Exhibit 2

Comments of Professor JoAnn Burkholder, Ph.D.

Comments on the Draft Environmental Assessment – C&H Hog Farms, Newton County, Arkansas, by the USDA Farm Service Agency and the U.S. SBA, August 2015

JoAnn Burkholder, Ph.D., 1 September 2015

Qualifications and Experience

I have a B.Sc. degree in Animal Ecology from Iowa State University, a M.Sc. degree from the University of Rhode Island, and a Ph.D. from Michigan State University. An accurate copy of my curriculum vitae is attached. Presently I am a William Neal Reynolds Distinguished Professor at North Carolina State University, and hold joint appointments in the Department of Applied Ecology and the Department of Plant and Microbial Biology. I also am an affiliate professor in the Department of Marine, Earth, and Atmospheric Sciences. My research interests include the acute and chronic effects of eutrophication and associated pollutants on aquatic ecosystems. I am working as an environmental consultant in submitting these Comments.

I am an expert in water pollution assessment and water quality monitoring and research in freshwaters and estuaries. I have more than 30 years of experience in research on nutrient pollution and its effects on aquatic ecosystems, including the impacts of concentrated (confined) swine and poultry feeding operations (CAFOs). For the past ~21 years my laboratory has been state-certified for measurement of nutrients, suspended solids, and more recently, fecal coliform bacteria and *Escherichia coli* in environmental water samples; thus, I am familiar with the strict quality control/quality assurance requirements needed for high-quality data.

I first gained experience about the impacts of industrial swine facilities on the environment and surrounding communities in 1995, when colleagues and I monitored a swine effluent waste holding pond rupture to receiving waters (Burkholder et al. 1997). That CAFO contained about twice as many animals (12,000) as the maximum capacity for the C&H Farm. About 25.8 million gallons of swine effluent spilled from a waste holding pond, and flowed overland before draining into a small stream that was about 3 feet wide. The conditions were filthy and stark. Fish were hanging from the bushes along the stream path, as they had been blown from the water by the high-volume waste. The water affected by the spill, by the time my associates and I arrived to sample, consisted of a 17-mile-long segment that contained no dissolved oxygen even at the surface. All of the fish we encountered were dead, even hardy species such as gar. The samples revealed fecal coliform bacterial densities at more than one million colony-forming units (cfu) per 100 milliliters (mL) at some sampling locations the day after the spill, including the site 17 miles downstream. Those concentrations represented a human health hazard, given that the state standard for safe human contact is 200 cfu of fecal coliform bacteria per 100 mL. Every one of us from my laboratory who sampled the water or surface sediments (upper inch of bottom mud in the stream segment where the effluent had passed) sustained a flu-like illness that persisted for about two weeks after sampling. For weeks after the spill, the surface sediments in the affected stream segment contained high concentrations of viable fecal bacteria. There are more than 100 disease-causing microorganisms in swine waste that can adversely affect human health (see Burkholder et al. 1997, and references therein). Aside from fecal bacteria as a general indicator, we had funding to test only for *Clostridium perfringens*, and detected ~460 cfu/100 mL. That organism can seriously affect human health; for example, *C. perfringens* can cause gangrene (see the Medline Plus Medical Encyclopedia, http://www.nlm.nih.gov/medlineplus/ency/article/000620.htm).

We also measured high concentrations of nutrients known to stimulate harmful algal "blooms" or outbreaks. Two to three weeks after the spill – in other words, after a lag period – there was a major algal bloom downstream in apparent response to the nutrient pollution, as well. Based on previous data for the area, the algal biomass was very high (up to 327 micrograms of chlorophyll *a* per liter, µg chl*a*/L) and in violation of the state standard (40 µg chl*a*/L; note that chlorophyll *a* is used in stream science as an indicator of algal biomass as in Wetzel 2001). In addition, the bloom consisted of certain harmful algae known to thrive in nutrient-polluted waters.

Since that research, I have helped colleagues assess a smaller swine CAFO effluent spill (Mallin et al. 1997). I also have assisted in analyses of samples taken from surface waters near swine CAFOs that had similar nutrient management as the C&H Farm (i.e., waste holding ponds and application of the swine effluent or slurry onto adjacent fields). Those samples reflected standard operating procedures at the adjacent swine CAFOs, that is, in the absence of waste spills. We routinely have measured concentrations of fecal bacteria at human health hazard levels, due to leakage from waste holding ponds or runoff from fields to which swine waste was applied (e.g., Mallin et al. 2014). We have also routinely measured high concentrations of nutrients such as nitrate, and very low concentrations of dissolved oxygen due to the high biochemical oxygen demand of the organic materials from swine wastes that contaminated adjacent surface waters. In other research, colleagues and I documented a 500-fold increase in ammonia to an upper estuary that was linked to swine CAFOs (Burkholder et al. 2006). I also served as the major advisor of Dr. Megan Rothenberger, whose Ph.D. thesis research identified swine CAFOs as the most important source of water quality degradation to a coastal river (Rothenberger et al. 2009).

In order to prepare these comments, I reviewed and assessed the available quarterly progress reports from the Big Creek Research and Extension Team (BCRET - http://www.bigcreekresearch.org/project_reports/default.aspx), the draft Environmental Assessment regarding the C&H CAFO (hereafter, EA), and the other reports and publications listed at the end of these comments, some of which contain information specific to karst areas such as northern Arkansas where this CAFO is located (e.g. Alpha et al. 2013, Brahana et al. undated).

Overall Evaluation

The authors of this EA assert that the EA "examines the environmental effects of C&H Hog Farms" (pp.1-1, 1-5). That assertion is misleading or, in some sections of the EA, false. *My overall evaluation is that this EA **does not** provide a rigorous, science-based assessment of the environmental effects of this CAFO.* The authors' overall evaluation about water resources (p.3-20), that "No significant impacts to water resources are anticipated and no mitigation measures are required," is not science-based. That evaluation is based, instead, upon vague statements in the EA that are unsupported by peer-reviewed science, culminating in the above invalid assertion that was presented as a "conclusion." My evaluation is explained in detail below, followed by a list of recommendations that should be followed in order to provide a realistic assessment of the environmental impacts of the C&H CAFO on surrounding water resources. Note that the EA refers to the "C&H Farm," but that name is a misnomer because C&H is an industrial-level swine production operation; it is not a "farm" in the traditional or historic sense of the word.

Supporting Rationale

I. *The EA Lacks Rigorous Assessment of Surface Water Impacts, in Part Due to its Reliance on a Poorly Designed Study by the BCRET*

The EA describes the animal holding units ("barns") of the C&H CAFO as being about half a mile from Big Creek, a tributary of the Buffalo National River which is a nationally important natural resource. What is much more germane, however, and not mentioned in the EA, is that most of the fields that have received or will receive applications of swine wastes from the C&H CAFO are much closer to, in some cases immediately adjacent to, Big Creek (see Figure 1, a color map of the area).

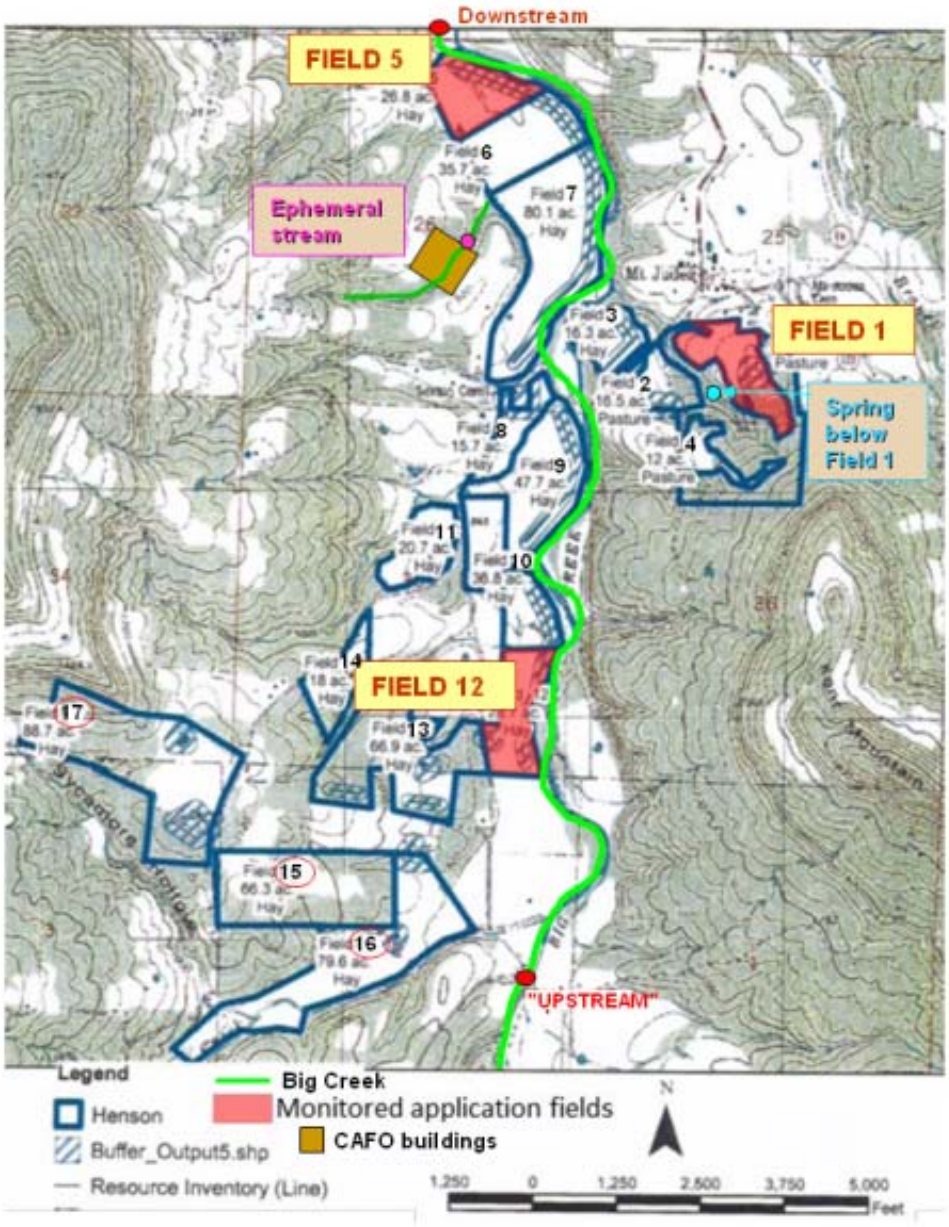

Figure 1. **Map indicating features of the C&H CAFO, and of the BCRET study design which, perhaps inadvertently, minimizes detection of surface water impacts of the C&H CAFO:** This map is modified

from the first BCRET quarterly progress report (October 1 to December 31, 2013, p.13) to show more clearly the locations of the main stream in the immediate area, Big Creek, and various other features. The map incorrectly depicts the location of field #5 (see BCRET addendum at http://arkansasagnews.uark.edu/bigcreekreport.quarter1addendum.pdf , and see the correct location of field #5 below in *Figure 2*). I have retained the map in these Comments because it is the only map published in all of the BCRET quarterly progress reports which shows the locations of the 17 fields in the C&H CAFO, 15 of which are used for swine waste application. This CAFO extends for approximately three river miles along the stream. Note that the downstream site is "buffered" or somewhat protected from swine wastes considering that fields #5 and #6, which do not receive swine waste applications, are nearest to and just upstream from the downstream station. In contrast, the field numbers circled in red (#15, #16, and #17) are near the so-called "upstream" station and, given the karst character of the area, could easily be contaminating it. The "upstream" station is in quotes here because the BCRET data show that its waters are degraded, that is, highly compromised by those fields and perhaps also by other upstream pollution sources (see text). In its degraded, compromised state, it is not an "upstream control." The combination of a seriously compromised "upstream control" station and a downstream station that is buffered from swine waste pollution skews the findings by artificially "minimizing" any upstream vs. downstream differences in surface water quality. See Tables 1 and 2 below for information on swine waste (mostly liquid effluent or "slurry") applications to fields in 2014 (Table 1) and in December 2013-October 2014 near the compromised "upstream control" station (Table 2).

Field	Area (acres)	Field Use	Application (Mar-Jun 2014, from WHP #1)	Conservation Practice(s)
H1	7.30	Continuously Grazed >0.75 An.Units	6,530 gallons/acre	None in place
H2	6.00	Continuously Grazed >0.75 An.Units	4,060 gallons/acre	None in place
H3	15.20	Rotational Grazing	5,590 gallons/acre	None in place
H4	6.80	Continuously Grazed >0.75 An.Units	4,760 gallons/acre	None in place
H7	64.30	Rotational Grazing	5,020 gallons/acre	None in place
H8	8.60	Rotational Grazing	13,150 gallons/acre	None in place
H9	35.50	Rotational Grazing	6,750 gallons/acre	None in place
H10	29.30	Rotational Grazing	14,760 gallons/acre	None in place
H11	14.20	Continuously Grazed >0.75 An.Units	5,690 gallons/acre	None in place
H12	10.90	Rotational Grazing	5,880 gallons/acre	None in place
H13	50.90	Rotational Grazing	6,530 gallons/acre	None in place
H14	7.30	Rotational Grazing	6,530 gallons/acre	None in place
H15	32.20	Rotational Grazing	6,530 gallons/acre	None in place
H16	15.20	Rotational Grazing	6,530 gallons/acre	None in place
H17	31.90	Rotational Grazing	6,530 gallons/acre	None in place

Table 1. **Characteristics of 15 of the 17 C&H CAFO fields**, taken from the Arkansas Dept. of Environmental Quality [ADEQ] Annual Report Form for C&H CAFO operations permitted under NPDES General Permit ARG590000. The swine "slurry" (mostly liquid effluent, along with a small percentage of solids) applied to 15 fields at the C&H CAFO in a 4-month period (March – June) of 2014 (WHP – waste holding pond). The fields are very close to, or immediately along, Big Creek. The BCRET progress reports upon which the EA mostly relied are founded upon a seriously inadequate study design, including lack of appropriate stations and lack of appropriate analyses to detect C&H CAFO-related water resource impacts (see text). Thus, the EA mistakenly asserts "no water resource impacts" from the C&H CAFO. This CAFO is permitted to apply the equivalent amount of untreated sewage effluent as would be contributed by a population of about 25,000 people (derived from U.S. EPA 2004), to highly permeable karst fields in very close proximity to receiving surface waters. Note that the acreages given differ from those reported in *Table 2* below.

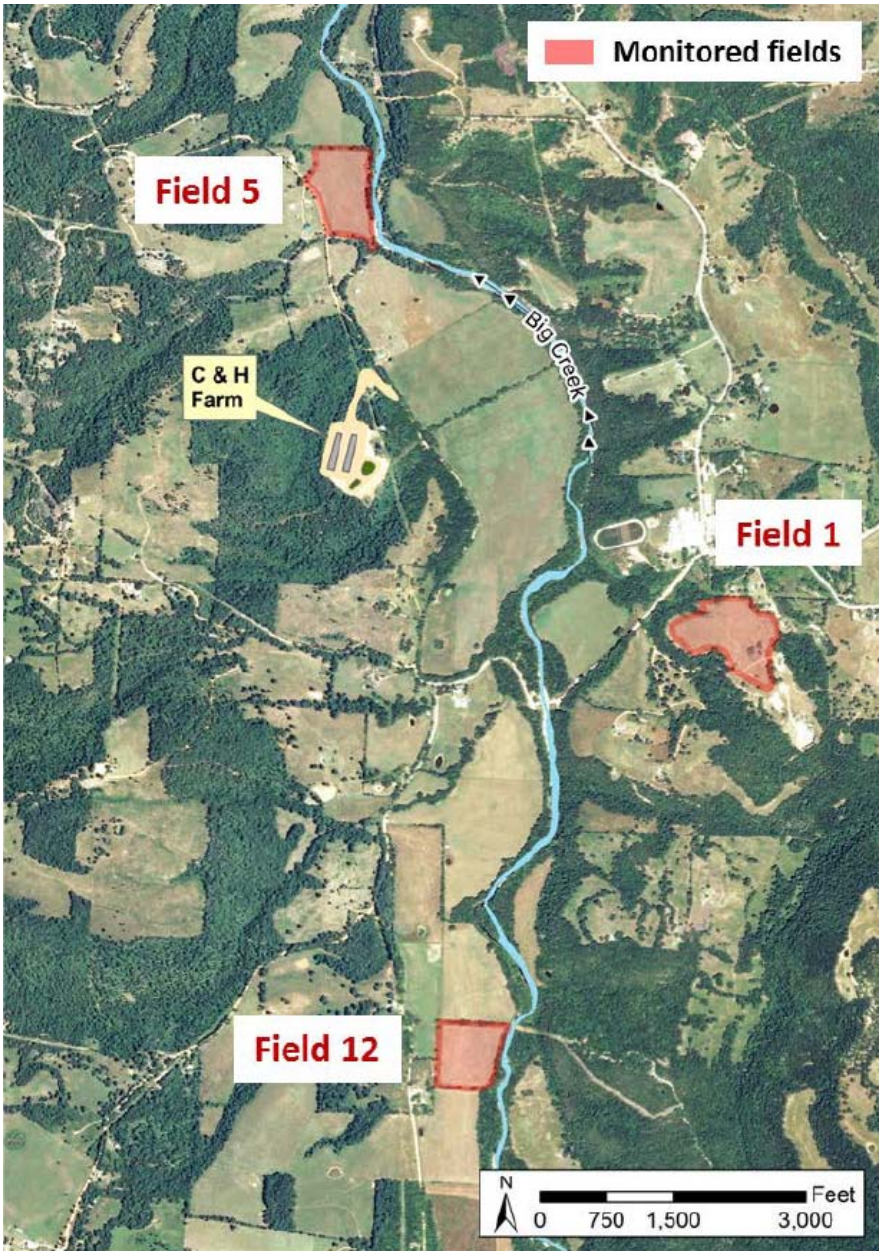

Figure 2. **Map from a BCRET addendum** to the October 1 to December 31, 2013 quarterly progress report, showing the correct location of monitored Field #5. Available at: http://arkansasagnews.uark.edu/bigcreekreport.quarter1addendum.pdf. Note that this field designation was later changed to Field #5a so that there would not be two fields numbered 5. Field #5A is just north of Field #5, and Field #5A is not one of the C&H CAFO's leased fields.

Date applied	Field #	Volume applied	Area applied	Average rate applied
		gallons	acres	gallons/acre
12/27/2013	15	3,000	1	3000
12/30/2013	15	6,000	2	3000
12/31/2013	15	24,000	9	2667
1/16/2014	15	18,000	7	2571
1/20/2014	15	36,000	13	2769
3/31/2014	15	42,000	14	3000
4/1/2014	15	45,000	15	3000
6/16/14	15	25,400	9	2822
6/17/14	15	16,800	6	2800
6/18/14	15	16,800	6	2800
6/19/14	15	11,200	4	2800
7/14/10	15	90,000	29	3103
7/28/14	15	8,200	3	2733
10/17/14	15	57,500	20	2875
10/18/14	15	34,500	12	2875
6/19/14	16	56,000	9	6222
1/07/14	17	25,000	9	2778
1/16/2014	17	6,000	2	3000
4/1/2014	17	30,000	10	3000
4/1/2014	17	3,000	10	300
4/18/2014	17	30,000	5	6000
4/22/14	17	21,000	7	3000
4/25/14	17	36,000	12	3000
6/07/14	17	22,400	8	2800
7/14/14	17	16,800	6	2800
7/22/14	17	11,800	4	2950
10/19/14	17	18,000	6	3000
10/20/14	17	46,000	16	2875
10/21/14	17	28,750	10	2875

Field #15 - 33,000 gallons of raw swine effluent slurry in December 2013

Field #15 - 401,400 gallons of raw swine effluent slurry during 6 months of 2014

Field #16 - 56,000 gallons of raw swine effluent in June 2014

Field #17 - 294,750 gallons of raw swine effluent slurry during 5 months of 2014

Table 2. **Timing and rate of swine effluent slurry applied by the C&H CAFO to fields #15, #16, and # 17 near the compromised, degraded "upstream control" station**, in the karst area where the CAFO is located, during December 2013 through October 2014. Compiled from the January 1 to March 31, 2015 BCRET quarterly progress report (pp. 33-35).

A total of 2,614,059 to 2,786,908 gallons of swine wastes (manure, process water, and litter) were produced at the C&H CAFO in the first two years of operation (ADEQ Annual Report Forms, 2013 and 2014, for C&H CAFO operations under NPDES General Permit ARG590000). Two of the 15

fields receiving swine waste applications from the C&H CAFO, fields #1 and #12, are being monitored by the BCRET. A third monitored field, field #5 (or #5a), does not receive C&H CAFO wastes but it cannot be considered a "control" because the polluted surface runoff data for that field indicate that it is compromised. The BCRET progress reports vaguely describe the monitored fields as "representative" of the 15 fields to which swine effluent is being applied, 'encompassing a range in landscape position, topography, and soil fertility levels.' However, as Table 3 shows, ***the monitored fields are not representative of average impacts being sustained, and in fact minimize the impacts being sustained*** in soils, surface runoff quality, or groundwater quality from land application of swine wastes from this CAFO.

Field number	Field area	Application area	Number of apps	Volume	Average rate applied	Average inches applied
		acres		gallons	gallons/acre	inches
1	28.5	13.0	2	46,000	3,538	0.13
2	16.5	6.0	1	22,600	3,767	0.14
3	16.8	27.0	3	118,100	4,374	0.16
4	12.0	8.5	3	28,800	3,388	0.12
7	80.1	123.0	4	396,200	3,221	0.12
8	15.7	9.0	1	25,000	2,778	0.10
9	47.7	35.0	2	103,800	2,966	0.11
10	36.8	64.0	5	249,200	3,894	0.14
11	20.7	17.0	1	51,000	3,000	0.11
12	28.7	9.9	1	48,000	4,848	0.18
13	66.9	151.0	11	453,550	3,004	0.11
14	18.0	23.0	2	73,000	3,174	0.12
15	66.3	150.0	15	434,400	2,896	0.11
16	79.6	9.0	1	56,000	6,222	0.23
17	88.7	105.0	13	294,750	2,807	0.10

Table 3. **The total amount of slurry applied to each of 15 fields between 12/15/2013 and 1/15/2015 by the C&H CAFO**. Modified from the January to March 2015 BCRET quarterly progress report (p.36). Red squares and ovals indicate the two fields monitored by the BCRET, and the small number of swine effluent applications (1-2) in each. Arrows indicate fields #15 and #17, near the highly compromised, degraded "upstream control" station and farthest from the downstream station. Fields #15 and #17 received approximately 6 to 9 times more waste than monitored fields #1 and #12, and about 10 times more waste applications. And, note that field #16, also near the "upstream control," had the highest average rate of swine waste applied per acre.

In Table 3, the "application area" refers to the cumulative total number of acres to which swine effluent was applied in a given field, and "volume" refers to the total volume of effluent applied to the field. From this table, the **mean volume of swine effluent or slurry** applied per field among the 15 fields was **160,023 gallons** during December 15, 2013 to January 15, 2015. *The two fields selected for monitoring received 46,000-48,000 gallons*, or only about one-third of the average volume of swine effluent applied per field. Monitored field characteristics are strongly dependent on the *frequency* of effluent applications, *as well as the total amount* of effluent applied. The average number of waste applications was 4.3 over that period. The two fields selected for monitoring received only 1-2 applications.

Thus, the BCRET team's assertion that the monitored fields were "representative" for characterizing the impacts of swine effluent on receiving lands, surface runoff, and groundwater is false. Also note that, as explained in the legend for Table 3 above, the two fields with red arrows (#15, #17), close to the highly compromised "upstream" station, received 13 to 15 applications and more total effluent than any other field except fields #7 and #13. Another field close to the "upstream" station, #16, received the highest average rate of swine waste applied per acre. These facts, considered together with the karst character of the area, likely explain the degraded water quality of the so-called "upstream" station. As another example of the lack of "representative" character of the two fields selected for monitoring, unmonitored field #13, immediately west of monitored field #12, received ten-fold more applications of swine effluent and about 10 times more total effluent than field #12. The BCRET has informed the general public that the three fields being monitored are the only fields that it has received permission to monitor from the private landowners leasing the fields to the C&H CAFO. This is clearly a major, serious problem in the study design because the fields are far from "representative" regarding the relatively small amount of swine waste they receive, and the fact that only two of the three monitored fields (#1 and #12) receive C&H CAFO swine wastes:

Field #5a (called Field #5 in the first BCRET quarterly progress report dated October 1 to December 31, 2013) is the third field being monitored by the BCRET team. *However, as mentioned above* (see Figure 2 legend), *swine effluent from the C&H CAFO is not applied to it*; the quarterly progress report states that nutrient runoff and leaching from all three fields (#1, #5a, and #12) captures whatever field management is being done by the land owners, including swine effluent application (fields #1 and #12 only) as well as grazing and mineral fertilizer application. The water quality degradation in fields #1 and #12 can be ascribed mostly or at least partially to swine effluent application from the C&H CAFO, whereas the source(s) of water quality degradation in the surface runoff from field #5a cannot be related to swine effluent application. Also as explained above, field #5 cannot be considered as a "control" because the degraded surface runoff from that field shows that it is highly compromised.

II. *The BCRET study design is seriously inadequate for characterizing impacts of the C&H CAFO on surface water quality.*

The EA states that the evaluation of surface water quality impacts was largely based on the BCRET study. Therein lies a major reason why the EA incorrectly asserted 'no impacts' from the C&H CAFO. Overall scrutiny of the BCRET study design shows that the surface water quality sampling sites (only 6-7, spanning a CAFO with 17 fields for realized or potential swine waste application that sprawls

along Big Creek for approximately 3 river miles – including *only one site* downstream from the CAFO on Big Creek itself, and no sites on the Buffalo National River) are ***sparse*** for use in providing an overall assessment of the impacts of this CAFO on water quality. Thus, the rationale for site selection is especially critical to assessment of the efficacy of the study design. *It is my opinion, as an expert on water quality impacts from swine CAFOs, that there is very high potential for major surface water degradation from the C&H CAFO. Furthermore, even the inadequate BCRET study has produced data indicating that the C&H CAFO is degrading the quality of surface waters.*

The EA (p.1-5) described consideration of data gathered prior to the initiation of operations at the C&H CAFO. On p.1-4 the EA states that for three days in April 2014, U.S. EPA Region 6 made an unannounced inspection of the CAFO to assess compliance with the facility's Arkansas Department of Environmental Quality [ADEQ] General Permit #ARG590001: "Water samples were collected from various streams upgradient and downgradient of the facility.…No areas of concern were identified…." The EA failed to show those data.

III. *In the BCRET study design, at least two "control" sites are seriously compromised or otherwise questionable, and a third site was highly degraded prior to C&H CAFO operation.*

- ***"Upstream control" on Big Creek*** - P. 3-7 of the EA states:

> By monitoring immediately upstream and downstream of the farm and at the fields, any measurable increase in nutrient or bacteria concentrations discharging from the operations would be recorded and the contribution from other sources would be eliminated or minimized.

That statement would only be true if the upstream station served as a clear "control" with minimal water quality degradation, so that C&H CAFO pollution could be discerned from a comparison of "upstream" versus "downstream" sites. As explained above, the BCRET instead is following an inadequate sampling design that includes only one downstream station that is buffered from the CAFO's pollution, for comparison with only one, highly compromised (degraded) "upstream" station, such that the CAFO impacts for most pollutants cannot be clearly discerned. The upstream station is especially degraded in a pollutant of major public concern, the fecal bacterium *Escherichia coli*. Also as explained above, it is likely that swine effluent from the C&H CAFO applied to fields in the southern area of the CAFO are contributing to the compromised, degraded condition of the "upstream" station.

The "one upstream versus one downstream station" approach, alone, for assessment of impacts to Big Creek is further confounded by the fact that the C&H CAFO is located in a karst area. Dr. Van Brahana, a renowned geoscientist retired from the University of Arkansas, conducted a dye study which shows in detail the interconnectedness of Big Creek and the Buffalo National River basins (Brahana et al. undated). The dye study supports general information known for karst areas, namely, that the highly porous soils can be expected to allow, much more easily, contamination, through multiple groundwater pathways, from the C&H CAFO throughout the Big Creek area and into the Buffalo National River.

- ***Left Fork Creek "control"*** - The EA states (p.3-8) that in May/June 2015, an additional monitoring station was belatedly established in a tributary of Big Creek as another "control" site; water quality in one station of its watershed, which was described as lacking a CAFO, is planned for comparison to the downstream station in Big Creek. The information given in the EA and the BCRET progress reports, however, is insufficient to enable assessment of whether the Left Fork sampling station is a suitable "control." Furthermore, on p.3-8 the EA criticized a sampling approach by the National Park Service (NPS):

> …the entire Left Fork Creek sub-watershed…encompassing approximately 38 square miles, empties into Big Creek above the [NPS] sampling site [BUFFT06]. Therefore, land use and development occurring in these sub-watersheds (or portions of) are contributing to the concentrations of nutrients and bacteria sampled….

That writing implies that the Left Fork Creek sub-watershed has various sources of pollution including nutrients and bacteria. The BCRET project team maintained that the sub-watershed lacks a swine CAFO, but what other sources of pollution does it have? The April-June 2015 BCRET quarterly report (Table 1) shows that the Left Fork watershed is ~25% larger than the Big Creek watershed upstream from the C&H CAFO. The area in urban development in that area of the Big Creek watershed is 448 acres, versus about a third more area (705 acres) in urban development within the Left Fork watershed. How do these two areas quantitatively compare in pollutant loads/composition relative to the pollution sources in the Big Creek watershed above the C&H CAFO? Without additional detailed, quantitative information, attempts by the BCRET to use the Left Fork as another "control" site are highly questionable.

- ***Spring*** – The water quality data for the one spring being sampled in the BCRET study, which is adjacent to field #1 (see 2nd progress report, and see photo on p.25 of that report), show that the spring water quality was frequently degraded in total suspended solids (TSS, e.g. 21.2 mg/L), nitrate-N (~2.5 to 3.3 mg/L), total coliform bacteria, and *Escherichia coli* densities during 2013, relative to other water quality stations. Application of C&H swine effluent to field #1 did not occur until March-June 2014, according to the ADEQ Annual Report Form for C&H CAFO operations permitted under NPDES General Permit ARG590000. Therefore, what was the source(s) of the contamination to the spring waters in 2013? Neither the BCRET progress reports nor the EA provide an explanation; in fact, they do not once mention this serious problem: The area has been described as containing numerous springs, yet only this spring is being sampled, and its water quality was clearly compromised prior to use of adjacent fields for swine effluent application.

Nevertheless, when field #1 received swine wastes, runoff from the field was extremely degraded (see below). The runoff from fields #1, and from other nearby fields such as fields #2, #3, and #4, would be expected to have contributed to contamination of this spring.

IV. *The BCRET study does not include diel sampling of dissolved oxygen, despite the fact that the high biochemical oxygen demand of swine wastes is known to cause severe oxygen deficits in contaminated receiving surface waters.*

There are reports (e.g., by Dr. Van Brahana, a renowned geoscientist retired from the University of

Arkansas) of a decrease in dissolved oxygen concentrations in Big Creek below the C&H CAFO in both summer and winter. Swine CAFO pollution is well known to drive the DO in receiving streams down to levels that can stress or kill beneficial aquatic life (Burkholder et al. 1997, 2007; Mallin 2000, and references therein). Dissolved oxygen is of fundamental importance to the biota of the Big Creek and Buffalo National River ecosystems; its measurement is straightforward using well accepted techniques (e.g. Reed et al. 2010); and it should have been included in the BCRET study.

V. *The BCRET study lacks use of tracking methods which, together with the poor study design and compromised "controls," will prevent rigorous evaluation of the C&H CAFO impacts.*

In various portions of the datasets shown in the BCRET quarterly progress reports, the one "upstream" location in Big Creek commonly has higher concentrations or comparable concentrations of some parameters than the station "downstream" from the C&H CAFO. According to the reports, the project team has failed to ensure that its selection of an "upstream control" station location is not so compromised by local pollution or land disturbance that the C&H CAFO influence in the stream cannot be detected.

The pollution from upstream needs to be isolated from the pollution being contributed by the C&H operation, which can be done using source various techniques such as microbial source tracking (e.g. Heaney et al. 2015, and references therein) and nitrogen/oxygen stable isotopes (e.g. Michener and Lajtha 2007, Eppich et al. 2012, Pastén-Zapata et al. 2014, and references therein). Yet, the reports have mentioned nothing about the **critical need** for use of these techniques in this study. A false 'conclusion' that could easily result from the inadequate BCRET study design would be, 'We could not detect anything above 'upstream background' in terms of water quality impacts from the C&H operation.' The BCRET project team thus far has elected *not* to use source tracking or stable isotope techniques which are **essential**, given the seriously inadequate study design, to verify the CAFO impacts.

VI. *The EA did not acknowledge a significant impact of the C&H CAFO in contaminating Big Creek with nitrate pollution, if based on its "upstream" versus "downstream" comparative approach.*

Based on the compromised upstream station as per the BCRET study design, the EA (p.3-13) stated that "no [statistically] significant difference has been found between dissolved or total phosphorus when comparing the upstream and downstream sites." On the same basis, the EA (p.3-15) reported that nitrate concentrations were greater at the downstream site. In fact, the nitrate levels reported at the "downstream" station sometimes exceeded levels known to stress or kill sensitive aquatic life (Camargo and Alonso 2005). In a recent presentation (August 11, 2015, University of Arkansas), Dr. A. Sharpley, the BCRET team leader, acknowledged that statistical analysis had shown that nitrate levels were significantly higher downstream than "upstream." Peer-reviewed science repeatedly has demonstrated that high levels of ammonia in swine wastes are oxidized to nitrate as the wastes move away from the site of origin, resulting in high levels of nitrate pollution to receiving waters (e.g. Evans et al. 1984; Stone et al. 1995, 1998; Ham and DeSutter 2000; Mallin 2000; Krapac et al. 2002).

Considering that the "upstream control" station is clearly degraded, as stated above, source tracking techniques are essential to verify the CAFO's contribution to downstream pollution of nitrate and other parameters and, likely, to the upstream pollution as well, as explained in the legend of Figure 1 and on p.8 of these Comments. However, the "yardstick" that the EA was using in considering the dissolved and total phosphorus data was, as stated on p.3-7 (and quoted above on p.9 of these Comments), an increase in downstream relative to upstream values would be interpreted as an impact from the C&H CAFO. According to the EA (p.3-7), then, higher downstream nitrate should have been interpreted as an impact from the C&H CAFO.

Yet, the EA authors tacitly refused to attribute the problem to contamination from the C&H CAFO. They instead vaguely attributed the significant increase in nitrate at the downstream site (which they neglected to characterize as statistically significant) as "reflective of the land use continuum and historic management of the greater catchment area that drains into and is monitored at the downstream site." The inconsistency is glaring; no significant difference between the compromised "upstream" station and the buffered downstream station is an accepted finding, but higher levels of pollution at the downstream station supposedly should be attributed to a "watershed continuum" rather than the C&H CAFO. This CAFO is not the only source contributing to the degraded water quality of the downstream station on Big Creek, but it is a *major* source located immediately upstream from that sampling site.

VII. *The EA overlooked evidence of frequent, high contamination of other surface waters by the C&H CAFO as evidenced in the BCRET progress reports.*

The EA (p.3-20) stated as its overall 'conclusion,' "No significant impacts to water resources are anticipated and no mitigation measures are required."

That assertion is irrational based on peer-reviewed science (see U.S. EPA 1998, 2013a; and see many peer-reviewed publications such as Evans et al. 1984; Westerman et al. 1985, 1995; Payne et al. 1988; Ritter and Chirnside 1990; Dewi et al. 1994; Stone et al. 1995, 1998; Huffman and Westerman 1995; Burkholder et al. 1997; Mallin et al. 1997; Stone et al. 1998; Ham and DeSutter 2000; Mallin 2000; Krapac et al. 2002; Spellman and Whiting 2007; Rothenberger et al. 2009).

Evidence of frequent, high contamination and degradation of surface waters by the C&H CAFO is illustrated in the following examples. For comparison:

- *Total phosphorus* (TP) *and nitrate-nitrogen* (NO_3^-N, here also including nitrite-N or NO_2^-N, as they typically are measured together) – Surface flowing waters in the area should have approximately 5.6 µg of total phosphorus/L (or 0.056 mg TP/L) and 30 µg nitrate-N/L (or 0.03 mg NO_3^-N/L) or less as a minimally impacted ("reference" or unpolluted) condition (U.S. EPA 2000 – level III nutrient sub-ecoregion 38). Median concentrations over a ~decadal period in the Buffalo National river near Big Creek during surface runoff events were 21 µg TP/L (0.021 mg TP/L and 140 µg NO_3^-N/L (0.14 mg nitrate-N/L) (White et al. 2004).

- *Total suspended solids* (TSS), *dissolved phosphorus* (DP), and *ammonia-N* (NH_3N) – Median concentrations over a ~decadal period in the Buffalo National River near Big Creek during surface runoff events were 30 mg TSS/L, 10 µg DP/L (or 0.01 mg DP/L), and 20 µg NH_3N/L (White et al. 2004).

- *Dissolved organic carbon* (DOC) – is typically less than 7 mg/L in streams draining small forested watersheds during stormflow, or streams draining agricultural cropland watersheds (e.g. Hinton et al. 1998, Hood et al. 2006, Warner et al. 2009, Bida 2013, and references therein).

- *Total coliform bacteria* – in potable waters, no more than 5.0% of samples should be positive for 1 or more total coliform bacteria within one month; or, for systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month (U.S. EPA; see http://water.epa.gov/drink/contaminants/basicinformation/pathogens.cfm). Note that total coliform bacteria are no longer recommended as an indicator for recreational waters (U.S. EPA; see http://water.epa.gov/type/rsl/monitoring/vms511.cfm). In the 1950s studies conducted by the U.S. Public Health Service reported adverse human health effects when total coliform density was ~2,300 per 100 mL (Stevenson 1953).

- *Escherichia coli* – According to the ADEQ, the following limits apply (taken from the BCRET January to March 31, 2015 quarterly progress report, p.56):

Primary Contact (May-Sept)	Maximum allowable is 126 colonies/100 mL as a geometric mean; maximum for a single-sample is 298 colonies/100 mL (Extraordinary Resource Waters [ERWs], Ecologically Sensitive Waterbodies [ESWs], and Natural and Scenic Waterways [NSWs]), or 410 colonies/100 mL (all other streams).
Primary Contact (Oct-Apr); or Secondary Contact	Maximum allowable is 630 colonies/100 mL as a geometric mean; maximum for a single sample, 1,490 colonies/100 mL (ERWs, ESWs, and NSWs) or 2,050 colonies/100 mL (all other streams).

The geometric mean is calculated from 5 or more samples collected within 30 days at evenly spaced time intervals. No more than 25% of samples from a group of 8 or more samples per contact season may exceed these limits (Arkansas Pollution Control and Ecology Commission 2011, p.5-5).

*** *Ephemeral Streams*** – A culvert sampled by the BCRET was described as an "ephemeral stream" (April 1 to June 30, 2014 quarterly progress report, pp. 30 and 63) (see Table 4). It is atypical because it drains the subwatershed containing a portion of the C&H CAFO. It may drain other pollution source(s) as well, but the CAFO is a source mentioned by the BCRET. Data are also included in the BCRET quarterly progress report dated April 1 to June 30, 2015 for an ephemeral stream that drains the area containing the animal holding units ("barns") of the C&H CAFO (Table 5; and see Figure 1).

Ephemeral streams, which flow for only part of an annual cycle, are generally small and represent the majority of river miles in the U.S. (U.S. EPA; see http://water.epa.gov/type/rsl/streams.cfm). The U.S. EPA (above website) described them as "the very foundation of our nation's great rivers." They play a significant role in the hydrological and ecological integrity of river ecosystems, and provide critical habitat for certain important fauna (McDonough et al. 2011).

Based on the data in Tables 4 and 5, the two sites examined by the BCRET are extremely degraded. The data for the "culvert" ephemeral stream show the highest total suspended solids that I have ever seen, extreme values ranging from more than 900 to more than 2,400 mg TSS/L (Table 4).

Date & time sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E_ coli	Total coliform
	mg/L							MPN/100 mL	
Culvert									
3/18/2014	0.009	0.028	0.05	0.64	0.63	1.0	0.7	19.3	365.4
3/26/2014	0.007	0.028	0.00	0.61	0.62	11.0	1.2	260.2	>2419.2
3/29/2014	0.004	0.042	0.00	0.69	0.81	3.3	4.9	ND	ND
4/2/2014	0.009	0.020	0.00	0.48	0.54	2.1	1.1	44.3	517.2
4/4/2014	0.026	0.262	0.46	0.85	2.36	908.8	6.5	ND	ND
4/8/2014	0.011	0.022	0.04	0.47	0.53	2.5	2.7	70.8	770.1
4/13/2014	0.003	0.016	0.00	0.46	0.49	4.7	1.8	8.5	195.6
4/13/2014	0.007	0.032	0.03	0.48	0.56	1.9	2.0	547.5	4320.0
4/22/2014	0.004	0.012	0.00	0.45	0.50	1.0	0.0	47.9	>2419.2
5/1/2014	0.005	0.010	0.00	0.448	0.50	1.5	0.6	90.5	4790.0
5/12/2014	0.010	0.290	0.61	0.939	2.33	847.6	4.7	N.D.	N.D.
5/13/2014	0.007	0.060	0.12	0.509	0.70	5.1	2.6	307.6	10760.0
5/19/2014	0.008	0.020	0.08	0.522	0.55	0.8	0.3	204.6	5940
5/28/2014	0.011	0.020	0.10	0.799	0.85	1.7	0.2	517.2	14830.0
6/22/2014	0.005	0.090	0.68	4.562	7.16	2096.3	4.09	N.D.	N.D.
6/27/2014	0.017	0.022	0.00	0.550	0.60	1.7	0.83	N.D.	N.D.
7/8/2014	0.023	0.054	0.37	0.759	2.89	1252.1	6.96	N.D.	N.D.
7/16/2014	0.006	0.032	0.06	0.601	0.67	16.8	0.56	N.D.	N.D.
7/23/2014	0.016	1.018	0.98	0.875	2.69	2642.0	5.09	N.D.	N.D.
7/31/2014	0.017	0.042	0.20	1.204	1.23	4.9	1.03	1732.9	30760.0
10/13/2014	0.004	0.068	0.08	0.996	1.37	11.2	3.28	N.D.	N.D.
12/15/2014	0.021	0.040	0.04	1.161	1.11	8.2	1.11	N.S.	N.S.
12/22/2014	0.011	0.026	<0.03	0.416	0.58	6.3	1.54	770.1	3550.0
1/8/2015	0.008	0.022	<0.03	0.448	0.59	2.4	1.73	25.6	1203.3
1/15/2015	0.007	0.028	<0.03	0.469	0.55	1.9	0.55	7.4	1413.6
1/21/2015	0.005	0.016	<0.03	0.370	0.46	1.0	2.34	155.3	2419.2
2/26/2015	0.006	0.022	<0.03	0.530	0.57	1.3	1.38	16.1	4790.0
3/3/2015	0.006	0.020	<0.03	0.477	0.52	ND	1.84	N.S.	N.S.

Table 4. Water quality of a culvert described by the BCRET as an ephemeral stream draining the subwatershed containing a portion of the C&H CAFO (the production houses, waste holding ponds, the well adjacent to the waste holding ponds, and surface runoff from field #1). Compiled from the following BCRET quarterly progress reports: April 1 to June 30, 2014; July 1 to September 30, 2014; October 1 to December 31, 2014; and January 1 to March 31, 2015. Numbers highlighted (red outlines, with arrows for most extreme values) are examples of excessive levels.

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
	mg/L							MPN/100 mL	
Ephemeral stream									
1/8/2015	0.008	0.022	<0.03	0.448	0.59	2.4	1.73	25.6	1203.3
1/15/2015	0.007	0.028	<0.03	0.469	0.55	1.9	0.55	7.4	1413.6
1/21/2015	0.005	0.016	<0.03	0.370	0.46	1.0	2.34	155.3	2419.2
2/26/2015	0.006	0.022	<0.03	0.530	0.57	1.3	1.38	16.1	4790.0
3/3/2015	0.006	0.020	<0.03	0.477	0.52	ND	1.84	N.S.	N.S.
3/11//2015	0.006	0.022	0.04	0.567	0.60	0.5	2.20	6.3	410.0
3/19/2015	0.007	0.018	0.01	0.529	0.63	1.0	4.31	14.6	866.4
3/25/2015	0.007	0.014	0.02	0.462	0.53	1.1	0.64	8.6	344.8
4/2/2015	0.006	0.032	0.02	0.467	0.46	1.8	4.41	5.2	547.5
4/15/2015	0.005	0.026	0.03	0.472	0.56	0.8	1.26	305.0	2430.0
4/23/2015	0.008	0.026	0.03	0.520	0.56	2.0	1.78	12.0	3270.0
4/29/2015	0.012	0.018	0.02	0.569	0.61	3.5	1.98	14.3	4080.0
5/7/2015	0.013	0.066	0.02	0.628	0.71	3.2	16.41	71.7	7170.0
5/8/2015	0.005	0.254	0.41	2.287	3.23	127.1	6.45	5200.0	241920
5/11/2015	0.008	0.146	0.15	0.941	1.80	22.0	8.09	N.S.	N.S.
5/14/2015	0.010	0.022	0.01	0.527	0.50	1.7	0.73	41.3	1986.3
5/18/2015	0.007	0.028	0.03	0.525	0.55	0.7	1.18	90.7	7630.0

Table 5. **Water quality in an ephemeral stream** sampled in the BCRET study near the animal holding units of the C&H CAFO (quarterly progress report dated April 1 to June 30, 2015, pp. 44-45; and see *Figure 1* of these Comments). Numbers highlighted (red outlines, with arrows for most extreme values) are excessive levels.

Considering that 30 mg TSS/L has been characteristic of surface waters in this area during storm/runoff events, these values are more suggestive of mud than water. Consistently at both stations, nitrate-N is excessive (Tables 4 and 5). The culvert station also has several excessive ammonia-N, total nitrogen (TN), *Escherichia coli*, and total coliform levels. The second site, described in Table 5, also had consistently high levels of nitrate and frequent high levels of total coliform bacteria, up to 241,920 MPN/100 mL. Yet, there is no mention in the EA of this extreme pollution of surface waters.

The BCRET quarterly progress reports (e.g. the October 1 to December 31, 2014 report, p.2) maintain that "no consistent or prolonged trends in nutrients or bacteria concentrations were evident at or among any of the monitoring locations. In fact…geometric mean bacterial levels tend to be greater under storm than base flow conditions." As corrective information, ***the concentrations of a given parameter in receiving surface waters and groundwaters should not be expected to be consistent; that is the nature of CAFO-imparted water pollution.*** Parameter levels should, and do, vary depending on the location with respect to swine waste practices at the CAFO, storm/runoff conditions, and soil characteristics (U.S. EPA 1998, 2013a - pp. 22-24). Extreme spikes in pollutant levels commonly occur during storm/runoff events (e.g. U.S. EPA 2013, Mallin et al. 2014); they may or may not be detected depending on the sampling location and frequency relative to the runoff.

**** Surface runoff from fields #1 and #12*** was highly contaminated during and after swine effluent application, and would have been expected to contribute to the contamination of nearby waters –

The EA (p.3-8) described field #1 as "pasture/slurry applied" and stated that the spring below field #1 had been sampled since September 2013, but neglected to add the important information as to *when* the field received swine effluent slurry from the C&H CAFO (March-June 2014). As mentioned, the spring below field #1, part of the C&H CAFO, was degraded in water quality when it was sampled in 2013 prior to the C&H swine effluent application. The fact that the elevated pollutants in the spring water included total suspended solids (TSS) indicates that surface runoff contributed to the pollution in the spring. Information is not available in the BCRET progress reports or the EA about the previous use of nearby fields such as field #1.

Nevertheless, during and following the period of swine effluent application in 2014, runoff from field #1 (and from field #12, based on sparse data) revealed excessive levels of some pollutants (DP, TP, NH_4^+N, NO_3^-N, TSS, and DOC) which would be expected to have contributed to the poor water quality of receiving waters such as the spring (note that fecal bacteria were not measured in these important runoff samples):

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Field 1									
5/8/2014	0.079	0.312	0.17	0.209	1.63	125.9	9.6	N.D.	N.D.
5/12/2014	0.190	0.366	0.10	0.126	1.33	42.1	10.2	N.D.	N.D.
5/28/2014	0.235	0.310	N.D.	N.D.	N.D.	56.1	164.7	N.D.	N.D.
6/20/2014	0.228	0.498	0.18	0.114	2.39	23.2	20.15	N.D.	N.D.
6/25/2014	1.166	1.374	0.10	0.333	1.18	12.3	7.80	N.D.	N.D.
7/23/2014	0.648	0.794	0.16	0.388	1.65	5.6	8.84	N.D.	N.D.
10/13/2014	0.529	0.746	0.98	0.698	2.89	65.7	9.46	N.D.	N.D.
3/26/2015	0.143	0.346	0.41	0.216	2.68	65.5	15.65	N.S.	N.S.
5/8/2015	0.525	0.714	0.16	0.475	2.19	16.9	13.28	N.S.	N.S.
5/11/2015	0.251	0.386	0.09	0.055	0.86	44.4	6.31	N.S.	N.S.
5/18/2015	0.208	0.512	0.54	0.410	3.59	53.7	26.12	N.S.	N.S.
Field 12									
5/8/2015	0.675	0.956	0.14	0.303	1.82	57.0	16.00	N.S.	N.S.
5/11/2015	0.194	0.364	0.09	0.135	0.83	36.7	7.03	N.S.	N.S.

Table 6. **Surface runoff from two fields to which C&H CAFO swine wastes had been applied** in the BCRET study, according to Table 3 in these Comments. Compiled from three BCRET quarterly progress reports: July 1 to September 30, 2014; October 1 to December 31, 2014; and April 1 to June 30, 2015. Red outlines indicate Note how sparse the data are for surface runoff from field #12 (n = 2 dates over a 1.5-year span). Nevertheless, those data (examples in red outlines, with arrows for excessively high levels) show excessive DP, TP, NH_4^+N,

NO_3^-N, and TSS; 1 of the 2 samples also contained excessive DOC. Also note that fecal bacteria have not once been sampled in surface runoff from the two fields being monitored that are receiving applications of C&H CAFO swine wastes.

Thus, regardless of the source of degraded spring water in 2013, during 2014 surface runoff from the fields containing C&H swine effluent was clearly contaminated with various pollutants during the effluent application period and for some time thereafter, and would have contributed to degradation of nearby surface waters such as the spring. Contaminated subsurface flow from field #1 likely also contributed to the degraded water quality of nearby shallow groundwaters.

Thus, overall regarding surface water quality, the EA (p.3-18) misstated that:

> There are no other data or other evidence to indicate that the operation of the C&H Hog Farms is adversely affecting surface water quality. While it is recognized that the available data are somewhat limited, these data are considered sufficient to conclude that if the farm's operation over the last 18 months was contributing measureable concentrations of nutrients or bacteria then it would be apparent in the water quality monitoring data collected to date, or be observed in emerging trends.

As corrective information, and as shown above, *there is substantial evidence indicating that the operation of the C&H CAFO is adversely affecting surface water quality*, such as the degraded surface runoff data from fields #1 and #12, and the degraded ephemeral stream near the animal holding units and waste holding ponds, related to this CAFO. The culvert 'ephemeral stream' data are at least partly related to this CAFO as well. Use of appropriate source tracking techniques (as explained in section V above) to verify that the water quality degradation indicated by the data is from C&H CAFO pollution should be conducted at the water quality sampling sites, and should be required of the BCRET study.

The EA (p. 3-14) stated, "If the waste ponds were leaking, or nutrients or bacteria applied to fields were leaching into upper alluvial groundwater, any measureable contribution of those pollutants would be realized at the downstream water quality monitoring station or the field monitoring stations." As explained above, the important "upstream control" station in the BCRET study design is highly compromised, commonly containing so much pollution that it is difficult to detect the C&H contribution for most pollutants. The compromised status of the upstream station would have generally obscured the contribution of the C&H CAFO to most of the pollutants being monitored in Big Creek. In addition, as noted, the statistically significantly higher nitrate at the downstream station – indicating an adverse impact of this CAFO – was not acknowledged in the EA, vaguely attributed instead to "the land use continuum …."

In addition, even with the inadequate study design, the BCRET quarterly progress reports indicate frequent water quality degradation by the C&H CAFO to adjacent water resources such as the ephemeral stream sites; surface runoff from fields #1 and #12 near the spring; the spring (before as well as after swine effluent waste application to the nearby fields); and the downstream area of Big Creek (regarding the latter, especially nitrate and total coliform bacteria). It is highly likely that source tracking techniques, which have not been used by the BCRET, would provide

additional, conclusive information regarding *Escherichia coli* and other parameters that presently are "confounded" due to the poor siting of the upstream sampling station on Big Creek, and/or due to the numerous data gaps for *E. coli* as shown in the progress reports.

VIII. *The EA failed to consider the potential for C&H CAFO impacts on the sensitive biota of receiving surface waters.*

Sensitive stream biota have been shown to be adversely impacted by low dissolved oxygen caused by swine CAFOs, and also adversely affected by the disease-causing microbes, high nutrient levels, high suspended solids, and other pollutants added by CAFOs (U.S. EPA 1998, Mallin 2000). Beneficial macroinvertebrates have been shown to be adversely affected by nitrate concentrations as low as 0.23 mg nitrate-N/L (Camargo et al. 2005). Early instar caddisfly larvae have sustained adverse effects from chronic toxicity of 1.4 to 2.4 mg nitrate-N/L (Camargo and Ward 1995). Endocrine functioning in vertebrates such as reptiles, amphibians, and fish has been damaged, as well (Guillette and Edwards 2005). Impacts on surface water biota were not once mentioned in the EA.

Moreover, nitrate is well known to be capable of traveling long distances (up to 200 miles or more), much farther than the approximately 10-mile distance from this CAFO to the confluence of Big Creek with the Buffalo National River (Mallin et al. 1993, Houser and Richardson 2010). Thus, nitrate impacts from this CAFO should be assessed in the larger river as well as the other surface waters.

The excessive ammonia-N concentrations in surface waters affected by the C&H CAFO, as noted in the above tables, are much higher than levels reported to stress and kill sensitive aquatic life (Camargo and Alonso 2006), and in violation of levels required to sustain sensitive biota as recommended by the U.S. EPA (2013b). Thus, ammonia impacts from this CAFO on sensitive aquatic life should be evaluated as well.

IX. *Future projections given in the EA are speculations unsupported by peer-reviewed science.*

- The EA (p.3-19) asserted that it is "highly unlikely" that a 50-year or 100-year heavy rainfall could cause a discharge from the waste holding ponds. That assertion was not supported by any peer-reviewed science literature. As corrective information, the C&H waste holding ponds are designed to accommodate a 25-year storm. Due to warming trends and expected climatic instability, heavy downpours that previously occurred about once every 20-25 years are projected to occur about every 4 to 15 years in the coming decades (Karl et al. 2009). Thus, "25-year storms" are expected to occur more frequently than once in 25 years, increasing the likelihood for a discharge from the waste holding ponds. A similar increase in frequency is expected for "50-year" and "100-year" storms.

- The EA (p.3-19) also asserted, absent scientific evaluation, that swine effluent releases from holding ponds deliberately or by accident would have only short-term impacts on surface water quality. The authors claimed that "these types of discharges would not result in long-term (chronic) or significant impacts to surface water quality." They cited no peer-reviewed science publications in support of these assertions. Beyond surface water quality, there was no mention

of impacts to fish and other aquatic life, and no mention of the Buffalo National River, a valuable national resource and sensitive ecosystem that would sustain the impacts from such swine effluent spills conveyed by its tributary, Big Creek. The cursory, dismissive statements contained in the EA are lacking in supporting analysis or in supporting science literature. As corrective information, *swine waste spills have been shown to cause acute, significant impacts in receiving waters lasting weeks to months* (Burkholder et al. 1997, 2007; Mallin 2000, and references therein). For example, Burkholder et al. (1997) tracked of a swine effluent spill in receiving surface waters and documented extreme impacts lasting several months. Downstream waters, at more than three times the distance from the C&H CAFO to the Buffalo River, were also significantly impacted. Chronic impacts were not examined but were expected to be substantial, given that there was no dissolved oxygen in the receiving stream for a week or more; the fish community was destroyed; the high suspended solids load appeared to bury bottom-dwelling fauna; and fecal bacteria continued to thrive in high numbers in the surficial sediments for months. Such effects can make even partial ecosystem recovery difficult (Burkholder and Glibert 2013).

Other research has shown that additions of wastes containing such extreme pollutant loads as swine effluent have caused irreversible damage in the form of regime shifts in receiving waters. The term, regime shift, is defined as an abrupt shift in the biota of an ecosystem in response to a major stressor (Collie et al. 2004). A major stressor such as a large-volume swine waste discharge can induce persistent, radical changes in the aquatic community, from beneficial organisms to noxious or undesirable organisms. When such a shift occurs, the food web changes, energy paths are altered, and the ecosystem usually is not able to provide the services it previously provided to beneficial biota or human users (Hershner 2011). The new dominant species in the affected ecosystem remains long-term (years), in aquatic communities that have undergone a regime shift in response to nutrient pollution.

- The EA (p.2-2) misleadingly stated,

> Periodically, waste from the ponds is pumped down and applied onto nearby fields that are used for pasture and hay production, *thus consuming the nutrients* in a full cycle system (emphasis added).

As corrective information, *the fact that this CAFO is located in a known karst area near the land surface makes full consumption of nutrients applied to fields unrealistic*. The CAFO design of field waste application used by C&H is known to cause substantial contamination of the airfield and surrounding natural resources including soils, surface waters, and groundwaters (Burkholder et al. 2007, and references therein). Karst topography is formed by dissolution of underlying carbonate rocks (limestone and dolomite), and/or other soluble rocks such as gypsum (Alpha et al. 2013). Karst soil or bedrock is permeable because air and water can move through them easily, making karst systems "very vulnerable to groundwater pollution…." (Alpha et al. 2013). Limestone (calcium carbonate) is known to strongly adsorb phosphorus (Stumm and Morgan 1996, Wetzel 2001); thus, recent work indicates that on an annual basis, up to ~70% of the total phosphorus (TP) flux (movement into/through the karst material) and ~90% of the soluble reactive phosphorus flux (highly bioavailable P) is retained by the karst material (Jarvie

et al. 2014). However, as Jarvie et al. (2014) also noted, subsequent P remobilization and release from the karst material may serve as a long-term source of P to surface waters. And, as the EA authors acknowledged (p.3-10), there is a [strong] hydraulic connection of surface water and groundwater in the area.

X. *The EA lacks a rigorous assessment of groundwater impacts from the C&H CAFO.*

The EA does not include a science-based analysis of the potential for groundwater impacts from the C&H CAFO, and it fails to consider data from a trench and a well which indicate that groundwater quality is being adversely affected by this CAFO. The EA (p.3-20) stated that data were not available to assess whether the waste holding ponds are leaking substantial pollutants; and that there are no karst features in the area where the buildings or holding ponds were constructed, despite the fact that this is a known karst area. The authors also asserted that:

> "No direct or indirect impacts to groundwater quality are expected since it is protected by rigid adherence to the farm's NPDES General Permit requirements and BMPs…."

As corrective information and as noted above, in this karst area the potential for such impacts is instead expected to be *high*. In addition, Brahana et al. (undated) recently conducted a dye study which showed in detail the interconnectedness of Big Creek and the Buffalo National River basins. The dye study supports general information known for karst areas, namely, that the highly porous soils can be expected to allow, much more easily, contamination from the C&H CAFO to groundwaters.

**** Water quality in the north and south ends of a long trench*** ("Interceptor Trench 1 [South], Interceptor Trench 2 [North]") near the swine waste holding ponds which, the BCRET team stated (July – Sept. 2014 quarterly progress report, p.2), was installed to monitor potential leakage. The trench samples are confusingly labeled as indicated above, implying that there are two trenches when instead there is one trench that is being sampled at each end. The trench location is shown in Figure 3 below; the holding ponds are shown and described in Figure 4. The water quality data for the trench are summarized in Table 7 below.

Figure 3. **Photos showing (left) the site of the seepage monitoring trench** near the swine waste holding ponds, **and (right) the "north" and "south" sample collection points**. From the July 1 to September 30,

2014 BCRET quarterly progress report (pp.15, and 16).

Figure 4. **More magnified view of the large swine waste "manure" or "slurry" holding ponds** as described by the BCRET. The yellow outer boundary was described as denoting the drainage area (59,457 square feet) into the waste holding ponds. The red inner boundary was described as denoting the top of the free board for holding pond 1 (16,999 square feet) and the larger holding pond, holding pond 2 (34,618 square feet). The volumes of waste holding ponds 1 and 2 were given as 616,395 gallons and 1,723,009 gallons. From the BCRET quarterly progress report dated October 1 to December 31, 2014, pp. 35-36.

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Interceptor Trench 1 (South)									
9/3/2014	0.004	0.003	0.04	0.937	1.22	3.7	0.68	N.D.	N.D.
9/11/2014	0.001	0.018	0.03	1.580	1.86	1.0	0.54	1.0	57,940
10/13/2014	<0.002	0.024	<0.03	1.251	1.46	71.4	0.83	15,650.0	61,310
11/5/2014	0.004	0.012	0.02	1.54	1.67	0.9	0.37	N.D.	N.D.
11/12/2014	0.004	0.012	0.02	1.54	1.67	0.9	0.37	N.D.	N.D.
12/22/2014	0.005	0.018	<0.03	0.881	0.83	6.1	1.09	1.0	630.0
1/8/2015	0.005	0.022	<0.03	0.769	0.75	4.7	0.88	1.0	13130.0
1/14/2015	0.007	0.028	<0.03	0.469	0.55	1.9	0.55	7.4	1413.6
2/26/2015	0.004	0.028	<0.03	0.712	0.76	46.0	0.60	1.0	41063.0
3/3/2015	0.003	0.024	<0.03	0.867	0.89	N.D.	0.95	N.S.	N.S.
3/11/2015	0.003	0.014	0.07	0.989	0.97	0.3	2.00	<1.0	2419.2
3/19/2015	0.003	0.012	0.01	0.849	0.93	<6.58	3.11	1.0	275.5

Table 7. **Data for surface water quality in a long trench** that was designed to capture any leakage from swine waste holding ponds at the C&H CAFO. The data for Interceptor Trench 1 (South) are compiled from three BCRET quarterly progress reports dated October 1 to December 31, 2014; January 1 to March 31, 2015; and April 1 to June 30, 2015. The data for Interceptor Trench 2 (North – next page) are compiled from two BCRET quarterly progress reports dated October 1 to December 31, 2014; and April 1 to June 30, 2015. Numbers highlighted (examples in red outlines) are excessive

levels indicating pollution from the C&H CAFO waste holding pond. Note that the project team implausibly has alluded to wildlife such as a bobcat as having contributed the total coliforms, but the consistently high nitrate instead indicates leakage from the waste holding pond.

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Interceptor Trench 1 (South) cont'd.									
3/25/2015	0.003	0.008	<0.03	0.838	0.88	0.2	0.59	<1.0	410.6
3/26/2015	0.004	0.026	0.02	0.904	1.00	15.4	0.69	<1.0	1553.1
4/2/2015	0.003	0.028	0.02	0.865	0.87	0.3	3.34	1.1	308.6
4/9/2015	0.006	0.018	<0.03	0.790	0.83	0.8	2.99	<1.0	187.2
4/15/2015	0.003	0.020	<0.03	0.857	0.93	1.3	4.29	<1.0	3180.0
4/23/2015	0.003	0.034	<0.03	0.877	0.97	1.2	1.18	3.1	2690.0
5/11/2015	0.003	0.060	0.02	0.916	0.97	27.6	1.78	N.S.	N.S.
Interceptor Trench 2 (North)									
9/11/2014	<0.002	0.010	0.03	2.033	2.31	3.2	0.70	81.3	27,550
10/13/2014	0.001	0.116	0.33	1.714	2.73	11.1	4.14	920.8	241,920
11/5/2014	0.004	0.032	0.03	3.375	3.65	33.1	0.87	N.D.	N.D.
11/12/2014	0.004	0.032	0.03	3.375	3.65	33.1	0.87	N.D.	N.D.
3/11//2015	0.003	0.056	0.04	1.443	1.59	1.2	3.51	<1.0	2419.2
3/19/2015	0.004	0.062	0.09	1.036	1.42	1.9	5.12	5.2	2419.2
3/26/2015	0.004	0.126	0.13	0.873	1.44	22.2	4.63	105.4	6950.0
5/11/2015	0.003	0.042	0.05	0.553	0.76	8.8	3.44	N.S.	N.S.
5/14/2015	0.005	0.042	0.02	0.904	0.94	29.9	1.20	81.6	1732.9
5/18/2015	0.002	0.020	<0.03	0.897	0.93	0.3	1.28	32.3	1732.9

Table 7, cont'd.

**** House well*** – The EA described a groundwater well located adjacent to the CAFO buildings, but did not analyze the data from the well, despite the fact that those data are included in the BCRET quarterly reports which were referenced in the EA. The data show that the well water is unsafe for human or animal consumption unless treated, as indicated by 1 or more total coliform bacteria or *Escherichia coli* bacteria detected (U.S. EPA; see http://water.epa.gov/drink/contaminants/basicinformation/pathogens.cfm). The water also has commonly contained substantial densities of coliform bacteria, including *Escherichia coli* (see the April 1 to June 30, 2015 BCRET quarterly progress report).

The BCRET reports offer no information about the potential for sources other than the C&H CAFO that could contribute to the contamination of the well water. It also is not known whether the groundwater source for the well was contaminated before the waste holding ponds were installed. The close proximity of the well to the animal holding units and the swine waste holding ponds, considered together with the data showing high leakage of the waste holding ponds, indicate that the C&H CAFO is a major contaminant source. Nevertheless, it is uncertain as to whether the data can be used to provide information about impacts of this CAFO because no information about the actual sampling procedure is provided in the BCRET reports. The reports should have stipulated whether the well samples were taken from the wellhead; if not, the data may not be useable.

Thus, based on the information in the BCRET quarterly progress reports, the available, useable data (that is, the trench samples) from the BCRET study indicate substantial leakage of nitrate, total suspended solids, total coliform bacteria, and *Escherichia coli* fecal bacteria. Such findings are supported by various peer-reviewed studies in the science literature (e.g. Huffman and Westerman 1995, Westerman et al. 1995, Ham and DeSutter 2000). Chronic contamination by fecal bacteria was also indicated for well water, which would render the well water unsafe for human or animal consumption without treatment. From the information provided, however, it cannot be determined as to whether the well was appropriately sampled.

Recommendations

The following actions are needed to make this EA a realistic, science-based environmental assessment of impacts and potential impacts to surrounding natural resources from the C&H CAFO:

- The EA should include the previously collected data from the U.S. EPA so that readers can evaluate whether the data support the environmental assessment.

- The EA should include a thorough, rigorous analysis, from peer-reviewed science, of known impacts from swine CAFOs to surface waters and groundwaters, including both accepted practices and waste spills.

- The EA should provide a scientifically rigorous assessment of the data from the BCRET study as summarized in these Comments, which do show degradation from this swine CAFO to both surface water (e.g. the surface runoff from fields #1 and #12) and groundwater (the trench data) natural resources.

- The BCRET study, heavily relied upon by the EA, is seriously inadequate in its present form to enable assessment of environmental impacts from the C&H CAFO. At present, the fields with swine waste application which are being sampled are not representative, such that data from those fields would be expected to show minimal impacts in comparison to fields receiving much more swine effluent. The extremely important "upstream control" station on Big Creek is so degraded that it does not serve as a control; it could even be receiving C&H CAFO swine effluent contamination because some of the most heavily waste-applied fields are near it. The spring station is compromised, considering that its water quality was degraded prior to

application of swine effluent from the C&H CAFO on nearby field #1. It is not known whether the well samples are useable because sufficient information about sampling procedures was not provided by the BCRET. The culvert (atypical) 'ephemeral stream' was described by the BCRET team as draining the sub-watershed that includes a portion of the C&H CAFO, and it may also drain other source(s). Source tracking should be used these water quality stations to verify the CAFO influence. Useful data for C&H CAFO impact assessment have been provided from the trench stations and the surface runoff from fields #1 and #12 – and those stations have shown major water quality degradation.

Compounding the above extreme inadequacies in the BCRET study design, the BCRET has thus far dismissed clear evidence of impacts from the C&H CAFO based on the trench data and the surface runoff data from fields #1 and #12 (the latter, even during swine waste application periods), by requiring that the data consistently show high pollutant concentrations. That requirement is not science-based. It is met for nitrate-N in the trench water and the ephemeral spring near the animal holding units (see Table 7 of these Comments) because nitrate is highly soluble (thus, not confounded by "stickiness" to surfaces such as soil particles), and because the swine waste holding ponds are a consistent landscape feature; they are located in very close proximity to the trench and the ephemeral stream. It is not met *all* of the time for most parameters at other water quality stations because, as shown in peer-reviewed science, the data depend on site-specific characteristics such as the CAFO waste management, soil conditions, runoff amount and frequency, and preceding storm conditions. The *extreme spikes* shown in various surface waters as summarized in these Comments, such as the surface runoff from Fields #1 and #2, *are typical of swine CAFO pollution to surface waters* (e.g. Westerman et al. 1985, Burkholder et al. 1997, Mallin 2000, U.S. EPA 2013a [pp.22-24]).

The BCRET study will require *essential* modifications for accurate assessment of water resource impacts from the C&H CAFO. The essential modifications should include, at a minimum,

(i) *Selection and use of an uncompromised "upstream control" sampling station* of Big Creek, at adequate distance from C&H CAFO swine waste application fields to ensure no contamination from those wastes.

(ii) *Selection and use of representative swine waste application fields* for characterization of average and maximal impacts of soils, karst features, surface runoff quality, and groundwater quality. The fields should be representative with respect to the amount of swine wastes applied. The present study design emphasizes one field with NO C&H CAFO swine waste application, and two fields with minimal C&H swine waste application. The fields selected for rigorous analysis of impacts from this CAFO should instead include at least one with an average frequency and volume/acre of swine waste applications, and at least one with a high frequency and volume/acre of swine waste applications.

If private landowners of such fields block access, then the BCRET should be required to present the findings from fields #1 and #12 as an assessment of *minimal* impacts from swine waste application, rather than the team's present incorrect description of

the two fields with minimal waste application as representative of the fields being used, on average, for much higher amounts of C&H CAFO swine waste application.

(iii) *Use of appropriate techniques* to verify the source/predominance of C&H-related fecal bacteria such as *Escherichia coli* (molecular techniques, e.g., Heaney et al. 2015) *and* nitrate-N pollution (stable isotope techniques, e.g., Michener and Lajtha 2007, Eppich et al. 2012, Pastén-Zapata et al. 2014, and references therein), at the water quality sampling stations including the ephemeral streams, Big Creek, surface runoff from Fields #1 and #12, the house well, and the trench.

(iv) *Diel sampling of dissolved oxygen* at appropriate intervals and stations throughout the year.

(v) *Replacement of total coliform measurements with fecal coliform measurements*. It is well known that total coliforms are ubiquitous in environmental samples, and can result in water samples from land disturbance, wildlife, etc. As explained above, decades ago federal agency guidance recommended the use of fecal coliforms rather than total coliforms as a much better, and better tracked, indicator of fecal contamination.

(vi) *Sampling the house well* directly from the well head, if this is not already being done. The well water should also be subjected to source tracking techniques as mentioned above.

(vii) *Assessment of impacts of the C&H CAFO on sensitive biota* in receiving surface waters. Environmental assessment of the C&H CAFO should address the high potential for such impacts, extending downstream to the Buffalo National River.

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Algal nutritional physiology and ecology, spanning the salinity gradient from freshwater to estuarine and marine species; and chronic effects of eutrophication (nutrient over-enrichment and associated pollutants) on aquatic ecosystems

Professional Experience

2013 - present	Director, CAAE, Department of Applied Ecology, NCSU
2013 - present	Professor, Department of Applied Ecology; jointly appointed to the Department of Plant & Microbial Biology (formerly the Department of Plant Biology), NCSU
1999 - 2012	Director, CAAE, Department of Plant Biology, NCSU
1998 - 2012	Professor, Department of Plant Biology (formerly the Department of Botany), NCSU
1993 - 1997	Associate Professor, Department of Botany, NCSU
1993 - present	Affiliate Professor, Department of Marine, Earth and Atmospheric Sciences (MEAS), NCSU
1986 - 1992	Assistant Professor, Department of Botany, NCSU
1982 - 1986	Graduate Research Assistant, Michigan State University (W.K. Kellogg Biological Station), Hickory Corners, MI
1981 (fall)	Instructor, *Introductory Chemistry* (for science majors), Quinebaug Valley Community College, Danielson, CT
1979 - 1980	Instructor of *Marine Botany,* summers, St. Georges College Prep. School, Newport, RI
1978 - 1981	Graduate Research Assistant and Graduate Teaching Assistant, Department of Botany, University of Rhode Island, Kingston, RI
1976 - 1977	Environmental Scientist, EcolSciences, Inc., Rockaway, NJ
1974 - 1975	Undergraduate Research Assistant, Limnology Laboratory, Department of Zoology, Iowa State University, Ames, IA

Awards and Distinctions

2009	Borlaug Joint Award for Service to the Environment and Society, College of Agriculture and Life Sciences/ College of Natural Resources, NCSU

2008	William Neal Reynolds Distinguished Professor, College of Agriculture and Life Sciences, NCSU, for excellence in research
2008	J. Compton River Achievement Award, River Network, lifetime achievement for leadership in research to advance water quality protection
2007	Darbaker Prize, Botanical Society of America, for excellence in research
2004	Fellow, American Association for the Advancement of Science (AAAS)
2003	Honorary Doctorate, Knox College, Galesburg, IL
2003	Provasoli Award, best paper of 2002, *Journal of Phycology*
2001	Honorary Doctorate, Southampton College - Long Island University
2000	Fellow, Aldo Leopold Leadership Program, Ecological Society of America
1999	Hutner Award, Society of Protozoologists, for excellence in microalgal research
1998	Scientific Freedom and Responsibility Award, AAAS
1998	Distinguished Service in Environmental Education Award, Environmental Educators of North Carolina
1998	Distinguished Scholarly Achievement Award, NCSU Honors Convocation
1998	Conservationist of the Year Award, National Wildlife Federation
1998	Conservationist of the Year Award, Governor of North Carolina and the North Carolina Wildlife Federation
1998	Jack Bayless Award – outstanding presentation of the year, South Carolina Fishery Workers Association, and the North and South Carolina chapters of the American Fisheries Society
1997	Admiral of the Chesapeake Award, Federal and State Leadership Summit, Washington, DC
1997	Outstanding Achievement Award, Society of Business and Professional Women of North Carolina
1997-2000	Pew Fellow in Marine Conservation, the Pew Foundation
1994	Outstanding Research Award, NCSU Alumni Association

Honors to the NCSU CAAE

2013	The CAAE was recognized as the reason why NCSU placed 31st among the top 50 "Colleges Saving the World" (http://www.onlinecollegesdatabase.org/50-colleges-saving-the-planet).
2012	The CAAE received the highest evaluation possible (Excellent) by an outside Peer Review Panel that reviewed in detail the Center's performance over its entire span of operation. The panel was organized by the NCSU College of Agriculture and Life Sciences, as required by the UNC Board of Governors.

Other Honors

2013	Invited presentation on Harmful Algae - Capital Hill Briefing, representing the Coastal and Estuarine Research Federation
2007	Theodore L. Jahn and Eugene C. Bovee Award, International Society of Protozoologists, for best graduate student research paper, to doctoral candidate Hayley Skelton (coauthors of the paper, Burkholder and Parrow)
2001	Elected member, Alumni Hall of Fame, Rock Valley College, Rockford, Illinois
2001	Convocation speaker, Appalachian State University
2001	Convocation speaker, Southampton College - Long Island University
1998	Special recognition for excellence in research, Phi Kappa Phi
1998	Invited testimony, Congressional Hearing on the Value of Estuaries, US Senate, Senate Environment and Public Works Committee
1998	Invited testimony, Congressional Hearing on Harmful Algal Blooms, US Senate, Committee on Commerce, Science and Transportation

1997	Invited testimony, Congressional Hearing on Fisheries Conservation, Wildlife and Oceans, US House of Representatives – Committee on Resources
1997	Invited testimony, Congressional Hearing on Harmful Algae and Human Health, US House of Representatives – Committee on Government Reform and Oversight
1997-1999	Science Advisor, Governor's Commission on *Pfiesteria*, Maryland
1993-1994	Member, North Carolina Coastal Futures Committee (governor-appointed)
1993-1995	Member, Board of Directors, Partnership for the Sounds (directive, environmental education for eastern North Carolina)
1992-1997	Member-at-large, North Carolina Marine Fisheries Commission (governor-appointed)
1985	Elected member, Phi Kappa Phi, Michigan State University
1984-1986	Graduate fellow, Department of Botany and Plant Pathology, Michigan State University

Selected Research Accomplishments

(with thanks to my graduate students, postdoctoral research associates and other research associates, and collaborators)

Freshwater Ecosystems

- First to maintain automated platform stations with depth profiling capability for advanced research and monitoring of North Carolina reservoirs; the real-time data from these stations is also helping to safeguard drinking water supplies depended upon by ~750,000 people.
- Experimentally quantified interactions between nutrient and sediment loadings in controlling noxious algal blooms in turbid reservoirs.
- First to document widespread occurrence, at low levels, of cyanotoxins in major potable water supplies in North Carolina.
- Documented novel nutritional and physical adaptations of a cryptic group of dinoflagellates in reservoirs affected by episodic suspended sediment loading.

Estuarine and Marine Ecosystems

- Discovered that water-column nitrate enrichment from sewage and other sources inhibits *Zostera marina*, the dominant seagrass of north temperate U.S. waters, as a direct physiological effect.
- Co-discovered the toxic dinoflagellates, *Pfiesteria piscicida* and *Pfiesteria shumwayae*, as causative agents of major estuarine fish kills; this research also led to colleagues' discovery of a group of *Pfiesteria* toxins new to science.
- First to design and maintain a series of automated platform stations for advanced research and monitoring of a North Carolina estuary; coauthor of a patent for an automated depth profiler.
- First to show that shallow lagoonal estuarine ecosystems are resilient to the adverse effects of hurricanes, recovering within 4-5 years.
- Helped to develop a model for water mass transport to the Neuse Estuary; used the model and a detailed dataset for improved quantification of nutrient loads, including decadal trend analysis.

Grants (past decade)

My research routinely involves analyzing the species composition and abundance of phytoplankton in samples from lakes, reservoirs, rivers, estuaries, and marine coastal environments. For example, my research associate, Ms. Elle Allen, and I recently analyzed 1,000 phytoplankton samples from lakes across the nation as part of a major contract to Dr. Beaver from the U.S. Environmental Protection Agency.

Support for my research and education outreach has been obtained from the National Science Foundation, National Park Service, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, U.S. Department of Defense, the Burroughs Wellcome Fund, the Park Foundation, the Z. Smith Reynolds Foundation, and North Carolina Clean Water Management Trust Fund.

Publications (Peer-reviewed, in scientific journals, books and symposia volumes)

1) Burkholder JM, Bachmann RW (1979) Potential phytoplankton productivity in three Iowa streams. *Proceedings of the Iowa Academy of Sciences* 86: 22-25.

2) Sheath RG, Burkholder JM (1983) Morphometry of *Batrachospermum* populations intermediate between *B. boryanum* and *B. ectocarpum* (Rhodophyta). *Journal of Phycology* l9: 324-331.

3) Burkholder JM, Sheath RG (1984) The seasonal distribution, abundance and diversity of desmids (Chlorophyta) in a softwater, north temperate stream. *Journal of Phycology* 20: 159-172.

4) Sheath RG, Burkholder JM (1985) Characteristics of softwater streams in Rhode Island. II. Composition and seasonal dynamics of macroalgal communities. *Hydrobiologia* 128: 109-118.

5) Burkholder JM, Sheath RG (1985) Characteristics of softwater streams in Rhode Island, U.S.A. I. A comparative analysis of physical and chemical features. *Hydrobiologia* 128: 97-108.

6) Bachmann MD, Carlton RG, Burkholder JM, Wetzel RG (1986) Symbiosis between salamander eggs and green algae: Microelectrode measurements inside eggs demonstrate effects of photosynthesis on oxygen concentrations. *Canadian Journal of Zoology* 64: 1586-1588.

7) Sheath RG, Burkholder JM, Hambrook JA, Hogeland A, Hoy E, Kane ME, Morison MO, Steinman AD, Van Alstyne KL (1986) Characteristics of softwater streams in Rhode Island. III. Distribution of macrophytic vegetation in a small drainage basin. *Hydrobiologia* 140: 183-191.

8) Sheath RG, Burkholder JM, Morison MO, Steinman AD, Van Alstyne KL (1986) Effect of tree canopy removal by gypsy moth larvae on the macroalgae of a Rhode Island headwater stream. *Journal of Phycology* 22: 567-570.

9) Moeller RE, Burkholder JM, Wetzel, RG (1988) Significance of sedimentary phosphorus to a rooted submersed macrophyte (*Najas flexilis*) and its algal epiphytes. *Aquatic Botany* 32: 261-281.

10) Sheath RG, Burkholder JM (1988) Stream macroalgae, pp. 53-59. In: *Freshwater and Marine Plants of Rhode Island*, by Sheath RG and Harlin MM (eds.). Kendall/Hunt Publishers, Dubuque (IA), 149 pp.

11) Burkholder JM, Wetzel RG (1989) Microbial colonization on natural and artificial macrophytes in a phosphorus-limited hardwater lake. *Journal of Phycology* 25: 55-65.

12) Burkholder JM, Wetzel RG (1989) Epiphytic microalgae on natural substrata in a hardwater lake: Seasonal dynamics of community structure, biomass, and ATP content. *Archives für Hydrobiologie/ Supplement* 83: 1-56.

13) Burkholder, J.M. and R.G. Wetzel (1990) Epiphytic alkaline phosphatase on natural and artificial plants in an oligotrophic lake: Re-evaluation of the role of macrophytes as a phosphorus source for epiphytes. *Limnology and Oceanography* 35: 736-747.

14) Burkholder JM, Wetzel RG, Klomparens KL (1990) Direct comparison of phosphate uptake by adnate and loosely attached microalgae within an intact biofilm matrix. *Applied and Environmental Microbiology* 56: 2882-2890.

15) Cuker BE, Gama P, Burkholder JM (1990) Type of suspended clay influences lake productivity and phytoplankton community response to phosphorus loading. *Limnology and Oceanography* 35: 830-839.

16) Burkholder JM, Cuker BE (1991) Response of periphyton communities to clay and phosphate loading in a shallow reservoir. *Journal of Phycology* 27: 373-384.

17) Everitt DT, Burkholder JM (1991) Seasonal dynamics of macrophyte communities from a stream flowing over granite flatrock in North Carolina, U.S.A. *Hydrobiologia* 222: 159-172.

18) Burkholder JM (1992) Phytoplankton and episodic suspended sediment loading: Phosphate partitioning and mechanisms for survival. *Limnology and Oceanography* 37: 974-988.

19) Burkholder JM, Mason KM, Glasgow HB (1992) Water-column nitrate enrichment promotes decline of eelgrass (*Zostera marina* L.): Evidence from seasonal mesocosm experiments. *Marine Ecology Progress Series* 81: 163-178.

20) Burkholder JM, Noga EJ, Hobbs CW, Glasgow HB, Smith SA (1992) New "phantom" dinoflagellate is the causative agent of major estuarine fish kills. *Nature* 358: 407-410, *Nature* 360: 768.

21) Mallin MA, Burkholder JM, Sullivan MJ (1992) Benthic microalgal contributions to coastal fishery yield. *Transactions of the American Fisheries Society* 121: 691-695.

22) Martin TH, Crowder LB, Dumas CF, Burkholder JM (1992) Indirect effects of fish on macrophytes in Bays Mountain Lake: Evidence for a littoral trophic cascade. *Oecologia* 89: 476-481.

23) Noga EJ, Smith SA, Burkholder JM, Hobbs CW, Bullis RW (1993) A new ichthyotoxic dinoflagellate**:** Cause of acute mortality in aquarium fishes. *Veterinary Record* 133: 48-49.

24) Burkholder JM, Glasgow HB, Cooke JE (1994) Comparative effects of water-column nitrate enrichment on eelgrass *Zostera marina*, shoalgrass *Halodule wrightii*, and widgeongrass *Ruppia maritima. Marine Ecology Progress Series* 105: 121-138.

25) Coleman VL, Burkholder JM (1994) Community structure and productivity of epiphytic microalgae on eelgrass (*Zostera marina* L.) under water-column nitrate enrichment. *Journal of Experimental Marine Biology and Ecology* 179: 29-48.

26) Burkholder JM, Glasgow HB (1995) Interactions of a toxic estuarine dinoflagellate with microbial predators and prey. *Archiv für Protistenkunde* 145: 177-188.

27) Burkholder JM, Glasgow HB, Hobbs CW (1995) Distribution and environmental conditions for fish kills linked to a toxic ambush-predator dinoflagellate. *Marine Ecology Progress Series* 124: 43-61.

28) Burkholder JM, Glasgow HB, Steidinger KA (1995) Stage transformations in the complex life cycle of an ichthyotoxic "ambush-predator" dinoflagellate, pp. 567-572. In: *Harmful Marine Algal Blooms,* by Lassus P, Arzul G, Erard E, Gentien P, Marcaillou C (eds.). Lavoiser, Intercept Ltd., Paris.

29) Coleman VL, Burkholder JM (1995) Response of microalgal epiphyte communities to nitrate enrichment in an eelgrass (*Zostera marina* L.) meadow. *Journal of Phycology* 31: 36-43.

30) Glasgow HB, Burkholder JM, Schmechel DE, Fester PA, Rublee PA (1995) Insidious effects of a toxic dinoflagellate on fish survival and human health. *Journal of Toxicology and Environmental Health* 46: 501-522.

31) Lewitus AJ, Jesien RV, Kana TM, Burkholder JM, Glasgow HB, May E (1995) Discovery of the "phantom" dinoflagellate in Chesapeake Bay. *Estuaries* 18: 373-378.

32) Mallin MA, Burkholder JM, Larsen LM, Glasgow HB (1995) Response of two zooplankton grazers to an ichthyotoxic estuarine dinoflagellate. *Journal of Plankton Research* 17: 351-363.

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39) Burkholder JM, Mallin MA, Glasgow HB, Larsen LM, McIver MR, Shank GC, Deamer-Melia N, Briley DS, Springer J, Touchette BW, Hannon EK (1997) Impacts to a coastal river and estuary from rupture of a large swine waste holding lagoon. *Journal of Environmental Quality* 26: 1451-1466.

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42) Burkholder JM (1998) Implications of harmful marine microalgae and heterotrophic dinoflagellates in management of sustainable marine fisheries. *Ecological Applications* 8: S37-S62.

43) Burkholder JM, Glasgow HB, Lewitus AJ (1998) Physiological ecology of *Pfiesteria piscicida* with general comments on "ambush-predator" dinoflagellates, pp. 175-191. In: *Physiological Ecology of Harmful Algae,* by Anderson DM, Cembella A, Hallegraeff GM (eds.). NATO ASI Series G: Ecological Sciences, Vol. 41. Springer-Verlag, Berlin, Germany.

44) Burkholder JM, Larsen LM, Glasgow HB, Mason KM, Gama P, Parsons JE (1998) Influence of sediment and phosphorus loading on phytoplankton communities in an urban piedmont reservoir. *Lake and Reservoir Management* 14: 110-121.

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Climate links and anthropogenic factors. *Science* 285: 1505-1510.

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52) Lewitus AJ, Glasgow HB, Burkholder JM (1999) Kleptoplastidy in the toxic dinoflagellate, *Pfiesteria piscicida*. *Journal of Phycology* 35:303-312.

53) Lewitus AJ, Willis BM, Hayes KC, Burkholder JM, Glasgow HB, Glibert PM, Burke MK (1999) Mixotrophy and nitrogen uptake by *Pfiesteria piscicida* (Dinophyceae). *Journal of Phycology* 35: 1430-1437.

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President's Committee of Advisors on Science and Technology (PCAST) (1998) *Teaming with Life: Investing in Science to Understand and Use America's Living Capital.* Section I: Make Use of Current Knowledge in Managing Biodiversity and Ecosystems of the U.S., p.27. PCAST Panel on Biodiversity and Ecosystems, Washington, DC.

Burkholder JM (1997) *Pfiesteria* and Nutrient Pollution. Requested by Maryland's Governor Glendening for a summit meeting of five governors of states in the Chesapeake Bay watershed, Annapolis, pp. 1-5.

Burkholder JM (1995) Fish kills' message: Get serious about reducing nutrient over-enrichment to our estuaries, pp.1-3. In: *WaterWise*, by Doll B (Ed.). Vol. 1, 2nd Quarter. NC Sea Grant News Letter, Raleigh.

Coastal Futures Committee (1994) *Charting a Course for our Coast - A Report to the Governor of North Carolina.* L.R. Preyer, Chair. NC Department of Environment, Health and Natural Resources, Raleigh, 106 pp. [As the only scientist on the 15-member committee, I contributed substantially to all sections related to water quality, habitat, and fisheries in the document, and to the executive summary of prioritized recommendations.]

Burkholder JM (1993) Vital grasses need clean water to grow. In: *Currents*, News Letter of the Pamlico-Tar River Foundation, Vol. 13, Fall, p.7, Washington (NC).

Burkholder JM (1993) A newly discovered toxic alga and its relationship to fish kills, pp.48-58. In: *Proceedings from the Second North Carolina Marine Recreational Fishing Forum.* NC Sea Grant Report UNC-SG-93-06. UNC Sea Grant, NCSU, Raleigh, 61 pp.

Burkholder JM (1993) Golf course runoff: View from below the water surface, pp. 18-23. In: *Is Golfing Green? The Impact of Golf Courses on the Coastal Environment*. Symposium Proceedings (sponsored by the NC Coastal Federation and the NCSU Cooperative Extension Service through the NC Sea Grant College Program), Wilmington.

Patent

U.S. Patent #7,040,157. "Variable depth automated dynamic water profiler", Reed, Glasgow, Burkholder, Toms, May 2006 (NCSU; patent sold to YSI, Inc.).

Professional Activities (examples)

Editorial

Guest Co-Editor, special issue, *Harmful Algae* (Intraspecific Variation, 2009)
Guest Co-Editor, special issue, *Harmful Algae* (Harmful Algae and Eutrophication), 2007
Guest Co-Editor, special issue, *Harmful Algae* (Ecology of *Pfiesteria*), 2006
Editorial Board, *Journal of Experimental Marine Biology and Ecology*, 2005 - present
Editorial Board, *Harmful Algae,* 2002 - present
Editorial Board, *Journal of Eukaryotic Microbiology*, 1996-1999
Editorial Board, *Journal of Phycology*, 1995-1997

Other Society Service

Member, Organizing Committee, International Symposium on Harmful Algae, 2009-2010

Member, Organizing Committee, National Symposium on Harmful Algae, 2000, 2002, 2003
Member, Ethics Committee, American Society of Limnology and Oceanography, 1996-1997
Member, Harmful Algae Technical Advisory Committee, Maryland Department of Natural Resources, 1998-2001
Session Chair, Ecology of Aquatic Protozoa session, XIth Meeting, International Congress of Protozoology, 2001
Session Chair, New Harmful Algae, 10th International Conference on Harmful Algal Blooms, 2000
Session Chair, *Pfiesteria* in the Southeast, 1st National Symposium on Harmful Algae, 2000
Session Chair, Harmful Algae, 15th Biennial International Conference of the Estuarine Research Federation, 1999
Session Co-Chair, Harmful Algal Blooms, Annual Summer Meeting, American Society of Limnology and Oceanography, 1998
Session Co-Chair, Harmful Algal Blooms, Joint Meeting - American Society of Limnology and Oceanography and American Geophysical Union, 1997
Chair, Hutchinson Award Committee, American Society of Limnology and Oceanography, 1996
Board of Directors, American Society of Limnology and Oceanography, 1994-1997
Session Chair, Ecology of Freshwater Algae, Joint Meeting - International Phycological Congress and Phycological Society of America, 1991
Session Chair, Phytoplankton, Annual Meeting, American Society of Limnology and Oceanography, 1988

External Panels and Reviews

Member, panel review of the annual South Florida Environmental Report for the South Florida Water Management District, 2006-2011
Examiner ("Opponent") of doctoral candidate Johannes Hagstrőm, Kalmar University, 2006
Member, review team for the Department of Botany, Miami University of Ohio, 2005
Member, review team for the Marine Sciences Programs, Institut für Meereskunde, Salzau, Germany, 1998
National Science Foundation, Biological Oceanography Panel, 1995
UNC Water Resources Research Institute Panel, 1991-1993
Member, review team, Lake Okeechobee Ecosystem Project, South Florida Water Management District, 1991

Workshops (Invited Participant)

The Importance of Algal Mixotrophy in Trophic Models of the Oceans – participant and invited speaker of an international workshop sponsored by the Leverhume Foundation, University of Maryland - Horn Point, Cambridge, MD, 2013
Taxonomy and Ecology of Algae in the Southeast – co-organizer of a workshop for members of the North Carolina Lake Management Society (NALMS – Southeast Chapter), sponsored by NALMS, 2009, 2010, 2011, 2012
Falls Lake Symposium: Christian Creation Stewardship – keynote speaker of a workshop attended by scientists and theologians, to encourage church memberships to become involved in environmental stewardship of the Falls Lake potable water supply, sponsored by the concerned citizens group, Wake Up Wake County, and organized by Drs. Bob George (editor, Theoecology Journal online) and Bruce Little (Center for Faith and Culture, Southeastern Theological Seminary), 2012
Algae Affecting Potable Water Supplies – AWWA, Savannah, GA, 2010
Identifying Harmful Cyanobacteria in North Carolina Potable Water Supplies – Organizer; two workshops for potable water treatment plant operators, sponsored by the NC Department of Health and Human Services, 2006
Occurrence of Toxigenic Cyanobacteria in the USA, International Symposium on Harmful Cyanobacterial Blooms, US Environmental Protection Agency (EPA), 2005

National Plan for Harmful Algal Research, Ecological Society of America and the National Oceanic and Atmospheric Administration (NOAA), 2004

Social and Environmental Impacts of Concentrated Animal Feed Operations, The University of Iowa and the National Institute of Environmental Health Sciences (NIEHS), 2004

Conflicted Science / Integrity in Science Conference and Workshop, Center for Science in the Public Interest, Washington, DC, 2003

Estuarine Fish Disease, Delaware Department of Natural Resources & Environmental Control, 2000

Harmful Algae Technical Advisory Committee Workshop, Maryland Department of Natural Resources (MD DNR) and Maryland Department of Environment (MD DE), 2000, 2001, 2002

Re-evaluation of Microbial Water Quality: Powerful New Tools for Detection and Risk Assessment, American Academy of Microbiology, 2000

Conservation Medicine Workshop, Center for Conservation Medicine of Tufts University, 1999

Harmful Algal Blooms: Research and Monitoring Programs, US EPA - Region IV, 1998

Pfiesteria Workshops - Sampling and Identification (organizer), NCSU, 1998

Pfiesteria Sampling and Identification Protocols, Centers for Disease Control & Prevention, 1998

European Harmful Algal Blooms (EUROHAB) Science Initiative, Marine Science and Technology Programme of the European Commission, 1998

Pfiesteria and Water Quality Monitoring Standards Workshop, NOAA, 1998

Pfiesteria and Human Health Workshop, Maryland Department of Health and Mental Hygiene and the Maryland Medical Team, University of Maryland and Johns Hopkins, 1998

State/Federal *Pfiesteria* Working Group - Monitoring Protocols, U.S EPA and NOAA, 1998

Maryland Technical Advisory Committee Workshop on *Pfiesteria*, Fish Kills and Water Quality Monitoring, MD DNR, Baltimore, MD, 1998

Pfiesteria Workshop, 14th Biennial International Conference of the Estuarine Research Federation, Providence, RI, 1997

The Cambridge *Pfiesteria*/Nutrients Workshop, convened by Governor Glendening of Maryland, 1997. The final report, *The Cambridge Consensus,* was used by the governor and the Maryland legislature to change policy about non-point water pollution control in tributaries to Chesapeake Bay and led to passage of the Maryland Water Quality Act of 1998.

Impacts of Toxic *Pfiesteria*/*Pfiesteria*-like Dinoflagellates on Fisheries and Human Health, US EPA (Philadelphia, PA; Washington, DC; Pensacola, FL), 1997; Delaware Department of Environment and Water Resources, 1997

Harmful Algal Blooms and Human Health, NIEHS, 1997

Pocomoke River Fish Disease, MD DNR, 1997

Climate Variability and Human Health, American Society of Microbiology, 1997

Developing an Environmental Education Video on Water Resource Issues in North Carolina, Z. Smith Reynolds Foundation, 1997

Control of Blue-Green Algae in Rainbow Springs, Florida, Department of Fisheries and Aquaculture, University of Florida, 1996

Sustainable Marine Fisheries, National Academy of Sciences Ocean Studies Board, 1996

Disease Events and Meteorology along the US Atlantic Coast, Harvard Medical School, 1995

National Nutrient Assessment Workshop – Estuaries, US EPA, Washington, DC, 1995

Harmful Algal Blooms - Research Initiative Development, NSF / NOAA, 1994

Seagrasses and Eutrophication Impacts, US EPA / Sarasota Bay National Estuary Program, 1993

Techniques in Sampling and Identification of *Pfiesteria* – NOAA, 1992; Florida Department of Environmental Protection - Florida Marine Research Institute, 1992; MD DNR, 1993; MD DE, 1993; Delaware Division of Water Quality, 1993

Target Issues: Development of RFP guidelines for a New NOAA Coastal Ocean Program Initiative on Harmful Algal Blooms, NOAA, 1992

Phytoplankton of the Southeastern United States, North Carolina Department of Environment, Health and Natural Resources (NC DEHNR) and Duke Power Company, 1992
Target Issues for Funding Support of Research on Toxic Phytoplankton, NOAA, 1992
Improved Data Base and Optimal Approaches for Modeling Water Quality in the Albemarle-Pamlico Estuarine System, US EPA and NC DEHNR, 1992
Water Quality Regulations for Protection of Seagrass Habitat on the Gulf Coast, US EPA, 1992
Improved Standards for Protecting Water Quality in the Albemarle-Pamlico Estuarine System, US EPA, 1991
Teaching Aquatic Botany to High School Students (organizer), NCSU, 1987, 1988
Light Microscope-Autoradiography of Microalgae (organizer), Bowling Green State University, Bowling Green, OH, 1987

Research Presentations

Water Quality (Eutrophication, Seagrasses, etc.)

2015
Decadal Analysis of Water Quality in Falls Lake, the Triangle's Major Potable Water Source (Burkholder et al., presentation and published abstract). Annual conference of the UNC Water Resources Research Institute, Raleigh, NC.

2014
Long-Term Data Show Continued Water Quality Degradation in the Neuse Estuary, and Inadequate Protection by the Total Nitrogen TMDL (Burkholder et al., presentation and published abstract). Annual conference of the UNC Water Resources Research Institute, Raleigh, NC.
Why Bother? - Who Needs Models for Mixotrophs in Coastal Ecosystems? (invited presentation, Burkholder) Leverhulme Trust Phytoplankton Mixotrophy Workshop, Swansea, United Kingdom.
Unprecedented Toxin-Producing Cyanobacterial Blooms in the Cape Fear River (Mallin et al., presentation and published abstract), Summer Meeting of the Sciences of Limnology and Oceanography, San Diego, CA.

2013
Outside Peer Review of the Marine Programs of the UNC System for the UNC Board of Governors, Morehead City, NC - The NCSU CAAE was later given an excellent evaluation by the Panel in its final report.
Coastal and Estuarine Research Federation, San Diego, CA - Onset of unprecedented toxin-producing cyanobacteria blooms in the Cape Fear River system, North Carolina - Mallin MA., Burkholder JM, McIver MR, Metheny JD, Strangman WK, Zimba PV, Wright JL (presentation, with published abstract).
Coastal and Estuarine Research Federation, San Diego, CA - Comparative ecotoxicology of an agricultural herbicide on benign and toxigenic estuarine phytoplankton - Flood S, Burkholder J, Cope G. (poster, with published abstract).

2012
UNC Water Resources Research Institute, Raleigh, NC – The NCSU Center for Applied Aquatic Ecology Falls Lake Monitoring and Research Program - Burkholder J, Reed R, Kinder C, Allen E, James J, Mackenzie L (poster, with published abstract)
Falls Lake Creation Care Symposium, Wake Forest, NC - Status of Water Quality in Falls Lake - J. Burkholder. The goal of this national symposium was for scientists to inform theologians about citizens' potential roles, including church congregations, in assisting with natural resource stewardship issues (keynote presentation, with published abstract)

2011

UNC Water Resources Research Institute, Raleigh, NC (excessive ammonium concentrations throughout the Falls Lake water column, and implications for the Falls Lake Rules - with published abstract)

American Water Works Association National Webinar, online technology used to monitor algae and associated environmental conditions (invited, with published abstract)

LOICZ Open Science Conference 2011 – Coastal Systems, Global Change and Sustainability, Yantai, China (Shumway SE, Burkholder JM: mitigating coastal eutrophication – are filter-feeding shellfish the answer?) (plenary, with published abstract)

2010

UNC Water Resources Research Institute, Raleigh, NC (status of water quality in the most important potable water supply in North Carolina - with published abstract)

2009

National Shellfisheries Association, Savannah, GA (bivalve shellfish aquaculture and eutrophication)

North Carolina Academy of Science, Warren Wilson College, Swannanoa, NC (documenting microbial changes in reservoirs using metagenomics – coauthor)

Department of Civil and Environmental Engineering, Northwestern University, Chicago, IL (decadal analysis of land use, water quality, and phytoplankton assemblages in a coastal watershed)

20th Biennial Conference of the Coastal and Estuarine Research Federation (increasing ammonium in eutrophic estuaries, and its potential importance in governing phytoplankton assemblages)

2008

Department of Occupational and Environmental Health, U IA (water quality and algal blooms in watersheds influenced by industrialized agriculture)

NOAA National Symposium on Shellfish and the Environment, Warwick, RI (chronic effects of eutrophication on shellfish)

American Society of Limnology and Oceanography, St. Johns, Newfoundland, Canada (microdynamics of physical/chemical structure in a lagoonal estuary - lead, R. Reed; with published abstract)

North Carolina Water Quality Monitoring Forum, Charlotte (recent advances in technology for tracking algal blooms and related environmental conditions; with published abstract)

2007

Horn Point Environmental Laboratory, U MD (chronic eutrophication of the Neuse Estuary)

UNC Water Resources Research Institute, Raleigh (CAAE's Falls Lake Monitoring and Research Program; with published abstract)

UNC Water Resources Research Institute, Raleigh (groundwater and benthic nitrogen flux in the Neuse Estuary - lead, K. Null; poster with published abstract)

UNC Water Resources Research Institute, Raleigh (long-term impacts of changing land use practices on water quality and phytoplankton assemblages in the Neuse River ecosystem - lead, M. Rothenberger; poster with published abstract)

Annual Conference of the North Carolina Academy of Science, Greenville (inorganic nitrogen flux across the sediment-water interface in the Neuse Estuary - lead, K. Null; poster with published abstract).

Conference, Water Initiatives: What's on the Horizon for Lake Users and Managers, Greensboro.

19th Biennial Conference of the Estuarine Research Federation, Norfolk, VA (temporal and spatial variability in high-resolution, cross-estuarine physical/chemical structure in the Neuse Estuary – lead, R. Reed; poster with published abstract).

19th Biennial Conference of the Estuarine Research Federation, Norfolk, VA (multivariate analysis of phytoplankton and environmental factors in a eutrophic estuary - lead, M. Rothenberger; poster with published abstract).

2006

Department of Biology, Cornell University (water quality trends in the Neuse Estuary)
Department of Marine Sciences, U CONN (water quality trends in the Neuse Estuary)

2005
Department of Biology, UNC Greensboro (water quality trends in the Neuse Estuary)
Wilkes Community College, Wilkesboro, NC (honors seminar series - water quality issues)

2003
Center for Science in the Public Interest: Conflicted Science Conference, Washington, DC (water quality and confined animal feed operations [CAFOs] - with published abstract)
Yale University - Conference, The Chicken (environmental impacts of CAFOs - with published abstract)

2002
Medical School, Harvard University (marine diseases, anthropogenic influences)
Wilkes Community College, Wilkesboro (honors seminar series - water quality issues)

2001
Washington College (Chesterton, MD; environmental impacts of CAFOs)
Veterinary, Wildlife and Ecological Toxicology Department, Veterinary Biosciences College of Veterinary Medicine, U IL (national water quality issues)
School of Design, NCSU (environmental effects of CAFOs)
Wilkes Community College (honors seminar series - water quality issues)
American Society of Agronomy and the Soil Science Society of America (Northeast Branch) – annual meeting, URI (environmental effects of CAFOs; with published abstract)

2000
American Fisheries Society - annual meeting, St. Louis, MO (environmental effects of CAFOs – with published abstract).
American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America - joint meeting, Minneapolis, MN (nutrient management on CAFOs, and effects on surface water resources - with published abstract)
Association of Southeastern Biologists, Chattanooga, TN: Plenary Speaker (national water quality issues - with published abstract)
Rock Valley College - Natural Resources and Community Action Series, Rockford, IL: Plenary Speaker (national water quality issues)
U MASS, Amherst - Environmental Policy Seminar Series (invited; national water quality issues)
Yale University, School of Forestry (national and state water quality issues)
Department of Zoology, U WA - Seattle (national water quality issues)
American Fisheries Society (NC chapter), New Hill, NC (impacts of Hurricane Floyd on water quality in the Neuse River and Estuary, and Pamlico Sound - with published abstract)

1999
US Department of Agriculture - National Resources Conservation Service, Washington, DC (state water quality issues)
Simon Fraser University - Oceans Limited Conference, Vancouver, British Columbia, Canada (chronic effects of eutrophication - with published abstract)
Department of Biology, University of Louisville, Louisville, KY (chronic effects of eutrophication)

1998
Society of Environmental Toxicology and Chemistry - annual meeting, Charlotte, NC: Keynote Speaker (effects of chronic eutrophication - with published abstract)

1997
Conference, Nutrients in the Neuse River: Working Toward Solutions (sponsor, UNC Water Resources Research Institute [WRRI]), NCSU (effects of chronic eutrophication - with published abstract)

1996
National Association of Biology Teachers - annual meeting, Charlotte, NC (effects of chronic eutrophication - with published abstract)
Texas A&M University, Corpus Christi (effects of pulsed nutrient enrichment on seagrass physiology)
Department of Zoology, Oregon State University (OSU), Corvallis (seagrasses and eutrophication)

1995
Statewide Nutrient Summit (sponsors, NC Sea Grant, NC DEHNR), NCSU (effects of chronic eutrophication - with published abstract)
Water Quality Research and Extension Overview, College of Agriculture and Life Sciences (CALS), NCSU (surface water quality research in CALS - with published abstract)

1994
NC Academy of Sciences - annual meeting, Manteo - Keynote Speaker (state water quality issues - with published abstract)

1993
UNC WRRI Seminar Series, Keynote Accomplishments in Research on Water Resources in NC, Raleigh (seagrasses and water-column nitrate enrichment - with published abstract)
Horn Point Environmental Laboratory, U MD (seagrasses and water-column nitrate enrichment)

1992
UNC WRRI Seminar Series, Keynote Accomplishments in Research on Water Resources in NC (sediment and phosphorus loading: predicting reservoir water quality – with published abstract)
American Society of Limnology and Oceanography - annual meeting, Edmonton, Alberta, Canada (seagrasses and eutrophication - with published abstract)

1990
Department of Zoology, U WI - Madison (algal phototrophy *vs.* heterotrophy in turbid reservoirs)

1987
Department of Biology, Bowling Green State University, Bowling Green, OH (biological interactions that structure stream plant communities)

1986 (nutrient interactions - macrophytes, epiphytes)
Department of Botany, NCSU
Department of Biology, Fordham University, Bronx, NY
Savannah River Ecology Laboratory, Aiken, SC
University of Michigan Biological Station, University of Michigan, Pellston, MI

1985
Department of Biology, West Virginia University, Morgantown, WV - importance of benthic microalgae in stream ecosystems
Massachusetts Audubon Society, Lincoln, MA - effects of acid deposition on aquatic ecosystems

Harmful Algal Research

2013
Leverhume Foundation International Workshop, U MD - Horn Point, Cambridge, MD (algal mixotrophy

and water-column nutrients)

2010

North American Lake Management Society (NALMS), Winston-Salem, NC (climate change and harmful algal blooms in the Southeast - with published abstract)

Webinar Lecture Series, Northwestern University, given at the University of British Columbia, Vancouver, BC, Canada (overview on harmful algae)

2008

Burdick Lecture, Department of Biology, Alfred University, Alfred, NY (*Pfiesteria*, other harmful dinoflagellates - toxicity, impacts)

Annual Toxicology and Risk Assessment Conference, Cincinnati, OH (the toxins of inland algae - with published abstract)

2007

Joint meeting of the Phycological Society of America and the International Society of Protozoologists (cyanobacteria in eutrophic turbid impoundments of the North Carolina Piedmont - lead, J. Burkholder; poster with published abstract)

Joint meeting of the Phycological Society of America and the International Society of Protozoologists (axenic cultivation of a heterotrophic dinoflagellate - lead, H. Skelton; with published abstract)

4th National Symposium on Harmful Algae, Woods Hole, MA (axenic cultivation of *Pfiesteria shumwayae* on a semi-defined medium; poster with published abstract)

2006

Kalmar University, Kalmar, Sweden (*Pfiesteria*, other harmful dinoflagellates - toxicity, impacts)

American Society of Limnology and Oceanography - annual summer meeting: Plenary Speaker, Victoria, British Columbia, Canada (stimulation of harmful algae by eutrophication – with published abstract)

2005

North American Lake Management Society (NALMS) - National Meeting, U WI - Madison – Keynote Speaker (cyanobacteria in potable water supplies - with published abstract)

GEOHAB (Global Ecology and Oceanography of Harmful Algal Blooms) Symposium, Nutritional Ecology of Harmful Algae, Baltimore, MD (importance of intraspecific variation – with published abstract)

Medical School, Harvard University (harmful algae and seafood safety)

NALMS Southeast Chapter Meeting, Asheville, NC (cyanobacteria in potable water supplies - with published abstract)

American Water Works Association - Source Water Protection Symposium, West Palm Beach, FL (cyanobacteria in potable water supplies - with published abstract)

2004

XIth International Conference on Harmful Algae, Cape Town, South Africa: Plenary Speaker (intraspecific variation in toxicity, behavior and nutrition - with published abstract)

St. Johns Water Management District, Orlando, FL (effects of harmful algae on fish and mammalian health)

International EnviroVet Program, Harbor Branch Oceanographic Institute, Fort Pierce, FL (marine diseases)

Department of Oceanography, U WA - Seattle (science, policy)

Shannon Point Marine Laboratory, Western Washington University (science, policy)

NSF Undergraduate Education Honors Program, NCSU (science, policy)

2003

Elon University - Voices of Discovery Seminar Series: Keynote Speaker (*Pfiesteria*)

International EnviroVet Program, Harbor Branch Oceanographic Institute (toxic dinoflagellates)

Florida Institute of Technology (toxic dinoflagellates)
Conference on Emerging Waterborne Pathogens, NC Department of Health and Human Services (DHHS), Wilmington, NC: Two presentations - toxic dinoflagellates; toxic cyanobacteria)

2002

Hopkins Marine Laboratory, Stanford University, Monterey, CA (*Pfiesteria*, other toxic dinoflagellates - science, policy, science ethics)
National Ocean Service, NOAA, Charleston, SC (progress in *Pfiesteria* research)
Symposium, Climate Change and Fisheries in the Gulf of Maine (sponsor, NOAA), College of the Atlantic, Bar Harbor, ME (harmful algae and climate change)
Department of Biology, UNH, Durham (toxic dinoflagellates).
Department of Biology, Williams College, Williamston, MA (toxic dinoflagellates)
Department of Biology, Miami University of Ohio, Athens (toxic dinoflagellates)

2001

XIth International Congress of Protozoology, Salzburg, Austria (dinoflagellates - complex life histories and feeding behaviors – with published abstract)
George Clark Lecture Series, Wetlands Institute, Cape May, NJ (*Pfiesteria*, other dinoflagellates)
Society for Risk Analysis, Research Triangle Park (biomarkers for species and toxins)
Environmental Lecture Series, Ashland University, Ashland, OH (harmful algae and eutrophication)
Marine Conservation Biology Series, Wheaton College, Springfield, MA (chronic effects of harmful algae on fish and mammalian health)

2000

IXth International Conference on Harmful Algal Blooms, Hobart, Tasmania, Australia: Plenary Speaker (toxic *Pfiesteria* - with published abstract)
Elliott-Nowell-White Symposium, Delta State University, Delta State, MS: Keynote Speaker (chronic and sublethal impacts of harmful algae on mammalian health)
Society of Toxicology of Canada - annual meeting, Montreal, Quebec, Canada (toxic dinoflagellates - with published abstract)
Department of Biology, State University of NY - Syracuse (toxic dinoflagellates)
Brookhaven National Laboratory, Brookhaven, NY (toxic dinoflagellates)
State University of New York - Stony Brook (toxic dinoflagellates)
XIIIth World Congress of the International Society of Toxinology, Paris, France (toxic *Pfiesteria*)
Centers for Disease Control & Prevention, Atlanta - conference, ***Pfiesteria*: From Biology to Public Health** (ecology and conservative analysis of role in fish kills - with published abstract)
National Association of Biology Teachers - Biotechnology Conference. VPI, Blacksburg (harmful algal research)
University of Mississippi, Oxford - Conference, Sustainability of Wetlands and Water Resources (toxic dinoflagellates)
Department of Biology, University of Memphis (toxic dinoflagellates)
Society of Microbiology - Northeast Chapter, Sturbridge, MA (toxic dinoflagellates)
Society of Toxicology - annual meeting (sponsor, US EPA), Philadelphia (toxic dinoflagellates - with published abstract)
Southeastern Estuarine Research Society - annual meeting in conjunction with the 29th Benthic Ecology Meeting and the annual meeting of the Atlantic Estuarine Research Society, Wilmington, NC (toxic dinoflagellates - with published abstract)

1999

National Academy of Sciences - Workshop on Critical Research Needs, Washington, DC (research needs to advance understanding about harmful algae)

Lake Biwa Research Institute, Forum on Water Quality, Kyoto, Japan: Keynote Speaker (*Pfiesteria*, other toxic dinoflagellates)
Woods Hole Oceanographic Institute, Falmouth, MA (toxic dinoflagellates)
Veterinary School, Tufts University, Grifton, MA (toxic dinoflagellates)
Department of Biology, Yale University (improved mitigation of harmful algal blooms)
Georgetown Conference on Policy and *Pfiesteria*, Georgetown University, Washington, DC: Keynote Speaker (science, policy of *Pfiesteria* - with published abstract)
American Association for the Advancement of Science (AAAS) - annual meeting, Anaheim, CA, session, "Human Health Risks in the Ocean" (chronic and sublethal impacts - with published abstract)
AAAS - annual meeting, Anaheim, CA, session "Harmful Algal Blooms" (toxic *Pfiesteria* - with published abstract)
Department of Geology, University of Oslo (Oslo, Norway) (toxic *Pfiesteria*)
Society of Protozoologists - annual meeting, Raleigh: Keynote Speaker (toxic *Pfiesteria* - with published abstract)
Department of Ecology Evolution and Behavior, U MN - Minneapolis (toxic dinoflagellates - with published abstract)
Phi Beta Kappa Seminar Series, Elon University (toxic *Pfiesteria*)
Honors Seminar Series, Southampton College, Southampton, NY (toxic dinoflagellates)
Department of Biology, Barton College, Wilson (toxic dinoflagellates)
Department of Biology, Davidson College, Davidson (toxic dinoflagellates)
Wilkes Community College, Wilkesboro (toxic dinoflagellates)
Department of Biology, NC A&T University, Greensboro (toxic dinoflagellates)
Department of Pathology, UNC Chapel Hill (toxic dinoflagellates)
Department of Biology, UNC Greensboro (toxic dinoflagellates)
Department of Biology, University of Louisville (toxic dinoflagellates)
Sigma Xi - NC Chapter meeting, Appalachian State University, Boone, NC (toxic *Pfiesteria*)

1998
AAAS - annual meeting, Philadelphia, session, "Management of Harmful Marine Microbes: When Science and Politics Don't Mix" (harmful algae - with published abstract)
Medical School, Harvard University (harmful algae)
Shallow Water Conference (sponsor, US EPA), Atlantic City, NJ: Keynote Speaker (effects of toxic *Pfiesteria* on fish and mammals - with published abstract)
Gordon Conference - annual meeting, Ventura, CA (acute/chronic effects of toxic dinoflagellates - with published abstract)
Department of Biology, Rutgers University (chronic effects of toxic dinoflagellates)
Department of Biology, URI (toxic dinoflagellates)
Department of Pharmacology, U GA - Athens (toxic dinoflagellates)
American Biological Safety Association - 41st Annual Biological Safety Conference, Lake Buena Vista, FL: Eagleston Lecture (*Pfiesteria*, other toxic dinoflagellates - with published abstract)
Wildlife Disease Association - 47th Annual Conference, U WI - Madison (toxic *Pfiesteria* - with published abstract)
Department of Biology, Purdue University (toxic dinoflagellates)
American Institute of Biological Sciences - 49th annual meeting (toxic dinoflagellates - with published abstract)
Microbiology Society of NC - annual meeting, Research Triangle Park: Keynote Speaker (*Pfiesteria*, other toxic dinoflagellates)
NC Water Resources Association - Conference on Water Pollution Issues in NC, Asheville: Keynote Speaker (*Pfiesteria*, other toxic dinoflagellates - with published abstract)
Northeast Algal Symposium - annual meeting, Plymouth, MA – Keynote Speaker (toxic *Pfiesteria* - with

published abstract)
American Society of Limnology and Oceanography - joint summer meeting with the Ecological Society of America, Symposium Session Honoring Minority Students: Keynote Speaker (*Pfiesteria*, other harmful algae – with published abstract)
Stanford University, Institute of Ecosystem Ecology (toxic *Pfiesteria*)
NASA, Goddard Space Center, Baltimore, MD (*Pfiesteria*, other toxic dinoflagellates)
Keynote Seminar Series in Marine Sciences, Wilmington, DE (sponsors, U DE, DE Sea Grant): Presentation (*Pfiesteria*)
Friends of the Library, NCSU (*Pfiesteria*, other toxic dinoflagellates)
Department of Biology, Auburn University (toxic dinoflagellates)
Department of Environmental Sciences, Drexel University, Philadelphia (toxic *Pfiesteria*)
Department of Biology, Hampden Sydney College, Hampden-Sydney, VA (toxic dinoflagellates)
Department of Biology, UNC Charlotte (*Pfiesteria*, other toxic dinoflagellates)
Headquarters, US EPA, Washington, DC (toxic *Pfiesteria*)
Distinguished Lecturer Series, Old Dominion University, Norfolk, VA (*Pfiesteria*)

1997
Society for Conservation Biology - annual meeting, Victoria, British Columbia, Canada (harmful algae and eutrophication - with published abstract)
Department of Biology, University at Buffalo, Buffalo, NY (*Pfiesteria*, other toxic dinoflagellates)
Departments of Zoology and Oceanography, OSU (toxic algae)
3rd Annual Conference on Population-Level Effects of Marine and Estuarine Contamination, Charleston, SC (science, policy - with published abstract)
Wagner College, Staten Island, NY (special college-wide seminar, toxic *Pfiesteria*)
Department of Biological Science, Florida State University, Tallahassee (toxic dinoflagellates)
Department of Botany, Duke University (*Pfiesteria*, other toxic dinoflagellates)
Conference on Fisheries, Habitat and Pollution (sponsors, SC Sea Grant, TerrAqua Environmental Science and Policy Institute), Charleston, SC (chronic and sublethal effects of harmful algae - with published abstract)
Institute of Ecosystem Studies, Millbrook, NY (chronic and sublethal effects)
American Fisheries Society, NC Chapter - annual meeting, Lake Wylie, SC (*Pfiesteria* - with published abstract)

1996
AAAS - annual meeting, session Global Change and Emerging Infectious Diseases (effects of harmful algae on fish and mammalian health - with published abstract)
NATO Workshop, Physiological Ecology of Harmful Marine Phytoplankton, Bermuda Biological Station for Research (raptorial dinoflagellates - with published abstract)
Sigma Xi - UNC Greensboro and NCCU Chapters: Keynote Speaker (toxic *Pfiesteria*)
Department of Biology, Southampton College, Long Island University, Southampton, NY (toxic dinoflagellates)
Department of Biology, University of Cincinnati, Cincinnati (toxic dinoflagellates)
NIEHS, Research Triangle Park (toxic *Pfiesteria*)
Whitney Laboratory, U FL - St. Augustine (toxic dinoflagellates)
Department of Biology, Wake Forest University, Winston-Salem (toxic dinoflagellates)
Association of Women in Science, UNC Chapel Hill (*Pfiesteria*, other toxic dinoflagellates)
Texas A & M University, Corpus Christi, TX (*Pfiesteria*, other toxic dinoflagellates)

1995
Society of Protozoologists - annual meeting, U AL, Tuscaloosa, AL: Keynote Speaker (toxic *Pfiesteria* and its microbial, macroinvertebrate and vertebrate prey - with published abstract)
5th Pan American Symposium on Animal, Plant and Microbial Toxins, Baltimore, MD (*Pfiesteria* - with published abstract)

Department of Toxicology, NCSU (toxic dinoflagellates)
Department of Biology, U MD, Baltimore, MD (toxic *Pfiesteria*)

1994
First International Conference on Ecosystem Health and Medicine, Ottawa, Ontario, Canada (effects on human health - with published abstract)
E-MAP Monitoring Program, US EPA, Research Triangle Park (emerging toxic algae - effects on fisheries and public health)
Department of Biology, University of Richmond (emerging toxic algae)
Department of Environmental Health, Boston University (toxic dinoflagellates)
Department of Biology, SUNY - Stony Brook (toxic dinoflagellates)
International Society for Evolutionary Protistology - Biennial Meeting, Halifax, Nova Scotia, Canada: Keynote Speaker (*Pfiesteria* and its prey - with published abstract)
Institute of Ecology, U GA - Athens (harmful heterotrophic dinoflagellates)
Department of Fisheries and Aquaculture, U FL - Gainesville (toxic dinoflagellates)

1993
Fifth International Conference on Modern and Fossil Dinoflagellates (Zeist, the Netherlands): Keynote Speaker (toxic *Pfiesteria* - with published abstract)
Beta Beta Beta Biological Honors Society, Elon University: Keynote Speaker (effects of toxic *Pfiesteria* on estuarine food webs)
Chesapeake Biological Laboratory, Solomons, MD (toxic dinoflagellates)
Southeastern Fisheries Society, Reidsville, NC (toxic dinoflagellates and fish health)
Dauphin Island Marine Laboratory, Dauphin Island, AL (toxic dinoflagellates)
Department of MEAS, NCSU (*Pfiesteria*)

1992
Vth International Symposium on Toxic Algae, Newport, RI (toxic *Pfiesteria* - with published abstract)
Southeast Regional Directors of the Sea Grant College Program - annual meeting: Keynote Speaker (*Pfiesteria*)
Department of Zoology, NCSU (toxic *Pfiesteria*)
US Geological Survey, Raleigh (toxic *Pfiesteria*)
NC Statewide Phytoplankton Meeting, Duke Power Company (Huntersville, NC: Keynote Speaker)
Department of Biology, UNC Wilmington (*Pfiesteria*, other toxic dinoflagellates)
Department of Biology, Appalachian State University, Boone, NC (toxic dinoflagellates)
Department of Biology, UNC Greensboro (toxic dinoflagellates)
US EPA, Narragansett, RI (*Pfiesteria*, other toxic dinoflagellates)
Department of Biology - Marine Sciences Group, UNC Chapel Hill (toxic dinoflagellates)
Bodega Marine Laboratory, U CA - Davis, Bodega Bay (toxic dinoflagellates)

Other Algae

2012
Phycological Society of America, Charleston, SC (Mixson, S. and J. Burkholder - enhancing lipid production in the marine microalga *Dunaliella* through environmental stressors - with published abstract)

2010
Webinar, Northwestern University special summer course for graduate students, given at the University of British Columbia, Vancouver, BC (the ecology of periphyton)

2007
Society of International Limnologists (SIL) - 30th Congress of the International Association of Theoretical

and Applied Limnology, Montreal, Quebec, Canada (importance of benthic microalgae across freshwater, estuarine and marine ecosystems - with published abstract)

1999

Society for General Microbiology - Symposium, Microbial Signaling and Communication, University of Edinburgh, Edinburgh, Scotland (signaling in dinoflagellates - with published abstract)

1991

Department of Biology, VPI, Blacksburg, VA (phytoplankton survival of pulsed suspended sediment loading)

1990

Center for Reservoir Research, Hancock Biological Station, Murray State University, Paducah, KY (phytoplankton and periphyton dynamics in turbid, eutrophic reservoirs)

Department of Zoology, NCSU - Aquatic Ecology Seminar Series (mutualistic symbioses involving algae)

Department of MEAS, NCSU (role of benthic microalgae in eutrophication of freshwater and coastal marine habitats)

1989

Experimental Lakes Area (ELA), University of Manitoba, Winnepeg, Manitoba, Canada (relative importance of the water column and macrophytes as nutrient sources for epiphytes)

Hampton University, Hampton, VA (biotechnology in aquatic ecology)

Department of Biology, University of Louisville, Louisville, KY (use of autoradiography to examine nutrient dynamics of microalgal biofilms)

Duke Marine Laboratory, Beaufort (nutrients and epiphytes – unifying trends in freshwater and marine ecosystems)

1988

Department of Biology, UNC Chapel Hill - Marine Macroalgae Seminar Series (epiphytes)

Department of Biology, East Carolina University (phosphorus sources for epiphytic microalgae)

Department of Botany, Duke University (nutrient sources for epiphytic microalgae)

Environmental Section, Carolina Power and Light Company, New Hill, NC (epiphytic microalgae - role in nutrient cycling of lakes)

Science Ethics and Environmental Issues

2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014

Park Scholars Program, NCSU (role of science ethics in environmental issues)

2005

Department of Epidemiology, UNC Chapel Hill, Forum "Funding, Academic Freedom, and Public Responsibility" (industry and water quality)

2004

Department of Biology, Cornell University (toxic algae)

Department of Civil Engineering, NCSU (water quality)

Department of Biology, UNC Asheville (water quality)

2003

New York Metropolitan Association of College and University Biologists – 36th Annual Conference, Wagner College, Staten Island: Keynote address (role of science ethics in natural resource issues)

NSF Environmental Education Program, NCSU (toxic algae, water quality)

1999

Department of Geology, University of Oslo, Oslo, Norway (toxic algae, water quality)

Park Foundation Lecture Series, College of Journalism, UNC Chapel Hill (critical role of journalists in

environmental science education and ethics)

1998

Metcalf Institute for Marine and Environmental Journalism - annual board meeting, URI: Keynote Speaker (how environmental journalists can help to strengthen science ethics)

Academic Contributions

Courses Taught

- PB 595A, *Aquatic Plant Ecology* (4 credits; 1987 - present, fall alternate years)
- PB 595W, *Environmental Issues in Aquatic Ecology* (3 credits, 1990 - present, usually fall alternate years) - special topics/current events graduate course
- PB/MB 774, *Phycology* (3 credits including laboratories; 1987 - present, spring alternate years)
- BO 595E, *Ecology, Evolution and Diversity* – (2003; course coordinator, Jon Stuckey); mini-course: designed and taught one of eight modules on aquatic vascular plants as bioinvaders
- PB 824C, *Plant Biology Colloquium* (1 credit) – co-taught with Nina Allen (spring 2002, 2004, 2006) or Bill Thompson (spring 2009, 2011, 2013); graduate students receive training to give presentations, write grant proposals, and critique grant proposals)
- HON 398, *Honors Seminar on Aquatic Ecology* (1 credit, spring 2008) – seminar/discussion course for undergraduate honors students on aquatic natural resource issues in North Carolina
- EMS 496/622/822 or TDE 490/610 – STEM Education Seminar Course, *Environmental Issues in Estuarine Ecology and Pedagogical Applications* (1 credit, spring 2010), co-taught with P. Simmons and A. Clark.

Guest Lectures (examples, past five years)

- PB 101, *Introduction to Plant Biology*, Department of Plant Biology, NCSU (once per year, 2006-2011)
- PB 250, *Plant Biology*, Department of Plant Biology, NCSU (2010, 2011)
- *Park Scholars*, NCSU (once per year, 2006-2011)
- Freshman Focus Program, "Science, Society, Uncertainty, and Conflicting Values" (Duke University, Durham, NC, 2010)

Major or Co-major Advisor of Graduate Students

Stacie Flood, Ph.D. (Plant and Microbial Biology, in progress, expected spring 2015)

Stephanie Mixson, Ph.D. (Plant & Microbial Biology [department name change] - 2013)
Thesis: *Dunaliella* spp. under environmental stress: Enhancing lipid production and optimizing harvest
Honor: Secured a grant to help support her dissertation research, from the Charles A. and Anne Morrow Lindbergh Foundation (2010)
Post-Graduate Position: Analytical Development Specialist, Medicago USA, Research Triangle Park (2013)

Eva Ngulo, M.A. (Plant Biology, 2011)
Final paper: Influence of clay treatment on noxious planktonic cyanobacteria

Kimberly Null, Ph.D. (MEAS; co-advisor with Dr. Dave DeMaster), 2010
Thesis: Ammonium dynamics in a shallow lagoonal estuary

Honors: Secured two grants to help support her dissertation research, from the NC Academy of Science (2006) and the Geological Society of America (2006)
Post-Graduate Positions: Post-Doctoral Research Associate, University of California - Santa Cruz, then Post-Doctoral Research Associate, East Carolina University - Greenville, NC (research in Antarctica)

Hayley Skelton, Ph.D. (MEAS; co-advisor, Dr. Dan Kamykowski), 2008
Thesis: Nutritional features and feeding behavior of the heterotrophic dinoflagellate, *Pfiesteria shumwayae*
Honor: Won the Theodore L. Jahn and Eugene C. Bovee Award for best graduate student research paper, annual meeting of the International Society of Protozoologists, Providence, RI (2007)
Post-Graduate Positions: Post-Doctoral Fellow, National Research Council, NOAA / University of Connecticut (2008), then Supervisor of Algal Culturing, Algenol Biofuels, Fort Myers, FL (2009)

Meghan Rothenberger, Ph.D. (Plant Biology), 2007
Thesis: Long-term impacts of changing land use practices on water quality and phytoplankton assemblages in the Neuse Estuary ecosystem, North Carolina
Honors: Won best graduate research presentation, Graduate Student Forum, Department of Plant Biology (2007)
Won best Ph.D. dissertation of the year (2007) at NCSU, from the NCSU Graduate School (2008)
Post-Graduate Positions: Post-Doctoral Associate, CAAE (Visiting Professor, UNC Greensboro; then assistant professor at Lafayette College, Easton, PA)

Susan Pate, M.Sc. (Botany), 2006
Thesis: Impacts of the toxic dinoflagellate *Alexandrium monilatum* on three ecologically important shellfish species
Post-Graduate Position: Laboratory Administrator (Biotechnology), Duke University

Matthew Parrow, Ph.D. (Botany), 2003
Thesis: Feeding, reproduction, and sexuality in *Pfiesteria* spp. and cryptoperidiniopsoid estuarine heterotrophic dinoflagellates
Honor: Won the Kellar Award for outstanding dissertation research (NCSU), 2004
Post-Graduate Positions: Post-Doctoral Associate, CAAE (now Assistant Professor, UNC Charlotte)

Paul Cancellieri, M.Sc. (Botany), 2001
Thesis: Chemosensory attraction of *Pfiesteria* spp. to fish secreta
Post-Graduate Position: Teacher, Durant Middle School, Raleigh

Howard Glasgow, Ph.D. (MEAS; co-advisor; main advisor, Dr. Dan Kamykowski), 2000
Thesis: Biology and impacts of toxic *Pfiesteria* complex species
Post-Graduate Position: Researcher, CAAE (permanently disabled by a neurological illness)

Jeffrey Springer, M.Sc. (MEAS; co-advisor, Dr. Dave Eggleston), 2000
Thesis: Interactions between two commercially important species of bivalve molluscs and the toxic estuarine dinoflagellate, *Pfiesteria piscicida*
Honor: Won the Best Student Presentation Award at the Annual Meeting of the National Shellfish Association, Seattle, WA, 2002
Post-Graduate Position: Research Associate, CAAE

Naomi Tsurumi, M.A. (Botany), 2000 Thesis: Influence of Industrialized Swine Agriculture on Air Quality
Post-Graduate Position: Environmental Policy M.A. program, Duke University

Brant Touchette, Ph.D. (Botany), 1999

Thesis: Physiological and developmental responses of eelgrass (*Zostera marina* L.) to increases in water-column nitrate and temperature
Post-Graduate Position: Assistant Professor, Elon University (now associate professor)

Elizabeth Fensin, M.Sc. (Botany), 1997
Thesis: Population dynamics of *Pfiesteria*-like dinoflagellates, and environmental controls in the mesohaline Neuse Estuary, North Carolina, USA
Post-Graduate Position: Research Assistant, North Carolina Department of Environment and Natural Resources (then called the NC Department of Environment, Health, and Natural Resources)

L. Michael Larsen, Ph.D. (Zoology; co-advisor with Dr. Sam Mosley), 1995
Thesis: Responses of *Diaphanosoma brachyurum* (Cladocera: Suicide) and other zooplankton to clay loading and algal food quality in a turbid southeastern reservoir.
Post-Graduate Position: Assistant Professor, Campbell University, Fayetteville, NC (now Professor and Department Chair, Biology)

Leslie (Taylor) Taggett, M.Sc. (Botany), 1995
Thesis: Nitrate reductase activity of two intertidal macroalgae across gradients of temperature, salinity and desiccation
Post-Graduate Position: Research Assistant – Analytical Chemistry Laboratory, NC DEHNR

Virginia Coleman, M.Sc. (Botany), 1993
Thesis: Community structure and productivity of epiphytic microalgae on eelgrass (*Zostera marina* L.) under water-column nitrate enrichment
Post-Graduate Position: Research Associate – Algal Laboratory, NC Department of Environment and Natural Resources

Phumelele Gama, M.S. (Botany), 1992
Thesis: Phytoplankton response to a sediment loading gradient in a mesotrophic reservoir
Post-Graduate Position: Lecturer of Botany, University of Zululand, South Africa

Deborah Everitt (Tan), M.S. (Botany), 1992
Thesis: Seasonal dynamics of macrophyte communities from a stream flowing over granite flatrock in North Carolina, USA
Post-Graduate Position: Stream Scientist, MD Department of Natural Resources

Other Graduate Student Committee Memberships

Ph.D.

Stephanie Archer, Applied Ecology
Yini Shangguan, U MD (Center for Environmental Science)
Brett Hartis, Fisheries, Wildlife and Conservation Biology
Geoff Sinclair, MEAS
Diane Whitaker, Science Education
Katherine Galucci, Science Education
Daniel Dickerson, Science Education
Nancy White, Forestry
Louis Elsing, Forestry
Dennis Hazel, Forestry
Gary Kirkpatrick, Zoology
Francois Bergand, Biological and Agricultural Engineering
Leslie Dorworth, MEAS
Thomas Shahady, Zoology

Randall Jackson, Zoology
Elise Irwin, Zoology
Kimberly Jones, Chemistry (UNC Wilmington)
George Hess, Biomathematics
Ann Darrien, Zoology
Elizabeth Marschall, Zoology

M.Sc. Susan Randolph, Science Education
John Grady, Plant Biology
Carolyn Foley, Botany
Chad Coley, Soil Science
Angela Poovey, Crop and Soil Science
Scott Thomas, Biological and Agricultural Engineering
Kristin Toffer, Biology, UNC Greensboro
Beth Buffington, Crop and Soil Science
Edward Walycz, MEAS
Lisa Hartley, Botany
Robert Clark, Zoology
Beth Walker, Zoology
Rose Ragnacci, MEAS
Karen Kracko, Zoology

Postdoctoral Associate Advisor

Meghan Rothenberger, 2007: Present position, Assistant Professor, Lafayette College
Matthew Parrow, 2004-2006: Present position, Assistant Professor, UNC Charlotte
Brant Touchette, 2000-2002: Present position, Associate Professor, Elon University
Cheng Zhang, 1999-2003: Present position, Research Scientist, North Carolina Department of Environment and Natural Resources

Visiting Fulbright Scholar

Allasanne Ouattara, Ivory Coast, 2008-2009: Professor from the University of Abobo-Adjamé

Activities in Other Academic Programs

Kenan Fellows Program (for gifted K-12 teachers)

Mentor to Amanda Warren
Mentor to Susan Randolph
Mentor to Diane Whittaker
Secondary mentor to Gayle Powell
Panelist on selection committee for Kenan Fellows

Other NC State Service

Member, Big Ideas Committee (college)
Member, William Neal Reynolds Distinguished Professor Selection Committee (college)
Member, College of Agriculture and Life Sciences Research Committee (college)
Member, Advisory Committee, Applied Ecology (departmental)
Member, Advisory Committee, Plant Biology (departmental)
Chair, Plant Biology Post-Tenure Evaluation Committee (departmental)
Member, Selection Committee for Evolutionary Ecologist Position (departmental)

Member, Larry A. Whitford Botany Scholarship/Fellowship Award Committee (departmental)
Member, Plant Biology Mentoring Committee for Alexander Krings (departmental)
Member, Plant Biology Mentoring Committee for Bill Hoffmann (departmental)
Member, Plant Biology Undergraduate Curriculum Committee (departmental)
Member, Search Committee, Plant Biology - Evolutionary Ecologist (departmental)
Member, Water Quality Committee (university)
Member, Water Resources Curriculum Committee (university)
Member, Ad Hoc Committee on Marine Science (university)
Member, Advisory Committee for the NCSU publication, *Results: Research and Innovation at North Carolina State University* (university)

Education Outreach (examples, past ~five years)

K-12 Students and Teachers

The CAAE's *Floating Classroom Program* aboard our research/education ship, *RV Humphries*: Provided hands-on education in aquatic science (1/2-day cruise on the Neuse Estuary for 278 8th graders and their teachers (2014), 345 9th graders and their teachers (2013), 360 9th graders and their teachers (2012), and 480 9th graders and their teachers (2011) from Wayne County schools in economically depressed areas
Guilford Co. high school teachers' training – presentation to ~30 teachers on designing experiments, 2011
Cardinal Gibbons High School, Cary, NC – presentation to ~80 students on water quality issues nationally and in our State (senior-level courses, *Ecology* and *Environmental Issue*s), 2010

General Citizenry

Good Shepherd United Church of Christ, Cary, NC, March 2015 (Anne Mackie)
Status of Drinking Water Quality and Protection in North Carolina (League of Women Voters), 2014
Forum on Status of the Neuse Estuary and Industrialized Swine Production (presentation to Coastal River Watch), 2013
Water Quality in High Rock Lake (presentation to the Yadkin Riverkeeper Foundation), 2013
Status of Water Quality in Falls Lake (presentation to the concerned citizens group, Wake Up Wake County), 2010

Other Service - Member, City of Raleigh Stormwater Commission, 2010-present

Society Memberships - AAAS, Association for the Sciences of Limnology and Oceanography, Estuarine Research Federation, Society of International Limnologists, North American Lake Management Society, Phi Kappa Phi, Phycological Society of America, Sigma Xi