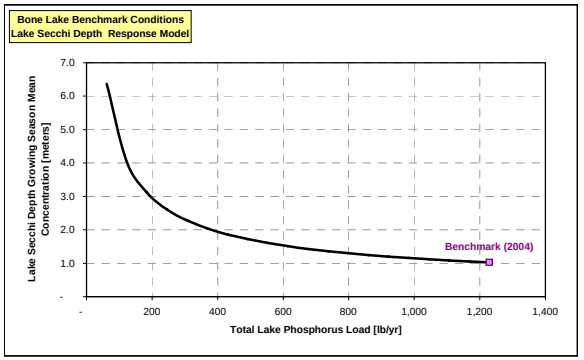


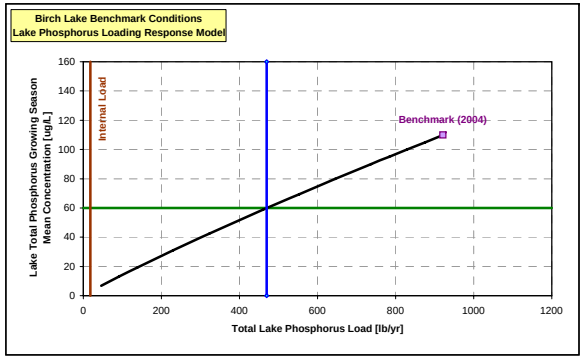


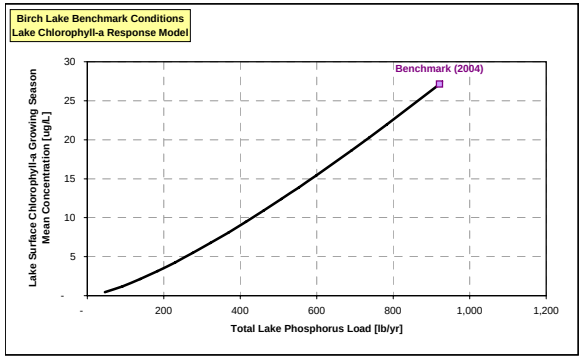


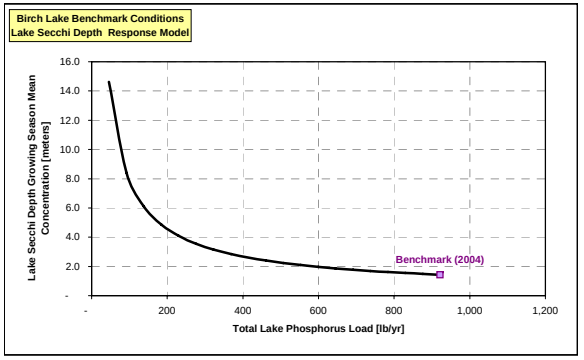












Legend:
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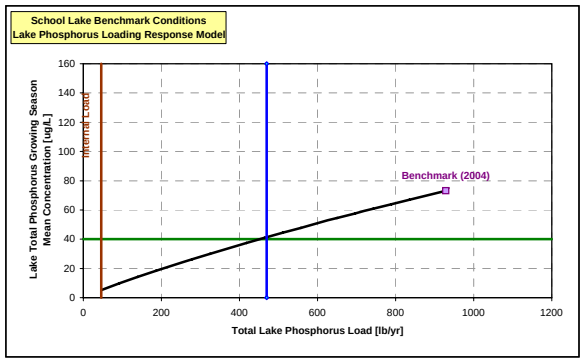

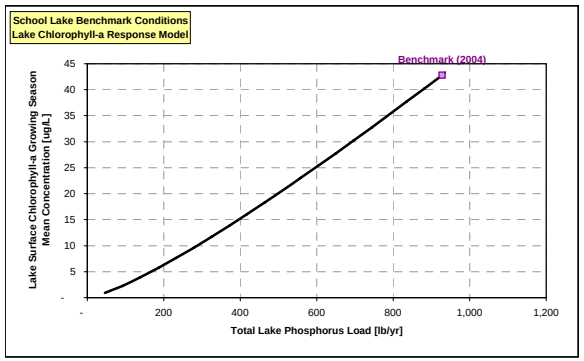

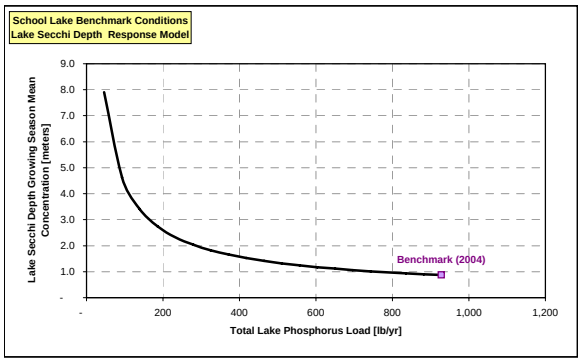

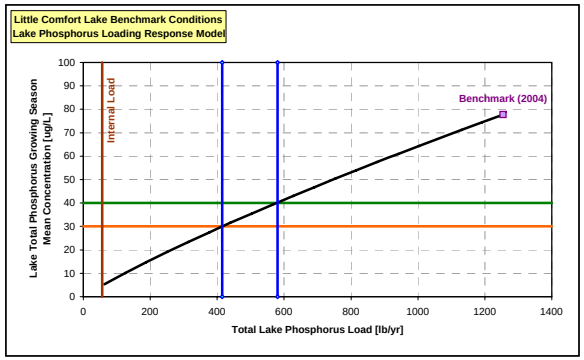

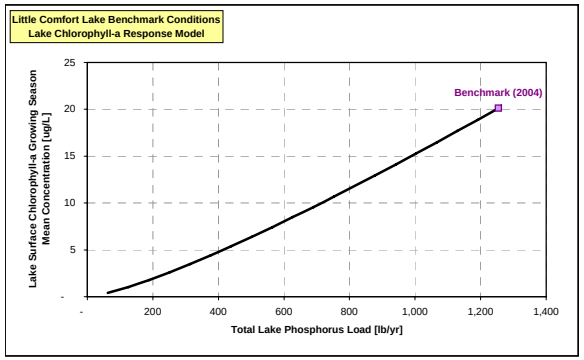

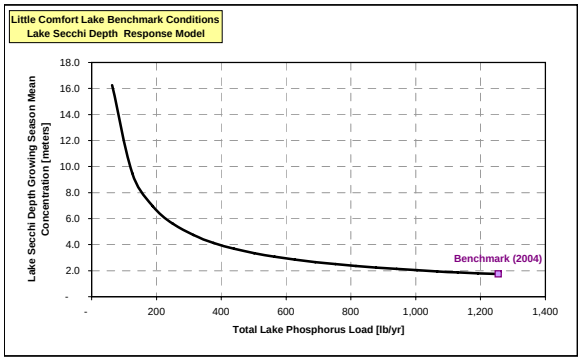

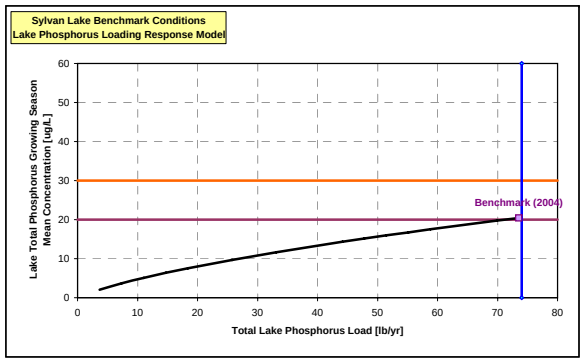

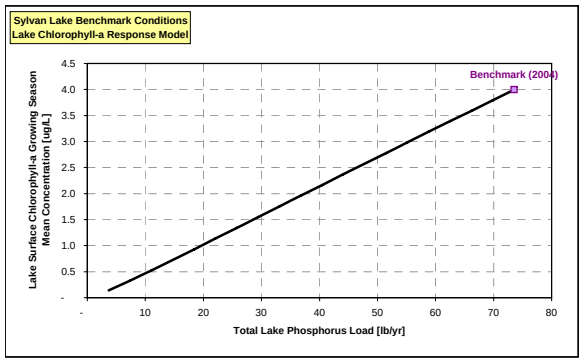

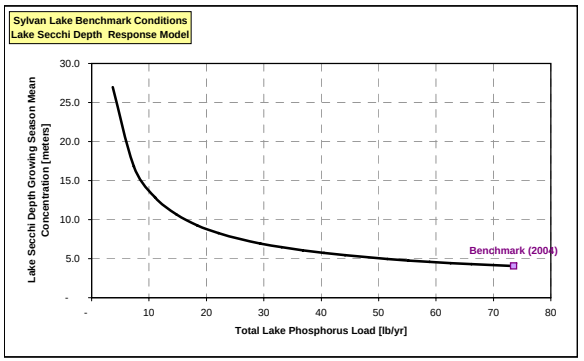

Legend:
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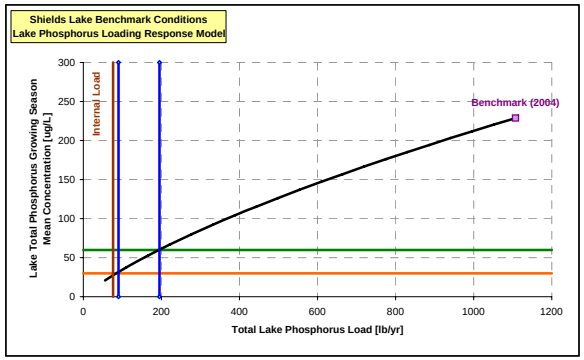
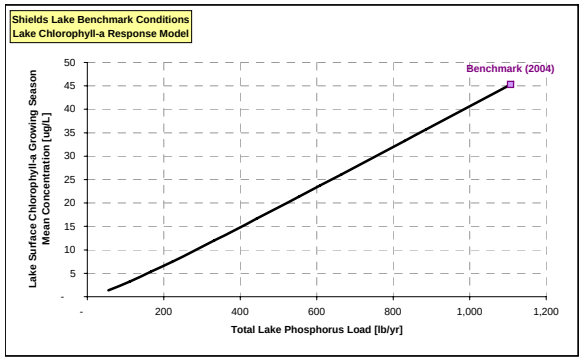
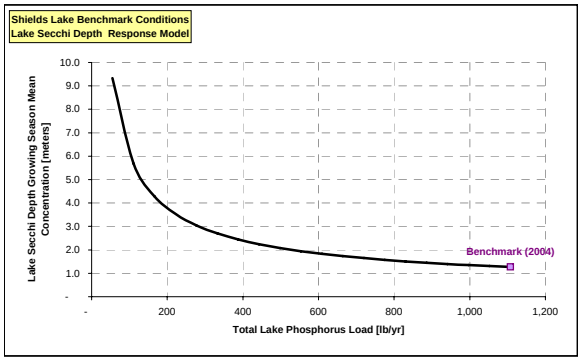
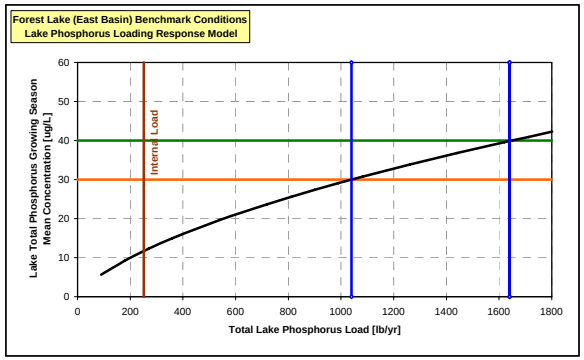
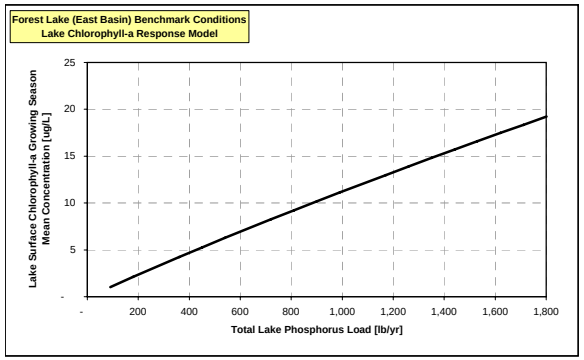
Purple - Non-Degradation Goal
Blue - Load Required to Meet Goals

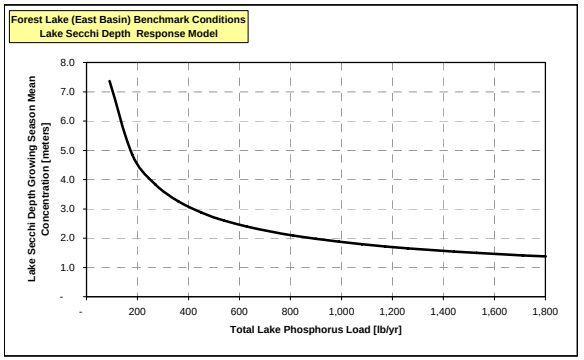


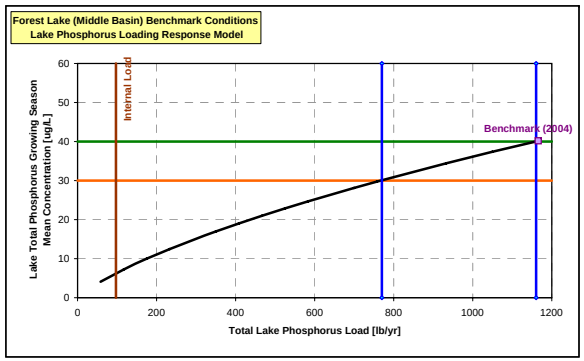


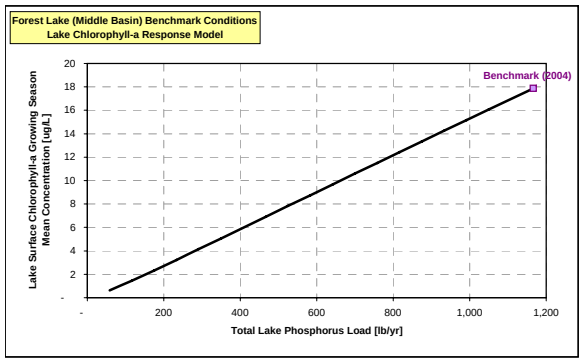


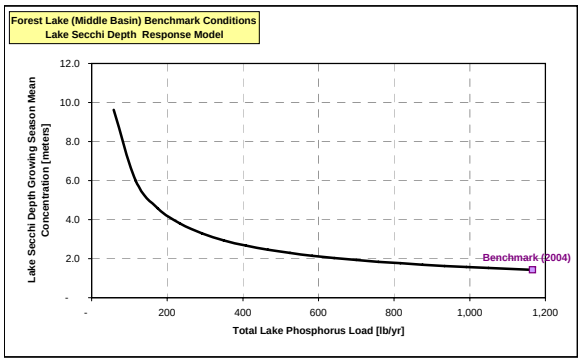












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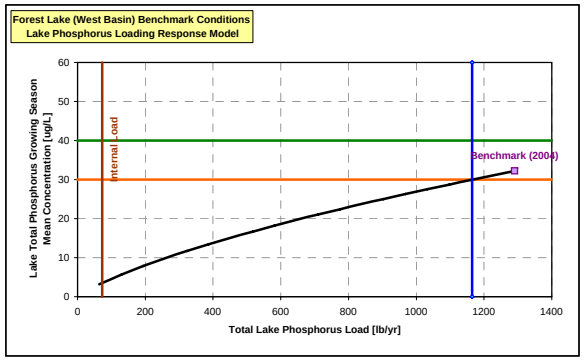

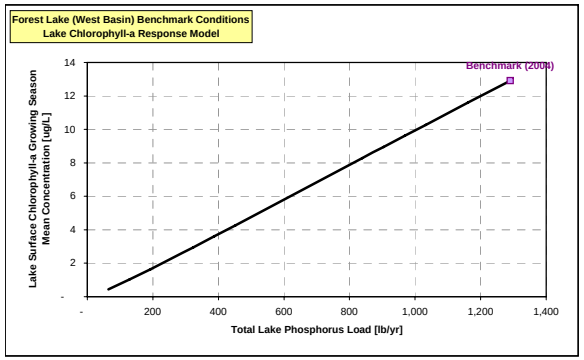

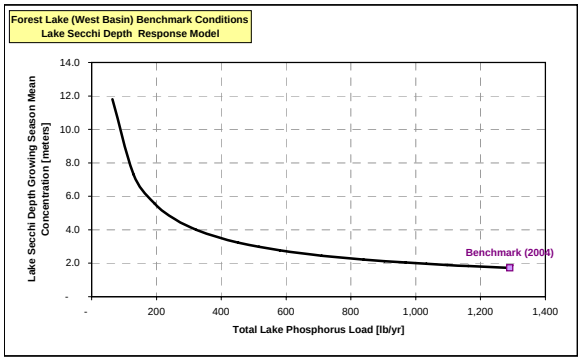

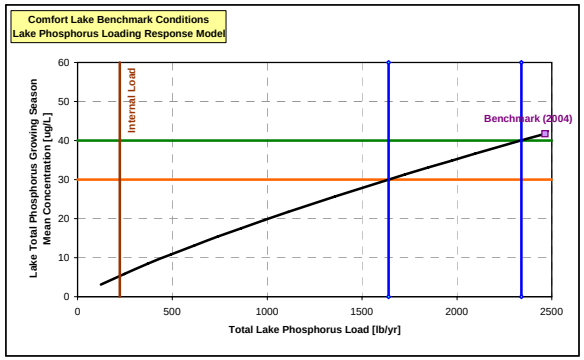

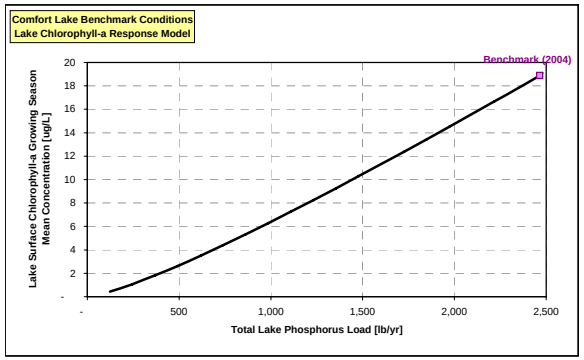

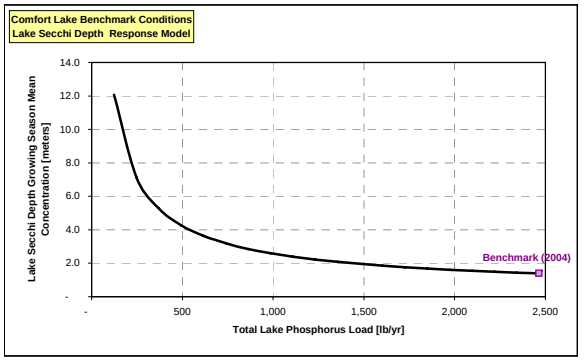

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Model Run for Benchmark Conditions (2004)

	Lake Name	Lake Physical Characteristics			
		Lake Area [acres]	Lake Mean Depth [ft]	Lake Volume [acre-ft]	Shallow or Deep
Benchmark Conditions (2004)	Lendt Lake	66	*3.0*	*199*	minor
	Moody Lake	34	13.8	465	deep
	Third Lake	65	*3.0*	*194*	minor
	Sea Lake	51	*3.0*	*152*	minor
	Bone Lake	204	13.4	2,735	deep
	Nielsen Lake	32	*3.0*	*95*	minor - d
	Birch Lake	32	2.8	88	shallow
	School Lake	50	10.8	532	deep
	Little Comfort Lake	35	18.4	649	deep
	Clear Lake	39	3.0	117	minor - d
	Twin Lake	21	3.0	63	minor - d
	Cranberry Lake	21	3.0	62	minor
	Elwell Lake	18	*3.0*	*54*	minor - d
	Sylvan Lake	84	9.4	792	deep
	Shields Lake	27	*7.4*	*203*	shallow
	Forest Lake East	779	12.6	9,779	deep
	Forest Lake Middle	367	11.1	4,089	deep
	Forest Lake West	1,074	9.9	10,590	deep
	Heims Lake	90	*3.0*	*269*	minor
	shallow pond	155	*1.0*	*155*	minor
	Comfort Lake	218	19.2	4,182	deep
	First Lake	51	*3.0*	*154*	minor - d
	Second Lake	87	*3.0*	*261*	minor - d
	Scandia - Lake West of S	*13*	*3.0*	*38*	minor - d

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		Water Quantity - Existing Conditions											
		Water Budget Outflow and Inflow Volumes											
		Outflow Volumes [ac-ft]					Inflow Volumes [ac-ft]						Change in Storage [acre-ft]
	Lake Name	Evapo-ration from Lake	Discharge through Outlet	Discharge via Groundwater	Regional Ground-water Outflow	Sum of Outflows	Water-shed Runoff	Precip-itation (direct)	Flow from Upstream Lakes via Surface	Flow from Upstream Lakes via Ground Water	Regional Ground-water Inflow	Sum of Inflows	
Benchmark Conditions (2004)	Lendt Lake	155	38		125	318	200	117	-	-	-	318	
	Moody Lake	81	470		64	614	498	61	38	16	-	614	-
	Third Lake	155	29		122	306	188	117	-	-	-	306	-
	Sea Lake	121		140		261	169	92	-	-	-	261	-
						-							
	Bone Lake	486	1,591		383	2,461	1,431	369	499	162	-	2,461	-
	Nielsen Lake	76		184	-	259	202	57	-	-	-	259	-
	Birch Lake	75	2,335		-	2,411	555	57	1,591	195	12	2,411	-
	School Lake	118	2,838		-	2,956	478	109	2,335	15	19	2,956	-
	Little Comfort Lake	84	3,810		-	3,895	967	78	2,838	2	14	3,898	4
	Clear Lake	93		123	-	216	59	71	-	72	15	216	-
	Twin Lake	51	243		-	293	117	38	-	130	8	293	-
	Cranberry Lake	49	620		-	669	381	37	243	-	8	669	-
	Elwell Lake	43		136	-	179	79	33	-	60	7	179	-
	Sylvan Lake	201		418	-	619	88	152	-	330	33	604	(15)
	Shields Lake	65	710		-	776	700	60	-	10	11	781	6
	Forest Lake East	1,859	2,564		-	4,423	1,313	1,607	620	656	305	4,502	79
	Forest Lake Middle	877	3,416		-	4,294	104	809	3,275	-	144	4,331	37
	Forest Lake West	2,564	4,957		-	7,521	1,382	2,356	3,416	55	421	7,630	109
	Heims Lake	214	87		-	301	74	192	-	-	35	301	-
	shallow pond	371	8,005		-	8,375	2,925	334	5,045	26	46	8,375	-
	Comfort Lake	521	12,175		-	12,696	347	472	11,815	42	85	12,761	66
	First Lake	123	-					*93*			-		
	Second Lake	208	*48*					*158*			-		
	Scandia - Lake West o	*31*	-					*23*			-		

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		Water Quality - Existing Conditions (1/3)			
		Phosphorus Budget Outflow			
		Outflow Phosphorus [lb]			
	Lake Name	Lake Outlet Flow	Regional Ground-water	Discharge via Groundwater	Sediment-ation
Benchmark Conditions (2004)	Lendt Lake	15	11.8	-	31
	Moody Lake	186	22.1	-	837
	Third Lake	11.2	9.0	-	20
	Sea Lake	23	-	22.9	58
	Bone Lake	254	49.1	-	975
	Nielsen Lake	35	-	34.9	58
	Birch Lake	587.4	-	-	334
	School Lake	475	-	-	453
	Little Comfort Lake	678	-	-	577
	Clear Lake	17	-	16.8	36
	Twin Lake	62.1	-	-	81
	Cranberry Lake	74	-	-	44
	Elwell Lake	19	-	18.7	23
	Sylvan Lake	20	-	19.5	54
	Shields Lake	321	-	-	786
	Forest Lake East	245	-	-	1,555
	Forest Lake Middle	311	-	-	855
	Forest Lake West	361	-	-	930
	Heims Lake	15.2	-	-	62
	shallow pond	1,335	-	-	607
	Comfort Lake	1,418	-	-	1,047
	First Lake	-	-	-	688
	Second Lake	9	-	-	103
	Scandia - Lake West o	-	-	-	130

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		Water Quality - Existing Conditions (2/3)												
		Phosphorus Budget Inflow (1/2)												
		Inflow Phosphorus [lb]												
	Lake Name	UAL CF	Runoff (Land use-based)	Landlocked Runoff Removals	Livestock CF	Livestock P Load	Landlocked Livestock P Load Removals	Landlocked Groundwater Load to Lake	P from Upstream Lakes Outlets	P from Upstream Minor Lake Outlets	Water-shed Load	Water-shed Load Increment	NOTES	Adjusted Water-shed Load
Benchmark Conditions (2004)	Lendt Lake	**1.00**	36	-	**1.00**	1	0	0	-		37	**-**		37
	Moody Lake	**1.00**	450	(19)	**1.00**	198	(4)	2	-	15	642	**-**		642
	Third Lake	**1.00**	-	-	**1.00**	6	0	0	-		6	**-**		6
	Sea Lake	**1.00**	73	-	**1.00**	1	0	0	-		74	**-**		74
	Bone Lake	**1.00**	695	(26)	**1.00**	77	0	25	186	29	986	**-**		986
	Nielsen Lake	**1.00**	85	-	**1.00**	4	0	0	-		89	**-**		89
	Birch Lake	**1.00**	292	(17)	**1.00**	106	(44)	30	254	23	643	**-**		643
	School Lake	**1.00**	180	(9)	**1.00**	133	(28)	2	587		865	**-**		865
	Little Comfort Lake	**1.00**	373	(10)	**1.00**	24	(1)	0	475		862	**314**		1,176
	Clear Lake	**1.00**	50	(16)	**1.00**	0	0	11	-		45	**-**		45
	Twin Lake	**1.00**	116	(13)	**1.00**	2	(1)	20	-	16	139	**-**		139
	Cranberry Lake	**1.00**	51	-	**1.00**	0	0	0	-	62	113	**-**		113
	Elwell Lake	**1.00**	96	(67)	**1.00**	0	0	9	-		38	**-**		38
	Sylvan Lake	**1.00**	246	(88)	**1.00**	0	0	50	-		208	**-**		208
	Shields Lake	**1.00**	202	(15)	**1.00**	1	0	2	-		189	**-**		189
	Forest Lake East	**1.00**	1,067	(78)	**1.00**	167	0	100	54	91	1,400	**-**		1,400
	Forest Lake Middle	**1.00**	431	-	**1.00**	1	0	0	*566*		999	**-**		999
	Forest Lake West	**1.00**	750	(58)	**1.00**	0	0	8	311		1,011	**-**		1,011
	Heims Lake	**1.00**	60	-	**1.00**	0	0	0	-		60	**-**		60
	shallow pond	**1.00**	1,536	(7)	**1.00**	5	0	4	361	15	1,914	**-**		1,914
	Comfort Lake	**1.00**	372	-	**1.00**	0	0	6	2,013		2,391	**-**		2,391
	First Lake	**1.00**	440	(16)	**1.00**	251	(2)	0	-	9	682	**-**		682
	Second Lake	**1.00**	102	(3)	**1.00**	1	0	0	-		100	**-**		100
	Scandia - Lake West o	**1.00**	124	(6)	**1.00**	12	(1)	0	-		129	**-**		129

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		Water Quality - Existing Conditions (3/3)											
		Phosphorus Budget Inflow (2/2)											
		Inflow Phosphorus [lb]											
	Lake Name	Atmos-pheric	Lake-shore Septic	Regional Ground-water	**Internal Load CF**	Lake Internal Load	Adjusted Internal Load	Internal + Direct Load	Total Lake P Load	Total Load Calibration Increment	Scenario Load Reduction	NOTES	Adjusted Total Lake P Load
Benchmark Conditions (2004)	Lendt Lake	9	-	-	**-**	-		9	46	**-**			46
	Moody Lake	4	9	-	**0.75**	490	368	381	1,023	**-**			1,023
	Third Lake	9	16	-	**-**	-		25	31	**-**			31
	Sea Lake	7	-	-	**-**	-		7	81	**-**			81
									-				-
	Bone Lake	27	84	-	**0.80**	165	132	243	1,229	**-**			1,229
	Nielsen Lake	4	-	-	**-**	-		4	93	**-**			93
	Birch Lake	4	4	2	**1.00**	18	18	28	672	**250**			922
	School Lake	7	8	3	**1.00**	46	46	63	928	**-**			928
	Little Comfort Lake	5	16	2	**1.00**	56	56	79	1,255	**-**			1,255
	Clear Lake	5	-	2	**-**	-		8	53	**-**			53
	Twin Lake	3	-	1	**-**	-		4	143	**-**			143
	Cranberry Lake	3	-	1	**-**	-		4	117	**-**			117
	Elwell Lake	2	-	1	**-**	-		3	42	**-**			42
	Sylvan Lake	11	72	5	**1.00**	17	17	105	314	**(240)**			74
	Shields Lake	4	-	2	**1.00**	76	76	81	270	**837**			1,107
	Forest Lake East	104	-	46	**1.00**	251	251	401	1,801	**-**			1,801
	Forest Lake Middle	49	-	22	**1.00**	97	97	168	1,166	**-**			1,166
	Forest Lake West	143	-	64	**1.00**	73	73	280	1,291	**-**			1,291
	Heims Lake	12	-	5	**-**	-		17	77	**-**			77
	shallow pond	21	-	7	**-**	-		28	1,942	**-**			1,942
	Comfort Lake	29	98	13	**0.60**	223	134	274	2,665	**(200)**			2,465
									-				-
	First Lake	7	-	-	**-**	-		7	688	**-**			688
	Second Lake	12	-	-	**-**	-		12	112	**-**			112
	Scandia - Lake West ol	2	-	-	**-**	-		2	130	**-**			130

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		Lake Response								
		Summer Surface Means								
		TP Concentration			Chlorophyll-*a* Concentration			Secchi Depth		
	Lake Name	Modeled TP [ug/l]	Estimated TP [ug/L]	Observed Growing Season Average TP [ug/L]	Chl-*a* Calibration Parameter	Modeled Chl-*a* [ug/l]	Observed Growing Season Average Chl-*a* [ug/L]	Secchi Calibration Parameter	Modeled Secchi [m]	Observed Growing Season Average Secchi [m]
Benchmark Conditions (2004)	Lendt Lake	41			**1.00**	19		**1.00**	1.4	
	Moody Lake	152	159		**0.37**	46		**0.88**	0.7	
	Third Lake	32.3			**1.00**	13		**1.00**	1.7	
	Sea Lake	72			**1.00**	42		**1.00**	0.9	
	Bone Lake	60.3		59.8	**1.00**	32	38	**1.00**	1.0	1.3
	Nielsen Lake	83			**1.00**	52		**1.00**	0.8	
	Birch Lake	110	128		**0.35**	27		**2.30**	1.4	
	School Lake	73	73		**1.00**	43		**1.00**	0.9	
	Little Comfort Lake	78	64		**0.43**	20		**1.30**	1.7	
	Clear Lake	60			**1.00**	32		**1.00**	1.0	
	Twin Lake	113.0			**1.00**	81		**1.00**	0.6	
	Cranberry Lake	53			**1.00**	26		**1.00**	1.1	
	Elwell Lake	61			**1.00**	33		**1.00**	1.0	
	Sylvan Lake	20		20	**0.60**	4	3	**1.20**	4.0	5.1
	Shields Lake	229		229	**0.20**	45	48	**1.50**	1.3	1.0
	Forest Lake East	42.3			**1.00**	19		**1.00**	1.4	
	Forest Lake Middle	40			**1.00**	18		**1.00**	1.4	
	Forest Lake West	32.2		32.8	**1.00**	13	10	**1.00**	1.7	1.9
	Heims Lake	62.2			**1.00**	34		**1.00**	1.0	
	shallow pond	60	85		**1.00**	32		**1.00**	1.0	
	Comfort Lake	42		40	**1.00**	19	17	**1.00**	1.4	1.8
				30%						
	First Lake	341			**1.00**	406		**1.00**	0.2	
	Second Lake	86			**1.00**	54		**1.00**	0.8	
	Scandia - Lake West o	294			**1.00**	327		**1.00**	0.3	

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Comfort Lake-Forest Lake Watershed District

Watershed and Lake Water Quality Modeling Investigation for the Development of a Watershed Capitol Improvement Plan

	Lake Name	Phosphorus Fate and Transport - - - Canfield & Bachmann Natural Lake Model							
		C-B *a* = 0.162		0.114					
		C-B *b* = 0.458		0.589					
		Total P Load [kg]	CB Calibration Factor	**Modeled Summer Mean TP [ug/l]**	Ratio of Corrected FWMC / Summer TP [--]	Phosphorus Outflow (Ratio-Adjusted) [kg/yr]	Phosphorus Retention (P Load - Outflow P) [kg/yr]	Phosphorus Outflow (Ratio-Adjusted) [lb/yr]	Phosphorus Retention (P Load - Outflow P) [lb/yr]
Benchmark Conditions (2004)	Lendt Lake	21	**1.00**	**41.4**	0.84	7.0	13.9	15.5	31
	Moody Lake	464	**1.20**	**152.0**	0.84	84	380	186	837
	Third Lake	14.1	**1.00**	**32.3**	0.84	5.1	9.1	11.2	20.0
	Sea Lake	37	**1.00**	**71.6**	0.84	10	26	23	58
	Bone Lake	557	**1.20**	**60.3**	0.78	115	442	254	975
	Nielsen Lake	42	**1.00**	**83.1**	0.84	16	26	35	58
	Birch Lake	418.0	**1.20**	**109.8**	0.84	266.4	151.6	587.4	334.2
	School Lake	421	**1.10**	**73.1**	0.84	215.5	205.5	475.2	453
	Little Comfort Lake	569	**1.00**	**77.7**	0.84	307	261	678	577
	Clear Lake	24	**1.00**	**60.4**	0.83	8	16	17	36
	Twin Lake	65.0	**1.00**	**113.0**	0.83	28.2	36.8	62.1	81.2
	Cranberry Lake	53	**1.00**	**52.6**	0.83	33.5	19.8	73.8	44
	Elwell Lake	19	**1.00**	**60.8**	0.83	8	10	19	23
	Sylvan Lake	33	**1.40**	**20.4**	0.84	9	24	20	54
	Shields Lake	502	**1.00**	**228.9**	0.73	146	357	321	786
	Forest Lake East	817	**1.20**	**42.3**	0.83	111	705	245	1,555
	Forest Lake Middle	529	**1.30**	**40.2**	0.83	141.0	388.0	310.9	855
	Forest Lake West	585.4	**1.00**	**32.2**	0.83	163.8	421.6	361.2	929.6
	Heims Lake	34.9	**1.00**	**62.2**	1.03	6.9	28.0	15.2	61.7
	shallow pond	881	**3.30**	**59.7**	1.03	605	275	1,335	607
	Comfort Lake	1,118	**1.20**	**41.7**	1.03	643.2	474.9	1,418.3	1,047
	First Lake	312	**1.00**	**341.5**	0.78	-	312	-	688
	Second Lake	51	**1.00**	**86.1**	0.78	4.0	47	8.8	102.9
	Scandia - Lake West o	59	**1.00**	**294.3**	0.78	-	59	-	130

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Model Run for Wet Conditions (2003)

	Lake Name	Lake Physical Characteristics			
		Lake Area [acres]	Lake Mean Depth [ft]	Lake Volume [acre-ft]	Shallow or Deep
Wet Conditions (2003)	Lendt Lake	66	*3.0*	*199*	minor
	Moody Lake	34	13.8	465	deep
	Third Lake	65	*3.0*	*194*	minor
	Sea Lake	51	*3.0*	*152*	minor
	Bone Lake	204	13.4	2,735	deep
	Nielsen Lake	32	*3.0*	*95*	minor - d
	Birch Lake	32	2.8	88	shallow
	School Lake	50	10.8	532	deep
	Little Comfort Lake	35	18.4	649	deep
	Clear Lake	39	3.0	117	minor - d
	Twin Lake	21	3.0	63	minor - d
	Cranberry Lake	21	3.0	62	minor
	Elwell Lake	18	*3.0*	*54*	minor - d
	Sylvan Lake	84	9.4	792	deep
	Shields Lake	27	*7.4*	*203*	deep
	Forest Lake East	779	12.6	9,779	deep
	Forest Lake Middle	367	11.1	4,089	deep
	Forest Lake West	1,074	9.9	10,590	deep
	Heims Lake	90	*3.0*	*269*	minor
	shallow pond	155	*1.0*	*155*	minor
	Comfort Lake	218	19.2	4,182	deep
	First Lake	51	*3.0*	*154*	minor - d
	Second Lake	87	*3.0*	*261*	minor - d
	Scandia - Lake West of S	*13*	*3.0*	*38*	minor - d

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		Water Quantity - Existing Conditions											
		Water Budget Outflow and Inflow Volumes											
		Outflow Volumes [ac-ft]					Inflow Volumes [ac-ft]						Change in Storage [acre-ft]
	Lake Name	Evapo-ration from Lake	Discharge through Outlet	Discharge via Groundwater	Regional Ground-water Outflow	Sum of Outflows	Water-shed Runoff	Precip-itation (direct)	Flow from Upstream Lakes via Surface	Flow from Upstream Lakes via Ground Water	Regional Ground-water Inflow	Sum of Inflows	
Wet Conditions (2003)	Lendt Lake	171	110		125	406	275	130	-	-	-	406	-
	Moody Lake	87	1,355		64	1,505	1,288	66	110	41	-	1,505	-
	Third Lake	166	84		122	372	245	127	-	-	-	372	-
	Sea Lake	130		188		318	222	97	-	-	-	318	-
						-							
	Bone Lake	523	2,137		383	3,044	996	391	1,439	218	-	3,044	-
	Nielsen Lake	81		211	-	292	232	60	-	-	-	292	-
	Birch Lake	81	3,395		-	3,476	1,042	60	2,137	224	12	3,476	-
	School Lake	127	4,125		-	4,252	727	94	3,395	17	19	4,252	-
	Little Comfort Lake	91	5,539		-	5,630	1,391	71	4,125	3	14	5,604	(26)
	Clear Lake	100		157	-	257	76	74	-	91	15	257	-
	Twin Lake	54	309		-	363	149	40	-	165	8	363	-
	Cranberry Lake	53	789		-	842	486	39	309	-	8	842	-
	Elwell Lake	46		173	-	220	101	34	-	77	7	220	-
	Sylvan Lake	216		532	-	748	98	160	-	421	33	711	(37)
	Shields Lake	70	904		-	974	880	52	-	13	11	955	(19)
	Forest Lake East	2,000	3,218		-	5,217	1,410	1,483	789	836	305	4,822	(395)
	Forest Lake Middle	943	4,269		-	5,213	50	711	4,122	-	144	5,026	(186)
	Forest Lake West	2,758	6,309		-	9,067	1,614	2,149	4,269	70	421	8,523	(545)
	Heims Lake	230	183		-	413	223	179	-	-	35	413	-
	shallow pond	399	8,468		-	8,867	1,936	311	6,493	16	46	8,867	-
	Comfort Lake	560	16,943		-	17,503	2,882	436	14,008	26	85	17,437	(66)
	First Lake	132	-		-			*101*	*71*		-		
	Second Lake	224	*71*		-			*171*	-		-		
	Scandia - Lake West o	*33*	-		-		*780*	*24*	-		-		

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		Water Quality - Existing Conditions (1/3)			
		Phosphorus Budget Outflow			
		Outflow Phosphorus [lb]			
	Lake Name	Lake Outlet Flow	Regional Ground-water	Discharge via Groundwater	Sediment-ation
Wet Conditions (2003)	Lendt Lake	12	-	-	44
	Moody Lake	436	-	-	942
	Third Lake	6.1	8.8	-	22
	Sea Lake	-	-	38.0	89
				-	
	Bone Lake	349	-	-	1,531
	Nielsen Lake	53	-	53.0	94
	Birch Lake	825	-	-	402
	School Lake	737	-	-	596
	Little Comfort Lake	1,018	-	-	731
	Clear Lake	-	-	25.6	51
	Twin Lake	95.9	-	-	120
	Cranberry Lake	116	-	-	67
	Elwell Lake	-	-	28.6	34
	Sylvan Lake	-	-	43.1	141
	Shields Lake	397	-	-	824
	Forest Lake East	372	-	-	2,230
	Forest Lake Middle	457	-	-	1,180
	Forest Lake West	550	-	-	1,330
	Heims Lake	34.6	-	-	80
	shallow pond	2,002	-	-	1,071
	Comfort Lake	2,262	-	-	1,437
				-	
	First Lake	-	-	-	1,101
	Second Lake	16	-	-	158
	Scandia - Lake West o	-	-	-	208

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		Water Quality - Existing Conditions (2/3)												
		Phosphorus Budget Inflow (1/2)												
		Inflow Phosphorus [lb]												
	Lake Name	UAL CF	Runoff (Land use-based)	Landlocked Runoff Removals	Livestock CF	Livestock P Load	Landlocked Livestock P Load Removals	Landlocked Groundwater Load to Lake	P from Upstream Lakes Outlets	P from Upstream Minor Lake Outlets	Water-shed Load	Water-shed Load Increment	NOTES	Adjusted Water-shed Load
Wet Conditions (2003)	Lendt Lake	**1.60**	58	-	**1.60**	1	0	0	-		60	**-**		60
	Moody Lake	**1.60**	719	(31)	**1.60**	317	(7)	6	-	12	1,017	**-**		1,017
	Third Lake	**1.60**	-	-	**1.60**	10	0	0	-		10	**-**		10
	Sea Lake	**1.60**	118	-	**1.60**	1	0	0	-		119	**-**		119
	Bone Lake	**1.60**	1,112	(42)	**1.60**	124	0	33	436	30	1,694	**-**		1,694
	Nielsen Lake	**1.60**	135	-	**1.60**	7	0	0	-		142	**-**		142
	Birch Lake	**1.60**	468	(28)	**1.60**	169	(71)	34	349	27	948	**-**		948
	School Lake	**1.60**	288	(14)	**1.60**	213	(45)	3	825		1,269	**-**		1,269
	Little Comfort Lake	**1.60**	597	(15)	**1.60**	38	(2)	0	737		1,355	**314**		1,669
	Clear Lake	**1.60**	80	(26)	**1.60**	0	0	14	-		68	**-**		68
	Twin Lake	**1.60**	186	(22)	**1.60**	3	(2)	25	-	20	211	**-**		211
	Cranberry Lake	**1.60**	82	-	**1.60**	0	0	0	-	96	178	**-**		178
	Elwell Lake	**1.60**	154	(108)	**1.60**	0	0	12	-		58	**-**		58
	Sylvan Lake	**1.60**	394	(141)	**1.60**	0	0	64	-		317	**-**		317
	Shields Lake	**1.60**	323	(25)	**1.60**	2	0	2	-		302	**-**		302
	Forest Lake East	**1.60**	1,707	(125)	**1.60**	266	0	127	68	138	2,182	**-**		2,182
	Forest Lake Middle	**1.60**	690	-	**1.60**	1	0	0	*769*		1,460	**-**		1,460
	Forest Lake West	**1.60**	1,200	(93)	**1.60**	0	0	11	457		1,574	**-**		1,574
	Heims Lake	**1.60**	95	-	**1.60**	0	0	0	-		95	**-**		95
	shallow pond	**1.60**	2,457	(11)	**1.60**	8	0	2	550	35	3,042	**-**		3,042
	Comfort Lake	**1.60**	596	-	**1.60**	0	0	4	3,020		3,619	**-**		3,619
	First Lake	**1.60**	704	(25)	**1.60**	401	(3)	0	-	16	1,093	**-**		1,093
	Second Lake	**1.60**	162	(4)	**1.60**	2	0	0	-		160	**-**		160
	Scandia - Lake West o	**1.60**	198	(10)	**1.60**	19	(1)	0	-		206	**-**		206

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		Water Quality - Existing Conditions (3/3)											
		Phosphorus Budget Inflow (2/2)											
		Inflow Phosphorus [lb]											
	Lake Name	Atmos-pheric	Lake-shore Septic	Regional Ground-water	**Internal Load CF**	Lake Internal Load	Adjusted Internal Load	Internal + Direct Load	Total Lake P Load	Total Load Calibration Increment	Scenario Load Reduction	NOTES	Adjusted Total Lake P Load
Wet Conditions (2003)	Lendt Lake	10	-	-	**-**	-		10	70	**-**			70
	Moody Lake	5	9	-	**0.75**	490	368	381	1,398	**-**			1,398
	Third Lake	10	16	-	**-**	-		26	37	**-**			37
	Sea Lake	8		-	**-**			8	127	**-**			127
				-					-				-
	Bone Lake	32	84	-	**0.80**	165	132	248	1,942	**-**			1,942
	Nielsen Lake	5	-	-	**-**	-		5	147	**-**			147
	Birch Lake	5	4	2	**1.00**	18	18	29	977	**250**			1,227
	School Lake	8	8	3	**1.00**	46	46	64	1,333	**-**			1,333
	Little Comfort Lake	6	16	2	**1.00**	56	56	80	1,749	**-**			1,749
	Clear Lake	6	-	2	**-**	-		8	77	**-**			77
	Twin Lake	3	-	1	**-**	-		5	216	**-**			216
	Cranberry Lake	3	-	1	**-**	-		4	183	**-**			183
	Elwell Lake	3	-	1	**-**	-		4	62	**-**			62
	Sylvan Lake	13	72	5	**1.00**	17	17	108	424	**(240)**			184
	Shields Lake	4	-	2	**1.00**	76	76	82	384	**837**			1,221
	Forest Lake East	123	-	46	**1.00**	251	251	420	2,602	**-**			2,602
	Forest Lake Middle	58	-	22	**1.00**	97	97	177	1,637	**-**			1,637
	Forest Lake West	169	-	64	**1.00**	73	73	306	1,880	**-**			1,880
	Heims Lake	14	-	5	**-**	-		19	115	**-**			115
	shallow pond	25		7	**-**	-	-	31	3,073	**-**			3,073
	Comfort Lake	34	98	13	**0.60**	223	134	279	3,899	**(200)**			3,699
									-				
	First Lake	8	-	-	**-**	-		8	1,101	**-**			1,101
	Second Lake	14	-	-	**-**	-		14	174	**-**			174
	Scandia - Lake West o	2	-	-	**-**	-		2	208	**-**			208

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		Lake Response								
		Summer Surface Means								
		TP Concentration			Chlorophyll-*a* Concentration			Secchi Depth		
	Lake Name	Modeled TP [ug/l]	Estimated TP [ug/L]	Observed Growing Season Average TP [ug/L]	Chl-*a* Calibration Parameter	Modeled Chl-*a* [ug/l]	Observed Growing Season Average Chl-*a* [ug/L]	Secchi Calibration Parameter	Modeled Secchi [m]	Observed Growing Season Average Secchi [m]
Wet Conditions (2003)	Lendt Lake	48			**1.00**	23		**1.00**	1.2	
	Moody Lake	141	205		**0.37**	41		**0.88**	0.8	
	Third Lake	31.6			**1.00**	13		**1.00**	1.7	
	Sea Lake	89			**1.00**	57		**1.00**	0.7	
	Bone Lake	77		82	**1.00**	46	48.4	**1.00**	0.8	0.93
	Nielsen Lake	110			**1.00**	78		**1.00**	0.6	
	Birch Lake	106.2	165		**0.35**	26		**2.30**	1.5	
	School Lake	78	94		**1.00**	47		**1.00**	0.8	
	Little Comfort Lake	80	82		**0.43**	21		**1.30**	1.7	
	Clear Lake	72			**1.00**	42		**1.00**	0.9	
	Twin Lake	137.2			**1.00**	107		**1.00**	0.5	
	Cranberry Lake	65			**1.00**	36		**1.00**	1.0	
	Elwell Lake	73			**1.00**	43		**1.00**	0.9	
	Sylvan Lake	35		17	**0.60**	9	3.7	**1.20**	2.6	4.27
	Shields Lake	222		381	**0.20**	43	46.3	**1.50**	1.3	1.16
	Forest Lake East	51			**1.00**	25		**1.00**	1.2	
	Forest Lake Middle	47			**1.00**	23		**1.00**	1.3	
	Forest Lake West	38.5		36.4	**1.00**	17	16.6	**1.00**	1.5	1.30
	Heims Lake	67.6			**1.00**	38		**1.00**	0.9	
	shallow pond	85			**1.00**	53		**1.00**	0.8	
	Comfort Lake	48		48	**1.00**	23	24.9	**1.00**	1.2	1.28
	First Lake	440			**1.00**	589		**1.00**	0.2	
	Second Lake	107			**1.00**	75		**1.00**	0.6	
	Scandia - Lake West o	379			**1.00**	473		**1.00**	0.2	

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		Phosphorus Fate and Transport - - - Canfield & Bachmann Natural Lake Model							
		C-B *a* = 0.162		0.114					
		C-B *b* = 0.458		0.589					
	Lake Name	Total P Load [kg]	CB Calibration Factor	**Modeled Summer Mean TP [ug/l]**	Ratio of Corrected FWMC / Summer TP [--]	Phosphorus Outflow (Ratio-Adjusted) [kg/yr]	Phosphorus Retention (P Load - Outflow P) [kg/yr]	Phosphorus Outflow (Ratio-Adjusted) [lb/yr]	Phosphorus Retention (P Load - Outflow P) [lb/yr]
Wet Conditions (2003)	Lendt Lake	32	**1.00**	**48.3**	0.84	11.8	20.1	26.0	44
	Moody Lake	634	**1.20**	**140.6**	0.84	207	427	457	942
	Third Lake	16.6	**1.00**	**31.6**	0.84	6.8	9.8	14.9	21.6
	Sea Lake	58	**1.00**	**88.5**	0.84	17	40	38	89
	Bone Lake	881	**1.20**	**76.6**	0.78	187	694	411	1,531
	Nielsen Lake	67	**1.00**	**110.0**	0.84	24	43	53	94
	Birch Lake	556.5	**1.20**	**106.2**	0.84	374.3	182.2	825.4	401.7
	School Lake	605	**1.10**	**78.0**	0.84	334.1	270.5	736.8	596
	Little Comfort Lake	793	**1.00**	**80.2**	0.84	461	332	1,018	731
	Clear Lake	35	**1.00**	**72.3**	0.83	12	23	26	51
	Twin Lake	97.8	**1.00**	**137.2**	0.83	43.5	54.3	95.9	119.8
	Cranberry Lake	83	**1.00**	**64.8**	0.83	52.5	30.3	115.8	67
	Elwell Lake	28	**1.00**	**73.1**	0.83	13	15	29	34
	Sylvan Lake	83	**1.40**	**35.4**	0.84	20	64	43	141
	Shields Lake	554	**1.00**	**222.1**	0.73	180	374	397	824
	Forest Lake East	1,180	**1.20**	**51.1**	0.83	169	1,011	372	2,230
	Forest Lake Middle	742	**1.30**	**47.2**	0.83	207.1	535.3	456.6	1,180
	Forest Lake West	852.8	**1.00**	**38.5**	0.83	249.7	603.1	550.5	1,329.9
	Heims Lake	52.1	**1.00**	**67.6**	1.03	15.7	36.4	34.6	80.2
	shallow pond	1,394	**3.30**	**84.7**	1.03	908	486	2,002	1,071
	Comfort Lake	1,677	**1.20**	**47.8**	1.03	1,025.7	651.7	2,261.7	1,437
	First Lake	499	**1.00**	**440.4**	0.78	-	499	-	1,101
	Second Lake	79	**1.00**	**107.3**	0.78	7.3	72	16.1	157.8
	Scandia - Lake West o	94	**1.00**	**378.9**	0.78	-	94	-	208

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Model Run for Dry Conditions (2006)

	Lake Name	Lake Physical Characteristics			
		Lake Area [acres]	Lake Mean Depth [ft]	Lake Volume [acre-ft]	Shallow or Deep
Dry Conditions (2006)	Lendt Lake	66	*3.0*	*199*	minor
	Moody Lake	34	13.8	465	deep
	Third Lake	65	*3.0*	*194*	minor
	Sea Lake	51	*3.0*	*152*	minor
	SM3				
	Bone Lake	204	13.4	2,735	deep
	Nielsen Lake	32	*3.0*	*95*	minor - d
	Birch Lake	32	2.8	88	shallow
	School Lake	50	10.8	532	deep
	Little Comfort Lake	35	18.4	649	deep
	Clear Lake	39	3.0	117	minor - d
	Twin Lake	21	3.0	63	minor - d
	Cranberry Lake	21	3.0	62	minor
	Elwell Lake	18	*3.0*	*54*	minor - d
	Sylvan Lake	84	9.4	792	deep
	Shields Lake	27	*7.4*	*203*	deep
	Forest Lake East	779	12.6	9,779	deep
	Forest Lake Middle	367	11.1	4,089	deep
	Forest Lake West	1,074	9.9	10,590	deep
	Heims Lake	90	*3.0*	*269*	minor
	shallow pond	155	*1.0*	*155*	minor
	Comfort Lake	218	19.2	4,182	deep
	First Lake	51	*3.0*	*154*	minor - d
	Second Lake	87	*3.0*	*261*	minor - d
	Scandia - Lake West of S	*13*	*3.0*	*38*	minor - d

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	Lake Name	Water Quantity - Existing Conditions Water Budget Outflow and Inflow Volumes Outflow Volumes [ac-ft] Evapo-ration from Lake	Discharge through Outlet	Discharge via Groundwater	Regional Ground-water Outflow	Sum of Outflows	Inflow Volumes [ac-ft] Water-shed Runoff	Precip-itation (direct)	Flow from Upstream Lakes via Surface	Flow from Upstream Lakes via Ground Water	Regional Ground-water Inflow	Sum of Inflows	Change in Storage [acre-ft]
Dry Conditions (2006)	Lendt Lake	171	7		125	302	177	125	-	-	-	302	
	Moody Lake	87	82		64	233	160	64	7	2	-	233	-
	Third Lake	166	7		122	296	173	122	-	-	-	296	-
	Sea Lake	130		35		165	79	86	-	-	-	165	-
	SM3	-	222		-	222	94	-	-	128	-	222	-
	Bone Lake	523	394		383	1,301	630	357	90	163	-	1,239	(62)
	Nielsen Lake	81		191	-	272	207	65	-	-	-	272	-
	Birch Lake	81	1,446		-	1,527	825	54	394	204	12	1,489	-
	School Lake	127	1,947		-	2,075	491	101	1,446	17	19	2,075	-
	Little Comfort Lake	91	3,074		-	3,165	1,098	72	1,947	34	14	3,165	-
	Clear Lake	100		38	-	139	39	62	-	22	15	139	-
	Twin Lake	54	76		-	130	47	34	-	41	8	130	-
	Cranberry Lake	53	193		-	246	130	33	76	-	8	246	-
	Elwell Lake	46		42	-	89	34	29	-	19	7	89	-
	Sylvan Lake	216		130	-	346	2	134	-	103	33	272	(74)
	Shields Lake	70	324		-	394	282	44	-	3	11	339	(55)
	Forest Lake East	2,000	840		-	2,840	499	1,244	193	205	305	2,446	(395)
	Forest Lake Middle	944	1,294		-	2,237	156	587	1,164	-	144	2,051	(186)
	Forest Lake West	2,759	1,546		-	4,305	314	1,715	1,294	17	421	3,761	(545)
	Heims Lake	230	28		-	258	24	199	-	-	35	258	-
	shallow pond	399	2,518		-	2,917	945	343	1,574	8	46	2,917	-
	Comfort Lake	560	5,666		-	6,227	42	471	5,592	14	85	6,205	(22)
	First Lake	132	-		-			*97*	*0*		-		
	Second Lake	224	*0*		-			*164*	-		-		
	Scandia - Lake West o	*33*	-		-		*522*	*22*	-		-		

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		Water Quality - Existing Conditions (1/3)			
		Phosphorus Budget Outflow			
		Outflow Phosphorus [lb]			
	Lake Name	Lake Outlet Flow	Regional Ground-water	Discharge via Groundwater	Sediment-ation
Dry Conditions (2006)	Lendt Lake	12	-	-	26
	Moody Lake	56	-	-	835
	Third Lake	9.5	8.9	-	19
	Sea Lake	7	-	6.7	58
	SM3	-		-	-
	Bone Lake	101	-	-	829
	Nielsen Lake	30	-	30.1	44
	Birch Lake	406	-	-	297
	School Lake	319	-	-	371
	Little Comfort Lake	530	-	-	496
	Clear Lake	6	-	5.8	31
	Twin Lake	23.4	-	-	74
	Cranberry Lake	31	-	-	37
	Elwell Lake	7	-	7.3	22
	Sylvan Lake	1	-	1.5	4
	Shields Lake	183	-	-	885
	Forest Lake East	78	-	-	1,313
	Forest Lake Middle	113	-	-	652
	Forest Lake West	119.5	-	-	803
	Heims Lake	4.9	-	-	58
	shallow pond	816	-	-	560
	Comfort Lake	725	-	-	989
				-	
	First Lake	-	-	-	544
	Second Lake	0	-	-	90
	Scandia - Lake West o	-	-	-	104

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		Water Quality - Existing Conditions (2/3)												
		Phosphorus Budget Inflow (1/2)												
		Inflow Phosphorus [lb]												
	Lake Name	UAL CF	Runoff (Land use-based)	Landlocked Runoff Removals	Livestock CF	Livestock P Load	Landlocked Livestock P Load Removals	Landlocked Groundwater Load to Lake	P from Upstream Lakes Outlets	P from Upstream Minor Lake Outlets	Water-shed Load	Water-shed Load Increment	NOTES	Adjusted Water-shed Load
Dry Conditions (2006)	Lendt Lake	**0.80**	29	-	**0.80**	1	0	0	-		30	**-**		30
	Moody Lake	**0.80**	360	(15)	**0.80**	158	(3)	0	-	12	511	**-**		511
	Third Lake	**0.80**	-	-	**0.80**	5	0	0	-		5	**-**		5
	Sea Lake	**0.80**	59	-	**0.80**	1	0	0	-		59	**-**		59
	SM3	**0.80**	145	(21)	**0.80**	1	0	20			144			144
	Bone Lake	**0.80**	556	(21)	**0.80**	62	0	25	56	14	691	**-**		691
	Nielsen Lake	**0.80**	68	-	**0.80**	3	0	0	-		71	**-**		71
	Birch Lake	**0.80**	234	(14)	**0.80**	85	(36)	31	101	24	425	**-**		425
	School Lake	**0.80**	144	(7)	**0.80**	106	(23)	3	406		629	**-**		629
	Little Comfort Lake	**0.80**	298	(8)	**0.80**	19	(1)	5	319		633	**314**		947
	Clear Lake	**0.80**	40	(13)	**0.80**	0	0	3	-		31	**-**		31
	Twin Lake	**0.80**	93	(11)	**0.80**	2	(1)	6	-	5	94	**-**		94
	Cranberry Lake	**0.80**	41	-	**0.80**	0	0	0	-	23	64	**-**		64
	Elwell Lake	**0.80**	77	(54)	**0.80**	0	0	3	-		26	**-**		26
	Sylvan Lake	**0.80**	197	(70)	**0.80**	0	0	16	-		142	**-**		142
	Shields Lake	**0.80**	161	(12)	**0.80**	1	0	0	-		151	**-**		151
	Forest Lake East	**0.80**	853	(62)	**0.80**	133	0	31	17	37	1,009	**-**		1,009
	Forest Lake Middle	**0.80**	345	-	**0.80**	1	0	0	*261*		607	**-**		607
	Forest Lake West	**0.80**	600	(47)	**0.80**	0	0	3	113		669	**-**		669
	Heims Lake	**0.80**	48	-	**0.80**	0	0	0	-		48	**-**		48
	shallow pond	**0.80**	1,229	(5)	**0.80**	4	0	1	119	5	1,353	**-**		1,353
	Comfort Lake	**0.80**	298	-	**0.80**	0	0	2	1,346		1,646	**-**		1,646
	First Lake	**0.80**	352	(13)	**0.80**	201	(2)	0	-	0	538	**-**		538
	Second Lake	**0.80**	81	(2)	**0.80**	1	0	0	-		80	**-**		80
	Scandia - Lake West o	**0.80**	99	(5)	**0.80**	10	(1)	0	-		103	**-**		103

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		Water Quality - Existing Conditions (3/3)											
		Phosphorus Budget Inflow (2/2)											
		Inflow Phosphorus [lb]											
	Lake Name	Atmos-pheric	Lake-shore Septic	Regional Ground-water	**Internal Load CF**	Lake Internal Load	Adjusted Internal Load	Internal + Direct Load	Total Lake P Load	Total Load Calibration Increment	Scenario Load Reduction	NOTES	Adjusted Total Lake P Load
Dry Conditions (2006)	Lendt Lake	7	-	-	**-**	-		7	37	**-**			37
	Moody Lake	4	9	-	**0.75**	490	368	380	891	**-**			891
	Third Lake	7	16	-	**-**	-		23	28	**-**			28
	Sea Lake	6		-	**-**	-		6	65	**-**			65
	SM3		-	-			-		144				144
	Bone Lake	22	84	-	**0.80**	165	132	238	930	**-**			930
	Nielsen Lake	3	-	-	**-**	-		3	75	**-**			75
	Birch Lake	3	4	2	**1.00**	18	18	28	453	**250**			703
	School Lake	5	8	3	**1.00**	46	46	62	691	**-**			691
	Little Comfort Lake	4	16	2	**1.00**	56	56	78	1,025	**-**			1,025
	Clear Lake	4	-	2	**-**	-		7	37	**-**			37
	Twin Lake	2	-	1	**-**	-		4	98	**-**			98
	Cranberry Lake	2	-	1	**-**	-		3	68	**-**			68
	Elwell Lake	2	-	1	**-**	-		3	29	**-**			29
	Sylvan Lake	9	72	5	**1.00**	17	17	103	245	**(240)**			5
	Shields Lake	3	-	2	**1.00**	76	76	81	231	**837**			1,068
	Forest Lake East	85	-	46	**1.00**	251	251	382	1,391	**-**			1,391
	Forest Lake Middle	40	-	22	**1.00**	97	97	159	765	**-**			765
	Forest Lake West	117	-	64	**1.00**	73	73	254	923	**-**			923
	Heims Lake	10	-	5	**-**	-		15	63	**-**			63
	shallow pond	17	-	7	**-**	-		24	1,377	**-**			1,377
	Comfort Lake	24	98	13	**0.60**	223	134	269	1,914	**(200)**			1,714
									-				
	First Lake	6	-	-	**-**	-		6	544	**-**			544
	Second Lake	9	-	-	**-**	-		9	90	**-**			90
	Scandia - Lake West o	1	-	-	**-**	-		1	104	**-**			104

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		Lake Response								
		Summer Surface Means								
		TP Concentration			Chlorophyll-*a* Concentration			Secchi Depth		
	Lake Name	Modeled TP [ug/l]	Estimated TP [ug/L]	Observed Growing Season Average TP [ug/L]	Chl-*a* Calibration Parameter	Modeled Chl-*a* [ug/l]	Observed Growing Season Average Chl-*a* [ug/L]	Secchi Calibration Parameter	Modeled Secchi [m]	Observed Growing Season Average Secchi [m]
Dry Conditions (2006)	Lendt Lake	38			**1.00**	17		**1.00**	1.5	
	Moody Lake	167		166	**0.37**	53	47	**0.88**	0.7	0.6
	Third Lake	32.1			**1.00**	13		**1.00**	1.7	
	Sea Lake	84			**1.00**	52		**1.00**	0.8	
	SM3									
	Bone Lake	61		60	**1.00**	33	21	**1.00**	1.0	1.6
	Nielsen Lake	69			**1.00**	39		**1.00**	0.9	
	Birch Lake	122.5		124	**0.35**	32	17	**2.30**	1.3	1.4
	School Lake	72		73	**1.00**	42	32	**1.00**	0.9	1.1
	Little Comfort Lake	75		76	**0.43**	19	25	**1.30**	1.8	1.4
	Clear Lake	66			**1.00**	37		**1.00**	0.9	
	Twin Lake	136.4			**1.00**	106		**1.00**	0.5	
	Cranberry Lake	71			**1.00**	41		**1.00**	0.9	
	Elwell Lake	76			**1.00**	45		**1.00**	0.8	
	Sylvan Lake	5	21		**0.60**	0		**1.20**	13.3	4.9
	Shields Lake	286		234	**0.20**	63	59	**1.50**	1.1	1.1
	Forest Lake East	41.0		41	**1.00**	18	21	**1.00**	1.4	1.5
	Forest Lake Middle	38.7		39	**1.00**	17	20	**1.00**	1.5	1.5
	Forest Lake West	34.1		39	**1.00**	14	20	**1.00**	1.6	1.4
	Heims Lake	63.7			**1.00**	35		**1.00**	1.0	
	shallow pond	116			**1.00**	84		**1.00**	0.6	
	Comfort Lake	46		50	**1.00**	22	12	**1.00**	1.3	2.0
	First Lake	300			**1.00**	337		**1.00**	0.3	
	Second Lake	85			**1.00**	53		**1.00**	0.8	
	Scandia - Lake West o	261			**1.00**	274		**1.00**	0.3	

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		Phosphorus Fate and Transport - - - Canfield & Bachmann Natural Lake Model							
		C-B *a* = 0.162		0.114					
		C-B *b* = 0.458		0.589					
	Lake Name	Total P Load [kg]	CB Calibration Factor	**Modeled Summer Mean TP [ug/l]**	Ratio of Corrected FWMC / Summer TP [--]	Phosphorus Outflow (Ratio-Adjusted) [kg/yr]	Phosphorus Retention (P Load - Outflow P) [kg/yr]	Phosphorus Outflow (Ratio-Adjusted) [lb/yr]	Phosphorus Retention (P Load - Outflow P) [lb/yr]
Dry Conditions (2006)	Lendt Lake	17	**1.00**	**38.4**	0.84	5.2	11.6	11.6	26
	Moody Lake	404	**1.20**	**166.5**	0.84	25	379	56	835
	Third Lake	12.8	**1.00**	**32.1**	0.84	4.3	8.5	9.5	18.8
	Sea Lake	29	**1.00**	**84.0**	0.84	3	26	7	58
	SM3								
	Bone Lake	422	**1.20**	**60.7**	0.78	46	376	101	829
	Nielsen Lake	34	**1.00**	**69.1**	0.84	14	20	30	44
	Birch Lake	318.6	**1.20**	**122.5**	0.84	184.0	134.6	405.7	296.8
	School Lake	313	**1.10**	**71.6**	0.84	144.8	168.4	319.4	371
	Little Comfort Lake	465	**1.00**	**75.2**	0.84	240	225	530	496
	Clear Lake	17	**1.00**	**66.4**	0.83	3	14	6	31
	Twin Lake	44.3	**1.00**	**136.4**	0.83	10.6	33.7	23.4	74.2
	Cranberry Lake	31	**1.00**	**71.3**	0.83	14.2	16.6	31.2	37
	Elwell Lake	13	**1.00**	**76.0**	0.83	3	10	7	22
	Sylvan Lake	2	**1.40**	**4.9**	0.84	1	2	1	4
	Shields Lake	484	**1.00**	**285.5**	0.73	83	401	183	885
	Forest Lake East	631	**1.20**	**41.0**	0.83	35	595	78	1,313
	Forest Lake Middle	347	**1.30**	**38.7**	0.83	51.4	295.7	113.3	652
	Forest Lake West	418.6	**1.00**	**34.1**	0.83	54.2	364.4	119.5	803.5
	Heims Lake	28.5	**1.00**	**63.7**	1.03	2.2	26.2	4.9	57.8
	shallow pond	624	**1.80**	**116.1**	1.03	370	254	816	560
	Comfort Lake	777	**1.20**	**45.8**	1.03	328.9	448.6	725.1	989
	First Lake	247	**1.00**	**300.5**	0.78	-	247	-	544
	Second Lake	41	**1.00**	**84.9**	0.78	0.0	41	0.0	89.6
	Scandia - Lake West o	47	**1.00**	**260.8**	0.78	-	47	-	104

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