



CAPE COD COMMISSION

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MEMORANDUM

TO: Pleasant Bay Resource Management Alliance, Watershed Working Group
Carole Ridley, Coordinator, Pleasant Bay Resource Management Alliance
Cape Cod Commission members: Brewster, Chatham, Harwich, Orleans

CC: Brian Howes, SMAST, UMASS Dartmouth
Tom Cambareri, CCC
Paul Niedzwiecki, CCC

FROM: Ed Eichner, Water Scientist

DATE: November 28, 2007

RE: Individual town nitrogen loads by TMDL watershed/segments to Pleasant Bay

As a follow-up on my September 25 memo detailing each town's nitrogen loading contribution to each of the individual subwatersheds to the Pleasant Bay estuary, the Alliance Watershed Working Group requested additional analysis to aggregate the loads according to the subembayments listed in the MassDEP TMDL for Pleasant Bay (May 2007). As with the September 25 analysis, each town's contribution of attenuated and unattenuated nitrogen loads under existing and buildout conditions were determined beginning with the Massachusetts Estuaries Project watershed model and reworking its results and equations to complete the requested analysis. Funding for this effort was provided by the current Management Challenges for Nitrogen Control grant that the Commission has from the US Environmental Protection Agency.

Table 1 show the results of the analysis with existing and buildout unattenuated loads for each of the 20-listed TMDL segments for Pleasant Bay, as well as the complementary attenuated loads and the TMDL watershed thresholds. This analysis incorporates the results of the analysis completed to breakdown the loads by town for each of the 95 subwatersheds. Total loads from this analysis by town are generally within 1% of the September 25 memo loads. This analysis also incorporates the percentage reductions in nitrogen load for the portion of the loads that flow out of the system at ponds that straddle the overall watershed boundary.

Table 1. Nitrogen Loads by Town for the Pleasant Bay TMDL Segments

All nitrogen loads are in kilograms per year. All loads account for load reductions caused by groundwater flow out of the watershed from ponds that straddle the outer boundary of the Pleasant Bay watershed. Watershed names are based on the segments listed in the MassDEP TMDL document for Pleasant Bay (May 2007). Target watershed loads for each TMDL segment are listed for comparison. No loads are listed for Little Pleasant Bay because the boundaries of this portion of the system are not included in the TMDL or the MEP Technical Report, which is the basis for the TMDL.

Watershed Name	Target Watershed Load from TMDL	EXISTING UNATTENUATED w/outflows included					EXISTING ATTENUATED					% Atten	BUILDOUT UNATTENUATED w/outflows included					BUILDOUT ATTENUATED					% Atten
		ORL	BRE	HAR	CHA	TOTAL	ORL	BRE	HAR	CHA	TOTAL		ORL	BRE	HAR	CHA	TOTAL	ORL	BRE	HAR	CHA	TOTAL	
Meetinghouse Pond	387	2256	0	0	0	2256	2256	0	0	0	0	0%	3008	0	0	0	3008	3008	0	0	0	0	0%
The River - upper	635	1174	61	0	0	1235	998	7	0	0	0	1005	1685	76	0	0	1761	1433	10	0	0	0	18%
The River - lower	891	1549	107	0	0	1656	1390	16	0	0	0	1405	2603	117	0	0	2720	2392	19	0	0	0	11%
Kescayo Gansett Pond	595	1139	248	0	0	1388	838	40	0	0	0	878	1628	283	0	0	1910	1230	53	0	0	0	33%
Areys Pond	336	367	282	0	0	650	367	95	0	0	0	463	636	286	0	0	922	636	96	0	0	0	21%
Namequoit River	631	1034	117	0	0	1151	935	51	0	0	0	987	1494	167	0	0	1661	1367	98	0	0	0	12%
Pah Wah Pond	266	679	0	0	0	679	679	0	0	0	0	679	1023	0	0	0	1023	1023	0	0	0	0	0%
Pochet Neck	1504	3135	0	0	0	3135	3073	0	0	0	0	3073	4411	0	0	0	4411	4336	0	0	0	0	2%
Little Pleasant Bay	2146																						
Quanset Pond	394	723	142	0	0	865	569	72	0	0	0	641	965	175	0	0	1141	771	89	0	0	0	25%
Round Cove	1080	0	2	1553	0	1554	0	1	1544	0	0	1%	0	2	1900	0	1901	0	1	1891	0	0	1%
Muddy Creek - Upper	1683	0	0	2584	1234	3819	0	0	2510	1154	3683	4%	0	0	3501	1373	4874	0	0	3403	1290	4694	4%
Muddy Creek - Lower	781	0	0	1809	1488	3297	0	0	1802	1294	3096	6%	0	0	2421	1501	3922	0	0	2413	1306	3719	5%
Pleasant Bay	7975	4055	6212	2732	1526	14525	3538	6077	2622	1526	13763	5%	6237	7468	3743	2265	19712	5543	7187	3630	2265	18625	6%
Ryder Cove	1632	0	0	0	4054	4054	0	0	0	3613	3613	11%	0	0	0	0	4559	0	0	0	4424	4424	3%
Frostfish Creek	256	0	0	0	1059	1059	0	0	0	1059	1059	0%	0	0	0	0	1211	0	0	0	1211	1211	0%
Crows Pond	1540	0	0	0	1542	1542	0	0	0	1537	1537	0%	0	0	0	0	1699	0	0	0	1694	1694	0%
Bassing Harbor	610	0	0	0	620	620	0	0	0	607	607	2%	0	0	0	0	730	0	0	0	716	716	2%
Chatham Harbor	6242	0	0	0	6377	6377	0	0	0	6309	6309	1%	0	0	0	0	7106	0	0	0	7030	7030	1%
System TOTAL	29656	16112	7171	8678	17900	49860	14644	6360	8478	17099	46580	7%	23691	8574	11565	20443	64272	21739	7553	11337	19935	60564	6%

Table 2 shows the percentage of the nitrogen loads from this analysis. The load percentages are the same as the September 25 memo results except for the attenuated buildout in Brewster which decreased by 1% due to a slight change in rounding.

Table 2 also shows percentage watershed land area and the watershed including estuary surface areas by town. These comparisons were used in the Popponesset Bay discussions of town fair shares and are provided in anticipation of similar future discussions for Pleasant Bay. The areas that these percentages are based on do not account for the portions of recharge that flow out of the system.

As mentioned above, this effort to determine subwatershed loads by individual town was funded using grant funds from the Commission's Management Challenges for Nitrogen Control grant that the Commission has from the US Environmental Protection Agency. The effort represents approximately \$2,000 worth of Cape Cod Commission staff time.

Table 2. Watershed Nitrogen Load and Watershed Area by Town for Pleasant Bay				
NITROGEN LOADS (%)	Orleans	Brewster	Harwich	Chatham
Existing Unattenuated	32%	14%	17%	36%
Existing Attenuated	31%	14%	18%	37%
Buildout Unattenuated	37%	13%	18%	32%
Buildout Attenuated	36%	12%	19%	33%
WATERSHED AREA				
Watershed Land (acres)	5,293	3,527	2,643	3,655
Estuary Surface (acres)	3,528	-	153	2,802
Land and Estuary (acres)	8,822	3,527	2,795	6,456
Watershed Land (%)	35%	23%	17%	24%
Estuary Surface (%)	54%	0%	2%	43%
Land and Estuary (%)	41%	16%	13%	30%
Notes:				
1) nitrogen loading percentages based on watershed load only; do not include loads on estuary surfaces				
2) all loads adjusted to account for nitrogen loads that flow out of the watershed				
3) attenuated loads account for reductions caused by application of multiple attenuation factors in situations where loads flow through multiple ponds				
4) watershed land area is not adjusted to account for flow out of the watershed system				
5) rounding may cause some totals to appear inaccurate				



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CC: Brian Howes, SMAST, UMASS Dartmouth
Tom Cambareri, CCC
Paul Niedzwiecki, CCC

FROM: Ed Eichner, Water Scientist

DATE: September 25, 2007

RE: Individual town nitrogen loads by individual subwatersheds to Pleasant Bay

During past Alliance Watershed Working Group discussions, it was decided that it would be useful to the Alliance and member towns to determine each town's contribution of attenuated and unattenuated nitrogen loads within each individual subwatershed to the Pleasant Bay estuary. Since the Cape Cod Commission had created the Massachusetts Estuaries Project watershed nitrogen loading model, I offered to rework the model's components to determine these nitrogen loads using funding from the current Management Challenges for Nitrogen Control grant that the Commission has from the US Environmental Protection Agency.

The results show that attenuation rates in individual subwatersheds vary between 0 and 79% (Table 1). Attenuated loads account for splitting of downgradient loads among various ponds, as well as application of all the attenuation factors these loads are reduced by prior to discharge into Pleasant Bay or its subestuaries. So, for example, one portion of an upgradient subwatershed load may pass through two ponds and be subject to two 50% reductions, while another portion may pass through only one pond before reaching the estuary. Both attenuated and unattenuated loads also account for portions of nitrogen loads that flow out of the system watershed at ponds that straddle the watershed boundary, such as Cliff Pond in Brewster or Goose Pond in Chatham. Watershed loads do not include any nitrogen loads on the surface of the estuary or subestuaries. The overall system loads are within 0.8% or less of the overall loads presented in the MEP report on Pleasant Bay. Overall attenuation rates for the entire system show that 7% of the load is attenuated under existing conditions, while 6% is projected to be attenuated under buildout conditions.

Table 1. Individual Subwatershed Nitrogen Loads for Pleasant Bay.

All analysis based on Massachusetts Estuaries Project watershed nitrogen loading model, which is documented in the Pleasant Bay MEP Technical Report (Howes, *et al.*, 2006). Loads are adjusted to account for portions of subwatershed loads that leave the system watershed via ponds that straddle the system watershed boundary. Loads include only watershed loads and do not include loads on estuary or subestuary surfaces.

Watershed Name	Shed ID#	EXISTING UNATTENUATED w/outflows included					EXISTING ATTENUATED					% Atten	UNATTENUATED BUILDOUT w/outflows included					ATTENUATED BUILDOUT					% Atten
		ORL	BRE	HAR	CHA	TOTAL	ORL	BRE	HAR	CHA	TOTAL		ORL	BRE	HAR	CHA	TOTAL	ORL	BRE	HAR	CHA	TOTAL	
Baker Pond GT 10	1	0	21	0	0	21	0	7	0	0	7	67%	0	34	0	0	34	0	11	0	0	11	67%
Baker Pond LT 10	2	107	23	0	0	130	35	8	0	0	43	67%	118	57	0	0	175	39	19	0	0	58	67%
Cliff Pond GT 10	3	0	231	0	0	231	0	48	0	0	48	79%	0	242	0	0	242	50	50	0	0	100	79%
Cliff Pond LT 10	4	0	176	0	0	176	0	36	0	0	36	79%	0	176	0	0	176	36	36	0	0	72	79%
Crystal Lake GT 10	5	128	0	0	0	128	64	0	0	0	64	50%	239	0	0	0	239	120	120	0	0	120	50%
Crystal Lake LT 10	6	388	0	0	0	388	194	0	0	0	194	50%	527	0	0	0	527	263	263	0	0	263	50%
Deep Pond GT 10	7	0	5	0	0	5	0	2	0	0	2	50%	0	173	0	0	173	86	86	0	0	86	50%
Deep Pond LT 10	8	117	53	0	0	171	59	27	0	0	85	50%	165	101	0	0	266	82	51	0	0	133	50%
Grassy Pond	9	0	0	183	0	183	0	0	87	0	87	52%	0	0	189	0	189	90	90	0	0	90	52%
Higgins Pond	10	0	134	0	0	134	0	37	0	0	37	72%	0	134	0	0	134	37	37	0	0	37	72%
Little Cliff Pond	11	0	123	0	0	123	0	25	0	0	25	79%	0	123	0	0	123	25	25	0	0	25	79%
Mud Pond	12	0	7	47	0	54	0	3	24	0	27	50%	0	7	47	0	54	3	24	0	0	27	50%
Pilgrim Lake LT 10	13	562	0	0	0	562	281	0	0	0	281	50%	730	0	0	0	730	281	281	0	0	281	50%
Rafe Pond	14	0	42	0	0	42	0	21	0	0	21	50%	0	42	0	0	42	21	21	0	0	21	50%
Ruth Pond GT 10	15	0	41	0	0	41	0	8	0	0	8	80%	0	41	0	0	41	8	8	0	0	8	80%
Ruth Pond LT 10	16	0	7	0	0	7	0	1	0	0	1	80%	0	7	0	0	7	1	1	0	0	1	80%
Sarahs Pond GT 10	17	311	0	0	0	311	156	0	0	0	156	50%	420	0	0	0	420	210	210	0	0	210	50%
Sarahs Pond LT 10	18	85	0	0	0	85	43	0	0	0	43	50%	166	0	0	0	166	83	83	0	0	83	50%
Shoal Pond GT 10	19	0	4	0	0	4	0	2	0	0	2	50%	0	4	0	0	4	2	2	0	0	2	50%
Shoal Pond LT 10	20	251	155	0	0	405	125	77	0	0	203	50%	315	177	0	0	492	158	88	0	0	246	50%
Twinings Pond GT 10	21	11	69	0	0	80	4	27	0	0	31	61%	22	103	0	0	125	9	40	0	0	49	61%
Twinings Pond LT 10	22	298	0	0	0	298	116	0	0	0	116	61%	362	0	0	0	362	141	141	0	0	141	61%
Uncle Harvey Pond	23	123	0	0	0	123	61	0	0	0	61	50%	151	0	0	0	151	75	75	0	0	75	50%
Uncle Seths Pond GT 10	24	0	6	0	0	6	0	3	0	0	3	50%	0	6	0	0	6	3	3	0	0	3	50%
Uncle Seths Pond LT 10	25	179	17	0	0	196	90	9	0	0	98	50%	193	56	0	0	250	97	28	0	0	125	50%
Cliff Pond WELL ORL	26	5	22	0	0	27	5	22	0	0	27	0%	5	22	0	0	27	5	22	0	0	27	0%
Freemant's Way WELL BRE	27	0	1063	0	0	1063	0	1063	0	0	1063	0%	0	1203	0	0	1203	0	1203	0	0	1203	0%
Gould Pond WELL ORL	28	249	27	0	0	276	124	14	0	0	138	50%	321	38	0	0	360	161	19	0	0	180	50%
Pleasant Bay Rd WELL HAR	29	0	0	331	0	331	0	0	331	0	331	0%	0	0	337	0	337	0	337	0	0	337	0%
Silas Rd WELL BRE	30	0	240	0	0	240	0	221	0	0	221	8%	0	296	0	0	296	273	273	0	0	273	8%
WELL 7 WELL ORL	31	345	61	0	0	406	345	61	0	0	406	0%	438	139	0	0	577	438	139	0	0	577	0%
Arey's Pond GT 10N	32	10	8	0	0	18	10	8	0	0	18	0%	16	8	0	0	24	16	8	0	0	24	0%
Arey's Pond GT 10S	33	2	0	0	0	2	2	0	0	0	2	0%	2	0	0	0	2	2	0	0	0	2	0%
Arey's Pond LT 10	34	351	0	0	0	351	351	0	0	0	351	0%	614	0	0	0	614	614	0	0	0	614	0%
Barley Neck GT 10	35	433	0	0	0	433	433	0	0	0	433	0%	517	0	0	0	517	517	0	0	0	517	0%
Barley Neck LT 10	36	456	0	0	0	456	456	0	0	0	456	0%	582	0	0	0	582	582	0	0	0	582	0%
Kescayo Gansett Pond GT 10	37	103	0	0	0	103	103	0	0	0	103	0%	204	0	0	0	204	204	0	0	0	204	0%
Kescayo Gansett Pond LT 10	38	268	0	0	0	268	268	0	0	0	268	0%	405	0	0	0	405	405	0	0	0	405	0%
Kescayo Gansett River	39	132	0	0	0	132	132	0	0	0	132	0%	171	0	0	0	171	171	0	0	0	171	0%
Kescayo Gansett Stream	40	45	0	0	0	45	45	0	0	0	45	0%	65	0	0	0	65	65	0	0	0	65	0%
Lower River LT 10	41	1237	0	0	0	1237	1237	0	0	0	1237	0%	2188	0	0	0	2188	2188	0	0	0	2188	0%
Meetinghouse Pond GT 10	42	953	0	0	0	953	953	0	0	0	953	0%	1278	0	0	0	1278	1278	0	0	0	1278	0%
Meetinghouse Pond LT 10	43	1303	0	0	0	1303	1303	0	0	0	1303	0%	1730	0	0	0	1730	1730	0	0	0	1730	0%
Namequoit River GT 10	44	38	40	0	0	78	38	40	0	0	78	0%	115	84	0	0	199	115	84	0	0	199	0%
Namequoit River LT 10	45	741	0	0	0	741	741	0	0	0	741	0%	1127	0	0	0	1127	1127	0	0	0	1127	0%
Pah Wah Pond Bog	46	48	0	0	0	48	48	0	0	0	48	0%	56	0	0	0	56	56	0	0	0	56	0%
Pah Wah Pond GT 10	47	386	0	0	0	386	386	0	0	0	386	0%	484	0	0	0	484	484	0	0	0	484	0%
Pah Wah Pond LT 10	48	246	0	0	0	246	246	0	0	0	246	0%	483	0	0	0	483	483	0	0	0	483	0%
Pleasant Bay GT 10 BREHAR	49	0	1361	395	0	1756	0	1361	395	0	1756	0%	0	1400	513	0	1913	1400	513	0	0	1913	0%
Pleasant Bay GT 10 HAR	50	0	0	592	0	592	0	0	592	0	592	0%	0	0	769	0	769	769	0	0	0	769	0%
Pleasant Bay GT 10 ORL	51	642	129	0	0	771	642	129	0	0	771	0%	927	230	0	0	1157	927	230	0	0	1157	0%
Pleasant Bay GT 10 ORL BRE	52	0	682	0	0	682	0	682	0	0	682	0%	0	1106	0	0	1106	1106	0	0	0	1106	0%
Pleasant Bay LT 10	53	1883	337	1199	1526	4945	1883	337	1199	1526	4945	0%	3098	388	1904	2265	7655	3098	388	1904	2265	7655	0%
Pochet Neck GT 10	54	787	0	0	0	787	787	0	0	0	787	0%	1037	0	0	0	1037	1037	0	0	0	1037	0%
Pochet Neck LT 10	55	465	0	0	0	465	465	0	0	0	465	0%	633	0	0	0	633	633	0	0	0	633	0%
Pochet Neck Stream GT 10	56	377	0	0	0	377	377	0	0	0	377	0%	478	0	0	0	478	478	0	0	0	478	0%
Pochet Neck Stream LT 10	57	493	0	0	0	493	493	0	0	0	493	0%	1014	0	0	0	1014	1014	0	0	0	1014	0%
Quanset Pond Bog	58	21	0	0	0	21	21	0	0	0	21	0%	47	0	0	0	47	47	0	0	0	47	0%
Quanset Pond GT 10	59	0	6	0	0	6	0	6	0	0	6	0%	6	0	0	0	6	6	0	0	0	6	0%
Quanset Pond LT 10	60	427	0	0	0	427	427	0	0	0	427	0%	592	0	0	0	592	592	0	0	0	592	0%
Round Cove GT 10	61	0	772	0	0	772	0	772	0	0	772	0%	0	900	0	0	900	900	0	0	0	900	0%
Round Cove LT 10	62	0	766	0	0	766	0	766	0	0	766	0%	0	984	0	0	984	984	0	0	0	984	0%
Tar Kiln Stream GT 10	63	0	1413	0	0	1413	0	1413	0	0	1413	0%	0	1464	0								

The preparation of these loads also presented the opportunity to re-evaluate the cumulative loads by individual town. Table 1 shows the sum of nitrogen load by town and Table 2 shows the relative percentage by town under existing and buildout conditions for both attenuated and unattenuated loads. Brewster and Harwich contribute a relatively stable percentage of the overall load to Pleasant Bay, while Chatham is the largest percentage under existing conditions and Orleans is the largest percentage under buildout conditions (see Table 2).

As mentioned above, this effort to determine subwatershed loads by individual town was funded using grant funds from the Commission's Management Challenges for Nitrogen Control grant that the Commission has from the US Environmental Protection Agency. The effort represents approximately \$2,000 worth of Cape Cod Commission staff time.

Table 2. Percentage Watershed Nitrogen Load by Town for Pleasant Bay				
	Orleans	Brewster	Harwich	Chatham
Existing Unattenuated	32%	14%	17%	36%
Existing Attenuated	31%	14%	18%	37%
Buildout Unattenuated	37%	13%	18%	32%
Buildout Attenuated	36%	13%	19%	33%
Notes:				
1) percentages based on watershed load only; do not include loads on estuary surfaces				
2) all loads adjusted to account for nitrogen loads that flow out of the watershed				
3) attenuated loads account for reductions caused by application of multiple attenuation factors in situations where loads flow through multiple ponds				

