University of Nevada, Reno

April 30, 2015

Mr. Michael Drinkwater
Truckee Meadows Water Reclamation Facility
8500 Clean Water Way
Reno, NV 89502

Project Title: **Truckee Meadows Water Reclamation Facility Dissolved Organic Nitrogen Treatment Study: Feasibility Study of Granular Activated Carbon and Ozone**
UNR PI(s): Dr. Eric Marchand
UNR SP No.: 1500887
Proposed project funding: $44,357

Dear Mr. Drinkwater,

The University of Nevada, Reno (UNR) will be pleased to participate in the above-referenced proposal project. Enclosed, please find the proposed documents, prepared according to standard University policies and procedures.

As a state institution of higher education, UNR is limited in indemnification and maintains self-insurance in accordance with Nevada Revised Statute. Only clauses applicable to non-profit educational institutions should be flowed down from any prime award. If an award is issued, UNR reserves the right to negotiate terms and conditions including flowed-down FARS clauses.

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Board of Regents, Nevada System of Higher Education, on behalf of the University of Nevada, Reno

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Reno, NV 89557-0240
(if by email: ospadmin@unr.edu)

For questions of a technical or program nature, please contact the project director. For contractual or business questions, please contact this office and refer to the above SP number.

Sincerely,

Melodie Gander
Associate Research Administrator, Pre-Award

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Proposal to the Truckee Meadows Water Reclamation Facility (TMWRF)

Truckee Meadows Water Reclamation Facility Dissolved Organic Nitrogen Treatment Study: Feasibility Study of Granular Activated Carbon

Principal Investigators:

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I. Introduction

A. Truckee Meadows Water Reclamation Facility Background

The Truckee Meadows Water Reclamation Facility (TMWRF) was built in 1964 and provides wastewater treatment services to the Reno-Sparks area[3]. The Nevada Division of Environmental Protection (NDEP) limits the amount of nitrogen allowed in the effluent discharged to Steamboat Creek, which flows into the Truckee River and eventually Pyramid Lake. TMWRF historical data indicates nitrogen level limits in effluent discharged into the Truckee River were exceeded five times between 2004 and 20114. In 2013, TMWRF failed to meet nitrogen level regulations resulting in $16,500 in fines. Due to these nitrogen level violations, the NDEP is now requiring approval of maps for new subdivisions to be evaluated on a monthly basis[1], thereby limiting growth in the area. With construction of Tesla's Gigafactory at the Tahoe-Reno Industrial Park, the Reno-Sparks area is forecasted for substantial growth[5], and there are concerns that TMWRF is not adequately prepared to accommodate additional water flows. The primary concern is not that TMWRF cannot process more water[1]; it is that the current levels of nitrogen in the effluent are approaching the total maximum daily load (TMDL) of 500 pounds per day. Nitrogen is a major concern in the area since high concentration can affect the amount of dissolved oxygen available for aquatic life in the Truckee River[6]. Laboratory tests by TMWRF have revealed that organic nitrogen makes up the largest fraction of the effluent nitrogen[4], so steps to reduce nitrogen should focus on organic nitrogen.

B. Dissolved Organic Nitrogen Background

Nitrogen speciation in wastewater is complex and there are a number of different compounds that may exist in treatment plant effluent. The major nitrogenous compounds of interest during wastewater treatment are: (1) Organic nitrogen (ON); (2) Ammonia (NH_3) or Ammonium (NH_4^+); (3) Nitrite (NO_2^-); (4) Nitrate (NO_3^-); and (5) Nitrogen gas (N_2) [7]. Of these compound classes, organic nitrogen is the least characterized since a large number of compounds can be classified as organic nitrogen. Organic nitrogen can be further classified as either particulate organic nitrogen (PON) or dissolved organic nitrogen (DON) with the operational definition of DON being filtered through a 0.45 μm filter. Since TMWRF utilizes dual-media filters prior to discharge, PON is a minimal component of the effluent nitrogen. Dissolved organic nitrogen consists of numerous different compounds where nitrogen is bound to an organic carbon compound. In domestic wastewater, nitrogen in DON is typically found in the amine ($-NH_2$) form since this is the most common form associated with typical domestic wastewater and biomolecules. DON can be a challenge to remove from wastewater treatment facilities since it may be non-biodegradable or slowly biodegradable. DON is a recurring theme at a number of wastewater treatment plants in the United States and around the world [12]. Figure 1 (from reference 13) details the range of effluent DON from a number of studies, with the 50% concentration ranging from about 0.8-1.5 mg/L.

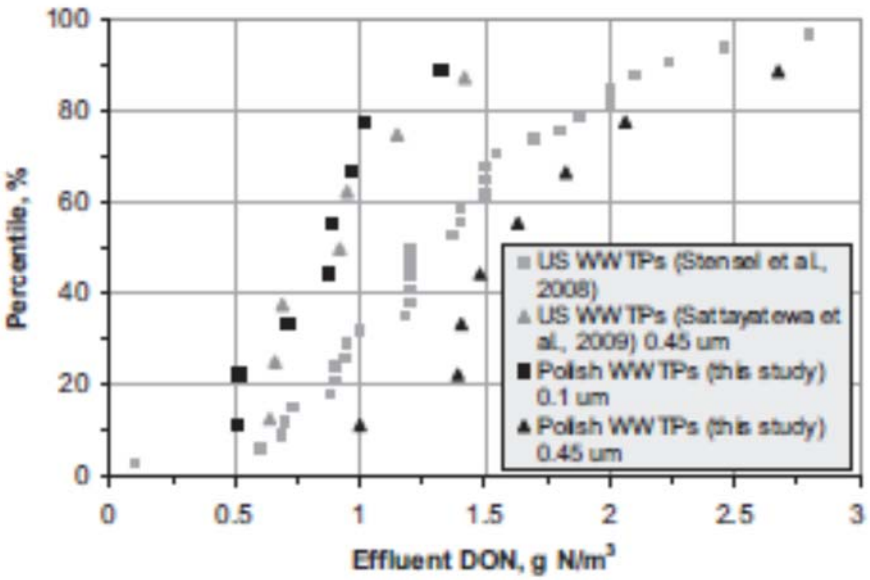

Figure 1: Probability distributions of secondary effluent DON concentrations (Czerwionka, 2012)

To identify potential solutions, it is proposed to study the role that target physical and chemical processes have on the fate of DON in TMWRF process water. Specifically, it is proposed to study both granular activated carbon (GAC) [2, 8] and ozonation [16] on the fate of DON in TMWRF process water. Since concentrations of DON vary throughout the treatment plant, it is proposed to study the role that these processes have on DON for a variety of water sources within the facility.

II. Scope of Work

The objective of the proposed study is to determine the treatability of DON collected from different process streams at TMWRF using granular activated carbon treatment. The specific tasks that will be performed include:

- Task 1: Literature Review and Detail Plan of Laboratory Study
- Task 2: Evaluation of DON data for TMWRF
- Task 3: Laboratory Studies: GAC treatment
- Task 4: Data Analysis, Cost Estimate, Treatment Analysis, and Recommendations

Throughout the project, there will be a number of dedicated meetings between UNR researchers and TMWRF stakeholders (this term will be used throughout this proposal to include city engineers, TMWRF process engineers, TMWRF manager, TMWRF operators, or other relevant personnel). Detailed information for each task is provided below.

Task 1. Literature Review and Detail Plan of Laboratory Study

There are numerous reports in the literature and industry trade journals detailing the presence, fate, and potential treatment options for DON in wastewater effluents [8, 10-17]; however, detailed research has not been conducted at TMWRF on DON treatment strategies. At the onset of the proposed research, a complete literature review will be conducted to better understand the processes that influence DON formation and degradation during treatment. In addition to external literature, the research team will work with TMWRF stakeholders to obtain relevant plant data to assist with the development of the laboratory studies. Initial efforts will focus on collecting and summarizing literature on DON trends observed at other treatment facilities and determining if these trends are applicable for TMWRF, identifying treatment processes targeting DON and their respective efficiency, and using these sources to develop a testing and research plan for the laboratory study. The current focus is on studying the effectiveness of granular activated carbon; however, if results of the literature review indicate that another treatment process has promise, then the prospect of including that in the current research will be discussed between UNR researchers and TMWRF stakeholders. As part of the literature review process, specific sampling locations will be proposed for testing the proposed treatment alternatives. At this time, it is planned that there will be a minimum of three different sampling locations within the plant: (a) TMWRF filter effluent, (b) secondary clarifier effluent, and (c) centrate. However, if it is deemed that other water sample locations would provide useful information, then those locations will be added to the research plan (Task 2 will provide additional insight and validation of sampling locations).

Task 1 Deliverables will include preparation of a draft literature review report that will be submitted to TMWRF stakeholders. The summary will also include a detailed laboratory experimental plan that will be reviewed and discussed at a meeting with UNR researchers and TMWRF stakeholders following a two-week review by TMWRF stakeholders.

Task 2. Evaluation of DON data for TMWRF

Data are currently being collected on DON concentrations within TMWRF process streams by the TMWRF water quality laboratory. This task will involve UNR researchers working in a collaborative manner with TMWRF stakeholders to summarize the data, identify spatial and temporal trends (where applicable), and attempt to develop a better understanding of the changes in DON concentrations throughout the facility at different times of year and under different operating conditions. This analysis will help provide valuable information to optimize the laboratory studies described in Task 3.

Task 2 Deliverables will include development of a technical memorandum (TM) by UNR researchers in conjunction with TMWRF stakeholders. This TM will be used as a basis for understanding the current DON character at the facility and inform researchers about potential operational strategies that might influence DON formation and persistence within the facility. Further, these data will provide insight into potential in-plant locations where implementing DON treatment strategies (e.g., GAC treatment) will provide the maximum benefit.

Task 3. Laboratory Studies

Following approval of Task 1 deliverables by TMWRF stakeholders and completion of Task 2, the experimental portion of research will commence. As described earlier, the specific design of all proposed experiments will be reviewed in conjunction with TMWRF stakeholders to ensure that the laboratory studies will complement treatment goals for the facility.

DON Size Fractions: Dissolved organic nitrogen has been analyzed by the water quality lab at TMWRF and the existing data will be available to the researchers, but additional analyses will be necessary to identify seasonal variations and the influence of changes in plant operation on the composition and character of DON. Literature [12-14] has revealed that the organic nitrogen size fractions can vary considerably between different facilities. Researchers have identified three standard size cutoffs (1.2 μm, 0.45 μm, and 0.1 μm) that play a role in DON fate and transport. While the technical definition of DON relates to the 0.45 μm-filtered water, understanding the dynamics of DON association with solids may provide useful information to UNR researchers and TMWRF stakeholders. Initial laboratory studies will be performed to identify the role that these different size fractions play at different locations in the treatment process and the data will be compared to reports in the literature.

Analytical Methods. Industry-accepted standard analytical techniques will be used for all analyses according to accepted laboratory methods[9]. A QA/QC plan will be developed for the DON analytical protocol and UNR researchers will interact with TMWRF lab personnel as appropriate to ensure that the analytical methods used are the same. While the majority of the sampling will focus on dissolved organic nitrogen, other water quality parameters will be monitored as appropriate (e.g., pH, UV absorbance, TOC, SUVA, conductivity, etc.).

Granular Activated Carbon Experiments. GAC has been shown to be effective at removing DON in a number of cases[10, 11]; however, it is not clear whether this approach will be effective with TMWRF DON. Specific protocols for the GAC experiments will developed as part of Task 1 and confirmed with TMWRF stakeholders before beginning Task 2 experiments. Based on the review of TMWRF water quality data, a uniform sampling collection time will be used to ensure that there is not any unintentional bias of sample data. Samples will be immediately characterized based on standard analytical techniques, filtered as appropriate, and stored on ice or at 4^{o}C until experiments begin. For the GAC study, a minimum of three different GAC sources will be used to identify the difference in treatment performance with different carbon size fractions and/or carbon types (i.e., traditional GAC versus novel or engineered activated carbon products). Initially, GAC isotherms will be conducted using 250 mL Erlenmeyer flasks on a shaker table incubated at 20^{o}C. Isotherm experiments will be conducted for 1-day to allow equilibrium to occur and then the liquid-phase DON concentration will be determined. Isotherm data will be fit to well-accepted isotherm equations such as the Freundlich and Langmuir expressions. The rate of sorption and storage capacity of different GAC stocks can be calculated to identify the best sorbent. A subset of the experiments will be performed with at least one TMWRF water stream that has been size fractionated at 1.2, 0.45, and 0.1 μm to identify whether one particular size fraction is preferentially removed. Following the isotherm experiments, small-scale column experiments will be performed with

the best-performing GAC sample. These experiments will be developed in consultation with TMWRF stakeholders to ensure that the results of the small-scale column studies will allow adequate transition to pilot-scale tests if that is agreed upon by TMWRF stakeholders.

Statistical Analyses: All experiments will be conducted in triplicate systems to allow for appropriate statistical tests to be performed. All data will be reported using average values with standard deviations to identify statistical significance and both positive and negative controls will be included in each experimental matrix.

Task 3 Deliverables will include preparation of a technical memorandum (TM) including the data obtained at the end of each major subtask of the study. The TM will also include preliminary data analysis, results, and discussion. The TM will be discussed at a meeting with UNR researchers and TMWRF stakeholders following a two-week review by TMWRF stakeholders.

Task 4: Data Analysis, Cost Estimate, Treatment Analysis, and Recommendations

Following the completion of Task 3 research, UNR researchers will perform the following tasks and present the findings in a workshop and draft report:

- Results and discussion from the laboratory study;
- Conclusions on the effectiveness of the DON treatment processes;
- Recommendations on the requirements of a pilot-study before full-scale design;
- Budget level cost estimate for a full-scale treatment unit and discussion of recommended flow rates if the process is to be scaled; and
- Development of a model to identify anticipated effluent DON concentrations with varying levels of partial plant treatment.

Task 4 Deliverables will include preparation of a technical memorandum (TM) including the data obtained at the end of each major subtask of the study. The TM will also include preliminary data analysis, results, and discussion. The TM will be discussed at a meeting with UNR researchers and TMWRF stakeholders following a two-week review by TMWRF stakeholders.

III. Project Duration and Cost

The proposed project duration is 7.5 months. The proposed project cost is $44,357 ($38,571 in base costs + $5,786 contingency) and a detailed breakdown is provided in Table 1 including a budget justification on page 8. The project will commence in May 16, 2015 and will be completed on December 31, 2015.

Table 1. TMWRF DON Treatability Study Budget – Phase 1 (GAC)

Categories	2015 Budget
a. Personnel	
PI and co-PIs	$4,500
Post-Doc	$0
Graduate Research Assistant - 12 months	$13,300
Undergraduate/Hourly Students	$1,200
Laboratory Technician, 1.5 months	$1,340
TOTAL PERSONNEL COSTS	$20,340
b. Fringe Benefits	
Faculty (summer - 4%)	$180
Faculty (academic – 32.25%)	$0
Post-Doc (27%)	$0
Laboratory Technician (42.25%)	$566
Grad. Research Assistant (15%)	$1,995
Student Hourly (2%)	$24
TOTAL FRINGE BENEFITS	$2,765
c. Travel	
Sample collection (under operating) - $500	$0
TOTAL TRAVEL COSTS	$0
d. Equipment	
No major equipment necessary	$0
TOTAL EQUIPMENT COSTS	$0
e. Supplies	
Consumables, Sample Collection, Analytical	$2,500
TOTAL SUPPLY COSTS	$2,500
f. Other	
Tuition - 1 semester	$1,828
TOTAL OTHER COSTS	$1,828
g. TOTAL DIRECT COSTS	$27,433
h. Indirect Costs	
UNR overhead Rate (43.5%)	$11,138
i. TOTAL PROJECT COSTS	$38,571
j. CONTINGENCY (15%)	$5,786
k. TOTAL REQUESTED	**$44,357**

Budget Justification

Personnel - $20,340

A total of $20,340 is requested for personnel funds. These include summer salary time for Drs. Marchand and Yang ($4,500), 8 months of Research Assistant (RA) funding for a graduate student ($13,300), about 120 hours for an undergraduate assistant ($1,200), and 1.0 months for the EnvE laboratory technician ($1,340).

Fringe Benefits - $2,765

A total of $2,765 is requested for fringe benefits according to the following rate: Faculty summer (4%); Graduate Assistant (15%); Student Hourly (2%); and Laboratory Technician (42.25%).

Supplies - $2,500

A total of $2,500 is requested for supplies (GAC, glassware, fittings, reactor vessels, etc.), analytical research equipment charges, laboratory disposables (gloves, pipet tips, Kimwipes, etc.), and transportation charges associated with sample collection at the treatment facility.

Other - $1,828

A total of $1,828 is requested for one semester of tuition for the graduate Research Assistant.

Indirect Costs - $11,138

A total of $11,138 is requested for indirect costs (the UNR indirect cost rate for all categories except tuition and equipment is 43.5%). [Additional Indirect Costs included in Contingency Costs shown below].

Contingency Costs - $5,786

A total of $5,786 is requested to cover contingency costs for unexpected project needs (15% of overall project). These funds require sponsor permission to use. For UNR budgeting purposes, the contingency will amount to $4,032.06 in operating and $1,753.94 in indirect costs.

TOTAL REQUEST: $44,357

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