

To: Dr. Suzanne Dorsey
Bald Head Island Conservancy

From: Dr. Lawrence B. Cahoon

Re: Water Issues on Bald Head Island

I was asked by the Conservancy to review the facts and issues concerning water use, treatment, and disposal on Bald Head Island. I visited the Island on January 3, 2008, toured the Island's wastewater treatment plant (WWTP) and Reverse Osmosis (RO) facility, and sampled ponds on the golf course that received treated effluents as well as other ponds that do not. I have reviewed reports prepared by Witt & Associates, the Micrim lab, McKim and Creed, Law and Company, Applied Resource Management, ESP Associates, Environmental Chemists, and Hartman Consulting, as well as data reports from the WWTP, NC Division of Water Quality, and Dr. Mike Mallin. I also spoke with Dr. Charles Stehman, Chief of the Groundwater Section of the NC Division of Water Quality's Wilmington Regional Office.

I should briefly review my own qualifications for offering the opinions I present here. My full *curriculum vitae* is attached, but as it is rather long I will summarize some of the relevant qualifications I bring to this discussion. I am currently Professor of Biology and Marine Biology at UNC Wilmington, where I am in my 26th year on the faculty. I teach courses in Biological Oceanography, Limnology, and Forensic Environmental Science, as well as our doctoral seminar in Oceanography and Environmental Science. I have directed 39 graduate students of my own and served on 65 graduate committees. I have published over 70 peer-reviewed papers and approximately 80 other non-peer reviewed reports, chapters, and papers. I have received external contracts and grants valued at over \$5 million. I have served various external professional committees and boards, including the Environmental Biology panel for the US Environmental Protection Agency and the UNC Water Resources Research Institute's Technical Review Committee, and am currently a AAAS BiosciEdNet (BEN) Scholar. I directed water quality monitoring for the South Brunswick Water and Sewer Authority (SBWSA) for 7 years (1996-2003), was UNCW's first Principal Investigator for the NOAA-funded Coastal Ocean Research and Monitoring Program, have been a long-term collaborator with Dr. Mallin in the New Hanover Tidal Creeks Program, and conducted water quality monitoring work for the Town of Lake Waccamaw in Columbus County leading to a Clean Water Management Trust Fund grant to the Town of over \$4 million. I am familiar with water quality and related issues at Bald Head Island, but have never received funding from any Bald Head Island organization prior to this engagement. My former student, Jason Hales, conducted flushing rate studies of Bald Head Creek, and my close colleague, Dr. Michael Mallin, has done water quality work in Bald Head Creek recently.

My review of the documents and other observations I have made lead to several conclusions:

1) There is no acute crisis at this time with respect to water quality or quantity at Bald Head Island. I see no credible evidence in any reports or data sets indicating any imminent threat to human health or the health of wild animals or pets. Water quality issues in Bald Head Creek appear to be unrelated to central wastewater treatment or to RO operations. I understand that there may be some isolated septic tanks on the island and that there may be a few private drinking water wells as well. I am unaware of any studies specifically identifying these as problems, nor have I heard specific concerns expressed about them. Most waste water is handled by the Village's WWTP and most drinking water is provided from a line from Brunswick County's system at Fort Caswell and from 16 wells serving the RO system.

The wastewater plant on the island is well managed and uses state of the art technology in its treatment process. Drinking water is safe and well processed. The staff is competent and they have excellent equipment and facilities, including software that manages all aspects of the operation and provides real-time information on system status 24/7.

2) The reports by Witt and Associates and the Micrim laboratory were not helpful in identifying or quantifying the real problems that should be considered in this situation. Witt's first visit in July, 2007, although elaborately reported, was mainly observational and speculative, with recommendations for collection of data. I note that Mr. Witt was apparently unaware of data sets I have seen from other consultants, the state, and the Island's facilities operators. Mr. Witt's second visit generated samples submitted to Micrim Laboratory for microbiological analyses. I note several serious problems with analysis of these samples. First, Mr. Witt's visit to Bald Head Island was on Oct. 2, 2007, but the samples he collected were delivered to Micrim Laboratory on Oct. 4, indicating a transit or "hold" time of 2 days. Among other analyses, fecal coliforms were analyzed by APHA standard method 9222D, the same membrane filtration method employed by my own laboratory (which was state-certified in 2003 for our SBWSA work). The maximum hold time limit for such samples is < 6 hours, so a 2-day hold time for these samples means the results cannot be trusted. Second, Micrim's written analysis of the microbiological confuses "green" algae and cyanobacteria in its discussion of the sample contents. "Green algae" are chlorophytes, members of the Eukaryota, whereas cyanobacteria are Prokaryota. This confusion is not only unhelpful, but misleading on Micrim's part, as "green" algae and cyanobacteria are common members of the freshwater microbiota in this area, but are quite different sets of organisms. Third, the other microbiota identified in Micrim's report, including various bacteria, microalgae, and fungi, are commonly encountered in surface waters in this region. Although some are opportunistic pathogens, such as *Klebsiella pneumoniae*, their presence in surface waters poses no threat to humans if they do not swim in those waters. I note that none of the waters in question here are used for swimming, as they are now posted both as waste water infiltration ponds and/or with warnings about alligators. I note also that waterfowl can be found in almost all surface waters in this region, and that they are certainly sources of microbiological contaminants. I do not consider Micrim Laboratory's microbiology report to indicate any imminent danger to public health. Aside from my questions about the validity of the sample handling, nothing reported from these samples is remarkable. I note for the record that there is no presumption that surface waters are

intended for use directly as drinking water. Moreover, I am aware of no reports of toxic algae blooms, other algae blooms, or other indicators of water quality degradation posing health threats on Bald Head Island.

3) It is clear that there are several water-related issues that do require careful consideration. It may be helpful to consider them in the same order as the direction of flow. It will also be helpful to consider them in a broader regional and temporal context as well, as Bald Head is an island only in some senses of the term.

The Island receives a substantial portion of its drinking water from Brunswick County's system at some cost over and above system operating expenses. The line under the Cape Fear River channel was struck and breached by a dredge last spring, forcing the island to rely exclusively on well water treated through the RO system. It is good to have the backup, as such breaches might happen again.

4) The RO system currently discharges into the same two ponds as the WWTP, but does so in violation of its NPDES permit, which allows only a discharge into the marine basin. RO backwash is somewhat elevated in chloride and Total Dissolved Solids, as expected, but is somewhat less than twice as concentrated with respect to these solutes as background values for ponds and irrigation wells in the area. I am aware of concerns about the effects of RO backwash water on surface aquifer salinity, but the studies I have reviewed do not show any convincing argument that there has been a harmful effect. Some ponds and some wells on the Island appear to have elevated salinities owing to natural processes. I note that many wells exceed NC standards for chloride in a strictly technical sense, but that is to be expected in this environment. The measurements I took during my visit on Jan. 3, 2008, showed a range of salinities between 0.3 and 0.8 parts per thousand (ppt), but no elevation in ponds receiving waste water discharges vs. other ponds. I also measured conductivity and saw a similar lack of clear differences in those values (~300 to 1200 μ S). Those values were also well within the ranges reported by other investigations and data reports. I saw no pattern in the data indicating that RO water was responsible for elevated salinities, TDS, or chloride levels in places where harm to vegetation has been claimed. Mr. Witt's observations to this effect were speculative; lacking actual data and clear demonstration of cause and effect, I see no real issue arising from his comments.

5) WWTP discharge into ponds #4 and #5, as they are commonly identified, does drive significantly elevated concentrations of nutrients, particularly nitrate-nitrogen and ortho-phosphate in those ponds vs. comparison ponds. This is to be expected in waste water and reflects very effective aerobic treatment of wastes. Low ammonia-nitrogen levels signal the same good outcome. I did not see evidence of significant eutrophication in the ponds receiving waste water effluents. I saw similar growths of benthic microalgae and filamentous algae in all ponds I visited. (NB: I do a lot of work with benthic microalgae – see my resume). I note that wildlife, particularly waterfowl, can be significant nutrient sources, and that fertilizer applications to lawns and turf grasses, no matter how well performed, will always yield leaching of soluble nutrients to groundwater. Theoretical values for nutrient uptake by crops and plant covers assume a maximum of 50% uptake,

with most of the rest lost to leaching. Nevertheless, the ponds receiving WWTP effluent had significantly higher nutrient levels than other ponds.

6) The sandy soils of the Island, which are coarser nearer the surface, facilitate rapid lateral transmission and vertical percolation of water from these ponds. I understand that occasional extreme rain events have overflowed the ponds receiving waste water, but will address that issue later. Highly porous, sandy soils can serve as an almost infinite sink for ortho-phosphate and nitrate. Nitrate in particular is rapidly cycled in such porous soils. Plant roots take up nutrients and under anaerobic conditions nitrate can be removed by bacterial denitrification. I have heard some concern expressed about lateral transmission of waste water effluent northward toward Bald Head Creek, but I regard that as highly unlikely to be problematic. Soil compaction under roadways, several of which lie between the waste water discharge and Bald Head Creek, makes lateral transmission very slow. Note that every roadway will function to retard lateral flow of near-surface groundwater. This means that the near-surface ground water supply is partially confined laterally, and may have to be viewed as effectively subdivided.

7) Overflow of the ponds receiving waste water is problematic from several points of view. First, Dr. Stehman pointed out that surface waters receiving waste water under a permit designated as “non-discharge” must have easements around them and a certain free-board adequate to contain high water levels, and that no discharge to other surface waters is permitted. Second, Dr. Stehman told me that each of these conditions has been violated. Consequently, I understand that a Notice of Violation was issued to the Village in conjunction with its un-permitted RO discharge, and that an “enforcement action”, i.e., a fine, will be forthcoming in consequence of the other additional violations. Something has to change about how discharges are handled, even though no critical threat to water quality or public health really exists as things stand now. The point is to protect these in the event that things go really wrong, such as a plant upset.

8) I understand that the Bald Head Island golf club and the Village do not see these issues in the same way. I will not take sides in this dispute. However, given the facts on the ground it seems to me there are several options. Before I discuss these options I must take the larger view I mentioned above.

9) The Island relies heavily on a finite but unknown quantity of fresh water in what appears to be two somewhat distinct but also somewhat connected aquifers. Irrigation wells at depths of 22-32 feet likely tap into a “surface” aquifer, and the RO wells tap a “deeper” aquifer around 60-65 ft, but these two aquifers are not well delineated and may be connected in some locations and separated by a clay aquitard in others. The total supply of fresh water on the island thereby has three sources: 1) a rain-fed surface aquifer, 2) a sub-surface aquifer of unknown size, age, and ultimate source, and 3) a fresh water subsidy purchased from Brunswick County. Clearly, a time of drought, such as the current period, poses a threat to the fresh water budget for the island. Excessive groundwater withdrawals, e.g., net withdrawals, quantified as water lost to evaporation, runoff, and evapo-transpiration, can allow intrusion of much saltier water into the island’s aquifers. Think of the island’s fresh water reserves as a pile – as that pile is lowered, the

surrounding salty water will intrude. Keeping the fresh water pile high is necessary to prevent that. In the longer term, sea level rise and increasing frequency of drought, two predicted effects of climate change, will challenge Bald Head Island's fresh water supply in ways not encountered previously. Serious thought must be given to maintaining the island's reserves of fresh groundwater. Projected increases in the Island's human population will exacerbate the problem. I am pleased to see that the Island community has already recognized the challenge posed by drought, but this will become the new "normal".

10) Use of the RO water supply raises three issues: 1) the current discharge is illegal and cannot continue without a modified permit. Satisfaction of the permit requirements for mixing the RO discharge with the current WWTP discharge will require resolution of the easement issue and the freeboard issue, as well as provision for occasional high water events. These conditions can be satisfied under several options, including construction of a discharge line to the Marina as specified in the current permit, or by negotiation and implementation of the easements and freeboards stipulated by NC DWQ regulations. 2) RO back wash water is somewhat saltier than might be desirable for return to some portions of the surface aquifer, particularly in times of drought. In the long run, a major contribution to the surface aquifer from RO backwash might cause trouble, but I do not think that is the case now. 3) RO water use requires withdrawals from a poorly known aquifer. I know that RO well salinities and chloride levels are monitored and that withdrawals are carefully controlled. Lacking a thorough and necessarily expensive (and even intrusive) study of the hydrogeology of the Island, careful monitoring of the wells as is now done is a good indicator of the state of that deeper aquifer. I recommend that as long as solute concentrations remain within long-term bounds the current withdrawal pattern can continue, but that if a clear upward trend in solutes is found, more reliance should be placed on Brunswick County water. 4) Removal of deeper aquifer water for RO reduces the total supply of reasonably fresh water on the island through net losses. Failure to replace that water and maintain the overall recharge of the aquifer system may allow faster sea water intrusion. Discharge of RO back wash water into the Marina or Bald Head Creek exacerbates this problem considerably.

11) I don't like surface discharges off-island if they can possibly be avoided. In this context, it is a waste of a limiting resource. I strongly endorse land application of properly treated waste water, whatever the source. I expect that resolution of the current easement and freeboard issues between the Village and the Club will be difficult. In this situation, maintenance of the Village's wastewater discharge to ponds #4 and #5 may be impossible under current regulations, whether RO back flush water is included or not in the discharge stream. Thus, I will pass along and endorse Dr. Stehman's suggestion that the Village mix the two waste streams and discharge them via land application in the forest preserve. The capacity of mature forest to absorb nutrients is enormous, and the natural vegetation is well adapted to a slightly salty water supply. This will maintain the Island's total fresh water reserves as well as any other option, and better than off-island discharges. I recommend that use of the well water supply to the RO facility be managed to prevent exceedence of the historical upper bounds on solute concentrations, and that Brunswick County water be used to dilute the water stream, particularly during extended

drought. The Village can take these steps without the Club's involvement, although a common position on these issues would be helpful. Finally, I recommend that the Bald Head Island community form a Water Resource Committee to oversee the management of water supply and use in the Island, with representatives from the Village, the Club, the homeowners association, the Conservancy, Brunswick County, NC Division of Water Resources, and, perhaps, external experts.

All parties must consider carefully what the current drought teaches us. Water is the ultimate limiting resource and this fact will be driven home in North Carolina and elsewhere at some point soon and in a very brutal fashion. We take it for granted here in the wet Eastern US, but that will change. Global warming, increasingly dry conditions in the Southeast, sea level rise, and the highly variable weather patterns we will see as wet El Niño years alternating with very dry La Niña years (as we have now) mean that major change is coming and we must adapt to it. Bald Head Island has the wherewithal to create a sustainable water use program, and is actually within striking distance of doing that. Failure will mean that sea water intrudes and destroys the precarious hold that life now has on the island.