

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

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 ponds that straddle the outer boundary of the Pleasant Bay watershed. Watershed names are based on the segments listed in the MassDEP All nitrogen loads are in kilograms per year. All loads account for load reductions caused by groundwater flow out of the watershed from is the basis for the TMDL.

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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 Nitro	gen Load a	nd Watershe	d Area by T	own 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%
I S.T.				

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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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: 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.

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Baker Pond GT 10	1	0	21	0	0	21	0	7	0	0	7	67%	0	34	0	0	34		11		_	11	67%
Baker Pond LT 10 Cliff Pond GT 10	2	107	231	0			35 0			0		67% 79%	118	57 242		0		39	19 50			58 50	67% 79%
Cliff Pond LT 10	4	0			0		0					79%	0			0			36			36	79%
Crystal Lake GT 10	5 6	128 388	0	0	0		64					50%	239			0		120				120	50%
Crystal Lake LT 10 Deep Pond GT 10	7	0	5	0	0	388 5	194 0		0	0		50% 50%	527	173				263	86			263 86	50% 50%
Deep Pond LT 10	8	117	53	183	0		59 0		0 87	0		50% 52%	165			0		82	51	90		133 90	50% 52%
Grassy Pond Higgins Pond	10	0	-		0		0			0		72%	0			0			37	90		37	72%
Little Cliff Pond	11	0		0	0		0	25	0			79%	0	123	0				25	0.1		25	79%
Mud Pond Pilgrim Lake LT 10	12			47	0	54 562	281	0	24	0	27 281	50% 50%	730	0	47			281	3	24		281	50% 62%
Rafe Pond	14						0	21	0	0		50%	0			0			21			21	50%
Ruth Pond GT 10 Ruth Pond LT 10	15 16	0	7	0	0	7	0	8	0	0		80% 80%	0	41	0	0			8			1	80% 80%
Sarahs Pond GT 10	17	311					156		0	0		50%	420					210				210	50%
Sarahs Pond LT 10 Shoal Pond GT 10	18 19	85				85 4	43	0	0	0		50% 50%	166	4		0		83	2			83	50% 50%
Shoal Pond LT 10	20	251	155	0	0	405	125		0	0	203	50%	315			0		158	88			246	50%
Twinings Pond GT 10 Twinings Pond LT 10	21	11 298	69 0			80 298	116	27	0	0		61% 61%	362	103		0		9 141	40			49 141	61% 61%
Uncle Harvey Pond	23	123	6	0	0	123	61		0	0	61	50% 50%	151			0		75				75	50%
Uncle Seths Pond GT 10 Uncle Seths Pond LT 10	24 25	179		0	0	196	90	9	0	0		50%	193	56		0		97	28			125	50% 50%
Cliff Pond WELL_ORL	26	5	22	0		27	5	22	0	0		0%	5	22	0			5	22			27	0%
Freeman's Way WELL_BRE Gould Pond WELL ORL	27 28	249		0			124		0	0		0% 50%	321	1203	0	0		161	1203 19			1203 180	0% 50%
Pleasant Bay Rd WELL_HAR	29	0	0	331	0	331	0	0	331	0	331	0%	0	0	337	0	337			337		337	0%
Silas Rd Well_BRE WELL 7 WELL_ORL	30	345		0	0		345		0	0		8% 0%	438			0		438	273 139			273 577	8% 0%
Arey's Pond GT 10N	32	10	8	0	0	18	10	8	0	0		0%	16	8	0	0	24	16	8			24	0%
Arey's Pond GT 10S Arey's Pond LT 10	33	351			0		351	0	0	0	351	0% 0%	614	0				614	-			614	0% 0%
Barley Neck GT 10	35	433	0	0	0	433	433	0	0	0	433	0%	517	0	0	0	517	517				517	0%
Barley Neck LT 10 Kescayo Gansett Pond GT 10	36 37	456 103	0		0		456 103	0	0	0		0% 0%	582 204	0		0		582 204			_	582 204	0% 0%
Kescayo Gansett Pond LT 10	38	268	0	0	0	268	268	0	0	0	268	0%	405	0	0	0	405	405				405	0%
Kescayo Gansett River Kescayo Gansett Stream	39 40	132 45	0				132 45	0		0		0% 0%	171 65	0		0		171 65				171 65	0% 0%
Lower River LT 10	41	1237	0	0	0	1237	1237	0	0	0	1237	0%	2188	0	0	0	2188	2188				2188	0%
Meetinghouse Pond GT 10 Meetinghouse Pond LT 10	42	953 1303	0		0		953 1303	0	0	0		0% 0%	1278 1730	0				1278 1730				1278 1730	0% 0%
Namequoit River GT 10	44	98	40	0	0	138	98	40	0	0	138	0%	115	84	0	0	199	115	84			199	0%
Namequoit River LT 10 Pah Wah Pond Bog	45 46	741 48	0	0	0		741 48	0	0	0	741 48	0% 0%	1127 56	0		0	1127 56	1127 56	_		_	1127 56	0% 0%
Pah Wah Pond GT 10	47	386	0	0	0	386	386	0	0	0	386	0%	484	0	0	0	484	484				484	0%
Pah Wah Pond LT 10 Pleasant Bay GT 10 BREHAR	48	246	1361	395	0	246 1756	246	1361	395	0	246 1756	0% 0%	483	1400	513	0	483 1913	483	1400	513		483 1913	0% 0%
Pleasant Bay GT 10_HAR	50	0	0	592	0	592	0	0	592	0	592	0%	0	0	769	0	769			769		769	0%
Pleasant Bay GT 10_ORL Pleasant Bay GT 10_ORLBRE	51 52	642	129 692	0	0	771 692	642	129 692	0	0		0% 0%	927 0	230 1106	0	0		927	230 1106			1157 1106	0% 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 55	787 465	0	0	0	787 465	787 465	0	0	0		0% 0%	1037 633	0	0	0		1037 633				1037 633	0% 0%
Pochet Neck LT 10 Pochet Neck Stream GT 10	56	377	0	0	0	377	377	0	0	0	377	0%	478	0	0	0	478	478				478	0%
Pochet Neck Stream LT 10 Quanset Pond Bog	57 58	493	0	0	0	493 21	493	0	0	0	493	0% 0%	1014 47	0		0	1014 47	1014 47				1014 47	0% 0%
Quanset Pond GT 10	59	0	6		0	6	0	6	0	0	6	0%	0	6	0	0	6		6			6	0%
Quanset Pond LT 10 Round Cove GT 10	60 61	427 0	0	772	0	427 772	427 0	0	772	0		0% 0%	592 0	0		0	592 900	592	_	900	_	592 900	0% 0%
Round Cove LT 10	62	0	0	766	0	766	0	0	766	0	766	0%	0	0	984	0	984			984		984	0%
Tar Kiln Stream GT 10 Tar Kiln Stream LT 10	63 64	172	1413 696	0	0	1413 868	0 172	1413 696	0	0	1413 868	0% 0%	388		0	0	1464 1134	388	1464 746			1464 1134	0% 0%
The Horseshoe	65	35	0	0	0	35	35	0	0	0	35	0%	68	0	0	0	68	68	. 40			68	0%
Upper River GT 10 Upper River LT 10	66 67	238 601	0	0	0	238 601	238 601	0	0	0	238 601	0% 0%	327 872	0	0	0	327 872	327 872				327 872	0% 0%
Mill Pond Fresh	68	0	0	115	53	168	0	0	54	25	79	53%	0	0	162	56	217	3.2		76	26	102	53%
Goose Pond Trout Pond	69 70	0	0		174 320	174 320	0		0	70 160	70 160	59% 50%	0		0	176 320	176 320			-1	72 160	72 160	59% 50%
Schoolhouse Pond	71	0	0	0	195	195	0	0	0	94	94	52%	0	0	0	200	200				97	97	52%
Stillwater Pond Lovers Lake	72 73	0	0		387 559	387 559	0		0	367 265	367 265	5% 53%	0	0		415 592	415 592				394 281	394 281	5% 53%
Emery Pond	74	0	0	0	71	71	0	0	0	36	36	50%	0	0	0	78	78				39	39	50%
Bassing Pond Hawksnest Pond	75 76	0	0	31	160	160 31	0	0	0 16	80 0	80 16	50% 47%	0	0	31	182	182 31			16	91	91 16	50% 47%
Muddy Crk WELL	77	0	0	589	0	589	0	0	589	0	589	0%	0	0	734	0	734			734		734	0%
Lower Muddy Crk Lower Muddy Crk 10E	78 79	0	0	384 0	937 164	1321 164	0		384	937 164	1321 164	0% 0%	0	0	692 0	937 175	1629 175			692	937 175	1629 175	0% 0%
Lower Muddy Crk 10W	80	0	0	828	0	828	0	0	828	0	828	0%	0	0	984	0	984	-		984		984	0%
Upper Muddy Crk Upper Muddy Crk 10E	81 82	0	0		952 123	2513 123	0	0	1561	952 123	2513 123	0% 0%	0		1723	1053 157	2776 157			1723	1053 157	2776 157	0% 0%
Upper Muddy Crk 10W	83	0	0	881	0	881	0	0	881	0	881	0%	0	0	1591	0	1591			1591		1591	0%
Ryder Cove Ryder Cove 10S	84 85	0				1833 485	0		0	485	1833 485	0% 0%	0			2118 558	558				2118 558	2118 558	0% 0%
Ryder Cove 10E	86	0	0	0	167	167	0	0	0	167	167	0%	0	0	0	228	228				228	228	0%
Ryder Cove 10W Crows Pond	87 88	0	0	0	367 882	367 882	0	0	0	367 882	367 882	0% 0%	0		0	378 1005	378 1005				378 1005	378 1005	0% 0%
Crows Pond 10	89	0	0	0	651	651	0	0	0	651	651	0%	0	0	0	685	685				685	685	0%
Bassing Harbor Bassing Harbor 10	90 91	0	0	0	360 234	360 234	0	0	0	360 234	360 234	0% 0%	0	0	0	394 307	394 307				394 307	394	0% 0%
Frostfish Creek	92	0	0		432	432	0	0	0	432	432	0%	0	0	0	510	510				510	510	0%
Frostfish Creek 10 Upper Frostfish Crk	93 94	0		0	363 264	363 264	0	0	0	363 264	363 264	0% 0%	0	0		397 304	397 304			-	397 304	397 304	0% 0%
Chatham Harbor	95	0	0	0	6242	6242	0	0	0	6242	6242	0%	0	0	0	6953	6953	-			6953	6953	0%
TOTALS		16112	7209	8673	17900	49894	14655	6404	8478	17079	46616	7%	23691	8612	11560	20443	64306	21679	7598	11338	19583	60197	6%

9/25/07 Cape Cod Commission 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 W	latershed Ni	trogen Load 1	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

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