Timmerhaus Fund Ambassadors Application – Connection through Wastewater
Principal Investigator: Cresten Mansfeldt

Along Colorado's Front Range, communities creatively apply their valuable water supply to meet new demands. This exploration of the full potential of water resources coincides with the evolving concept of One Water within the environmental engineering and public health professions. One Water reconsiders how surface water, drinking water, and wastewater can satisfy new or increased demands such as wildfire mitigation, resource recovery, and public health surveillance. For example, utilizing wastewater-based surveillance (WBS) to assist in the intervention of public health threats such as the spread of coronaviruses, poxviruses, and polioviruses has been both more widely employed and reported within the media. However, the technical success of WBS outpaced the appreciation of the monitored community's relationship with and understanding of wastewater within the urban water cycle. Therefore, this proposal seeks to develop workshops for three separate target groups – high school students, undergraduate students, and local area water resource professionals – to **explore** the current understanding of wastewater and WBS, **empower** these groups on the engineered water cycle, and **establish** a connection between these groups and the Environmental Engineering Program at the University of Colorado Boulder (CU Boulder).

Satisfying this overall objective requires fulfilling three main tasks:

1. Form and learn with a focus group of Denver Public Schools (DPS) High School students,
2. Host an undergraduate workshop at the University of Colorado Boulder, and
3. Host a series of workshops with Colorado water resource professionals.

Task 1. Form and learn with a focus group of DPS High School students

The intent of Task 1 is to form a cohort of DPS High School students that will be involved in multiple activities surrounding wastewater. First, an initial interview session will be conducted in which general questions surrounding the understanding of the students on the engineered water cycle, how they currently engage with the system within Denver, and their perceptions and feedback surrounding using WBS. This will be conducted onsite in an interactive session with the Principal Investigator Prof. Cresten Mansfeldt travelling to the DPS Montbello High School. Second, the students will be asked to complete a journal on water usage and habits. Third, the students will be asked to complete a **safe** photo essay of their wastewater's community journey utilizing the freely available Denver Sewer Map to emphasize how our waste connects communities in different ways (Figure 1). This photo essay will be submitted to the University of Colorado Boulder's Natural History Museum for consideration of displaying in the BioLounge (letter of support attached from Events and Communications Specialist Suzanne Balog; similar to PI Mansfeldt's previous work with a Solid Waste display; https://www.colorado.edu/cumuseum/throwns-waste) as well as the Colorado History Museum. This workshop will be run in coordination with Science Senior Team Lead Dr. Madeline Percy at Montbello High School (letter of support attached).

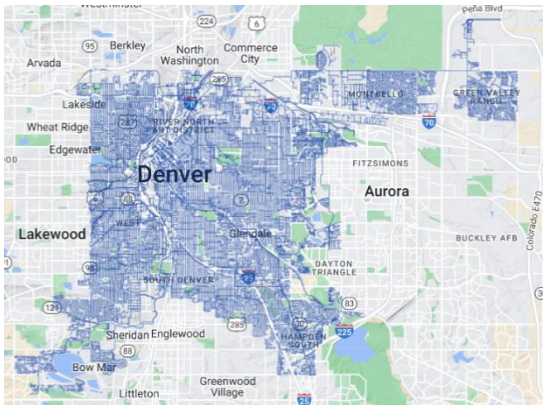
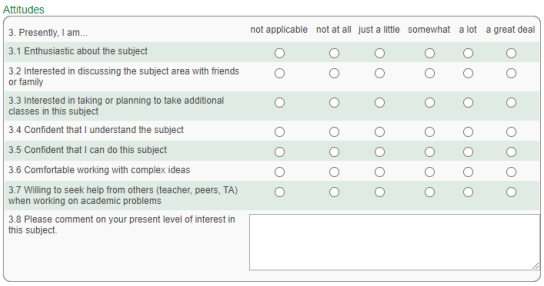


Figure 1. Denver sewer map available from https://koordinates.com/layer/101971-denver-colorado-sanitary-sewer-mains/

Audience: In total, 40-45 DPS Montebello High School 10th grade students will be recruited into the program. The audience will have varying proficiency in English, Spanish, French, Persian, Somali, and Marshallese. These students will have prior exposure to high school biology and chemistry, but not physics. With coordination with DPS teachers, this workshop will enable practical lessons surrounding gravity and hydraulics to be worked into the local curricula. Additionally, targeting Montbello High School within the 2022-2023 academic year enables onsite demonstrations of premise plumbing as the school itself is under renovation (the principal is confirming with the onsite contractors that student tours will have access).

Main Activities Supported by the Timmerhaus Fund: As the collaboration has the potential to expand with resources available from the DPS and from PI Mansfeldt's startup fund, the activities designated for the Timmerhaus Fund to support and measure the success of the project include the following:

1. Three workshop sessions in which participants will fill out a National Science Foundation (NSF) Student Assessment of Learning Gains (SALG) survey during the first and last session to assess how attitudinal perceptions of wastewater monitoring shifts with cognitive understanding of the process. The survey format and questions will be submitted for revision and approval first to the Institutional Review Board (IRB) of the University of Colorado Boulder and subsequently to the IRB of DPS. Specific questions will be solicited from the Colorado Department of Public Health (see letter of support from Director Allison Wheeler) and will be posed as an agenda item at the Centers for Disease Control and Prevention (CDC) Wastewater Surveillance Centers of Excellence in Colorado (only one of two nationwide) Advisory Board of which PI Mansfeldt is a member. These surveys and workshops will be conducted onsite at DPS Montebello High School. DPS has offered to translate all material, surveys, slides, and handouts, from English into Spanish, French, Persian, Somali, and Marshallese to support broad access for students. **Metrics for Success**: *75% of those attending the first workshop complete the full series of workshops and submit both SALG surveys.*


Attitudes

3. Presently, I am...	not applicable	not at all	just a little	somewhat	a lot	a great deal
3.1 Enthusiastic about the subject	○	○	○	○	○	○
3.2 Interested in discussing the subject area with friends or family	○	○	○	○	○	○
3.3 Interested in taking or planning to take additional classes in this subject	○	○	○	○	○	○
3.4 Confident that I understand the subject	○	○	○	○	○	○
3.5 Confident that I can do this subject	○	○	○	○	○	○
3.6 Comfortable working with complex ideas	○	○	○	○	○	○
3.7 Willing to seek help from others (teacher, peers, TA) when working on academic problems	○	○	○	○	○	○
3.8 Please comment on your present level of interest in this subject.						

Figure 2. Example of the National Science Foundation (NSF) Student Assessment of Learning Gains (SALG)

2. A month-long, collaborative online journal of water and waste habits and notable experiences to provide continuous engagement. This digital material will be hosted on CU Boulder's Microsoft Exchange data management infrastructure to ensure privacy and FERPA protection. With permission of student contributors, selections of these entries will be used to support the subsequent photo display described below. **Metrics for Success**: *50% of those attending the first workshop complete at least seven days of entry over the course of the month, resulting in an archive of over 140 unique responses.*
3. A photo essay of student's personal wastewater flow. The images generated will be organized into a collection to display the disconnect between the communities defined on the surface and those underground. The images are intended to be displayed at the University of Colorado Boulder Natural History Museum. Additionally, the high school students will be invited to the unveiling of the project at the CU Museum of Natural History to serve as a

direct connection between campus and the Montbello High School community. **Metrics for Success:** *75% of those attending the first workshop submit a portfolio of photos representing their sewer route, of which 50% (37% of total participants) attend the opening of the photo display at the University of Colorado Boulder Natural History Museum*.

Expected Outcomes: Report on the understanding and utilization of the urban water cycle of high-school age students; public art display representing the efforts of the students; translated material available in English, Spanish, French, Persian, Marshallese, and Somali; and broader connections between and recruitment efforts by the University of Colorado Boulder and DPS high schools.

Required Resources for Task 1 Directly Supported by the Timmerhaus Fund: Transportation to and from Boulder and Montbello high school for involved graduate students for the workshop and high school participants for the photo display and campus visit (PI Mansfeldt resides in Denver and is not seeking transportation funding for this portion of the project; DPS has offered their own commercial fleet for any potential off-school grounds activities); CU Boulder merchandise to be handed out at the workshops (t-shirts, mugs, sweatshirts, etc.); reimbursement for translation services; food and refreshments for the three main workshops; printing cost reimbursement for the photo essays; emergency camera fund in case students do not have or lose access to a camera during the project; and summer salary support for PI Mansfeldt and a graduate student, spread across this and all aspects of the proposal.

Task 2. Host an undergraduate seminar at the University of Colorado Boulder

Our relationship with waste evolves as we age, and the focus of Task 2 explores this progress within the undergraduate population at the University of Colorado Boulder. During the academic year, a monthly seminar series will be hosted by Prof. Cresten Mansfeldt covering topics inclusive of how the suffrage movement altered gendered access to sanitation, how the u-neck of a toilet revolutionized what we flush, how toilet paper is contributing to climate change, and how public toilet access has been central to past and current campaigns to exclude identities from public spaces. However, the main seminar supported by the Timmerhaus fund will explore the perception of the participants on previous on-campus WBS and the broader ongoing campaigns at the national and international level. Students will be provided with short surveys and be involved in small discussions to explore their current understanding of water and wastewater in modern society.

Audience: This seminar will be advertised explicitly on listservs to Environmental Engineering, Environmental Science, and Engineering students but also through more wider means such as hanging posters on campus and posting on the activity calendar, and will be open to all interested students. In total, the anticipated audience is 50 students, primarily targeting sophomores through juniors to enable a bit further separation in life experience from the DPS Montbello High School cohort of 10^{th} grade students.

Main Activities Supported by the Timmerhaus Fund: As this undergraduate seminar series has the potential to overlap substantially with the duties and expectations of a professor, the activities designated for the Timmerhaus Fund to support that are unique from a conventional seminar is as follows:

1. The primary workshop will have undergraduate participants complete a NSF SALG survey prior to and just after the session. This survey will assess how attitudinal perceptions of wastewater monitoring shifts with age in school when compared to the high school responses and after furthering the cognitive understanding of the process advances over the workshop. The survey format and questions will be submitted for revision and approval to the University of Colorado Boulder IRB. Specific questions will be solicited from the other stakeholders within this project. This workshop will be conducted in the Sustainability, Energy and Environment Community (SEEC) Building on the University of Colorado Boulder's campus. **Metrics for Success**: *Over 50 undergraduates attend the seminar with 75% of those attending submitting both SALG surveys.*

2. To increase access to the materials, an additional presentation using the materials generated for the primary workshop will be recorded, uploaded to YouTube, and posted on PI Mansfeldt's laboratory website (www.cmbmgem.com). **Metric for Success**: *Posting a publicly viewable recording to enable broader access.*

Expected Outcomes: Report on the understanding and utilization of the urban water cycle of undergraduate age students; an internal educational effort to broaden the understanding of the Environmental Engineering Program with CU Boulder students.

Required Resources for Task 2 Directly Supported by the Timmerhaus Fund: Food and refreshments for the main workshop. CU Boulder Merchandise to even the incentive between the DPS Montbello High School workshop and the undergraduate workshop.

Task 3. Host a series of workshops with Colorado water resource professionals.

Professional understanding of the water cycle pulls from diverse expertise, and therefore to engage an audience with a high degree of technical proficiency, multiple workshops targeting Colorado water experts will explore opportunities and challenges associated with WBS. The structure of the workshops will employ an initial investigative question/discussion period, a short presentation on the current state of WBS throughout the state of Colorado, and a final discussion period. This workshop will be hosted by Prof. Cresten Mansfeldt at local breweries or coffeeshops, identifying and inviting partners of interest in the water profession with the assistance of Maya MacHamer at the Boulder Watershed Collective (see letter of support) and representation from public health officials with the assistance of Allison Wheeler at the Colorado Department of Public Health and the Environment (CDPHE). Additionally, representative of the CDPHE will be invited to share the community's perception directly with those operating the surveillance campaigns throughout Colorado.

Audience: Each workshop will target an audience of approximately 10-20 local water and public health experts in a given community. Three main workshops are anticipated, hosted in Boulder, Denver, and Grand Junction. The Boulder workshop will operate in conjunction with the Boulder Creek Watershed Collective. The Denver workshop will operate in cooperation with the Denver Department of Public Health, specifically engaging Director Gregg Thomas (initial contact and expression of interest on October 7th, 2022). The Grand Junction workshop will operate in cooperation with the Grand Junction Department of Public Health, specifically engaging with

Disease Surveillance and Emergency Response Manager Rachel Burmeister (initial contact and expression of interest on October 21st, 2022). In combination, the total attendance target across these three workshops is at least 50 water and public health professionals across the State of Colorado.

Main Activities Supported by the Timmerhaus Fund: Similar to the previous tasks, Task 3 has the potential to expand with resources available from the CDPHE. Therefore, the activity designated for the Timmerhaus Fund to support and measure the success of the project includes the following:

1. Three workshop sessions hosted in Boulder, Denver, and Grand Junction, Colorado, in which participants will provide panel feedback to assess how attitudinal perceptions of wastewater monitoring are represented in the community with the highest understanding of the process. The panel questions will be submitted for revision and approval to the Institutional Review Board (IRB) of the University of Colorado Boulder. Specific questions will be solicited from the CDPHE. **Metrics for Success**: *Successfully conducting the workshops prior to July 2023 in Boulder, Denver, and Grand Junction, CO and having over 50 participants in attendance when summed across all workshops.*

Expected Outcomes: Report on the understanding and utilization of WBS by water professional experts; broader connections between the Environmental Engineering Program at CU Boulder with local professionals in the area.

Required Resources for Task 3 Directly Supported by the Timmerhaus Fund: Transportation costs for PI Mansfeldt and a Graduate Student to travel to Denver and Grand Junction. Food and refreshments for the main workshop. Professional CU Boulder Merchandise such as mugs, pens, and USB drives.

Overall Summary:

Accomplishing these three tasks fulfills the main objectives of *exploring* the community's perception of, *empowering* individuals within, and *establishing* connections between groups connected to our modern water cycle.

Personel: The principal investigator and organizer of this effort is Assistant Professor Cresten Mansfeldt from the Department of Civil, Environmental, and Architectural Engineering at the University of Colorado Boulder. He oversaw the on-campus sewage monitoring for the SARS-CoV-2 virus from 2020-2021. He currently organizes national and international workshops for environmental engineers and public health experts surrounding the ethics of wastewater surveillance. Overall, he sees using our sewage infrastructure as a way to strengthen the ties between communities and institutions. Additionally, a graduate student will be recruited to assist in the application of these efforts.

Career Commitment: PI Mansfeldt arrived at the intersection of technical research and engagement through the wastewater-based surveillance campaign conducted on CU Boulder's campus. Initial efforts by the Creative Microbial BioMaintenance for Greener Environments and Municipalities (CMBM-GEM), which PI Mansfeldt leads, focused heavily on technique development and process optimization. However, during the operation of the surveillance

campaign, the technical capabilities to perform this type of research were demonstrated to far outpace the societal knowledge of or acceptance of these new technologies. Therefore, to explore this crucial public health interface and preserve the access to and integrity of the sewer networks across the United States, PI Mansfeldt became more focused on the ethical and stakeholder engaged deployment of these techniques.

This Timmerhaus Presidential Scholar Award is intended to support these early efforts in strengthening the ties between the technical capabilities of CU Boulder and the public at large. Additionally, by conducting this approach in a scientific manner of learning how the presentation and discussion of information, this outreach will also serve as the basis for gathering data necessary for larger National Science Foundation (NSF) Ethical and Responsible Research Program grants and for constructing a NSF CAREER narrative. However, this type of research and engagement is often difficult to support through conventional grants and departmental resources more geared toward campus curricula and innovation. Therefore, this invaluable resource will enable the collection of crucial data focusing on the often-overlooked relationship society maintains with sewers, strengthen collaborations between CU Boulder and communities throughout the state, and promote the recruitment of young scholars into future CU Boulder freshman classes.

Timeline: The main activities in support of this community engagement project will occur within 2023. The current projected timeline highlights that the majority of activity will conclude by July 2023 (Figure 3).

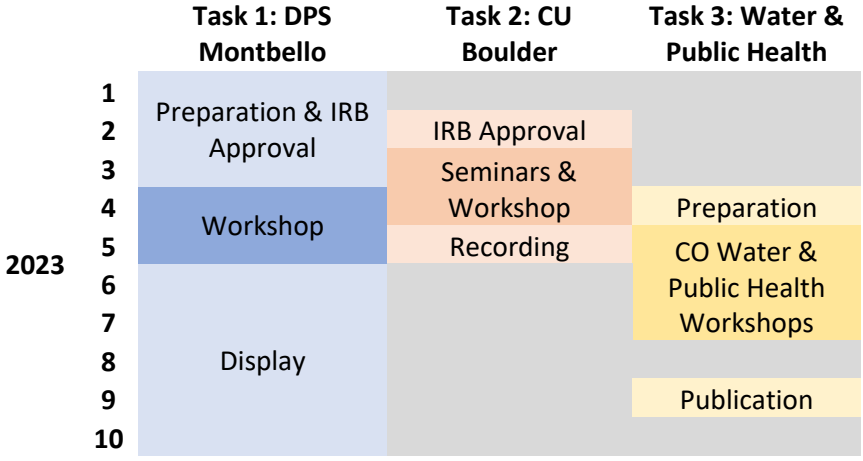


Figure 3. *Timeline representing the major activities for the three tasks in support of this WBS community engagement project.*

These anticipated timelines require flexibility during the coordination with the key stakeholders at DPS Montbello High School and with the water and public health professionals across CO. Task 3 already has flexibility built in with scheduled workshops occurring over the summer. However, the main scheduling constraint is likely Task 1, requiring coordination in either the Spring or Fall semesters to ensure student participation during the academic year. Currently, the main plan is to target the Spring 2023 10th grade class.

Budget and Budget Justification: The total requested budget for achieving the objectives for these three tasks is presented below:

Task 1: The main cost associated with the collaboration with the students at DPS Montbello High School are associated with incentives (food and refreshments as well as CU Boulder Merchandise) to encourage and sustain student participation. Additionally, the CU Boulder Merchandise will encompass t-shirts, sweatshirts, and other visible clothing to enable further representation of CU's collaboration and outreach to motivate students to apply. Uniquely, achieving equitable access to the presentation material, a portion of the cost is set aside to reimburse DPS for translation services to provide key wastewater information in English, Spanish, French, Persian, Somali, and Marshallese. Similarly, an emergency camera fund will ease the burden of access dependent on technology access. The cost for Task 1 is higher than in the preproposal to reflect more accurately the anticipated cost per student with an expanded enrollment of 40-45 and provide for more equitable access to the workshop materials.

Transportation	$400
CU Boulder merchandise	$4,000
Translation services	$1,000
Food and refreshments	$1,000
Printing costs	$500
Emergency camera fund	$200
Task 1 Total	**$7,100**

Task 2: The cost associated with the collaboration with undergraduate students include food and refreshments and CU Boulder merchandise to incentivize participation. This cost is higher than the preproposal to ensure that cross comparisons of the data between the DPS Montbello High School surveys and the CU Boulder workshop have similar initial motivations.

CU Boulder merchandise	$500
Food and refreshments	$500
Task 2 Total	**$1,000**

Task 3: The main cost associated with the collaboration with water professionals around the State of Colorado include the transportation to locations such as Grand Junction, providing CU Boulder merchandise for attending the workshop, and food and refreshments.

Transportation	$200
CU Boulder merchandise	$1,000
Food and refreshments	$1,000
Task 3 Total	**$2,200**

Project Support: To ensure the availability and commitment of PI Mansfeldt during the early career stage, one-half month of salary support for the summer is sought. Additionally, support for graduate student effort during the summer enables the training of and collaboration with an early career researcher in public engaged work.

Summer salary PI Mansfeldt	$7,000
Graduate student support	$2,500
Project Costs	**$9,500**
Total Request	**$19,800**

Additional Resources Matching this Investment: The intent of applying for this Timmerhaus Fund is to provide the initial seed to further the ability of PI Mansfeldt to proactively engage with the wider public on concerns surrounding our wastewater and sewer infrastructure. In addition to the support sought here, the DPS Montbello High School has offered an array of resources ranging from vehicles to additional staff support, and PI Mansfeldt will subsidize any additional costs with his startup funds. However, the limitation on these funds to a short-term investment requires seeking more consistent and long-term support. Therefore, to maintain broader engagement, PI Mansfeldt will incorporate the findings, collaborations, and generated materials into external NSF grant applications to ensure that longer term engagement on these key issues. Additionally, this application will be shared with Director David Meens at the University of Colorado Boulder Office of Outreach and Engagement to identify further support and partnerships.

Madelyn S. Percy
Montbello High School
5000 Crown Blvd.
Denver, CO 80239

madelyn_percy@dpsk12.net
(720) 423-5900

28 October 2022

To whom it may concern:

I am writing in support of Dr. Mansfeldt's Timmerhaus Fund Ambassadors application, titled "Connection through wastewater." As the Senior Team Lead and science department chair at Montbello High School, a Title 1 school in the Far Northeast region of Denver Public Schools (DPS), I am confident that the activities proposed in Task 1 will not only serve my community of students, but help build deeper connections between members of our community and the CU system. In support of the activities proposed in Task 1 of Dr. Mansfeldt's proposal, I will provide translation support in Spanish and DPS will provide translation services in Marshallese, Persian, French, and Somali to ensure that all students at the school who are interested in participating in the proposed activities will be able to do so. Additionally, colleagues in the electives department have agreed to support students participating in the activities by helping students access high-quality cameras and allowing students to incorporate their photo essays in other applications at the school.

I am extremely excited to support Dr. Mansfeldt's application.

Best,

Dr. Madelyn Percy

COLORADO
Department of Public Health & Environment

October 19, 2022

Dr. Cresten Mansfeldt
University of Colorado Boulder
4001 Discovery Drive
Boulder, CO 80303

Dear Dr. Mansfeldt,

On behalf of the Wastewater Surveillance Unit at the Colorado Department of Public Health and Environment, I am pleased to provide this letter of support for your 'Connections through Wastewater' application to the Timmerhaus Fund Ambassadors Program. CDPHE will provide connections to public health water resource professionals around the state to assist in the project. We will participate in some of the proposed workshops, share our experience in wastewater surveillance, and learn from your expertise.

CDPHE started working in the field of wastewater surveillance in August of 2020. We have established a robust statewide wastewater monitoring program covering 3.5 million people in Colorado. In August of 2022, CDPHE and our colleagues at the University of Denver were designated by the CDC as a National Wastewater Center of Excellence - one of two in the nation. As a Center of Excellence, we will work with the CDC to continue to expand the number of states participating in wastewater surveillance.

CDPHE considers you a leader in the field of wastewater surveillance and have enjoyed following your work throughout the pandemic. We look forward to working with you on this project. Please contact me with any questions (720-443-2104).

Sincerely,

Allison Wheeler, MSPH
Co-Director, Colorado NWSS Center of Excellence
Wastewater Surveillance Unit Manager
Colorado Department of Public Health and Environment

October 28, 2022

Re: Letter of Support for Fund Ambassadors Application – Connection through Wastewater.

Dear Review Committee,

The Boulder Watershed Collective (BWC) would like to express our support for the Connection through Wastewater project spearheaded by Cresten Mansfeldt. In Boulder County and across the West we are all familiar with the preciousness of our water resources, the need for bold innovation and conservation and the critical role that education and engagement plays in creating sustainable solutions for the future. As an organization that prioritizes community engagement, we appreciate the recognition by Mr. Mansfeldt and his team that understanding local perspectives and existing knowledge related to wastewater use is a powerful tool to complement the continued technical advances that wastewater surveillance can provide to our communities.

The BWC works to cultivate partnerships, promote community stewardship, and revitalize social and ecological systems within the Boulder Creek watershed and beyond. We do this work to create a resilient watershed where landscapes and communities thrive. This project aligns with our organization's mission, and we are excited to support and participate in this project.

Thank you for your consideration of this proposal as it will help create a more knowledgeable population which is better equipped to adapt to future environmental and public health challenges.

Sincerely,

Maya MacHamer, Director
Boulder Watershed Collective
www.boulderwatershedcollective.org

Museum of Natural History
UNIVERSITY OF COLORADO **BOULDER**

October 20, 2022

Subject: Connection through Wastewater Project Proposal

The CU Museum of Natural History was very happy with the outcomes from our recent collaboration with Assistant Professor, Dr. Cresten Mansfeldt.

The ***Thrones of Waste*** pop-up exhibition (December 2021- May 2022) within our BioLounge Gallery included a grand opening celebration for campus and community members. The exhibit showcased chairs constructed from upcycled waste materials and the opening event was highlighted by the engaging and inspiring stories that each civil engineering student–turned "artist" presented regarding the construction their final project.

The **Connection through Wastewater project** proposal is of interest as it provides an important opportunity to explore the topical and multi-faceted subject of wastewater as a natural resource. A future collaboration regarding **Connection through Wastewater** would be a novel exhibition and squares well with the CU Museum's JEDI (Justice, Equity, Diversity & Inclusion) Committee's goals and interests. Additionally, if this project becomes a reality, we would be certain to translate the exhibit copy into both English and Spanish.

Sincerely,

Suzanne Balog
Thrones of Waste Project Liaison