Willard Bay Project Proposal Form

Applicant Name: Westminster College (Dr. Betsy Kleba, Dr. Frank Black, and Dr. Bonnie Baxter)

Project Title: Utah's indigenous microbial communities as bioremediation tools for the clean-up of oil contaminated ecosystems

Agency Name: Westminster College
Mailing Address: 1840 South 1300 East, Salt Lake City, UT 84105
Phone: (801)-832-2366 E-mail: bkleba@westminstercollege.edu
☐Individual ☐Non-Profit ☐Govt. Agency ☒Academic ☐Commercial ☐Other

1. Estimated Project Costs:

Labor: $37,000
Materials: $14,600
Equipment: $19,400
Administration: $20,720
Miscellaneous: $18,000 (Summer science camp)
TOTAL requested: $109,720

Other sources of project funding: Westminster College Amount: $54,400

Total project cost including other sources of funding: $164,120

2. Describe the purpose and need of the project:

The extensive network of natural gas and oil transmission lines traversing the Wasatch Front Range, along with the presence of multiple refineries in the region, places many areas of northern Utah at risk for hydrocarbon contamination in the event of an oil spill or pipeline leak. Indeed, the two oil spills into Red Butte Creek in 2010 and the discharge of diesel fuel adjacent to Willard Bay in 2013 are but recent examples illustrating this risk, which will only increase with an increase in the transport of waxy crude oil from the Uintas to refineries in Salt Lake City by truck or the proposed Uinta Express Oil Pipeline. Hydrocarbon contamination of surrounding environments by oil spills poses adverse effects for the health of humans and the entire ecosystem, necessitating immediate and comprehensive action to mitigate these risks. In all cases above, clean-up was carried out using conventional methods that relied on soaking up available contaminants and/or removing contaminated soil from the site.

Physical and chemical remediation techniques can effectively be used to contain and clean-up oil at sites proximal to an oil spill or release where the amounts and concentrations of the organic compounds involved remain high. However, these approaches become both less effective and more costly once the contamination has found its way into larger environmental compartments and results in more diffuse contamination. When the spread and dilution of such oil contamination occurs, bioremediation often represents one of the few effective options to further decrease levels of the hydrocarbon contaminants, especially in large bodies of water, such as the large impoundments that characterize the Great Salt Lake (GSL). While some natural attenuation and bioremediation can occur in the absence of human intervention, the rates at which these take place often render them less effective over time scales of interest. However, an understanding of the processes and organisms involved in bioremediation can be used to dramatically increase rates of hydrocarbon degradation by more eco-friendly methods that require far fewer resources or money than traditional engineered approaches.

Bioremediation is the process by which biological activities rid an environment of chemical pollutants. Most commonly, bioremediation employs microbes containing enzymes able to transform and decompose the pollutant. Many ecosystems are thought to contain a natural population of microbes with

the capacity to degrade hydrocarbons. For example, much of the degradation of oil released by the Deepwater Horizon spill in 2010 has been carried out by the indigenous population of oil-degrading bacteria found naturally in the Gulf of Mexico[1-3]. A primary challenge to bioremediation is that the indigenous population of microbes may not have the capacity to degrade all contaminants present, or their ability to degrade the contaminants may be hindered by the eventual lack of other resources (i.e. while there is plenty of carbon available in the oil, nitrogen or phosphorous become limiting nutrients)[4,5]. To overcome these obstacles, modern bioremediation requires an understanding of the degradative capacity of indigenous microbes along with an analysis of factors that can facilitate the growth of these microbes and their biotransformation of the pollutants.

In 1978, Ward and Brock[6] demonstrated that the North Arm of the GSL contained a microbial community capable of degrading C_{15}-C_{40} alkanes by culturing environmental samples on a medium with mineral oil as the sole source of carbon. While they were able to grow organisms in media up to 20% salt, they were not successful at culturing hydrocarbon-degraders at higher salinities, and the rate of hydrocarbon-degradation by the GSL microbial community decreased with increasing salt concentration. Recently, we have repeated some of this work to identify individual members of the GSL microbial community in order to characterize their unique hydrocarbon-degrading capabilities. We have been able to culture and isolate a number of microbes on a low-nutrient medium with mineral oil as the sole carbon source (Figure 1), confirming the continued presence of hydrocarbon-degraders in the North Arm of the GSL. Our initial selection procedure utilized a medium of low salinity (<1%), demonstrating that our isolates do not require high salt concentrations for survival despite the high salinity of the environment from which they were isolated. Thus, these oil-degrading microbes from the hypersaline North Arm also thrive under lower salt conditions, making them generally employable for use across a large salinity gradient, including freshwater aquatic environments like Willard Bay.

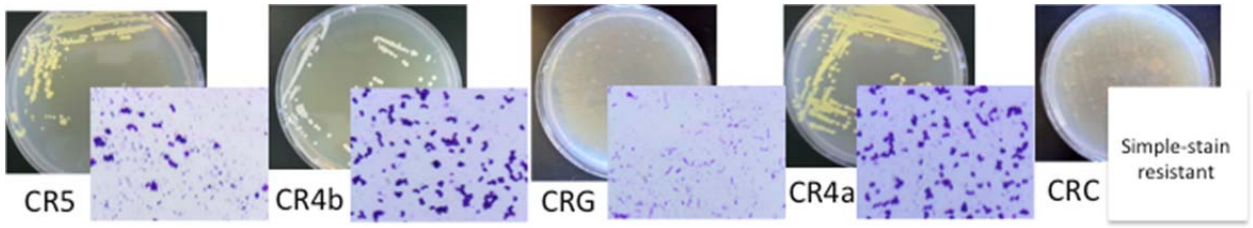

Figure 1. Colony morphology (on plates) and cell morphology (by microscopy after staining) for five oil degrading microbial cultures isolated from the GSL by selection on media containing mineral oil as the sole carbon source.

Initial DNA sequencing results show that the GSL petrophile community contains members from the following genera: *Bacillus*, *Micrococcus*, and *Paenibacillus*. Importantly, there are a number of species within each of these genera that have been shown to be able to degrade hydrocarbons in other environments[7-12]. What is interesting about our isolates is that they have extraordinary wide salinity tolerance, making them useful for bioremediation in both hypersaline and freshwater environments. Although there isn't a published record of a hydrocarbon-degrading bacterial community living in Willard Bay, given its close proximity to the GSL and its exposure to low levels of hydrocarbons from natural and human activities (boat use on the Bay, incomplete combustion and vehicle exhaust from I-80) it is likely that this ecosystem contains its own indigenous population of hydrocarbon-degraders, some of which may be the same as those found in other regions of the GSL.

The proposed research and educational activities aim to (1) evaluate the feasibility of using bioremediation as an effective strategy to clean-up oil spills in aquatic ecosystems in Utah using the unique microbial communities that inhabit our local ecosystems, and (2) integrate an educational component to ensure that the state's educators, citizens, and scientists of tomorrow are informed about options for dealing with oil spills and related problems arising from our industrial endeavors.

Research questions:

1. How does the community composition of hydrocarbon-degrading microbes vary between regions of the GSL: from freshwater Willard Bay, to the saline South Arm, to the hypersaline North Arm?
2. Exactly which hydrocarbons are degraded by microorganism in various regions of the GSL and what are the chemical products of this degradation?
3. What physical or chemical variables control rates of hydrocarbon biodegradation, and does effective hydrocarbon degradation by local microbes require the addition of a limiting nutrient?

3. Estimated time frame of the project with significant milestones.

The project period will be 2.3 years. All activities and the final report will be completed by Dec., 2016:

	2014	2015				2016			
Activity	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Instrumentation upgrade and testing	X								
Sample collection/field work			X	X					
Isolate oil-degrading microbes			X	X	X	X	X		
Characterize oil-degrading microbe growth, limitation			X	X	X	X	X	X	
Measure hydrocarbon degradation rates, products					X	X	X	X	
Summer science camps			X	X			X	X	
Annual and final reports					X				X

4. Describe the location of the project with a map, including details on areas that will be enhanced:

Natural surface waters and aquatic sediment will be collected from three sites around the GSL: Willard Bay (salinity <0.2%), Gilbert Bay (salinity ≈ 12%), and Gunnison Bay (salinity ≈ 28%). These three sites were chosen because they differ substantially in their salinity and nutrient levels, and thus our results from these dissimilar locations are expected to be more widely applicable to the bioremediation of other aquatic environments found throughout the Great Salt Lake ecosystem. We may also collect samples from Farmington Bay, which has lower salinities and higher nutrient levels than Gilbert Bay due to substantial wastewater treatment effluent inputs, which may also result in different microbial communities in Farmington Bay.

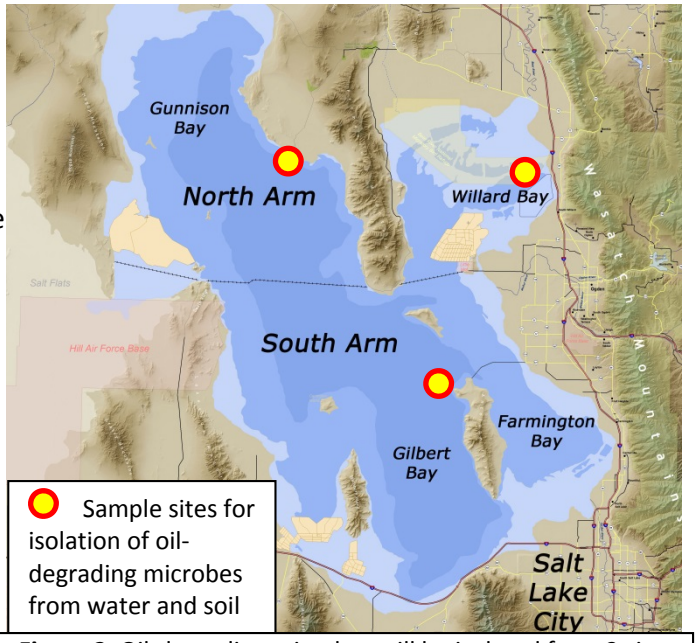

Figure 2. Oil-degrading microbes will be isolated from 3 sites.

5-6. Describe how the project will enhance and protect waterways affected by the Willard Bay diesel release and improve conditions of the following: wildlife, habitat, natural vegetation, water quality or emergency response. Describe project's connectivity to other natural areas:

Results from the proposed research will provide information on the feasibility of bioremediation in Willard Bay, other regions of the GSL, and more broadly in other aquatic ecosystems in northern Utah. This information can be used to develop more effective methods for cleaning up existing and future hydrocarbon contamination that will be low cost and eco-friendly. These new bioremediation tools will thus improve and enhance ecosystem services, including improved wildlife habitat, protection of wildlife and natural vegetation, improved water quality, and safe fishing, boating, and swimming.

7. Describe any additional social benefits of implementing this project:

This project will provide immense social benefit through multi-faceted educational experiences to high school teachers, high school students, and college students in Utah. Camp Great Salt Lake is a week-long camp for high school students coordinated through Westminster College's Great Salt Lake Institute (GSLI). The camp promotes science and environmental education using the GSL as a model system. Campers learn about native plants and wildlife, study the geochemistry and ecology of the GSL's extreme ecosystem, and conduct lab and field experiments. We will develop additional modules specifically on oil spills and contamination of the GSL, as well as the different techniques used to clean-up oil spills and other industrial releases. This camp specifically targets and provides scholarships for minorities, women, and other groups that are underrepresented in scientific fields to broaden participation in science by these groups and improve their achievement and retention in the STEM pipeline. Camp Great Salt Lake targets the following three populations:

1. Twenty five high school students from Salt Lake Valley public schools, with a focus on women and students from backgrounds and groups underrepresented in science and technology.
2. Undergraduate student teachers, who develop camp curriculum and help lead camp activities.
3. Public school teachers, who serve as consultants and mentor student teachers.

The Great Salt Lake Summer Camp is a powerful learning experience for high school students and provides valuable training for current and future teachers. Most of the students and teachers involved can only participate if they receive scholarships. Rio Tinto has been the primary funder for this camp over the last four years. The recent landslide has jeopardized their science education funding in the near future. Therefore, we seek funds to support the future of this program and ensure it continues to serve as an important learning resource in our community. The goals of Camp Great Salt Lake are to:

1. Increase student interest in science and environmental issues, particularly those involving the unique environments comprising the Great Salt Lake, using fun, interactive hands-on activities.
2. Provide students in Utah with their first personal experience with college and college life, increasing their likelihood of attending college and getting a degree in a STEM field.
3. Create a valuable and unique experience for student teachers that empowers them to teach interdisciplinary and engaging science lesson on the GSL at their future schools throughout Utah.

At least 8-10 undergraduate students, from Westminster College and McNair Scholars from across Utah, will be involved in all stages of the proposed research. Thus, this project will also provide training for future scientists and researchers in Utah that will have the skills and topical knowledge required to contribute to research and management issues related to the GSL, water quality, ecosystem function, and contaminant mitigation in their future capacities in the private or public sectors long after they leave Westminster.

8. Project plans and details, including rights to work on specified piece of land:

All research and educational activities will be carried out on public land. All field sampling will be coordinated with the relevant state and local agencies and necessary permits or permission will be secured prior to any work. The project will include the following four research components:

A. *Cultivate and isolate hydrocarbon-degrading microbes from Willard Bay (WB), the South Arm (SA), and the North Arm (NA) of the Great Salt Lake (GSL). This includes culturing mixed populations as well as isolating and cultivating pure cultures for subsequent identification of individual members.*

Many ecosystems have naturally existing populations of microbes capable of degrading hydrocarbons (petrophiles). In the event of an oil spill it would be ideal to simply stimulate the growth of the indigenous hydrocarbon-degrading microbes to increase their rate of degradation. Alternatively, the abundance of these same hydrocarbon-degrading organisms could be increased by cultivating the

indigenous microbes in a lab and then adding them back to the same natural environment. A third option could involve transferring petrophilic microbes from neighboring ecosystems whose hydrocarbon-degrading capabilities are substantially greater than those of the organisms already present. *In all cases bioremediation would utilize microbes already present in the GSL ecosystem, and would not involve introducing non-native organisms.*

The first step toward realizing any of the above possibilities is to identify and characterize the hydrocarbon-degrading microbial community residing within various compartments of the greater GSL watershed, including Willard Bay. Given that the NA of the GSL has a documented population of hydrocarbon-degraders it is likely that Willard Bay and other nearby environments are also inhabited by microbes with similar functionality, but this has never been tested. And while the hydrocarbon-degraders isolated from the North Arm can grow under low-salt conditions it is not known if they can thrive and degrade hydrocarbons in other nearby aquatic environments. We will utilize the selection system that we have already tested and used, based on the work by Ward & Brock[6], to select for and cultivate mixed populations of hydrocarbon-degraders from WB, the SA, and the NA of the GSL to isolate pure cultures of microbes for identification by sequencing of the 16S ribosomal RNA gene.

B. *Determine optimal growth conditions for individual isolates and mixed populations of the hydrocarbon-degraders from WB, the SA, and the NA when mineral oil is the only carbon source*. *Elucidate what physical and chemical variables control and ultimately limit rates of biodegradation.*

In the event of an oil spill, hydrocarbons become a dominant carbon source and can facilitate rapid growth by microbes capable of metabolizing these compounds. Despite the abundance of carbon, however, microbial growth is often limited by the relative dearth of other nutrients, such as nitrogen, phosphorus, or oxygen. Even in the face of such nutrient limitation, the bioremediation of hydrocarbon contaminated sites can be successful with the addition of the limiting nutrient. However, such an approach requires an understanding of growth limitation so that the correct compound can be added in the necessary amount to facilitation bioremediation but avoid eutrophication.

In the event of another oil spill along the GSL, it will be important to determine the growth requirements of the hydrocarbon-degrading microbes to establish the environmental parameters needed to facilitate maximal growth of this population. To this end, the effects of temperature, salinity, and pH on growth rates of mixed populations and pure cultures will be measured in order to establish the feasibility of the indigenous hydrocarbon community for potential bioremediation within their original and nearby ecosystems. In addition, controls on growth rates of the petrophile cultures will be measured under in-situ conditions with hydrocarbons serving as the dominant carbon source until nutrient limitation occurs, then experiments using nitrogen, phosphorus, and oxygen additions will be used to identify the limiting nutrient under ambient conditions and to determine nutrient ratios that facilitate optimum growth of the indigenous petrophile community.

C. *Determine which hydrocarbons are degraded by individual isolates and mixed petrophile cultures, and identify the chemical products of this degradation.*

We will use culture experiments to determine which individual microbes and mixed populations of petrophiles are able to degrade specific hydrocarbons found in oil and various distillates (e.g., diesel fuel). Because no single organism can degrade all hydrocarbons, an important first step in characterizing the capacity of an indigenous microbial community to degrade oil is to determine which specific compounds can be metabolized by individual community members or the mixed petrophile microbial community. In the event of a spill, the appropriate microbe or microbes could be added or stimulated to degrade the specific types of hydrocarbons involved. Likewise, it is important to ensure that the degradation byproducts are not more toxic or harmful than the parent compounds from the original oil spill. We will use HPLC and mass spectrometry to quantify rates of biodegradation of individual hydrocarbons and the

major degradation byproducts during short- and long-term incubation experiments when various microbial strains are grown on different hydrocarbon contaminants.

D. *Determine and compare rate of hydrocarbon degradation for isolates and petrophile communities under optimal conditions.*

The rate of hydrocarbon degradation for individual isolates and mixed populations of microbial consortia will be determined in growth experiments spanning days to weeks in order to estimate the time required for a particular addition or treatment to decrease hydrocarbon concentrations to acceptable levels. These rates could then be used to model the half-life of specific hydrocarbons from an oil spill given different environmental conditions affecting microbial growth and biodegradation. Once the indigenous population of petrophilic microbes has been identified and characterized as described above, the corollary to this work is to study the hydrocarbon-degrading capacities of these microbes under natural conditions. Should the foundational studies described above yield a functional consortium of hydrocarbon-degraders, we propose to conduct mesocosm experiments in which contaminated water and sediment from various parts of the GSL are either (1) amended with additional populations of the hydrocarbon-degrading microbes isolated from the same region of the GSL or adjacent impoundments, (2) amended with populations of hydrocarbon-degrading microbes isolated from other regions of the GSL, or (3) amended with the nutrient(s) determined to be growth limiting. Microbial growth rates and hydrocarbon degradation rates will be measured in parallel to assess the feasibility and effectiveness of these three methods for facilitating the bioremediation of oil contaminated aquatic ecosystems. The timing and extent of these experiments will be contingent upon the progress and findings of the necessary preceding experiments.

9. Describe your experience in implementing projects of similar scope and magnitude:

The proposed research builds upon ongoing research by Dr. Kleba on the characterization of oil metabolizing microbes in the North Arm of Great Salt Lake. Dr. Black has extensive experience conducting research on environmental contaminants, both trace metals and organic compounds, with field and lab components using the analysis techniques to be employed. These prior research activities by the PI's have resulted in > 100 research articles, book chapters, and presentations at national and international conferences (see CV's). These prior research and educational activities have been funded by the NSF, the Utah DNR Division of Forestry, Fire, and State Lands, iUtah, and other funding agencies.

This project has multi-agency support – see attached letters of support from:

- John Luft, Manager of the Utah Division of Wildlife's Great Salt Lake Ecosystem Program
- Rob Baskin, Supervisory hydrologist for the USGS
- Lynn DeFrietas, Director of Friends of the Great Salt Lake

10. Describe how ongoing maintenance of the project will be funded and carried out:

In addition to the funds requested, an additional $54,400 will be provided by Westminster College. This project is cost-effective and attainable as it will utilize existing expertise and infrastructure, including Westminster College's LEED platinum-certified Meldrum Science Center, existing research instrumentation in the research labs run by Dr. Kleba and Dr. Black, and existing camp and field supplies provided by the GSLI, all of which substantially reduce the funds needed.

11. List consultants or agency partners that have participated in project development:

Dr. Betsy Kleba	Westminster College	Salt Lake City, UT 84105	(801)-832-2366
Dr. Frank Black	Westminster College	Salt Lake City, UT 84105	(801)-832-2351
Dr. Bonnie Baxter	Westminster College	Salt Lake City, UT 84105	(801)-832-2345

Signature Betsy Kleba Signature Frank Black Signature Bonnie K. Baxter Date 5-2-14

List of Supplemental Documents

References cited
Letters of support from:

- Utah Division of Wildlife's Great Salt Lake Ecosystem Program
- US Geological Society
- Friends of the Great Salt Lake

Curriculum vitae of all project participants

References cited

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Governor
SPENCER J. COX
Lieutenant Governor

State of Utah
DEPARTMENT OF NATURAL RESOURCES
MICHAEL R. STYLER
Executive Director
Division of Wildlife Resources
GREGORY J. SHEEHAN
Division Director

April 30, 2014

Utah Department of Environmental Quality
Division of Water Quality
195 North 1950 West
Salt Lake City, Utah 84114

UDEQ,

The Utah Division of Wildlife Resources and its Great Salt Lake Ecosystem Program (GSLEP) wholeheartedly support Westminster College and its research proposal titled, "Characterizing and utilizing indigenous microbial communities for the bioremediation of hydrocarbon contamination in aquatics ecosystems in Utah."

The GSLEP monitors the brine shrimp population as well as the birds that utilize the Great Salt Lake during their migration. The lake supports a multi-million dollar brine shrimp industry, a large number of recreational waterfowl hunters, numerous avian species, and abundant recreational opportunities for the general public. It would be extremely important to understand the ability to alleviate or minimize the effects of hydrocarbon contamination on this unique and important ecosystem.

The GSLEP has partnered with Westminster College in the past, utilizing their expertise to help better understand the ecosystem. The proposed research provides an exciting opportunity to help us better understand the potential to mitigate any contaminant spills in or around the lake. Additionally, we would be happy to provide any assistance at our disposal to help facilitate the objectives as described in the research proposal.

Sincerely,

John Luft
Program Manager
Great Salt Lake Ecosystem Program

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UTAH DNR WILDLIFE RESOURCES

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Utah Water Science Center
2329 Orton Circle
Salt Lake City, Utah 84119-2047

28 April 2014

Re: Willard Bay Water Quality Projects proposal review: **Utah's indigenous microbial communities as bioremediation tools for the clean-up of oil contaminated ecosystems** *by* Drs. Betsy Kleba, Frank Black, and Bonnie Baxter, Westminster College, Salt Lake City, Utah.

To: Utah Division of Water Quality

I have been requested to review the subject proposal and provide feedback to the authors and to you regarding its overall importance in the context of research on Great Salt Lake and its potential for success.

I have reviewed the proposal and am very intrigued by the ideas presented therein. Success of bioremediation efforts depend on the establishment and maintenance of conditions that favor enhanced oil biodegradation rates in a contaminated environment. After initial surficial oil cleanup efforts, there comes a point where further remediation in sensitive areas likely is more harmful for the environment than allowing and enhancing the natural bioremediation efforts of indigenous microbial populations. At that point, bioremediation becomes the best alternative in removal of residual oils from the environment.

The benefits of bioremediation are well known. In a well-documented experiment by Jenisch-Anton and others (2000), heavy oil from Rozel Point was seriously degraded by bacterial action. Similar studies have shown that bacteria can convert the majority of petroleum hydrocarbons, including PAHs (among the most toxic fractions) to biomass, CO_2, and H_2O. Indigenous populations of microorganisms played a significant role reducing the environmental impact of recent oil spills (Alan, 2011), and with the addition of nutrients and oxygen, rates of bioremediation can be significantly enhanced.

The proposed research aims to answer three basic questions (paraphrased):

1. If Willard Bay and other regions of GSL contain their own communities of hydrocarbon degrading microorganisms, how does the community structure differ and what influences those differences?

2. Exactly which hydrocarbons can be degraded by microbes isolated from various regions of GSL, and what are the chemical products of this degradation?

3. Does the effective degradation of hydrocarbons by these local microbial communities require the addition of nutrients, oxygen, or other compounds?

While I suspect that a complete answer to question #2 may be well outside of the funding level for this project, it is possible that specific more detrimental compounds could be investigated.

The identification of hydrocarbon remediation potential for varying salinities around Great Salt Lake would alone be of great benefit. The proposed additional characterization of soils, and other physical and chemical parameters in areas of high contamination potential, identification of indigenous hydrocarbon-degrading microbial communities, and knowledge of the effects of bioremediation enhancements to the system, would provide a very valuable set of data for use in both remediation of hydrocarbon contamination and in understanding of the ecosystem of Great Salt Lake.

In my opinion, determining the hydrocarbon remediation potential around Great Salt Lake would be of great benefit to future hydrocarbon remediation efforts and a worthwhile investment. This proposal has a high probability of success as this group of investigators have a demonstrated expertise in halophilic and halotolerant bacteria and are well equipped to perform the proposed research.

Robert L. Baskin

Digitally signed by Robert L. Baskin
DN: cn=Robert L. Baskin, o=U.S. Geological Survey, ou=Utah Water Science Center, email=rbaskin@usgs.gov, c=US
Date: 2014.04.30 17:29:13 -06'00'

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FRIENDS *of Great Salt Lake*

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April 30, 2014

To Whom It May Concern at the Utah Division of Water Quality:

Re: Willard Bay project proposal: Utah's indigenous microbial communities as bioremediation tools for the clean-up of oil contaminated ecosystems

FRIENDS of Great Salt Lake is a nonprofit organization whose mission it to preserve and protect the Great Salt Lake Ecosystem through education, research and advocacy. We are pleased to submit this letter in support of the Westminster College's proposal to investigate the utilization of Great Salt Lake microbes as potential bioremediation tools for oil contaminated systems.

Great Salt Lake is a unique water body of global importance to millions of waterbirds dependent upon its biota as a major food source during migration and nesting. It is the most important inland site for shorebirds in North America and the major site of waterfowl nesting and migration in the Intermountain West.

In our work to encourage responsible stewardship and protection of this hemispherically important ecosystem, we rely on building effective partnerships, depend upon sound science, and emphasize the importance of ongoing research to increase our overall understanding about the dynamics of this unique system.

Westminster College faculty with Great Salt Lake Institute (GSLI) are valued contributors to all of these factors. GSLI is recognized by state agencies, industry, academia and other conservation interests as a "place-based" research and educational entity that generates and contributes critical scientific insights about the ecology of the Great Salt Lake.

Dr. Kleba's ongoing research to isolate and identify hydrocarbon-degrading microbes found at GSL provides a basis for understanding how future oil spills might be mitigated using Utah's indigenous microbial community with the capacity to degrade chemical pollutants. This research coupled with GSLI's successful track record working with high school students in a science summer camp setting will make a meaningful and positive impact on the participants in camp GSL creating a more knowledgeable and informed citizenry.

FRIENDS hopes you will give strong consideration Westminster College's proposal because that funding will translate into valuable tools that will benefit all of us who are working to preserve and protect Great Salt Lake.

In saline,

Lynn de Freitas, Executive Director

The mission of FRIENDS of Great Salt Lake is to preserve and protect the Great Salt Lake ecosystem and to increase public awareness and appreciation of the lake through education, research, and advocacy.

BETSY KLEBA, PH.D.

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bkleba@westminstercollege.edu 801-832-2366

EDUCATION

Doctorate of Philosophy (2006) — UNIVERSITY OF CALIFORNIA, BERKELEY
Infectious Diseases & Immunity

Bachelor of Science (1998) — UNIVERSITY OF UTAH
Ecology and Evolutionary Biology

RESEARCH EXPERIENCE

Westminster College, Salt Lake City, UT — Primary Investigator (2011-Present)
Biology Department

Research summary: Isolation, identification, and characterization of halophilic petrophiles inhabiting waters and sediments near naturally occurring oil seeps in the north arm of Great Salt Lake and halophilic microbes residing in salt crust of Bonneville Salt Flats.

NIH, NIAID, Laboratory of Intracellular Parasites — Postdoctoral Fellow (2006-2010)
Rocky Mountain Laboratories, Hamilton, MT — Mentor: Dr. Ted Hackstadt

Research summary: Utilized mariner-based transposon mutagenesis to identify putative virulence factors in the obligate intracellular bacterial pathogen *Rickettsia rickettsii*.

University of California, Berkeley — Doctorate of Philosophy (2000-2006)
Program in Infectious Diseases & Immunity — Mentor: Dr. Richard S. Stephens

Research summary: Utilized scFv libraries to identify antigens exposed on the surface of *Chlamydia* for vaccine candidate identification. Developed selective permeabilization and metabolic labeling protocol to detect chlamydial virulence proteins that localize within the host cell cytosol.

University of Utah — Bachelor of Science (1997-1998)
Biology Department — Mentor: Dr. Wayne K. Potts

Research summary: Conducted an epidemiological survey of the intestinal parasites that colonize wild house mice in order to determine overall burden and effects on population health.

TEACHING EXPERIENCE

Assistant Professor
Westminster College, Salt Lake City, UT - Biology Department (2010-Present)

- Bio111 - Clinical Microbiology
- Bio131 - Human Genetics
- Bio205 - Introduction to Cell Biology
- Bio303 - Microbiology
- Bio402 - Immunology
- Bio420 - Biology Senior Seminar
- Bio430 - Undergraduate Research

Adjunct Instructor
University of Montana, Missoula, MT - Division of Biological Sciences (2008)

- Cell & Molecular Biology

Instructor
B.R.A.S.S. (Biomedical Research After School Scholars) - Rocky Mountain Laboratories, Hamilton, MT (2007-2008)

- Immunology

Teaching Assistant
University of California, Berkeley, CA - Program in Infectious Diseases & Immunity (2004-2006)

- Integrity & Conduct in Research
- Microbial Pathogenesis Graduate Seminar

MENTORING EXPERIENCE

Student Research Mentorship

D. Le: Westminster College undergraduate student (Spring 2014)
L. Carter: Westminster College undergraduate student (Spring 2014)
C. Rivera: Westminster College undergraduate student (Summer 2013-present)
A. Fratto: Westminster College undergraduate student (Summer 2013-present)
D. Sumampong: Westminster College undergraduate student (Fall 2012)
A. Cooper: Westminster College undergraduate student (Fall 2012)
N. Batty: Westminster College undergraduate student (2012-2013)
L. Wolf: Westminster College undergraduate student (2012-2013)
C. Mulkey: Westminster College undergraduate student (Spring 2012)
C. Johnston: Westminster College undergraduate student (2011-2012)
A. Roach: Westminster College undergraduate student (2011-2012)
J. Rymer: Westminster College undergraduate student (May 2011)
H. Fischer: Hamilton High School student summer intern (2009)
K. Fischer: HHS student summer intern (2007) and college biomedical research fellow (2008)
K. Lightfield: U.C. Berkeley PhD student in the Program in Infectious Disease & Immunity (2005)
A. To: U.C. Berkeley PhD student in the Program in Infectious Disease & Immunity (2004)

Other Student Mentorship

S. Ridl: Westminster College undergraduate student – faculty internship coordinator (Summer 2013)
J. *Taylor*: Westminster College undergraduate student – faculty internship coordinator (Spring 2011)
D. Coombs: Westminster College undergraduate student – honors thesis advisor (2010-2011)

COMMUNITY SERVICE

Westminster College - Campus
Summer Undergraduate Research seminar co-coordinator (Summer 2014)
Arts & Sciences – new faculty mentor (2013-2014)
Academic Calendar task force member (Spring 2013)
Griffin "Swoop-In" participant (11Nov2013)
Health professions advisor (2011-Present)
Westminster College Liberal Education Committee member (2011-Present)
Member of R. Costa - Faculty Contract Review Committee (Fall 2013)
Member of H. Hu - Faculty Contract Review Committee (Spring 2013)
Admitted Student Day recruiting event participant (24Mar12)
Take a Professor to Lunch participant (Oct2011 and Oct2012)
Late Night Breakfast server (Spring2011)
Westminster Experience recruiting event participant (19Nov11)
Senior Summer Block Party recruiting event participant (5Aug11)
Open House for prospective transfer student event participant (28Jul11 and 20Sep11)

Westminster College - Science Division
Biology department assessment representative (2013-2014)
Biology student majors/minors advisor (2011-Present)
Biology department assessment development and review committee (2011-2012)
Biology core class curriculum review & revision participant (2011)
Major Explorations Science Division informational event participant (Oct2010, Oct 2011, Oct2012, Oct2013)

Broader Community

President-elect, Intermountain Branch of American Society of Microbiology (2013-2014)
Science Olympiad – developed and hosted Microbe Mission event (Feb2011 and Feb2012)
Ad hoc reviewer for *Journal of Bacteriology & Parasitology* (2011)
Tooele County Magazine interview for Bonneville Salt Flats article (Fall 2011)
GSL Exploration Summer Camp activity leader (Jun2011)
Spiders & Insects-Oh My! Presentation to Pre-K kids at SLC Jewish Community Center - Salt Lake City, UT (May 11)
Poster Judge for ASM Intermountain Branch Annual Meeting - Weber State University, Ogden, UT (9Apr11)
Science Fair Judge for City Academy Charter School, Salt Lake City, UT (Feb2011)
RML Fellows Organization Committee member (2007-2010), President (2009-2010)
NIAID Fellows Retreat Planning Committee member (2008-2009)
Judge for Hamilton Middle School Science Fair (2008)
Ad hoc reviewer for *Cellular Microbiology* (2006-2007)
Graduate Group in Infectious Diseases and Immunity Student Advocate, Faculty liaison, Group President (2001-2005)

PROFESSIONAL MEMBERSHIPS

International Society for Extremophiles (2012-present)
National Association of Advisors for Health Professions (2011-Present)
American Society for Cell Biology (2000-Present)
American Society for Microbiology (1999-Present)
ASM-Intermountain Branch member (2010-present)

AWARDS AND FELLOWSHIPS

Westminster College Grants

BRINE Funds from departmental Keck grant
Westminster College faculty summer research grant awardee, Summer 2014 $4,000
BRINE Funds from departmental Keck grant
Westminster College faculty summer research grant awardee, Summer 2013 $4,000
BRINE Funds from departmental Keck grant
Westminster College faculty summer research grant awardee, Summer 2012 $4,000
Gore Professional Development grant
Westminster College faculty summer research grant awardee, Summer 2011 $3,000

External Grants

Myriad Genetics Excellence in Learning Leadership Award
Westminster College faculty awardee (2013) $20,000

Other Awards & Fellowships

Postdoctoral Intramural Research Training Award Fellowship
Laboratory of Intracellular Parasites, Host-Parasite Interactions Section
National Institute of Allergy and Infectious Diseases, NIH (2006-2010)
Brian Ridpath Award
For excellence in the seminar presentation of doctoral dissertation research.
U.C. Berkeley (2006)
Margaret Beattie Award
For excellence in research within the laboratory sciences.

U.C. Berkeley (2006)
Albert & Mildred Krueger Memorial Scholarship
U.C. Berkeley (2005)

Infectious Diseases & Immunity Leadership Award
For outstanding contribution to the Graduate Group in Infectious Diseases & Immunity.

U.C. Berkeley Graduate Division Fellowship
U.C. Berkeley (2000)

INVITED TALKS

"Extremophiles – The Microbial Life of Utah's Unique Geology." Intermountain Branch of the American Society of Microbiology annual meeting. Provo, UT. Invited speaker 8 March 2014.

"Microbial life inhabits Bonneville Salt Flats, Utah, U.S.A." Halophiles International Conference. Storrs, CT. Invited speaker, 23-27 June 2013.

"Pushing the limits: Looking for Life in Extreme Environments." Forum for Questioning Minds. Salt Lake City, UT. Invited speaker, 10 March, 2013.

"Going to extremes: The search for life in salt." Rocky Mountain Laboratories, NIAID, NIH. Hamilton, MT. Invited speaker, May 2012.

"From RML to a PUI: life as a college professor." Rocky Mountain Laboratories, NIAID, NIH. Hamilton, MT. Invited by RML Post-doctoral Fellows Association, May 2012.

INVITED PANELIST

B. Kleba, G. Dressler, N. Fitzkee, and J. Coker, "Academia: Negotiation and Transitioning." 5th Annual NIH Career Symposium. Office of Intramural Training & Education, NIH, Bethesda, MD. May 2012.

POSTER PRESENTATIONS

G. Boogaerts, A. Moran-Reyna, J. R. Black, A. Shows, H. Minton, Z. Grace, C. Johnson*, N. Batty*, **B. Kleba**, J. A. Coker. Preliminary Characterization of the Microbial Community in the Bonneville Salt Flats. 10th International Congress on Extremophiles. (2014) Saint Petersburg, Russia.

C. Rivera* and **B. Kleba**. Biodegradation of hydrocarbons by Great Salt Lake microorganisms. Intermountain Branch of American Society of Microbiology Annual Meeting. (2014) Provo, UT.

A. Fratto* and **B. Kleba**. Life at the Extremes: Finding earthly analogs for potential life on Mars. Intermountain Branch of American Society of Microbiology Annual Meeting. (2014) Provo, UT.

N. S. Batty*[2], A. M. Roach*, C. E. Mulkey*, **B. Kleba.** Isolation & Identification of Hydrocarbon Metabolizing Microbes from Great Salt Lake. Intermountain Branch of American Society of Microbiology Annual Meeting. (2013) Pocatello, ID.

L. Wolf*[3], N. Batty*, C. Johnston*, A. Moran-Reyna, Z. Grace, A. Shows, H. Minton, L. Landen, J. A. Coker, **B. Kleba**. Identification of the Microbial Life on the Bonneville Salt Flats. Intermountain Branch of American Society of Microbiology Annual Meeting. (2013) Pocatello, ID.

A. M. Roach*, N. S. Batty*, C. E. Mulkey*, **B. Kleba.** Isolation of Hydrocarbon-Degrading Extremely Halophilic Archaea from a Contaminated Hypersaline Environment. Friends of Great Salt Lake Issues Forum. (2012) Salt Lake City, UT.

N. S. Batty*[1], A. Roach*, C. Mulkey*, **B. Kleba.** Isolation of Hydrocarbon Metabolizing Microorganisms from the Great Salt Lake. Friends of Great Salt Lake Issues Forum. (2012) Salt Lake City, UT.

B. Kleba and Ted Hackstadt. Toward Identification of *Rickettsia rickettsii* Type IV Secretion Effector Proteins. Banff International Meeting on Infectious Diseases. (2008) Banff, Alberta, Canada.

B. Kleba and Ted Hackstadt. Characterization of *Rickettsia rickettsii* Type IV Secretion ATPase, VirB11. American Society for Rickettsiology. 21st General Meeting. (2007) Colorado Springs, Colorado.

B. Kleba and R.S. Stephens. *Chlamydia* Circumvent Vacuolar Isolation by Acquiring Compounds Directly from Cell Cytosol. Cold Spring Harbor Meeting. Microbial Pathogenesis & Host Response. (2005) Cold Spring Harbor, NY.

B. Kleba and R.S. Stephens. *Chlamydia*-Associated Fibronectin Does Not Enhance Infectivity, *In Vitro.* American Society for Microbiology. 104th General Meeting. (2004) New Orleans, Louisiana.

B. Kleba, E.A. Lindquist, R.S. Stephens. *Chlamydia*-Specific scFv Antibody Binds Host Cell Fibronectin; B–260. American Society for Microbiology. 101st General Meeting. (2001) Orlando, Florida.

* denotes undergraduate researcher
[1] denotes 1st place award recognition for outstanding poster presentation by student at conference
[2] denotes 2nd place award recognition for outstanding poster presentation by student at conference
[3] denotes 3rd place award recognition for outstanding poster presentation by student at conference

BOOK CHAPTERS

Bonnie K. Baxter, Jaimi K. Butler, **Betsy Kleba.** Worth Your Salt: Halophiles in Education. In *Advances in Understanding the Biology of Halophilic Bacteria and Archaea* (ed. R.H. Vreeland), pp217-226. (2012) Springer.

PEER REVIEWED PUBLICATIONS

Tina R. Clark, Amanda M. Lackey, **Betsy Kleba** , Lonnie O. Driskell, Ericka I. Lutter, Craig Martens, David O. Wood, Ted Hackstadt. Transformation frequency of a mariner-based transposon in *Rickettsia rickettsii*. Journal of Bacteriology. 2011. 193: 4993-4995.

Tina R. Clark, Damon W. Ellison, **Betsy Kleba** , Ted Hackstadt. Complementation of *Rickettsia rickettsii* RelA/SpoT restores a nonlytic plaque phenotype. Infection and Immunity. 2011. 79:1631-1637.

Betsy Kleba , Tina R. Clark, Ericka I. Lutter, Damon W. Ellison, Ted Hackstadt. Disruption of the *Rickettsia rickettsii* Sca2 autotransporter inhibits actin-based motility. Infection and Immunity. 2010. 78:2240-2247.

Betsy Kleba and Richard S. Stephens. Chlamydial Effector Proteins Localized to the Host Cell Cytoplasmic Compartment. Infection and Immunity (2008) 76: 4842-4850.

Betsy Kleba and Richard S. Stephens. Bacteria-associated fibronectin does not enhance *Chlamydia trachomatis* infectivity in vitro. Microbial Pathogenesis (2005) 39: 53-55.

Betsy Kleba, Erin Banta, Erika A. Lindquist, Richard S. Stephens. Recruitment of Mammalian Cell Fibronectin to the Surface of *Chlamydia trachomatis.* Infection and Immunity (2002) 70: 3935-3938.

Erika Lindquist, James D. Marks, **Betsy Kleba**, Richard S. Stephens. Phage-display antibody detection of *Chlamydia trachomatis*-associated antigens. Microbiology (2002) 148: 443-351.

Frank J. Black

Chemistry Department, Westminster College
Salt Lake City, UT 84105
fblack@westminstercollege.edu; (801) 832-2351

EDUCATION

2008 **Ph.D. Biogeochemistry, Environmental Toxicology**, University of California, Santa Cruz
Thesis topic: Biogeochemical cycling of mercury in the environment.
Thesis advisor and committee: A. Russell Flegal; Kenneth Bruland, David Sedlak, Chad Saltikov

2000 **B.A. Environmental Earth Science**, Dartmouth College; Hanover, New Hampshire
Cum Laude, high honors in major
Senior Honors Thesis: Stable carbon isotope analysis of paleosols around contrasting volcanoes

EXPERIENCE and POSITIONS HELD

2011-present **Assistant Professor** of Geochemistry, Chemistry Department, Westminster College

2009-2011 **Post-doctoral Scholar**, Geosciences Department, Princeton University
Advisors: François Morel, Anne Kraepiel, Satish Myneni
Research on the chemical speciation, mobility, and bioavailability of Mo, V, and Fe in soils as controls on nitrogen fixation by free living heterotrophic bacteria. Use of ICP-MS, XRD, SEM, synchrotron based XANES and EXAFS.

2008-2009 **Fulbright Scholar/Visiting Researcher,** Okavango Research Centre, Univ. of Botswana Study of mercury in water, fish, and human hair in the Okavango Delta of Botswana. Risk assessment of mercury toxicity to subsistence fishing communities.

2003-2008 **Research Assistant**, Environmental Toxicology Department, UC Santa Cruz
Research on Hg(II) complexation in aquatic systems, role of reduced sulfur in Hg binding, factors controlling MMHg photo-degradation, upwelling of DMHg in coastal waters, stability of DMHg in seawater, sources of MMHg in rainwater, and submarine groundwater discharge of MMHg to coastal waters. Use of CVAFS, ICP-OES, ICP-MS, voltammetry, ion chromatography, HPLC, UV/VIS, fluorescence spectroscopy.

2003 **Research Assistant**, Swiss Federal Institute of Environmental Science and Technology
Study of cadmium complexation in freshwaters using anoidic stripping voltammetry, evaluation of multiple analytical methods for measuring trace metal speciation and bioavailability, comparison to results from chemical speciation modeling.

1999-2000 **Research Assistant**, Thayer School of Engineering, Dartmouth College, Hanover, NH
Conducted research of ice-metal interfaces using atomic force microscopy.

1998-1999 **Research Assistant**, Sandia National Laboratories, Albuquerque, NM
Experiments of uranium mobility and sorption onto geologic media, geochemical and hydrologic modeling of pollutant plumes in groundwater.

MENTORING EXPERIENCE

2013-2014	Chris Mansfield*, undergraduate chemistry research, Westminster College
2013	Lauren Carter, undergraduate biology research, Westminster College
2011-2013	Heidi Saxton*, undergraduate biology research, Westminster College
2011-2013	Jeff Collins*, undergraduate biogeochemistry research, Westminster College
2011-2013	Jim Goodman*, undergraduate biology research, Westminster College
2010-2011	Sarah Bluher, undergraduate biogeochemistry research, Princeton University
2007-2008	Noc Bin Hoang†, undergraduate environmental chemistry research thesis, UCSC
2007-2008	Kevin Thorpe†, undergraduate environmental chemistry research thesis, UCSC
2006-2008	Brett Poulin*†, undergraduate environmental chemistry research thesis, UCSC
2007	Norman Forsberg†, undergraduate chemistry research thesis, UCSC
2006	Cameron Zachreson, undergraduate chemistry winter term project, Oberlin College
2004-2005	Melanie Gault-Ringold*†, undergraduate environmental chemistry research, UCSC

*Undergraduate co-author on published paper.
†Received departmental honors and Dean's or Chancellor's Award.

AWARDS, HONORS, FUNDING

2013-2014	iUtah Research Catalyst Grant
2013-2014	Utah Division of Natural Resources Great Salt Lake Research Grant (Co-PI)
2012-2013	Utah Division of Natural Resources Great Salt Lake Research Grant (Co-PI)
2012	Myriad Faculty Research Award
2010-2011	National Science Foundation Earth Sciences Post-Doctoral Fellowship
2008-2009	Fulbright Grant
2008-2009	California Sea Grant Program Development Grant
2007-2008	UC Santa Cruz President's Dissertation-Year Fellowship
2007	STEPS Institute Graduate Research Award
2006	Dr. Earl Myers and Ethel Myers Oceanographic Trust Graduate Student Grant
2006	GSA Travel Grant
2006	Goldschmidt Conference NSF/Geochemical Society Travel Grant
2005-2006	Packard Endowment for Ocean Sciences and Technology Research Grant
2005	Center for Dynamics and Evolution of the Land Sea Interface Graduate Student Grant
2005	Nominated for UC Santa Cruz Teaching Assistant of the Year Award
2004-2007	National Science Foundation Graduate Student Fellowship
2004-2005	UC Toxic Substances Teaching and Research Graduate Student Fellowship
2003	ARCS Foundation Fellowship (Achievement Rewards for College Scientists)
2002-2003	UC Santa Cruz Chancellor's Fellowship
2000	Sigma Xi Reed Memorial Award, honorary membership in Sigma Xi Scientific Society
2000	Mellon Memorial Research Grant
1999	Richter Research Grant
1999	Francis L. Town Award in Earth Sciences

PUBLICATIONS

Goodman, J.R., Collins, J.N., Saxton, H.J., Mansfields, C.R., and **Black, F.J.**, 2014. Controls on the spatial and temporal variability in total mercury and methylmercury in water and brine flies at the Great Salt Lake, Utah, and implications for mercury exposure to migratory birds. *Limnology and Oceanography*, in review.

Mansfield, C.R. and **Black, F.J.**, 2014. Quantification of monomethylmercury in natural waters by direct ethylation: Interference characterization and method optimization. *Analytica Chimica Acta*, in review.

Saxton, H.J., Goodman, J.R., Collins, J.N., and **Black, F.J.**, 2013. Maternal transfer of inorganic mercury and methylmercury in aquatic and terrestrial arthropods. *Environmental Toxicology and Chemistry*, 32: 2630-2636.

McGinn, P.J., Dickinson, K.E., Park, K.C., Whitney, C.G., MacQuarrie, S.P., **Black, F.J.**, Frigon, J.C., Guiot, S.R., and O'Leary, S.J.B, 2012. Assessment of the bioenergy and bioremediation potentials of the microalga *Scenedesmus sp*. AMDD cultivated in municipal wastewater effluent in batch and continuous mode. *Algal Research*, 1: 155-165.

Black, F.J., Poulin, B.A., and Flegal, A.R., 2012. Factors controlling the abiotic photo-demethylation of monomethylmercury in surface waters. *Geochimica et Cosmochimica Acta*, 84: 492–507.

Black, F.J., Conaway, C.H., and Flegal, A.R., 2012. Mercury in the marine environment. In: *Mercury in the Environment: Pattern and Process*, Michael S. Bank (Ed.), University of California Press, Berkeley, CA.

Black, F.J., Bokhutlo, T., Somoxa, A., Maethamako, M., Modisaemang, O., Kemosedile, T., Cobb-Adams, C., Mosepele, K., and Chimbari, M., 2011. The tropical African mercury anomaly: lower than expected mercury concentrations in fish and human hair. *Science of the Total Environment*, 409: 1967–1975.

Quan, T., Yuh, P., and **Black, F.J.**, 2010. Central Dog-ma Disease Detectives: A molecular biology inquiry activity for undergraduates. *Learning from Inquiry in Practice Volume*, University of California Press.

Conaway, C.H., **Black, F.J.**, Weiss-Penzias, P., Gault-Ringold, M., and Flegal, A.R., 2010. Mercury speciation in Pacific coastal rainwater, Monterey Bay, California. *Atmospheric Environment*, 44: 1788-1797.

David, N., McKee, L.J., **Black, F.J.**, Flegal, A.R., Conaway, C.H., Schoellhammer, D.H., and Ganju, N.K., 2009. Mercury concentrations and loads in a large river system tributary to San Francisco Bay, California, USA. *Environmental Toxicology and Chemistry*, 28: 2091–2100.

Black, F.J., Paytan, A., Knee, K.L., de Sieyes, N.R., Ganguli, P.M., Gray, E., and Flegal, A.R., 2009. Submarine groundwater discharge of total mercury and monomethylmercury to central California coastal waters. *Environmental Science and Technology*, 43: 5652–5659.

Black, F.J., Conaway, C.H., and Flegal, A.R., 2009. Stability of dimethyl mercury in seawater and its conversion to monomethyl mercury. *Environmental Science and Technology,* 43: 4056–4062.

Conaway, C.H., **Black, F.J,** Gault-Ringold, M., Pennington, J.T., Chavez, F.P., and Flegal, A.R., 2009. Dimethylmercury in coastal upwelling waters, Monterey Bay, California. *Environmental Science and Technology*, 43: 1305–1309.

Black, F.J., Gallon, C., and Flegal, A.R., 2008. Ecological Processes: Sediment Retention and Release. In: *Encyclopedia of Ecology*. Jorgensen, S.E. (Ed.), Elsevier Press.

Conaway, C.H., **Black, F.J.**, Grieb, T.M, Roy, S., and Flegal, A.R., 2008. Mercury in the San Francisco Estuary. *Reviews of Environmental Contamination and Toxicology*, 194: 29–48.

Black, F.J., Bruland, K.W., and Flegal, A.R., 2007. Competing ligand exchange-sold phase extraction method for the determination of the complexation of dissolved inorganic Hg(II) in natural waters. *Analytica Chimica Acta*, 598: 318–333.

Sigg, L, **Black, F.J.**, Buffle, J., Cao, J., Cleaven, R., Davison, W., Galceran, J., Gunkel, P., Kalis, E., Kistler, D., Martin, M., Noel, S., Nur, Y, Odzak, N., Puy, J., Van Riemsdijk, W., Temminghoff, E., Tercier-Waeber, M.L., Toepperwien, S., Town, R.M., Unsworth, E., Warnken, K.W., Weng, L., Xue, H., Ozhang, A., 2006. Comparison of analytical techniques for dynamic trace metal speciation in natural freshwaters. *Environmental Science and Technology*, 40: 1934–1941**.**

Unsworth, E. R.; Warnken, K. W.; Zhang, H.; Davison, W.; **Black, F.J.**; Buffle, J.; Cao, J.; Cleven, R.; Galceran, J.; Gunkel, P.; Kalis, E.; Kistler, D.; van Leeuwen, H. P.; Martin, M.; Noel, S.; Nur, Y.; Odzak, N.; Puy, J.; van Riemsdijk, W.; Sigg, L.; Temminghoff, E.; Tercier-Waeber, M.-L.; Toepperwien, S.; Town, R. M.; Weng, L.; Xue, H., 2006. Model predictions of metal speciation in freshwaters compared to measurements by in-situ techniques. *Environmental Science and Technology*, 40: 1942–1949.

SELECTED PRESENTATION ABSTRACTS (national and international meetings)

Black, F.J., Collins, J.N., Goodman, J.R., and Saxton, H.J. Seasonal low in methylmercury concentrations in brine flies helps minimize mercury exposure to migratory birds at the GSL during breeding and nesting. 13th Conference on Mercury as a Global Pollutant, Edinburg, Scotland, 2013.

Saxon, H.J., Goodman, J.R., Collins, J.N., and Black, F.J. Methylmercury partitioning during egg formation in invertebrates. 13th Conference on Mercury as a Global Pollutant, Edinburg, Scotland, 2013.

Goodman, J.R., Collins, J.N., Saxton, H.J., and Black, F.J. The Importance of Arachnids in the Trophic Transfer and Bioaccumulation of Mercury in the Terrestrial Ecosystem of the Great Salt Lake. 13th Conference on Mercury as a Global Pollutant, Edinburg, Scotland, 2013.

Bidez, C., Anderson, M., Black, F.J., and Clay, C.A. Urban stream health: Macroinvertebrates and periphyton as indicators. Ecological Society of America annual meeting, Minneapolis, MN, 2013.

Reynolds, H.A., Stracey, C.M., and Black, F.J. An assessment of mercury concentrations in a terrestrial songbird at the Great Salt Lake. Ecological Society of America annual meeting, Minneapolis, MN, 2013.

Black, F.J., Bokhutlo, T., Somoxa, A., Maethamako, M., Modisaemang, O., Kemosedile, T., Cobb-Adams, C., Mosepele, K., and Chimbari, M., 2011. The tropical African mercury anomaly: lower than expected mercury concentrations in fish and human hair. 10th International Conference on Mercury as a Global Pollutant.

Ganguli, P.M., Black, F.J., Swarzenski, P.W., Conaway, C.H., Paytan, A., Miller, L.G., and Flegal., A.R., 2010. Mercury speciation and transport in submarine groundwater discharge. NorCal Society of Environmental Toxicology and Chemistry Conference.

Quan, T., Black, F.J., and Yuh, P., 2010. Central Dog-ma inquiry activity for UCSC MARC/MBRS/CAMP Biochemistry short course. Learning from Inquiry in Practice Conference.

Black, F.J., and Flegal, A.R., 2006. Complexation of Inorganic Mercury and the Distribution of Complexing Ligands Along a Stream Transect. V.M. Goldschmidt Conference.

Black, F.J., Saltikov, C., and Flegal, A.R., 2006. Inorganic mercury (II) speciation and bioavailability, the saga continues. 8th International Conference on Mercury as a Global Pollutant.

Conaway, C.H., Black, F.J., Gault-Ringold, M., Pennington, J.T., and Flegal, A.R., 2006. Upwelling of dimethylmercury in Monterey Bay as a potential source of monomethylmercury to the atmosphere. 8th International Conference on Mercury as a Global Pollutant.

Black, F.J., Saltikov, C., and Flegal, A.R., 2005. Implications for bioavailability: The role of reduced sulfur ligands in the complexation of inorganic mercury in freshwaters. UC TSR&TP 2005 Symposium.

Black, F.J., and Flegal, A.R., 2004. Complexation of inorganic mercury in freshwaters: Spatial variability and ligand sources. American Geophysical Union 2004 Fall Meeting.

Black, F.J., 2000, Stable carbon isotope analysis of paleosols, Volcan Arenal, Costa Rica, and Volcan Cotopaxi, Ecuador: Evidence of maize cultivation. Sigma Xi Wetterhahn Symposium.

COMMUNITY INVOLVEMENT AND OTHER ACTIVITIES

2012	**Community Garden Work**, Salt Lake City Refugee Garden, Roots to Grow
2012-2013	**Volunteer Science Fair Judge,** Weilenmann School of Discovery, Park City, UT
2012	**Chemistry outreach activities**, Davis High School, Davis, UT
2010	**Volunteer Science Teacher,** Foundation Academy Charter School, Trenton, NJ
2009	**Organizer, Instructor,** World Wetlands Day activities, 3 schools in Maun, Botswana
2007-2008	**Participant,** *Re-Thinking Science Learning and Teaching* program, UCSC & U. of Hawaii
2006	**Participant,** *On the Cutting Edge*, research and teaching professional development, Stanford U.
2003-2008	**Volunteer Judge**, Santa Cruz County Science Fair
2003-2006	**Volunteer Science Teacher,** Lakeview Middle School, Watsonville, CA
2001	**Instructor**, Alpine Environmental Education Center; Switzerland
2000, 2002	**Trip Leader**, Overland Travel, backpacking and mountain biking trips

PEER REVIEWER

Environmental Science and Technology
Geochimica et Cosmochimica Acta
Marine Chemistry
Environmental Pollution
Ecotoxicology and Environmental Safety
Environmental Chemistry
Journal of Chemical Education

PROFESSIONAL MEMBERSHIPS

American Geophysical Union
American Chemical Society
The Geochemical Society

Bonnie K. Baxter, Ph.D.
Professor of Biology
Director, Great Salt Lake Institute
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Meldrum Science Center
Office 378
1840 South 1300 East
Salt Lake City, UT 84105

Education

University of North Carolina-Chapel Hill	Genetics/Molecular Biology	Ph.D. 1994
Elon University (NC)	Biology	B.S. 1988

Research Interests

Great Salt Lake microbial diversity; DNA damage, repair and photoprotection in halophilic Archaea; Preservation of ancient macromolecules in halite crystals; Astrobiology; Inquiry-based science teaching and learning.

Professional Experience

2009-present	Professor of Biology, Westminster College
2008-present	Director, Great Salt Lake Institute
2003-present	Associate Professor of Biology, Westminster College
1998-2003	Assistant Professor of Biology, Westminster College
1998-2001	Science Division Chair, Westminster College
1994-1998	Postdoctoral Research Associate, Department of Biochemistry & Biophysics, Washington State University

Professional Organization

1997-present	Council on Undergraduate Research, CUR
2003-present	American Society for Microbiology, ASM
2003-present	International Society for Salt Lake Research, ISSLR
2004-present	National Association for Research in Science Teaching, NARST
2004-present	Project Kaleidoscope, PKal

Grants

2014 PI, Kennecott Utah Copper / Rio Tinto STEM Education Grant, which will support 2012 "Camp Great Salt Lake." This is a high school summer in-residence science camp. $15,000

2013 Co-PI, National Science Foundation. "Halophiles 2013: The International Congress on Halophilic Microorganisms" This grant paid for American graduate and undergraduate students to attend the International Halophiles Conference held June, 2013. (DEB-1331792) $15,000

2012-2014 PI, W.M. Keck Foundation "Great Salt Lake: BRINE (Building Research, Innovation and Novel Experimentation)" This grant supports three years of undergraduate research for student/faculty teams working on Great Salt Lake projects. $250,000

2012 PI, NASA Rocky Mountain Space Grant. GSLI was given funds to support undergraduate research on Astrobiology. $6000

2012 PI, Kennecott Utah Copper / Rio Tinto STEM Education Grant, which supported 2012 "Camp Great Salt Lake." This is a high school summer in-residence science camp. $15,000

2012-2013 Co-PI, U.S. Department of Education Math Science Partnership grant "Astrobiology Curriculum for Earth Science Teachers." 2012-13 was year two, and $16,000 went to Westminster to support the development of Earth Science (High School) Teacher Astrobiology workshops and curriculum for Great Salt Lake. $40,000

2009-2010 PI, Utah State Department of Natural Resources: "Great Salt Lake microalgae populations as indicator species of habitat quality: Novel methods for monitoring" $40,000

2008-2010 Co-PI, WIRED (Workforce Innovation In Regional Economic Development) grant, US Dept. of Labor through Utah state governor's office of economic development for undergraduate research and outreach activities of Great Salt Lake Institute. $460,000

2007-2008 PI, National Science Foundation: "Halophiles: Exploring Life at High Salinity," (MCB-0735025) $15,000

2007-2008 PI, Joint Genome Institute, Laboratory Sequencing Program: "Probing Two Unique Ecosystems in Great Salt Lake: An Examination of Primary Productivity and the Extraordinary Microbial and Metabolic Diversity" 140 Mbases of DNA Sequencing Provided

2005-2007 Co-PI, Sub-Contract, US Air Force: "Novel Hydrogenases from Great Salt Lake Algae Species." Baxter was responsible for sampling Great Salt Lake phytoplankton species and testing them for the presence of Hydrogen pathway genes. (PI: Matthew Posewitz at the National Renewable Energy Lab, Golden, CO). $10,000

2005-2007 Co-PI, U.S. Department of Education: Math and Science Partnership Grant, "21st Century Biology." This grant funded to high school Biology teacher continuing education in Genetics. Baxter was involved with developing and teaching a two-week summer course and follow-up learning communities throughout the school year. (PI: Louisa Stark, Executive Director, Genetics Science Learning Center, University of Utah) $15,000

1999-2001 PI, National Science Foundation: "The Great Salt Lake Project: Inquiry-Based Training of Pre-Service Teachers Using a Unique Local Ecosystem," (DUE-9950624). $260,000

1998 PI, Willard Eccles Foundation Grant: "Undergraduate Research in DNA Repair,", Renovated facilities and created undergraduate research program for Westminster College, research focused on DNA repair in Great Salt Lake halophiles. $60,000

1996-1998 PI, National Institutes of Health (National Institute of Environmental Health Sciences): "Nucleosome Unfolding During DNA Repair in Human Cells," Postdoctoral Training Fellowship Grant. $90,000

Honors/Awards

2013 Elected to Utah Women's Forum

2012 Awarded one of the "30 Women to Watch" Utah Business Week Magazine awards for high achieving women in Utah.

2008 Distinguished Alumna of the Year, Elon University.

2007 Utah State Governor's Medal for Science and Technology.

2007 Voted one of the five "Women Changing Utah" by Salt Lake Magazine for research and education efforts related to Great Salt Lake.

2004 Project Kaleidoscope, Faculty of the 21st Century.
Elected to national network dedicated to reform in undergraduate science education

2003 Council for Advancement and Support of Education (CASE) Circle of Excellence Award for website: "Science at the Great Salt Lake"

2001 Utah State Distinguished Project in Teacher Education
for NSF-funded "The Great Salt Lake Project"

Mentored Undergraduate Research Student Fellowships

2012 NASA, Austin Wood, "Mercury Methylation Activities in Great Salt Lake"

2009 American Society for Microbiology Undergraduate Research Fellowship, Lindsy Brickell: "Measurement of thymine dimers in Great Salt Lake halophiles"

2007 American Society for Microbiology Undergraduate Research Fellowship, Rue Van Dyke: "Mechanism for UV resistance in Halophiles: Carotenoid Investigation"

2007 Barry M. Goldwater Scholarship, Honorable Mention, Misty Riddle, "Identification of Great Salt Lake Microbes Associated with the Brine Shrimp, *Artemia Fransiscana*."

2006 American Society for Microbiology Undergraduate Research Fellowship, Misty Riddle, "Microorganisms Associated with Great Salt Lake *Artemia franciscana*"

2006, 2007 Friends of Great Salt Lake Doyle Stephens Research Fellowship, Misty Riddle, "Microbial Influence in the Great Salt Lake: Identification of Great Salt Lake Microbes Associated with the Brine Shrimp, *Artemia Fransiscana*." Co-advised with Brian Avery.

2005 American Society for Microbiology Undergraduate Research Fellowship, Michael Acord, "Great Salt Lake Microbial Diversity"

2004 Friends of Great Salt Lake Doyle Stephens Research Fellowship, Ashlee Allred, "Carotenoids and Photoprotection in Great Salt Lake Halophilic Archaea"

2004-2006 Barry M. Goldwater Scholarship, Ashlee Allred, "UV Resistance in Great Salt Lake Halophiles"

Publications *denotes student authors

Book Chapters

Baxter, B.K., Butler, JK, and Kleba, B. *Worth Your Salt: Halophiles in Education*. In Ed., R. H. Vreeland, Advances in Understanding the Biology of Halophilic Microorganisms. Springer, The Netherlands, 2013.

Baxter, B.K. and Newell, B. *Science, Power and Diversity: Bringing Science to Honors in an Interdisciplinary Format.* EB Buckner and K Garbutt, eds. The Other Culture: Science and Math Education in Honors. National Collegiate Honors Council, 2012.

Baxter, BK, *Mangalea, M.R., Willcox, S., Sabet, S., *Nagoulat M.N. and Griffith, J.G. *Haloviruses of Great Salt Lake: a model for understanding viral diversity*, In: Ventosa, A., Oren, A and Ma,Y., eds., *Halophiles and Hypersaline Environments: Current Research and Future Trends*. Springer, the Netherlands, 2011.

Oren, A., **Baxter, B.K.** and Weimer, B.C. *Microbial Communities in Salt Lakes: Phylogenetic Diversity, Metabolic Diversity, and in situ Activities: Summary of a Roundtable Discussion on our Current Understanding, Limitations to our Knowledge, and Future Approaches.* In: Oren, A., Naftz, D.L., and Wurtsbaugh, W.A. (eds.), *Saline lakes around the world: unique systems with unique values.* The S.J. and Jessie E. Quinney Natural Resources Research Library, published in conjunction with the Utah State University College of Natural Resources, vol XV: 257-263, 2009.

Newell, B. and **Baxter, B.K.** *A Scientific perspective on Diversity: An interdisciplinary approach to discussions of race, gender, sexual orientation, and class.* In: Coleman, L.L. and Kotinek, J.D., eds., Setting the Table for Diversity. National Collegiate Honors Council, University of Nebraska, Lincoln, NE, pp 151- 170.

Baxter, B.K.,Litchfield, C.D., Sowers, K., Griffith, J. D., DasSarma, P.A. and DasSarma, S. *Great Salt Lake Microbial Diversity*. In: Gunde-Cimerron, N., Oren, A., Plemenita, A. (eds.) *Adaptation to Life in High Salt Concentrations in Archaea Bacteria, and Eukarya*. Springer, the Netherlands, 2005.

Peer-Reviewed Research Journal Articles

Baxter, B.K., Gunde-Cimerman, N. and Oren, A. Salty sisters: the women of halophiles. Frontiers in Microbiology, in press, 2014

*D'Adamo S., Jinkerson R.E., Boyd E.S., Brown S.L., **Baxter B.K.**, Peters J.W., Posewitz, M. *Evolutionary and Biotechnological Implications of Robust Hydrogenase Activity in Halophilic Strains of Tetraselmis*. PLoS ONE 9(1): e85812. doi:10.1371/journal.pone.0085812, 2014.

*Riddle M.R., **Baxter B.K.**, Avery B.J., *Molecular identification of microorganisms associated with the brine shrimp Artemia franciscana.* Aquatic Biosystems., 9:7.DOI: 10.1186/2046-9063-9-7 MS: 1327815152742145 URL: http://www.aquaticbiosystems.org/content/9/1/7 2013.

*Meuser J.E., **Baxter B.K.,** Spear J.R., Peters J.W., Posewitz M.C. and Boyd E.S. *Contrasting Patterns of Community Assembly in the Stratified Water Column of Great Salt Lake, Utah.* Microbial Ecology 66(2): 268-280, 2013.

*Pugin, B., *Blamey, J.M., **Baxter, B.K.** and Wiegel, J. *Amphibacillus cookii sp. nov., a facultatively aerobic, sporeforming, moderate halophilic, alkalithermotolerant bacterium from Great Salt Lake, Utah.* Int J Syst Evol Microbiol ijs.0.034629-0; 2011.

Griffith, J.D., Willcox, S., Powers, D.W., Nelson, R. and **Baxter, B.K.** *Discovery of Abundant Cellulose Microfibers Encased in 250 Ma Permian halite: A Macromolecular Target in the Search for Life on Other Planets*, Astrobiology 8(2): 215-228, 2008.

Baxter, B.K., Jenkins, C.C., Southerland, S., Wilson, P. *Using a Multilevel Assessment Scheme in Reforming Science Methods Courses*, Journal of Science Teacher Education 15(3): 211-232, 2004.

Baxter, B. K.*Power Point and Inquiry-Based Learning, or Curse the Bullets!* Theories and Practices in Supervision and Curriculum XXI:20-24, 2003.

Baxter, B.K. and Smerdon, M. J. *Nucleosome Unfolding During DNA Repair in Normal and Xeroderma Pigmentosum (Group C) Human Cells,* Journal of Biological Chemistry 273: 17517, 1998.

Yang, C.C., **Baxter, B.K.** and Topal, M.D. *DNA cleavage by NaeI: Protein purification, rate-limiting step, and accuracy*, Biochemistry 33:14918, 1994.

Baxter, B.K. and Topal, M.D. *Evidence that cleavage enhancer stabilizes an active conformation of NaeI dimer.* Biochemistry 32:8291, 1993.

Peer-Reviewed Conference Proceedings Articles

Baxter, B.K., *Eddington, B., *Riddle, M.R., *Webster, T.N. and Avery, B.J. Great *Salt Lake Halophilic Microorganisms as Models for Astrobiology: Evidence for Desiccation Tolerance and Ultraviolet Radiation Resistance*. In: Hoover, R.B., Levin, G.V., Rozanov, A.Y., and Davies, P. C.W. (eds.) *Instruments, Methods, and Missions for Astrobiology X*, 6694:669415. SPIE, Bellingham, WA, 2007.

*Day, J., Griffith, J., and **Baxter, B.K.** *The Revival of Halophilic Archaea from Recently Formed Halite Crystals Obtained from Great Salt Lake*, Utah, Proceedings of the National Conference on Undergraduate Research Lexington, Virginia, April 21-23, 2005

Public Education Articles

Baxter, B.K. and *Allred, A., *Microbial Life in Hypersaline Environments*, Website for Wood's Hole Microbial Life Series http://serc.carleton.edu/microbelife/extreme/hypersaline/index.html

Baxter, B.K. *Life at the Extreme: Great Salt Lake Microorganisms*, Friends of Great Salt Lake Newsletter, Volume 11, No. 2, Winter, 2006.

Community Connections and Outreach

2013-present Member, Utah Women's Forum

2012-present Trustee, NASA Rocky Mountain Space Grant Consortium

2009-present Member, Technical Advisory Group for Division of Wildlife Resources Great Salt Lake Ecosystem Project

2008-present Director of Great Salt Lake Institute at Westminster College, which supports research and education of our unique Great Salt Lake. GSLI has a strong outreach component, featuring activities for undergraduate research, K-12 students, K-12 teachers, and research collaboration.

2007-2010 Board President, Salt Lake Center for Science Education, Salt Lake District charter school for grades 6-12.

2007-2011 Team Leader, Great Salt Lake Observatory design team for the new Utah Museum of Natural History.

2006-2010 Science Advisor, Paleotechnology, a Salt Lake City microbial biotech company

2006-2007 Consultant, "Water Education for Science Teachers (WEST)," assisted in Great Salt Lake field-work with K-12 students, teachers, and science graduate students. Lectured on inquiry-based pedagogy using the lake as a scientific model. Funded by the National Science Foundation G-K12 program (PI: Holly Godsey, University of Utah).

2006 Featured in "Strange new Species," a children's book by Elin Kelsey. The chapter contains information on the search for novel microorganisms in Great Salt Lake. Associated with this publication was a contest for naming one of these microbes. Science magazine published the winners' names and pictures: Science 312, May 2006, p.843.

2004-2006 Member, Science Education Research Council, research committee for the Utah State Office of Education Science Advisor