Environmental Protection Agency
Climate Pollution Reduction Grant – Implementation

Applicant: **Hampton Roads Sanitation District (HRSD)**

Application Title: **Implementation of Partial Denitrification with Anammox (PdNA) in Wastewater Treatment to Reduce Greenhouse Gas**

1. Overall Project Summary and Approach

a. Description of GHG Reduction Measures

Hampton Roads Sanitation District (HRSD) is an independent political subdivision of the Commonwealth of Virginia. HRSD provides wastewater treatment to 1.9 million people in southeastern Virginia and the eastern shore of Virginia – or one fifth of Virginia's population. HRSD serves the Virginia Beach-Norfolk-Newport News Metropolitan Statistical Area (MSA) and beyond. The HRSD territory is approximately 5,000 square miles, and encompasses nine cities, eleven counties and several large military facilities. HRSD owns and operates 16 wastewater treatment plants with eight major plants and eight smaller plants. The combined capacity of the eight major plants is approximately 225 million gallons daily. The eight smaller rural treatment plants have a combined capacity of 1.75 million gallons daily. HRSD currently treats an average of **150** million gallons of wastewater daily. The HRSD system also maintains 538 miles of interceptor pipelines ranging from six to 66 inches in diameter, along with 89 pump stations in Hampton Roads and 44 pump stations in the small communities.

This proposal is to request EPA assistance funds in the amount of $59,540,142 to implement greenhouse gas (GHG) reduction measures at four of its wastewater treatment plants (aka, water resource recovery plants). These measures are contained in the Hampton Roads Planning District Commission (HRPDC) Priority Climate Action Plan (PCAP) developed under the EPA Climate Reduction Planning Grant (CPRG).

HRSD desires to implement a proven, cutting-edge treatment process that reduces greenhouse gas (GHG) emissions during the wastewater treatment process. This treatment utilizes a specialized bacteria known as anammox, to successfully remove harmful macronutrients from the waste stream. This implementation of partial denitrification with anammox (PdNA) can achieve the benefits of shortcut nitrogen removal without nitrite oxidizing bacteria (NOB) out-selection. The PdNA process has four key benefits:

i. Improves treatment by allowing for higher loading to the plant, which will increase the treatment plant's capacity.

ii. Reduces chemical usage by reducing carbon, methanol and caustic.

iii. Reduces the use of electricity via aeration energy.

iv. Achieves process intensification which creates a better product for advanced treatment. A better product for advanced treatment will allow for more successful aquafer recharge at HRSD, known as Sustainable Water Initiative for Tomorrow (SWIFT).

Utilizing PdNA with SWIFT will provide substantial community benefits, including reduction of hazardous air pollutant, coupled with drought resilience and climate change mitigation.

This shortcut nitrogen removal can be achieved in the mainstream treatment process by coupling ammonia over nitrate/nitrite (AvN) aeration control in suspended growth with a biofilm-based partial denitrification anammox (PdNA) reaction. Continued development and successful deployment of this shortcut nitrogen removal strategy (PdNA) at wastewater treatment plants, including SWIFT program treatment plants, will provide lower toxic emissions and lifecycle cost benefits for HRSD by reducing energy and chemical consumption. Since the PdNA process is replicable, other wastewater treatment plants will be able to achieve the same cost savings and reduction in GHG.

In addition, shortcut nitrogen removal may also help HRSD defer or avoid future capital costs associated with capacity expansion through its potential process intensification benefit in lieu of the tankage requirements otherwise required with a conventional nitrogen removal process. The proposed project costs are significantly less than adding tanks for capacity, and far less than 5% of the cost of building a new treatment plant.

There are two targeted benefits of PdNA shortcut nitrogen removal, and both have the added benefit of reducing operating costs:

i. Environmentally Preferred – Compared with conventional nitrogen removal, shortcut nitrogen removal in the mainstream will reduce electrical energy consumption and is anticipated to reduce chemical (methanol & caustic) consumption.

ii. Future Capacity – Compared with conventional nitrogen removal, shortcut nitrogen removal enables higher organic and nitrogen loading capacity from the biological unit processes.

Nutrient removal requirements for wastewater treatment plants, referred to hereafter as Water Resource Recovery Facilities (WRRFs) are becoming increasingly stringent. Conventional nitrogen removal involves the oxidation of all the influent ammonia to nitrate (nitrification) followed by conversion of nitrate to nitrogen gas (denitrification). This traditional nitrification denitrification (NDN) process is very energy intensive and often requires external carbon for denitrification. If a WRRF's energy source is non-renewable, then energy consumption will result in the generation of scope 2 emissions (indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling). Furthermore, external carbon sources are a significant contributor to scope 1 direct emissions (direct GHG emissions that occur from sources that are controlled or owned by an organization, such as emissions associated with fuel combustion in boilers, furnaces, and vehicles) during denitrification and to scope 3 embodied carbon emissions resulting from their manufacturing processes. Thus, reducing the consumption of energy and supplementary carbon will lead to a substantial decrease in greenhouse gas emissions at a WRRF.

Water Resource Recovery Facilities are also faced with costly capacity expansions (and associated Scope 3 embodied carbon emissions) that are required to meet nutrient limits for current and future flows.

Therefore, the purpose of this treatment is to reduce aeration energy and carbon requirements for nitrogen removal and consequently reduce the greenhouse gas emissions associated with nitrogen removal and capacity expansions at WRRFs using the "Partial Denitrification – Anammox" (PdNA) process. A partial denitrification efficiency of at least 50% and PdNA rates greater than 1.0 g total inorganic nitrogen (TIN)/m2/d will be demonstrated which will increase facility capacity and reduce GHG emissions by at least 30%.

Over the past 10 years, researchers have focused on alternative strategies that "shortcut" the NDN pathway and enable significant reductions in facility size while achieving or exceeding energy neutrality and completely eliminating the use of supplemental chemicals. The most efficient of these pathways is called deammonification, which relies on a combination of ammonia oxidizing bacteria (AOB) and anaerobic ammonium oxidizers (anammox), that convert nitrite and ammonium to nitrogen gas without the use of organic carbon. This process has been applied successfully on warm, concentrated industrial and WRRF sidestreams where process conditions favor the growth of anammox using a strategy referred to as partial nitritation – anammox (PNA). However, applying PNA to mainstream domestic wastewater treatment has been more challenging. The key to successful PNA involves the out-selection of bacteria that convert nitrite to nitrate (known as "NOB out selection"). To date, NOB out-selection has proven difficult to reliably achieve on dilute waste streams, which in turn has prevented the adoption of PNA in full-scale mainstream wastewater treatment processes.

During the course of PNA research, an alternative nitrogen removal pathway, PdNA, was identified and shown to provide virtually all of the same benefits of reduction in carbon emissions, facility size, and operational costs, but with considerably greater reliability and ease of implementation. This can strategically be applied to any existing commercial equipment package or process configuration in use today for biological nitrogen removal. Implementation of mainstream anammox (through PNA or PdNA) is often referred to as the "Holy Grail" of next generation wastewater treatment. Utilities have been leading the research and development in this area for good reason - routing nitrogen through the anammox metabolism fundamentally changes how treatment plants utilize and generate valuable resources while simultaneously intensifying treatment processes. Although mainstream anammox implementation appears to focus on nitrogen removal, the PdNA process is critical to meaningful and practical reductions in carbon footprints and the transition to sustainable wastewater treatment (and reuse). Despite over 12 years of research, little progress has been made in PNA. However, the transition to PdNA in the past five to six years has completely changed the landscape.

There is now a practical path to implementation, and the HRSD proposed project – HRSD Implementation of Partial Denitrification with Anammox (PdNA) in Wastewater Treatment to Reduce Greenhouse Gas – represents the next critical step for the industry in mainstream anammox. In this proposal, we plan to fundamentally change the traditional NDN best practice paradigm by implementing the PdNA process which has significantly lower energy and carbon demands. PdNA can be retrofitted into existing treatment trains, which results in increased treatment capacity while minimizing capital expenses and minimizing the scope 3 embodied carbon emissions associated with concrete infrastructure. This process provides facility-wide benefits (primary fermentation, carbon diversion, and solids handling) resulting from the implementation of PdNA, all of which will result in significant decarbonization of WRRFs.

Because the PdNA process is replicable, our plan is to implement PdNA treatment at four HRSD treatment facilities. When implemented, the PdNA process will help toward reducing emissions that cause climate change.

b. **Demonstration of Funding Need**

Hampton Roads Sanitation District (HRSD) has the knowledge, capacity, and ability to implement PdNA, but is restrained by the capital expenditure ($59,540,142) associated with this retrofit construction upgrade. HRSD's FY2024-2033 Capital Improvement Plan (CIP) is already prioritized at an estimated cost of $3,709,000,000 and increasing with the upcoming iteration. These CIP projects are necessary to maintain EPA water quality compliance. HRSD is required by its Enabling Act to meet its obligation by charging user fees for its wastewater treatment services; no taxing authority is authorized by the Enabling Act. This means that HRSD is a cost recovery organization, fully funded by charges collected directly from customers receiving wastewater treatment services. HRSD had 9% increases to our customer rates in FY2024 with plans to increase again in FY25 to cover the growing costs. HRSD strives to keep costs down; however, the increasing costs for construction and maintenance have led to year-over-year rate increases. To keep ratepayer costs down, HRSD is pursuing cost-saving innovative measures, and other grant funding and low-interest loans.

c. **Transformative Impact**

The implementation of AvN+PdNA at HRSD will lead to 2,702 metric tons of CO_2-equivalent (CO2-e) reduction per year in and around the Water Resource Recovery Facilities as shown on the attached map. These benefits are achieved without negative impact to low-income and/or disadvantaged communities.

Implementing the PdNA process will also lead to significant cost savings for treating wastewater.

i. $480,000 savings per year at the HRSD James River Treatment Plant in chemical and energy compared to operating the system in the traditional nitrification + denitrification process. This helps to moderate costs to customers in the entire HRSD service area. The current projected savings with PdNA at the James River Treatment Plant are estimated to be $218,000 per year in methanol, $196,000 per year in caustic, and $90,000 per year in energy savings. The other benefit with AvN+PdNA is the aerobic capacity gain, because HRSD can operate at higher ammonia concentration in the aeration tanks with PdNA downstream to remove this excess ammonia.

ii. The implementation of AvN+PdNA at the HRSD Willliamsburg Treatment Plant will lead to $263,000 saving per year in chemical and energy compared to operating a system in the traditional nitrification+denitrification process. The current projected savings are $213,000 per year in methanol and $50,000 per year in energy savings.

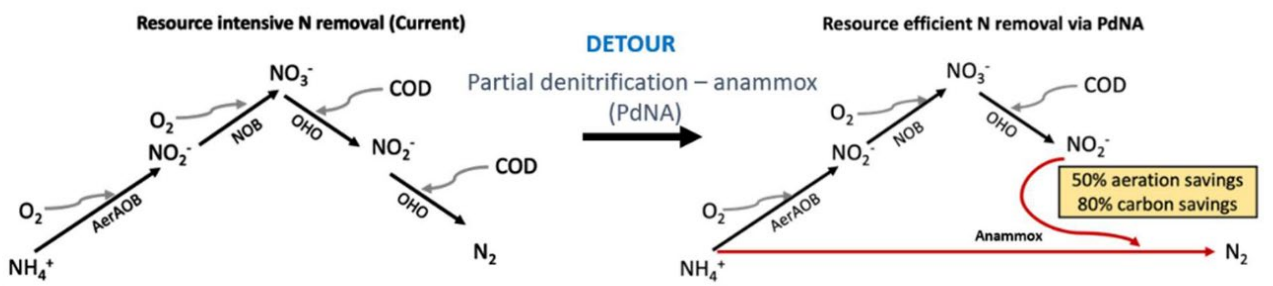
iii. The implementation of PdNA at the HRSD Army Base Treatment Plant will also provide chemical savings and energy savings. Current projections include $100,000 per year in methanol, $120,000 per year in caustic and $11,000 per year in energy savings.

iv. The implementation of PdNA at the HRSD Nansemond Treatment Plant will also provide chemical savings and energy savings. Current projections include $250,000 per year in methanol and $60,000 per year in energy savings.

v. Implementing PdNA technologies at four HRSD WRRFs will results in approximately 2702 metric tons of CO2-e reduced each year.

Widespread adoption of PdNA is essential for decarbonizing the water sector, since water and wastewater treatment are energy intensive processes that account for **3%** of the total energy load in the United States (McCarty et al., 2011)[i]. In wastewater treatment, up to **80%** of a facility's energy load is used to provide air in aeration basins for the biological treatment of carbon, nitrogen, and phosphorus (McCarty et al., 2011)[ii]. As WRRFs strive to become more sustainable, the need to implement energy-efficient and carbon-efficient treatment technologies is further motivated by new nutrient regulations for discharges, water reuse, and climate change. To address these challenges, WRRFs must focus on the implementation of shortcut nitrogen removal and anammox processes which can reduce energy and carbon inputs for nitrogen removal. As explained earlier, traditional NDN requires a large amount of energy and external carbon.

Figure A: NDN and PdNA Metabolic Pathways



Deammonification through PdNA (Figure A) represents an intensified and sustainable alternative to traditional NDN. PdNA bypasses steps in traditional nitrogen removal by:

i. oxidizing only a portion of the influent ammonium to either nitrite or nitrate, as the remainder of the influent ammonium is directly metabolized with nitrite by anammox bacteria to produce nitrogen gas; and

ii. partially short-circuiting the conventional denitrification pathway by reducing nitrate to nitrite with carbon. Bypassing these steps results in oxygen, alkalinity, and net carbon savings. Since PdNA requires only a portion of the influent ammonium to be oxidized to nitrite/nitrate, the aerobic SRT can decrease which increases the treatment capacity and reduces carbon emissions associated with capacity expansion.

2. Impact of GHG Reduction Measures

a. Magnitude of GHG Reductions from 2025 through 2030

Implementing PdNA technologies at four additional HRSD WRRFs will result in approximately **13,510** metric tons of CO2-equivalent (CO2-e) reduced from 2025-2030.

b. Magnitude of GHG Reductions from 2025 through 2050

Implementing PdNA technologies at four HRSD WRRFs will result in approximately **67,550** metric tons of CO2-e reduced from 2025-2050.

c. **Cost Effectiveness of GHG Reductions**

Water Resource Recovery Facilities (WRRFs) face a multitude of challenges including increasingly stringent effluent discharge permits, the need to expand treatment capacity to match growing populations, and high energy and carbon demands for nitrogen removal. In many cases, these challenges can require facilities to make significant investments in new infrastructure, including constructing larger WRRFs and upgrading secondary treatment basins to support the increased demand for nitrogen removal. In some cases, it is possible to retrofit existing WRRFs to increase their capacity, rather than building entirely new infrastructure. Specifically, this implementation of PdNA can:

i. increase the overall treatment capacity without the need for major infrastructure investments,

ii. result in significant energy and carbon savings, and

iii. minimize the scope 1, 2, and 3 emissions from the capacity expansion.

However, since every WRRF is unique in terms of its design, capacity, wastewater characteristics, and treatment processes, the specific challenges and requirements of retrofits at a facility will vary. Consequently, PdNA retrofits requirements can vary from facility to facility with respect to headloss, supplemental carbon availability, and overall basin configuration. Despite these challenges, retrofitting can be a cost-effective and sustainable approach to increasing WRRF capacity.

Table 1. Cost-Benefit Analysis

Costs-Benefit Analysis				
Treatment Plant	**Benefits**			**Costs**
	Methanol Savings	**Caustic Savings**	**Electricity Savings**	**Implement PdNA**
James River	$218,000	$196,000	$90,000	
Williamsburg	$213,000		$50,000	
Army Base	$100,000	$12,000	$11,000	
Nansemond	$250,000		$60,000	
		Total Cost Benefits per year	$ 1,200,000	$ 62,501,742
		Total Cost Benefits over 25 years (2025-2050)	$ 30,000,000	
		GHG Reduction Benefits per year	2,702 metric tons CO2-e	
		GHG Reduction Benefits over 25 years (2025-2050)	67,550 metric tons CO2-e	

d. **Documentation of GHG Reduction Assumptions** – *Up to 10 additional pages as an appendix to the workplan (see Appendix C of the NOFO)*

A quantitative life-cycle assessment (LCA) of various nutrient management strategies at the Nansemond Treatment Plant (NTP) had been previously developed under DOE Grant DOE DE-EE0009508, *Crossing the Finish Line: Integration of Data-Driven Process Control for Maximization of Energy and Resource Efficiency in Advanced Water Resource* (work performed by Leah Pifer, University of Michigan). The LCA considered nutrient removal at NTP at industry standard (conventional nitrification-denitrification), NTP baseline (ammonia-based aeration control and conventional denitrification), and enhanced treatment (partial denitrification-Anammox, PdNA) treatment strategies. In terms of global warming potential, the primary processes attributed to CO_2-equivalent (CO2-e) emission included consumption of commodity grade methanol, electrical power usage, plastic media (for fixed-film retention of Anammox bacteria for the PdNA strategy), material transport to NTP, and concrete for reactor basins. The LCA was computed using input values from the Ecoinvent 3.10 database and global warming potential was calculated based on the ReCiPe 2016 (National Institute for Public Health and the Environment, The Netherlands).

For NTP, the reduction in CO2-e emissions was calculated by applying the differential rate of net CO2-e emissions from the NTP baseline and enhanced treatment strategies and applying that value to the average annual flow for the facility.

To estimate CO2-e reductions associated with nutrient upgrades at the Army Base, James River, and Williamsburg Treatment Plants, assessment was made for each facility as to the relevant analogous baseline nutrient removal condition (i.e. industry standard or NTP baseline) and the processes required for each facility to transition to enhanced (PdNA) nitrogen removal. Similar to NTP, the calculated differential rate of net CO_2e emissions was then applied to the average annual flow for the facility.

3. Environmental Results – Outputs, Outcomes, and Performance Measures

a. Expected Outputs and Outcomes

Implementing PdNA technologies at four HRSD WRRFs will result in approximately **2,702** metric tons of CO2-e reduced each year (See Table 2).

Table 2. Outcomes by Water Resource Recovery Facility

Water Resource Recovery Facility / Treatment Plant	Current	Future	Removed metric-tons CO2-e / year
Nansemond	ABAC+DN	AVN-PDNA	936
Army Base	SOTA	AVN-PDNA	779
James River	ABAC+DN	AVN-PDNA	468
Williamsburg	SOTA	AVN-PDNA	519
Total			**2,702**

b. Performance Measures and Plan

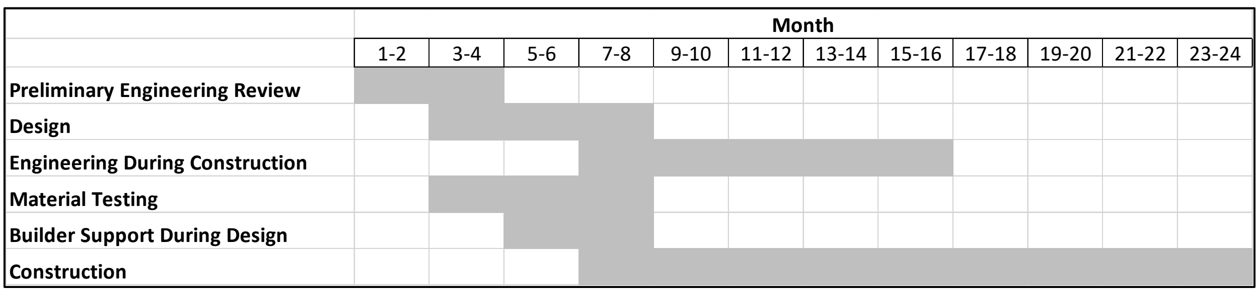
Greenhouse Gasses (GHGs) will be reduced at Hampton Roads Sanitation District (HRSD) with the implementation of PdNA treatment technology at Nansemond, Army Base, James River, and Williamsburg Treatment Facilities (WRRFs). The implementation of PdNA will occur as close to the schedule in section c below, meeting the carbon reduction goals, treatment enhancement goals, and cost savings for replicable and scalable projects.

c. Authorities, Implementation Timeline, and Milestones

Table 3. Milestones

	Milestone Description	Start Date	Timeframe	End Date
1	Commission approves & accepts Award	10/1/24	3 weeks	10/22/24
2	Execute grant agreement with EPA	10/22/24	1 month	11/31/24
3	Bid, evaluation of bids, and bid awards for Design-Build retrofit contractors	12/1/24	5 weeks	1/8/25
4	Begin quarterly progress and financial reports	12/1/24	1 month	12/31/24
5	Notice to Proceed issued to contractors	1/9/25	1 day	1/9/25
6	Preliminary Engineering Review	1/10/25	4 months	5/10/25
7	Design	4/1/25	6 months	9/30/25
8	Material Testing	1/10//25	4 months	5/10/25
9	Site work: Builder support during Design	5/10/25	4 months	9/30/25
10	Engineering during retrofit construction	8/1/25	12 months	7/30/25
11	Retrofit construction	8/1/25	14 months	9/30/26
12	Substantial completion	9/30/26	1 day	9/30/26
13	Grant award closeout	10/1/26	120 days	1/28/26

Table 4. Timeline



4. Low-Income and Disadvantaged Communities

As depicted in the attached map, the HRSD service area, and more specifically, the areas of the four treatment plants in this proposal, have significant populations at or above the 90th percentile of EJ Supplemental Indexes.

a. **Community Benefits:** Maps of the EPA EJScreen Census block groups and a list of relevant jurisdictions are attached to the application. The significant cost reductions in energy and chemical will provide benefits to all HRSD customers, by controlling wastewater treatment rates. The reduction of GHGs provides a positive environmental impact, which benefits the entire region.

Employment opportunities for local area residents will become available because of the retrofit construction. HRSD and contractor-paid employees are paid at or above prevailing wages. HRSD adheres to Federal funding requirements for wages and worker rights, including Davis-Bacon Act and Build America Buy America regulations, and requires the same of its contractors on federally funded projects and who may hire laborers and other specialized employees to complete their roles. As noted in the Job Quality section, HRSD provides a comprehensive Apprenticeship program to HRSD employees.

b. **Community Engagement:** This proposed project will reap positive impacts to communities, without disruption or negative side effects. Hampton Roads Sanitation District (HRSD) will provide notice on the public facing www.HRSD.com website. HRSD will also conduct outreach to communities throughout the HRSD Service Area and technical experts will be present as needed to discuss this innovative PdNA treatment project. These activities will be included on the quarterly progress reports.

A letter of support from Hampton Road Planning District Commission is attached to the application.

5. JOB QUALITY:

a. HRSD recognizes the value of each employee and our employees are central to the operations and talent management strategies. HRSD has a diversely qualified workforce that helps protect public health and the environment every day. HRSD incorporates high labor standards with excellent benefits and an emphasis on job quality, retention, inclusion, and equity. HRSD is committed to being an equal opportunity employer. HRSD does not discriminate against individuals in employment on the basis of race, sex, including sexual orientation, pregnancy, religion, color, national origin, age, disability, military or veteran status, genetic information, engaging in protect activity or any addition protect characteristics recognized by federal, state, and local law. HRSD empowers workers by providing information about worker rights, resources, and workforce development opportunities. To the extent possible, HRSD aligns with the Good Jobs Principles of the Departments of Commerce and Labor, including recruitment, benefits, DEI, job security and working conditions, organizational culture, pay, and skills and career advancement.

b. We hold our contractors to employee standards required by Federal and State laws.

c. HRSD created the nation's first wastewater industry Apprenticeship Program to perpetuate excellence in our workforce. Our Apprenticeship Program is custom designed to help individuals achieve the training and experience needed for a successful HRSD career.

d. HRSD has a robust Learning and Development center committed to employee continuing education and training. HRSD offers on-site in-person or online training and/or travel to off-site training to keep the workforce up-to-date and in the forefront of improvements in wastewater treatment and water resource recovery.

e. HRSD reimburses full-time and part-time employees for tuition, books, and/or fees required for course or degree completion. Courses must be successfully completed with a C or better for undergraduate, B or better for graduate, or a "pass" for a pass/fail basis.

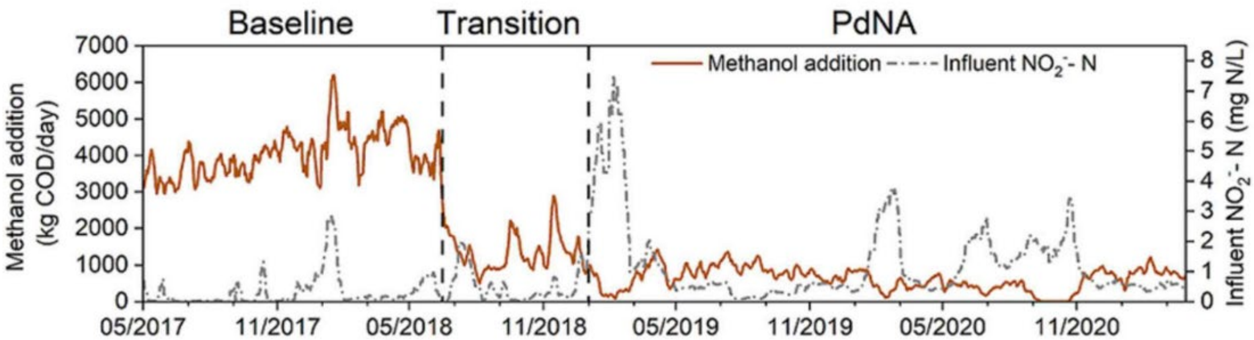
f. HRSD supervisors and managers provide day-to-day coaching and development intended to give each employee opportunities for improved performance, job growth, and employment satisfaction.

6. PROGRAMMATIC CAPABILITY AND PAST PERFORMANCE

a. **Past Performance - Feasibility – Previous work and prior results**

Mainstream PdNA applications have been shown to be more reliable and robust than previous mainstream PNA reactors. Successful operation of full-scale mainstream PdNA, in select configurations, has been shown at HRSD, with research in suspended growth, deep bed filter, IFAS, and moving bed biofilm reactors (MBBR) configurations demonstrating feasibility of the process. The most robust example of the feasibility of PdNA has been shown through the success of the first full-scale mainstream application in retrofitted deep-bed filters at HRSD's York River WRRF in Seaford, Virginia in 2018. This process has been in operation for more than 4 years, with the use of PdNA leading to methanol savings of 85%, shown in **Figure B**, and alkalinity savings of 100%. PdNA increase in capacity of 35% (Fofana et al., 2022)[iii]**.** The successful operation of this plant has illustrated the feasibility of long-term, stable use of full-scale mainstream PdNA, as well as its many benefits.

Figure B



b. **Past Performance – Federal and State Funds**
HRSD has a robust finance department with high credit ratings, and system capabilities for tracking separate grant funds and expenses in accordance with GAAP and other Federal requirements.

i. Environmental Protection Agency – Water Infrastructure Finance Innovation Act (WIFIA) Loans: N19105VA $225,865,648, issued September 28, 2020; and N19152VA $476,581,587, issued September 21, 2021. Requirements are reviewed and approved by the Owners Consultant and coordinated with DEQ, EPA, and construction vendors to ensure agreement compliance. Using consistent oversight, HRSD has been compliant with managing the WIFIA loan reporting requirements. Projects under these loans are in progress and no final technical reports have been completed to date.

ii. Virginia Department of Environmental Quality (DEQ) – Clean Water Revolving Loan Fund (VCWRLF) pass-through funding: 515751 $100,000,000, issued September 28, 2020, and completed; and 515660 $26,063,013, issued April 29, 2022. HRSD works closely with DEQ and the Virginia Resources Authority (VRA) which serves as the financial manager of the VCWRLF. Per the agreements, all construction contracts must be compliance with the American Iron and Steel and Davis Bacon Wage requirements. These requirements are reviewed and approved by HRSD project managers and coordinated with DEQ and construction vendors to ensure agreement compliance. HRSD has been compliant with managing both loan reporting requirements.

iii. Virginia Department of Health – Marina Program $77,500. Grant award for the Boater Education and Pump Out Program. This program was funded in whole by VDH from

1996 – 2006 and has been funded in part from 2007- present. Grant funding from VDH has been renewed annually.

c. **Reporting Requirements -** quarterly financial and programmatic. HRSD has a history of meeting reporting requirements under its agreements. HRSD has the proven capacity to continue to complete timely and accurate reports. HRSD Finance has systems in place to prepare accurate financial reports. The Technical Services division will hire a program manager to oversee the progress reports, as well as progress reports provided by contractors.

d. **Staff Expertise –** Resumes / CVs are provided for the primary collaborators, Charles Bott, Ph.D., Chris Wilson, Ph.D., and Kevin Parker, MBA.

CHARLES B. BOTT, Ph.D., P.E., BCEE

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Dr. Charles B. Bott joined HRSD in 2009 and is the Chief Technology Officer. He manages technology innovation and research and development for HRSD's wastewater treatment plants and interceptor system. Charles is also an Adjunct Professor in the Departments of Civil and Environmental Engineering at Virginia Polytechnic Institute and State University (Virginia Tech) and Old Dominion University. He was formerly an Associate Professor in the Department of Civil and Environmental Engineering at the Virginia Military Institute and a consulting engineer with Parsons Engineering Science. Charles has a bachelor's degree in Civil Engineering from the Virginia Military Institute, a master's degree in Environmental Engineering from the Johns Hopkins University, and a Ph.D. in Civil and Environmental Engineering from Virginia Tech. He is a fellow of the Water Environment Federation (WEF), a member of the Science and Technology Advisory Committee to the Chesapeake Bay Program Executive Council, and a member of the National Science Foundation Engineering Directorate Advisory Committee. Charles is a professional engineer in Virginia, a board-certified Environmental Engineer, and a licensed wastewater treatment plant operator – Virginia Class I. He is a two-time winner of the WEF Harrison Prescott Eddy Medal for outstanding contribution to wastewater principles/processes research, and he was a previous member of the WEF Board of Trustees. Charles' technical interests include municipal and industrial wastewater treatment process engineering, as well as renewable energy generation and resource efficiency. He has specific expertise in the areas of advanced water treatment technologies, chemical and biological phosphorus removal, nitrification/denitrification, nutrient recovery, deammonification/ anammox, biological treatment process modeling and design, and biogas conditioning. Important areas of focus include mainstream shortcut nitrogen removal, processes for biological treatment intensification, and technologies for potable reuse.

EDUCATION

1996	B.S.	Civil Engineering with Minor in Math – Distinguished Graduate, Virginia Military Institute, Lexington, Virginia.
1997	M.S.E.	Environmental Engineering, Johns Hopkins University, Baltimore, Maryland.
2001	Ph.D.	Civil and Environmental Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Dissertation Title: *Elucidating the Role of Toxin-Induced Microbial Stress Responses in Biological Wastewater Treatment Process Upset*

PROFESSIONAL EXPERIENCE AND REGISTRATION

2015 – present:	Chief Technology Officer & Director of Water Technology and Research, Hampton Roads Sanitation District, Virginia
2009 – 2015:	Chief of Special Projects (research & development), Hampton Roads Sanitation District, Virginia.
2007 – present:	Adjunct Professor, Department of Civil and Environmental Engineering, Virginia Tech.
2009 – present:	Adjunct Professor, Department of Civil and Environmental Engineering, Old Dominion University.

2007 – 2009: Associate Professor, Department of Civil and Environmental Engineering, Virginia Military Institute.
2007 – 2013: Principal, Green kW Energy, Inc. (renewable energy company focusing on landfill and digester biogas treatment and small (<4 MW) energy generation projects).
2003 – 2009: Independent Engineering Consultant for utilities, industries and consulting firms
2003 – 2007: Assistant Professor, Department of Civil and Environmental Engineering, Virginia Military Institute.
2001 – 2003: Environmental Engineer, Parsons Corporation, Fairfax, Virginia.
2001 – 2003: Adjunct Professor, Department of Civil and Environmental Engineering, Virginia Tech, Northern Virginia Graduate Center.
1997 – 2001: Research Assistant, Department of Civil and Environmental Engineering, Virginia Tech
2000: Class Instructor, Department of Civil and Environmental Engineering, Virginia Tech.
1996 & 1997: Project Engineer, Combined Technologies, Inc., Richmond, Virginia (geotechnical and geoenvironmental engineering).

- Professional Engineer, Virginia (Lic. No. 0402 039023)
- Board Certified Environmental Engineer - AAEE (No. 07-10056)
- Class I Wastewater Works Operator, Virginia (Lic. No. 1909 002174)
- Class V Waterworks Operator, Virginia (Lic. No. 1955 007251)
- Virginia Firefighter 1&2
- Virginia Hazardous Material Operations & OSHA Hazwoper
- Virginia Emergency Vehicle Operations

HONORS AND NOTABLE RECOGNITIONS

2023: National Association of Clean Water Agencies (NACWA), National Environmental Achievement Award for HRSD “Taking a DETOUR for Shortcut Nitrogen Removal: Partial Denitrification-Annamox (PdNA)”

2022-present: Chief Engineer, Exmore Virginia Volunteer Community Fire and Rescue Company

2021-present: National Science Foundation, Engineering Directorate Advisory Committee

2019: Water Environment Federation Ralph Fuhrman Medal for Outstanding Water Quality Academic-Practice Collaboration

2018: Association of Environmental Engineering and Science Professors, Fredrick George Pohland Medal for sustained and outstanding efforts to bridge environmental engineering research, education, and practice.

2018: Academy of Distinguished Alumni, Virginia Tech, Charles E. Via, Jr. Via Department of Civil and Environmental Engineering

2018: Virginia Water Environment Association, A.H Paessler Award in recognition of a government employee’s service to the water environment field and the association.

2016: Virginia Water Environment Association, Enslow-Hedgepeth Award

2016: Fellow of the Water Environment Federation

2015: Environmental Science and Technology Letters, Best of the Best Paper Award for Delgado-Vela et al. 2015.

2015: Water Environment Federation Harrison Prescott Eddy Medal for outstanding contribution to wastewater principles/processes research for the publication: Rieger, L., Jones, R.M., Dold, P.L., and Bott, C.B. 2014. Ammonia-based feedforward and feedback aeration control in activated sludge processes. *Water Environment Research*, 86(1), 63-73.

2014: IWA Global Project Innovation Awards, Applied Research Grand Honour Award for: "Unlocking the mysteries of mainstream deammonification – A paradigm shift for the wastewater industry," AECOM, DC Water, HSRD, PUB Singapore, STRASS, ARAConsult

2014: National Association of Clean Water Agencies (NACWA), Operations & Environmental Performance National Environmental Achievement Award for "HRSD Nutrient Removal Program: Advancement Through Management of Sidestream Loads Initiative"

2010-2018: Science and Technology Advisory Committee to THE Chesapeake Bay Program Exec Council.

2009: Virginia Military Institute Wilbur S. Hinman, Jr. '26 Research Award for the Engineering Division with Mark W. Miller ('09/CE) for excellence in stimulating, encouraging, and conducting research

2008: Outstanding Young Water Environment Professional Award, Water Environment Federation

2008: Young Professional Award, Virginia Water Environment Association

2008-2009: VMI Wachtmeister Faculty Development Leave for the academic year

2008: Outstanding Young Alumni Award, Virginia Tech, Charles E. Via, Jr. Department of Civil and Environmental Engineering

2007-2010: Appointed by the Governor of Virginia – State Representative on the Science and Technical Advisory Committee to the Chesapeake Bay Program Executive Council

2007-2010: Appointed by the Governor of Virginia – Virginia Board for Waterworks and Wastewater Works Operators

2007 & 2008: VMI Nominee and Finalist - Virginia Rising Star Outstanding Faculty Award

2006: Virginia Military Institute Corps of Cadets Mentor Award

2006: American Society for Engineering Education (ASEE) Southeastern Section Outstanding New Professor Award

2005: Virginia Military Institute Thomas Jefferson Teaching Award presented to a junior member of the faculty whose character and teaching reflect those qualities which are essential to the positive advancement of mankind

2005: Virginia Military Institute Wilbur S. Hinman, Jr. '26 Research Award for the Engineering Division with James O. Shambley ('05/CE) for excellence in stimulating, encouraging, and conducting research

2003: Water Environment Federation Harrison Prescott Eddy Medal for outstanding contribution to wastewater principles/processes research for the publication:

Bott, C.B. and Love, N.G. 2002. Investigating a Mechanistic Cause for Activated Sludge Deflocculation in Response to Shock Loads of Toxic Electrophilic Chemicals. *Water Environment Research*, 74(3), 306-315.

2002: 29th Annual AEESP (Association of Environmental Engineering and Science Professors) Doctoral Dissertation Award

2001: Parsons Excellence in Action Award, Avtex Fibers Superfund Site

2000: Outstanding Graduate Student Award for the College of Engineering, Virginia Tech

1997-2000: Charles E. Via, Jr. Civil and Environmental Engineering Fellowship, Virginia Tech – Via Fellowship

1997-2000: Virginia Tech Cunningham Fellowship

1999: Waste Policy Institute Graduate Fellowship - Virginia Tech

1995: Member of Phi Kappa Phi

1995: Member of Tau Beta Pi

PUBLICATIONS & PATENTS (GOOGLE SCHOLAR RECORD)

h-index = 44

https://scholar.google.com/citations?hl=en&user=8RTDgEIAAAAJ

Christopher A. Wilson, Ph.D, P.E.
Chief of Process Engineering and Research
Hampton Roads Sanitation District
Virginia Beach, VA 23455
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Research and Professional Experience Overview

Dr. Christopher Wilson has 20 years of post-graduate experience in the design and operation of wastewater treatment and residual solids management facilities as both a consulting engineers and public utility manager. He is currently appointed as an adjunct member of the faculties of the Virginia Polytechnic Institute and State University (Virginia Tech) and Old Dominion University (ODU). In his current position as Chief of Process Engineering and Research for Hampton Roads Sanitation District (HRSD), Dr. Wilson co-advises and manages the research conducted by approximately 15 graduate researchers from Virginia Tech and ODU working on diverse projects ranging from advanced digestion and solids management to indirect potable reuse and managed aquifer recharge. He also serves as Chief Process Engineer for HRSD and oversees treatment, residuals management, and resource recovery operations for 16 treatment facilities with a combined permitted capacity of 249 million gallons per day.

Prior to joining HRSD, Dr. Wilson served as Residuals and Biosolids Practice Leader for Greeley and Hansen from 2010-2016 where he completed and consulted on residuals management plants, process operations and detailed designs for public utilities across the United States. He is a past Vice-Chair of the Water Environment Federation Residuals and Biosolids Committee and current Chair of the Residuals and Biosolids Technical Symposium Committee for WEFTEC.

Professional Experience and Registration

HRSD, Virginia Beach, VA	2016-Present	Chief of Process Engineering and Research
Virginia Tech, Blacksburg, VA	2017-Present	Adjunct Professor, Civil and Env. Engineering
Old Dominion Univ, Norfolk, VA	2018-Present	Adjunct Professor, Civil and Env. Engineering
Greeley and Hansen, Richmond, VA	2008-2016	Residuals and Biosolids Practice Leader Senior Associate
Professional Engineer	2010-Present	Commonwealth of Virginia
Wastewater Treatment Operator, Class 1	2020-Present	Commonwealth of Virginia

Education

Doctor of Philosophy in Civil Engineering **2009**
Virginia Polytechnic Institute and State University, Blacksburg, Virginia
Dissertation Title: *Mechanisms of Methanogenic Inhibition in Advanced Anaerobic Digestion*
Advisor: John. T. Novak
Master of Science in Environmental Engineering **2006**
Virginia Polytechnic Institute and State University, Blacksburg, Virginia
Thesis Title: *The Effect of Steady-State Digestion Temperature on the Performance, Stability, and Biosolids Odor Production Associated with Thermophilic Anaerobic Digestion*
Advisor: John. T. Novak
Bachelor of Science in Civil and Environmental Engineering **2004**
Bucknell University, Lewisburg, Pennsylvania
Advisor: Thomas D. DiStefano

Peer-reviewed Publications

Cotto I, Dai Z, Huo L, Anderson CL, Vilardi KJ, Ijaz U, Khunjar W, Wilson CA, De Clippeleir H, Gilmore K, Bailey E, Pinto AJ (2020) Long solids retention times and attached growth phase favor prevalence of comammox bacteria in nitrogen removal systems, Water Research, Volume 169.

Sun Y and Vaidya R, Khunjar WO, Rosenfeldt EJ, Selbes M, Wilson CA, Bott CB, Titcomb M, Wang Z (2019) Mathematical modeling of biologically active filtration (BAF) for potable water production applications, Water Research, Volume 167.

Angeles LA, Mullen R, Huang I, Wilson CA, Khunjar W, Sirotkin H, McElroy A, Aga D. (2019) Assessing pharmaceutical removal and reduction in toxicity provided by advanced wastewater treatment systems. Environmental Science: Water Research & Technology

Vaidya R, Buehlmann PH, Salazar-Benites G, Schimmoller L, Nading T, Wilson CA, Bott CB, Gonzalez R, and Novak JT (2019) Pilot Plant Performance Comparing Carbon-Based and Membrane-Based Potable Reuse Schemes. Environmental Engineering Science. Volume 36, Issue 11.

Shaw A, Takács I , Pagilla K, Riffat R, DeClippeleir H, Wilson CA, Murthy SN (2015) Towards universal half-saturation coefficients: describing extant KS as a function of diffusion. Water Environment Research. 87(5) 387-391.

Wett B, Takács I, Batstone D, Wilson CA, Murthy SN (2014) Anaerobic model for high-solids or high-temperature digestion – additional pathway of acetate oxidation. Water Science and Technology. 68 (8) 1634-1640.

Wilson CA, Takács I, Wett B, Novak JT, Murthy SN (2012) The kinetics of process dependent ammonia inhibition of methanogenesis from acetic acid. Water Research. 46 (19) 6247–6256.

McNamara PJ, Wilson CA, Wogen MT, Murthy SN, Novak JT, Novak PJ (2012) The effect of thermal hydrolysis pretreatment on the anaerobic degradation of nonylphenol and short-chain nonylphenol ethoxylates in digested biosolids. Water Research. 46 (9) 2937-2946.

Wilson CA, Tanneru C., Banjade S., Murthy SN, Novak JT (2011) Anaerobic digestion of raw and thermally hydrolyzed wastewater solids under various operational conditions. Water Environment Research. 9 (83) 769-896.

Ma Y, Wilson CA, Novak JT, Riffatt R, Aynur S, Murthy SN, Pruden A (2011) Effect of various sludge digestion conditions on sulfonamide, macrolide, and tetracycline resistance genes and Class I integrons. Environmental Science and Technology. 45 (18) 7855-7861.

Wilson CA, Novak JT (2009) Hydrolysis of macromolecular components of primary and secondary wastewater sludge by thermal hydrolytic pretreatment. Water Research. 43 (18) 4489-4496.

Wilson CA, Murthy SN, Fang Y, Novak JT (2008) Effect of steady-state temperature on the performance and stability of thermophilic anaerobic digestion. Water Science and Technology. 57 (2) 297-304.

Google Scholar (h-index 15)

Awards and Honors

Hampton Roads Top 40 under 40, Virginia Media Events Inside Business	**2020**
Gus H. Radebaugh Award, Central States Water Environment Association	**2013**
Sonny Roden Memorial Scholarship, Virginia Water Environment Association	**2007**
Charles E. Via, Jr. Doctoral Fellowship, Virginia Polytechnic Institute and State University	**2006**
Michael D. LaGrega Award, Bucknell University	**2004**

KEVIN M. PARKER
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(757) 376-0886 kparker@hrsd.com

CURRENT POSITION:

Chief of the Technical Services Division in the Water Quality Department of the Hampton Roads Sanitation District (HRSD). 26 years of HRSD experience.

EDUCATION:

REGENT UNIVERSITY, Virginia Beach, VA (2017)
M.B.A. (Concentration: General Management) **GPA 3.9**

CHRISTOPHER NEWPORT UNIVERSITY, Newport News, VA (2010)
M.S. Environmental Science **GPA 3.8**

OLD DOMINION UNIVERSITY, Norfolk, VA (1999)
B.S. **Minor:** Chemistry **GPA 3.5**

WESTERN BRANCH HIGH (Honor Graduate), Chesapeake, VA (1995)

COURSEWORK OVERVIEW:

Undergraduate (B.S.):
University Chemistry I & II, Organic Chemistry I & II, Analytical Chemistry,
Biology I & II, Microbiology, Anatomy and Physiology, Toxicology,
Wastewater Systems, Statistics, Industrial Hygiene, Principles of Safety, Occupational Health,
Communicable Disease Control, Oceanography, Genetics

Graduate (M.S.):
GIS, Biometry, Ergonomics, Occupational Safety Management, Occupational Health and Safety Standards, Limnology and Stream Ecology, Wetland Plant Identification, Environmental Regulations, Scientific and Technical Writing, Global Change

M.B.A. (Concentration in General Management):
Managerial Economics, Business Ethics, Marketing, Accounting, Managing People, Technology and Innovation, Managing Organizations, Finance, Management of Small Business Systems and Technology, Business Planning and Launch, Servant Leadership, Operations and Supply Chain Management, Corporate Learning and Change

WORK EXPERIENCE:

-Developed Course and Teach - **Water Resource Recovery / Wastewater Treatment 101** course
-Twenty-six years of experience in Wastewater Treatment studies and **Management** of complex environmental / water quality monitoring programs and wastewater treatability studies. Advocacy and promotion of water reclamation / recycling programs including reuse through groundwater aquifer replenishment (SWIFT program at HRSD).
-Inaugural **Chairperson of the HRSD Sustainability Advocacy Group** (SAG):
*Piloted Alternative work arrangements: Drafted and implemented the HRSD telework policy
*Implemented the "blue can" HRSD recycling program
*Developed a hazardous waste / universal waste disposal program
-Developed reuse agreement with Nestle Purina to assign a $ value to the water

-**Committee Chair** of the Joint AWWA/VWEA Water Reuse Committee
2015- 2016 (established the committee after 3 years of inactivity)
-Active in VAMWA – PFAS Committee
-Active in VA AWWA Utilities Management Committee – Small Communities
-Active in AWWA National Small Communities Outreach Committee
-Active in AWWA/VWEA- Sustainable Utilities (Water Reuse)
-Active in WateReuse Mid-Atlantic Section (original member)
-Permits: Ensuring compliance with stringent state and federal regulatory requirements including VPDES.
-Development of the work center's **annual budget (>$5M)**
  ***including** the development of the **TSD Budget Model** for expense forecasting
-Storm water, surface water, groundwater, and wastewater **program management:** staffing, funding, water quality monitoring, and data interpretation.
-Whole Effluent Toxicity (WET) testing in the EPA regulated NPDES program. Chronic and acute tests on two sensitive species.
-**Chlorophyll Monitoring** and Assessment Program- Operation of a **research vessel** on the James River, sample collection, equipment maintenance/calibration, and supervision of project scheduling
-**Air Quality** monitoring
-**Presented** at the National Water Reuse Symposium, AEE World Energy Conference, Virginia Lab Practices Conference, local universities, VWEA / CWEA Education Workshops, VA WaterJam, and many other local events
-Developed the **TSD Intern Program**
-Business Case Evaluation Team
-Technical Writings/Publications - AEE, WET, VWEA Conduit and AWWA Tap Into VA
- Calculate HRSD Annual **Carbon Footprint**

EMPLOYMENT:

HAMPTON ROADS SANITATION DISTRICT (HRSD)
Virginia Beach, VA (October 1997-present) Water Quality Department

CERTIFICATIONS / SPECIAL TRAINING:
Graduate of the **EPA Water Quality Standards Academy**
Virginia Tech **Wastewater Short School** Levels 1&2 Certificates
Old Dominion University **Occupational Safety Certificate Program**
Awareness training for the **transport of hazardous materials /** DOT
Confined Space and Rescue training and certification
Visible Emissions Evaluator Certification (Method 9)
US EPA **Storm Water** Pilot Training Course (Phase I) MS4s
VDOT traffic flagging training
Virginia **Boating** Education and Safety Course
Virginia Natural Resources Leadership Academy (2023-2024)

7. **BUDGET** (up to 10 additional pages may be added if needed as an appendix to the Workplan)

a. Budget Spreadsheet. SF424A and SF424C are attached to the application.

Category	Description	Total	year 1	year 2
Personnel	HRSD PdNA Project Manager @ $95,000 with 4% increase per year	193,800.00	95,000.00	98,800.00
Fringe	1 FTE @ 59% Salary (above) x 4 years	114,342.00	56,050.00	58,292.00
	Subtotal	**308,142.00**		
Construction	Preliminary Engineering Review	617,000.00	617,000.00	
Design-Build	Design	2,468,000.00	2,468,000.00	
	Engineering During Construction	2,468,000.00	1,234,000.00	1,234,000.00
	Site Work: Builder Support During Design	493,600.00	493,600.00	
	Material Testing	123,400.00	123,400.00	
	Construction	52,062,000.00	13,015,500.00	39,046,500.00
	Contingency	-		
	Subtotal	**58,232,000.00**		
Equipment	Aerators, instrumentation, and media	1,000,000.00	1,000,000.00	
	Subtotal	**1,000,000.00**		
	Amount Requested	**59,540,142.00**	**19,102,550.00**	**40,437,592.00**
	Contingency - HRSD contribution	2,603,100.00		
	Total Project Cost	**62,143,242.00**		

b. Costs by Location and Type

Location / Type	Budget
HRSD Project Manager	308,142
James River PdNA MBBR	34,250,000
Williamsburg PdNA	10,385,100
Army Base PdNA	5,730,000
Nansemond PdNA adder for Advanced Nutrient Reduction	11,470,000
Total Project Cost	62,143,242.00
Minus Contingency	(2,603,100.00)
Amount Requested	**59,540,142.00**

c. Budget Narrative

i. **Personnel $308,142**

An HRSD Project Manager (Professional Engineer) will oversee consultant design-build activities, organize, help plan, and execute the PdNA project at the designated treatment facilities while managing associated budgets and schedules. The HRSD

Project Manager will lead the project team, define project goals, communicate with stakeholders, and see the PdNA project through to its completion.

ii. **Preliminary Engineering Review $617,000**
The Preliminary Engineering Report (PER) document is developed by the hired consulting engineering company to assist the HRSD Project Manager (Professional Engineer) and the project team in the planning and assessment of the PdNA project. The PER includes an assessment of existing treatment and the enhancement to PdNA implementation. The PER will evaluate GHG reduction through improved treatment, a reduction in chemical usage, the reduced use of electricity, and process intensification.

iii. **Design $2,648,000**
The hired consulting engineering company will develop the plans to construct PdNA treatment at four HRSD WRRFs, including Nansemond, James River, Williamsburg, and Army Base. The design includes the details of the project lifecycle where ideas, processes, resources, and deliverables are planned out.

iv. **Engineering During Construction $2,468,000**
During construction, it is anticipated that additional engineering services will be needed to fine tune and maximize efficiency of PdNA processes.

v. **Material Testing**
Prior to construction, or during early phase construction, certain material testing will be performed to ensure the best operation and treatment process success. Material testing puts resources like concrete, rebar, structural steel, and masonry through assessments that examine and analyze performance prior to and during construction. The materials to be tested include structural materials as mentioned, but also instrumentation, and other equipment and fixtures critical to PdNA operation.

vi. **Builder Support During Design**
The construction/builder involvement in the design phase is critical to successful communication between the design teams and the construction teams to ensure that project planning accounts for needs and addresses potential concerns.

vii. **Construction**
The hired consulting construction company will complete the physical processes of building, retrofitting, installing, programing, and all the associated activities to upgrade the four mentioned HRSD WRRFs to PdNA treatment. The construction contractor must plan, manage, monitor and coordinate health, safety, and all construction work carried out by their company. This construction will entail structural modification to existing wastewater process tanks, building of concrete/steel structures, the retrofitting of existing structures, the installation and relocation of equipment such as aerators, the installation of new instrumentation and the associated logic controllers and software, and the installation of PdNA plastic media.

d. Expenditure of Awarded Funds – HRSD takes prudent measures to ensure that our expenses are allowable, reasonable, and allocable.

References

[i] *McCarty, et al., 2011. Domestic wastewater treatment as a net energy producer-can this be achieved? Env. Sci. Tech*

[ii] Ibid

[iii] *Fofana, R., et al., 2022. Full-scale transition from denitrification to partial denitrification–anammox (PdNA) in deepbed filters: Operational strategies for and benefits of PdNA implementation. Water Environ. Res.*