BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
Petition of Emerald Polymer	)	
	)	AS 19-002
Additives, LLC for an Adjusted	)	
	)	(Adjusted Standard)
Standard from 35 Ill. Adm. Code	)	
	)	
304.122(b)	)	

WRITTEN EXPERT TESTIMONY T. HOUSTON FLIPPIN

I. INTRODUCTION

1. This Expert Written Testimony is submitted to the Illinois Pollution Control Board (Board) in the matter captioned as *In the Matter of: Petition of Emerald Polymer Additives, LLC for an Adjusted Standard from 35 Ill. Adm. Code 122(b)*, AS 19-002, and in accordance with the Hearing Officer's order dated November 25, 2019.

II. QUALIFICATIONS AND EXPERIENCE

2. My name is Thomas Houston Flippin. I am an Executive Engineer in the Industrial Water practice of Brown and Caldwell.

3. I was retained by B.F. Goodrich Company in September 1988 to provide wastewater treatment consulting services and have continued to provide such services at the chemical manufacturing facility located at 1550 County Road 1450 N., in Henry, Illinois (Henry Plant or Emerald Plant) for the last 31 years. During this entire time period, I have served as lead engineer on all Henry Plant matters in which my firm, Brown and Caldwell, has been involved, first for B.F. Goodrich Company and then for its successors-in-interest, including Noveon, Inc. and Emerald Polymer Additives, LLC (Emerald).

4. I received two degrees from Vanderbilt University. I received my Bachelor of Engineering Degree in Civil Engineering in 1982 and my Master of Science Degree in Environmental and Water Resources Engineering in 1984.

5. I immediately went to work for AWARE Incorporated in 1984 and have remained with the same company for the last 35 years in progressively more responsible positions (beginning as a project engineer and eventually being named Executive Engineer) in the area of wastewater engineering. A copy of my resume providing more details on my experience has been marked as Petitioner's Hearing Exhibit 10. My firm has changed names twice. In 1989, we renamed ourselves Eckenfelder Incorporated. In 1998, we were acquired by Brown and Caldwell.

6. During my career, I have personally conducted treatment (treatability) testing of industrial wastewaters and contaminated groundwaters and developed treatment process design criteria from test data. I have provided troubleshooting or optimization services for wastewater treatment facilities (WWTFs), conducted waste minimization studies and developed cost savings for treatment plants. I have also overseen the work described above, designed wastewater and contaminated groundwater treatment processes, assisted in effluent permit negotiations, supported expert testimony preparation and trained treatment plant operators in process operations and troubleshooting.

7. I am a licensed professional engineer in sixteen states, including Illinois. I am also a Board Certified Environmental Engineer with the American Academy of Environmental Engineers.

8. I have published several technical papers, of which more than 10 are directly related to the Henry Plant's issues. My publications are listed on pages 5-7 of my resume. I

have also served as a presenter at numerous conferences, including, most recently, at the 92nd Annual Water Environment Foundation Technical Exhibition and Conference (WEFTEC) in September 2019.

III. EXPERIENCE SPECIFICALLY RELATED TO AMMONIA REDUCTION

9. I have developed the process design for the following biological nitrification facilities. Each of these are operational today and have been historically in compliance with their permits.

- American Cyanamid Superfund Site, Bridgewater, NJ
- BASF (formerly Ciba-Geigy), McIntosh, AL
- Gulf Coast Waste Disposal Authority, Pasadena, TX
- Phillips 66 (formerly ConocoPhillips), Roxana, IL
- Waste Management Services-Woodside Landfill- Walker, LA

10. I have provided optimization assistance for the following biological nitrification facilities. Each of these are operational today and have been historically in compliance with their permits.

- American Cyanamid Superfund Site, Bridgewater, NJ
- Ashland Chemical, Calvert City, KY
- CHS-Laurel, MT
- City of Rochester, MN
- Confidential ammunitions manufacturer, United States
- Gulf Coast Waste Disposal Authority, Pasadena,
- Republic Services-Middle Point Landfill- Murfreesboro, TN
- Valero, Benicia, CA

- Waste Management-Sainte-Sophie, Quebec, Canada

11. I have developed the process design for the following biological nitrification and denitrification facilities.

- Ashland Chemical, Calvert City, KY
- Bush Brothers, Dandridge, TN
- Chesterfield County, VA
- Confidential ammunitions manufacturer, United States
- Dairy Farmers of America, Garden, City, KS
- Dairy Farmers of America, Cass City, MI
- Great Lakes Cheese. Adams, NY
- Lily Del Caribe- Puerto Rico
- Valero-Pembroke, Wales
- Waste Management-Atlantic Waste Disposal, Waverly, VA

12. Lastly, I developed the process design for three breakpoint chlorination facilities: Koch Fertilizer Company, Enid, OK; Republic Services-Middle Point Landfill- Murfreesboro, TN; and Valero, Benicia, CA. The Koch facility was pilot-scale tested and is in final design currently. It treats approximately one-fifth of the effluent ammonia-nitrogen load as the Emerald-Henry Plant. Other treatment alternatives considered for the Koch facility were ozonation, perozonation, alkaline air stripping, steam stripping, precipitation as struvite, electrochemical oxidation, reverse osmosis, suspended growth biological nitrification, and nitrification via artificial wetlands. The breakpoint chlorination system at Republic Services was ultimately replaced with single stage nitrification designed to accommodate a significantly inhibited

nitrification rate. One other option considered for interim treatment at Republic Services was a reported ammonia selective membrane treatment system that proved economically unviable.

IV. HENRY PLANT EXPERIENCE

13. From 1988 to 2004, I provided the following assistance in chronological order listed below.

- Setup, conduct and oversight of treatability testing that was used to develop process design of C-18 wastewater pretreatment system and aeration basin upgrade. Testing was also used to set allowable loading rates of various wastestreams.
- Setup, conduct and oversight of treatability testing that was used to develop conceptual level design criteria for alternative processes for effluent ammonia-nitrogen reduction. Developed conceptual level designs for these alternative processes. Worked with construction cost estimators and venders to develop conceptual level cost estimates of these alternative processes.
- Provided guidance to B.F. Goodrich and Noveon, as requested, regarding WWTF operations and full-scale testing of processes and procedures intended to reduce effluent biochemical oxygen demand (BOD), total suspended solids (TSS) and/or ammonia-nitrogen.
- Authored or reviewed all reports submitted to B.F. Goodrich and Noveon by Brown and Caldwell (formerly AWARE Incorporated and Eckenfelder Inc) during entire period of 1988 through 2004.
- Represented Noveon in discussions with IEPA regarding the Petition for an Adjusted Standard, AS 2002-005, and testified during proceedings before the Illinois Pollution Control Board.

14. From 2005 to 2019, I provided the following assistance in chronological order listed below.

- In August 2012, prepared a letter report to Emerald's counsel regarding ammonia-nitrogen treatment alternatives for the Henry Plant that was identified as Exhibit 13 to Emerald's petition for an adjusted standard in AS 13-002 and advised Emerald in connection with discussions with IEPA.
- Design and oversight of treatability testing that was used to develop conceptual level design criteria for alternative processes for effluent ammonia-nitrogen reduction, including granular activated carbon treatment and river water dilution. Developed conceptual level designs for these alternatives processes. Worked with construction

cost estimators and vendors to develop conceptual level cost estimates of these alternative processes. This work is described in more detail in Section VI, below.

- Provide guidance to Emerald, as requested, regarding WWTF operations and full-scale testing of processes and procedures intended to reduce effluent BOD, TSS, and/or ammonia-nitrogen.

- Prepared my expert report for this case, AS 19-002, which has been marked as Petitioner's Hearing Exhibit 12.

- Authored or reviewed all reports submitted to Emerald by Brown and Caldwell during entire period of 2005 through 2019.

V. MISCELLANEOUS TOPICS

15. Pursuant to its discharge permits, the Henry Plant generally collects five samples of wastewater effluent each week and tests the samples for the concentration (mg/L) of ammonia nitrogen. Each concentration is then used with the flow rate to calculate a daily ammonia load (lbs/day), a 30-day average concentration and a 30-day average load. According to the definitions in the standard conditions in Attachment H to the Henry Plant's 2016 NPDES permit, a 30-day average value is calculated as the sum of all measured daily discharges during a calendar month divided by the number of measured values during that month. This produces a large amount of data, which can be unwieldy to analyze unless it is compiled and summarized.

16. Ammonia sample results and flow data from the Henry Plant's annual DMR summary reports, which have been identified as Petitioner's Hearing Exhibit 2, were entered into excel worksheets with one worksheet for each calendar year. I reviewed those worksheets to verify that the data was correctly entered. Additional worksheets were prepared to present certain summary data from the annual worksheets. I checked the formulas for those worksheets to ensure that they accurately presented the data described. The documents marked as Petitioner's Hearing Exhibit 3 provide the following summary data on the ammonia-nitrogen discharged from the Henry Plant from 2013 to June 2019. On EP003097-003099, the second

and third columns show the maximum daily ammonia sample result (mg/L) and the maximum calculated daily load (lb/day), respectively, for each month in each year. The fourth and fifth columns show the 30-day average of daily ammonia samples (mg/L) and calculated daily ammonia load (lb/day), respectively. The shaded values on EP003097-003099 are the highest monthly values during each year. The table at the bottom of EP003099 shows a percentage calculated by dividing the highest monthly value for each year by the corresponding limit in the Henry Plant's 2016 NPDES permit, which is the same as the limit established in AS13-2.

17. In preparation for this case, I reviewed my written testimony submitted to the Board in AS 02-5. In particular, I reviewed the portion of that testimony related to whether the Henry Plant is applying the best available technology economically available (BAT) as identified by USEPA for the Organic Chemical, Plastics, and Synthetic Fibers industrial category. That testimony is still accurate and the Henry Plant does apply BAT.

VI. APRIL 13, 2018 TECHNICAL MEMORANDUM

18. At the request of Emerald and as required by the Board in AS 13-002, Brown and Caldwell studied two treatment alternatives, as reported in our April 13, 2018 Technical Memorandum (the 2018 Technical Memorandum). The two alternatives were: (1) use of granular activated carbon (GAC) treatment on the polymer chemicals (PC) wastewater at the Henry Plant to remove mercaptobenzothiazole (MBT) so that nitrification can occur (GAC treatment); and (2) extracting water from the Illinois River and pumping it uphill to dilute the primary clarifier effluent so that MBT concentrations are reduced enough to allow nitrification to occur (river water dilution). A copy of my 2018 Technical Memorandum is included in Petitioner's Hearing Exhibit 11.

19. The scope of work for these studies consisted of bench scale treatability testing and developing a preliminary design and cost estimate for each option. Laboratory testing was required to evaluate nitrification potential and feasibility.

20. Based on the results from the bench scale tests, preliminary designs and class 5 cost estimates were completed to investigate the economic feasibility of achieving nitrification (biological ammonia-nitrogen removal) through these two methods in comparison to NH3-N removal.

a. Laboratory Testing

21. Fed Batch Reactor (FBR) tests were performed on five combinations of biomass and test waters to investigate the viability of GAC treatment and river water dilution in facilitating nitrification at the Henry Plant. Table 1 to my 2018 Technical Memorandum outlines the five FBR tests run during this investigation. Further description of the pretreatment and testing process for the FBR tests is included in my 2018 Technical Memorandum at pages 3-12.

22. Based on the FBR testing performed, we reached the following conclusions:

- The unpretreated wastewater will continue to cause substantial nitrification inhibition due to high concentrations of MBT.
- Pretreatment of the PC/C-18 wastewater utilizing solids separation and GAC would allow the Henry Plant to nitrify in an uninhibited manner following removal of MBT from the biomass through alkaline washing.
- Diluting the unpretreated clarifier wastewater with water extracted and pumped from the Illinois River requires a dilution percentage in excess of 90% for uninhibited nitrification to occur. At 90% dilution, the nitrification rate observed could be sustainable as long as the MBT concentration in the PC/C-18 wastewater remained within the values used in the FBR testing. The sustainability of the performance of this treatment alternative for NH3-N removal is unlikely due to the inherent variability of the influent MBT concentration (that is, it can vary outside the FBR test range) and the difficulty in maintaining target temperatures in the biological treatment systems while heating a large river water flow (approximately 7 million gallons/day, or MGD).

These conclusions and the basis for them are described further in my 2018 Technical Memorandum at pages 12-13.

b. Conceptual Level Design and Cost Estimates

23. At the conclusion of treatability testing, we developed conceptual designs and Class 5 cost estimates to evaluate additional equipment facility changes needed for each alternative.

24. Class 5 estimates are used to prepare planning level cost scopes or evaluation of alternative schemes, long range capital outlay planning and can also form the base work for the Class 5 Planning Level or Design Technical Feasibility Estimate. As a result, these estimates are intended only for use as aids in conceptual level treatment selection.

25. A complete breakdown of the capital costs associated with each alternative is presented in Attachment A to my 2018 Technical Memorandum. The major annual operating and maintenance costs are summarized in Table 6 and Table 7 to my 2018 Technical Memorandum.

26. The conceptual level design of the GAC treatment alternative is described at pages 13-14 of my 2018 Technical Memorandum. A block flow diagram depicting the GAC treatment alternative is also included in Attachment B to my 2018 Technical Memorandum.

27. The estimated capital cost for the GAC treatment alternative was approximately $5.3 million. Depending on the source of GAC, this treatment alternative would also increase plant operating costs by $3.102 to $4.160 million per year. We calculated a present worth cost for this alternative of $27 million based on the combination of the capital cost and the increased annual operating costs and assuming a 10-year project duration, zero salvage value, 5% interest and 2% inflation. We concluded that this investment would result in approximately 1.9 million pounds of NH3-N being removed over the course of 10 years resulting in an average cost of

\$14/pound of NH3-N removed. More details on these calculations are on pages 13-15 of my 2018 Technical Memorandum.

28. This estimate is 20-fold higher than the costs reported by the publicly owned treatment works serving Decatur, Illinois; Bloomington, Illinois; and Normal, Illinois in 2015 (less than \$0.70/pound of NH3-N removed). Further, this estimate is 11-fold higher than the median cost reported by 15 reporting entities in the 2015 survey conducted by the National Association of Clean Water Agencies (\$1.33 per pound of NH3-N removed).

29. Based on this comparison, it is my opinion that the removal of NH3-N via GAC treatment at the Emerald plant is not economically reasonable. In addition, the alternative would have other negative environmental side-effects. It would require a significant increase in diesel truck traffic to bring in fresh GAC and haul-out spent GAC for disposal. This would increase greenhouse gas emissions along with being a burden on local roads and residents. Also, the spent GAC is usually taken to an incineration facility, which involves even more emissions of greenhouse gas.

30. The conceptual level design of the river water dilution alternative is described at pages 15-16 of my 2018 Technical Memorandum. A block flow diagram depicting the river water dilution alternative is also included in Attachment B to my 2018 Technical Memorandum.

31. The estimated capital cost for the river water dilution alternative was approximately \$23 million excluding the steam generation and supply system. This alternative would also increase operating costs for the Henry Plant by about \$4.4 million every year of operation. We calculated a present worth cost of \$54 million based on the combination of capital costs and increased annual operating costs and assuming a 10-year project duration, zero salvage value, 5% interest and 2% inflation. We concluded that this investment would result in roughly

1.9 million pounds of NH3-N being removed over the course of 10 years resulting in an average cost of $28 per pound of NH3-N removed. More details on these calculations are on pages 15-16 of my 2018 Technical Memorandum.

32. This estimate is 40-fold higher than the costs reported by the publicly owned treatment works serving Decatur, Illinois; Bloomington, Illinois; and Normal. Illinois in 2015 (<$0.70 per pound of N113-N removed). Further, this estimate is 21-fold higher than the median cost reported by 15 reporting entities in the 2015 survey conducted by the National Association of Clean Water Agencies ($1.33 per pound of NH3-N removed). So, this alternative is roughly twice the cost of the GAC treatment alternative while it would provide no added environmental benefit, probably could not reliably achieve compliance and would have several negative side-effects.

33. In my experience and opinion, the river water dilution alternative for NH3-N removal performance is unlikely to be consistently sustainable due to the inherent variability of the influent MBT concentration and the difficulty in maintaining target temperatures in the biological treatment systems while heating a large river water flow (approximately 7 MGD). In my opinion, although the treatability study for this alternative indicated it can achieve compliance, at plant scale with inherent process variability, it will not achieve compliance all of the time.

34. Emerald estimated in an April 17, 2018 letter to IEPA that is included in Exhibit 11 that the heating equipment required by the river water dilution alternative would emit 38,000 metric tons of CO_2e greenhouse gases, 35 tons of nitrogen oxides and 30 tons of carbon monoxide per year. In my opinion, this is another negative environmental side-effect from this alternative.

35. This alternative would also increase the heat load to the Illinois River 10-fold which would adversely impact localized water quality. It would also greatly complicate utility and treatment plant operations.

VII. OCTOBER 11, 2019 EXPERT REPORT

36. In 2019, under my supervision, Brown and Caldwell updated its analysis of the costs of several alternatives previously considered and added the evaluation of an additional alternative. I was also asked to review the Illinois Environmental Protection Agency's July 19, 2019 Recommendation and express my opinion on some of the positions taken by IEPA. That work resulted in the preparation of my expert report in this matter dated October 11, 2019 (Expert Report). My Expert Report has been marked as Petitioner's Hearing Exhibit 12.

37. As regards IEPA's Recommendation, my Expert Report responds to and rebuts several of the bases upon which the IEPA opposed Emerald's request and also explains why some of the IEPA's suggestions would not help control ammonia-nitrogen in the Henry Plant's discharge.

a. Rebuttal of IEPA Suggestions

38. IEPA objected on Page 16 of the Recommendation to my comparison of unit cost (dollars per pound of ammonia-nitrogen removed) as a means of comparing alternatives and judging economic reasonableness of ammonia-nitrogen removal. IEPA also objected, on this same page, to the use of present worth costs (accounting for both capital and operating costs) instead of capital costs alone when calculating cost of treatment.

39. At a conceptual level, comparing alternatives solely based on estimated capital costs makes no sense. That approach would favor alternatives that have proportionally lower capital costs even if the operating costs were much higher so that total costs of such alternatives

are higher. An example of the error in IEPA's position can be seen in Table 2 of my Expert Report. Breakpoint chlorination has the lowest capital cost of the alternatives considered. If the comparison is limited to capital costs, it appears to be the least costly. But, it has very high operating costs actually making it the second most costly alternative to implement. A comparison based solely on capital costs is incomplete and, in my opinion, deeply flawed.

40. IEPA's objection to considering unit costs is also flawed. Again, the reason can be seen by comparing two alternatives in my Tables 2 and 3. Looking at just the present worth cost, land application appears to be the least expensive alternative. But, that conclusion is wrong because it fails to understand that the land application can, at best, reduce the annual effluent ammonia-nitrogen discharged from the Henry Plant by approximately 22%. Calculating the present worth cost on a $/lb of NH_3-N removed takes that additional factor into account and shows that land application is actually the second highest cost alternative.

41. In my opinion, comparing alternatives on present worth costs expressed on a unit of pollutant removed basis is the appropriate and best standard for evaluating true treatment costs. The latest cost document provided by the National Association of Clean Water Agencies (NACWA) reports that the median unit cost of ammonia-nitrogen treatment for 12 agencies was $1.53 per pound of ammonia-nitrogen removed, which is higher than the cost reported by the Greater Peoria Sanitation District ($0.81 per pound). The basis for these reported costs includes, in all cases, annual operating and maintenance costs. In some cases, these costs may include capitalized present worth cost (amount of money needed today to fund capital and operating costs for a defined project life). The exclusion of capitalized costs by most NACWA members in these reported unit costs is due to the nature of the municipal wastewater treatment plants. Exclusion of capital costs in unit costs by NACWA members is due to several factors. These

include the difficulty in separating capital costs into those required for treatment of flow, biochemical oxygen demand (BOD), total suspended solids (TSS), and ammonia-nitrogen (NH3-N). In municipal plants, the same pieces of equipment contribute to treatment of all four components (flow, BOD, TSS and NH3-N). In the Emerald plant, the costs described herein are focused entirely on NH3-N removal, and therefore, delineation of capitalized present worth costs are straightforward. Contrary to NACWA, IEPA has focused strictly on capital costs of projects that included ammonia-nitrogen removal. Such focus is misguided and results in an incomplete understanding of ammonia-nitrogen removal costs.

42. IEPA's Recommendation also references a number of project capital costs reportedly incurred by public treatment works in the State of Illinois when including ammonia-nitrogen removal in their treatment plant upgrades, including facilities in Geneva, Batavia, Saint Charles, Fox River, Kishwaukee, Newark and Mount Carmel. A discussion of each of these seven "cost examples" is included in Petitioner's Hearing Exhibit 12.

43. The "cost examples" referenced by IEPA all relied upon the lowest cost means of ammonia-nitrogen removal which is single-stage biological nitrification.

44. The Emerald plant provides the same degree of aerobic treatment conditions that allow single-stage nitrification in these IEPA-referenced plants, that is, a solids retention time in excess of 30 days, surplus alkalinity, and available phosphorus. However, the Emerald plant cannot nitrify within a single stage like these other plants due to the presence of MBT in the process wastewater.

45. This compound is foundational to the production processes at the Emerald Plant and has been consistently present in the primary clarifier effluent at 160 mg/L or higher for days at a time (versus a nitrification inhibition threshold of 3 mg/L). To establish reliable single-stage nitrification, MBT removal from the process wastewater would have to exceed 98 percent which has been demonstrated in prior documents as being complex and very costly.

46. Only five of the seven wastewater treatment facilities upgrades referenced by IEPA in its Recommendation had anything to do with ammonia-nitrogen removal. None of these five treatment plant upgrades were implemented solely to accomplish ammonia-nitrogen removal. They were implemented in large part to better accommodate higher flows, greater BOD removal, greater TSS removal, and/or improved disinfection.

47. Consequently, the total costs of these upgrades as reflected in the Recommendation cannot be legitimately used to compare or evaluate costs of ammonia-nitrogen removal at the Emerald plant.

48. IEPA's Recommendation (pages 6 and 27-28) makes reference to the fact that Emerald currently operates one biotreater at its facility and, in the event that the Board grants Emerald's Petition, requests that the Board require Emerald to operate three other biotreaters within four years. The problem with IEPA's position is that it is unsupported by any analysis that operating more biotreaters will reduce ammonia-nitrogen in the effluent.

49. Ammonia-nitrogen removal at the wastewater treatment facility is a function of solids retention time (SRT) and the extent of BOD removal. The maximum amount of ammonia-nitrogen removal will occur at the lowest achievable SRT that ensures sufficient BOD removal.

50. The wastewater treatment plant is already capable of operating at this condition (SRT of 30 to 60 days depending upon production) with only the North Biotreater in service. In fact, I recommended to plant personnel that they only operate the North Biotreater, which is the largest, and shut the others down.

51. In my opinion, operating additional biotreaters will have no impact on effluent ammonia-nitrogen but will make operations more complicated.

52. IEPA has recommended that Emerald implement an in-plant ammonia-nitrogen (NH3-N) monitoring program in hopes of reducing effluent ammonia-nitrogen through at-source detection and control. This strategy might work if effluent ammonia-nitrogen was strongly correlated to influent ammonia-nitrogen.

53. However, this is not the case since influent organic nitrogen (not ammonia nitrogen) is the primary contributor to effluent ammonia-nitrogen.

54. The two primary raw wastewater contributors to the wastewater treatment plant (PVC Tank and PC Tank) were monitored approximately 3 days per week for Total Kjeldahl Nitrogen (TKN) and ammonia-nitrogen (NH3-N) during the period of March 28, 2019 through August 8, 2019. The difference between TKN and NH3-N concentrations represent organic nitrogen. Under normal biological treatment conditions, organic nitrogen is converted to NH3-N. These data are summarized in Figure 1 to Petitioner's Hearing Exhibit 12.

55. The results of the PVC Tank and PC Tank are discussed in detail at pages 4-5 of my Expert Report. The overall findings and conclusions are as follows:

- Only 40 percent of the TKN loading for the PVC tank is comprised of ammonia-nitrogen. This discharge stream includes the nitrogen loading of tertiary filter backwash water and sludge dewatering filtrate which is generated when treating both PVC tank and PC tank wastewaters. Nitrification of this stream alone has been considered in prior evaluations, but does not offer a means of complying with regulatory effluent limits. Recent sampling results continue to demonstrate this finding.
- Only 1 percent of the TKN loading in the PC tank was ammonia-nitrogen.
- Ammonia-nitrogen contributed only 30 percent of the TKN loading discharged by the PVC and PC tank combined. Consequently, in-plant monitoring of ammonia-nitrogen only has the ability to influence 30 percent of the potential final effluent NH3-N load. This finding that the bulk of the final effluent NH3-N loading is due to organic nitrogen present in the raw wastewaters that is converted to ammonia-nitrogen through biological treatment has been documented throughout the years.

56. The Emerald wastewater treatment plant did provide 46 percent removal of influent TKN reducing the effluent ammonia-nitrogen by 344 lbs/day. This removal was associated with nutrient requirements for the BOD removal accomplished by biological treatment within the plant.

57. Any in-plant monitoring would need to focus on TKN monitoring. Unlike NH3-N, there are no direct monitoring probes for TKN in wastewater. Consequently, real-time monitoring and quick response would be impractical.

58. In my opinion, additional sampling of process wastewater sources to determine the origin of effluent ammonia nitrogen is not needed.

b. Updated Conceptual Level Designs and Cost Estimates for Alternatives, including Land Application.

59. Brown & Caldwell was also asked to update its evaluation of the costs of various treatment alternatives previously considered and to evaluate the cost of a land application alternative. Updating costs for every alternative is not necessary because many alternatives are known not to achieve significant effluent ammonia-nitrogen reductions or would have costs in

excess of other more effective alternatives. Costs have been calculated for five alternatives considered most likely to be effective and for land application.

60. The conceptual level cost estimates prepared are the same kind of Class 5 estimates used in evaluating the GAC and river water dilution alternatives in 2018. These estimates were developed by generating equipment costs for each alternative and then applying multiplication factors for direct and indirect costs. The direct costs include freight, tax, purchased equipment installation, installed piping, installed electrical systems, buildings, other structural components, yard improvements, and installed service utilities. Indirect costs include engineering and supervision, construction expenses, legal expenses, and contractor's fee.

61. A contingency multiplication factor is applied to the sum of the direct and indirect costs. The sum of the direct, indirect and contingency results in the fixed capital cost (FCC).

62. The most economical and reliable processes for ammonia-nitrogen removal at the Emerald Plant would consist of further treating the plant final effluent (not plant raw wastewater influent). We updated the design final effluent wasteload information based on 2018 information when the plant was reportedly operating at typical production levels. A summary of the design final effluent wasteload is illustrated in Table 1 to Petitioner's Hearing Exhibit 12.

63. This wasteload was used to update the conceptual level designs and cost estimates for the most economically feasible alternatives, including: (1) ozonation; (2) alkaline stripping; (3) tertiary nitrification; (4) breakpoint chlorination; and (5) ion exchange. Because of IEPA's interest, we also estimated costs for land application even though it will not achieve compliance. The details around each of these cost estimates are included as Attachment A to Petitioner's Hearing Exhibit 12. Initially we had only intended to cost five alternatives in total. When I saw

data on the low levels of MBT in the treatment plant effluent (as opposed to higher levels in the treatment plant influent), I added the re-evaluation of tertiary nitrification.

64. A summary of treatment alternatives performance and costs are shown in Table 2 to Petitioner's Hearing Exhibit 12 and presented as unit costs in Table 3 of that exhibit.

65. These data indicate that tertiary nitrification and ion exchange offer the lowest unit cost for ammonia removal based on annual operations and maintenance costs with ion exchange having a much lower capital cost. On a present worth basis, Emerald would have to commit a minimum of $12 per pound solely for NH3-N removed over the next 10 years, which is approximately 8-fold the median unit costs reported by NACWA.

66. In my opinion, there are no other treatment alternatives for ammonia-nitrogen removal that are worthy of being considered. All other alternatives have been shown to be incapable of achieving reliable compliance or have costs in excess of the alternatives re-evaluated in 2019 as described in my Expert Report.

67. My opinion in this regard also extends to the Algaewheel® technology alternative suggested in IEPA's Recommendation. That technology has similarities to the tertiary nitrification alternative using rotating biological contactors (RBCs) downstream of the secondary clarifier evaluated in my Expert Report. In our alternative, heterotrophic bacteria, which remove BOD, and nitrifying bacteria would grow on fixed film media offered in the RBCs. The bacteria on the RBC media should then be able to nitrify ammonia-nitrogen, if, that is, the level of MBT can be kept low enough in the current plant effluent. The Algaewheel® alternative works in a similar way except that algae replaces the bacteria on the RBCs. As compared to bacteria, use of algae as a nitrifier is a newer technology, which means it is less proven and likely more costly because the technology is still patent-protected.

c. Environmental Impact of Effluent Ammonia-Nitrogen Removal

68. The Illinois River over many years has shown no violations of the acute and chronic water quality standards for ammonia-nitrogen downstream of Emerald's discharge.

69. The results of Whole Effluent Toxicity (WET) testing conducted at the Henry Plant have repeatedly shown no toxic effects from Emerald's effluent outside the approved zone of initial dilution.

70. These results demonstrate that Emerald's construction and continued use of the current wastewater treatment plant, the multi-port diffuser, replacement of the BBTS Wet Scrubber and other actions have produced an effluent that has no material negative effect on the environment. In contrast, every alternative that we have considered has identifiable negative side-effects on the environment.

71. Only one of the six treatment alternatives that we analyzed in 2019 does not require chemical addition to the final effluent. However, this alternative of land application only reduces the annual nitrogen load on the river by 22 percent and requires complexity related to operating and maintaining a river water treatment system, three pumping systems, and an elaborate irrigation system. It also generates hay which has no defined dependable outlet for use.

72. IEPA's further suggestion that the land application alternative be extended to farm land not owned by Emerald is even more implausible. While I am aware of some industrial waste water that is land applied, it is mostly from food processing plants. It is quite rare that the effluent from a chemical plant is land applied. I am also aware of no instance of a chemical plant effluent being land applied onto row crops, such as corn or soybeans, which are dominant crops in Illinois. In addition, corn and soybeans are less salt tolerant than hay (the crop we evaluated

for land application), so to spray the effluent on those crops would require even higher river water dilution than we planned for in our evaluation.

73. The other five alternatives require extensive chemical addition which will appreciably increase the effluent salt load to the Illinois River. These alternatives would either substitute salt for ammonia nitrogen in the Henry Plant's discharge with unknown repercussions for toxicity or require an even more costly fourth level of treatment to reduce the salt.

74. The only two alternatives that can reliably comply with the regulatory limits (breakpoint chlorination and ion exchange) either (a) generate an effluent that may cause failure of the existing effluent aquatic toxicity criterion or (b) generate a liquid waste whose disposal method, destination, and costs are uncertain.

75. In addition, every alternative will indirectly increase greenhouse gas emissions due to increased power consumption and additional diesel truck traffic.

76. The same is true for the GAC and river water dilution alternatives as described above.

77. The collateral negative environmental impact of the treatment alternatives (e.g., greenhouse gas emissions and decreased effluent water quality with respect to higher salt levels) is appreciably more adverse than the current effluent ammonia-nitrogen load.

78. Given that Emerald's effluent has no negative environmental impact and the treatment alternatives have negative collateral environmental effects, implementing any of those alternatives and incurring the estimated costs solely for ammonia-nitrogen removal would be a unique and unreasonable requirement.

79. In my opinion, implementing any of these alternatives is unwise from an environmental standpoint.