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STATE OF ILLINOIS
Pollution Control Board

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

Noveon, Inc.)
)
v.) **PCB 91-17**
) (Permit Appeal)
Illinois Environmental)
Protection Agency)

IN THE MATTER OF:)
)
Petition of Noveon, Inc.)
) **AS 02-5**
)
for an Adjusted Standard from)
35 Ill. Adm. Code 304.122)

NOTICE OF FILING

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PLEASE TAKE NOTICE that on **Friday, February 6, 2004**, we filed the Written Expert Testimony of Houston Flippin, a copy of which is herewith served upon you.

Respectfully submitted, NOVEON, INC.

By: ______________________
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STATE OF ILLINOIS
Pollution Control Board

Petition of Noveon, Inc. AS 02-5 For An Adjusted Standard NPDES Adjusted From 35 ILL ADM. Code Standard 304.122

Written Testimony of T. Houston Flippin as wastewater treatment expert representing Noveon, Inc. in this proceeding.

Introduction and Experience of T. Houston Flippin as Wastewater Treatment Expert Representing Noveon Inc.

My name is Thomas Houston Flippin. I was retained by Noveon, Inc in December 1989 to provide wastewater treatment services and have continued to provide such services for the last 14 years. During this entire time period, I have served as lead process engineer on all Noveon-Henry Plant matters in which my firm Brown and Caldwell has been involved. My firm was previously known as Eckenfelder Inc and was acquired by Brown and Caldwell in 1998.

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

I immediately went to work for AWARE Incorporated in 1984 and have remained with the same company for the last 20 years in progressively more responsible positions (from project engineer to project manager to principal engineer) in the area of wastewater engineering (see Exhibit A for resume documenting this experience). My firm has changed names twice. In 1989, we renamed ourselves Eckenfelder Incorporated in 1989 to honor Wes Eckenfelder our Chairman Emeritus who is still with us today. Much of what I have learned has been under Dr. Eckenfelder as a graduate student and as a co-worker. In 1998, Eckenfelder Inc was acquired by Brown and Caldwell.

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) and conducted waste minimization studies. 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. I currently serve as lead process engineer on more technically challenging projects and to train other engineers within the firm.

I am a licensed professional engineer in the states of Illinois, Michigan, Kentucky, and Tennessee. I also am certified as a Diplomat in the American Academy of Environmental Engineers in the specialty area of water supply and wastewater. This certification is held by less than 1300 people in the United States and requires stringent peer review and testing to acquire.

I have published 16 technical papers of which 7 are directly related to the Noveon-Henry Plant's issues and have provided material for 1 textbook (Activated Sludge Treatment of Industrial Wastewaters, John L. Musterman and W. Wesley Eckenfelder, Technomic Publishing Company, 1995). I also provided the technical review of a chapter from another textbook ("Granular Carbon Adsorption of Toxics" from Toxicity Reduction in Industrial Effluents, Perry W. Lankford and W. Wesley Eckenfelder, Van Nostrand Reinhold, 1992).

I have served as in instructor in numerous workshops including the following:

- "Clarifier Operation and Maintenance" sponsored by Mississippi Water Pollution Control Operators' Association in 1997;
- "Aerobic Biological Treatment" sponsored by Tennessee State University in 1997, 1998, and 1999;
- "Activated Sludge Treatment" sponsored by Brown and Caldwell and attended by more than 10 industries during each offering in November 1999, March 2000, May 2001, November 2002, and November 2003; and
- "Wastewater Strategies for Industrial Compliance: Gulf Coast Issues and Solutions" sponsored by Tulane University and Louisiana Chemical Association in December 2003.

Specific Design Experience Related to this Petition

I have developed the process design for following biological nitrification facilities. Each of these are fully operational today and meeting permit compliance.

Noveon-Henry Plant Experience:

1989 to 2004: Have provided the following assistance in chronological order listed below. I have also spent a cumulative of at least 2 months onsite at this facility throughout the years with no more than two years elapsing between visits. My last visit to the plant was in the Fall of 2003.

- Optimization of WWTF operations.
- 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,.
- Train WWTF operators in process optimization and analytical testing.
- 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 as requested guidance to Noveon regarding WWTF operations and full-scale testing of processes and procedures intended to provide reduce effluent ammonia-nitrogen.
- Authored or reviewed all reports submitted to Noveon by Brown and Caldwell (formerly AWARE Incorporated and Eckenfelder Inc) during entire period of 1987 through 2004.
- Represented Noveon in discussions with IEPA regarding the Petition for an Adjusted Standard.

Noveon-Henry Plant Wastewater Treatment Facilities

Many of the terms that I have used above and throughout this report are defined below as the Noveon-Henry Plant Wastewater Treatment Facility (WWTF) is described. An understanding of the WWTF is critical to understanding the evaluations conducted and the conclusions reached.

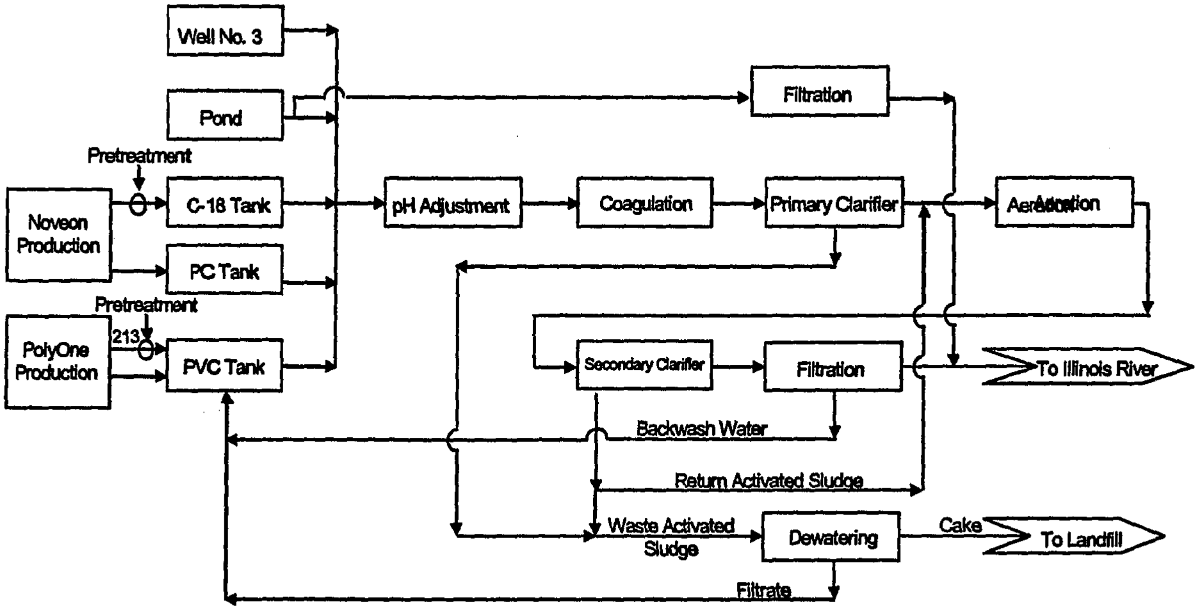

FIGURE 1

BLOCK FLOW DIAGRAM OF WASTESTREAM SOURCES AND WWTF

The wastewater treatment facility at the Henry Plant site is owned and operated by Noveon, Inc. This facility treats wastewaters discharged from two manufacturing areas (resins and specialty chemicals) that were once owned by BF Goodrich. BF Goodrich sold the resin business to the Geon Company who later sold it to the PolyOne Corporation. BF Goodrich sold the specialty chemicals business and the site's wastewater treatment facility to Noveon, Inc. The wastewaters discharged by Noveon comprise about 35 percent of the total dry weather flowrate to the WWTF with the remaining 60 percent being discharged from the PolyOne production areas.

Wastewaters from the Noveon-Henry Plant production areas discharge to one of two places as illustrated in Figure 1. All wastewaters excluding those from C-18 manufacturing discharge directly to an equalization tank (the PC Tank), as shown in Figure 1. The wastewaters from C-18 manufacturing discharge to a pretreatment system and are then pumped to an equalization tank (C-18 Tank). Prior work that I either conducted or oversaw defined that the C-18 wastewaters were causing the WWTF to be unable to comply with effluent BOD limits. These wastewaters contained compounds that caused the bacteria responsible for organics removal, also known as BOD removal, to slow down or become inhibited. This work also defined the pretreatment of the C-18 wastewater that would be required for the WWTF to treat these wastewaters while complying with effluent BOD limits. Prior to installing pretreatment, the bulk of the C-18 wastewaters were collected and transported for off-site treatment and disposal. After this pretreatment was installed, the pretreatment allowed the Noveon-Henry Plant to treat all C-18 wastewaters onsite while maintaining compliance with effluent BOD limits. This pretreatment was not required of the other Noveon wastewaters. This pretreatment also had no effect on effluent ammonia-nitrogen concentrations nor would it have any such effect if applied to any other Noveon wastewater.

Wastewaters from the PolyOne Plant production areas discharge to one of two places as illustrated in Figure 1. All wastewaters excluding those from 213 manufacturing discharge directly to an equalization tank (the PVC Tank). The wastewaters from 213 manufacturing discharge to a pretreatment system and are then pumped to same equalization tank (PVC Tank). Prior work by others had indicated that the 213 wastewaters were causing the WWTF to be unable to comply with effluent Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) limits. These wastewaters contained compounds that kept solids from settling in the primary and secondary clarifiers as well as fine solids that passed through the WWTF. Pretreatment was installed to mitigate these affects. It has been successful in allowing the Noveon-Henry Plant to treat all 213 wastewaters onsite while maintaining compliance with effluent BOD and TSS limits. This pretreatment was not required of the other Polyone wastewaters. This pretreatment also had no effect on effluent ammonia-nitrogen concentrations nor would it have any such effect if applied to any other Polyone wastewater.

Stormwater from the both the Noveon and PolyOne sites and discharges from cooling towers, boilers, and river water treatment are discharged to the Storm/Utility Pond (the "Pond") as illustrated in Figure 1. A portion of the Pond contents are pumped through a filter to remove TSS prior to discharge the Illinois River. The remaining portion is pumped to the PVC Tank for subsequent treatment. The amount of Pond Water returned to the PVC Tank is a function of the capacity of the filter treating the Pond Water, the PVC Tank operating level, and the need for other wastewater to compliment the required PC Tank discharge flowrate. The PVC Tank has a minimum allowable operating level, below which the tank mixer shuts off. Work that I have conducted and overseen has indicated that the PC Tank discharge must be limited to approximately 23 percent of the combined influent flow to the aeration basins to maintain compliance with effluent BOD limits. The PC Tank discharge contains compounds that can inhibit or slow down the bacteria responsible for BOD removal if their concentrations are allowed to exceed certain critical concentrations. So the amount of Pond water diverted to the PVC Tank for subsequent treatment increases during a wet weather period when the capacity of the filter on the pond discharge is approached, when the PVC Tank level nears its minimum operating level, and when the flow contribution of the PC Tank discharge approaches 23 percent. The contents of the PVC Tank, PC Tank, and C-18 Tank are pumped to a pH adjustment tank along with groundwater from a recovery well (Well No. 3). The pH of the combined wastewater is adjusted. Coagulant and polymer are added to the combined wastewater to assist in removing solids from the combined wastewater in the sedimentation basin (also known as primary clarifier). The solids settle for approximately one hour in the primary clarifier. The settled solids then combine with solids discharged from the bottom of the second sedimentation basin (also known as the secondary clarifier) and are dewatered using a filter press. The dewatered solids are disposed in a permitted off-site landfill. The filtrate from sludge dewatering is returned to the PVC Tank for reprocessing through the WWTF. When the filter press is not operating, the sludge from the primary clarifier underflow is pumped back to the PVC Tank for reprocessing in the WWTF and sludge discharge from the secondary clarifier is ceased.

The effluent from the primary clarifier is pumped to four aeration basins (2.0 million gallons combined volume) that operate in parallel. These basins are aerated to mix the tank contents and to maintain a minimum operating dissolved oxygen concentration of 1.5 mg/L. Sludge is returned from the bottom of the secondary clarifier to keep these tanks supplied with an acclimated culture of bacteria. pH is controlled as needed to maintain an optimum range for bacterial growth (pH 6.5 to pH 8.5). The bacteria grown in this tank remove organic compounds with the aid of dissolved oxygen, ammonia-nitrogen, and phosphorus. In the process of this removal these bacteria also break away ammonia-nitrogen from organic compounds containing amines (also known as organic nitrogen compounds). Both biological treatment steps are illustrated below. Dissolved oxygen needed for biodegradation is provided by the aeration equipment. The two predominant nutrients required for biological degradation are ammonia-nitrogen and phosphorus. Ammonia-nitrogen is present in the wastewater and is formed through degradation of the organic nitrogen in the compound. Phosphorus is added to the return sludge going back to the aeration tanks.

Biological Treatment Reactions

> Organic compounds (measured as BOD, Biochemical Oxygen Demand) + Ammonia-Nitrogen + Phosphorus+ Dissolved Oxygen + Bacteria yields More Bacteria (reproduction and growth) + Carbon Dioxide + Water

> Organic Nitrogen (an organic compound with essentially ammonia-nitrogen attached) + Phosphorus+ Dissolved Oxygen + Bacteria yields Organic Compound + Ammonia-Nitrogen…The Organic compound then gets degraded just like above using some of the ammonia-nitrogen generated.

The bacteria stay in the aeration tanks about 2.5 days where they degrade organic compounds and organic nitrogen. They are then discharged through a line where they get conditioned with polymer to help them settle better in the secondary clarifier. They settle approximately 3 hours in the secondary clarifier. They are removed continuously off the bottom of the clarifier and sent back to the aeration tanks to degrade more organic compounds and organic nitrogen. A portion of the bacteria is removed from the system (termed "sludge wasting") to control population growth and keep the average age of the bacteria (the Mean Cell Residence Time) and Food-To-Mass (F/M) ratio in an optimal range. The bacteria removed from the system are discharged to the filter press for sludge dewatering and subsequent off-site disposal in a landfill.

The treatment described includes pretreatment, primary treatment (pH adjustment, coagulation and primary clarifier), and secondary treatment (aeration and secondary clarifier with sludge return). This treatment is defined by USEPA as the "Best Available Technology Economically Available" for the Organic Chemicals, Plastics, and Synthetic Fibers industrial category (Code of Federal Regulations Title 40, Part 414.83, Subpart H).This industrial category includes Noveon and PolyOne. However, Noveon treats the wastewater even further by discharging the effluent from the secondary clarifier to a filter to remove additional solids. This additional treatment process is termed tertiary treatment.

Noveon also filters the water coming out of the Pond to remove solids. These two filtered wastewater streams combine and discharge through the effluent compliance point that Noveon monitors for flow and regulated compounds such as specific organics, BOD and TSS.

The design and operation of Noveon's WWTF are compatible with conditions defined by 35 ILL. Admin. Code 370.920, 35 ILL. Admin. Code 370.1210, and Ten State Standards to grow nitrifying or ammonia-degrading bacteria as illustrated below in Table 1. However, they do not grow. The Illinois regulations cited and the Ten State Standards are design and operating standards that are intended to promote complete nitrification in municipal wastewater treatment facilities. These standards are intentionally excessive (or conservative) and allow for a significant margin of error in waste load determinations and operating conditions based on my experience. There are no Illinois or Ten State standards for single stage nitrification of industrial wastewater treatment facilities since the nature of these wastewaters varies from industry to industry. These industrial design standards are developed on a site specific basis using wastewater characterization data, treatability testing, and professional experience.

Nitrifying or ammonia-degrading bacteria are much more sensitive than the bacteria that degrade organic compounds and organic nitrogen. There are compounds present in the Noveon wastewater that prevent or inhibit their growth. If the bacteria were not inhibited and could grow in the aeration tanks they would provide ammonia removal in the same tankage as the other bacteria use to provide organics removal. Consequently, the treatment would be termed single stage nitrification since in the same tankage (same stage) both organics removal and ammonia removal occur. If you were to grow these ammonia-degrading bacteria in a system downstream of the secondary clarifier, it would be called tertiary nitrification. These nitrifying bacteria grow in the manner described as follows:

Biological Treatment Reaction

Ammonia-Nitrogen + Phosphorus+ Dissolved Oxygen + Alkalinity + Bacteria yields More Bacteria (reproduction and growth) + Nitrate-Nitrogen

Table 1. Comparison of Illinois Standards, 10 State Standards, and Noveon-Henry Plant Conditions for Single Stage Nitrification

Condition	Illinois Standard[a]	Ten State Standard[b]	Noveon Plant[c]
Aeration Tank Loading, lbs BOD/day per 1000 cu ft	≤ 15	≤ 15	14
Aeration Basin Mixed Liquor DO, mg/L	≥ 2	≥ 2	≥ 2
Aeration Basin Mixed Liquor pH, s.u.	7.2 to 8.4	Not Defined	6.8 to 7.2
Sludge Age, days	≥ 20	Not Defined	≥ 40
Aeration Basin Mixed Liquor Temperature, degrees F	≥ 50	Not Defined	≥ 80
Aeration Basin Average Hydraulic Residence Time, days	≥ 0.33	Not Defined	2.5
Aeration Basin F/M Ratio, lbs BOD/day per lb MLVSS	Not Defined	0.05 to 0.10	0.10
Return Activated Sludge Flow, % of Ave Influent Flow	15 to 100	50 to 200	100

[a] Illinois Administrative Code, Title 35, Subtitle C, Part 370, Subpart I, Title 370.920 and Subpart L, Title 370.1210. Both govern municipal (not industrial) WWTF design.

[b] Recommended Standards for Wastewater Treatment Facilities, 1997 Edition, Wastewater Committee of The Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (includes Illinois), Chapter 90. These standards are to provide guidance in the design of municipal (not industrial) WWTF design.

[c] 1999 through 2004.

Applicability of 35 ILL. Admin. Code 304.122: The provisions of Illinois Title 35, Subtitle C, Part 304, Subpart A, Section 304.122 (35 ILL. Admin. Code 304.122) is stated as follows:

a) No effluent from any source which discharges to the Illinois River, The Des Plaines River downstream of its confluence with the Chicago River System or the Calumet River System, and whose untreated waste load is 50,000 or more population equivalents shall contain more than 2.5 mg/L of total ammonia nitrogen as N during the months of April through October, or 4 mg/L at other times.

b) Sources discharging to any of the above waters and whose untreated waste load cannot be computed on a population equivalent basis comparable to that used for municipal waste treatment plants and whose total ammonia nitrogen as N discharge exceeds 45.4 kg/day(100 pounds per day) shall not discharge an effluent of more than 3.0 mg/L of total ammonia nitrogen as N.

c) In addition to the effluent standards set forth in subsections (a) and (b) of this Section, all sources are subject to Section 304.105."

Section 304.105 states "In addition to the other requirements of this Part, no effluent shall, alone or in combination with other sources, cause a violation of any applicable water quality standard."

Noveon has retained another expert (e.g., Mike Corn, P.E. of AquAeTer) that will testify that Noveon can and will comply with water quality standards (section 304.122c) in the Illinois River for ammonia-nitrogen if they are allowed to install an effluent diffuser. Noveon has requested IEPA to grant approval of such installation and is committed to such installation once approval is granted. An effluent diffuser will more uniformly distribute the discharge of the Noveon in the Illinois River. The remainder of my testimony is based on Noveon's compliance with Section 304.122c.

In my professional opinion, Sections 304.122a and 304.122b do not apply to the Noveon-Henry Plant discharge for several reasons.

- The Noveon-Henry Plant untreated waste load can be "computed on a population equivalent basis comparable to that used for municipal wastewater treatment plants". Consequently, 304.122b does not apply. In my opinion, the word "comparable" merely questions whether the data exist to express an untreated waste load in population equivalents like one does when either designing or evaluating a municipal wastewater treatment plant. The data do exists and such calculations can be and have been made. The results from such calculations allow one to put the Noveon-Henry Plant's untreated waste load in a perspective others can readily understand (population equivalents). The term "population equivalent basis" is intended to put the relative size of an untreated waste load in perspective. The term was never intended to describe how the waste load was to be treated but only the magnitude of the waste load

- There are sources that could discharge to a river for which "a population equivalent basis comparable to that used for municipal waste treatment plants" could not be computed. These would be discharges for which data could not be gathered to calculate population equivalents. IEPA uses BOD, TSS, and flow for determining population equivalents. Presumably these discharges would be those for which BOD, TSS, and flow could not be reliably determined. This is not the case with the Noveon-Henry Plant discharge.

- An untreated waste load can be and has been calculated by myself and IEPA for the Noveon-Henry Plant discharge on "a population equivalent basis comparable to that used for municipal waste treatment plants". The correct results from these calculations are stated below and clearly define the Noveon-Henry Plant discharge as having less than 50,000 population equivalents. Consequently, 304.122a does not apply.

- Since Sections 304.122a and 304.122b do not apply, the Noveon-Henry Plant is not required to provide additional effluent ammonia-nitrogen removal. Furthermore, the

As stated above, correct calculations clearly define the Noveon-Henry Plant discharge as having less than 50,000 population equivalents. IEPA has calculated the population equivalents of the Noveon-Henry Plant for flow and BOD (Response to First Set of Interrogatories of Noveon, Inc. to Illinois Environmental Protection Agency, pages 4 and 5) based on data provided in the Baxter and Woodman-Wastewater Treatment Plant Report dated June 1994. This report did not present any data on the combined untreated wasteload. The report discussed the wasteload fed from the equalization tanks to the primary clarifier. However, this wasteload contains wastestreams that are internal to the WWTF that add flow, BOD, and TSS including primary clarifier sludge when sludge dewatering is not occurring, filtrate from sludge dewatering, and backwash water from the tertiary (secondary clarifier effluent) filter. Even with this addition, IEPA calculated flow and BOD population equivalents of 916 and 19,412, respectively (page 4). I corrected the population equivalent calculation for TSS based on data collected by Noveon during the period of July 2002 through June 2003. The corrected value was 24,955 as illustrated below and in Figure 1. This calculation depends upon calculating the untreated waste load TSS coming to (not recycling within) the WWTF from all sources: PC Tank, PVC Lift Station Discharge which represents the waste load discharged from the PolyOne production areas, the 213 wastestream waste load before pretreatment, the PC Tank discharge, and the C-18 Tank discharge (pretreatment does not change the flow or TSS of this discharge but does increase its BOD). The TSS discharged by the combined Well No. 3 and Storm/Utility Pond discharges are less than 25 percent of the total influent wasteload as illustrated in the Baxter and Woodman report.

- **PVC Lift Station Discharge Averages(not the PVC Tank Discharge Averages presented in Baxter and Woodman Report): 133 gpm, 1957 mg/TSS, and 3123 lbs/day TSS**

- **PC Tank Discharge Averages: 94 gpm, 900 mg/L TSS, and 1015 lbs/day TSS**

- **C-18 Tank Discharge Averages: 3.6 gpm, 300 mg/L TSS, and 13 lbs/day TSS**

- **213 Averages (included in PVC Tank Discharge data presented in Baxter and Woodman Report) : 35 gpm, 2000 mg/L TSS (estimate), and 840 lbs/day TSS (estimate)**

- **Total: 4991 lbs/day TSS or a population equivalent (PE) of 4991 lbs/day TSS divided by 0.20 lbs/day TSS per person(capita) or 24,955 population equivalents.** This is much less than PE of 265,000 calculated by IEPA in the Response to First Set of Interrogatories of Noveon, Inc. to Illinois Environmental Protection Agency, pages 4 and 5. The reason for this large discrepancy is due to recycle solids included in the IEPA calculation. These solids stay within the WWTF and are not part of the untreated waste load for which these calculations are reserved.

Even though not a part of the IEPA's definition of "population equivalent", population equivalents can also be calculated based on ammonia-nitrogen and Total Kjeldahl Nitrogen (TKN) loads that are really the thrust of 35 ILL. Admin. Code 304.122. TKN is the summation of ammonia-nitrogen and organic-nitrogen. The wasteload used to develop all effluent ammonia-nitrogen reduction options included average loadings of 385 lbs/day ammonia-nitrogen and 1038 lbs/day Total Kjeldahl Nitrogen (TKN). Based on population equivalent factors of 0.019 lbs ammonia-nitrogen/ capita per day and 0.029 lbs TKN/capita per day (see Wastewater Engineering: Treatment and Reuse: Metcalf and Eddy, Inc., Fourth Edition, page 182), the Noveon-Henry Plant population equivalents would be 20,263 and 35,793, respectively.

In my professional opinion, all correct and relevant population equivalent calculations for the Noveon-Henry Plant place it under 50,000 population equivalents rendering 35 ILL. Admin. Code 304.122a and 304.122b not applicable.

Highlights of Effluent Ammonia-Nitrogen Reduction Evaluations at Noveon-Henry Plant

It is my professional opinion that 35 ILL. Admin. Code 304.122a and 304.122b do not apply. Consequently, no effluent limitations and therefore no additional effluent ammonia-nitrogen reductions are required.

The Noveon-Henry Plant currently provides effluent ammonia-nitrogen reduction through source control and removal associated with BOD removal nutrient requirements. However, in an effort to resolve disputes with the IEPA, Noveon retained Brown and Caldwell (where I serve as lead engineer) to evaluate whether there were any feasible technologies that would provide additional effluent ammonia-nitrogen reduction. Both Noveon and Brown and Caldwell have extensively evaluated additional effluent ammonia-nitrogen reduction over the last 14 years.

All statements made below represent my understanding of the issues and my professional opinion regarding these issues.

1.0 Unique Characteristics of the Noveon-Henry Plant and its Associated Wastewaters:

In my professional opinion, several factors make the Noveon-Henry Plant and its associated wastewaters unique as it relates to the Petition for Adjusted Standard. These factors make the wastewaters at The Noveon-Henry Plant more difficult and more costly to treat than either municipal wastewaters or most other industrial wastewaters. These factors are listed below.

First, IEPA has reported that there are only three other plants in the country that generate a similar wastewater. Two of these three plants discharge to a Publicly Owned Treatment Works. Only one of these plants discharges directly to a receiving water. So, the wastewater is not commonly found.

Second, the building block of Noveon's main product line at the facility (rubber accelerators) is MBT (mercaptobenzothiazole). As a building block, it is present in numerous wastestreams throughout the plant sewer system. It is also a well-recognized inhibitor of biological nitrification even at trace levels of 3 ppm as reported by M.L. Hockenbury and C.P.L. Grady in the Journal of the Water Pollution Control Federation in 1977 (see Exhibit B). This compound is poorly degradable as you would hope for a rubber-making additive. No consumer wants to buy readily degradable tires and other rubber products. Because of its poor degradability, MBT is used as an additive to nitrogen fertilizers to inhibit biological nitrification in the soil so that more ammonia nitrogen will be available to the crops (see Exhibit B for article published in the National Corn Handbook, February 1992). However, the large use of this inhibiting compound in production at the Noveon-Henry Plant make the most widely practiced and least expensive ammonia-nitrogen removal process (single stage nitrification) unavailable at the Noveon-Henry Plant. MBT removal is provided in the WWTF Noveon-Henry Plant, just not to the trace levels required to initiate biological nitrification. Consequently, atypical and expensive processes would be required to reduce effluent ammonia-nitrogen concentrations.

Third, the Noveon-Henry Plant and PolyOne Plant contain wastestreams that require pretreatment ahead of the onsite biological treatment plant to prevent process upsets and non-compliance with effluent BOD and TSS limits. Consequently, there is an inherent unreliability with any biological treatment process used onsite whether it is used for BOD removal or nitrification.

Fourth, the Noveon wastewater contains several degradable organic nitrogen compounds such as tertiary butyl amine. When these compounds are degraded, they release ammonia-nitrogen. Consequently, the effluent ammonia-nitrogen concentration increase as the presence of these compounds increase in the influent wastewater and as these compounds are more thoroughly biodegraded. This explains why the influent ammonia-nitrogen concentration at the Noveon-Henry Plant is much less than the effluent concentration (less than 40 mg/L versus greater than 80 mg/L). Consequently, the majority of the effluent ammonia-nitrogen at The Noveon-Henry Plant is due to thorough biological treatment of organic compounds.

Fifth, the compounds present in the Noveon-Henry Plant wastewater make oxygen transfer into this wastewater about half as efficient as municipal wastewater as measured by a parameter known as "alpha". Alpha is the ratio of oxygen transfer in wastewater divided by the oxygen transfer in tapwater. In municipal wastewater this alpha value for fine bubble diffused aeration is typically 0.60 versus the 0.35 measured in the Noveon-Henry Plant wastewater in 1987 by Gerry Shell. Consequently, the Noveon-Henry Plant has to use about twice the horsepower to transfer the same amount of oxygen at municipal wastewater treatment plants. Furthermore, this increased power has to be accompanied by increased aeration tankage to keep operating power levels in a reasonable range.

Sixth, the Noveon-Henry Plant wastewater is lightly buffered. Consequently, if biological nitrification could be implemented with inhibitor control, the majority of alkalinity would have to be added whereas in biological nitrification of municipal wastewater the majority (if not all) of the alkalinity required is present in the wastewater.

Eighth, the Noveon-Henry Plant does not have any additional appreciable power available at the WWTF. Any significant additional power required at the WWTF would require installation of a new motor control center and installation of a new power line to a substation located approximately 0.5 miles away. Consequently, any WWTF upgrade (regardless of magnitude) to address effluent ammonia-nitrogen reduction will require a significant cost of power delivery.

2.0 History of Effluent Ammonia-Nitrogen Reduction Evaluations at the Noveon-Henry Plant

During the last 14 years, Noveon and Brown and Caldwell have conducted extensively evaluated whether there were any feasible technologies that would provide additional effluent ammonia-nitrogen reduction at the Noveon-Henry Plant. These evaluations have consisted of literature review, consultation with additional experts, laboratory-scale treatment investigations, full-scale operations and capital enhancements, and full-scale plant trial investigations. Many of these evaluations were based on results of prior evaluations in an attempt to continue to build on findings of prior evaluations. In my professional opinion, there have been "no relevant stones left unturned". The significant evaluations in which I have participated are summarized below.

2.1 Single Stage Nitrification, Powdered Activated Carbon Addition, Effluent Ion Exchange and Tertiary (Effluent) Nitrification

When I first got involved at the Noveon-Henry Plant in 1989, the focus was on developing a strategy for achieving consistent effluent BOD compliance. Brown and Caldwell conducted continuous flow treatability testing, that I designed and oversaw, that indicated this compliance could be achieved with pretreatment of one major wastestream (C-18). During the course of the treatability studies, we noticed that the WWTF would discharge elevated concentrations of ammonia-nitrogen while providing excellent BOD removal. Despite carefully controlled conditions of F/M, MCRT, pH, temperature and DO that should prompt biological nitrification, none was observed. This indicated that MBT and possibly other bio-inhibitors were present in the influent at sufficient levels to prevent biological nitrification. Batch testing was conducted in early 1989 to determine if powdered activated carbon (PAC) could be added to remove these inhibitors and allow biological nitrification. Furthermore, batch testing also evaluated selective ion exchange treatment (clinoptilolite) of the effluent, and tertiary (effluent) nitrification of the effluent. This work indicated that an untenable, large dose of PAC would be required to allow single stage nitrification (5000 mg/L or 17 tons/day). Because of this finding (untenable carbon usage) and the certainty of fouling problems, no further consideration was given to carbon treatment . This work also indicated that even the most appropriate ion exchange was not selective for ammonia-nitrogen removal due to the other competing cations in the wastewater (approximately 100 pounds resin required to remove 1 pound of ammonia-nitrogen). Lastly, this work suggested that the effluent could be biologically nitrified with yet another or tertiary treatment unit. Consequently, subsequent evaluations considered more thoroughly tertiary nitrification.

2.2 Further Evaluation of Tertiary Nitrification and Pretreatment with Single Stage Nitrification

Based on these results, Noveon's corporate Research and Development group initiated a continuous flow treatability study that focused on tertiary nitrification with alkalinity addition. This work was conducted over about a 6 month period using fixed film biological nitrification and secondary clarifier effluent samples that were collected monthly. The work indicated that tertiary nitrification could be accomplished and low discharge ammonia-nitrogen concentrations (less than 6 mg/L) could be achieved with alkalinity addition and effective performance of upstream treatment processes. There were legitimate concerns about how reliably this process would have performed under the daily variability of secondary clarifier effluent quality.

Brown and Caldwell also initiated a series of batch treatability tests that I designed and oversaw. This testing was to identify if available technologies could be used to remove the bio-inhibitors present in the influent wastewater to the extent that the most widely practiced and least expensive ammonia-nitrogen removal process (single stage nitrification) could be employed. These treatability tests evaluated hydrogen peroxide treatment, clay absorption, and precipitation. However, the rate of biological nitrification was slower than would be expected for an uninhibited system indicating that bio-inhibitors were still present in the effluent from the treatment plant. This work indicated that precipitation and filtration of the Noveon wastewater at pH 2 would allow single stage nitrification to proceed. However, this pretreatment would require significant acid addition to lower the wastewater pH from pH 10 to pH 2 and then significant alkali addition to increase the pH from Ph 2 to pH 7 for biological treatment. The precipitant from the pH 2 pretreatment was analyzed and found to be predominantly MBT (a known nitrification inhibitor).

2.3 Further Evaluation of Pretreatment (pH 2 Precipitation and Solvent Extraction) and Single Stage Nitrification

Based on results of the work described above, Brown and Caldwell conducted a continuous flow treatability study, which I designed and oversaw, to evaluate pH 2 pretreatment of the PC wastewater and single stage nitrification. This study indicated that single stage nitrification could be achieved with this pretreatment. The rate of nitrification was inhibited indicating that some bio-inhibitors still remained in the combined influent. Effluent ammonia-nitrogen concentrations from this process varied from 1 mg/L to 20 mg/L, indicating a variation in remaining influent bio-inhibitor concentrations. It was concluded that this pretreatment process would support single stage nitrification. However, effluent ammonia-nitrogen concentrations would not consistently achieve those limited by 35 ILL. Admin. Code 304.122a or 304.122b.

During this same period of time, Noveon investigated a process used in Germany for MBT recovery. This process used solvent extraction. Results of this investigation reportedly indicated that the process would pose safety concerns (potential for explosions) and would also be cost prohibitive to implement at the Henry Plant (reportedly greater than $10 million).

2.4 Assessment of WWTF for Compliance with Conventional Design for Single Stage Nitrification [35 ILL. Admin. Code 370.1210 and 370.920]

Noveon retained Baxter and Woodman in 1994 to review the WWTF for compliance with the Illinois design standards for single stage nitrification of municipal wastewaters. These standards are intentionally excessive (or conservative) and allow for a significant margin of error in waste load determinations and operating conditions based on my experience. There are no Illinois design standards for single stage nitrification of industrial wastewaters. These industrial design standards are developed on a site specific basis using wastewater characterization data, treatability testing, and professional experience.

The review by Baxter and Woodman indicated the WWTF would comply with the municipal wastewater standards with the addition of about 65 percent more aeration tankage. I was convinced that the WWTF would not provide single stage nitrification with this additional aeration tankage. However, Noveon expanded the aeration tankage in 1998 by 100 percent to provide greater aeration capacity and greater treatment plant flexibility. This addition put the WWTF in full compliance with 35 ILL. Admin. Code 370.1210 and 370.920 and Ten State Standards (which includes Illinois) for single stage nitrification and yet the WWTF did not exhibit any nitrification. The reason nitrification was not achieved was not due to a lack of equipment, but rather the presence of bio-inhibition.

2.5 Alternative Bacteria

IEPA had conducted a literature search and found an article that seemed to imply that special bacteria could be grown in the Noveon-Henry Plant that would both degrade the difficult compounds (such as morpholine) and remove ammonia-nitrogen at the same time. I explained to IEPA that these were not the findings of this article. However, IEPA was persistent that these bacteria could achieve both types of degradation (morpholine and ammonia-nitrogen). Consequently, Noveon brought in the author of this article from England (Dr. Jeremy Knapp). Dr. Knapp reviewed the Noveon-Henry Plant operation. He then explained that the bacteria that he wrote about were already present in the Noveon-Henry Plant based on morpholine removal data he had reviewed and that the conditions present in the Noveon-Henry Plant were suitable for maintaining a culture of these bacteria. He further explained that these bacteria do not provide nitrification. He also explained that the Noveon-Henry Plant provided all the right conditions for single stage nitrification if bio-inhibiting compounds were not present.

Noveon on several occasions has tried adding specialty bacteria to remove difficult to degrade compounds. During these same periods, Noveon has added nitrifying bacteria from the Peoria POTW. In no instance has Noveon been able to initiate nitrification. This indicates that the lack of nitrification is due to inhibitors that are not degraded within the confines of the Noveon-Henry Plant even with special bacteria addition. Furthermore, this Plant offers the biological treatment opportunity that is required by Ten State Standards and 35 ILL. Admin. Code 370.1210 and 370.920 for single stage nitrification.

2.6 Numerous Occasions of Seeding Plant with Nitrifying Bacteria

The Noveon-Henry Plant has been in compliance since 1998 with Ten State Standards and 35 ILL. Admin. Code 370.1210 and 370.920 for single stage nitrification. Since this time, Noveon has added on numerous occasions bacteria from other WWTF that are actively nitrifying. These additions were intended to improve the Noveon-Henry Plant WWTF performance. Yet, in no case has nitrification occurred at the Noveon-Henry Plant despite optimum conditions of MCRT (greater than 30 days), temperature (28 to 32 degrees C), pH (6.8 to 7.5), DO (greater than 2 mg/L). Again, it is my professional opinion that this is due to the presence of bio-inhibiting compounds in the influent.

2.7 Full-Scale Plant Trial of Alkaline Air Stripping to Achieve Effluent Ammonia-Nitrogen Reduction

The Noveon-Henry Plant conducted a full-scale trial of alkaline air stripping of the combined influent. This required Noveon to set up an interim pumping system, caustic addition system, and acid addition system. This interim system diverted all primary clarifier effluent (approximately 560 gallons per minute) to an aeration basin that had been set aside for this testing. Caustic was added to the aeration basin to maintain a target pH value of 10.5. A surface aerator was placed in this basin and operated to assist in air stripping. Effluent from this tank was diverted to a blend tank where the pH was lowered. The blend tank contents were then pumped to the other three aeration basins for biological treatment. This treatment did demonstrate a modest reduction in effluent ammonia-nitrogen (less than 20 percent). This reduction was low, in my opinion, due primarily to the fact that the majority of the effluent ammonia-nitrogen is formed during biological treatment. Secondly, the pH control method was unable to consistently keep the tank contents at or above pH 10.5.

2.8 Full-Scale Trial of Pretreatment and Single Stage Nitrification

Noveon environmental staff conducted a literature search and found an article that indicated that MBT could be co-precipitated with ferric hydroxide at an elevated pH (see Exhibit B). The article indicated that significant removal could be accomplished at pH 4.5 versus the pH 2 pretreatment evaluated by Brown and Caldwell. Noveon conducted a full-scale trial of this pretreatment system in hopes of achieving single stage nitrification. I reviewed the article, believed their was a likelihood of success in this trial, helped design the trial conduct, reviewed data from the trial and witnessed this trial in progress. The trial involved Noveon installing an interim precipitation system and separate sludge dewatering system to treat and segregate pretreatment byproducts (sludge and filtrate from sludge dewatering). The entire PC wastewater discharge (120 gpm) was routed through this system involving ferric chloride addition to lower the PC Tank wastewater to pH 4.5. The pH adjusted water was allowed to separate in interim clarifiers. The treated wastewater was transferred using an interim pumping system to the existing primary treatment system. The precipitated sludge was dewatered using an interim filter press with precoat addition system. The filtrate from sludge dewatering was routed back to the pretreatment system. The pretreatment system was operated for months and did demonstrate significant MBT removal (greater than 50 percent). At the end of this operating period, Noveon brought in a tanker load (5000 gallons) of bacteria from a plant in Indiana that had a high population of active nitrifying bacteria. The bacteria were added to the aeration basins. The pretreatment system continued to operate while Noveon checked for signs of nitrification in the activated sludge system. The activated sludge system was operated under adequate DO, pH, MCRT and alkalinity control to prompt nitrification. No nitrification occurred despite this large investment of resources (greater than $100,000) and time (greater than 4 months). It is my opinion that nitrification did not occur because of the continued presence of bio-inhibiting compounds in the influent (MBT and likely others).

2.9 Consideration of Other Lesser Known Technologies

Another consultant (Ecology and Environment, Inc) was retained to review the work of Brown and Caldwell for Noveon. This consultant believed that all feasible technologies had been considered for effluent ammonia-nitrogen reduction excluding ozonation. A conceptual level design and cost estimate was developed for this treatment process. The process would presumably achieve a 98 percent reduction in effluent ammonia-nitrogen but at a present worth cost of $20.32 million (almost twice the cost of any other process considered). This process would also significantly increase the effluent total dissolved salt concentration due to the caustic addition required to neutralize the acid generated from this process. Additionally, a significant substation upgrade would be required to deliver the additional power consumed (equivalent to approximately 3500 hp demand).

I discovered in 2003 a company in Memphis, Tennessee that had a patented membrane that selectively separated ammonia-nitrogen from wastewater containing little other constituents besides ammonia-nitrogen. This membrane was tested to remove ammonia-nitrogen from a landfill leachate and groundwater stream that was less concentrated in other constituents than the Noveon wastewater. The company concluded after actual testing that the membrane would not be suitable for treating the leachate and groundwater stream due to interference caused by other compounds present in the wastestream. Consequently, I did not further pursue use of this membrane at the Noveon-Henry Plant for effluent ammonia-nitrogen reduction.

2.10 Comparative Performance and Costs of all Proven Effluent Ammonia-Nitrogen Reduction Processes

After approximately 14 years of extensive evaluations by Noveon and Brown and Caldwell, all applicable treatment processes, in my professional opinion, have been considered for effluent ammonia-nitrogen removal. Treatment processes considered went beyond those included in the USEPA Process Design Manual: Nitrogen Control (EPA 625R93010). No stone has gone unturned.

The proven treatment processes described above have been developed by me and support staff well enough to accomplish the following:

- predict potential effluent ammonia-nitrogen reduction,
- understand the pros and cons,
- develop conceptual level designs for their application, and
- develop conceptual level design cost estimates (capital, annual, and present worth costs) for these treatment alternatives to within 30 percent accuracy using available influent waste load data.

The proven treatment processes that were evaluated are listed below.

- Alkaline air stripping (air stripping at pH 10.5) of PC Tank contents with off-gas collection and treatment. Noveon believed this off-gas collection and treatment would be required to comply with air quality regulations. At high pH ammonia-nitrogen exists as a gas dissolved in liquid and can be removed from the liquid by air stripping.

- Alkaline air stripping of PVC Tank contents.

- Alkaline air stripping of secondary clarifier effluent.

- Struvite precipitation of combined influent prior to primary clarification. Ammonia-nitrogen can be precipitated as $NH_4MgPO_4(H_2O)_6$.

- Breakpoint chlorination of secondary clarifier effluent. The addition of chlorine converts ammonia-nitrogen to nitrogen gas that exits the liquid to the atmosphere without the need for air stripping.

- Nitrification of PVC Tank wastewater (non-PC wastewaters). Nitrification is a process by which bacteria convert ammonia-nitrogen to nitrate-nitrogen. The bacteria consume large amounts of oxygen (4.6 lbs oxygen/lb ammonia-nitrogen removed) and alkalinity (7.14 lbs alkalinity/lb ammonia-nitrogen removed).

- Nitrification of the combined wastewater. This process would require pretreatment of the PC wastewater to remove bio-inhibitors.

- Nitrification of secondary clarifier effluent (tertiary nitrification).

- Ion exchange treatment of the final effluent. Ion exchange is a process where another cation (e.g., sodium (Na^+) or hydrogen (H^+) is released from a resin into the water so another cation (NH_4^+) can be removed from the water.

The treatment process evaluation described above is briefly summarized in Exhibits C, D, and E. This evaluation established that the process offering the lowest present worth cost for reducing effluent ammonia-nitrogen was alkaline stripping of the PC Tank contents ($2.31 million). This alternative however would only provide a 27 percent reduction in effluent ammonia-nitrogen. If 35 ILL. Admin. Code 304.122b was applicable, and I strongly believe that it is not, the average effluent ammonia-nitrogen would have to be reduced by 98 percent (135 mg/L reduced to 3 mg/L). Under peak effluent conditions, the effluent ammonia nitrogen reduction would have to exceed 98 percent. The process offering the lowest present worth cost that would be capable of meeting the 98 percent reduction requirement was ion exchange ($5.07 million). However, this process would be complicated to operate, would generate a waste byproduct (liquid ammonium chloride) requiring offsite disposal and would be prone to fouling by scaling and bacterial growth. The next least expensive process capable of achieving 98 percent reduction was breakpoint chlorination ($9.73 million). However, this process poses significant safety and site security concerns (chlorine gas is extremely hazardous), would significantly increase effluent total dissolved salt (TDS) concentrations and therefore would increase effluent aquatic toxicity, and could generate chlorinated organics that could in turn increase effluent aquatic toxicity. Lastly, the next least expensive process capable of achieving 98 percent reduction was nitrification of the combined wastestream as a single stage process ($11.71 million) or as a tertiary process ($11.41 million). Both processes would result in an increase in effluent TDS and both processes would provide variable performance based on the variability of influent bio-inhibiting compounds. At times, neither process would comply with the requirements of 35 ILL. Admin. Code 304.122a and 304.122b (even those these are not applicable to the Noveon-Henry Plant).

2.11 Evaluation of Alternative Methods of Effluent Ammonia-Nitrogen Measurement

Numerous treatment processes were evaluated to reduce effluent ammonia-nitrogen. Effluent ammonia-nitrogen was reduced but with greater difficulty in many cases than expected. This difficulty made me question whether there could be a fundamental error in the measurement of effluent ammonia-nitrogen. The method used by the IEPA laboratory and the outside laboratory used by the Noveon-Henry Plant for effluent compliance monitoring were the same. Both laboratories used the ion selective probe method. This method is recognized by USEPA as registering artificially elevated values in the presence of organic nitrogen compounds. These compounds are likely to be present in the Noveon-Henry Plant effluent. Noveon, at my suggestion, conducted a testing program where the secondary clarifier effluent was analyzed using the historical method without distillation, the historical method with distillation, and the phenate method with distillation. All three methods are approved by USEPA. The last method mentioned was the method least prone to interference by organic nitrogen. Results of this test method indicated a slightly lower value for effluent ammonia-nitrogen with distillation and with the phenate method. However, the average of all values was within 15 percent regardless of the method selected. This finding indicated the historical effluent ammonia-nitrogen concentrations were reasonably accurate and that the historical method could continue to be used with reasonable accuracy to monitor effluent ammonia-nitrogen concentrations. The effluent concentrations measured throughout all treatment evaluations could be considered reasonably accurate. Effluent ammonia-nitrogen reduction had indeed been as difficult to achieve as measured.

3.0 OTHER ISSUES RAISED BY IEPA

3.1 GAC Treatment of Influent

GAC (granular activated carbon) has been used to remove inhibitors from wastewaters and one of the inhibitors (possibly the predominate inhibitor) is removable by GAC. So, at face value this suggestion appears reasonable. However, several factors render it non-practical. First, the influent does contain some organics that are readily degradable such as isopropyl alcohol and ethanol. These readily degradable organics would cause bacteria to grow on the GAC column and slime over the

GAC pore spaces rendering the GAC unavailable for removal of inhibitors. Second, the inhibitors are not the only compounds in the influent that would be adsorbed by the GAC prior to being slimed over. Recall that 5000 mg/L PAC or 17 tons/day was required to prompt nitrification. Consequently, the GAC usage (even if sliming were not an issue) would be excessive in the order of tons/day.

3.2 Implication that Noveon has not implemented any Ammonia-Nitrogen Removal Measures

Noveon has installed in-plant recovery devices and instituted pollution prevention plans to minimize the discharge of organic nitrogen (such as tertiary butyl amine) to the WWTF which have been converted to ammonia-nitrogen through biological treatment had such recovery not been provided. Noveon has even been recognized by the State of Illinois for progress in pollution prevention (Annual Governor's Award for Pollution Prevention in 1999, 2002, and 2003 with Governor's Citation Award for Pollution Prevention in 1998). Second, the Noveon-Henry Plant has consistently removed ammonia-nitrogen through its WWTF as a nutrient required for BOD removal (approximately 0.04 lbs ammonia-nitrogen removed/lb BOD removed). BOD-removing bacteria are more tolerant of inhibitors than are nitrifying bacteria. Without this BOD removal, Noveon would discharge approximately an additional 20 mg/L ammonia-nitrogen in the final effluent. The Noveon wastewater just contains more ammonia-nitrogen than required as a nutrient for BOD removal. Lastly, it should be noted that Noveon has exerted significant effort in conducting two full-scale trials in an attempt to demonstrate a WWTF modification that would provide effluent ammonia-nitrogen reduction. One trial provided less than a 20 percent reduction and the other trial provided no reduction.

3.3 Attempt to Compare Cost of Ammonia-Nitrogen Removal between Noveon and Others

As described in 1 above, the Noveon-Henry Plant has several unique features that render its cost of providing ammonia-nitrogen removal more expensive than others. The comparisons made by the IEPA considered only the capital costs of single stage nitrification. Operations and maintenance (annual) costs were not included in the comparison. However, as noted in **Exhibit C,** these annual costs for Noveon would be significant. The facilities used in the comparisons by the IEPA were likely required to add little or no chemicals to achieve nitrification whereas the Noveon-Henry Plant would be required to spend $788,000 annually on chemicals alone. This high chemical cost is due to chemicals required for the pH 2 pretreatment process (acid to lower the pH and caustic to raise the pH for biological treatment) and caustic required providing the alkalinity consumed in nitrification. This yields a present worth chemical only cost of $5.29 million excluded from the cost comparisons made by IEPA (based on a 10 year project life). IEPA suggested that a 20 year project life would be more representative. Under this project life, the present worth cost of chemicals would increase to $7.73 million. Either way, this is a significant omission in cost comparisons. In addition, this does not include the added operating cost that Noveon would have related to pretreatment system operations and increased aeration horsepower. Only present worth cost comparisons are meaningful when there is a significant difference in operating costs as is the case here. In my professional opinion, there is no doubt that single stage nitrification at the Noveon-Henry Plant would be far more expensive on a present worth basis than any facility the IEPA used in its comparisons.

It is likely that a present worth cost comparison of these facilities would reveal that the cost of ammonia-nitrogen removal is less than $0.20/lb (the surcharge cost imposed by the Knoxville Utility Board on ammonia-nitrogen is $0.12/pound of ammonia-nitrogen) for the POTWs. The present worth cost for Noveon to implement single stage nitrification is $3.60/lb to $2.32/lb (depending on whether a 10 year or 20 year project life is assumed, respectively) of ammonia-nitrogen reduced or 18 to 12 times the cost for facilities of the type described by the IEPA.

4.0 INCREMENTAL COST OF PROVIDING EFFLUENT AMMONIA-NITROGEN REDUCTION

The IEPA suggested that they would be more supportive of Noveon's Petition for Adjusted Standard if some effluent ammonia-nitrogen removal were provided. It is my professional opinion that IEPA has failed to recognize that the Noveon-Henry Plant already provides effluent ammonia-nitrogen reduction through source control practices and ammonia-nitrogen removal accomplished in BOD removal. Nevertheless, Noveon requested that Brown and Caldwell calculate the cost of incrementally providing effluent ammonia-nitrogen reduction. I personally developed the basis for this cost analysis and reviewed and approved the process by which they were calculated. In some cases incremental effluent ammonia-nitrogen would be accomplished by treating only a portion of the wastewater. In other cases, it would be accomplished by sizing the treatment vessel to only provide partial treatment. The results of this exercise are summarized in **Exhibit D**.

These results indicated that even a 25 percent reduction in effluent ammonia-nitrogen would have a present worth cost of $1.8 million to $ 3.9 million depending upon the treatment process selected. More importantly, the 25 percent reduction would not achieve compliance with 35 ILL. Admin. Code 304.122b assuming it applied and it does not apply.

5.0 SUMMARY

The Noveon-Henry Plant currently provides effluent ammonia-nitrogen reduction through source control and removal associated with BOD removal nutrient requirements. In my professional opinion, any further reduction in effluent ammonia-nitrogen is not required by 35 ILL. Admin. Code 304.122 if IEPA approves Noveon's installation of an effluent diffuser. This diffuser will allow a more uniform distribution of the effluent from the WWTF in the Illinois River and will allow water quality criteria to be maintained. Both 304.122a and 304.122b do not apply because the Noveon-Henry Plant clearly has an untreated wasteload with a population equivalent less than 50,000 based on all relevant calculations.

Consequently, no effluent limitations and therefore no additional effluent ammonia-nitrogen reductions are required by this Code.

Extensive efforts have been made by Noveon and its consultants over the last 14 years in examining effluent ammonia-nitrogen reductions. These extensive improvements and studies have not been taken to seek compliance with 35 ILL. Admin. Code 304.122. They have been undertaken in good faith to resolve disputes with the IEPA and to evaluate whether there were any feasible technologies that would provide additional effluent ammonia-nitrogen reduction.

The findings of effluent ammonia-nitrogen reduction efforts have been shared with IEPA and are summarized in **Exhibits C, D, and E**. These findings show the following:

- The Noveon-Henry Plant has at least eight unique characteristics that render it unusually difficult and expensive to achieve any further ammonia-nitrogen removal.

- Every proven treatment process for effluent ammonia-nitrogen reduction has been considered by the Noveon-Henry Plant, even one that was in the developmental stages.

- Noveon has had several consultants evaluate effluent ammonia-nitrogen removal. These have included a well-respected Illinois firm, a nationally-recognized engineering firm, and a research professor from England.

- No treatment technology was found by IEPA or any of these consultants that could provide significant effluent ammonia-nitrogen reduction (greater than 50 percent) for a present worth cost of less than $5.0 million. Even a 25 percent effluent ammonia-nitrogen reduction had a present worth cost of at least $1.8 million. Neither of these removals is required to comply with 35 ILL. Admin. Code 304.122a or 304.122b since they are not applicable to the Noveon-Henry Plant.

- The present worth cost of installing single stage nitrification, like facilities IEPA used in cost comparisons, was $11.7 million. This cost when compared to the surcharge cost imposed by a POTW on ammonia-nitrogen indicated that the Noveon-Henry Plant costs for ammonia-nitrogen removal would be 18 times greater than that for a POTW. This cost difference was not revealed in IEPA analysis due a lack of consideration given to disproportionate operating costs.

In my professional opinion, Noveon has gone far beyond that which Illinois regulations require in evaluating effluent ammonia-nitrogen removal. Good faith and a willingness to work with IEPA have been demonstrated. Fourteen years and considerable resources have been applied in effort to find an agreeable position with IEPA. Such an agreement was not reached. Noveon's Petition for Adjusted Standard is reasonable and should be supported by the Board in conformity with Illinois regulations.

CERTIFICATE OF SERVICE

The undersigned certifies that a copy of the foregoing **Notice of Filing** and Written Expert Testimony of Houston Flippinwas filed by hand delivery with the Clerk of the Illinois Pollution Control Board and served upon the parties to whom said Notice is directed by first class mail, postage prepaid, by depositing in the U.S. Mail at 191 N. Wacker Drive, Chicago, Illinois on Friday, February 6, 2004 and facsimile.

Exhibit A

EXHIBIT A

RESUME OF T. HOUSTON FLIPPIN, P.E., DEE

Principal Engineer
Wastewater Department

T. Houston Flippin, P.E., DEE

Assignment

Capacity Evaluation

Education

M.S., Environmental and Water Resource Engineering, Vanderbilt University, 1984

B.E., Civil and Environmental Engineering, Vanderbilt University, 1982

Registration

Professional Engineer: Tennessee, Illinois, Kentucky, and Michigan

Diplomate: American Academy of Environmental Engineers

Experience

20 years

Joined Firm

1984

Relevant Expertise

- Developing site specific operating guidelines and treatment capacities.
- Developing cost savings for treatment plants.
- Training client staff in process operations and troubleshooting.

Experience Summary

Houston Flippin has 20 years of experience in industrial and municipal wastewater management. Mr. Flippin is particularly adept at maximizing treatment process performance. This is due to years of conducting, evaluating, and developing full-scale process design and operating guidelines from bench-, pilot- and full-scale wastewater treatment studies. These studies have evaluated both biological and physical/chemical processes for treating waters, wastewaters, and sludges laden with conventional pollutants, priority pollutants, and aquatic toxicants. Mr. Flippin has used this experience to both develop treatment cost savings (capital and operating) while maintaining reliable effluent compliance and to negotiate more reasonable effluent limits. His "hands on" experience and his talent for communication has made him a frequent workshop lecture, client staff trainer, and negotiator. Recent work on the industrial side has involved developing innovative, reliable and cost-effective pretreatment processes and minimizing upgrade costs of treatment lagoon systems. Recent work on the municipal side has involved rerating capacities of POTWs using site-specific data, developing cost saving actions for aeration and sludge handling, and developing staff reorganization plans to enhance productivity. Mr. Flippin also has experience in potable water treatment, stormwater permitting, wasteload surveys, and waste minimization.

Organic Chemicals, Herbicides and Pesticides

Process Design, Start-up Assistance and Operator Training, Ciba-Geigy Corporation

Lead Engineer and Author. Responsible for an on-site treatability studies, process design development, and final report for the treatment of wastewaters discharged from Ciba-Geigy Corporation's largest U.S. organic chemicals manufacturing complex including pesticides. The project began by evaluating conversion of the existing aerated lagoon system to activated sludge. This conversion was necessary to meet effluent requirements under higher loading conditions and to meet RCRA closure requirements of on-site surface impoundments. This evaluation involved an activated sludge treatability study evaluating the impact of varying total dissolved solids concentrations (0.5 percent to 2.5 percent), temperatures (8°C to 20°C) and RCRA regulated stream discharge contributions. A process design for the aerated lagoon/activated sludge conversion was developed, presented, and implemented. Mr. Flippin developed materials for and assisted in the operator training course which preceded startup of the activated sludge plant. A follow-up treatability study was conducted and focused on TKN, TOC, acute toxicity and color reduction through the use of PACT® treatment as compared to tertiary GAC treatment. Special batch treatability testing evaluated alternative source control methods for a highly colored wastestream. A process design was developed to meet revised treatment objectives, a final report was issued, and a new WWTF was constructed. Startup assistance and operator training were provided for both WWTFs.

Process Design, Rhodia, Mount Pleasant, Tennessee

Lead Engineer and Author. Responsible for an treatability studies, process design development, and final report for the treatment of herbicide wastewaters. Treatments evaluated impact of photolytic decomposition, carbon adsorption, and macroreticular resins. Solution implemented included minor treatment and recycle of waters. Site converted to a nearly zero discharge operation.

POTW Impact and Discharge Negotiations, American Cyanamid, Barceloneta, Puerto Rico

Lead Engineer and Author. Responsible for an treatability studies that evaluated impact of herbicide and pesticide wastestreams on POTW. Testing indicated no adverse impact on BOD removal, nitrification, and sludge quality at the desired discharge rates. Results of testing were used to negotiate allowed discharges of these wastestreams to the POTW without pretreatment.

WWTF Troubleshooting, Zeneca Fine Chemicals, Mount Pleasant, Tennessee

Lead Engineer and Author. Responsible for treatability studies that evaluated impact of various organic chemical, herbicide and pesticide wastestreams on site's biological wastewater treatment facility (WWTF). Developed approach for screening impact of new wastestreams on the WWTF. Prescribed maximum allowable discharge rates of each process waststream to prevent upset of the WWTF.

Pulp and Paper

Comprehensive Wastewater Management Plan, Chesapeake Corporation, West Point, Virginia

Lead Engineer, Field Team Manager, and Author. Developed a comprehensive wastewater management plan for a Chesapeake Corporation 1,800 tpd integrated mill. Wastewater characterization studies defined sources and distribution of waxes through the pulping and paper making process, the impact of secondary fiber production on WWTF solids management, the impact of bleaching process chlorine substitution on influent wasteloads, effect of separate and combined settling of pulp mill and paper mill wastewaters, and impact of various equalization basin sizes and modes of operation on influent load dampening. Batch treatability tests evaluated alternative primary clarification schemes, alternative site applications of dissolved air flotation (DAF) for wax removal and solids recovery, impact of CO_2 stripping/coagulation and flocculation on pure oxygen activated sludge settleability and impact of secondary fiber on activated sludge settling properties. Continuous flow treatability studies evaluated the effects of secondary fiber production, secondary fiber wastestream DAF pretreatment, aeration basin temperatures, slimicide loadings and bleaching plant chlorine substitution on pure oxygen activated sludge plant performance (particularly sludge settleability). The continuous flow treatability studies also involved evaluation of several types of biological selectors to control filamentous sludge bulking: aerobic, two-stage aerobic, anoxic/anaerobic, and extended anoxic/anaerobic. Elements of this project were presented by Mr. Flippin at the 1992 TAPPI Environmental Conference.

Lagoon Modeling and Upgrade Evaluation, Confidential Client, Midwest

Lead Engineer. Developed alternative upgrade measures for a wastewater treatment lagoon system to accommodate increased wasteload while not exhibiting H_2S emissions. One alternative was based on operating the lagoons without oxygen and nutrient deficiencies and thus achieving greater BOD removal rates. This alternative was based on treatability data. The second alternative was based on operating the lagoons under oxygen and nutrient limitations, which decreased BOD removal rates but minimized upgrade requirements. Extensive full-scale system data was used to develop a model for evaluating system performance under alternative conditions. The project is currently in the final design stage.

Hazardous Waste

Groundwater Remediation Process Design, FLTG, Incorporated, Crosby, Texas

Project Manager and Lead Engineer. Responsible for a groundwater remediation project for a company formed by 80 principle responsible parties. This Superfund site groundwater treatability investigation considered how best to upgrade the existing treatment facility. Air stripping, peroxidation, ozonation, ultrafiltration, carbon adsorption, resin adsorption, and anaerobic degradation separately and in conjunction with activated sludge treatment were considered. Following a series of batch and continuous flow treatability tests, activated sludge treatment followed by granular activated carbon treatment was selected as the most cost-effective means of achieving discharge targets. In addition, a cost-effective sludge treatment and disposal plan were developed.

Textiles

Toxicity Reduction Evaluation/Toxicity Identification Evaluation, Globe Manufacturing, Gastonia, North Carolina

Project Manager, Lead Engineer, and Author. Managed a wastewater pretreatment project where the industrial discharge was cited as the source of the POTW's effluent aquatic toxicity problem. Treatability tests were conducted which screened the effects of the following treatment processes on effluent toxicity reduction: air stripping, cation exchange resin, activated silica, macroreticular resin, granular activated carbon, and biohydrolysis.

Results of these tests and further desktop evaluations indicated the biotoxicant was ethylene diamine and that activated sludge treatment would provide the most cost-effective treatment. Continuous flow treatability studies were used to develop the process design for the selected process. Submitted design basis report for the pretreatment facility, reviewed final design drawings and specifications, and provided startup assistance. The pretreatment facility eliminated all acute and chronic toxicity associated with the wastestream discharge at its flow contribution to the POTW. Elements of this project were published in *Water Science Technology*, Volume 29, No. 9 (1994).

Food Processing

Waste Minimization, Quaker Oats, Newport, Tennessee

Project Manager, Lead Engineer, and Author. Developed a waste minimization plan for a Quaker Oats facility. On-site wastewater characterization studies coupled with interview of site personnel were used to develop practical, cost-effective waste minimization recommendations. Implementation of the plan resulted in significant reduction of product losses and sewer pretreatment surcharges.

Combined Municipal/Industrial Wastewater Management

ISP Chemicals, Calvert City, Kentucky

Principal Engineer/ Site CSM: Investigation of the impact of eight waste streams on the onsite activated sludge process.

Clariant Corporation, Elgin, South Carolina

Provided alternative treatment system analyses prior to the construction of a Greenfield wastewater treatment facility.

Cooperative and Cost Effective Wastewater Treatment, Ryan Foods Company, Murray, Kentucky

Project Manager and *Principal Engineer.* Worked with City of Murray and industry to develop a "win-win" strategy for minimizing wastewater treatment costs for both the City and industry. Early estimates by the City's consultant had indicated that the POTW would have to spend approximately $10 million to accommodate the discharge wasteload on the POTW with Ryan Foods at maximum loading (and without pretreatment). Estimates indicated that Ryan Foods would have to spend $3 million to meet the limits requested by the City if pretreatment were to be installed. A review of pertinent information indicated the opportunity for significant savings by both parties. Treatability studies were conducted and POTW performance data were reviewed. This work indicated that a much less costly approach could be taken. A final design was developed for the pretreatment facility and installed at a cost of $1.6 million. The pretreatment facility reduced the wasteload by approximately70 percent. However, the remaining wasteload to the POTW exceeded the "rated capacity" of the POTW. A site-specific analysis was conducted and used to rerate the capacity of the POTW. A major component of this analysis was sludge stabilization and alternative disposal methods. This rerating allowed the POTW to gain an additional 29 percent in rated capacity for a cost of $0.7 million. So, in the end, the City of Murray and Ryan Foods both saved more than $1 million each. The City also received definition of alternative sludge disposal methods and a description of the incremental upgrades that would be required in the future as the "real rated capacity" of the POTW was approached.

Municipal Wastewater Management

Change Management Program, Metro Water Services, Nashville, Tennessee

Assistant Task Manager for Operations Group. Worked with client to identify cost-saving action items to reduce annual O&M costs at two water treatment plants and three wastewater treatment plants. The purpose in these reductions was to render the plants' operating costs competitive with that estimated by private contractors and thus "stave off privatization." Annual savings of greater than $1,000,000 were identified. Currently serving as advisor to teams implementing savings regarding sludge thickening and dewatering and aeration. In addition to this work, have assisted client in process troubleshooting which has allowed client to avoid effluent non-compliance.

Petrochemical and Synthetic Fuels

Safety Kleen Corporation, East Chicago, Indiana

Lead Engineer, Project Manager, and Author. Responsible for on-site wastewater treatment facility (WWTF) process troubleshooting and training to facilitate compliance with pretreatment limits at this facility, one of the largest oil re-refineries in the world. Treatability studies and process design were required for WWTF modifications to accommodate increased production and more stringent pretreatment limits.

Brown and Caldwell provided sampling and analytical procedures modified for cyanide, ammonia, and orthophosphate analyses. A more comprehensive and site-specific procedure was implemented to evaluate the chemical conditioning requirements of the mixed liquor. "In situ" oxygen transfer was determined to assess upgrade requirements.

Treatability studies were conducted. The effects of operating temperature (30°C to 60°C) and F/M ratio (0.1 lb COD/lb MLVSS • day to 0.7 lb COD/lb MLVSS • day) on activated sludge settleability and effluent quality were evaluated. The effects of steam stripping, as a pretreatment step, on activated sludge system performance were evaluated. Metals precipitation with lime, alum and caustic was studied as a pretreatment and post treatment process. High pH air stripping and breakpoint chlorination were examined as effluent NH3-N reduction technologies. Effluent peroxidation and ozonation were evaluated as a means of providing effluent total phenolics reduction. The use of a biological selector and chemical conditioning (e.g., coagulation and flocculation) were investigated as means of improving sludge settleability.

A process design to upgrade the existing WWTF was provided and included a four stage, aerobic biological selector, temperature and pH control, coagulation, flocculation, increased RAS pumping capacity, breakpoint chlorination and tertiary filtration. Final design guidance was provided on selection of equipment for the biological selector and tertiary filtration.

Booth Oil Company, Buffalo, New York

Lead Engineer and Author. Responsible for wastewater sampling program to define treatment process limitations under increased future loading conditions. Treatability testing was conducted to evaluate alternatives for controlling total phenolics discharge. Both improvements in oil/water separation and hydrogen peroxide treatment were considered. A report presenting alternatives for upgrading WWTF operations and for prioritizing capital improvements was presented.

Groundwater Remediation Process Design, FLTG, Incorporated, Crosby, Texas

Project Manager and Lead Engineer. Responsible for a groundwater remediation project for a company formed by 80 principle responsible parties (almost exclusively petrochemical industries and refineries). The groundwater at this site exhibited an influent COD of approximately 600 mg/L and had free product present. A groundwater treatability investigation was conducted to determine how best to upgrade the existing treatment facility. Air stripping, peroxidation, ozonation, ultrafiltration, carbon adsorption, resin adsorption, and anaerobic degradation separately and in conjunction with activated sludge treatment were considered. Following a series of batch and continuous flow treatability tests, activated sludge treatment followed by granular activated carbon treatment was selected as the most cost-effective means of achieving discharge targets. In addition, a cost-effective sludge treatment and disposal plan were developed.

Reilly Industries, Lone Star, Texas

Lead Engineer, Project Manager and Author. Responsible for a two-tiered project at this coal tar plant. Treatability studies were conducted and process designs were developed for alternative wastewater treatment facility upgrades that would allow plant to meet more restrictive pretreatment limits. A work plan was developed in cooperation with TNRCC that would allow the POTW to seek permit relief which in turn would allow the plant to not require WWTF upgrades.

Permitting

Hunt Foods (formerly Quaker Oats), Newport, Tennessee
Project Manager and *Principal Engineer* on project involving wasteload minimization, pretreatment facility design and negotiation of pretreatment limits.

Laidlaw (formerly Osco, Inc), Nashville, Tennessee
Project Manager and Principal Engineer on project involving pretreatment facility design, startup, troubleshooting, and pretreatment permit negotiations.

J. Hungerford Smith, Humboldt, Tennessee
Principal Engineer on project involving pretreatment facility design, POTW upgrade design, and pretreatment permit negotiations.

Ryan Foods Company, Murray, Kentucky
Project Manager and *Principal Engineer* on project involving pretreatment facility design, construction management, startup, operator training, POTW upgrades, pretreatment permit negotiations, and negotiation of re-rated capacity of POTW with Kentucky Division of Water.

BF Goodrich Performance Materials, Henry, Illinois
Project Manager and Principal Engineer on project involving treatment facility design, startup, operator training, treatment facility troubleshooting and NPDES permit negotiations with Illinois EPA. Meeting with Illinois Water Pollution Control Board is pending.

ISP Chemicals, Texas City, Texas
Project Manager and Principal Engineer on project involving modifying existing NPDES permits for stormwater and wastewater. Project also involved conduct of testing to get adjusted metals limits.

OxyVinyls (formerly Geon Canada), Niagara Falls, Ontario, Canada
Project Manager and Principal Engineer on project involving treatment facility troubleshooting, operator training, and "NPDES equivalent" permit negotiations.

Confidential Client, Barceloneta, Puerto Rico
Project Manager and Principal Engineer on project involving treatability testing and pretreatment permit negotiations.

Toxicity Reduction

Thiokol Corporation, Brigham City, Utah
Lead Engineer on effluent toxicity identification evaluation (TIE) followed by toxicity reduction evaluation (TRE) as a part of treatability studies for a newly designed WWTF. The new WWTF replaced two existing WWTFs that were abandoned. Acidification, air stripping, alkalinization, chemical

reduction with sodium thiosulfate, filtration, granular activated carbon, ion exchange (anion and cation), macroreticular resin, and metal complexing with EDTA, were evaluated as a means of achieving effluent toxicity reduction for a selected wastestream. High salinity was identified as the toxicant. The client decided to blend the selected wastestream with other wastestreams causing a decrease in wastewater salinity and an increase in wastewater BOD. Activated sludge treatment followed by ozonation as a means of toxicity reduction and disinfection was determined to provide consistent compliance with effluent BOD and toxicity limits. A process design was provided. The newly designed WWTFs included grit removal, equalization, activated sludge treatment, granular media filtration and ozonation. The final design for the WWTF was reviewed for consistency with the process design.

Confidential Client, Indiana

Lead Engineer and Project Engineer A Toxicity Identification Evaluation (TIE) was conducted for a large-volume producer of metal ingots and sheet aluminum. The TIE used Phase I laboratory characterization procedures, single stream toxicity testing, and resynthesis testing with major wastestreams treated for toxicity removal. Both *Ceriodaphnia* and the fathead minnow were used in acute tests throughout the study. Study results indicated that adsorptive organic compounds associated with an internal waste treatment process were primarily responsible for toxicity. Pure chemical tests with the wastewater treatment polymer used at the site indicated that the polymer may play a role in effluent toxicity.

A Toxicity Reduction Evaluation (TRE) work plan was also conducted for the client to develop a means to cost-effectively reduce effluent toxicity as required by the State. Services included wasteload characterization and wastewater treatment facility (WWTF) optimization.

Memberships

National Society of Professional Engineers (NSPE)

Technical Association of the Pulp and Paper Industry (TAPPI)
  Water Quality Committee Member

Water Environment Federation
  Pretreatment Committee Member

Chi Epsilon - National Civil Engineering Honor Society

Publications/Presentations

"Enhanced Activated Sludge Treatment of High Strength Bio-inhibitory Industrial Wastewater" with R. Rhoades, 10th Annual WEF Industrial Wastes Technical and Regulatory Conference, Philadelphia, Pennsylvania, August 2004.

"Treatment Alternatives for Removing Ammonia-Nitrogen from Landfill Leachate" with R.E. Ash and B.N. Card, Annual Tennessee Solid and Hazardous Waste Conference, Gatlinburg, Tennessee, April 2004.

"Alternative Considerations in Sizing Aeration Basins" with W. W. Eckenfelder, Design, Performance and Operation of Biological Treatment Processes Pre-Conference Workshop, Vanderbilt University and USEPA Conference, "Industrial Wastewater and Best Available Treatment Technologies: Performance, Reliability, and Economics", Nashville, Tennessee, February 2003.

"Modifying Equalization to Provide Pretreatment of High Strength Wastewaters" with D.A. Moye, 19th Annual North Carolina AWWA/WEF Conference Proceedings, Winston-Salem, North Carolina, November 2002.

"Benefits of Using Nitrate as Nutrient in Activated Sludge Treatment Systems" with W. W. Eckenfelder and D.A. Moye, 8th Annual WEF Industrial Wastes Technical and Regulatory Conference, Atlantic City, New Jersey, August 2002.

"Biological Treatment of High TDS Wastewaters," with W. W. Eckenfelder and V. J. Boero, Water Environment Federation- Industrial Waste Technical and Regulatory Conference, Charleston, South Carolina, August 2001.

"Competitive Performance for Water and Wastewater Utilities," with J.L. Pintenich, Nashville Quality Forum, Nashville, Tennessee, October 1999.

"Reclaiming POTW Capacity," with M.L. Roeder, American Society of Civil Engineers-Tennessee Section Annual Meeting, Nashville, Tennessee, October 1999.

"Batch Activated Sludge Testing to Determine The Impact of Industrial Discharges on POTW Performance", with J.S. Allen, *Proceedings of 1998 WEF Industrial Wastes Specialty Conference*, Nashville, Tennessee, March 1998.

"Economics of Treating Poorly Degradable Wastewaters in the Chemical Industry," with K.D. Torrens, *Proceedings of 1998 WEF Industrial Wastes Specialty Conference*, Nashville, Tennessee, March 1998.

"Effects of Elevated Temperature on the Activated Sludge Process," with W.W. Eckenfelder, Jr., *Proceedings of 1994 TAPPI International Environmental Conference*, Portland, Oregon, April 1994.

"Toxicity Identification and Reduction in the Primary Metals Industry," presented at *Spring AIChE Conference*, Atlanta, Georgia, April 1994.

"Treatability Studies and Process Design for Toxicity Reduction for a Synthetic Fiber Plant," with J.L. Musterman, *Water Science Technology*, Vol. 29, No. 9 (1994).

"Granular Carbon Adsorption of Toxics," technical review of chapter four in *Toxicity Reduction in Industrial Effluents*, P. W. Lankford and W. W. Eckenfelder, Jr. (Eds), Van Nostrand Reinhold, 1992.

"Diagnosing and Solving a Pulp and Paper Mill's Poor Activated Sludge Settleability Problems Through Treatability Studies," with M. A. Bellanca, *Proceedings of 1992 TAPPI Environmental Conference*, Richmond, Virginia, 1992.

"Hydrogen Peroxide Pretreatment of Inhibitory Wastestream – Bench Scale Treatability Testing to Full Scale Implementation: A Case History," with R. L. Linneman, *Proceedings of Chemical Oxidation: Technology for 1990's*, Vanderbilt University, Nashville, Tennessee, 1991.

"Control of Sludge Bulking in a Carbohydrate Wastewater Using a Biosorption Contactor," with W. W. Eckenfelder, Jr. and M. A. Goronszy, *Proceedings of the 39th Annual Purdue Industrial Waste Conference*, 1984.

Research Topics

Biodegradation of PCBs and HCB, research conducted at ECKENFELDER INC.

Volatile Organic Compound Emissions from Activated Sludge Systems, research conducted at ECKENFELDER INC.

Performance of Selective Bacteria in Industrial Activated Sludge Systems, research conducted at Vanderbilt University

Biosorption for Improved Reactor Capacity, research conducted at Vanderbilt University

Control of Activated Sludge Bulking Through the Use of a Biosorption Contactor, research conducted at Vanderbilt University

Workshops

Instructor, Tennessee State University, "Monitoring Requirements, Operating Guidelines, Calculations, and Troubleshooting," presented during "Aerobic Biological Wastewater Treatment Workshop," Nashville, Tennessee, November 1997, April 1998, November 1998, and April 1999. N

Instructor, Mississippi Water Pollution Control Operators' Association, Inc., "Clarifier Operation and Maintenance Workshop," Tunica, Mississippi, April 1997.

Instructor, Brown and Caldwell, "Activated Sludge Wastewater Treatment Workshop, " attended by participants from over 3 municipalities and 10 industries, Nashville, Tennessee, November 1999, March 2000, May 2001, November 2002, and November 2003.

Instructor, Tulane University and Louisiana Chemical Association, "Wastewater Strategies for Industrial Compliance: Gulf Coast Issues and Solutions", New Orleans, Louisiana, December 2003.

Honors

Who's Who of Citation's Environmental Registry, 1991

Eckenfelder Inc. Technical Employee of the Year Award, 1990

Outstanding Young Men of America, 1986

Exhibit B

EXHIBIT B

PERTINENT ARTICLES FROM LITERATURE REVIEW

NATIONAL
CORN
HANDBOOK

CROP FERTILIZATION **NCH-55**

Nitrification Inhibitors for Corn Production

D. W. Nelson, University of Nebraska
D. Huber, Purdue University

Reviewers
K. D. Frank, Univesrity of Nebraska
R. G. Hoeft, University of Illinois
D. R. Keeney, University of Wisconsin
G. L. Malzer, University of Minnesota
G. W. Randall, University of Minnesota
W. I. Segars, University of Georgia
J. T. Touchton, Auburn University
L. F. Welch, University of Illinois (retired)
H. F. Reetz, Jr., Potash & Phosphorus Institute, Illinois

Nitrogen (N) is an essential element for plant growth and reproduction. The amounts of N taken up by corn exceed those of any other soil-derived element. Today an average 25% of plant-available N in soils (ammonium and nitrate) originates from the decomposition (mineralization) of organic N compounds in humus, plant and animal residues, and organic fertilizers, 5% from N in rainfall, and 70% from applied inorganic N fertilizers (Figure 1). In soils, organic N is converted to ammonium through microbial decomposition. Ammonium formed in soil, added as fertilizer, or in precipitation is rapidly oxidized to nitrate in the nitrification process carried out by specific bacteria. Nitrification results in the production of nitrate, a form of plant-available N which is readily lost from soils. Nitrification inhibitors are chemicals that slow down or delay the nitrification process, thereby decreasing the possibility that large losses of nitrate will occur before the fertilizer nitrogen is taken up by plants. This publication discusses N losses from soils, characteristics of nitrification inhibitors, and how nitrification inhibitors can be used to improve efficiency of corn production.

THE NITRIFICATION PROCESS

Ammonium (NH_4^+) added to soils or formed by decomposition of organic N compounds is oxidized to nitrite (NO_2) by *Nitrosomonas* bacteria, and nitrite is further oxidized to nitrate (NO_3) by *Nitrobacter* bacteria in a process termed nitrification (Figure 1). Nitrate is normally the form of N taken up by plants; however, most plants can also assimilate ammonium. In most soils, nitrification of applied ammonium is rapid (2-3 weeks), but nitrification rates are greatly reduced by cool soil temperature (50°F), low pH (5.5), and waterlogged conditions. Nitrification converts ammonium, a positively charged ion that is bound to clay and organic matter, to nitrite and nitrate, negatively charged ions that are free in the soil solution and are readily lost from the plant rooting zone of soils.

N LOSS FROM SOILS

Only about 50% of the applied N is taken up by corn during the year following fertilizer addition. About 25% is immobilized during residue decomposition or remains in the soil as nitrate. The remaining 25% is lost from the plant rooting zone by leaching and/or dentrification. (See Table 1 for a generalized estimate of the fate of fertilizer N added to soils.) Some of the immobilized N will be mineralized (5% per year) and will be available to subsequent crops. Nitrate remaining in the profile at the end of the cropping season will be available to the succeeding crop unless lost over the winter and spring by leaching or dentrification.

Leaching is important in coarse-textured soils. Nitrate may be leached from naturally well-drained or tile-drained soils by percolating water. One inch of infiltrating water will move nitrate 1 to 2.5 inches downward in clay loam and sandy soils, respectively. Thus, during periods of excess rainfall, leaching may move nitrate out of the effective rooting zone of plants.

Denitrification (the microbiological conversion of nitrate and nitrite to gaseous forms of N) is the major pathway of N loss from most fine-textured soils. It normally occurs in soils that become waterlogged by

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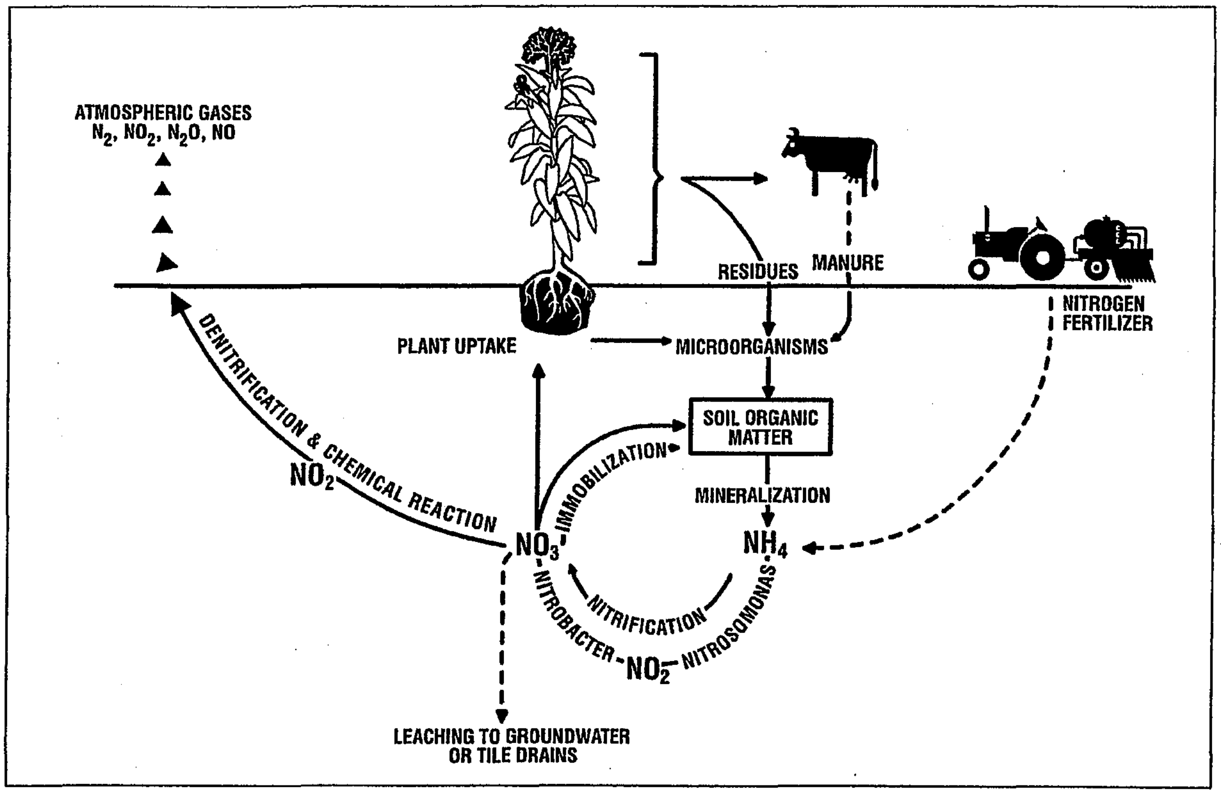

Figure 1. The nitrogen cycle in soils (adapted from Nitrogen in Agricultural Soils).

excessive rainfall or irrigation. Denitrification occurs at maximum rates when soils are warm (60°F), pH values are high (7), nitrate is plentiful, and an energy source (carbon) is available. In waterlogged soils, more than 100 lb. of nitrate N per acre can be denitrified within a 5-day period. However, in cold soils (40°F) or soils with low pH values (5), denitrification rates are slow.

TYPES AND USES OF NITRIFICATION INHIBITORS

Nitrification inhibitors (NI) are chemicals that reduce the rate at which ammonium is converted to nitrate by killing or interfering with the metabolism of *Nitrosomonas* bacteria (Figure 1). The loss of N from the rooting zone can be minimized by maintaining applied N in the ammonium form during periods of excess rainfall prior to rapid N uptake by crops. A number of compounds have been shown to inhibit nitrification in laboratory and field studies (Table 2); however, only N-Serve® and Dwell® have U.S. Environmental Protection Agency approval for use on cropland in the United States. Additional compounds are used in Japan and other countries; and registration is expected for additional compounds in the U.S.

N-Serve is currently labeled for corn, sorghum, wheat, cotton, rice, and other crops and is sold in emulsifiable and nonemulsifiable formulations. Dwell was registered as a nitrification inhibitor in 1982, but it is uncertain if the product will be marketed. Both chemicals are effective nitrification inhibitors when 0.5 lb. of active ingredient (a.i.) per acre is used in a band application with anhydrous ammonia or N solution fertilizers.

Table 1. Generalized Fate of Fertilizer Nitrogen Applied to Corn.[1]

	Soil texture	
Fate of applied N	**coarse**	**medium and fine**
	------% of applied N------	
Plant uptake (first year)	40 - 60	50 - 60
Remains in soil as organic and inorganic N	20 - 25	25 - 30
Lost from root zone:		
Denitrification	5 - 10	15 - 25
Leaching	15 - 20	0 - 10

[1] Average values over years for soils in the Cornbelt and southeastern U.S. and irrigated soils of the Great Plains and western valleys.

N-Serve and Dwell may also be impregnated on solid fertilizers or mixed with N solution fertilizers prior to broadcast applications. However, incorporation of the nitrification inhibitor-treated fertilizer must occur shortly after application because both compounds are volatile. Higher rates (2 to 4 times band applications) of N-Serve and Dwell are often required to control nitrification of broadcast ammoniacal fertilizers. Recent studies have shown that NI can also be effectively used with liquid animal manures and sewage sludges that are injected into the soil.

Table 2. Compounds Marketed or Proposed as Nitrification Inhibitors.

Chemical name	Common or trade name	Manufacturer	Registered in the U.S.A.
Produced commercially:			
2-chloro-6-(trichloromethyl)-pyridine	N-Serve	Dow Chemical Co.	Yes
5-ethoxy-3-trichloromethyl-1, 2, 4-thiadiazol	Dwell, Terrazole (etradiazol)	Uniroyal Chemical	Yes
Dicyandiamide	DCD	SKW Trostberg AG	No
2-amino-4-chloro-6-methyl-pyrimidine	AM	Mitsui Toatsu Co.	No
2-mercapto-benzothiazole	MBT	Onodo Chemical Industries	No
2-sulfanilamidothiazole	ST	Mitsui Toatsu Co.	No
Thiourea	TU	Nitto Ryuso	No
Proposed as nitrification inhibitors:			
2,4-diamino-6-trichloromethyl-5-triazine	--	Amer. Cyanamid Co.	No
Polyetherionophores	--	Amer. Cyanamid Co.	No
4-amino-1, 2, 4-triazole	--	Ishihara Industries	No
3-mercapto-1, 2, 4-triazole	--	Nippon Gas Indus.	No
Potassium azide	--	Pittsb. Plate Glass Co.	No
Carbon bisulfide	--	Imperial Chem. Indus.	No
Sodium trithiocarbonate	--	Imperial Chem. Indus.	No
Ammonium dithiocarbamate	--	FMC	No
2, 3, dihydro-2, 2-dimethyl-7-benzofuranol methyl-carbamate	Furadan (carbofuran)	FMC	No
N-(2, 6-dimethylphenyl)-N-(Methoxyacetyl)-alanine methyl ester	--	Olin Corp.	No
Ammonium thiosulfate	--	--	No
1-hydroxypyrazole	--	BASF	No
2-methylpyrazole-1-carboxamide	CMP	GDR	No

EFFECTS OF NITRIFICATION INHIBITORS

A number of studies throughout the United States have demonstrated that NI effectively retards the conversion of ammonium to nitrate in a variety of soils. Results indicate that application of NI delays the conversion of ammonium to nitrate for 4 to 10 weeks, depending upon soil pH and temperature. With fall applications of N fertilizers, NI minimize nitrification until low soil temperatures (40°F) stop the process. With spring applications, NI prevent the formation of nitrate during the late spring when rainfall is high and uptake of N by crops is low.

Corn yields are often increased as N losses from soils are reduced by the application of NI with both conventional tillage and reduced tillage systems (Table 3). The potential benefit from NI application depends on a number of site-specific factors, such as soil type, climate, cultural practices, and N management program. Highest probability of yield response from NI occurs with excessively drained or poorly drained soils because of N losses from leaching and denitrification, respectively. For example, a study in Indiana with fall-applied anhydrous ammonia showed that N-Serve application increased corn yields by 300% with a very poorly drained silty clay soil and 1% with a well-drained sandy loam soil. Significant corn yield responses from NI addition have also been observed with irrigated sandy soils (Table 4). Yield responses from NI are more frequent with fall N applications than with spring applications because of lower N losses from denitrification normally experienced when fertilizers are applied nearer to the time of crop need. There have been consistent yield responses from NI added to ammoniacal fertilizers for corn produced with a no-till system, presumably because of larger N losses from denitrification normally experienced with this production method.

The increased availability of inorganic N and the presence of ammonium in the soil resulting from NI addition also have been shown to increase the protein concentration of corn grain (Table 5). The feeding value of corn increases as the protein level increases. The application of NI to inorganic and organic N fertilizers also has reduced the severity of *Diplodia* and *Gibberella* stalk rots of corn, likely because of altered N metabolism in plants assimilating the ammonium form of N (Table 6). Corn stalks in areas receiving NI-treated fertilizers tend to remain green later in the growing season and have thicker rinds, both of which reduce pathogen effects and lodging. Grain moisture content at harvest is unaffected by NI addition to fertilizers.

The amounts of nitrate leached into groundwater and ozone-destroying nitrous oxide (N_2O) emitted into the atmosphere through denitrification are reduced by NI application. The use of NI also gives great flexibility in timing the application of N fertilizers. For example, with most Cornbelt soils all of the N needed for a corn crop can be applied as anhydrous ammonia during

Table 3. Effects on Grain Yields of Corn Grown with Conventional and No-Till Systems from Addition of Nitrification Inhibitors to Fall- and Spring-Applied Ammoniacal Fertilizers.[1]

Location	Time of application	No. of experiments	No. of yield increases from NI[2]	% Yield increase from NI[3]
Indiana	Fall	24	17	12.5
	Spring	51	29	5.8
	Spring (no-till)	12	9	10.0
No. Illinois	Fall	12	5	5.0
	Spring	14	2	-1.0
So. Illinois	Fall (NH_3)	7	7	4.6
	Spring (NH_3)	9	7	4.6
	Spring (no-till)	2	2	8.5
	Fall (N solution)	5	4	3.3
	Spring (N solution)	5	2	-1.2
Kentucky	Spring (no-till)	8	7	14.3
Wisconsin	Fall	2	1	4.7
	Spring	2	0	1.5

[1] Adapted from R. G. Hoeft 1984. Current status of nitrification inhibitors. In R. O. Hauck (ed.) Nitrogen in Crop Production. Am. Soc. of Agronomy, Madison, WI.

[2] Significant at 95% probability level.

[3] Average percent yield increase across all N rates and locations.

the previous fall if a NI is used, thereby reducing the workload in the critical spring planting season. The use of NI permits early spring application of N in many areas of the United States where N losses are a consistent problem.

Data in Table 3 show that NI addition does not result in yield increases in all soils and climatic conditions. In fact, in some situations there is a low probability of a corn yield increase from NI. Since the purpose of NI application is to increase the efficiency and amount of N available to plants by reducing N losses, no response to NI will be obtained during seasons or with soil types having little or no N loss. Little or no N loss occurs during seasons with below average rainfall following N application because N loss through leaching and denitrification is directly related to the amount and distribution of rainfall and the drainage characteristics of the soil.

No yield response will be obtained from NI addition when N rates used are far in excess of those required for maximum yield. For example, if maximum corn yields could be obtained with 150 pounds of N per acre but 300 pounds per acre are applied, as much as one-half of the applied N could be lost before a decrease in yield occurs. Late side-dress injections of N may reduce yield through mechanical damage to the root system and increased root rot. Immobilization of late-season applied N with a NI may further exacerbate this condition.

In sandy soils with very low cation exchange capacities, the addition of NI to ammoniacal fertilizers may not reduce N loss or increase crop yield because of differential movement of ammonia and NI from the zone of placement. Some studies have shown that ammonium ions were leached below the NI treated zone by rainfall and irrigation water. In this situation, nitrification deeper in the profile produced nitrate that was subsequently removed from the rooting zone by leaching.

Table 4. Effects of Nitrification Inhibitors on the Yield of Irrigated Corn Fertilized with Urea. (Hubbard Loamy Sand).[1]

	Nitrification Inhibitor		
N rate	None	N-Serve	Dwell
lb/acre	------corn yield, bu/acre------		
0	59	--	--
60	89	119	98
120	105	151	145
180	136	170	171
240	171	182	186

[1] Taken from G. L. Malzer, T. J. Graff, and J. Lensing. 1979. Influence of nitrogen rate, timing of nitrogen application and use of nitrification inhibitors for irrigated spring wheat and corn. In Univ. Minn. Soil Series 105 Report on Field Research in Soils.

Table 5. Effect of a Nitrification Inhibitor on Corn Grain Protein Concentration.[1]

	Treatment	
N applied	NH_3	NH_3 + N Serve
lb/acre	------grain protein, %------	
0	6.76	--
60	7.76	9.24
120	9.38	10.60
180	10.80	11.71

[1] Study conducted in Indiana using B73 x Mo17 corn hybrid.

Table 6. Effects of a Nitrification Inhibitor on Stalk Rot of Corn.[1]

No. of	N	Treatment	
studies	source	N	N + N Serve
		------% plants with stalk rot[1]------	
3	NH_3	38	16
4	Swine manure	54	23

[1] Average values for all locations, years, and N rates from studies in Indiana.

WHERE SHOULD NITRIFICATION INHIBITORS BE USED?

The response of corn to applications of NI with ammoniacal fertilizers varies greatly throughout the United States because of major differences in N loss potential from differing climate, soils, and production systems. A summary of research results on corn yield responses from NI addition for various corn production regions is presented in Table 7, and the probabilities for obtaining a yield response from NI for several combinations of region, soil texture, and time of fertilizer application are given in Table 8. The addition of NI to fertilizer should be looked upon as insurance against N loss, and, thus, a decision to use NI should be based on the probability of obtaining yield increases over a period of time, e.g., 5 years. The usefulness of NI for corn production in three general regions of the United States is discussed below.

Southeast

The response of corn to NI applications in the southeastern United States has been mixed. The relatively high soil temperatures during the winter result in nitrification of fall-applied N and subsequent leaching or denitrification of the nitrate that is formed. The addition of NI does not alleviate this problem because of the limited longevity of the currently registered inhibitor compounds in soil and the long period of time between N application and crop uptake of the nutrient. Thus, yield responses to NI added to fall-applied fertilizers have not been consistently observed. A number of studies have shown modest corn yield increases from the addition of NI to spring-applied N even though inhibitor persistence is limited by high soil temperatures. Overall, the probability of corn yield response from currently available NI in the southeastern U.S. is poor for fall-applied N and fair to poor for spring-applied N.

Eastern Cornbelt

The response of corn to NI application has been more consistent over years in the eastern Cornbelt than other portions of the United States because of high rainfall, finer textured soils, and cold soil temperatures during the winter. However, overall only about 50 and 70% of the trials with spring- and fall-applied N have shown yield response from NI. Yield responses have been obtained with both spring- and fall-applied N in Indiana, Kentucky, Ohio, and southern Illinois. The consistency of yield responses to NI has been less in Michigan, Wisconsin, Missouri, central and northern Illinois, and Iowa than in other eastern Cornbelt states. However, all states in the eastern Cornbelt have studies showing corn yield increases from NI addition, and the largest and most consistent increases are normally observed with fall-applied N or with non-tillage programs.

There is a good probability of obtaining a yield increase from application of NI to fall-applied ammoniacal fertilizers in the eastern Cornbelt because of the large N loss normally associated with fall applications. The use of NI will allow producers to apply N fertilizers somewhat earlier than generally considered feasible (50°F is traditionally considered the maximum soil temperature for application of ammoniacal fertilizers in the fall without a NI). Fall application of N is not recommended for low CEC coarse-textured soils because of the possibility of ammonium leaching.

The probability is good that NI added to spring-preplant N will increase yields of corn growth on fine-textured soils of the eastern Cornbelt because of the likelihood of N losses by denitrification after fertilization. Only a fair probability exists for a yield response to NI added with spring-preplant N applied to silt loams and coarser textured soils. The probability of loss in such soils depends upon the nitrification rate following fertilization, the internal drainage of the soil, and the distribution and intensity

Table 7. Regional Summary of Corn Yield Responses from Nitrification Inhibitors Added to Ammoniacal Fertilizers Appled at Varying Times.[1]

Region	Time of application	% of studies with yield increase	% yield increase[2]
Southeast (GA, MD, NC, SC, TN)	Fall	17	14
	Spring	43	15
Eastern Cornbelt (IL, IN, OH, KY)	Fall	69	9
	Spring	51	3
	Spring (no-till)	82	13
Northern Cornbelt (MI, MN, WI) not irrigated	Fall	25	5
	Spring	17	12
Western Cornbelt (KS, MN, NE) irrigated coarse-textured soils	Spring	52	30
Western Cornbelt (KS, NE) irrigated medium- and fine-textured soils	Spring	10	5

[1] Data taken from a variety of research progress reports and published materials.

[2] Average increases obtained in experiments where NI addition gave significant yield increases.

of rainfall. Heavy rains occurring 2 to 8 weeks after fertilization may result in extensive N losses and yield responses to NI application. However, if a below average rainfall period follows fertilization, little N loss or response to NI will occur.

Western Cornbelt

Few yield responses to NI have been observed with dryland corn or irrigated corn produced on fine-textured soils in Minnesota, North Dakota, South Dakota, and other states west of the Missouri river. However, the use of NI has resulted in increased yields in areas where preplant N is applied to irrigated corn grown on sandy soils. Data from Minnesota (Table 4) illustrate the type of responses that are sometimes obtained when a NI is used to reduce nitrate leaching in irrigated sandy soils.

There is poor probability of yield response with spring-applied fertilizer for dryland corn production in the western Cornbelt; however, with irrigated coarse-textured soils the probability of a yield increase improves. There is a fair probability of a response to NI with fall applied fertilizer on finer textured soils. Fall application of ammoniacal fertilizers is not recommended for sandy soils.

ADDITIONAL CONSIDERATIONS WHEN USING NITRIFICATION INHIBITORS

More consistent yield responses have been obtained with no-till grown corn than with conventional tillage systems fertilized in the spring (Tables 3 and 8). This finding results from greater infiltration rates, higher water contents, a higher population of denitrifying bacteria in no-till soils and, thus, increased N losses from leaching and/or denitrification.

The probability of yield responses to NI added to spring-sidedress-applied N is considered low for all soils because the fertilizer is added close to the time of plant uptake. However, a few investigators in the eastern Cornbelt have observed significant yield increases from NI added to early sidedressed N fertilizers. Additional studies are needed at several locations in all corn-growing regions to determine the long-term probability of a response to NI application with sidedress N should exist on coarse-textured soils receiving excess rainfall or irrigation water.

The commercially available NI have properties that affect how they can be added to various types of fertilizers. N-Serve and Dwell can be impregnated on solid fertilizers, or an emulsifiable formulation may be mixed with N solution fertilizers. N-Serve can be added directly to bulk anhydrous ammonia because of its high solubility in liquid ammonia. However, Dwell is not soluble in ammonia, but can be added to anhydrous ammonia with a small electric pump that meters the compound into the ammonia stream between the nitrolator and the manifold system on the applicator.

Table 8. Probability of Corn Yield Increase from the Addition of NI to Ammoniacal Fertilizers Applied at Varying Times.

		Region of the U.S.		
Soil texture	Application time	Southeast	Eastern Cornbelt	Western Cornbelt
		---Probability of corn yield increase[1]---		
Sands	Fall	Poor	Poor	Poor
	Spring	Fair	Fair	Fair[2]
Loamy sands, sandy loams, and loams	Fall	Poor	Fair	Poor
	Spring	Fair	Fair[3]	Fair[2]
Silt loams	Fall	Poor	Good	Fair
	Spring	Fair	Fair[3]	Poor
Clay loams and clays	Fall	Poor	Good	Fair
	Spring	Fair	Good	Poor

[1] Poor = less than 20% chance of yield increase at any location any year; fair = 20-60% chance of increase; good = greater than 60% chance of increase.

[2] Fair for irrigated soils, poor for dryland corn.

[3] Good for no-till production systems.

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File: Agronomy 2-2

Exhibit C

EXHIBIT C

SUMMARY DOCUMENT OF EFFLUENT AMMONIA-NITROGEN REDUCTION EVALUATIONS FOR NOVEON-HENRY PLANT

BROWN AND
CALDWELL

MEMORANDUM

TO: Mark Latham, Esq. **JOB NO:** 27-21522.001

FROM: T. Houston Flippin, P.E., DEE

DATE: May 17, 2002

SUBJECT: Ammonia-Nitrogen Treatment Alternatives Support Exhibit

Brown and Caldwell is providing below a summary of information intended to support the discussion of ammonia-nitrogen (NH_3-N) treatment alternatives described in the Petition For Adjusted Standard. This information is the product of treatability testing, full-scale plant testing, and data provided by the Noveon-Henry Plant staff.

In order to develop treatment alternatives, a "design influent and effluent wasteload" was required. This wasteloads were developed based on individual wastestream data gathered in 1995 and effluent data gathered in 1999 through 2000 and are summarized below in Tables 1 and 2. A flow schematic is provided in Attachment A of the wastewater treatment facility (WWTF) provided at the Henry Plant.

Table 1. Influent Wasteload Used In Developing Treatment Alternatives

Parameter	PVC Tank	PC Tank	C-18 Tank	Holding Pond/ Well No. 3 Waters	Total
Flowrate, gpm					
Average	401	107	6	46	560
Peak	499	150	15	105	769
SCOD, lbs/day					
Average	2,650	8,280	1,320	50	12,300
Peak	4,330	10,840	2,940	50	18,160
Estimated BOD, lbs/day					
Average	795	2,485	395	15	3,690
Peak	1,300	3,250	880	15	5,445
TKN, lbs/day					
Average	459	494	82	3	1038
Peak	640	693	198	7	1537
NH_3-N, lbs/day					
Average	295	62	27	1	385
Peak	411	87	66	3	571

Table 2. Effluent Wasteload Used In Developing Treatment Alternatives

Parameter	Effluent Value
NH_3-N, lbs/day	
Average	909
Peak	1408

The following treatment alternatives were considered for ammonia reduction. Illustrations of each are provided in Attachment A.

- alkaline air stripping of PC Tank contents with off-gas collection and treatment (No. 1)
- alkaline air stripping of PVC Tank contents (No. 2)
- alkaline air stripping of secondary clarifier effluent (No. 3)
- struvite ($NH_4MgPO_46H_20$) precipitation from combined influent (No. 4)
- breakpoint chlorination of secondary clarifier effluent (No. 5)
- nitrification of PVC Tank wastewater (non-PC wastewaters) (No. 6)
- nitrification of combined wastewater (No. 7)
- ion exchange treatment of final effluent (No. 8)
- ozonation of final effluent (No.9)
- nitrification of secondary clarifier effluent (tertiary nitrification) (No. 10)

A summary of conceptual level capital costs for each of these alternatives are summarized in Table 3. The total costs presented in this table are considered accurate to within ± 30 percent.

Table 3. Capital Cost Estimates For Treatment Alternatives

	Upgrade Costs in $ Millions for Treatment Alternative Number									
Upgrade Components	1	2	3	4	5	6	7	8	9	10
Pretreatment	0.65	0.10	0.00	0.05	0.00	0.02	0.43	0.00	0.00	0.00
Primary Treatment	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
Secondary Treatment	0.00	0.00	0.00	0.00	0.00	1.12	1.91	0.00	0.00	0.00
Tertiary Treatment			4.21		0.75			0.57	4.6	4.00
Sub-total	0.65	0.10	4.21	0.05	0.75	1.39	2.34	0.57	4.6	4.00
Sitework/Interface Piping	0.10	0.01	0.32	0.01	0.11	0.21	0.35	0.09	0.20	0.50
Electrical/Instrumentation	0.25	0.16	0.40	0.16	0.26	0.36	0.50	0.24	0.50	0.30
Contractor Indirects (8 %)	0.05	0.01	0.34	0.00	0.06	0.11	0.19	0.05	0.37	0.32
Engin./Constr. Mgmt (18 %)	0.12	0.02	0.76	0.01	0.14	0.25	0.42	0.10	0.83	0.72
Performance Bonds (1 %)	0.01	0.00	0.04	0.00	0.01	0.01	0.02	0.00	0.05	0.04
Sub-total	1.17	0.30	6.07	0.22	1.33	2.33	3.82	1.04	6.54	5.88
Contingency (15 %)	0.18	0.04	0.91	0.03	0.20	0.35	0.57	0.16	0.98	0.88
Total Installed Cost	1.35	0.34	6.98	0.25	1.53	2.68	4.40	1.20	7.52	6.76

A summary of conceptual level operations and maintenance costs for each of these alternatives are summarized in Table 4. The total costs presented in this table are considered accurate to within ± 30 percent.

Table 4. Annual Operating and Maintenance Cost Estimates For Treatment Alternatives

	Annual O/M Costs in $ Thousands for Treatment Alternative Number									
Cost Components	1	2	3	4	5	6	7	8	9	10
Labor ($40/hour)	32	32	60	8	60	60	60	60	30	60
Electrical ($0.06/kwh)	64	29	214	0	4	10	98	10	1,363	88
Natural Gas ($0.06/therm)	18	0	0	0	0	0	0	0	0	0
Chemicals (Plant Costs)	0	1,794	575	642	1,028	218	788	147	226	459
Resin Replace. ($35/cu ft)	0	0	0	0	0	0	0	242	0	0
Off-site Disposal[a]	0	0	0	0	0	0	0	51	0	0
Maintenance Materials[b]	17	2	105	1	19	11	45	14	115	22
Sub-total	130	1,858	954	652	1,111	299	990	524	1,735	629
Contingency (10 %)	13	186	95	65	111	30	99	52	173	63
Total Annual	143	2,044	1,049	717	1,222	329	1,089	576	1,908	692

[a] Cost of disposing of spent regenerant containing 29.7 percent by weight NH_4Cl (8 percent N) assumed to be $0.10/gallon.
[b] Based on 5 percent of equipment costs.

A comparison of alternatives regarding present worth costs and ammonia removal is provided in Table 5.

Table 5. Comparison of Present Worth Costs and Ammonia Removal for Treatment Alternatives

	Treatment Alternative Number									
Components	1	2	3	4	5	6	7	8	9	10
NH_3-N Removal, lbs/day	247	147	864	217	891	423	891	891	891	891
NH3-N Removal, %	27	16	95	24	98	47	98	98	98	98
Present Worth Costs										
• Capital	1.35	0.34	6.98	0.25	1.53	2.68	4.40	1.20	7.52	6.76
• O/M[a]	0.96	13.71	7.04	4.81	8.20	2.20	7.31	3.87	12.80	4.64
• Total	2.31	14.06	14.02	5.06	9.73	4.88	11.71	5.07	20.32	11.41

[a] Based on 10 year period, 8 percent annual interest, and no salvage value.

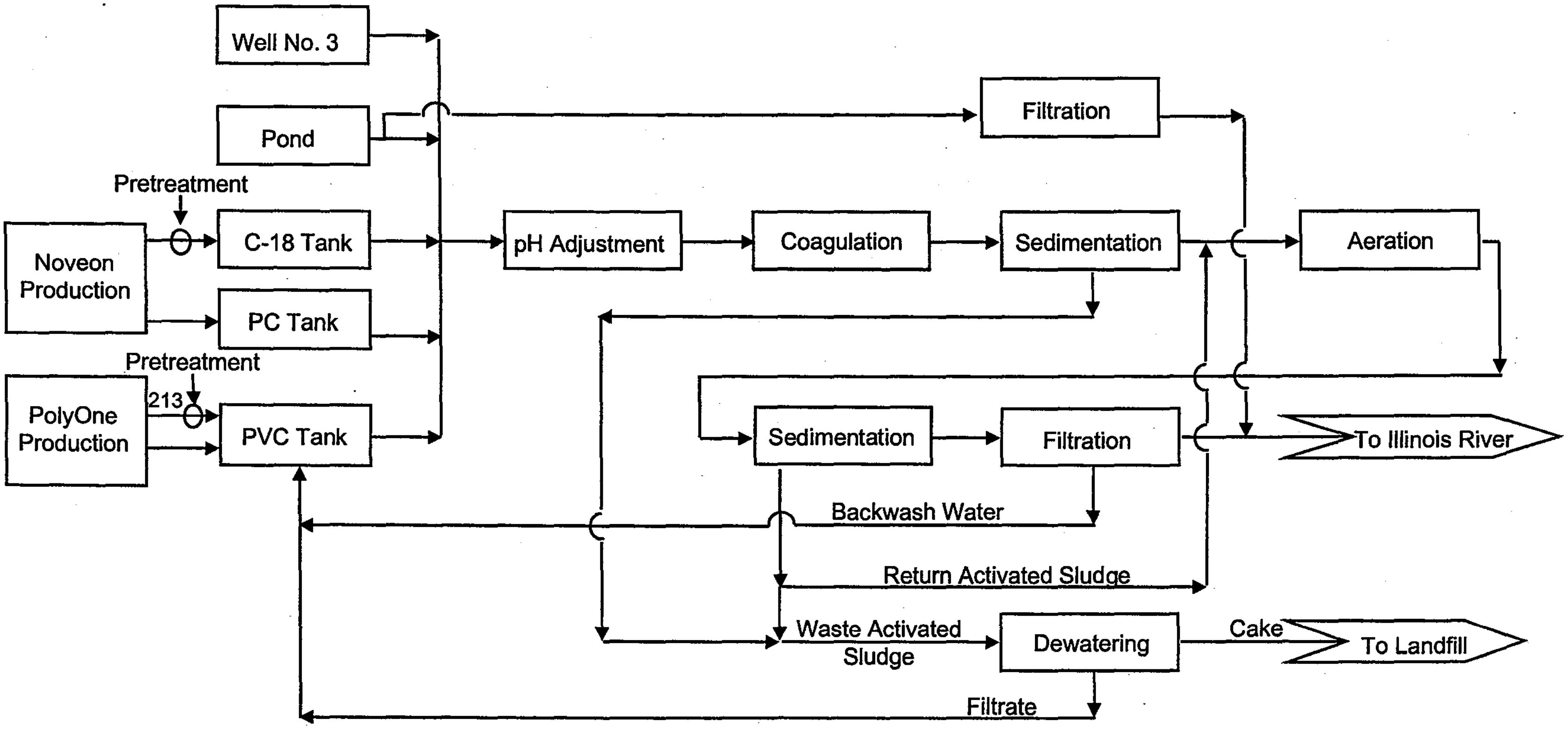

FIGURE 1

BLOCK FLOW DIAGRAM OF WASTESTREAM SOURCES AND WWTF

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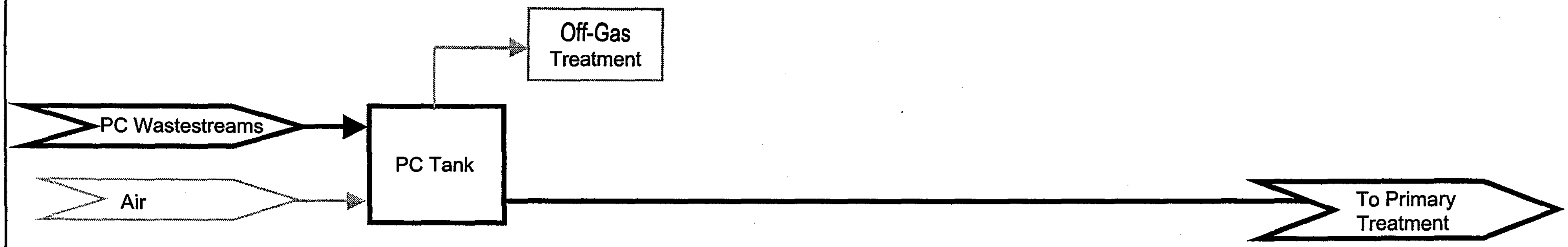
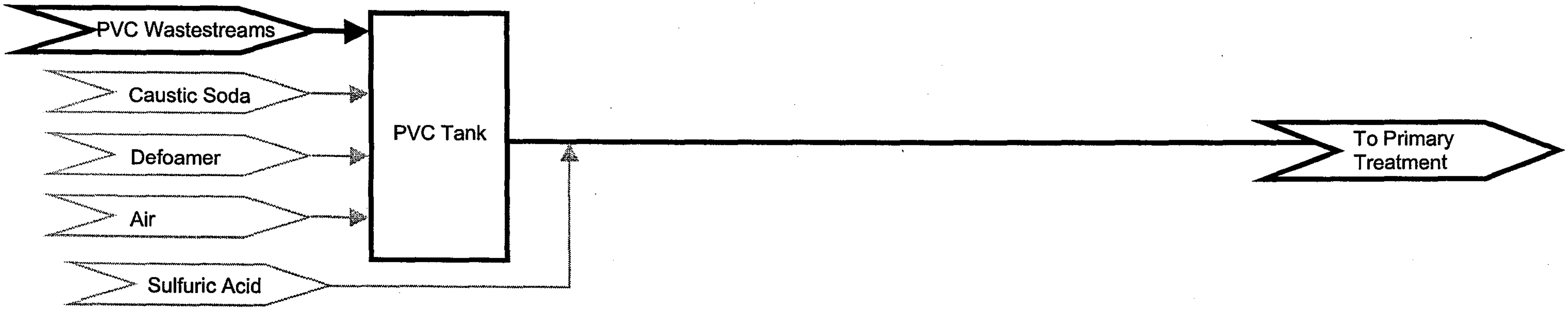
CALDWELL

Nashville, Tennessee

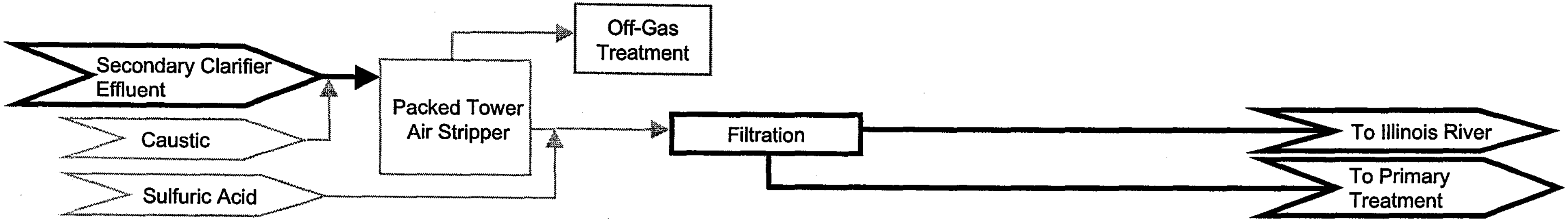
P:/PROJ/21522/Fig 1



ALTERNATIVE NO.1 - ALKALINE AIR STRIPPING OF PC TANK CONTENTS



ALTERNATIVE NO. 2 - ALKALINE AIR STRIPPING OF PVC TANK CONTENTS



ALTERNATIVE NO. 3 - ALKALINE AIR STRIPPING OF SECONDARY CLARIFIER EFFLUENT

▬ **Existing Equipment**

▭ **New Equipment**

P:/PROJ/21522/Fig 2

FIGURE 2

BLOCK FLOW DIAGRAM OF ALKALINE AIR STRIPPING TREATMENT ALTERNATIVES (Nos. 1, 2, and 3)

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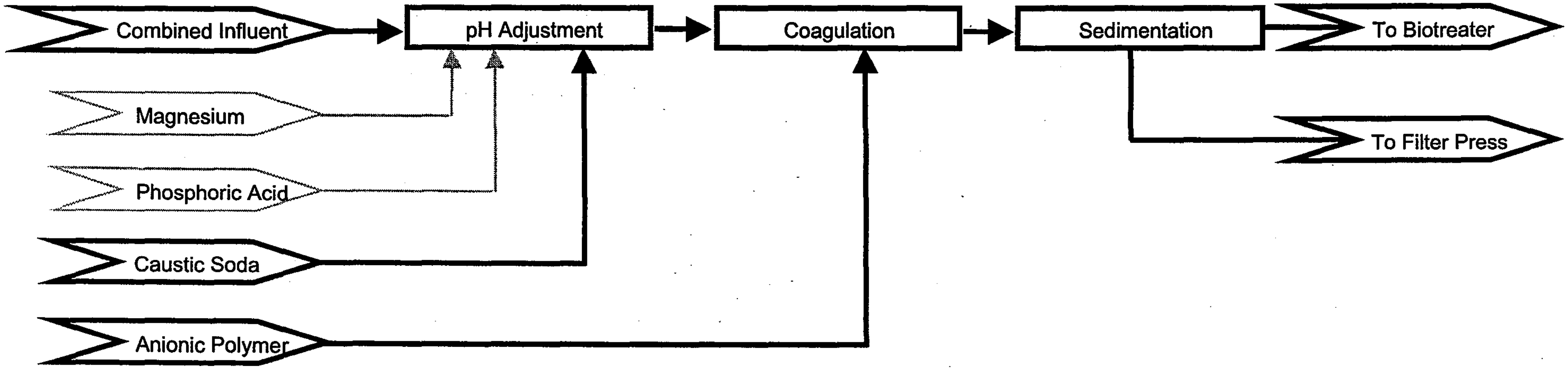


NOTE: Existing $FeCl_3$ Addition would be discontinued

▭ Existing Equipment
▭ New Equipment

FIGURE 3

BLOCK FLOW DIAGRAM OF STRUVITE PRECIPITATION TREATMENT ALTERNATIVE (No. 4)

BROWN AND CALDWELL

Nashville, Tennessee

P:/PROJ/21522/Fig 3

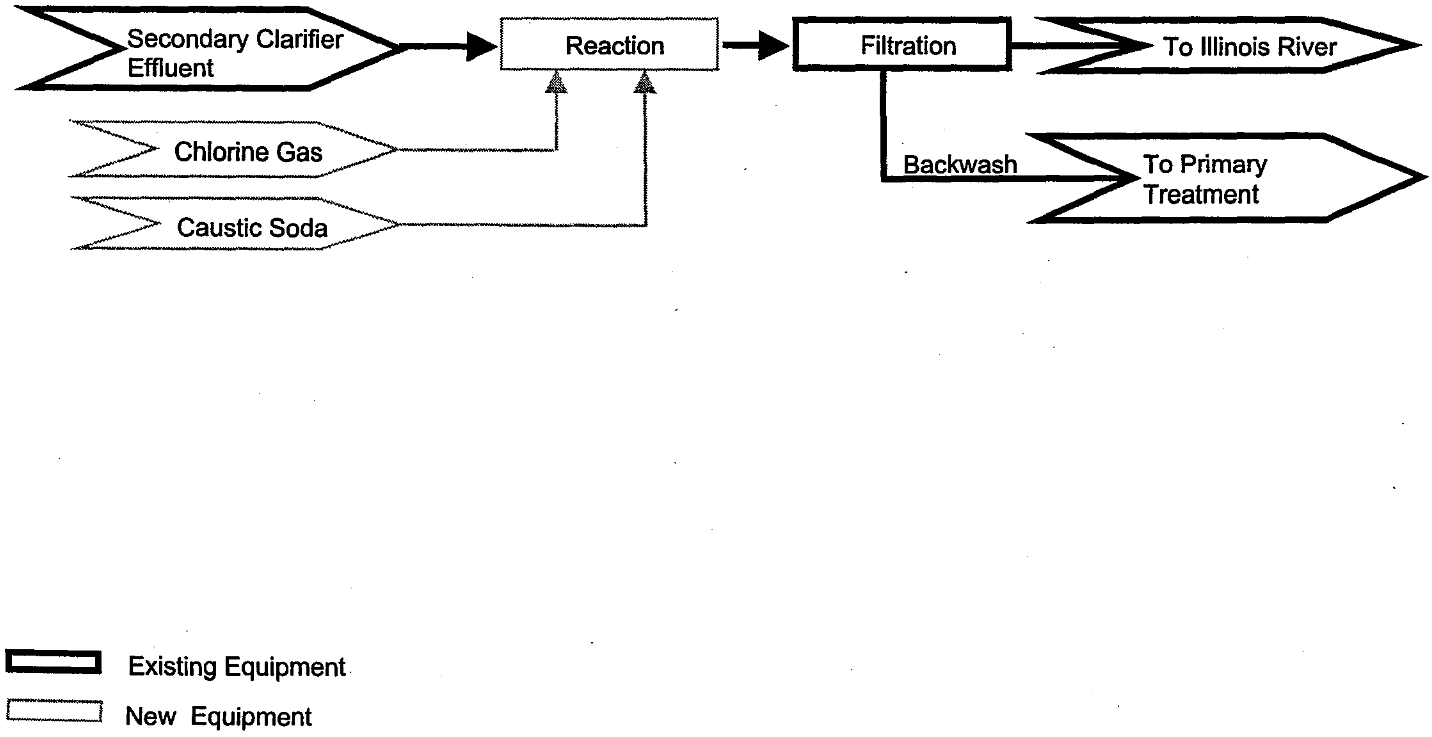


FIGURE 4

BLOCK FLOW DIAGRAM OF BREAKPOINT CHLORINATION ALTERNATIVE (No. 5)

BROWN AND CALDWELL

Nashville, Tennessee

P:/PROJ/21522/Fig 4

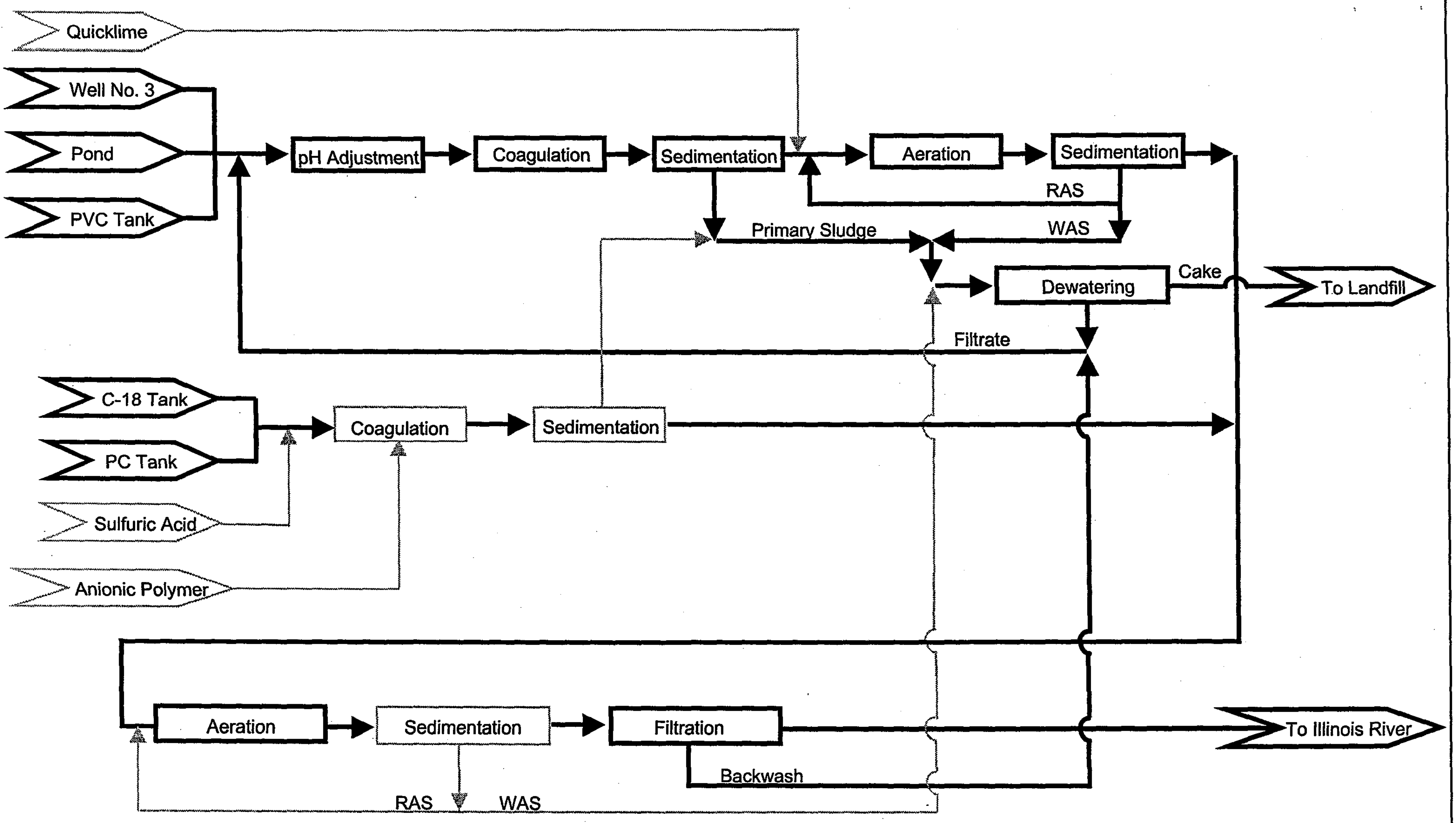


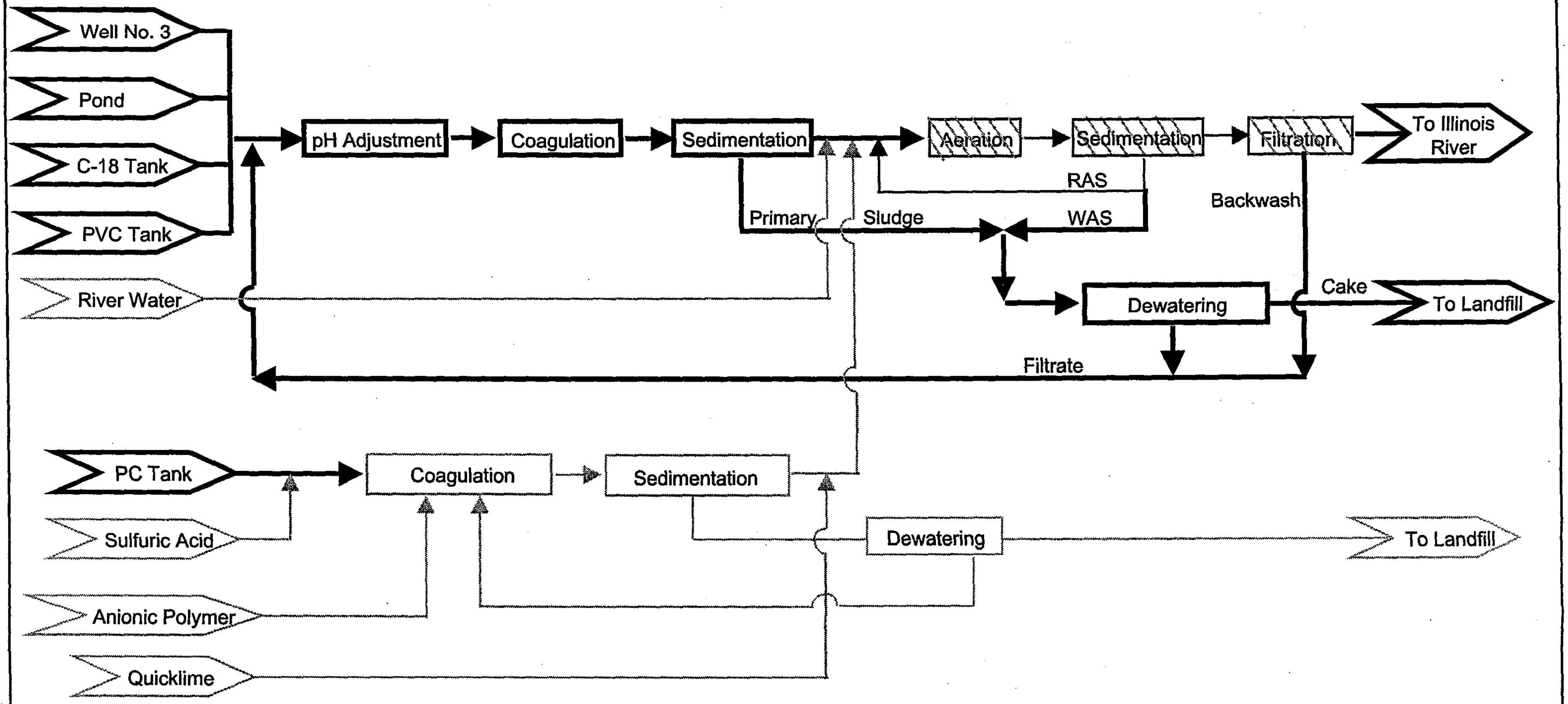
FIGURE 5

BLOCK FLOW DIAGRAM OF NON-PC WASTESTREAM NITRIFICATION TREATMENT ALTERNATIVE (No. 6)

BROWN AND CALDWELL

Nashville, Tennessee

P:/PROJ/21522/Fig 5



▬ Existing Equipment

▭ New Equipment

▨ Upgraded Equipment

P:/PROJ/21522/Fig 6

FIGURE 6

BLOCK FLOW DIAGRAM OF COMBINED WASTESTREAM NITRIFICATION TREATMENT ALTERNATIVE (No. 7)

BROWN AND CALDWELL

Nashville, Tennessee

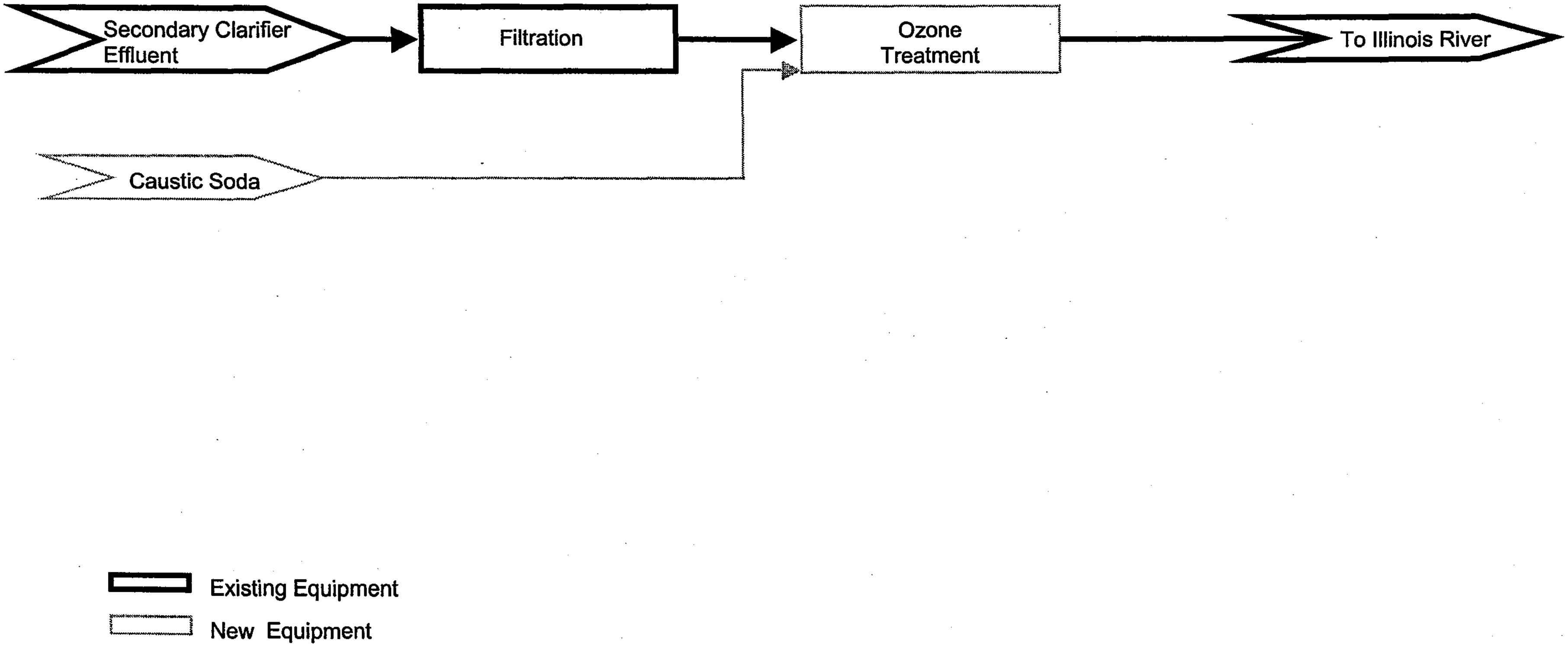


FIGURE 8

BLOCK FLOW DIAGRAM OF OZONE TREATMENT ALTERNATIVE (No. 9)

BROWN AND CALDWELL

Nashville, Tennessee

P:/PROJ/21522/Fig 8

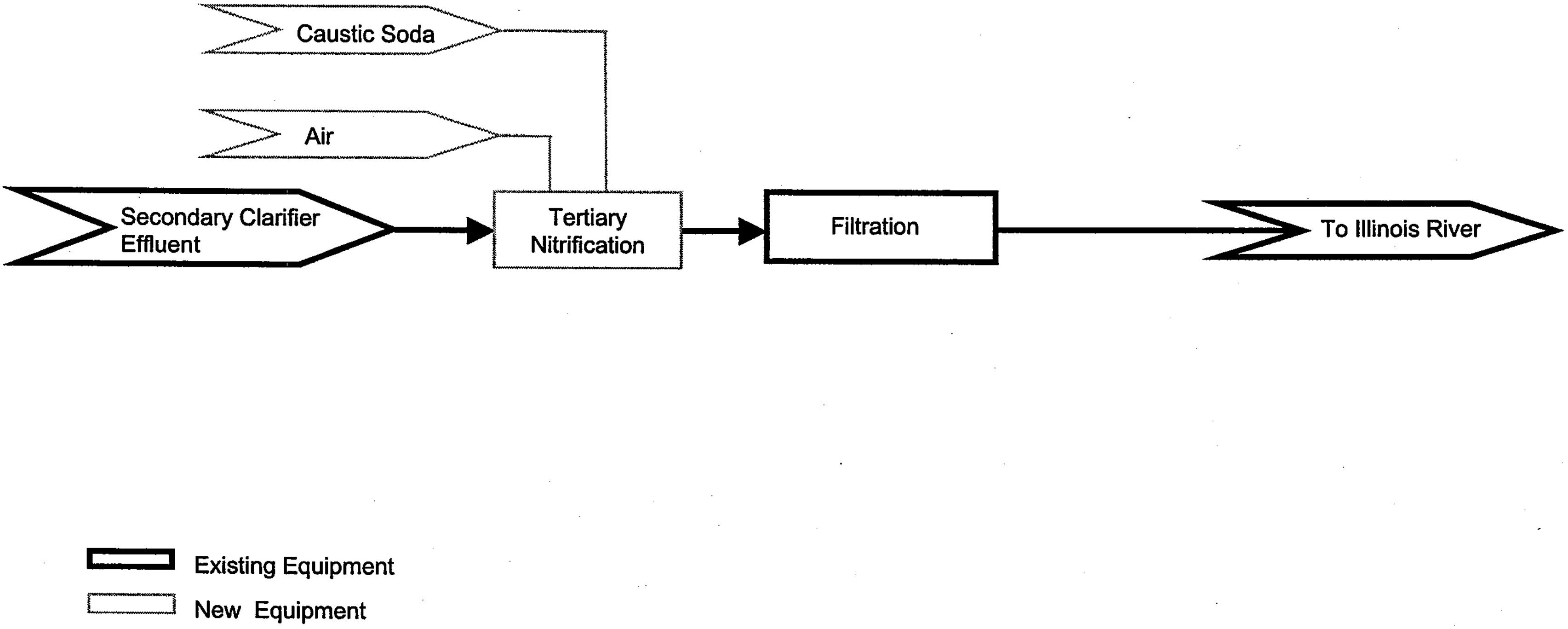


FIGURE 9

BLOCK FLOW DIAGRAM OF TERTIARY NITRIFICATION TREATMENT ALTERNATIVE (No. 10)

BROWN AND CALDWELL

Nashville, Tennessee

P:/PROJ/21522/Fig 9

Exhibit D

EXHIBIT D

SUMMARY OF COST ANALYSIS FOR PROVIDING INCREMENTAL EFFLUENT AMMONIA-NITROGEN REMOVAL AT THE NOVEON-HENRY PLANT

WWTF Component	Basis	PC Tank Stripping w/ Off-gas	PVC Tank Stripping w/o Off-gas	Effluent Stripping w/ Off-gas	Effluent Stripping No Off-gas	Effluent Stripping No Off-gas 75% removal	Effluent Stripping No Off-gas 50% removal	Effluent Stripping No Off-gas 25% removal	Struvite Precipitation	Effluent BP Chlorination	Non-PC Nitrification	Combined Nitrification
Additional Operations/ Maintenance Labor												
* Labor Hours		800	800	1500	1300	1300	1000	1000	200	1500	1500	1500
*** Annual Cost, $**	$40/hr	32000	32000	60000	52000	52000	40000	40000	8000	60000	60000	60000
Electrical Usage												
* hp		162	75	545	505	450	300	300	1	10	25	250
* kwh		1058664	490122	3561553	3300155	2940732	1960488	1960488	6535	65350	163374	1633740
*** Annual Cost, $**	$0.06/kwh	63520	29407	213693	198009	176444	117629	117629	392	3921	9802	98024
Maintenance Materials												
* Low End Equipment Costs, $		330,000	40,000	2106000	1263600	1013600	631800	379080	15000	375000	222,000	890,000
*** Annual Costs, $**	5% of E Costs	16500	2000	105300	63180	50680	31590	18954	750	18750	11100	44500
Chemical Costs												
* 50 % NaOH, $ year	$240/ton	0	1770431.04	434000	434000	434000	217000	108500	0	955541	217772	742484
* 98% H2SO4, $/year	$46/ton	0	24238	141000	119850	119850	70500	35250	0	0	0	45333
* 75 % H3PO4, $/year	$335/ton	0	0	0	0	0	0	0	407160	0	0	0
* 62 % Mg(OH)2, $/year	$220/ton	0	0	0	0	0	0	0	235205	0	0	0
* 98% HCl, $/year	$70/ton	0	0	0	0	0	0	0	0	0	0	0
* Chlorine Gas, $/year	$50/ton	0	0	0	0	0	0	0	0	72681	0	0
*Annual Costs, $/year		0	1794669	575000	553850	553850	287500	143750	642365	1028222	217772	787817
Annual Resin Replacement, $/year	$90/cu ft	0	0	0	0	0	0	0	0	0	0	0
Annual Off-site Disposal, $/year	$0.10/gal											
Natural Gas Cost, $/ year												
Annual Cost, $/ year	$0.06/therm	18240	0	0	0	0	0	0	0	0	0	0
Subtotal Annual Costs, $/year		130260	1858076	953993	867039	832974	476719	320333	651507	1110893	298674	990341
Contingency (10%),$/yr		13026	185808	95399	86704	83297	47672	32033	65151	111089	29867	99034
Total Annual Cost, $/year		143286	2043884	1049393	953743	916271	524391	352367	716657	1221982	328542	1089375
Present Worth of Annual Costs $	10 years 8 percent interest	961448	13714462	7041424	6399617	6148181	3518665	2364380	4808771	8199501	2204516	7309707
Capital Costs, $		1,345,138	344,023	6,983,076	4,522,426	3,770,418	2,453,930	1,541,358	253,748	1,526,625	2,676,729	4,397,370
Total Present Worth, $		2,306,586	14,058,484	14,024,500	10,922,043	9,918,598	5,972,595	3,905,738	5,062,519	9,726,126	4,881,245	11,707,077
Average NH3-N Removal, lbs/day		247	147	864	864	648	432	216	217	891	423	891
Average NH3-N Removal, %		27.2	16.2	95.0	95.0	71.3	47.5	23.8	23.9	98.0	46.5	98.0
Present Worth Cost, $/lb NH3-N		2.56	26.13	4.45	3.47	4.20	3.79	4.96	6.39	2.99	3.16	3.60

WWTF Component	Basis	Effluent Ion Exchange	Effluent Ion Exchange	Effluent Ion Exchange	Effluent Ion Exchange	Ozonation	Tertiary Nitrification	Tertiary Nitrification	Tertiary Nitrification	Tertiary Nitrification
			75% removal	50% removal	25% removal			75% removal	50% removal	25% removal
Additional Operations/ Maintenance Labor										
* Labor Hours		1500	1500	1500	1500	750	1500	1500	1500	1500
* **Annual Cost, $**	$40/hr	60000	60000	60000	60000	30000	60000	60000	60000	60000
Electrical Usage										
* hp		25	18.75	12.5	6.25		225	168.75	112.5	56.25
* kwh		163374	122531	81687	40844	22727273	1470366	1102775	735183	367592
* **Annual Cost, $**	$0.06/kwh	9802	7352	4901	2451	1363636	88222	66166	44111	22055
Maintenance Materials										
* Low End Equipment Costs, $		284000	227200	170400	85200	2300000	444000	355200	266400	133200
* **Annual Costs, $**	5% of E Costs	14200	11360	8520	4260	115000	22200	17760	13320	6660
Chemical Costs										
* 50 % NaOH, $ year	$240/ton	129861	97396	64930	32465	226145	458660	343995	229330	114665
* 98% H2SO4, $/year	$46/ton	0				0	0			
* 75 % H3PO4, $/year	$335/ton	0	0	0	0	0	0	0	0	0
* 62 % Mg(OH)2, $/year	$220/ton	0	0	0	0	0	0	0	0	0
* 98% HCl, $/year	$70/ton	17044	12783	8522	4261	0	0	0	0	0
* Chlorine Gas, $/year	$50/ton	0	0	0	0	0	0	0	0	0
*Annual Costs, $/year		146905	110179	73453	36726	226145	458660	343995	229330	114665
Annual Resin Replacement, $/year	$90/cu ft	242449	181837	121224	60612	0	0	0	0	0
Annual Off-site Disposal, $/year	$0.10/gal	50727	38045	25363	12682					
Natural Gas Cost, $/ year										
Annual Cost, $/ year	$0.06/therm	0	0	0	0	0	0	0	0	0
Subtotal Annual Costs, $/year		524083	408772	293462	176731	1734781	629082	487921	346761	203380
Contingency (10%),$/yr		52408	40877	29346	17673	173478	62908	48792	34676	20338
Total Annual Cost, $/year		576492	449650	322808	194404	1908259	691990	536713	381437	223718
Present Worth of Annual Costs $	10 years 8 percent interest	3868259	3017150	2166041	1304450	12804419	4643251	3601346	2559441	1501151
Capital Costs, $		1,198,024	1,095,472	787,814	480,157	7,523,300	6,762,000	6,223,800	4,264,200	2,304,600
Total Present Worth, $		5,066,283	4,112,621	2,953,855	1,784,607	20,327,719	11,405,251	9,825,146	6,823,641	3,805,751
Average NH3-N Removal, lbs/day		891	668	445	223	891	891	668	445	223
Average NH3-N Removal, %		98.0	73.5	49.0	24.5	98.0	98.0	73.5	49.0	24.5
Present Worth Cost, $/lb NH3-N		1.56	1.69	1.82	2.20	6.25	3.51	4.03	4.20	4.68

Exhibit E

EXHIBIT E

SUMMARY TABLE COMPARING COST, EFFLUENT AMMONIA-NITROGEN REDUCTION PERCENTAGES, RELIABILITY, AND PROS AND CONS OF ALTERNATIVE EFFLUENT AMMONIA-NITROGEN REDUCTION PROCESSES FOR THE NOVEON-HENRY PLANT

Comparison of Costs and Removals of Effluent NH_3-N Removal Processes for the Noveon-Henry Wastewater Treatment Facility with 10-Year Project Life

Process	Capital Cost ($ millions)	Annual Operating Cost ($ millions/year)	Present Worth Cost[a]		Effluent NH_3-N Removal (Average %)
			($ millions)	($/lb NH_3-N removed)	
PC Tank Stripping with Off-gas Control	1.35	0.130	2.21	2.45	27
	1.31	0.125	2.15	4.60	14
PVC Tank Stripping without Off-gas Control	0.344	2.04	14.1	26.13	16
	0.317	2.03	14.0	51.89	8
Effluent Stripping with Off-gas Control	6.98	1.05	14.1	4.42	95
Effluent Stripping without Off-gas Control	4.52	0.894	10.5	3.34	95
	3.77	0.850	9.5	3.83	75
	2.45	0.483	5.7	3.44	50
	1.54	0.332	3.8	4.59	25
Struvite Precipitation	0.254	0.669	4.74	5.99	24
	0.254	0.539	3.87	6.53	18
Effluent Breakpoint Chlorination	1.53	1.22	9.73	2.99	98

Comparison of Costs and Removals of Effluent NH_3-N Removal Processes for the Noveon-Henry Wastewater Treatment Facility with 10-Year Project Life

Process	Capital Cost ($ millions)	Annual Operating Cost ($ millions/year)	Present Worth Cost		Effluent NH_3-N Removal (Average %)
			($ millions)	($/lb NH_3-N removed)	
Non-PC Nitrification	2.68	0.329	4.88	3.16	47
Combined Single-Stage Nitrification	4.40	1.09	11.7	3.60	98
• MBT Removal Process	0.86	0.441	3.82		Less Than 25
• WWTF Upgrades	3.54	0.649	7.88		0
Effluent Ion Exchange	1.20	0.688	5.82	1.79	98
	1.10	0.533	4.67	1.88	75
	0.79	0.379	3.33	2.01	50
	0.48	0.222	1.97	2.38	25
Effluent Ozonation	7.52	1.91	20.3	6.25	98
Tertiary Nitrification	6.76	0.692	11.4	3.51	98
	6.22	0.536	9.83	4.03	75
	4.26	0.381	6.82	4.20	50
	2.30	0.223	3.81	4.68	25

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[a] 10 years at 8% interest.

Comparison of Costs and Removals of Effluent NH_3-N Removal Processes for the Noveon-Henry Wastewater Treatment Facility with 20-Year Project Life

Process	Capital Cost ($ millions)	Annual Operating Cost ($ millions/year)	Present Worth Cost[a] ($ millions)	Present Worth Cost[a] ($/lb NH_3-N removed)	Effluent NH_3-N Removal (Average %)
PC Tank Stripping with Off-gas Control	1.35	0.130	2.63	1.46	27
	1.31	0.125	2.54	2.72	14
PVC Tank Stripping without Off-gas Control	0.344	2.04	20.4	18.90	16
	0.317	2.03	20.2	37.43	8
Effluent Stripping with Off-gas Control	6.98	1.05	17.3	2.71	95
Effluent Stripping without Off-gas Control	4.52	0.894	13.3	2.12	95
	3.77	0.850	12.1	2.44	75
	2.45	0.483	7.2	2.17	50
	1.54	0.332	4.8	2.90	25
Struvite Precipitation	0.254	0.669	6.8	4.30	24
	0.254	0.539	5.5	4.64	18
Effluent Breakpoint Chlorination	1.53	1.22	13.5	1.08	98

Comparison of Costs and Removals of Effluent NH_3-N Removal Processes for the Noveon-Henry Wastewater Treatment Facility with 20-Year Project Life

Process	Capital Cost ($ millions)	Annual Operating Cost ($ millions/year)	Present Worth Cost		Effluent NH_3-N Removal (Average %)
			($ millions)	($/lb NH_3-N removed)	
Non-PC Nitrification	2.68	0.329	5.9	1.91	47
Combined Single-Stage Nitrification	4.40	1.09	15.1	2.32	98
• MBT Removal Process	0.86	0.441	5.2		Less Than 25
• WWTF Upgrades	3.54	0.649	9.9		0
Effluent Ion Exchange	1.20	0.688	8.0	1.23	98
	1.10	0.533	6.3	1.27	75
	0.79	0.379	4.5	1.36	50
	0.48	0.222	2.7	1.63	25
Effluent Ozonation	7.52	1.91	26.3	4.05	98
Tertiary Nitrification	6.76	0.692	13.6	2.09	98
	6.22	0.536	11.5	2.36	75
	4.26	0.381	8.0	2.46	50
	2.30	0.223	4.5	2.76	25

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[a] 20 years at 8% interest.

Comparison of Removals and Reliability of Effluent NH_3-N Removal Processes for the Noveon-Henry Wastewater Treatment Facility

Process	Effluent NH_3-N Removal		
	(Average %)	Reliability Rating[1]	Comments
PC Tank Stripping with Off-gas Control	27	8	Involves adding surface aerator, oversized withdrawal fan, off-gas collection and thermal oxidation of off-gas. Off-gas collection and treatment are needed for VOC control. No chemical addition required since PC Tank contents are normally pH 11 s.u. Simple to operate. Performance will vary as volatile amine content varies in wastewater. Average removals of 0 to 27 percent could be achieved by varying the size of the surface aerator placed in the tank.
PVC Tank Stripping without Off-gas Control	16	7	Involves adding caustic addition and surface aerator to PVC tank contents. Acid addition in primary system will be required to lower pH to 9.0 s.u. Simple to operate. Strong foaming potential in PVC Tank which would reduce effectiveness. Performance will vary based on production discharges of NH_3-N and volatile amines, and NH_3-N returned in sludge dewatering filtrate and tertiary filter backwash. Removals of 0 to 16 percent could be achieved by varying the size of the surface aerator placed in the tank. Will increase effluent TDS.
Effluent Stripping with Off-gas Control	95	7	Involves pumping sand filter effluent through two packed towers in series. Caustic is added to increase pH to 11.5 s.u. and acid is added to lower the treated effluent pH to 8 s.u. Off-gas is directed to an acid scrubber for recovery of $(NH_4)_2SO_4$. Scrubber discharge would be disposed off-site. Complex to operate. Equipment must be housed in heated building to prevent freezing. Fouling of tower media with precipitants is anticipated. Removals of 75 to 95 percent would be achieved by treating the whole effluent through different sized columns. Removals of 25 to 50 percent would be achieved by treating only a portion of the final effluent. Will increase effluent TDS.

Comparison of Removals and Reliability of Effluent NH_3-N Removal Processes for the Noveon-Henry Wastewater Treatment Facility (Continued)

Process	Effluent NH_3-N Removal		
	(Average %)	Reliability Rating[1]	Comments
Effluent Stripping without Off-gas Control	95	8	Same as above but without off-gas collection and treatment. NH3-N would be discharged to atmosphere. Will increase effluent TDS.
Struvite Precipitation	24	6	Involves feeding magnesium hydroxide and phosphoric acid to existing primary treatment system. Simple to operate. However, the precipitant is prone to foul pumps and piping. Removal could be varied between 18 and 24 percent depending upon the quantity of magnesium hydroxide added. Performance will vary strictly as a function of influent NH_3-N load. Will increase effluent TDS.
Effluent Breakpoint Chlorination	98	9	Involves routing secondary clarifier effluent through chlorination step prior to tertiary filtration. Caustic is fed to maintain pH control. Reliable process. Creates safety concerns and may form chlorinated organics. Will increase effluent TDS.
Non-PC Nitrification	47	7	Involves using existing activated sludge system to provide BOD removal and nitrification of PVC wastewater. Treated effluent from this system would be combined with PC wastewater and treated in new activated sludge system. Complex system to operate. Two WWTFs that would be subject to upset. Performance would vary as a function of PVC NH_3-N and amine loading. Will increase effluent TDS.