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WIHAH

ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

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Conference on **W**ater **I**nnovations for **H**ealthy **A**rctic **H**omes

Addressing the challenges of providing safe and affordable access to household running water and sanitation in remote Arctic and sub-Arctic communities

September 18-21, 2016 @ Hilton Hotel, Anchorage, Alaska

The WIHAH conference brought together Alaskan, U.S., and international engineers, health experts, researchers, community members, policymakers, and innovators to discuss health benefits, challenges and innovations associated with making running water and sewer in remote northern communities safe, affordable and sustainable. A conference proceedings publication including a summary report of the meeting was produced. This conference consisted of expert speaker and poster presentation sessions, along with selected innovative technical demonstrations.

This circumpolar conference was identified as an official event in conjunction with the U.S. Chairmanship of the

Arctic Council, as an endorsed project of the Arctic Council Sustainable Development Working Group. The Alaska Department of Environmental Conservation partnered with a number of U.S. agencies to sponsor this informative conference. Federal sponsors included the U.S. Environmental Protection Agency, U.S. Arctic Research Commission; U.S. the Centers for Disease Control and Prevention; the U.S. Department of State; and the U.S. Department of Agriculture, Rural Development Program.

Conference themes:

- The impact of household water and sanitation on Arctic human health
- Climate change impacts on water and sanitation infrastructure in the Arctic
- Innovative engineering approaches to increase access to water of adequate quality and quantity, including water reuse
- Methods of ownership, operations and maintenance to maximize useful life of water and sewer systems in the Arctic
- Regulations and policies affecting access to and the cost of providing adequate quantities of water in the home

Please contact fatima.ochante@alaska.gov with any questions.

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WIHAH

ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

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CONFERENCE

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

ADDRESSING THE CHALLENGES OF PROVIDING SAFE AND AFFORDABLE ACCESS TO HOUSEHOLD RUNNING WATER AND SANITATION IN REMOTE ARCTIC AND SUB-ARCTIC COMMUNITIES

CONFERENCE THEMES

THE IMPACT OF HOUSEHOLD WATER AND SANITATION ON ARCTIC HUMAN HEALTH

CLIMATE CHANGE IMPACTS ON WATER AND SANITATION INFRASTRUCTURE IN THE ARCTIC

INNOVATIVE ENGINEERING APPROACHES TO INCREASE ACCESS TO WATER OF ADEQUATE QUALITY AND QUANTITY, INCLUDING WATER REUSE

METHODS OF OWNERSHIP, OPERATIONS AND MAINTENANCE TO MAXIMIZE USEFUL LIFE OF WATER AND SEWER SYSTEMS IN THE ARCTIC

REGULATIONS AND POLICIES AFFECTING ACCESS TO AND THE COST OF PROVIDING ADEQUATE QUANTITIES OF WATER IN THE HOME

ANCHORAGE HILTON
ANCHORAGE, ALASKA
SEPTEMBER 18-21, 2016

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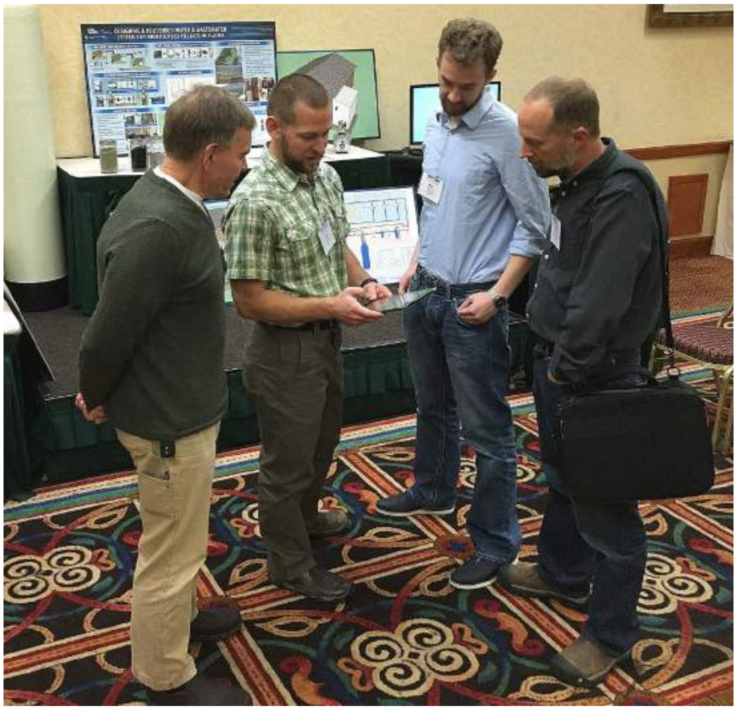
SUMMIT's Dave Cramer, DOWL's Chase Nelson and Mitch Titus, Bob White from YKHC

The Water Innovations for Healthy Arctic Homes (WIHAH) conference was held in Anchorage, Alaska, September 18–21, 2016, and was hosted by the Alaska Department of Environmental Conservation. WIHAH was part of an Arctic Council project, endorsed by the Council's Sustainable Development Working Group and co-lead by the United States and the Kingdom of Denmark during the U.S. Chairmanship in 2015-2017. A related meeting, "Sanitation in Cold Climate Regions" (ARTEK Event), was held in Sisimiut, Greenland, in April, 2016[1]. Both meetings convened international experts, engineers, health experts, academics and community members to share information, explore innovations, and encourage partnerships toward the goal of promoting safe and affordable access to household running water and sanitation services in remote Arctic communities.

The United Nations Sustainable Development Goal (SDG) #6 aims to "achieve universal and equitable access to safe and affordable drinking water for all" by 2030[2]. Many Arctic and sub-Arctic households in Alaska, Canada, Greenland and Russia suffer from a lack of access to sufficient water and sanitation services, contributing to high rates of infectious diseases. Such services are fundamental to sustainable development and community resilience in a rapidly changing Arctic. However, the challenges associated with building and operating water and sanitation systems in the Arctic are formidable. Construction costs often exceed available government funding and rural communities face logistical and economic difficulties to keep systems running. Unless alternative funding mechanisms are adopted or innovative approaches to water and sanitation services are implemented, many Arctic and sub-Arctic residents may never have indoor plumbing and SDG #6 will not be met in the Arctic region.

Arctic nations and communities have responded to the challenges of providing water and sanitation service in different ways. These include differences in planning, design and construction techniques; water and sanitation service expectations; regulations for water and wastewater; and use of subsidies to support the cost of operating sanitation systems. Further, climate and environmental change is forcing many communities to adapt to changes in source water, infrastructure support and shorelines. These differences represent opportunities and both WIHAH and ARTEK events in 2016 were convened so that the Arctic communities could meet, compare experiences, learn from each other and develop new approaches that increase access to water and sanitation services and improve the health of Arctic residents.

Conference Themes

The WIHAH Conference was organized to promote learning and discussion among persons with a range of professional and personal experiences. Invited keynote speakers and presentations submitted by attendees were selected to address five conference themes to promote interdisciplinary learning. These five themes are described in the paragraphs below.

Bill Griffith talks with Blanche Okbaok-Garnie

The First Theme – The first theme addressed the direct and indirect effects of household water and sanitation on Arctic human health. One presentation covered community perspectives on water insecurity in three remote Iñupiaq villages in rural Alaska. Another addressed water infrastructure and its effect on health and well-being in the context of a First Nations community in northern Canada. A third presentation described significant declines in skin, respiratory, and gastrointestinal illness following the first-time provision of piped water to the homes in four rural Alaska Native communities. A fourth evaluated the association of gastrointestinal illness with contaminated stored household drinking water in a rural Canadian community. The final presentation covered health education and behavior change perspectives to maximize the health benefits of existing infrastructure.

The Second Theme – The second theme focused on climate change effects on water and sanitation systems across the North, with impacts on traditional and engineered water sources. The Arctic is experiencing thawing permafrost, rising sea levels, increases in the number and intensity of storm surges, saltwater intrusion into coastal groundwater, and northward movement of animal populations that bring with them new pathogens. Additionally, climate-related environmental changes have caused loss of tundra ponds and caused damage to water intakes and impoundments from sediments, ice and erosion. In this session, presenters described these changes, identified key vulnerability points in water systems and urged managers to pursue water resource vulnerability assessments. Presenters also reviewed data collected from the Arctic Council Survey on Water and Sanitation in the Arctic, which documented the status of water and sanitation service and associated health outcomes, and described climate-related vulnerabilities and adaptation strategies for community water and sanitation systems and source water protection.

The Third Theme – The third theme highlighted innovative engineering approaches to increase access to water of adequate quality and quantity, including water reuse. Two engineers presented information about novel methodologies for treating wastewater from domestic and fish processing sources. A unique concept came from a university in Florida, where 100 percent of the water used in a student dormitory is treated and reused on-site. An Alaskan engineer shared new research on the generation of energy from household wastewater treatment systems, and others shared information about a pilot project to convert human waste to bio fuel. Finally, an industry engineer presented information about a small community wastewater treatment system that may hold potential for Alaska villages.

Innovative Decentralized Approaches to Household Running Water & Sanitation Service

The conference also featured sessions on research and development of innovative decentralized approaches to household running water and sanitation service. In Alaska, there are four pilot systems in development or early trials, and each was showcased at the conference. Three systems are being developed as part of the Alaska Water and Sewer Challenge[3]. These systems would all provide running water and sewer for a kitchen and bathroom sink, a toilet, a clothes washing machine and a shower. Performance targets include capital and operating costs, water quality and quantity, and constructability. Design teams reported on current progress toward meeting these targets. In addition, the Alaska Native Tribal Health Consortium (ANTHC) developed a pilot system which includes a bathroom sink and a toilet. This system is being field tested in the village of Kivalina, Alaska. Thirty people from remote Alaska villages attended the conference and each attended this session on demonstration systems. After

Megan Alvanna-Stimpfle

the conference, a special meeting was held with these village residents to gather their feedback and ideas on the systems.

The Fourth Theme – The fourth theme covered methods of ownership, operations and maintenance to maximize the useful operational life of existing water and sanitation systems in the Arctic. One speaker addressed how utility systems can apply energy efficiency improvements and risk assessment tools to improve system operation and maintenance. Another presenter discussed how outreach and education can improve a community's knowledge and appreciation of its water system, thus extending the health benefits. Another presentation addressed methods to assess the affordability of water service at the household level and how this could be used in evaluating sustainability of a new community system. These examples included methods that have been implemented successfully in sanitation systems across the Arctic.

The Fifth Theme – Theme five covered regulations and policies affecting access to, and costs of, providing adequate quantities of in-home water. Although water and sanitation regulations differ across the Arctic, no Arctic Council member state has regulations on water reuse at the household level. The closest documents are 2012 Water Reuse Guidelines published by the United States Environmental Protection Agency. A risk-based framework for the development of public health performance standards for decentralized non-drinking water systems is being developed by the Water Environment Research Foundation (WERF) in Alexandria, Virginia. How these performance standards are accepted by the public may depend on an approach utilizing social change marketing, which could include greater involvement of communities and regional institutions to gain acceptance of water reuse within the home and the new WERF standards.

Ways Forward & Next Steps

The following are ideas and suggestions from WIHAH participants for the next steps needed to improve health of Arctic residents through improved access to water and sanitation services. These were the perspectives of individuals and do not necessarily represent the official recommendations of the conference supporters or national governments.

Innovations

- Continue to evaluate alternatives to centralized and fully piped systems (examples include household systems, separator toilets, and countertop drinking water treatment systems) for their suitability in isolated Arctic communities and their impact on human health. These alternatives could be components of future Alaska Challenge systems.
- Consider an integrated approach to introduce components of the Alaska Water and Sewer Challenge so the communities do not have to wait until the end of the piloting stage to see improvements in the level of service in their homes.
- Ensure new systems are simple and reliable.
- Research and develop ways to dispose of waste and to take advantage of waste

Members of the conference core planning group included Dennis Wagner, Tom Hennessy, Cheryl Rosa, Jonathan Bressler, Bill Griffith and Fatima Ochante

as a potential resource. One example suggested was bio-digesters for Alaska villages that will provide both a method of disposing of human waste and a source of energy for the community. Another suggestion was composting waste to support food production.

Communications
- Create materials that describe the health impacts of inadequate access to water and sanitation service in Arctic communities that can be used to educate legislators and decision makers.
- Seek community input (e.g. Alaska village residents) early and often when developing new approaches to water and sanitation services.

Addressing Changing Environments
- Develop a database of water and sanitation infrastructure, source water or treatment systems at risk from environmental or climate change.
- Conduct a comprehensive Arctic-wide hydrologic modeling and water resource assessment.
- Develop and implement a water resource vulnerability assessment.
- Review the findings of the 2008-2009 Alaska Climate Change Sub-Cabinet to consider current relevance or informative value.

Operations, Maintenance & Regulation
- Apply a scoring methodology that integrates risk and cost in order to prioritize further planning, monitoring and response efforts.
- Follow-up with the (WERF) for the development of public health performance standards for decentralized non-potable water systems that could be used in the Arctic.
- Evaluate the economics of providing a subsidy to remote communities for supporting operations and maintenance and preventing catastrophic system failures.

Building Local Capacity
- Encourage and support community planning efforts that specifically address climate change and its impacts on water and sanitation source water and infrastructure.

- Encourage and support emergency response preparations to ensure villages are ready to address water and sanitation-related disasters. Scenario planning may be a good activity to use in these preparations.

Addressing Health Concerns

- Quantify the economic consequences of inadequate access to in-home water and wastewater services, including direct health care costs (morbidity and mortality, health care expenses) and indirect costs, such as lower educational attainment due to illness, decreased subsistence and employment activities. Such analyses should include methods that account for the unique cultural context of the Arctic, including individual and cultural values.
- Conduct an assessment of how much water is needed per-person per-day to provide the best benefit for health in Arctic communities. In doing this, consider newer technologies not available in prior World Health Organization (WHO) water quantity standards. These could include low-flow faucets, separating or dry toilets, and water reuse methods that could conserve water and reduce cost for a similar gain in health. Also, consider the water related needs that can be centralized (e.g. laundry) versus those that must be available in the house (e.g. handwashing).

Circumpolar Cooperation

- Through the Arctic Council Sustainable Development Working Group and its Arctic Human Health Expert Group (AHHEG), Arctic states should cooperate to share data about water and sanitation access in their Arctic communities, as well as progress toward the Sustainable Development Goal #6.
- Through AHHEG, and through non-Council bodies such as the International Circumpolar Surveillance network, Arctic states should cooperate to track water-related infectious diseases (both water-borne and water-washed) in the Arctic region over time, and to study how changes in water and sanitation access affect these rates.
- The Arctic Council should continue to create forums for Arctic communities to share innovations in water and sanitation technology, cost management methods, and climate change adaptation strategies.
- Arctic states should cooperate with one another to assess the quantity of water needed for good health in the Arctic, and to consider adopting standards for providing adequate

Alaska press member, Johanna Eurich, talks with conference participants water quantity and engineering methods for achieving these standards.

Conclusion

In conclusion, both the WIHAH and ARTEK conferences were successful in promoting useful discussions among groups that do not usually interact, but have a shared interest in improving water and sanitation services. The suggestions for next steps provide a way forward and offer action items for groups ranging from local communities to the Arctic Council. The durable record of this Arctic Council project will include these conference proceedings and a special Arctic-themed issue of the journal, "Environmental Science and Pollution Research," which will feature research articles written by attendees of the WIHAH and ARTEK meetings. Further progress on innovations in water and sanitation services can be found at the websites of the Alaska Water and Sewer Challenge[3] and the U.S. Arctic Research Commission[4]. The WIHAH sponsors and organizers sincerely thank the conference participants and hope that our efforts will be a step toward improving health for Arctic residents through the provision of in-home water and sanitation services for all.

References

1 http://www.conferencemanager.dk/ArtekEvent2016 Accessed 16 December, 2016
2 http://www.un.org/sustainabledevelopment/water-and-sanitation/ Accessed 16 December, 2016
3 http://watersewerchallenge.alaska.gov/ Accessed 16 December, 2016
4 https://www.arctic.gov/water-san/index.html Accessed 16 December, 2016

Plenary speaker Danielle Arigoni

ORGANIZING COMMITTEE

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Bill Griffith, Alaska Department of Environmental Conservation

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Cheryl Rosa, U.S. Arctic Research Commission

Dennis Wagner, U.S. Environmental Protection Agency

Elizabeth Hodges, University of Alaska Anchorage

Fatima Ochante, Alaska Department of Environmental Conservation

Jonathan Bressler, Alaska Department of Health & Social Services

Josh Glasser, U.S. Department of State

Korie Hickel, Alaska Native Tribal Health Consortium

Sharon Hildebrand, University of Alaska Southeast

Stephen Bolan, U.S. Indian Health Service

Tasha Deardorff, U.S. Department of Agriculture, Rural Division

Thomas Hennessy, U.S. CDC Arctic Investigations Program

Tim Thomas, Alaska Native Tribal Health Consortium

PRESENTATIONS

Presentation slides are available for download at http://wihah2016.com/presentations/

PRESENTATIONS

Opening Remarks

- Welcoming Remarks – Larry Hartig, Commissioner, Alaska Department of Environmental Conservation
- Opening Session – Bill Griffith, Facility Programs Manager, Alaska Department of Environmental Conservation

Keynotes

- An Introduction to the Arctic Council and the Sustainable Development Working Group – Ann Meceda, Arctic Affairs Officer, Acting Chair SDWG, U.S. Department of State
- Climate Change, Disaster Resilience and Relocation at HUD – Danielle Arigoni, Acting Director, HUD's Office of Economic Resilience
- Climate Change Consequences – Eric Hoberg, US National Parasite Collection, Agricultural Research Service, US Department of Agriculture and Smithsonian Institution
- The Impact of Water and Sanitation Services on Health – Tom Hennessy, Director, Arctic Investigations Program, National Center for Emerging and Zoonotic Infectious Diseases, US Centers for Disease Control and Prevention
- Pathogen Risk Management Considerations for Safe Household Water Uses – Nick Ashbolt, Al-HS Transitional Health Chair in Water, University of Alberta School of Public Health
- Reuse Regulations and Challenges of Regulating On-site Systems – Guy Carpenter, President, WateReuse Association
- Water Security in the Arctic: Perspectives from the Model Arctic Council - Carolyn Kozak, Sharon Hildebrand, Stephen Penner

International Reception Presentations

- Household Water Treatment and Safe Storage: Experience from the Developing World Lessons for Rural Alaska? – Robert Quick, MD, MPH, Centers for Disease Control and Prevention
- Arctic WASH Contributions from the Kingdom of Denmark – Greenland – Pernille Jensen & Kristian Hammeken, Centre of Arctic Technology, Department of Civil Engineering, Technical, University of Denmark
- A Bend in the River: Transitioning to a Time of Permanent Change – John Matthews, Alliance for Global Water Adaptation

Overview of Household Pilot Systems in Development

- State of Alaska's R&D Project: The Alaska Water & Sewer Challenge – Bill Griffith & Fatima Ochante, Village Safe Water Program, Alaska Department of Environmental Conservation
- Alaska Water Sewer Challenge – Phase 3: Team University of Alaska Anchorage (view animation), Aaron Dotson, Associate Professor, University of Alaska Anchorage

- Alaska Water & Sewer Challenge: Designing a Household Water & Wastewater System for Underserved Villages in Alaska, Chris Schulz & Janelle Rogers, CDM Smith, Chase Nelson & Mitch Titus, DOWL, Bruno Grunau, CCHRC, Laurie Krieger, Manoff Group
- Alaska Water + Sewer Challenge: Water Innovations for Healthy Arctic Homes, Summit Consulting Services
- The Portable Alternative Sanitation System (PASS)

Conference Theme: The Impact of Household Water & Sanitation on Arctic Human Health

- Community Perspectives on Water Insecurity in Rural Alaska – Laura Eichelberger, PhD, MPH, Univeristy of Texas at San Antonio
- Education and Behavior Change Efforts to Maximize the Health Benefits and Sustainability of Water and Sanitation – AJ Salkoski, Sr. Program Manager & John Nichols, Manager of Utility Operations, Alaska Native Tribal Health Consortium
- Impact of In-home Piped Water on Rates of Infectious Disease – The Four Village Study – Tim Thomas, Alaska Native Tribal Health Consortium, Centers for Disease Control and Prevention, Arctic Investigations Program
- Water Infrastructure and Well-being: What Does the Data Tell Us? – Melanie O'Gorman & Stephen Penner, University of Winnipeg MB, Canada
- Water Quality and Health in Northern Canada: Contamination of Stored Drinking Water and Associations with Acute Gastrointestinal Illness in an Inuit Community – Carlee Wright

Conference Theme: Climate Change Impacts on Water & Sanitation Infrastructure in the Arctic

- Vulnerability of Northern Water Supply Lakes to Changing Climate and Demand– Michael Bakaic, York University
- Vulnerability of Fresh Water Supply in Arctic Canada – Andrew Medeiros & Michael Bakaic, York Univserity, Department of Geography
- Climate Change and Community Water Security Emerging Challenges and Strategies – Mike Brubaker, Alaska Native Tribal Health Consortium
- Survey on Water and Sanitation in the Arctic: Access, Disease Surveillance, and Threats from Climate Change – Jonathan Bressler, MPH, Section of Epidemiology, Division of Public Health, Alaska Department of Health and Social Services & Tom Hennessy, MD, MPH, Arctic Investigations Program, National Center for Emerging Zoonotic Infectious Diseases, Centers for Disease Control and Prevention

Conference Theme: Innovative Engineering Approaches to Increase Access to Water of Adequate Quality & Quantity, Including Water Reuse

- Charting a New Direction for Wastewater Treatment in the Canadian North – Ken Johnson, Planner, Engineer and Historian, Cryofront
- Natural Engineered Wastewater Treatment: NEWT – Thomas Kasun, Natural Engineered Water Treatment

- Preliminary Test Results from an Electrically-Assisted, Anaerobic Sewage Treatment System – Bob Tsigonis, Lifewater Engineering Company & Yehuda Kleiner and Boris Tartakovsky, National Research Council of Canada
- Relocate: Kivalina Biochar Reactor – Jennifer Marlow & Michael Gerace, Re-Locate LLC
- Net-Zero Water: Energy-Positive Municipal Water Management – James Englehardt, University of Miami College of Engineering
- Potentials and Challenges of Biogas from Fish Industry Waste in the Arctic – Pernille Jensen, Arctic Technology Center, Department of Civil Engineering, Technical University of Denmark

Conference Theme: Regulations & Policies Affecting Access to and the Cost of Providing Adequate Quantities of Water in the Home

- EPA Regulations, Policies, and Guidelines for Water Reuse: Implications for Decentralized Greywater Reuse – Robert Bastian, Senior Environmental Scientist, Office of Wastewater Management, U.S. Environmental Protection Agency
- Greenland: Far from Reaching The United Nations Millennium Development Goals. Why? – Kåre Hendriksen, Arctic Technology Centre, Technical University of Denmark
- Beyond Education: Using Social Change Marketing to Drive Behavior Change – Kathy Anderson, MPRH, PhD, University of Alaska Anchorage, Alaska Pacific University, University of South Florida
- Sewer and Water Regulatory Reform in Alaska – Megan Alvanna-Stimpfle, Nome Port Commission

Conference Theme: Methods of Ownership, Operations & Maintenance to Maximize Useful Life of Water & Sewer Systems in the Arctic

- Techniques and Design to Adapt – Michael Black, Department of Rural Utility Management, Alaska Native Tribal Health Consortium
- Applying a Water Safety Plan Approach – Graham Gagnon, Kaycie Lane & Amina Stoddart, Civil and Resource Engineering, Dalhousie University
- A New Affordability Indicator for Rural Alaskan Water Utilities – Barbara Johnson, Ms Resource and Applied Economics candidate, School of Management, University of Alaska Fairbanks
- Maximizing Sustainability in Arctic Water and Sewer: Energy Efficiency – Gavin Dixon, Senior Project Manager, Alaska Native Tribal Health Consortium Rural Energy Initiative
- Water is Life Project – James Temte, Alaska Native Tribal Health Consortium, National Tribal Water Center & Alaska Rural Utility Collaborative

Country Comparisons: Water & Sanitation Service

- Country Comparisons
- Water and Sanitation Summary for Greenland – Kåre Hendriksen, Associate Professor PhD, Arctic Technology Centre, Technical University of Denmark
- Department of Health Nunavut – Michele LeBlanc-Harvard, EHS to the CMOH Territory of Nunavut
- Water and Sanitation Summary for Northwest Territories-Canada – Peter Workman, Chief Environmental Health Officer, Department of Health and Social Services, Government of Northwest Territories
- Water and Sanitation Summary for Yukon, Canada – Tyler Heal, EIT, Civil Eingineering Lead, Yukon, Stantec Consulting Ltd.
- Water and Sanitation Summary for Alaska – Bill Griffith, Facility Programs Manager, Alaska Department of Environmental Conservation
- Peculiarities of Water Supply and Drinking Water Quality in the Russion Arctic – Cheryl Rosa on behalf of Alexey Dudarev, Head of Hygiene Department, Northwest Public Health Research Center, St. Petersburg, Russia.
  [Note: This presentation is not available. Please refer to the abstract on page 73 for background and contact information.]

County Comparison presenters Cheryl Rosa (on behalf of Alexey Dudarev), Bill Griffith, Peter Workman, Michele LeBlanc-Harvard, Tyler Heal and Kare Hendriksen

PRESENTER BIOGRAPHIES

PRESENTER BIOGRAPHIES

Megan Alvanna-Stimpfle was born and raised in Nome, Alaska. She is of King Island Inupiaq heritage and takes pride in Eskimo dancing and learning her language. She holds a master's degree in applied economics from Johns Hopkins University and a Bachelor of Science in economics from George Mason University. For five years, Alvanna-Stimpfle served as a legislative assistant for Senator Lisa Murkowski in Washington D.C., responsible for helping develop policies addressing infrastructure and sanitation, housing, health delivery, public safety and justice, land management, and fish and wildlife management for Alaska Natives and rural Alaskans. She helped organize the Arctic Imperative Summit to bring Arctic and Coastal Alaska issues to the forefront of American policy. Living in Nome, she serves on the Nome Port Commission and is an elected member of the King Island Traditional Council.

Kathryn Anderson holds adjunct faculty positions at the University of Alaska Anchorage (UAA), Alaska Pacific University, and the University of South Florida, where she teaches social change marketing, commercial marketing, and program management. She is the owner of Pescatore Systems International, an Anchorage-based consulting firm specializing in social change marketing and program evaluation. Anderson holds an interdisciplinary Ph.D. from the University of Alaska Fairbanks and a Master's in Public Health from UAA. She also holds a Bachelor of Science degree in mathematics from Arizona State University, a Master's in Computer Science from Rutgers University, and she completed the Harvard Business School Advanced Management Program in 1995. Anderson currently serves on the governing boards of Providence Alaska Health and the Allergy and Asthma Foundation Alaska Chapter. She resides in Anchorage and Homer with her husband.

Danielle Arigoni has been a leader in key federal efforts to expand investment in sustainability and resilience for almost two decades. She serves as acting director for the U.S. Housing and Urban Development (HUD) Office of Economic Resilience, which recently awarded $1 billion to states and localities to pilot resilient disaster recovery strategies considering climate risk. She serves as staff lead on the White House Council on Climate Preparedness and Resilience and for HUD Secretary Julian Castro's Climate Council.

Nicholas Ashbolt received his Ph.D. in microbiology from the University of Tasmania in 1985 and specializes in applying microbial risk assessment to support guidelines and water safety plan management of urban water services. Since September 2013 he has been the Alberta Innovates-Health Solutions Translational Health Chair in Infectious Diseases (water), School of Public Health at the University of Alberta. Previously, he was the senior research microbiologist in the Office of Research and Development, U.S. Environmental Protection Agency, in Cincinnati, OH, (2007-2013); head of the School of Civil and Environmental Engineering (2005-2007), University of New South Wales,Sydney, where he was a professor (1994-2007) and deputy director of theCentre for Water & Waste Technology (1996-2005); and principal scientist (wastewater) from 1990 to 1994 at Sydney Water Corporation, Australia.

Dr. Ashbolt's present research focuses on understanding the ecology of saprozoic pathogens in engineered water systems to develop improved management of Legionella, non-tuberculous mycobacteria and Pseudomonas aeruginosa within water safety plans. Through his career he has focused on translating microbiological risks into best management practices and regulatory reform; pioneering developments and uptake of quantitative microbial risk assessment (QMRA) into the World Health Organization's (WHO) harmonized approach (Stockholm Framework) and its incorporation into Australian, Canadian, Scandinavian, American, and WHO drinking water, recreational water and reuse water guidelines and regulations. He has focused his research on filling research gaps identified by QMRA-derived performance targets used in water sanitation safety plans. This involves not only researching enteric pathogens, but also opportunistic (saprozoic) pathogens that grow in environmental media and engineered systems. He has a record of substantial research funding ($13 million) and has supervised 14 Master of Science and 23 Ph.D. students to completion, and is currently advising four Master of Science and two Ph.D. thesis students.

Michael Bakaic graduated from the Master of Environmental Studies program at York University. Through studies in Toronto and at the University of Alaska Fairbanks, Bakaic has focused his research on the development of water infrastructure in Canada's North. His major project has been to conduct water supply forecasts for the communities in the Canadian territory of Nunavut. By developing novel climate and demand forecasting methods, his research has contributed to the development of water security in this territory.

Bob Bastian is a senior environmental scientist with EPA's Office of Wastewater Management in Washington, D.C., where he has worked for more than 40 years dealing with a wide range of wastewater and biosolids management issues associated with publicly owned treatment works and on-site wastewater treatment systems, such as innovative treatment processes, wastewater and biosolids reuse, decentralized wastewater treatment, water quality benefits of wastewater treatment, on-site power production and energy recovery, and toxics control, including coordinating the agency's efforts to develop and update the EPA Guidelines for Water Reuse document. He has also has served as an EPA liaison with numerous interagency workgroups and committees, as well as external groups such as the Water Science & Technology Board of the National Academy of Sciences, WEF, WE&RF, NWRI, WRF, WateReuse Association, and NSF International's Joint Wastewater Committee. Bastian earned his Bachelor and Master of Science degrees in biology, earth sciences and mathematics from Bowling Green State University in Ohio. He also served as an officer in the U.S. Army Corps of Engineers before joining EPA in 1975.

Michael Black has overseen the Department of Rural Utility Management at the Alaska Native Tribal Health Consortium (ANTHC) since December 2012. Prior to this appointment, he was Director of Program Development for the consortium's Division of Environmental Health and Engineering. Before joining ANTHC in 2010, in 2007 he was appointed as Deputy Commissioner for the Alaska Department of Commerce, Community and Economic Development. The previous 25 years he worked with rural communities on the issues of economic development, local governance, infrastructure development and financial management as a local government specialist for the Department of Community and Regional Affairs, and later as Director of the Division of Community and Regional Affairs in the Department of Commerce, Community and Economic Development. He has served on numerous committees, boards and task forces dealing with rural issues in his tenure with the State of Alaska, including the Rural Sanitation Task Force, Federal Field Work Group on Alaska Rural Sanitation, Alaska Climate Change Subcabinet, Immediate Action Work Group, Alaska Workforce Investment Board, and the Alaska Rural Action Subcabinet. He earned a Bachelor of Business Administration in business development from Ohio University (1970) and a Master of Management Studies in environmental management from Duke University (1974).

Jonathan Bressler is a Council of State and Territorial Epidemiologists fellow, working as an epidemiologist with the Environmental Public Health Program at the Alaska Department of Health and Social Services. He earned a Master of Science in public health in global epidemiology from Emory University, where he conducted his thesis on the impact of pit latrines on trachoma prevalence in Guinea. He served as a Peace Corps volunteer in Burkina Faso, Africa. Bressler enjoys writing, language, travel, hockey, skiing, hiking, playing music, GIS mapping, statistical analysis, and good food.

Mike Brubaker specializes in assessing health conditions in rural communities, focusing on environment, pollution, development, and climate change. Brubaker was born in Juneau, Alaska, and raised in Anchorage. He earned his Bachelor of Science in biology from St. Lawrence University in New York and a Master of Science in environmental management from the University of San Francisco. He was a Peace Corps volunteer in Hungary from 1995 to 1997. Since 1998 he has worked in the Alaska Tribal Health System. Before coming to the Alaska Native Tribal Health Consortium, he spent 10 years working for the Aleutian and Pribilof Islands Association, a regional tribal health consortium. He was a founding member of the Center for Climate and Health and started the Local Environmental Observer Network in 2011. Brubaker has been lead author on more than a dozen books and reports about climate change impact on rural Alaska communities. He publishes a weekly e-journal entitled, "The Northern Climate Observer."

Guy Carpenter is a senior water executive whose 25-year career includes utility operations, water resources planning and management, public policy development, engineering consulting, elected public service, and bringing intellectual property to commercialization. He earned a Bachelor in Science in chemistry from Northern Arizona University and is a registered civil engineer in Arizona. Carpenter currently serves as a board member for the Central Arizona Project, which delivers Colorado River water to the three-county area in Arizona where 85 percent of the state's population lives. He is also National WateReuse Association President, and has served on the association board for six years. He also serves on advisory boards for the University of Arizona Water Resources Research Center, and the Arizona State University Kyl Center for Water Policy at the Morrison Institute. Carpenter recently resigned from Carollo Engineers as its national water reuse technical practice director to become senior vice president of strategic operations for AquaTecture, which develops public-private partnerships for water and wastewater projects, bringing transformative intellectual property to market, and providing temporary staffing services for water and wastewater systems.

Gavin Dixon is a senior project manager for the Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC). In this role, he manages energy auditing, energy efficiency projects and renewable energy projects for sanitation systems in rural villages across Alaska. He is also responsible for the development of an innovative energy efficiency training for sanitation operators in partnership with Alaska's Institute of Technology. Dixon has been with ANTHC since 2011, working with the energy program since its inception.

Alexey A. Dudarev has been head of the hygiene department of the Northwest Public Health Research Centre in St-Petersburg, Russia, since 2000. He graduated from the St-Petersburg State Medical Academy in 1987. He has more than 20 years of experience studying environmental health conditions in the Russian Arctic. From 1987 to 2000 he was a researcher at the Research Institute of Radiation Hygiene, also in St. Petersburg, where he studied the problem of increased levels of natural and artificial radioactivity in the Russian Arctic, including consequences of Novaya Zemlja nuclear testing explosions and the Chernobyl disaster. Since 2000, he has been involved in research related to issues on the occurrence of persistent toxic substances in the Russian North, and health effects among the indigenous population. He has also organized and participated in multiple field expeditions throughout the Russian Arctic.

Dr. Dudarev is a key researcher in several international projects including the Arctic Monitoring and Assessment Program (AMAP) and Global Environmental Facility project called the "Persistent Toxic Substances, Food Security and Indigenous Peoples of the Russian North" (2001-2004); the AIA project "PTS in Kamchatka and Commander Islands" (2003-2004), and IPEN projects on PCBs and DDTs in the Russian Arctic (2006). Other accomplishments include co-authoring the First Regional Monitoring Report (Eastern Europe) for POPs Global Monitoring Plan under the Stockholm Convention (2008), and being the principal investigator from the Russian side of the AMAP Sustainable Development Working Group project called "Food and Water Security in the Context of Health in the Arctic" (2012-2013), and for the EU Kolarctic project "Food and Health Security in the Norwegian, Finnish and Russian Border Region" (2013-2016). Dudarev has been a member of the AMAP Human Health Assessment Group (HHAG) since 2002 and co-authored its "Human Health in the Arctic" reports from 2009 to 2015. He is a member of the International Union for Circumpolar Health and has written or co-authored more than 170 scientific publications addressing Arctic environmental health; exposure and effects of persistent toxic substances in the Arctic; Arctic food and water security; cancer epidemiology; indoor air quality; air ionization; and radiation ecology.

Laura Eichelberger holds a Ph.D. in cultural and medical anthropology from the University of Arizona, and a Master of Science in public health from Johns Hopkins Bloomberg School of Public Health. She is an assistant professor of anthropology at the University of Texas in San Antonio, and a former cancer prevention fellow at the National Cancer Institute. In her research, Eichelberger combines ethnographic and epidemiologic methods to examine the relationships between issues of water insecurity, energy security, sustainability, and health at different life stages. Throughout, she examines how people make sense of experiences of water insecurity through political, economic, and cultural frameworks.

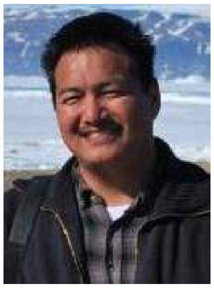
Eichelberger's interests in water and health brought her back to her home state of Alaska, where she has examined problems related to adequate water and sanitation in remote communities in Western and Northwestern Alaska for more than 10 years. Her current research investigates how climate change is affecting health through the built environment. She is also exploring how local definitions of sustainability and the concept of "community-based adaptation" inform responses by community leaders, government agencies, and private entities.

James Englehardt has been a professor of environmental engineering at the University of Miami since 1992. Previously, he was research engineer for Johns Manville Corporation's filtration and minerals division (1983-1987), and field engineer for GE Water Treatment and Process Technologies (1978-1980). He serves on the EPA Science Advisory Board and Drinking Water Advisory Committee; the editorial board of the ASCE-ASME journal; and the Miami-Dade County Small Business Advisory Board for Architecture and Engineering. He has published 112 peer-reviewed journal articles and technical papers. Awards include the EPA NCEA Science Advisor's Award; the AAAS-EPA Robert C. Barnard Environmental Science & Engineering Award for Advances in Risk Assessment; the University of Miami Johnson A. Edosomwan Outstanding Publication Award; and two Eliahu I. Jury Awards for excellence in research.

Graham Gagnon is a professor in the Department of Civil and Resource Engineering at Dalhousie University in Nova Scotia, Canada. He holds a Ph.D. in civil engineering from the University of Waterloo (1997) and a Bachelor of Engineering degree in environmental engineering from the University of Guelph in Ontario, Canada (1993). In 1998, Gagnon was hired as an assistant professor in civil engineering at Dalhousie University in Nova Scotia, Canada, and in 2002 he was awarded a Canada Research Chair in water quality and treatment. In 2006, he became the engineering faculty's first Natural Sciences and Engineering Research Council (NSERC) of Canada Industrial Research Presenter biographies Chair, through a partnership between NSERC and Halifax Water. In 2012, this position was renewed with additional industrial partners, namely: Cape Breton Regional Municipality, LuminUltra, Ltd., CBCL, Ltd., and Mantech, Inc. Gagnon works closely with his students and research partners to deliver timely solutions that have broad impacts on the water industry. He has authored more than 125 peer-reviewed journal articles, 250 conference proceedings, and has supervised more than 50 graduate students in his 18-year career at Dalhousie University. In 2013, he was awarded the Fuller Award from the American Water Works Association through the Atlantic Canada section for his constructive leadership in the water industry.

Michael Gerace, artist and architect, is the co-director of Re-Locate, a transdisciplinary and global collective collaborating with the Inupiaq Eskimo and whaling community of Kivalina, Alaska, to develop strategies for village relocation due to rising seas and melting permafrost. Re-Locate brings public attention to the political, cultural, and environmental issues underlying relocation and the climate displacement of communities around the world. It also works with the village to initiate a community-led and culturally specific relocation.

Bill Griffith has managed State of Alaska Department of Environmental Conservation Division of Water facility programs since 2004. He holds a Bachelor of Science degree in civil engineering and English from Carnegie Mellon University, and a Master of Science degree in construction engineering from the University of New Mexico. After serving as a U.S. Peace Corps volunteer in Nepal, he spent 10 years helping design, construct and operate water and sewer systems on the Navajo Indian Reservation, and then with villages in Alaska's Interior. He worked as a program manager for the Alaska Native Tribal Health Consortium before coming to work for the state.



Kristian Hammeken has studied Arctic Technology (Bachelor of Engineering) and has focused on environmental aspects and planning from The Technical University of Denmark (DTU). Inuit and born in Scoresbysund, he spent his childhood in a little settlement called Kap Tobin where his family's livelihood was hunting. Later he moved to the town of Scoresbysund and finished primary school, before attending Danish/Greenlandic college in South Greenland. He began studying engineering in 2006 in Sisimiut Greenland and finished in Denmark in 2015. Between 1998 and 2006, Kristian worked as a local firefighter and deputy in the leisure center for school children. In 2000 he worked as a reserve officer. He has four children and is working on completing his master's degree in Environmental Engineering at Technical University of Denmark.

Larry Hartig is an attorney with more than 20 years of experience in environmental law, regulations, permits and land use issues. Prior to his appointment in 2007 as the Alaska Department of Environmental Conservation Commissioner, he was in private practice as an attorney with the Anchorage law firm of Hartig Rhodes Hoge & Lekisch. Joining the firm in 1983, he worked primarily on environmental, natural resources, and commercial matters. His practice included assisting clients in obtaining environmental and other permits for natural resource development projects, as well as those involving environmental compliance and cleanup of contaminated properties. Clients included government, private developers, industry, and Alaska Native Corporations. He also worked as a landman in the Alyeska Pipeline Service Company Land/Legal Department from1972 to 1976. Hartig has a bachelor of arts degree from the University of Utah and received his law degree from Lewis & Clark College in Portland, Oregon. He is a member of the Exxon Valdez Oil Spill Trustee Council and the Alaska Bar Association, as well as being a former member of the Alaska Board of Forestry.

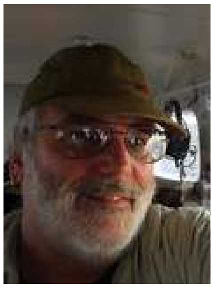
Tyler Heal was born and raised in Yellowknife, Northwest Territories. His family has been working in civil construction in Northern Canada since 1939. As Stantec's civil engineering lead for the Yukon, he continues in this commitment to, and passion for, the North. Having lived and worked in the Northwest Territories, Nunavut and the Yukon (where he is currently based), his interests include community-based solutions to infrastructure challenges, the history and heritage of Northern Canada, and the contemporary issues faced by Northern and indigenous communities.

Kåre Hendriksen is associate professor at the Technical University of Denmark, Arctic Technology Centre (ARTEK) and is affiliated with the Arctic engineering study program. He divides his time between Sisimiut, Greenland, and Denmark, teaching courses on sustainable development, Greenlandic social studies, and planning. Hendriksen has also worked as a consultant for the Greenlandic Home Rule Government and managed local vocational schools in Greenland during the 1990s. Over the last 20 years, he has conducted research and innovation projects in Greenland on sustainable development with emphasis on the local development dynamic, including the economic aspects of settlements, the island's economic character, trade possibilities, the interaction between the infrastructure level and business development, and governance and capacity building. Through his research, Hendriksen has collected empirical data in most Greenlandic settlements and often explored these locations with local hunters by boat or a dogsled team. Current activities in the Arctic focus on sustainable development in existing and new industries around infrastructure, business development and settlement patterns; capacity building and intercultural aspects of learning in relation to the role of consultants and governments in processes of certification; and the role of professional knowledge. He is an accomplished facilitator and specializes in the processes of dialogue and learning in relation to social and technological change.

Tom Hennessy is Director of the Arctic Investigations Program for the US Centers for Disease Control and Prevention (CDC), a field station for infectious diseases in Anchorage, Alaska. Dr. Hennessy joined the U.S. Public Health Service in 1990 and served on the Navajo Reservation until he joined CDC in 1994. He graduated from Antioch College in Ohio, the Mayo Medical School in Minnesota, and Emory University's Rollins School of Public Health in Atlanta, Georgia. He completed residencies in family and preventive medicine and is a graduate of the CDC Epidemic Intelligence Service. His interests include vaccine preventable diseases, food and waterborne infections, zoonotic infectious diseases and reducing health disparities. He was part of the Ebola outbreak response in West Africa in 2014 and 2015 and led an investigation of risk factors for Ebola transmission within households in Sierra Leone in West Africa. Hennessy is an affiliate faculty member of the University of Alaska Anchorage, Department of Health Sciences. He is also co-chair for the Arctic Human Health Experts Group, a multinational advisory group to the Arctic Council.

Korie Hickel is a senior environmental health consultant with the Alaska Native Tribal Health Consortium. She oversees environmental public health programs that address topics including healthy homes and air quality, water and sanitation, and brownfields and community environmental health. Undergraduate studies in international health, then earning a Master of Public Health degree through the University of California at Berkeley, equipped her efforts to partner with Alaska Natives and American Indians to address diverse water and sanitation public health issues through research, health education and promotion, and environmental health field work. Hickel's interest in water and sanitation work focuses on human health, including access to adequate and sustainable water and sanitation services, and how residents use the provided services. She works on multi-disciplinary teams to incorporate health education and behavior change methods in water and sanitation projects and advances efforts to maximize health benefits provided by available water and sanitation technology.

Sharon Hildebrand An educational plan is the standard in Western culture. However, this long-term planning is not a new concept to indigenous people. In growing up along the Yukon River, Sharon learned early on that family members and people in her community were also planners and coordinators. For example, her grandmother knew the importance of seasonal planning, preparing for camp, and caring for the fish in the summer. She also learned the importance of helping where needed and treating people with respect. These values prepared her for her current educational endeavors, which includes earning her graduate degree in public administration. She also contributes to her community by volunteering for various organizations and is part of an international research team in cooperation with Russia and Galena, Alaska. She lives in Fairbanks with her husband and two sons.



Eric Hoberg is a field biologist and biogeographer who explores the history of the biosphere in a continuum across evolutionary and ecological time. Born in San Francisco, he was educated at the University of Alaska in biology (1971-1975) where a passion for high latitudes first developed. His graduate studies followed at the University of Saskatchewan, Canada (1979), and the University of Washington (1984). He has also worked at Oregon State University, the Atlantic Veterinary College, University of Prince Edward Island, and since 1990 in his current positions as a senior research zoologist and chief curator of the U.S. National Parasite Collection with the Department of Agriculture and appointment as the curator of parasitic nematodes at the Smithsonian Institution's National Museum of Natural History. Field-based research over the past several decades has centered on the high northern latitudes spanning Siberia, Alaska, and the Central Canadian Arctic. Episodic climate change and ecological perturbation over the past 3 million years are examined as drivers of faunal assembly, structure and patterns of diversity. Integrated studies, field collections, museum archives and transboundary approaches are the baselines for defining pathogen biodiversity. The nature of historical processes emphasizes the impact of ecological perturbations and the necessity to anticipate the outcomes of accelerating climate warming and globalization on emergence of pathogens and diseases which now pose direct consequences for ecosystem integrity, and animal and human health.

Pernille Erland Jensen has been affiliated with the Arctic Technology Centre (ARTEK) at the Department of Civil Engineering of the Technical University of Demark since 2006. She heads the center's research area on Arctic Environmental Engineering, and teaches undergraduate and graduate courses on Arctic environmental engineering topics in Greenland and Denmark. She has developed courses for ARTEK including field work courses in Greenland and e-learning courses and modules, which may be taken online. Pernille's research sets off in the field of environmental engineering, and her goal is to contribute to develop solutions for sustainable management residuals and prevent loss of resources from the technosphere of urban environments. In the Arctic context, her focus has been on developing technologies for safe domestic wastewater handling tailored for the small remote Arctic communities, and on safe and sustainable management of residuals from the dominant industries in Greenland: fish production and mining. She has been a member of the International Association for Cold Regions Development Studies since 2013, and she is also a member of the Thematic Network of Environmental Impact Assessment under the University of the Arctic. She has authored more than 40 scientific journal papers, supervised five Ph.D. students and participated in numerous national and international research and development projects.

Barbara Johnson is a graduate student in the Master of Science resource and applied economics program at the University of Alaska Fairbanks. Her current research centers on issues surrounding water resources in Arctic and Subarctic communities. She has also researched the costs and benefits of the development of water infrastructure for the United Nations University Institute for Water, Environment and Health.

Ken Johnson is a planner and engineer with more than 30 years of experience in planning and engineering in remote and cold regions. His experience and expertise includes community planning and water and sanitation infrastructure, including treatment, distribution, collection, and disposal, solid waste management, drainage management, and climate change adaptation. He has lived and worked in the Yukon, Northwest and Nunavut territories, and has completed work in more than 40 communities across the Northern Region.

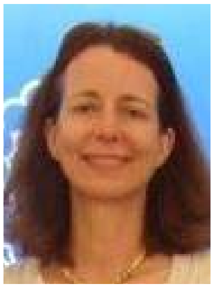
Tom Kasun is a senior business development manager at the Alcoa Technical Center (ATC) near Pittsburgh, PA. For the past three years, he has been a member of ATC's commercialization group, which helps companies match innovative, Alcoa-developed technology solutions with complex, recurring challenges. Two years ago, his role was expanded to include collaborating with third parties to grow the company's Natural Engineered Wastewater Treatment (NEWT) technology. Prior to this, Kasun led the rolling lubrication and surface technology group where he developed a passion for reducing Alcoa's environmental footprint through enabling water and oil reuse. He continues to be a thought leader in this area, and his experience in development, implementation and management of metalworking fluids has helped save Alcoa tens of millions of dollars each year through increased productivity, lower scrap and reduced lubricants usage. Kasun has been an integral member of the Alcoa lubricants commercial team since 1991. He holds five patents and recently served as chairman of the Alcoa Global Rolled Product patent committee managing the full life cycle of intellectual property from invention through licensing of patents and trade secrets. He has worked at ATC for 32 years. Prior to this, he worked in the metallization department at IBM in Endicott, NY, where he developed a "dry process" for etching metals to eliminate "wet chemicals" and process step elimination. He received his bachelor (1981) and masters (1983) degrees in chemical engineering from Pennsylvania State University.

Carolyn Kozak is a graduate student in Arctic and Northern Studies at the University of Alaska Fairbanks (UAF). Prior to moving to Fairbanks, she worked as a curator and public programmer for the Anchorage Museum at Rasmuson Center for more than six years. This practical application of history with the museum, through exhibition development and public engagement, sparked an intellectual curiosity for the circumpolar north and a sense of personal responsibility to its people, both past and present. Since joining the UAF campus, Kozak has been selected as a student ambassador to the University of the Arctic (UArctic), a cooperative network of universities, colleges, research institutes and other organizations concerned with education in the North. She participated in the first fully international Model Arctic Council in March 2016 and attended the UArctic Congress in St. Petersburg, Russia, as part of her student ambassadorship. Kozak's research interests include national identities, image literacy, and media messaging of climate change.

Michele LeBlanc-Harvard has bachelor degrees in psychology and environmental health, applying her skill set in the fields of public and environmental health in Canada and the United States, She was an instructor in the environmental health program at Cape Breton University in Nova Scotia, Canada, where she enjoyed facilitating a love of environmental health in her students. LeBlanc-Harvard moved to the Arctic during a leave of absence from her position as an environmental health officer for Health Canada where she was part of the traveling public program. As an environmental health specialist for the chief medical officer of health for the Territory of Nunavut, she is responsible for developing Nunavut's environmental health program, which includes developing new drinking water regulations. This is an important time in Nunavut's population health development and she feels honored to contribute to these efforts. LeBlanc-Harvard has lived in the Arctic for seven years and now calls Iqaluit Nunavut home. She lives there with her three children and husband who works as an extreme guide. As a family, they enjoy dog sledding, snow sailing, ice fishing, skiing and camping.

Jen Marlow co-owns Re-Locate, joint developers of the Kivalina biochar reactor. She is also co-executive director of Three Degrees Warmer, a climate justice nonprofit; co-director of Re-Locate, a transdisciplinary global collective working in Kivalina, Alaska, to support village efforts to relocate; and an affiliate professor at the University of Washington School of Law. As a lawyer, Marlow has worked on landmark state and federal climate change lawsuits, advising clients and courts of the applicability of international human rights laws to climate change-related claims.

John H. Matthews is the Secretariat Coordinator and co-founder of the Alliance for Global Water Adaptation, which is hosted by the World Bank and the Stockholm International Water Institute (SIWI). His work blends technical and policy knowledge for climate adaptation and water management for practical implementation. He has worked on five continents and in more than 20 countries. He has written primarily on decision-making frameworks for adapting water infrastructure and ecosystems to climate impacts. He co-founded the #ClimateIsWater advocacy group, led by the World Water Council. Recent projects have included leading teams to develop green and climate bond resilience criteria for water investments, co-authoring a guidance and leading a global community of practice focused on mainstreaming climate adaptation into public water management institutions, developing climate-sensitive approaches to environmental allocations such as eflows, working with global policy instruments and institutions to embed water-climate knowledge into climate mitigation and adaptation initiatives, coordinating efforts to use finance mechanisms to implement nature-based solutions to climate adaptation, assembling curricula to build capacity around sustainable resource management, and exploring new economic tools to support integrated long-term planning. He is a columnist with OoskaNews, a senior water fellow at Colorado State University, and a courtesy faculty member of the Water Resources Graduate Program at Oregon State University. Previously, John started and directed global freshwater climate adaptation programs for WWF and Conservation International. He has Ph.D. in ecology from the University of Texas, where he studied long-distance migration of dragonflies.



Ann Meceda is a Foreign Service Officer with the U.S. Department of State. She currently serves as an Arctic Affairs Officer for the Bureau of Oceans and International Environmental and Scientific Affairs, where she works as the U.S. Head of Delegation to the Sustainable Development Working Group of the Arctic Council. During the fall of 2016 she was the acting chair of this group, supporting the U.S. Senior Arctic Official and other key stakeholders on Arctic policy issues. Recently, Meceda served as the political and labor officer in Casablanca, Morocco, working extensively on interagency programs addressing labor and social issues. She has also served in Germany, Slovakia, and Tunisia. She has an undergraduate degree from the University of California, Los Angeles, in mass communications and business, and earned a Master's degree in Business Administration from the Haas School of Business at University of California, Berkeley.

Andrew Medeiros is an expert in freshwater ecology, biogeochemical processes, and Arctic environments. His research focuses on understanding the ecological trajectory of northern ecosystems in the past, present, and future. Research on the evolution of northern aquatic ecosystems over thousands of years enables him to make predictions and create models of future responses to environmental change. Medeiros is motivated by seeing science in action and has worked to build relationships and establish trust with First Nation and Inuit communities, each at the forefront of environmental change in the North. This allows him to combine quantitative modeling to examine issues of fresh water quantity and quality as it applies to northern communities. The data allows researchers to conduct risk analysis for municipal water supplies, and research areas of concern for local residents. His findings resulted in a fundamental shift in the way this knowledge is applied to water security challenges faced by northern communities. These research methods can be applied to freshwater resource assessments, fisheries management, and biomonitoring. Medeiros has received numerous awards, internships and grants throughout his career including the W. Garfield Weston Postdoctoral Fellowship in Northern Research in 2012 and 2013. He has contributed his Arctic expertise to 15 peer-reviewed scientific publications, and for regional and international television segments. He was also a scientific advisor and contributing author for The Economics of Ecosystems and Biodiversity, an initiative of the Arctic Council administered by the Conservation of Arctic Flora and Fauna. Medeiros is currently an adjunct professor in the Department of Geography at York University in Canada.

John Nichols has 19 years of experience with water and sewer design, construction and operations. He currently serves as manager of utility operations for the Alaska Native Tribal Health Consortium (ANTHC). He leads a department of 35 direct and 100 contract employees, providing engineering services and technical assistance to 150 rural Alaska community water and sewer systems. Technical assistance includes water plant operator training, energy efficiency training and retrofits, troubleshooting and operational engineering assistance, and emergency response. The department also provides full water and sewer management services to 27 rural Alaska communities through the Alaska Rural Utility Collaborative (ARUC), which provides customer billing and collections, water operator guidance, purchasing of supplies, rate setting and data collection for each member of the community, resulting in some of the most complete village water and sewer operational data in Alaska, especially in the areas of energy use and energy efficiency results. ARUC's purpose is to empower communities in rural Alaska to sustainably provide safe water and sanitation services. Nichols is a licensed engineer who started his career as public works director in Dillingham, Alaska. He then joined ANTHC in Anchorage, Alaska, designing and building water and sewer system in Western Alaska villages. He has also worked as a field engineer at the Indian Health Service Fort Hall Field Office in Idaho, designing and building water and sewer mains on the Fort Hall Reservation, before returning to ANTHC in 2007.

Jim Nordlund was appointed by President Obama to the position of Alaska State Director for the U.S. Department of Agriculture, Rural Development (USDA-RD), in August 2009. Since then, USDA-RD has invested nearly $2 billion in Alaska's rural communities in electric, telecommunications, and sanitation projects; community facilities; and housing, energy and business development. He has lived in Alaska for 33 years and was previously the owner of Nordlund Carpentry, a residential building contractor in Anchorage. His work in Alaska includes seven years as the director of public assistance, where he managed 500 employees and a $250 million budget, serving in the Alaska State House of Representatives, and being a commercial fisherman. Nordlund has a bachelor's degree from St. John's University in Minnesota and a Master of Public Administration from the University of Colorado. He lives in Anchorage with his wife and daughter.

Melanie O'Gorman is an associate professor in the University of Winnipeg Department of Economics. Her research and teaching are in the areas of macroeconomics and economic development. She is currently leading a research project which explores the determinants of high school graduation and achievement in the Canadian Arctic, and another on the financing of water infrastructure in Manitoba First Nations. She continues to conduct research related to hydroelectric development with the Wa Ni Ska Tan Hydro Alliance. O'Gorman also chairs the master of arts program in environmental, resource and development economics at the University of Winnipeg, which trains students in the area of sustainable development.

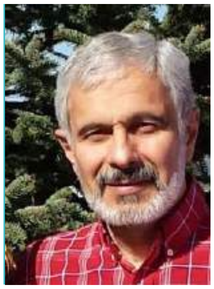
Stephen Penner Stephen Penner is an experienced senior leader with tactical and strategic experience in building resilient communities. He is pursuing a master's degree in development practice in indigenous development at the University of Winnipeg while maintaining ties to his 25 years of businesses development. His focus has been around building bridges between social business and the needs of healthy communities. This includes examining how access to healthy water infrastructure supports northern communities. He is also working with Professor Melanie O'Gorman researching existing positive community models that maintain healthy water infrastructures and discovering how they accomplish this feat. His recent summer placement was with the Cree Nation Government and it was built around two projects involving community consultations, with the main project involving the building of a framework for a trade and commerce agreement. The second project was to gather opinions on the idea of the "Cree Story," which would authenticate and certify Cree arts and crafts. Stephen and his facilitation team conducted consultations with more than 18 Cree entities and economic development corporations, seven chiefs and councils, and meeting with entrepreneurial groups totaling 500 people across Eeyou Istchee Territory. After the WIHAH Conference, Stephen will present a paper entitled "Gathering Circles for Indigenous Ecopreneurship Among First Nations Communities of Southern Quebec" at the International Summit of Co-World Cooperatives in Quebec City. The cooperative model is explored in the context of marketing traditional foods within a confederation of first nations. He is also employed at the University of Winnipeg, serving as the marketing liaison for athletics where he launched the Wesmen's Indigenous Days. He also works as a volunteer with inner city high school students.

Robert Quick is a medical epidemiologist in the Waterborne Diseases Prevention Branch at the Centers for Disease Control and Prevention. He received his medical training at the University of California, San Francisco, obtained an MPH from the University of California, Berkeley, completed residencies in family practice and preventive medicine, and worked as medical director and clinician at the Indian Health Service hospital in Bethel, Alaska. For the past 25 years, he has worked at CDC, conducting research on the etiology, control, and prevention of enteric diseases in the developing world. His work on cholera in Latin America and Africa revealed the seriousness and extent of the problem of lack of access to safe water and sanitation in the developing world and inspired a research focus on waterborne diseases and their prevention. With colleagues at CDC and the Pan American Health Organization, he developed the Safe Water System, a simple, inexpensive household based water quality intervention, and has conducted field trials in Latin America, Africa, and Asia to establish the evidence base regarding its use and dissemination (www.cdc.gov/safewater). More recently, he has conducted field trials of other water treatment technologies, and has designed, implemented, and evaluated projects that integrate water treatment technologies, handwashing, and other public health interventions (including micronutrient Sprinkles, improved cook stoves, HIV counseling and testing, rapid syphilis screening, and nurse training) with maternal and child health services, school programs, and HIV care and support services. To carry out this work in the developing world, he has collaborated with numerous partners from the public and private sectors, Rotary Club, NGOs, UN agencies, and academic institutions.

AJ Salkoski is senior program manager for the Alaska Native Tribal Health Consortium (ANTHC) Tribal Air Quality & Healthy Homes Programs and has eight years of environmental health experience in Alaska. He works on several government-funded studies and projects to find the relationship between indoor air quality and the need for respiratory medical care among high risk Alaska Native children, and to work on air quality issues in Alaska Native communities. He also has experience with projects focused on solid waste management, community planning, and energy efficiency in rural Alaska communities.

James Temte is a member of the Northern Cheyenne Tribe and grew up in the Rocky Mountains of Wyoming and Colorado. He joined the National Tribal Water Center (NTWC) in 2014 and now serves as its director. Temte earned his undergraduate degree in molecular biology and chemistry from Fort Lewis College in Colorado, and a Master of Science at the University of Alaska Anchorage in applied environmental science and technology. He was the Alaska Tribal Conference on Environmental Management Director, National Tribal Air Association Vice Chair, and served on the Climate Registry Board of Directors. He has a passion for public art, tribal sovereignty, self-determination, protecting the environment, and human health. His interest in water and sanitation work focuses on human health, including affordable access to adequate and sustainable water and sanitation services. He loves to work with communities on multidisciplinary teams to incorporate innovative health education techniques to inspire positive actions.

Tim Thomas, M.D., works as Clinical and Research Services Department Director in the Native Tribal Health Consortium (ANTHC) Division of Community Health Services. He has expertise as a medical epidemiologist with considerable clinical and research experience in Kenya and Alaska, addressing issues of health disparity among impoverished and minority populations. His clinical experience has involved work in Somalia for the "Doctors Without Borders" program in Kenya at a mission hospital, and at the Yukon Kuskokwim Health Corporation in Bethel, Alaska. He completed the Centers for Disease Control and Prevention (CDC) Epidemic Intelligence Service training in 1999 and has subsequently been primarily engaged in research. He worked in Kenya for seven years as head of an HIV research department at the Kenya Medical Research Institute (KEMRI) CDC Field station. As principal investigator of this CDC-sponsored phase 2B clinical trial, he investigated the use of antiretrovirals during late pregnancy and breastfeeding. Dr. Thomas returned to Alaska in 2008 to work with the CDC Arctic Investigations Program, primarily on water and sanitation and oral health issues. In October 2011, he joined ANTHC as director of its clinical and research services department where he has continued his work on oral health and sanitation, along with other research activities.



Bob Tsigonis earned a Bachelor of Science in engineering from Thayer School of Engineering at Dartmouth College in New Hampshire and a master's degree from the University of Alaska Fairbanks. He is a registered engineer who has practiced environmental engineering in Alaska since 1973. Tsigonis founded Lifewater Engineering Company, which manufactures innovative on-site sewage treatment systems for extremely cold climates and poor soils. He holds U.S. and Canadian patents on these sewage treatment systems and a U.S. patent on a fluid distribution box that distributes fluid equally from all ports, regardless of the orientation of the box. Lifewater also manufactures extremely rough duty boats for the shallow rivers of Alaska. He helps teach a cold region engineering short course for the University of Washington in Seattle and enjoys volunteering with organizations that provide water and sanitation services to people in underdeveloped areas around the world.

Peter Workman became the chief environmental health officer in the Northwest Territories in 2015. Prior to that, for 10 years he worked as a health emergency planner, environmental health consultant, and environmental health officer in Nunavut. He has experience working in rural, urban and remote regions in Canada with public health as his focus, in the areas of drinking water, sanitation, communicable disease investigation and food safety. Workman is a member of the Canadian Drinking Water Committee, which is the federal provincial and territorial group that authors Canadian Drinking Water Quality Guidelines, a national set of standards used to govern drinking water across Canada.

Carlee Wright completed her baccalaureate degree at the University of Guelph in Ontario, Canada, in 2014, majoring in biological science. She is a thesis-based master of science student in epidemiology at the Ontario Veterinary College, working with Dr. Sherilee Harper. Her research focuses on drinking water and acute gastrointestinal illness (AGI) in northern Canada, in the Inuit community of Rigolet, Nunatsiavut. Her project makes use of an EcoHealth research framework to assess the contamination of stored drinking water and its possible associations with self-reported AGI, and aims to understand drinking water consumption patterns in Rigolet and how they have changed, resulting from new drinking water infrastructure in the Canadian Inuit community. The goal of this work is to help inform sustainable drinking water interventions to reduce risk of waterborne infections, and to inform risk assessments and public health messaging in Nunatsiavut and other Northern indigenous communities.


Greenland and Norway participants Kristian Hammeken, Kåre Hendriksen and Pernille Jensen


Water and Sanitation in the Arctic
Healthy Alaskans 2020 estimates that in 2010, 78% of rural Alaskan homes had water and sewer service
Among all Alaskan homes, 95.6% have complete plumbing
Among all U.S. homes, 99.6% have complete plumbing
Access to water and sewer is still inadequate, and SDG #6 for access to water and sewer service for all has not been achieved in the Arctic region.
Higher water service has been associated with lower rates of water-washed disease in the Arctic, such as skin and respiratory tract infections

ABSTRACTS

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Country Comparisons

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Overview of Household Pilot Systems in Development

State of Alaska Department of Environmental Conservation: The Alaska Water & Sewer Challenge Project Teams:

TITLE

Accelerating Climate Change and a Warming World: Consequences for Sustainability and Safety of Arctic Water and Food Resources

PRESENTER

Eric P. Hoberg
Agricultural Research Service, USDA, Animal Parasitic Diseases Laboratory, BARC East 1180, 10300 Baltimore Avenue, Beltsville, MD 20705
Eric.Hoberg@ars.usda.gov

CONCLUSIONS

Dramatic environmental and ecological perturbations have swept across Arctic latitudes as global warming has accelerated over the past 50 years. Climate change is now strongly modifying physical environments with direct and indirect impacts that cascade through terrestrial, aquatic and marine systems. Northern latitudes historically have been dominated by events of extreme climate variation, such as those characterizing earth history and cycles of glaciation over the past 3 million years. These episodic events resulted in the world around us and the diversity of plants and animals that have come to symbolize the far north and which remain the cultural focus of traditional subsistence lifestyles across the circumpolar region. Climate determines activity and distribution, timing of migrations, and the seasonally circumscribed windows that define life histories for a diverse interconnected assemblage of fishes, birds, mammals and invertebrates. The northern world is now in rapid transition that is historically unprecedented. Perturbations to this natural world, particularly new patterns of temperature, precipitation and humidity, sea-level rise and marine incursions, directly influence ecosystem structure and the occurrence of pathogens. Disruption of long established biotic connections and development of new pathways for pathogen transmission serve as the potential for emerging diseases in animals and humans related to surface water resources and subsistence food chains. Interacting with overall habitat change and other biotic and abiotic factors, the potential for disease can have an influence on the availability and consistent access to potable drinking water and sustainable, safe and secure food resources on which northern communities are dependent. Accelerating environmental change associated with increasing rates of anthropogenic perturbation is exerting a pervasive impact on the Arctic Region. Recognition of the biotic impacts of climate warming can contribute to active anticipation, adaptation and mitigation of the emerging effects of environmental disruption and changing pathogen distribution for northern communities.

TITLE

Pathogen Risk Management Considerations for Safe Household Water Uses

PRESENTER

Nicholas J. Ashbolt, School of Public Health, University of Alberta, Edmonton AB, Canada (Ashbolt@ualberta.ca)

CONCLUSIONS

In general, about 80 percent of all infectious diseases are environmentally transmitted, with viral illnesses dominating. In developed regions, like the United States, the annual rate of water-associated diarrhea runs at about 0.7 cases per 100,000, and results in about 5,000 deaths by year from enteric (waterborne) pathogens. However, water-based, environmental pathogens (e.g. Legionella pneumophila, non-tuberculous mycobacteria and Pseudomonas aeruginosa) cause some 7,000-20,000 deaths by year in the United States, mostly from respiratory and wound infections. For remote Arctic communities with very limited access to clean liquid water and sanitation systems, there are additional infectious disease issues including from a lack of wash-water, which is compounded by social and cultural conditions[1]. For example, sharing clothes washing machines in confined washeterias is known to increase respiratory disease, but inadequate clothes and body washing increases skin infections. However, simply installing traditional centralized water and wastewater services is neither economically sustainable nor practical for remote communities often lacking trained personnel and who are unable to maintain such infrastructure[2]. Though widely recognized that water services need to integrate social, cultural and economic factors so as to provide effective solutions, various groups working with remote aboriginal Arctic communities have largely not succeeded in achieving that goal. Furthermore, there are often large voids between groups working on community health and those deciding on water and sanitation service innovation. Of the myriad of factors to consider, a key engineering question is, "What is the per capita drinking versus household water requirement for good health, and how can water services be managed effectively?" Current targets may range from 100-L per person per day (pppd) to the World Health Organization (WHO) suggesting a minimum of 50-L pppd. In considering what constitutes safe drinking and washing water quality, we need to move beyond outdated reliance on E. coli criteria (say < 1 per 100 mL of drinking water, and <200 if not <10,000 per 100 mL of treated wastewater), which are not based on site-specific risk assessment approaches (e.g. to achieve WHO tolerable annual health burden of < 1 disability adjusted life year [DALY] per million people), and are likely to result in systems meeting criteria but delivering unacceptable levels of pathogens to consumers[3]. Furthermore, when considering pathogens that are largely person-to-person spread but potentially also via water systems, such as Helicobacter pylori, overall health benefits versus the need to treat are not simple decisions[4]. This presentation will provide a systematic approach to design potable and non-potable household waters to meet disease burden benchmarks within a community, as a guide to those seeking input to improve the knowledge base, management, and health targets for remote Arctic communities.

[1] Thomas, T. K.; Ritter, T.; Bruden, D.; Bruce, M.; Byrd, K.; R. Goldberger; Dobson, J.; Hickel, K.; Smith, J.; Hennessy, T. (2016). Impact of providing in-home water service on the rates of infectious diseases: results from four communities in Western Alaska. J Wat Health 14:132-141.
[2] Daley, K.; Castleden, H.; Jamieson, R.; Furgal, C.; Ell, L. (2015). Water systems, sanitation, and public health risks in remote communities: Inuit resident perspectives from the Canadian Arctic. Soc Sci Med 135: 124-32.
[3] Ashbolt, N.J. (2015). Microbial contamination of drinking water and human health from community water systems. Cur Environ Health Rep 2: 95-106.
[4] McMahon, B. J.; Bruce, M. G.; Koch, A.; Goodman, K. J.; Tsukanov, V.; Mulvad, G.; Borresen, M. L.; Sacco, F.; Barrett, D.; Westby, S.; Parkinson, A. J. (2016). The diagnosis and treatment of Helicobacter pylori infection in Arctic regions with a high prevalence of infection: Expert Commentary. Epi Inf 144:225-233.

Key words: Rainwater, drinking water, blackwater, greywater, quantitative microbial risk assessment, water and sanitation safety plans

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TITLE

Reuse Regulations and Challenge of Regulating On-site Systems

PRESENTER

Guy Carpenter

CONCLUSIONS

Abstract not available. For more information contact Guy Carpenter at gcarpenter@aqua-tecture.net or (424) 832-7017.

TITLE

The Impact of Water and Sanitation Services on Health

PRESENTER

Dr. Thomas Hennessy

CONCLUSIONS

Important health disparities have been documented among northern populations with limited access to in-home improved drinking water and sanitation services. The Arctic Council recognized this in 2016 by endorsing the initiative entitled "Improving Health through Safe and Affordable Access to Household Running Water and Sewer in Arctic and Sub-Arctic Communities." This presentation will review the evidence linking water to health, with a focus on water-borne and water-washed diseases. We will also explore the water-health relationship and the implications for how we design and operate water systems, how we evaluate the benefits of water service and how we work with communities and homeowners to maximize the benefits of water services.

TITLE

Water Security in the Arctic: Perspectives from the Model Arctic Council

PRESENTERS

Carolyn Kozak, Graduate Student
Arctic and Northern Studies, University of Alaska Fairbanks

Sharon Hildebrand, Graduate Student
School of Business, University of Alaska Southeast

Stephen Penner, Graduate Student
Development Practice in Indigenous Development, University of Winnipeg

CONCLUSIONS

This presentation will discuss the perspectives of students who attended the first fully international Model Arctic Council (MAC) in March 2016. This was held in conjunction with the Arctic Science Summit Week (ASSW) at the University of Alaska Fairbanks. The ASSW brought researchers, traditional and local knowledge holders and policymakers together to advance research objectives in the Arctic. The MAC is an experiential learning exercise in which undergraduate and graduate students of institutions from around the world gather to represent and simulate the work of the Arctic Council member states, permanent participants, and observers. The perspective of three student representatives to the MAC will be shared as they considered the new Arctic Council initiative called "Improving Health through Safe and Affordable Access to Household Running Water and Sewer" (Arctic WASH). Their experiences participating in the simulation and the resulting recommendations to the Fairbanks declaration at the MAC conclusion will be shared. These actions focused on three themes: social justice, economic sustainability, and environmental protection. Strong local participation in water and sewer projects was deemed vital, with special emphasis given to the role of traditional local knowledge and traditional ecological knowledge holders in the planning and implementation process. International cooperation was also heavily stressed, encouraging complete participation in international water and sewer conferences, comprehensive reports on climate change vulnerabilities and adaptation strategies needed, and the need for established metrics and best practices for monitoring implementation.

THE IMPACT OF HOUSEHOLD WATER & SANITATION ON ARCTIC HUMAN HEALTH

TITLE

Community Perspectives on Water Insecurity and Climate-Related Vulnerabilities in a Remote Iñupiaq Community

PRESENTER

Laura Eichelberger, MPH, Ph.D., University of Texas at San Antonio

INTRODUCTION & METHODS

Less than five years ago, the sound of running water finally became a daily reality for most residents in the Village of Buckland, a small Iñupiaq community just south of the Arctic Circle in Northwest Alaska. Based on a total of over two years of ethnographic fieldwork during the years of 2008, 2009, and 2016, involving interviews, observations, and surveys, I examined what daily life was like for residents prior to the completion of the running water and sewer system, and how life has changed since its near completion this year.

RESULTS

In 2008 and 2009, a survey of 21 households revealed that residents consumed an average of less than three gallons per person, per day. The amount of water they had access to depended on a combination of physical ability, access to gasoline or a vehicle, and male kin. In 2016, Buckland residents overwhelmingly reported an improvement in public health, particularly among their children who they report are sick less often. They attribute these observed improvements in health on increased access to clean water, which has improved their ability to maintain clean living conditions. Many residents, however, fear that the rapid rate of erosion and the lack of erosion prevention near the new system represents a significant threat to their newly constructed infrastructure.

This study provides local perspectives on the importance of clean water access, and concerns about climate-related vulnerabilities. It also highlights how anthropological methods can be used to study the status of water and sewer service, health outcomes, and climate related vulnerabilities.

TITLE

Education and Behavior Change Efforts to Maximize the Health Benefits and Sustainability of Water and Sanitation Infrastructure

PRESENTERS

Korie Hickel: Presented by John Nichols and AJ Salkoski

INTRODUCTION

The Indian Health Service (IHS) has provided water and sanitation infrastructure in American Indian and Alaska Native (AI/AN) communities since 1958 with the goal to prevent water- and sanitation-related disease. However, challenges remain as some communities still lack piped service, residents don't always use available services, and utilities communities struggle to operate and maintain their water and sewer systems. This evidence suggests that an ecological approach made up of education, engineering, and support at all levels of the community is needed.

METHODS

The Alaska Native Tribal Health Consortium (ANTHC) has established several programs that target all levels of the community: individuals (residents, operators, managers); social and community networks (families, neighbors, opinion leaders); and social systems (councils, utilities, collaboratives).

RESULTS

ANTHC efforts to improve customer knowledge resulted in increased knowledge, increased payments of bills, decreased operations and maintenance O&M issues, and decreased utility debt. Health education and promotion efforts resulted in improvements in healthy behaviors and outcomes. Efforts to increase consumption of treated water showed a significant increase pre- to post-intervention (39-60 percent). Preliminary results from a healthy homes study also found improved health such as reduced hospitalizations and clinic visits following the intervention.

CONCLUSIONS

The health benefits of sanitation systems are greatly impacted by how they are used, operated, and managed long term. ANTHC supplements engineering and construction services with education and behavior change efforts to maximize the health benefits and sustainability of the provided infrastructure.

This presentation will give an overview of ANTHC's education, promotion, and behavior change efforts; lessons learned; and steps forward to further improve our services and work to achieve the vision that Alaska Native people are the healthiest people in the world.

TITLE

Impact of In-home Water Service on the Rates of Infectious Diseases: Results from Four Communities in Western Alaska

PRESENTERS

Thomas TK, Ritter T, Bruden D, Bruce M, Byrd K, Goldberg R, Dobson J, Hickel K, Smith J, Hennessy T

BACKGROUND

About 20 percent of rural Alaskan homes lack in-home piped water so residents must haul water to their homes. Recent studies in Alaska demonstrated associations between increased rates of skin and respiratory tract infections and lack of in-home piped water, presumably due to a reduced quantity of water available for handwashing, bathing and laundry, resulting in what are known as "water-washed" infections. We assessed rates of water-related infections in residents of communities transitioning to in-home piped water.

METHODS

Residents of four communities consented to a review of medical records for the period three years before and three years after their community received piped water. We selected clinic and hospital encounters with ICD-9CM codes for respiratory, skin and gastrointestinal (GI) infections, and calculated annual illness episodes for each infection category after adjusting for age and removing repeat encounters within 14 days of the initial report.

RESULTS

We enrolled 1,032 individuals (72 percent of the 2,010 total among a four-community population) and obtained 5,477 person-years of observation. There were 9,840 illness episodes with at least one ICD-9CM code of interest; 8,155 (83 percent) respiratory, 1,666 (17 percent) skin, 241 (two percent) GI. Water use increased from average 5.7 liters, per capita, per day (l/c/d) to 97.3 l/c/d. There were significant (p-value <0.05) declines in respiratory [16.4 percent, 95 percent confidence interval (CI): 11.5-21.0 percent], skin (20.4 percent, 95 percent CI: 10.0-29.7 percent), and GI infections (37.8 percent, 95 percent CI: 13.3-55.3 percent) in homes that received piped water, primarily among those aged 0-19 years.

DISCUSSION

Households that must haul water are severely limited in the amount of water available for personal hygiene. We demonstrated significant declines in respiratory, skin and GI infection rates among individuals in communities that transitioned from hauling water to in-home piped water. This study reinforces the importance of adequate quantities of water to address the morbidity caused by water-washed infections.

TITLE

Water Infrastructure and Well-being: What Does the Data Tell Us?

PRESENTERS

- Stephen Penner, Master of Development Practice (Indigenous Development) student, University of Winnipeg
- Melanie O'Gorman, Associate Professor, Department of Economics, University of Winnipeg

INTRODUCTION

In this presentation, we will discuss the findings of three statistical analyses relating data on water infrastructure and well-being in First Nations, Métis and Inuit communities in Canada. The question our study addresses is: Are poorer quality water/wastewater systems associated with poorer health outcomes in Canada, and if so, to what extent?

METHODS

Our first analysis explores the relationship between self-reported health among individuals off-reserve using two waves (2001 and 2006) of the Aboriginal Peoples Survey (APS). We then conduct a similar analysis using the First Nations Regional Health Survey (RHS). This wide-ranging dataset allows us to control for a larger number of factors influencing health relative to the APS, for example, the extent to which a community is remote, an individual's emotional well-being, and the quality of governance. The third analysis uses data collected jointly by our research group and St. Theresa Point First Nation. This data includes information from a survey among individuals, and thus allows us to better understand community members' concerns about the quality of their water and wastewater services, and how such inadequate services affect them.

RESULTS

We find large, negative impacts of unsafe drinking water, a lack of indoor plumbing and the use of cisterns on self-reported physical and mental health.

CONCLUSIONS

These three analyses demonstrate that inadequate access to water and wastewater services disadvantage residents in multiple ways, or rather, that having indoor plumbing, safe drinking water and proper sanitation facilities have wide-ranging and large benefits. This paper sheds light on the magnitude of health costs resulting from a lack of water access and poor water quality in First Nations, Métis and Inuit communities.

TITLE

Water Quality and Health in Northern Canada: Contamination of Stored Drinking Water and Associations with Acute Gastrointestinal Illness in an Inuit Community

PRESENTERS

C. Wright[1], J. Sargeant[1], V. Edge[1,4], J. Ford[2,4], K. Farahbakhsh[1], RICG[3], IHACC Research Team[4], and S. L. Harper[1,4]

[1] University of Guelph, Guelph, Ontario, Canada;
[2] McGill University, Montreal, Quebec, Canada;
[3] Rigolet Inuit Community Government, Rigolet, Nunatsiavut, Labrador, Canada;
[4] Indigenous Health Adaptation to Climate Change Research Team

INTRODUCTION

One of the highest self-reported incidence rates of acute gastrointestinal illness (AGI) in the global peer-reviewed literature occurs in Inuit communities in the Canadian Arctic. This may be, in part, due to the consumption of contaminated drinking water. For instance, in many communities, water is stored in containers, which may result in secondary water contamination. Using an EcoHealth research framework, the goal of this study was to characterize how households stored drinking water, identify potential risk factors for contamination, and examine possible water-related associations with AGI in Rigolet.

METHODS

A retrospective, cross-sectional census survey was conducted in June 2014, capturing data on water storage, potential demographic and behavioral risk factors, and self-reported AGI. Water samples were collected from storage containers and analyzed for presence of total coliforms.

RESULTS

Most households stored drinking water in containers despite the availability of tap water, and 25.2 percent (95 percent CI 17.7-34.7 percent) of stored samples tested positive for coliforms. Transfer devices were significantly associated with increased odds of coliform presence. The annual incidence rate of AGI was 2.43 cases per person, per year (95 percent CI 1.76–3.10); however, no water-related risk factors for AGI were identified.

CONCLUSIONS

Potential exposure to waterborne pathogens may be reduced through simple household-level interventions, such as regular cleaning of transfer devices.

CLIMATE CHANGE IMPACTS ON WATER & SANITATION INFRASTRUCTURE IN THE ARCTIC

TITLE

Vulnerability of Northern Water Supply Lakes to Changing Climate and Demand

PRESENTERS

M. Bakaic, A.S. Medeiros

METHODS

Arctic regions face a unique vulnerability to shifts in seasonality, which will influence the summer recharge potential of freshwater reservoirs from decreased precipitation and increased evaporative stress. This pressure puts many northern communities at risk due to limited existing freshwater supply. However, many small, remote northern communities in Canada lack baseline knowledge of their own existing supply, demand, or knowledge of reservoir recharge potential. We therefore address this knowledge gap through a water resource assessment of municipal supply over a 20-year planning horizon in two of the largest populated communities in Arctic Canada using existing data sources. Forecasts are made for several climate and demand scenarios. Generated models found significant and immediate vulnerability of the end-of-winter freshwater supply. This was pronounced for climate scenarios indicating reduced winter precipitation and/or increased ice thickness of reservoirs. Our heuristic supply forecasts indicate an immediate need for freshwater management strategies for northern communities in Canada.

The development of our novel Long Term Forecasting (LTF) protocol employed climate and growth scenarios which were intended for applications where historical in situ data was limited and in situations of limited local funding and capacity for conducting water resource assessments. While these limitations restrict in-depth fieldwork and detailed assessments, they do not preclude the immediate need for supply forecasting. The LTF protocol can provide heuristic supply forecasts able to be expanded in detail based on the severity of vulnerability presented.

This method can rapidly generate preliminary forecasts using accessible data with low fieldwork commitment for small communities that rely on unassessed water supplies. Thus, short-term risk can be identified to direct planning, adaptation, and infrastructure responses to changing climate and demand.

TITLE

Vulnerability of Freshwater Supply in Arctic Canada

PRESENTERS

Andrew S. Medeiros[1*], Michael Bakaic[2], and Jessica F. Peters[3]

[1] Department of Geography, York University, Toronto, ON, M3J 1P3, Canada
[2] Department of Environmental Studies, York University, Toronto, ON, M3J 1P3, Canada
[3] Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, ON, N2L 3C5, Canada

INTRODUCTION

Water is a fundamental component of the ecological integrity, economic development, and sustainability of northern regions, as well as being critical for the health and well-being of northerners. However, environmental change has altered fragile thermodynamic relationships of northern ecosystems by shifting seasonal transitions, altering precipitation regimes, reducing long-term snow cover, and increasing the high sun season. Snow melt is a crucial source of water for many shallow subarctic lakes, but snowfall is projected to decrease in some regions, with profound ecological consequences. Here, we assess the relative importance of hydrological processes on the sustainability of lakes and rivers as municipal water sources in Arctic Canada using water isotope tracers and hydrologic modeling.

METHODS

An isotope mass balance model was used to calculate input water isotope compositions and evaporation-to-inflow (E/I) ratios to distinguish the relative roles of snowmelt, rainfall, and evaporation on lake and river water balances. We then utilized Hydrological Modeling Software (HMS-HEC) to examine the influence of climate on municipal supply.

RESULTS

Results show that both lakes and rivers were strongly influenced by rainfall throughout the open-water season. Supply lakes were found to have little evaporative enrichment. We also note a systematic, positive offset measured between lake water $\delta^{18}O$ and $\delta^{18}O$ inferred from cellulose in recently deposited surface sediments from multiple northern regions. Forecasts of municipal water supply indicate a pronounced vulnerability to reduced winter precipitation and/or increased ice thickness of reservoirs on the municipal supply.

CONCLUSIONS

Our findings indicate a lower-than-average snowmelt runoff in recent years, which is forecast to significantly affect municipal supply. Notably, some lakes were observed to undergo near-complete desiccation following a winter of very low snowfall. These findings fuel concerns that a decrease in snowmelt runoff will lead to widespread desiccation of shallow lakes, including the primary municipal supply of many northern communities in Canada.

TITLE

Climate Change and Community Water Security: Emerging Challenges and Strategies

PRESENTER

Mike Brubaker, Director Community Environment and Health, Alaska Native Tribal Health Consortium

CONCLUSIONS

Climate change is having a wide range of impacts on community health, including on the water resources and infrastructure. From source waters to point of use, the tribal health system is awakening to new challenges and responding by developing adaptive strategies that are effective and appropriate.

In 2008, responding to the growing concerns about climate change, ANTHC's Board of Directors established the Center for Climate and Health, for the purpose of describing the connections between climate change, environmental impacts and health effects. Community listening sessions and assessments have been performed across Alaska, providing an in-depth analysis of local impacts and concerns. Water security has been an important focus and priority.

The condition of drinking source waters (lakes, reservoirs, rivers, and groundwater) have never been so dynamic, with communities facing unprecedented challenges with the water season, supply and quality. The infrastructure that delivers water to homes and businesses is also impacted, in some cases with widespread damage and service interruption. ANTHC has developed a variety of strategies to help communities address climate change impacts. The approach can be divided into three categories: 1) building capacity, 2) raising awareness, and 3) engineering for resilience.

In this presentation, selected findings from community assessments are described, including specific examples of environmental drivers (erosion permafrost thaw, snow season change, drought) and examples of strategies that are increasing water security by building capacity, raising awareness and by engineering for greater resilience.

TITLE

International Survey on Water and Sanitation in the Arctic

PRESENTERS

Jonathan M. Bressler, Thomas W. Hennessy

INTRODUCTION

The 2015 United Nations Goals for Sustainable Development include providing access to safe and affordable drinking water, and adequate sanitation and hygiene for all by 2030. In the Arctic, inadequate water and sanitation services are associated with poorer health status, and mostly affect rural and indigenous populations. For Arctic nations, providing and maintaining water and sanitation services presents unique challenges including emerging threats related to climate change. As an endorsed project of the Arctic Council's Sustainable Development Work Group, we seek to describe the current state of water and sanitation services, water-related disease monitoring, and the environmental changes affecting water and sanitation in northern circumpolar populations.

METHODS

We surveyed professionals in Arctic health, water, and sanitation; government officials responsible for health, environment or water sanitation; and interested residents in Arctic and sub-Arctic communities through an online survey.
The survey collected information on access to water and sanitation facilities, reportable water-related diseases, and the impact of climate change on water and sanitation.

RESULTS

The survey is ongoing. As of June 30, 2016, 130 responses from seven countries have been received. Detailed information was provided by four respondents from Canada, six from Finland, five from Greenland, one from Iceland, one from Norway, three from Sweden, and 32 from the United States. Reported access to water and sanitation varied from 75 to 100 percent of the population, though other sources indicate that this percentage is much lower in some communities. Reportable diseases and data sources vary by country, and respondents reported that climate change affects water and sanitation access in six arctic nations.

CONCLUSIONS

Initial survey responses indicate that inadequate access to water and sanitation exists throughout the Arctic, related health measures are commonly recorded, and climate change is affecting water and sanitation service in many communities.

INNOVATIVE ENGINEERING APPROACHES TO INCREASE ACCESS TO WATER OF ADEQUATE QUALITY & QUANTITY, INCLUDING WATER REUSE

TITLE

Charting a New Direction for Wastewater Treatment in Nunavut

PRESENTER

Ken Johnson

CONCLUSIONS

The so-called "leaky lagoon" was a generally accepted design concept for many years in the Nunavut Territory, formerly the Northwest Territories. However, because of the application of more stringent effluent quality standards and the requirement of a controlled effluent discharge, this design concept is now unacceptable. The current design concept applied for lagoon systems in the Far North is a retention lagoon with a seasonal discharge. In addition, use of wetlands has emerged as a supplementary process for lagoon systems.

The construction of retention lagoons applies modern geomembranes in many cases because of the absence of fine soil materials for the construction of structures with low permeability. New issues are emerging with the construction of these relatively complex earth structures because of the extreme cold climate, permafrost earth regime, and construction techniques.

The anticipated costs of remedial work to address these issues are about half of the capital costs of the original multimillion dollar structures, which are beyond the available capital funding. A much-needed new direction is being charted based on research to develop northern science for wastewater treatment. This science is being communicated to regulators and communities, to incorporate social science, and engineering and applied science. With this activity, it is anticipated that a new, more appropriate direction for wastewater treatment may emerge for Nunavut.

TITLE

Natural Engineering Wastewater Treatment (NEWT™) for Alaska Villages

PRESENTER

Thomas Kasun

INTRODUCTION

NEWT™ is an innovative wastewater treatment system that cleans wastewater while meeting stringent permitting requirements, even in the most challenging environmental conditions. It also provides high quality water treatment at a lower total cost. By engineering and enhancing the familiar biological, chemical, and physical processes from conventional wastewater treatment, NEWT™ provides a wetland-based technology that serves as a cleaner and greener solution.

METHODS

The NEWT™ system's three steps include: (1) anaerobic treatment tanks which break down and separate organic material in the water; (2) passive engineered wetlands that use vegetation and oxygenation for further treatment of organics and removal of nitrogen and metals; and, (3) a UV system to disinfect the water. The combination of these stages enables a dramatic reduction in sludge disposal over the system lifetime. The result is water treated to the same or better quality as that of a conventional system.

RESULTS

Alcoa has used the NEWT™ system in two different climates: one at the Alcoa Technical Center near Pittsburgh, PA, and the second in Saudi Arabia. Both systems have delivered superior water quality across six and two years of operations, respectively. In Pittsburgh, the NEWT™ system cleans the water sufficiently enough to meet a discharge permit, while in Saudi Arabia 90 percent of the water is reused as industrial process water and 10 percent is used for irrigation, which must meet Royal Commission Standards. The treated water from these processes is water quality, sufficient to consider reuse.

Both processes have been through some notable extremes while in operation. For example, in 2015, the Pittsburgh NEWT™ system was subjected to ambient temperatures of -30 F in the first quarter of 2015 and 13 inches of rain in June 2015. The effluent quality of the water stayed within the permit levels in both of these extreme conditions. With a similar design, the system in Saudi Arabia has produced superior water quality, where temperatures can reach 110 F.

CONCLUSIONS

Extra benefits of the NEWT™ system include a significant reduction in operating and maintenance costs because of its simplicity, and there are virtually no mechanical operations that need monitoring. The capability for water reuse increases access to scarce water resources. All of this makes NEWT™ an ideal solution for remote areas of the world, including the Arctic.

TITLE

Design, Construction, Operation, and Demonstration of a Municipal Net-Zero Water System for Nearly Closed-Loop Reuse of Water and Energy

PRESENTERS

James D. Englehardt, Ph.D., P.E.
Tingting Wu, Ph.D.
Lucien Gassie
Tianjiao Guo, Ph.D.

INTRODUCTION

Net-zero water (NZW), or nearly closed-loop direct potable water reuse systems, can recycle both water and thermal wastewater energy. However, design and operating experience are limited. The objective of this paper is to present results of a project to develop an advanced oxidation-based NZW system.

METHODS

A mineralizing urban NZW system was designed for energy-positive, 100 percent recycling of comingled black and grey water to drinking water standards, and mineralization of emerging organics, constructed and operated for two years to serve a four-bedroom, four-bath university residence hall apartment. The system comprises a septic tank, denitrifying membrane bioreactor (MBR), aerated aluminum electrocoagulation/flocculation, vacuum ultrafilter, and peroxone or UV/H_2O_2 advanced oxidation, with 14 percent rainwater make-up and concomitant discharge of 14 percent of treated water (ultimately for reuse in irrigation).

RESULTS

The process produced a mineral water meeting 115 of 115 Florida drinking water standards with total dissolved solids of ~ 500 mg/L, pH 7.8, turbidity 0.12 NTU, and NO_3-N concentration 3.0 mg/L. Chemical oxygen demand was reduced to below the detection limit (<0.7 mg/L). None of 97 hormones, personal care products, and pharmaceuticals analyzed were detected in the product water. Neither virus nor protozoa were detected in the treated water. All but six of 1,006 emerging organic constituents analyzed were either undetected or removed >90 percent in treatment.

CONCLUSIONS

An urban net-zero water system has been demonstrated capable of recycling 85 percent of municipal water. No concentrate is produced, and sludge pumping was projected on a 12- to 24-month cycle. A distributed, peroxone-based NZW system is projected to save more energy than is consumed in treatment, due largely to retention of wastewater thermal energy. Costs in urban and suburban areas are projected to be competitive with current water and wastewater service costs at scales above ca. one plant per 100 - 10,000 residences.

TITLE

Preliminary Test Results from an Electrically-Assisted, Anaerobic Sewage Treatment System

PRESENTERS

Bob Tsigonis, Primary Author and Presenter
Yehuda Kleiner and Boris Tartakovsky, Co-authors

INTRODUCTION

The correlation between health and affordable access to running water and sewer services in Alaska has been well documented, and a similar correlation exists for communities in northern Canada. Engineers, public health officials, and social scientists are working on both sides of the border looking for solutions.

METHODS

National Research Council Canada (NRCC) has been developing and testing an innovative, anaerobic sewage treatment technology that they think could be well-suited for northern homes and communities. This technology uses low voltage electricity to enhance microbial performance, and if a simple method can be found to harness the energy from low volumes of methane, it may be net energy positive.

When NRCC contacted Lifewater Engineering Company (Lifewater) in the latter part of 2015, both organizations immediately recognized the synergy of working together to advance this technology from the lab to the field, so a collaborative working agreement was established whereby each organization could provide expertise, equipment, and manpower to jointly accomplish in a short time what would otherwise take many years.

RESULTS

A pilot test system was designed jointly by NRCC and Lifewater, was fabricated by

Lifewater, and is being tested by Lifewater in their shop in Fairbanks, with input and oversight from NRCC in Ottawa. A summary of preliminary pilot test results will be presented.

CONCLUSIONS

The potential for use of this sewage treatment technology in northern homes and communities will be discussed. Possible deployment scenarios in Alaska, Canada, and around the world may also be presented.

TITLE

The Kivalina Biochar Reactor: The Arctic's First Human Waste Bioreactor

PRESENTERS

Re-Locate LLC (either Michael Gerace or Jennifer Marlow) and Jeff Hallowell, President, Biomass Controls, LLC, Co-authors

INTRODUCTION

Working with Kivalina City and Tribal Councils and families, Re-Locate is partnering with Biomass Controls, LLC, to design and build a winterized human waste biochar reactor to improve sanitation with relocatable technologies in Kivalina, Alaska. The Kivalina Biochar Reactor is built to run successfully in Kivalina's Arctic environment, and to coexist within existing social and economic roles and responsibilities for managing waste.

METHODS

Re-Locate conducted ethnographic research into current waste management practices in Kivalina. We mapped waste collection, circulation, and disposal with honeybucket collectors in Kivalina; and installed a waterless toilet as a dewatering front-end strategy for making biochar reactor technology more compatible with freezing Arctic temperatures on the whole. Biomass Controls built a prototype reactor, validated cold-weather operability, and is keeping daily records of data on: moisture content of feedstock that mimics expected Kivalina waste volumes and inputs, heat exchange in the unit's catalytic converter, stack temperatures, emissions, and quality and contents of output biochar.

RESULTS

We tested the prototype reactor by processing solid waste, wipes, plastic bags, toilet paper, and cardboard—waste streams that mimic the kinds of inputs we expect the Kivalina reactor will handle. A solid waste mix tested at around 55 percent moisture pyrolyzed waste at 1,300 degrees F and produced verifiable biochar.

CONCLUSIONS

Human waste biochar reactors are a relocatable sanitation solution for Kivalina and other villages without adequate water and sanitation. The applicability of biochar reactor technology to as an Arctic sanitation solution compels further testing and innovation of alternative waterless/dewatering toilet technology to replace the honey bucket system, and other relocatable alternatives to centralized piped infrastructure.

TITLE

Potentials and Challenges of Biogas from Fish Industry Waste in the Arctic

AUTHORS

Pernille Erland Jensen*, Arctic Technology Centre, Department of Civil Engineering, Technical University of Denmark. DK-2800 Lyngby, Denmark
Stefan Heiske, Department of Chemical Engineering, Technical University of Denmark. DK-2800 Lyngby, Denmark

INTRODUCTION

The fish industry is a main industry in many Arctic locations. In most places with local fish and seafood processing facilities, by-products are disposed of at sea. Oxygen depletion and dead sea bottom is observed, and by the anaerobic conditions developed at the seabed, the organic material is biodegraded and methane produced, contributing to the global warming. The objective of this study was to determine the biogas potential of fish industry by-products from Greenland. The biogas potential arises from the same organic fraction causing the methane production at the seabed, and takes advantage of the same microbiological processes, however under controlled conditions and with collection of the biogas for energy utilization.

METHODS

Methane potential of Greenlandic shrimp, crab, and halibut by-products, as well as co-digestion of shrimp by-products with waste water sludge and common brown algae, was tested in lab scale batch experiments at mesophilic conditions. Fate of indicator microorganisms was investigated.

RESULTS

All residues had biogas potentials similar to, or higher than, conventional feedstocks like manure and silage. Waste water sludge and brown algae had potentials comparable to manure. The combined shrimp and algae digestion showed indication of synergistic effects. Indicator bacteria were reduced significantly while coliphages (virus indicators) were not.

CONCLUSIONS

Fish and seafood by-products from the fish processing industry constitute a significant resource for energy and may provide an economic incentive to install digesters, which can also partly stabilize waste water sludge, though additional heat treatment may be necessary depending on final use of digestate.

REGULATIONS AND POLICIES AFFECTING ACCESS TO, AND THE COST OF, PROVIDING ADEQUATE QUANTITIES OF WATER IN THE HOME

TITLE

EPA Regulations, Policies, and Guidelines for Water Reuse: Implications for Decentralized Greywater Reuse

PRESENTER

Robert K. Bastian, Senior Environmental Scientist
Office of Wastewater Management
U.S. Environmental Protection Agency
Washington, D.C. 20460

INTRODUCTION

How do current EPA regulations, policies and recommendations from the agency address decentralized greywater reuse? Do other standards and sources of guidance address decentralized greywater reuse?

METHODS

Provide background information on the EPA 2012 *Guidelines for Water Reuse* document and its coverage of decentralized greywater reuse, as well as other sources of standards and guidance, such as applicable NSF/ANSI standards, examples of state standards, WateReuse Association/WEF/AWWA *White Paper on Graywater,* and the NRC/NAS report.

RESULTS

We do not have any EPA regulations focused on water reuse in general, or specific to decentralized greywater reuse. However, among many other things, the 2012 EPA *Guidelines for Water Reuse* document provides recommended minimum requirements for a series of water reuse practices that may be helpful. And there are other sources of standards and guidance that may also be helpful.

CONCLUSIONS

Indoor uses of greywater will likely need to comply with standards similar to those imposed on indoor use of reclaimed water.

TITLE

Greenland – Far from Reaching the United Nations Millennium Development Goal - Why?

PRESENTER

Kåre Hendriksen, Associate Professor, Ph.D., Arctic Technology Centre, Technical University of Denmark

CONCLUSIONS

Too few households in Greenland have piped water, just as a good part of the population must leave their black wastewater in plastic containers, often referred to as "honeybuckets." Consequently, Greenland is far from meeting The United Nations Millennium Development Goal. There are social and geographical inequalities. Typically, it is the socially disadvantaged families who do not have running water. Sanitation is a virtually unknown phenomenon in the smaller settlements.

The lack of access to piped water and sewer reflects some key issues:
It may be technically challenging to ensure adequate water supply at a number of Greenlandic settlements. Large parts of the High Arctic Greenland are desert, and many settlements are located on small islands without large water reserves. Because of climatic and geophysical conditions, sewage systems are costly to establish and operate, and it requires adequate water supply.

There are political and institutional challenges, too. Water and sanitation in small settlements does not seem to be a priority, compared to investments in other forms of infrastructure and social facilities in major cities.

For Greenland settlements, infrastructure such as electricity, water, and sewage are based on island operation. Over the latest decades, the former nationwide technical organization, which was responsible for the establishment and operation of infrastructure, has been divided into sectors in a number of independent companies, with no financial incentive for cooperation. This means that coordinated rationalization gains are not exploited, whereby infrastructure cost–

especially in smaller settlements—will increase significantly.

The factual distribution of household tap water and sewer connections across settlement types will be presented, and the social aspects will be explained. Discussion will center around why Greenland does not make meeting The United Nations Millennium Development Goal a bigger priority—one that could be well within reach—and what can be done to achieve this goal.

TITLE

Beyond Education: Using Social Change Marketing to Effect New Behaviors

PRESENTER

Kathryn J. Anderson, Ph.D., MPH

INTRODUCTION

Knowledge is not always sufficient to motivate people to change. While educational campaigns have been effective for relatively simple behavior changes, many problems we are tackling today are far more complex and, quite simply, people do not always practice what they know is best. Humans have free will, competing interests, live in particular social contexts that may be different from ours, and have unique psychological makeups.

Social change marketing is a well-established discipline that has been used successfully worldwide to affect behavior change in these more complex situations. It has been used to change behaviors in arenas such as conserving water and energy conservation, using pesticides, breastfeeding, and practicing safe sex.

Social change marketing is built on principles from diverse fields such as commercial marketing, psychology, and behavioral economics. It is behavior-change centric, theory informed, and research directed. Social marketers emphasize the need for the careful segmentation of audiences, and they strive to deeply understand the barriers to change and the potential benefits of change, specifically from the target audience perspective. Social marketing programs, or interventions, are built upon these principles and insights, and they are crafted to make behavior change easier, less objectionable, and more related to the target audience's own perception of value.

CONCLUSIONS

This talk will discuss the principles of social change marketing, describe some interesting successful programs, and lay out some ways that this discipline might be appropriate for influencing behavior changes relative to rural sanitation initiatives.

TITLE

Proposed Reforms to Alaska Water & Sewer Improvement Efforts

PRESENTER

Megan Alvanna-Stimpfle

CONCLUSIONS

Addressing the issues of housing, and sewer and water in our communities, remains Kawerak's top priority. While funds are needed for first-time service, operations and maintenance funds are needed for infrastructure improvements. Five villages within the Bering Straits Region remain unconnected to running water and sewer: Diomede, Wales, Shishmaref, Stebbins and Teller. In three other communities, 30-50 percent of the homes in the community still need to be connected: Golovin, Gambell and St. Michael. Ongoing sewer and water upgrades and maintenance remain concerns in the remaining seven communities of Elim, Koyuk, Savoonga, Shaktoolik, Unalakleet, White Mountain and Brevig Mission.

Multiple Federal Programs

There is an average of $68.2 million annually funded by a combination of six federal funding streams and the State of Alaska. Designated sewer and water funding includes:

- United States Department of Agriculture Rural Development Capital Improvement Program
- Environmental Protection Agency (EPA) Infrastructure Grant Capital Improvement Program
- Indian Health Service Sanitation Program
- Environmental Protection Agency Safe Drinking Water Act
- Environmental Protection Agency Clean Water Act Indian Set Aside
- Indian Health Service Housing Priority System

There are three main allocation systems for these funds that ultimately end up being managed or administered by either the Alaska Native Tribal Health Consortium (ANTHC) or the State of Alaska Village Safe Water Program, which may or may not duplicate government services. Roughly $33 million is allocated by the capital improvements program in the form of grants, accounting for 44 percent of funds going into sewer and water investments. The Indian Health Service (HIS)

Sanitation Deficiency System represents 30 percent of total funding, reflecting an investment of $22.5 million annually.

Complex Regulatory Structure

As highlighted by the ANTHC, federal funding streams must be coordinated to complete construction of a community system. For example, EPA Safe Drinking Water Act funding can only be used for community water facilities and water service lines, but no funding can be used for hooking up homes, or for interior plumbing. IHS housing dollars can be used for water and sewer facilities on "like new" Alaska Native-owned homes, but cannot be used for interior plumbing. IHS sanitation funding can be used for interior plumbing and Alaska Native-owned homes. An EPA Infrastructure Grant can be used for planning, water and sewer facilities, and indoor plumbing, however it cannot be used for plumbing or service lines to HUD homes constructed after 2000. This regulatory structure provides for complicated planning and delays as funding must be pieced together to complete a community.

Reform Principles

- Greater involvement and coordination by communities and regional institutions, including accuracy and consistency of data
- Leveraging federal investment with private sector investment
- One regulatory structure supporting community development/investment plans

It is important to acknowledge that some communities in Alaska have strong local leadership, while others rely on the expertise of the state or ANTHC to administer development projects. It will be important for decision makers to discuss transferring the responsibility or portions of it to communities or regional institutions, allowing for knowledge to empower communities as they try and determine how to manage or coordinate funding the investment of sewer and water. Knowing where communities and regions lie on the statewide IHS sanitation deficiency system, and the timeline for construction and investment, empowers leaders with how to coordinate or solicit private sector funds.

Currently, it is the responsibility of engineers managed by ANTHC or the state to input data into the IHS Sanitation Deficiency system. It is important that communities and regional tribal organizations take an active role in the input of data, ultimately determining their position within the IHS Sanitation Deficiency System. Ensuring the accuracy and consistency of data for communities across Alaska is imperative for a just system.

Many communities use private donations (by CDQ groups for example) to manage sewer and water, and utility systems. Active, real-time updates to the IHS sanitation deficiency system are a possibility to improve the current management of the list, not only to reflect priority local investments in the region, but also to examine greater leveraging and coordination of private, state and federal funds.

Once a development plan for a community is formed and verified by an administering agency, any source of federal funding could be used to complete the project. Such a system would require federal agencies to waive the regulatory structure in support of a community development plan, or to adopt a common regulatory structure. Should timelines and federal funding sources be identified, communities, regional institutions, the statewide tribal health organization, or the State of Alaska could enter into contracts with the private sector to construct systems with federal and state programs, making payments over time, as established by the IHS Joint Venture Program or the tribal transportation options.

METHODS OF OWNERSHIP, OPERATIONS & MAINTENANCE TO MAXIMIZE USEFUL LIFE OF WATER & SEWER SYSTEMS IN THE ARCTIC

TITLE

Techniques and Design of Building to Make It More Compatible With This New Arctic Environment

PRESENTER

Michael Black

INTRODUCTION

Much of rural Alaska is experiencing a changing environment related to a warming Arctic. Much of these changes are reflected in the warmer seasons and the amounts and form of precipitation. There are increasingly obvious changes in the natural environment. With those changes, there are also changes in the built environment. Roads are unstable, building foundations are compromised, barge landings and fuel delivery points are lost to both erosion and sedimentation, lack of sea ice allows fall flooding and storm surge to threaten coastal infrastructure, and snow loads are increasingly stressing roof structures. Water and sewer is experiencing its share of threats from the changing environment. Traditional engineering of water and sewer systems will be challenged by these changing conditions.

METHODS

The Alaska Rural Utility Consortium (ARUC) is a group of 29 communities from around Alaska that have entrusted the Alaska Native Tribal Health Consortium (ANTHC) to operate and maintain their water and sewer utilities. This consortia of Arctic and sub-Arctic systems is a natural laboratory for the ANTHC Division of Environmental Health and Engineering to discover the problems that are emerging for sanitation systems in a warming environment. Through innovative engineering and operating methodologies, ANTHC has had to address changing Arctic conditions to keep these systems working and affordable for the customers.

The lessons learned by ARUC should be shared. That is the purpose of my presentation. I will examine the changing conditions that are challenging traditional water and wastewater engineering and share some of the ways we have adapted traditional approaches.

RESULTS

We are losing some of our source water as tundra ponds disappear. We are having to reach out for source water to more reliable sources such as groundwater and rivers.

Rivers, however, are increasingly laden with sediment and their chemistry is changing. We have had to further filter water from rivers as thermokarsts have dumped large amount of sediment into the water column.

Southeast Alaska and Kodiak Island are experiencing less precipitation and the source waters are being lost for some communities. We have found the need for more impoundments. Permafrost is melting, which means our pipes require different pilings and can no longer rely on cribbed foundations. We have also seen pipes sagging and differential settling with buildings that require a flexible connection to allow for movement of the pipe in relation to buildings they serve.

Lack of sea ice allows for a longer flooding and storm surge season that requires us to protect pipes by elevating the pilings or armoring the vulnerable areas. Melting permafrost also threatens water treatment plant foundations. We are currently designing a retrofit of the traditional passive thermosyphon to convert to an active refrigeration of the foundation using solar powered chillers.

CONCLUSIONS

The engineering community must modify the techniques and design of buildings to make it more compatible with this new Arctic environment, or we stand to lose all the hard-fought gains in public health infrastructure that have significantly extended life quality and expectancy.

TITLE

Applying a Water Safety Plan (WSP) Approach to Small Systems in Northern Canada

PRESENTERS

Graham Gagnon, Amina Stoddart, Kaycie Lane
Centre for Water Resources Studies, Dalhousie University Halifax, Nova Scotia

CONCLUSIONS

The typical model for potable water delivery by the Government of Nunavut (GN) in Canada is to extract water from surface waters and pipe or truck it to reservoirs within the community. From there, it is trucked to public buildings and households and stored in small on-site tanks. Depending on the community, chlorination for microbial control is performed either upon discharge from the reservoir, or directly within the water delivery truck. Communities in Nunavut face unique potable water treatment and delivery challenges associated with climate and remoteness, including a lack of operator training; lag time between sample collection, analysis and reporting; and aging infrastructure.

To address the unique challenges associated with potable water treatment and delivery in these communities, we are developing a water safety plan (WSP). WSPs are a preventative risk assessment and management tool, recommended by the World Health Organization (WHO), that critically analyze a water treatment system from source water to consumption to identify water quality hazards and associated risks to human health. Although use of WSPs has been advocated by the WHO since 2001, WSPs are not ubiquitous across Canada. However, other Arctic jurisdictions, such as Iceland, have successfully used WSPs as a regulatory tool to help ensure safe drinking water.

The objective of this paper is to describe a WSP framework that has been uniquely tailored to identify risks to drinking water safety, from the source to the tap, for GN communities. The proposed framework relies on a series of survey questions that, when answered, can be used to systematically determine the likelihood and consequence of predetermined hazards to provide a semi-quantitative assessment of risk. When a threshold risk is identified, the hazard is revealed and preventative measures for the hazard are suggested. The proposed WSP will require pilot application to understand adoption, but is a first step in preventative drinking water regulations from a risk management perspective.

TITLE

A New Affordability Indicator for Rural Alaska Water Utilities

PRESENTERS

Barbara Johnson, Joseph M. Little, Co-presenters

INTRODUCTION

This research presents an alternative to the current affordability indicator used by Village Safe Water, a program of the Alaska Department of Environmental Conservation (DEC). Both indicators are used and compared to assess whether rural Alaska communities can financially sustain water utilities over the lifetime of the infrastructure. Currently, the DEC considers a water utility to be affordable if annual operations and repair costs do not exceed five percent of the community's median household income (MHI). Because many rural Alaska community economies are a mixture of subsistence and cash activities, the MHI indicator often fails to accurately assess affordability.

METHODS

After a literature review, the EPA affordability matrix for sewage utility was picked as a template. The matrix was adapted to the Alaska context and the new indicator applied to past and future projects.

RESULTS

The new indicator combines a residential indicator (RI) and a financial capability index (FCI). RI is based on the percentage for each income quintile of the annual utility cost. FCI is composed of socioeconomic indicators. The new indicator was retroactively applied to a project and found to more accurately assess affordability. The new affordability indicator assesses utilities as unaffordable more often than the MHI indicator.

CONCLUSIONS

A community's socioeconomic situation impacts the affordability of water utilities. Given this, it is recommended that affordability assessments include socioeconomic indicators. Furthermore, using income quintiles rather than MHI is encouraged as the quintiles provide a more detailed picture of the impact of user fees on the population.

TITLE

Affordable Sustainable Sanitation Through Energy Efficiency

PRESENTER

Gavin Dixon, Alaska Native Tribal Health Consortium (ANTHC), Rural Energy Initiative

INTRODUCTION

Providing basic sanitation service of any type in rural and Arctic Alaska is very expensive. This is partially due to the extensive use of high-cost fuel and electricity in operating water and sewer systems in these harsh climates. On average, energy costs make up 40 percent of the total cost of providing services. The ANTHC Rural Energy Initiative has worked for six years to identify and implement opportunities to reduce energy consumption and decrease the cost of providing water and sewer service, thereby expanding access to basic sanitation through affordability of service, as well as through sustainability of sanitation infrastructure.

METHODS

Our team set out to identify the best opportunities to reduce energy costs through a series of sanitation facility energy audits. Once completed, ANTHC worked with funding agencies and communities to identify funding to implement relatively low-cost energy efficiency measures in a variety of community sanitation systems across Alaska. Based upon the findings of the audits, it was determined that a team that could provide minor plumbing and electrical improvements and focus on providing operator training would be best.

RESULTS

More than 35 communities have received energy efficiency improvements and training in their sanitation systems over the last two years. These systems have benefitted from reduced costs of providing services through reduced energy usage, with an estimated annual energy savings of $500,000 annually. Additional benefits of the program include improved functionality and reliability of delivering services, increased operator confidence, improved comfort, and expanded lifespan of struggling facilities.

CONCLUSIONS

Energy efficiency improvements solve a variety of problems for water and sewer systems in rural Alaska. ANTHC's low cost sanitation energy efficiency training and retrofit program has reduced costs, improved reliability, expanded the useful life of aging infrastructure, and improved operator confidence and effectiveness.

TITLE

National Tribal Water Center

PRESENTERS

James Temte, Alaska Native Tribal Health Consortium
Marleah Labelle, Alaska Native Tribal Health Consortium

INTRODUCTION

Access to clean water is vital to good health. In rural Alaska, residents in villages with higher service rates—where more than 80 percent of residents have clean water and sanitation access in the home—have shown a significant decrease in hospitalization due to pneumonia, diarrhea, respiratory diseases and skin infections. Unfortunately, Alaska ranks last amongst U.S. states in percentage of the population with access to water and sanitation facilities (93.7 percent as of 2000). Many of the existing water systems are at risk of failure due to the multitude of challenges inherent in operating, maintaining and managing them in harsh Arctic environments.

METHODS

In an effort to improve the sustainability of these systems, the "Water is Life" project was started. This health promotion campaign targets three specific groups at different levels of the social ecological model of public health: 1) water consumers, 2) water treatment plant operators, and, 3) utility managers and tribal governments. The project unites these groups to create a shared vision and raise public awareness of their water and sanitation system through the creation of a large-scale mural. The mural serves as a catalyst to create teachable moments that encourage water infrastructure awareness and behavior change. The mural and educational activities connect the traditional water culture and values of the tribe to the modern sanitation infrastructure and healthy water use behaviors.

RESULTS

"Water is Life" helps build community pride and ownership of the system, improving water system sustainability. Results from pilot projects demonstrate successful water system financial sustainability, as seen from a $50,000 deficit becoming a positive balance, city government involvement, and effective community engagement.

CONCLUSIONS

This presentation will discuss the vision, process, evaluation and results of the "Water is Life" project conducted in Russian Mission and Deering in May and June 2016.

TITLE

Peculiarities of Water Supply and Drinking Water Quality in the Russian Arctic
Note: This presentation is not available.

PRESENTER

Alexey Dudarev
Head of Hygiene Department, Northwest Public Health Research Center
St Petersburg, Russia

CONCLUSIONS

Population of the "Arctic Zone" of the Russian Federation (Murmansk Oblast, Northern Karelia, Northern Arkhangelsk Oblast, Nenets Okrug, Yamal-Nenets Okrug, Taimyr, Northern Yakutia, Chukotka) is about 2.5 million, including 115,000 indigenous people. Half of the total Arctic population lives in the cities and the other half lives in small settlements (90 percent of habitation). Centralized water supply exists in most of the big towns, but not all of them are equipped with water pre-treatment facilities. In rural areas, most of the population uses drinking water from non-centralized sources. Continuous permafrost, which occupies most of the Russian Arctic Zone (excluding Murmansk Oblast), is the main cause of infrequent use of underground water sources. In small settlements, water pipes usually supply untreated and non-disinfected drinking water directly from surface water sources. A majority of these water supply systems in rural areas are used only in summer. During the winter months, most water for household needs and drinking is delivered from surrounding reservoirs. Some communities have ''technical'' pipeline water-delivery systems from the nearest lake or river, and use constant water preheating during cold seasons, which serves as a centralized combination of house heating and hot-water supply, to prevent the water from freezing. In severe cold climate zones, where wells are unavailable or impossible to construct, water is typically delivered by trucks carrying water tanks in summer and sawn ice blocks in the winter. Usually the drinking water quality is low due to weak protection of aquifers from pollution, lack of sanitary protection zones, serious deterioration of water distribution and sewerage networks, and the numerous accidents on these networks that leads to secondary pollution of drinking water. Drinking water in the Russian Arctic, as a rule, does not meet hygienic standards for chemical substances and biologic agents.

OVERVIEW OF HOUSEHOLD PILOT SYSTEMS IN DEVELOPMENT

State of Alaska Department of Environmental Conservation:
The Alaska Water & Sewer Challenge Project Teams:

TITLE

University of Alaska Anchorage (UAA) Team

PRESENTER

Aaron Dotson, UAA

CONCLUSIONS

The University of Alaska Anchorage (UAA) team has developed a prototype treatment system utilizing membranes and high dose ultraviolet light (UV) to demonstrate on-site water reuse as an alternative to a conventional community water and sewer system. Further, in-home plumbing concepts evaluated include isolated systems for each fixture that operates on 12-volt direct current electrical power and are pneumatically driven with low-pressure air.

At the time of the conference, the team is testing treatment system configuration No. 4 since the Phase II proposal. The current configuration recycles used water originating from the kitchen sink, bathroom sink, shower and clothes washer. Recycling is performed by initially concentrating this greywater using nanofiltration (NF), where NF reject is recycled to the greywater tank and the NF membrane permeate product is disinfected by ultraviolet (UV) and sent to an intermediate tank. From this intermediate tank, the water is fed to a reverse osmosis (RO) membrane filtration step, where RO reject is recycled to the intermediate tank and RO membrane permeate product is disinfected by UV and sent to the wash water tank where is it pumped into the home for non-potable, full-body contact reuse.

The Wostman EcoFlush diverting toilet, used in this prototype, flushes into a 15.5-gallon tank intended for sealed small system haul. In the case of a non-functional community haul system, the tank is small enough for personal haul.

Treatment system configurations operated prior to this conference produced wash water with turbidity <1 NTU, no observable color and ultraviolet transmittance of greater than 95 percent. Ongoing modifications are aimed at reducing the concentration of organic matter in the wash water believed to originate from urea in urine and soap. To date, the system reuses each gallon of water hauled into the system at least five times prior to disposal.

TITLE

DOWL Alaska Team

Christopher R. Schulz, P.E., CDM Smith, Denver, CO
Janelle Rogers, Ph.D., P.E., CDM Smith, Nashville, TN
Chase Nelson, PE DOWL, Fairbanks, AK
Mitch Titus, DOWL, Fairbanks, AK
Bruno Grunau, CCHRC, Fairbanks, AK
Laurie Krieger, Ph.D., Manoff Group, Washington, DC

PRESENTER

Christopher R. Schulz, P.E., CDM Smith, Denver, CO

CONCLUSIONS

The Alaska Department of Environmental Conservation (ADEC) has initiated the Alaska Water and Sewer Challenge (AWSC), an applied research project to create innovative and cost-effective home-based water and wastewater system (HWWS) solutions for households in remote Alaska villages. The DOWL Team is one of three engineering teams selected by ADEC for Phase 3 of this project which covers design, construction, monitoring, testing and optimization of a prototype HWWS. Our prototype system includes greywater and blackwater (waste) storage tanks in a small "bump out" (vestibule) attached to the house, treatment and recycling of greywater for cleaning and washing in the home, and a separate point-of-use (POU) filter for drinking water. The greywater treatment system includes a two-stage granular activated carbon (GAC) filter for tubidity and disolved organics reduction, and a two-lamp self-cleaning ultraviolet system for disinfection. The POU filter includes replaceable ceramic filter elements and is designed to treat and store melted ice water in the winter and rainwater in the spring and summer. A low-volume flush toilet (< 0.5 gallons per flush) can be used to reduce wastewater volumes to the blackwater tank and the frequency of wastewater hauling. The HWWS is designed to supply 40 to 80 gallons per household per day assuming an average household size of four people. The capital cost of the system, including shipping and household plumbing improvements, is about $53,000, and the monthly operating cost based on unit prices for power, water and liquid waste hauling in the village of Shishmaref is $141.

This presentation will highlight the key design features of the HWWS and how we co-designed the system with end-users in three villages we visited during the project—Shishmaref, Kwigilingok and Tununak—to meet their specific needs. We will also present the test plan and preliminary results of prototype testing of the HWWS at the Cold Climate Housing Research Center in Fairbanks, Alaska.

TITLE

Summit Consulting Services Team

PRESENTER

Parke Ruesch, Summit Consulting Services

CONCLUSIONS

Summit's proposed system for the Alaska Water Sewer Challenge is intended to be flexible and modifiable to meet the needs and capabilities of the individual homeowner, and to be installed and maintained with a local labor force. Summit is working with Agnew::Beck Consulting, Re-Locate and the communities of Kongiganak and Kivalina on the system design and increasing end user acceptance.

Summit is testing the prototype system in a building designed like a typical home in rural Alaska and in environmental conditions similar to what would be expected in more remote villages. We are utilizing standard village home construction techniques such as the plumbing wall and raised platforms to install tankage and system components. Our goal is to reduce the amount of water and waste water hauled by reusing wash water. The 50-gallon raw water storage tanks would need to be filled every three days and waste water would need to be pumped from the home every three days. Fifty-seven gallons are treated and cycled through the system for wash purposes.

Raw water is added to the system from rainwater off the building roof and three surface water sources. Raw water is treated to drinking water standards by multi-stage cartridges, an ultrafiltration membrane and media disinfection. It is also added as make-up to the wash water system as needed. Wash water will be reused from the bathroom sink, laundry and shower. This wash water is treated via an aeration and biological process, and disinfected by ultraviolet or advanced oxidation. The cleaned and treated wash water is then available at the bathroom sink, laundry and shower, as well as at the kitchen and utility sinks, and for flushing the toilet. The system is being tested with two toilet configurations, a low-flush toilet and a urine-diverting dry toilet.

TITLE

Alaska Native Tribal Health Consortium (ANTHC)
The Portable Alternative Sanitation System (PASS):
A Water and Sanitation Pilot Project

PRESENTERS

Korie Hickel, Senior Environmental Health Consultant, ANTHC
Mia Heavener, Senior Civil Engineer, ANTHC

INTRODUCTION

Residents of Kivalina, Alaska, are faced with dire sanitation needs, but struggle to obtain funding assistance because of the community's threatened status. Flooding and erosion have impacted critical sanitation infrastructure and make investment in new stationary infrastructure undesirable. Effective low-cost methods to address sanitation are needed for the interim, until the community relocates.

In 2015, the ANTHC led a team in designing and installing nine in-home water and sanitation systems as a pilot project. The systems incorporated low-water use fixtures, separating toilets, rainwater catchment systems, and seepage pits. The systems were designed to address basic sanitation needs of the residents including safe potable water, hand washing with flowing water, and safe handling and disposal of sewage. Homeowner training and involvement in the project were incorporated as critical elements to the project's success.

METHODS

An evaluation of the systems will be completed in August 2016. Outcomes include homeowner acceptance, mechanical functionality, amount of water used, and operational costs. Data is collected through questionnaires completed onsite with household representatives and documentation of activities.

RESULTS

Preliminary results demonstrate increased water usage, reduced exposure to sewage, and overall satisfaction. Key modifications carried out or planned in response to feedback include modifications to the greywater tank, refining the ventilation, exchanging the piping material for greater freeze protection, and improving the local support system.

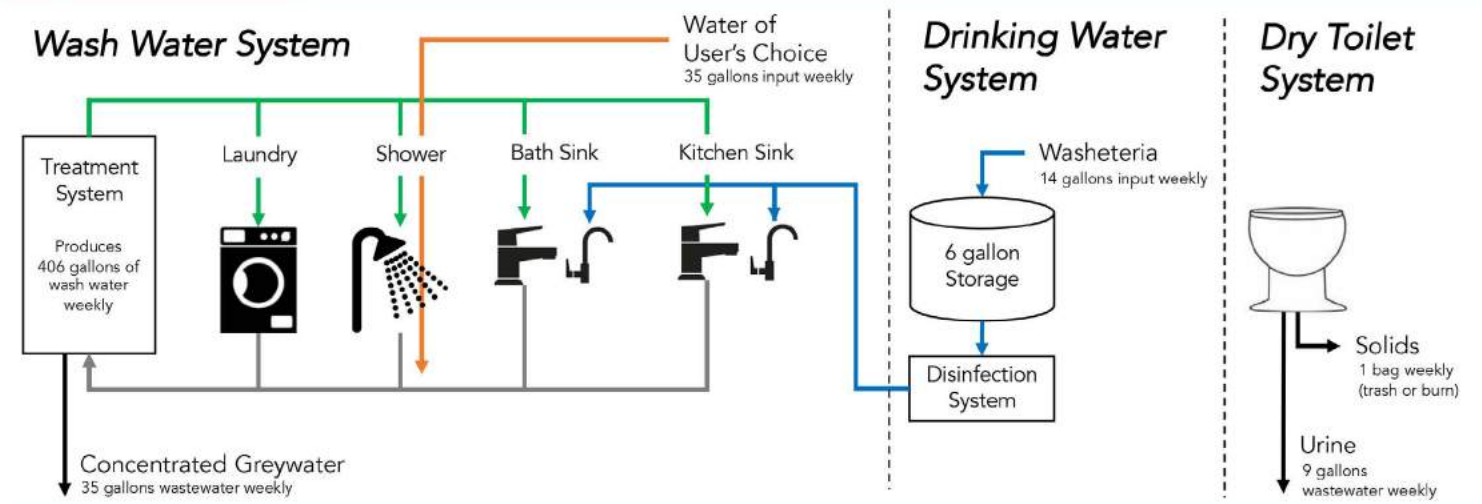
CONCLUSIONS

The pilot project has been a success with improvements in quality of life and resident satisfaction. Installing any type of system in a home presents challenges when homeowners must maintain their own systems in remote locations and under extreme conditions. Operation and maintenance support will be a key element in the successful application of any type of community wide in-home sanitation technology.

This presentation will explain the project, lessons learned, and outcomes of the evaluation.

OVERVIEW OF HOUSEHOLD WATER & SEWER PILOT SYSTEMS IN DEVELOPMENT

Alaska Water Sewer Challenge – Phase 3
Onsite Water Reuse Research Prototype Development



System Highlights

In order for a household of four people to use 420 gallons of water weekly, a total of 49 gallons of water will need to be brought into the home weekly, 14 gallons of drinking water from the washeteria and 35 gallons from a water source of user's choice (e.g. rain, ice, river, lake) to be used at the fixtures for washing.

Also, 44 gallons of wastewater will need to be removed from the home each week, 35 gallons of concentrated greywater created by the wash water treatment system and about 9 gallons of urine from the toilet.

System components for wash water treatment are located inside a shipping container attached to the house. The drinking water treatment is located under the kitchen counter.

The only source of water recommended for drinking and cooking purposes is washeteria water to ensure that this water meets drinking water standards. Drinking water is provided at the kitchen and bathroom sinks at a separate faucet.

Greywater from the kitchen sink, laundry, shower, and bathroom sink will be recycled and made available at the kitchen sink, laundry, shower and bathroom sink as wash water for uses other than drinking and cooking.

Hot water is made available in the system for showers, sinks and the clothes washer hook-up from small volume electric water heaters.

University of Alaska Anchorage is working with partner communities in the Yukon-Kuskokwim and Interior regions to gather feedback on the system from potential end users.

Questions, Comments or Looking for more information?
Website: www.ReuseWaterAK.com *Facebook:* www.facebook.com/ReuseWaterAK *Email:* addotson@alaska.edu *Phone:* 907.786.6041

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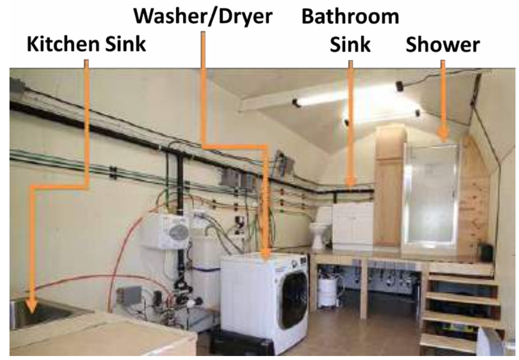

Greywater Treatment System

- Air assisted soap removal
- Four stage filtration
  - strainer
  - ceramic microfilter
  - nanofilter membrane
  - reverse osmosis membrane
- UV disinfection
- Ozone tank disinfection

Daily Water Availability

Fixture	Operation	gallons
Toilet	24 uses	0
Shower	22 min	22
Bathroom Sink	24, ½ min uses	14
Kitchen Sink	user choice	10
Laundry	1 load per day	12
Drinking Water	0.5 gal/person/day	2
	TOTAL	60

Research Prototype

Left – 10-ft shipping container greywater treatment system

Right – Fixture prototype shed

Wash Water

Fixture Prototype

12 volt Battery Operated/Backup
- Air driven greywater plumbing
- Individual fixture pumps

Smart Small Tank Water Heaters

High Efficiency Water/Dryer

Fixture associated strainers

Wash Water Quality

Designed for greater than 99.99999% reduction of bacteria and viruses
- confirmed with total coliform bacteria

Typical Wash Water Quality

Turbidity - 0.1NTU
Organic Carbon – 0.5 mg-C/L
pH between 6-8
0 MPN/100mL total coliform
no odor
soft water

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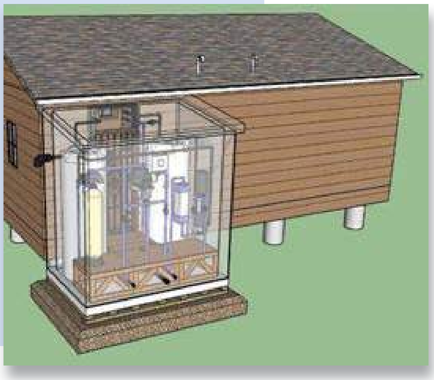
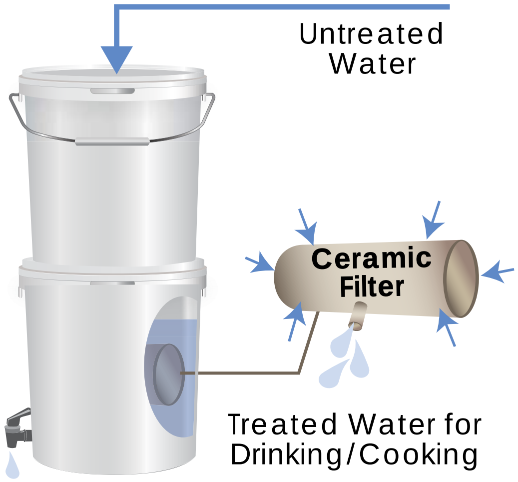
Prototype Household Water and Sewer System

System Highlights

- In order for a household of four people to use 60 gallons of water per day, a total of **90 gallons** of water will need to be **brought into the home** each week.
- Also, **90 gallons** of wastewater will need to be **removed from the home** each week. Wastewater is produced by flushing the toilet or using the kitchen sink. All other water; from the bathroom sink, the shower, and the wash machine is recycled.
- System components for water treatment are **located in a "vestibule" attached to the side of the house.**
- Sources of water that can be treated **for drinking and cooking** purposes include **rain water, water from a lake, or water from a river.**
- Sources of water that can be used **for wash water** include **rain water, water from a lake, or water from a river.** Wash water refers to the water used in the house for uses besides drinking and cooking. The drinking water system is completely separate from the wash water systems.
- **Hot water** can be made available to any of the fixtures based on plumbing arrangements and user preference.
- DOWL is working with partner communities in the **Yukon Kuskokwim and Norton Sound Regions** to gather feedback on the system from potential end users.



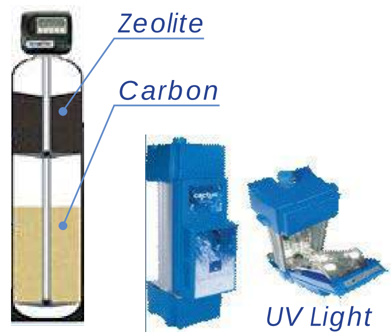
The proposed DOWL System has the following features:



A stand-alone filtration system for drinking and cooking Water. This filtration system consists of a filter with special coatings to remove bacteria. It is also being tested to see if it removes viruses. The filter units are located in a 5-gallon bucket and the whole unit sits on a kitchen counter top. Untreated water from local sources can be loaded into the filter and treated for drinking. An additional bucket with holes can be placed in the top of the unit to hold melting ice. Information on this simple drinking water filtration system can be viewed on the internet: ***https://youtube/v5PKNtAoDHA*** *Drinking water is safe and the filter units are inexpensive and user friendly.*

Point of Use Filter

A separate system that treats and recycles wash water in the home. This allows for water to be used multiple times before it turns to wastewater as it goes through the toilet and kitchen sink. The wash water recycling system takes water from the bathroom faucet, the washing machine, and the shower and filters it through a two-stage carbon/zeolite filter, and then disinfects it twice using Ultra-violet (UV) lights. (A zeolite filter uses minerals as adsorbents.) Wash water that goes through the recycling system is safe, but not meant for drinking and cooking. *Components within the proposed DOWL system are available commercially. A maintenance cooperative through a local government could stock replacement parts that would apply to all systems in a community.*



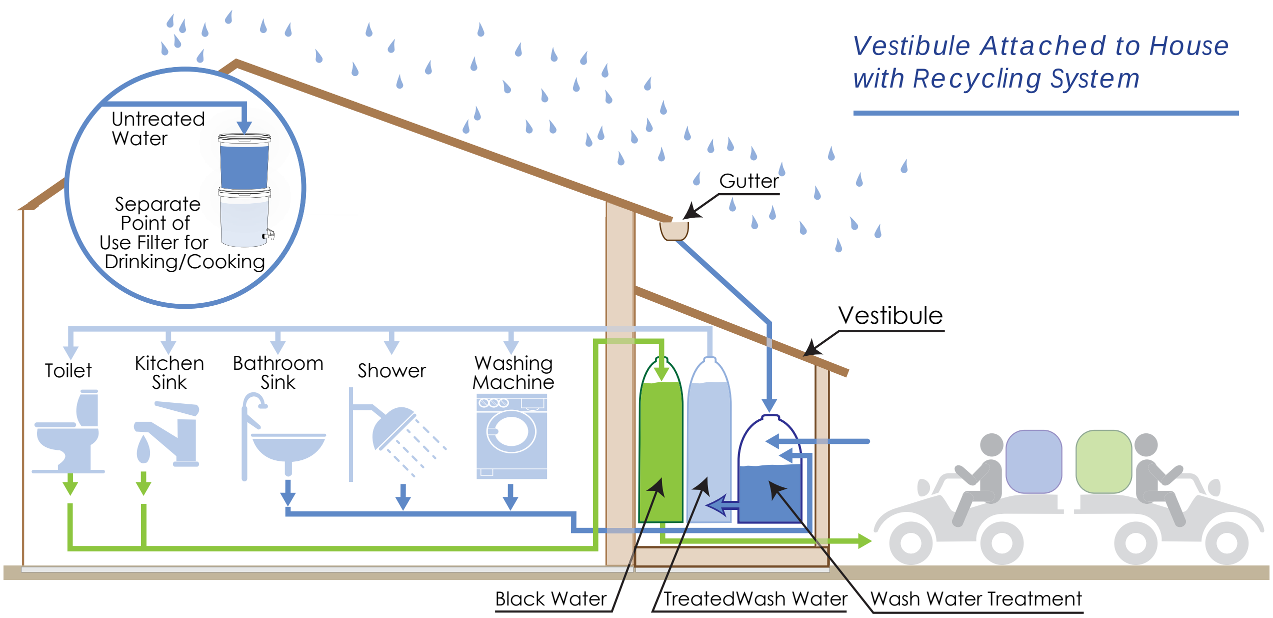
Two Stage Carbon/Zeolite Filter for Filtration Followed by Ultraviolet Light for Disinfection

- **Separate tanks for storing wash water and wastewater.** Wastewater generated from the flush toilet, and the kitchen sink is transferred to a holding tank where it is held until it can be pumped away from the household by the local government. No water from the toilet or the kitchen sink enters the wash water recycling system. There is a separate storage tank for treated wash water. Treated wash water is stored in this tank until it distributed to the different fixtures.

- **A "vestibule" attached to the side of the house.** The water recycling system and the tanks for storing water are housed in a "vestibule" that attaches to the side of the house. These components are placed in the vestibule so the tanks and recycling system do not take up space inside the home. The vestibule also allows heat from the house to drift into the vestibule, so a separate heating system is not required. The vestibule is super insulated and has a separate foundation system to allow the vestibule to allow for ground movement.

- **Low energy demand.** Since the vestibule is super insulated it will not take much energy to heat it. A small energy demand will come from the pumps and disinfection system. The disinfection system, which is an ultraviolet light, has about the same energy demand as a normal light bulb. Holding tanks for wastewater are kept inside the warm vestibule, so no heat trace is needed.

Vestibule Attached to House with Recycling System

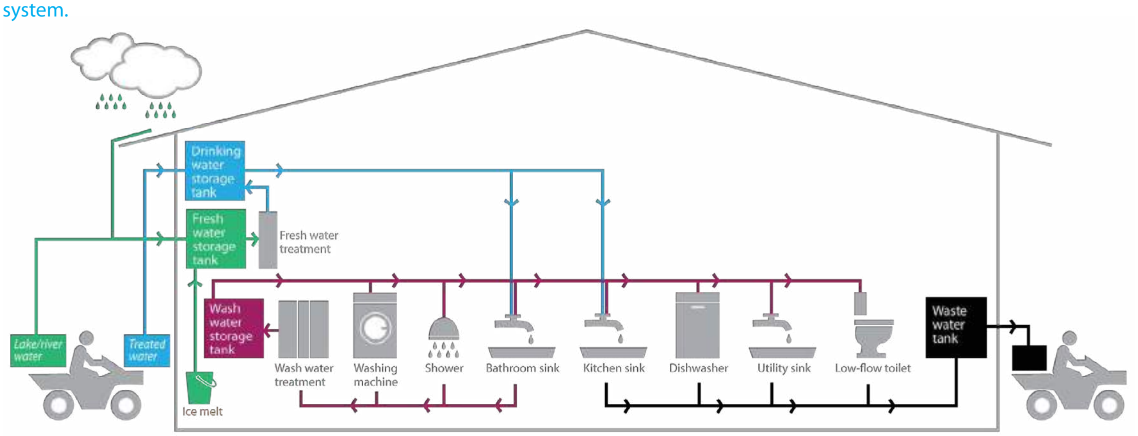


SUMMIT CONSULTING SERVICES

IN-HOME WATER TREATMENT AND WASTE WATER SYSTEM

Drinking Water

Drinking water is available at the kitchen and bathroom sink. Treated or fresh water must be hauled or collected every three to five days to refill the 50 gallon fresh water tank. Rain water can be directly piped into the system when available. Fresh or natural water passes through two pre-screening filters, two filters to remove bacteria, and a filter to remove taste and odor to clean it for drinking. Treated water can also be added to the system.



Wash Water

Wash water is recycled from the washing machine, shower and bathroom sink. The wash water is treated to be used again for washing uses at the washing machine, shower, bathroom, kitchen sink, dishwasher, utility sink and to flush the toilet.

Wash water is treated in four steps using a pre-filter to remove dirt and hair, a pump with air to remove soap, then a filter to remove oils and bacteria and an ultraviolet light to kill viruses.

Waste Water

Water from the kitchen sink, dishwasher, utility sink and toilets drain to a waste water tank. Waste water is pumped out of the house through a button on the outside of the house.

Ten to 17 gallons of waste water is produced each day, depending on the toilet choice. Waste water must be pumped and hauled every three to five days from the 50 gallon waste water tank.

SYSTEM HIGHLIGHTS

In order for a household of four people to use 60 gallons of water per day, a total of **70 to120 gallons** of water will need to be **brought into the home** each week.

Also, **70 to 120 gallons** of wastewater will need to be **removed from the home** each week. Wastewater is produced by the kitchen sink, utility sink, dishwasher and toilet.

System components for water treatment are **located inside the home. Tanks are incorporated into walls. The wash water treatment system is located in the bathroom.**

Sources of water that can be treated **for drinking and cooking** purposes include **rain, lake, river, ice melt, washeteria water**.

Sources of water that can be used **for wash water** include the **shower, bathroom sink and washing machine.** Wash water refers to water used in the house for uses besides drinking and cooking.

Hot water is made available by the system for showers, sinks and the clothes washer hook-up.

Summit Consulting is working with partner communities in the **Yukon-Kuskokwim and Northwest Arctic regions** to gather feedback on the system from potential end users.

Questions? Want More Info?

Website: www.summitwsc.com Facebook: www.facebook.com/summitakwsc Contact: meghan@agnewbeck.com or 907.222.5424

IN-HOME SYSTEM DESIGN

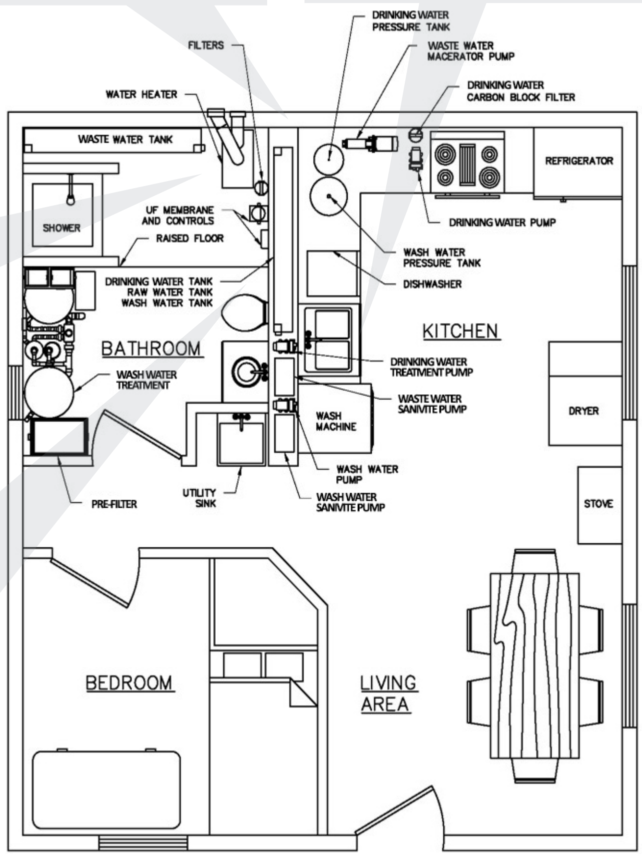
- Fits completely within the home.
- Flexible system components to meet home owner needs.
- Designed to be installed and maintained by local labor.

Rainwater catchment, intake and water overflow pipes, and waste water outlet.

Wash water and drinking water are available at the kitchen sink.

Waste water storage tank, drinking water filters and freeze-thaw protection using heat trace pipes

In-wall water storage tanks, drinking water filters, and a low-flow or dry toilet option.



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⊕ CLEAN WATER AND SAFE WASTE DISPOSAL SOLUTION

PORTABLE

The biggest drawback of a typical piped water and sewer system is that they are not portable. Some Alaskan communities are vulnerable to flooding and erosion; therefore, some funding agencies have been reluctant to invest in infrastructure. The PASS systems can be assembled and reassembled if a community has to relocate.

ALTERNATIVE

The Alaska Native Tribal Health Consortium and the Cold Climate Housing Research Center have designed and implemented a low cost sanitation alternative for communities that are affected by climate change. The PASS systems are approximately $26,000 per household as compared to a traditional piped system that costs approximately $168,000 per household.

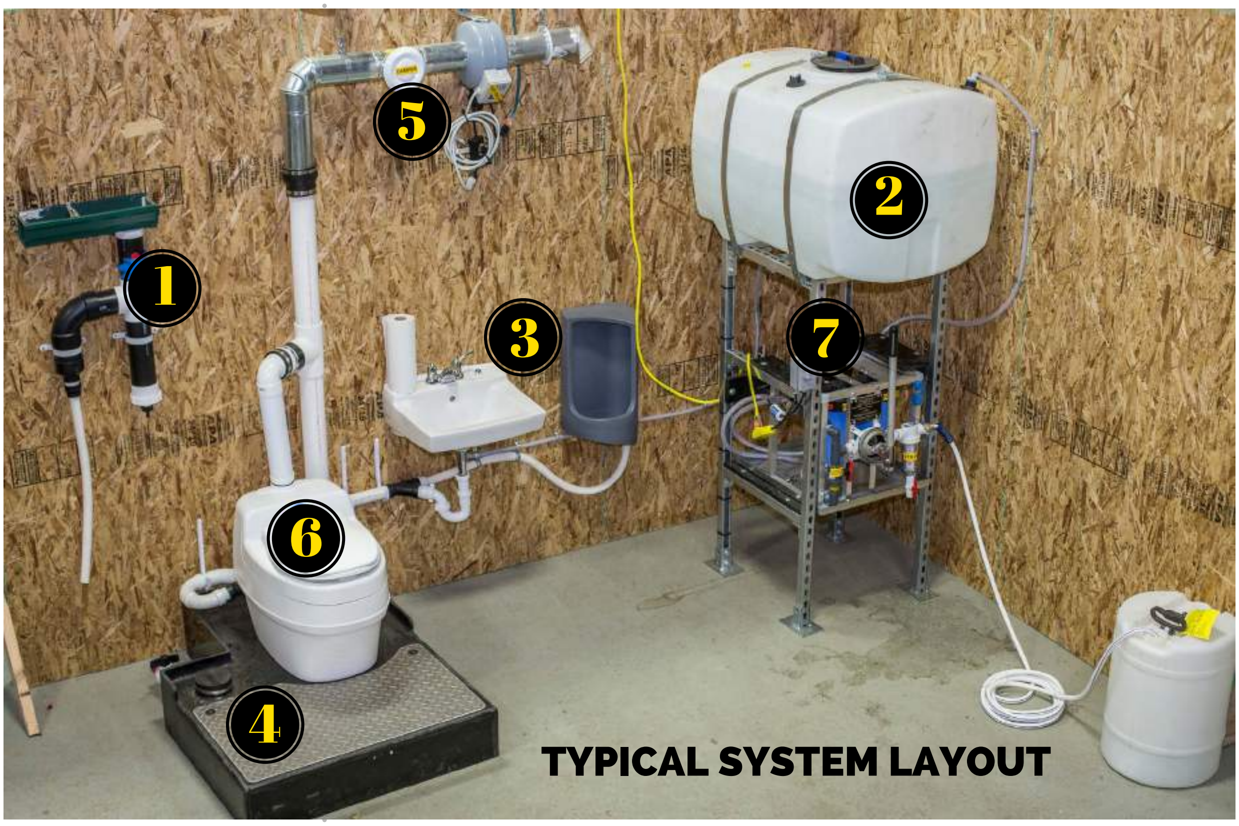
SANITATION

The PASS was implemented in nine homes in Kivalina, Alaska. Kivalina has been operating on a self-haul system. This exposure to raw sewage places community members at risk for waterborne pathogens. The innovative systems vastly improve hauling by limiting exposure to waste, minimizing odor, and reducing frequency and weight of hauls.

SYSTEM

The system is entirely homeowner-based, designed to address the most basic sanitation needs, and can be moved with the community. The systems are stand-alone models; as homes are moved to the new village site away from the eroding coastline, residents can bring their clean water and safe sewer systems with them.

PORTABLE ALTERNATIVE SANITATION SYSTEM



1. RAIN CATCHMENT

For an 800-square-foot home with a catchment area of approximately 1,200 square feet, it is possible to recover nearly 3,000 gallons or more of rain each year to supplement the quantity of water hauled to the home.

2. WATER STORAGE TANK

The 100-gallon, gravity-fed tank does not require electricity.

3. LOW-FLOW SINK AND WATERLESS URINAL

The sink and urinal conserves water while providing for hygiene and sanitation needs.

4. GREY WATER TANK

The grey water tank purges into the seepage pit below when full.

5. INTEGRATED VENTILATION

An energy-efficient combined ventilation system dries the waste, reduces odors, and ventilates the home.

6. SEPARATING TOILET

Waste is separated into liquid and solid components where the liquid is disposed of into a seepage pit and dried solids are disposed of in the landfill.

7. WATER TREATMENT SYSTEM

The water treatment system incorporates membranes and chlorination for point-of-use treatment to ensure the water is safe to drink despite its condition upon entering the system.

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Fatima Ochante, Chris Dankmeyer and Andrew Beaver observe pilot systems presentations

WIHAH

ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

WIHAH2016.COM

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

ANCHORAGE, ALASKA
SEPTEMBER 18-21, 2016

The WIHAH conference brought together Alaskan, U.S., and international engineers, health experts, researchers, community members, policymakers, and innovators to discuss health benefits, challenges and innovations associated with making running water and sewer in remote northern communities safe, affordable and sustainable. It included expert speaker and poster presentation sessions, along with selected innovative technical demonstrations.

This circumpolar conference is identified as an official event in conjunction with the U.S. Chairmanship of the Arctic Council, as an endorsed project of the Arctic Council Sustainable Development Working Group. The Alaska Department of Environmental Conservation is partnering with a number of U.S. agencies to sponsor this informative conference. Federal sponsors include the U.S. Environmental Protection Agency, U.S. Arctic Research Commission; the U.S. Centers for Disease Control and Prevention; the U.S. Department of State; and the U.S. Department of Agriculture, Rural Development Program.

Conference Presentations

ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21
WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

Conference Presentations

Opening Remarks

- WIHAH Welcome Remarks – Larry Hartig
- WIHAH Opening Remarks – Bill Griffith

Keynotes

- Climate Change, Disaster Resilience and Relocation at HUD – Danielle Arigoni
- Climate Change Consequences – Eric Hoberg
- The Impact of Water and Sanitation Services on Health – Tom Hennessy
- Pathogen risk management considerations for safe household water uses – Nick Ashbolt
- Reuse Regulations and Challenges of Regulating On-site Systems – Guy Carpenter
- An Introduction to the Arctic Council and the Sustainable Development Working Group – Ann Meceda
- Water Security in the Arctic: Perspectives from the Model Arctic Council – Carolyn Kozak, Sharon Hildebrand, Stephen Penner

International Reception Presentations

- Household Water Treatment and Safe Storage: Experience from the Developing World Lessons for Rural Alaska? – Robert Quick
- Arctic WASH contributions from the Kingdom of Denmark – Pernille Jensen & Kristian Hammeken
- A Bend in the River: Transitioning to a Time of Permanent Change – John Matthews

Overview of Household Pilot Systems in Development

Overview of State of Alaska Water & Sewer Challenge Project

- State of Alaska Water & Sewer Challenge – Team: University of Alaska Anchorage – (view animation)
- State of Alaska Water & Sewer Challenge – Team: DOWL Alaska
- State of Alaska Water & Sewer Challenge – Team: Summit Consulting
- Alaska Native Tribal Health Consortium – The Portable Alternative Sanitation System (PASS)

Conference Theme: The Impact of Household Water and Sanitation on Arctic Human Health

- Community Perspectives on Water Insecurity in Rural Alaska – Laura Eichelberger
- Education and Behavior Change Efforts to Maximize the Health Benefits and Sustainability of Water and Sanitation – AJ Salkoski & John Nichols
- Impact of In-home Piped Water on Rates of Infectious Disease – The Four Village Study – Tim Thomas
- Water Infrastructure and Well-being: What Does the Data Tell Us? – Melanie O'Gorman & Stephen Penner
- Water Quality and Health in Northern Canada: Contamination of Stored Drinking Water and Associations with Acute Gastrointestinal Illness in an Inuit Community – Carlee Wright

Conference Theme: Climate Change Impacts on Water and Sanitation Infrastructure in the Arctic

- Vulnerability of northern water supply lakes to changing climate and Demand – Michael Bakaic
- Vulnerability of fresh water supply in Arctic Canada – Andrew Medeiros & Michael Bakaic
- Climate Change and Community Water Security Emerging Challenges and Strategies – Mike Brubaker
- Survey on Water and Sanitation in the Arctic: Access, Disease Surveillance, and Threats from Climate Change – Jonathan Bressler & Tom Hennessy

Conference Theme: Innovative Engineering Approaches to Increase Access to Water of Adequate Quality and Quantity, Including Water Reuse

- Charting a new direction for wastewater treatment in the Canadian north – Ken Johnson
- Natural Engineered Wastewater Treatment: NEWT – Thomas Kasun
- Preliminary Test Results from an Electrically-Assisted, Anaerobic Sewage Treatment System – Bob Tsigonis
- Relocate: Kivalina Biochar Reactor – Jennifer Marlow & Michael Gerace
- Net-Zero Water: Energy-Positive Municipal Water Management – James Englehardt
- Potentials and challenges of biogas from fish industry waste in the Arctic – Pernille Jensen

Conference Theme: Regulations and Policies Affecting Access to and the Cost of Providing Adequate Quantities of Water in the Home

- EPA Regulations, Policies, and Guidelines for Water Reuse: Implications for Decentralized Greywater Reuse – Robert Bastian
- Greenland: Far from reaching The United Nations Millennium Development Goals. Why ? – Kåre Hendriksen

- Beyond Education: Using Social Change Marketing to Drive Behavior Change – Kathy Anderson
- Sewer and Water Regulatory Reform in Alaska – Megan Alvanna-Stimpfle

Conference Theme: Methods of Ownership, Operations and Maintenance to Maximize Useful Life of Water and Sewer Systems in the Arctic

- Applying a Water Safety Plan Approach – Graham Gagnon
- A New Affordability Indicator for Rural Alaskan Water Utilities – Barbara Johnson
- Maximizing Sustainability in Arctic Water and Sewer: Energy Efficiency – Gavin Dixon
- Water is Life Project – James Temte
- Michael Black – Techniques and design of building to make it more compatible with this new Arctic environment

Country Comparisons: Water & Sanitation Service

- Overview of Information Addressed through Country Comparisons
- Denmark (Greenland) – Kåre Hendriksen
- Canada (Nunavut) – Michele LeBlanc-Harvard
- Canada (NW Territories) – Peter Workman
- Canada (Yukon) – Tyler Heal
- United States (Alaska) – Bill Griffith

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ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

Welcoming Remarks
Larry Hartig

Commissioner

Alaska Department of Environmental Conservation

WIHAH Sponsors

DEPARTMENT OF ENVIRONMENTAL CONSERVATION
STATE OF ALASKA

USDA
United States Department of Agriculture
Rural Development

UNITED STATES
ARCTIC RESEARCH COMMISSION

EPA

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

ONE ARCTIC
ARCTIC COUNCIL
U.S. CHAIRMANSHIP
2015-2017

Alaska Department of Environmental Conservation: Helping to build and maintain safe water and sewer services in remote arctic communities

- Village Safe Water Program
- Operations Assistance Program, including Operator Certification and Remote Maintenance Workers
- Drinking Water Program
- Wastewater Discharge Authorization Program

Progress in Alaska Village Sanitation

- 30 years ago, fewer than 25% of rural Alaska households had running water and flush toilets.
- In 1996, 55% of rural homes had piped or covered haul service.
- Today, approximately 85% of rural homes have indoor plumbing (over 90% if regional hubs are included in the calculation).
- Almost $2.5 billion invested to date.

However…

- 3,300 homes in Alaska are still without running water and sewer service, primarily in 30 villages without centralized systems.
- These villages are the most challenging to serve. Many are small and prone to flooding, and may lack good water sources and gravel for construction.
- Estimated capital cost of serving these villages ranges from $15 million - $65 million (between $400,000 - $2 million per home)
- Many communities cannot afford the high operation cost associated with piped or haul systems, which can exceed $200 per month per household (over 5% of median household income)

The Alaska Water and Sewer Challenge

- State-funded research and development project, started in 2013
- Projected to last 5 – 7 years
- Focus on “decentralized” approaches – household based systems that utilize water re-use technologies
- Goal is to significantly reduce the capital and operating costs of in-home running water and sewer in rural Alaska homes

Overview of Household Pilot Systems

Prototypes will be showcased in the Denali Room
Monday and Tuesday afternoons (session is repeated)

Alaska Native Tribal Health Consortium:

- Kivalina system

Alaska Water & Sewer Challenge:

- University of Alaska Anchorage
- DOWL Engineering
- Summit Consulting

Country Comparisons

Tuesday Opening Session

- Presentations include Alaska, Russia, Greenland, and Canada, including Yukon, Nunavut and Northwest Territories.
- Information about water and sewer service levels, costs, regulations, and current challenges

Conference Themes

All speaker tracks repeated

- Impact of household water and sanitation on Arctic human health
- Climate change impacts on water and sanitation infrastructure in the Arctic
- Innovative engineering approaches to increase access to water of adequate quality and quantity, including water reuse
- Methods of ownership, operations and maintenance to maximize useful life of water and sewer systems in the Arctic
- Regulations and policies affecting access to and the cost of providing adequate quantities of water in the home

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ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

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ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

Opening Session
Bill Griffith

Facility Programs Manager

Alaska Department of Environmental Conservation

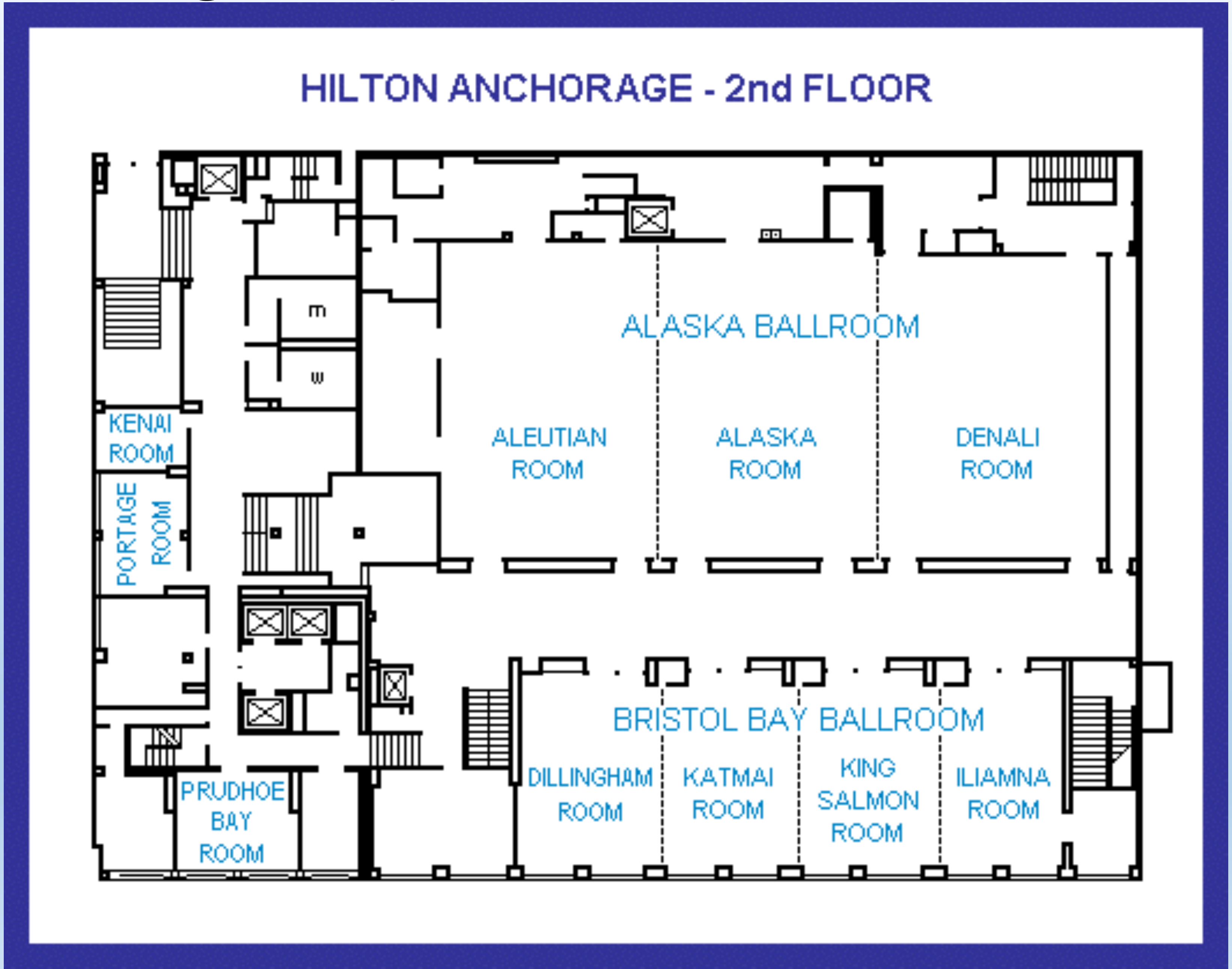
WIHAH Conference Planning Committee

- Stephen Bolan, *US Indian Health Service*
- Jonathan Bressler, *Alaska Department of Health and Social Services*
- Tasha Deardorff, *US Department of Agriculture – Rural Division*
- Carrie Eischens, *US Arctic Research Commission*
- Josh Glasser, *US Department of State*
- Bill Griffith, *Alaska Department of Environmental Conservation*
- Thomas Hennessy, *Arctic Investigations Program, US Centers for Disease Control and Prevention*
- Korie Hickel, *Alaska Native Tribal Health Consortium*
- Sharon Hildebrand, *University of Alaska Southeast*
- Elizabeth Hodges, *University of Alaska Anchorage*
- Carolyn Kozak, *University of Alaska Fairbanks*
- Brian Lefferts, *Yukon-Kuskokwim Health Corporation*
- Fatima Ochante, *Alaska Department of Environmental Conservation*
- Cheryl Rosa, *US Arctic Research Commission*
- Tim Thomas, *Alaska Native Tribal Health Consortium*
- Dennis Wagner, *US Environmental Protection Agency*

200 Conference Participants, including:

- 19 people from 6 other countries, including Canada, Russia and Greenland
- 17 people from the Lower 48
- 30 people from 20 different remote Alaska Villages
- 34 additional Alaskans from outside Anchorage

Emergency Exits and Restrooms



Reminders…

Please silence cell phones in this and other conference rooms.

Conference rooms can get cold, so carry a jacket or sweater if needed.

Overview of Conference Structure

- Mini-breakfast is served in the Denali Room, next door, 7:00 – 8:00 am.
- Morning plenary session is 8:00 – 9:30 am, followed by morning break.
- Morning and afternoon speaker tracks are across the hall and next door in the Denali Room.
- Lunch served in Alaska/Aleutian room (where we are now) at noon.
- Afternoon snacks and drinks are served in the hallway during break.

- All speaker tracks are scheduled twice. With a little planning, you can attend every session.

  (Health track this morning, go to Engineering Track this afternoon. Climate track this morning, go to Pilot Systems this afternoon.)

Please note:

- All Alaska village travelers: Please make sure to check in at the registration desk and pick up your envelope.
- Tables are available up for vendor information.
- All presentations will be posted on the conference website.
- Abstracts will also be posted on the website, and will be included in the conference proceedings.
- A press room is available for interviews.
- Allyson Taylor is conference coordinator, and she can assist with any logistical questions and contacts. (Wearing a black vest.)

Denali Room (next door):

- Overviews of household pilot systems will be presented on Tuesday and Wednesday afternoon.
- Displays are available for viewing throughout the conference.
- Representatives from pilot system teams will be available after lunch and during breaks.
- Display about the graywater treatment lab, operated by the Yukon Kuskokwim Health Corporation, is also set up on the wall.
- Sign up sheet for Tuesday evening field trip to the University of Alaska, Anchorage pilot system. (Tuesday at 6:00 pm)

WIHAH

ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21

WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

An Introduction to the Arctic Council and the Sustainable Development Working Group

Ann Meceda
Arctic Affairs Officer, Acting Chair SDWG
U.S. Department of State

September 19, 2016

Arctic Council Overview

- High level forum, not an international organization
- 8 Arctic States make decisions by consensus
- Mandate: environmental protection and **sustainable development**
- “The Arctic Council should not deal with matters related to military security”
- Role of Permanent Participants

ONE ARCTIC
ARCTIC COUNCIL
U.S. CHAIRMANSHIP
2015 - 2017

Observers in the Council

12 State Observers

Germany (1998)
United Kingdom (1998)
France (2000)
Italy (2013)
China (2013)
Japan (2013)
Poland (1998)
The Netherlands (1998)
Spain (2006)
India (2013)
Republic of Korea (2013)
Singapore (2013)

20 Inter-Governmental, Inter-Parliamentary and Non-Governmental Observers

United Nations Economic Commission for Europe (1998)
United Nations Environment Program (1998)
Nordic Council of Ministers (1998)
Standing Committee of the Parliamentarians of the Arctic Region (1998)
International Federation of Red Cross & Red Crescent Societies (2000)
International Union for the Conservation of Nature (2000)
North Atlantic Marine Mammal Commission (2000)
United Nations Development Program (2002)
Nordic Environment Finance Corporation (2004)
International Arctic Science Committee (1998)
Northern Forum (1998)
World Wide Fund for Nature-Global Arctic Program (1998)
International Union for Circumpolar Health (1998)
Advisory Committee on Protection of the Seas (2000)
Association of World Reindeer Herders (2000)
Circumpolar Conservation Union (2000)
International Arctic Social Sciences Association (2000)
International Work Group for Indigenous Affairs (2002)
University of the Arctic (2002)
Arctic Cultural Gateway (2004)

16 Pending Observer Applications

Turkey ● Greece ● Switzerland ● Mongolia ● Oceana ● Association of Oil and Gas Producers ● OSPAR (the Oslo-Paris Commission) ● Greenpeace ● International Hydrographic Organization ● Association of Polar Early Career Scientists ● World Meteorological Organization ● Norwegian Scientific Academy for Polar Research ● International Chamber of Shipping ● International Council for the Exploration of the Sea ● West Nordic Council ● National Geographic Society

U.S. Chairmanship

- April 2015 – May 2017
- Finland next
- Second U.S. Chairmanship in the 20 year Council History
- "One Arctic: Shared Opportunities, Challenges and Responsibilities"

U.S. Chairmanship Team

Chair of the Arctic Council
Secretary of State John Kerry

Coordinator of the Chairmanship
Special Representative for
the Arctic, Admiral Robert Papp

Special Advisor on Arctic Science and Policy
Fran Ulmer

Chair of the Senior Arctic Officials
Ambassador David Balton

U.S. Senior Arctic Official
Julie Gourley

ONE ARCTIC
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2015 - 2017

U.S. Chairmanship Pillars

- "One Arctic: Shared Opportunities, Challenges and Responsibilities"
  - Improve economic and living conditions
  - Address the impacts of climate change
  - Promote Arctic Ocean safety, security and stewardship

ONE ARCTIC
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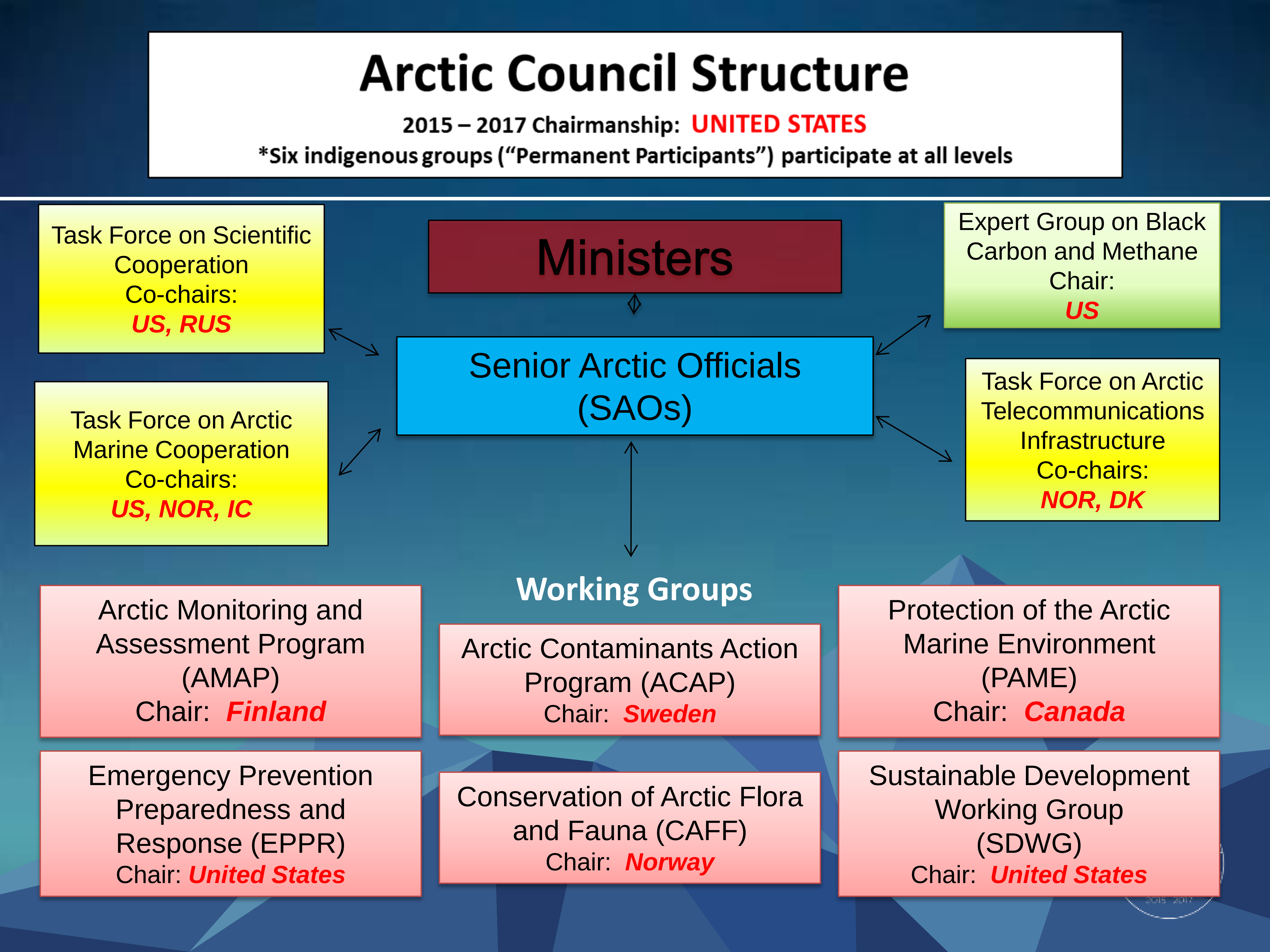
2015 - 2017



Arctic Council Structure
2015 – 2017 Chairmanship: UNITED STATES
*Six indigenous groups ("Permanent Participants") participate at all levels
Ministers
Senior Arctic Officials (SAOs)
Task Force on Scientific Cooperation
Co-chairs:
US, RUS
Task Force on Arctic Marine Cooperation
Co-chairs:
US, NOR, IC
Expert Group on Black Carbon and Methane
Chair:
US
Task Force on Arctic Telecommunications Infrastructure
Co-chairs:
NOR, DK
Working Groups
Arctic Monitoring and Assessment Program (AMAP)
Chair: Finland
Arctic Contaminants Action Program (ACAP)
Chair: Sweden
Protection of the Arctic Marine Environment (PAME)
Chair: Canada
Emergency Prevention Preparedness and Response (EPPR)
Chair: United States
Conservation of Arctic Flora and Fauna (CAFF)
Chair: Norway
Sustainable Development Working Group (SDWG)
Chair: United States

Sustainable Development Working Group (SDWG)
Chair: ***United States***

Mandate of the SDWG

- "to advance sustainable development in the Arctic, including opportunities to protect and enhance the environment and the economies, culture and health of indigenous communities and of other inhabitants of the Arctic, as well as to improve the environmental, economic and social conditions of Arctic communities as a whole."

Barrow, Alaska, October 13, 2000

SDWG Projects

Include:

- **Water, Sanitation and Health**
- Renewable Energy
- Telecommunications Infrastructure
- Suicide Prevention and Mental Wellness
- Preservation of Traditional Food Culture

WASH Project: Improving Health through Safe and Affordable Access to Household Running Water and Sewer in Arctic and Sub-Arctic communities

- To catalyze further domestic and international work and cooperation
- Co-lead with Kingdom of Denmark
- Two conferences:
  - ARTEK, Sisimuit, Greenland - April 2016
  - WIHAH, Anchorage, AK – Sept 2016

Project Desired Outcomes

- The conferences, their reports, and relevant side meetings will:
  - promote the exchange of ideas regarding technical, governance, and regulatory approaches and flexibility for safe sanitation systems.
- Survey of circumpolar WASH infrastructure
- Summary report to Ministers

ONE ARCTIC

ARCTIC COUNCIL

U.S. CHAIRMANSHIP

2015–2017

Climate Change, Disaster Resilience and Relocation at HUD

Danielle Arigoni,
Acting Director, HUD's Office of Economic resilience

Evolution of HUD's Resilience Work

1974+: CDBG

2000+: CDBG-Disaster Recovery

2010-2015: Innovative regional planning

2014-2016+: Rebuild by Design and NDRC

2010+: Priority goal for energy

2016+: ConPlan, vulnerability mapping and relocation

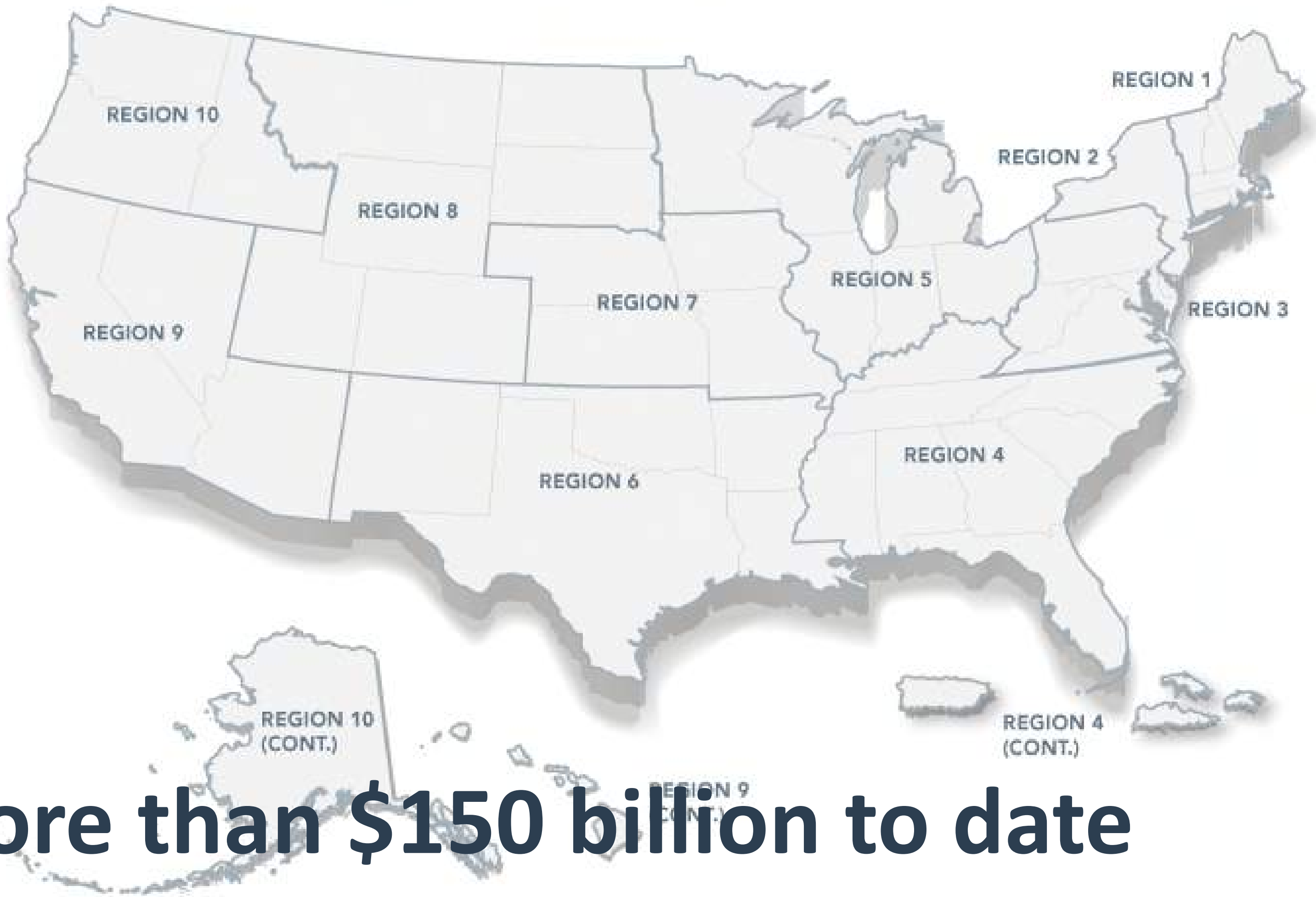
Core programs

Special initiatives

Strategic plan

Regulatory change

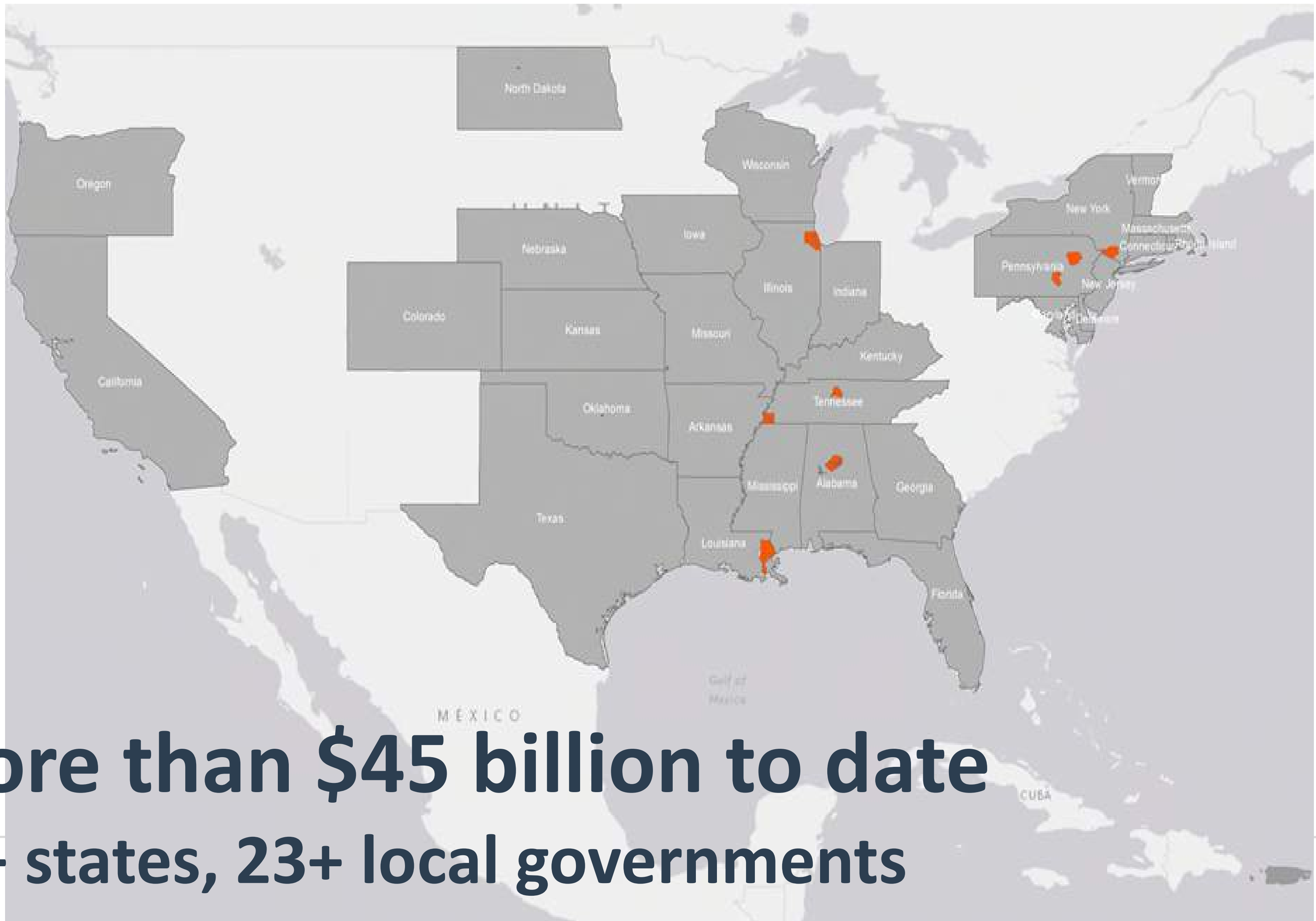
1974-present: CDBG **Block Grants**



More than $150 billion to date

1200+ grantees, 7000+ local governments funded

2005-present: CDBG **Disaster Recovery**



More than $45 billion to date

29+ states, 23+ local governments

CDBG-DR **Process**

CONGRESS → HUD → GRANTEE

CONGRESS

Approves appropriation

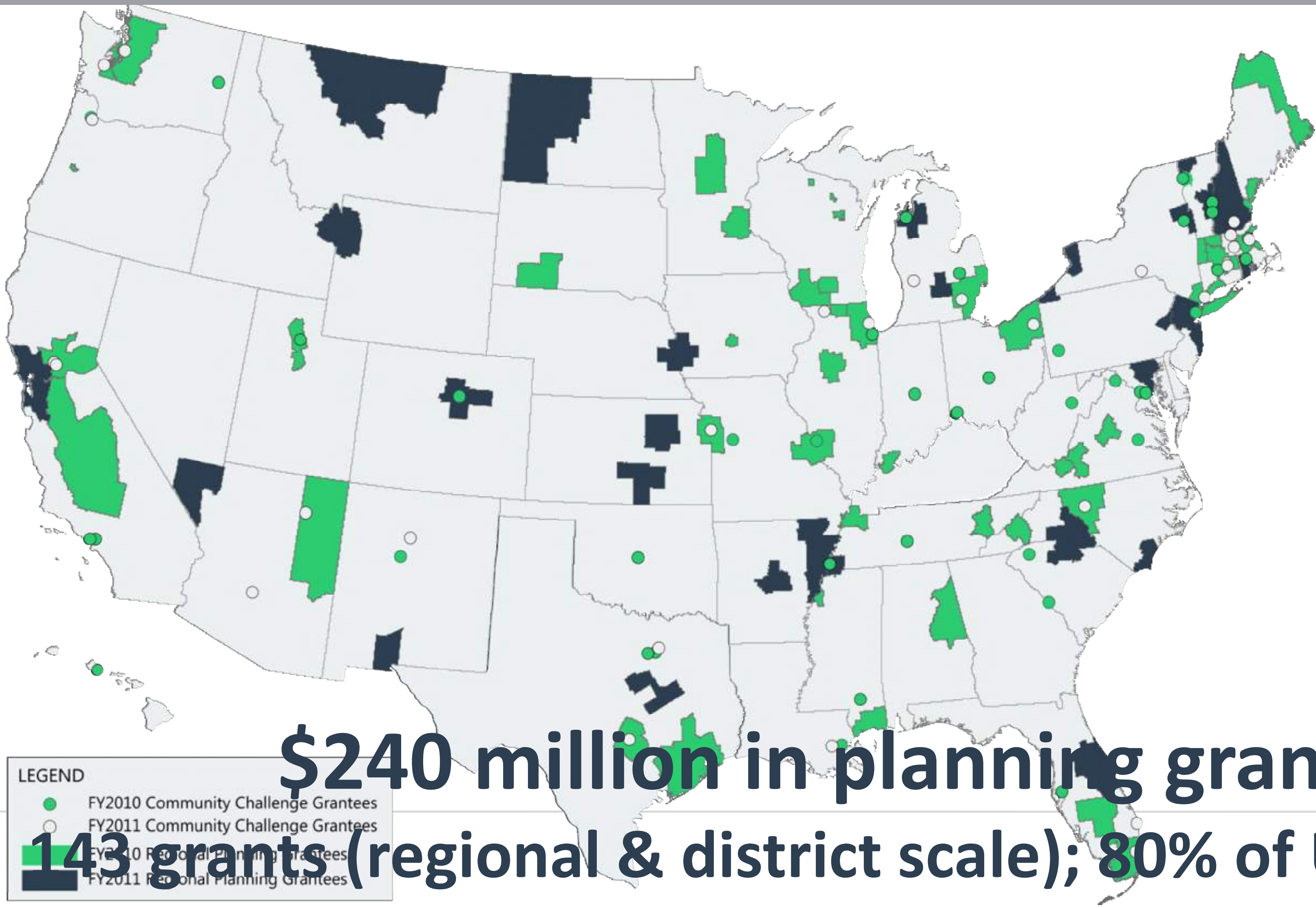
HUD

1. Calculates & announces allocations
2. Publishes a notice in the federal register
3. Awards funds

GRANTEE

1. Prepares action plan
2. Administers programs or activities or works with another entity to distribute funds

2010-2015: **Sustainable Communities** Planning Grants



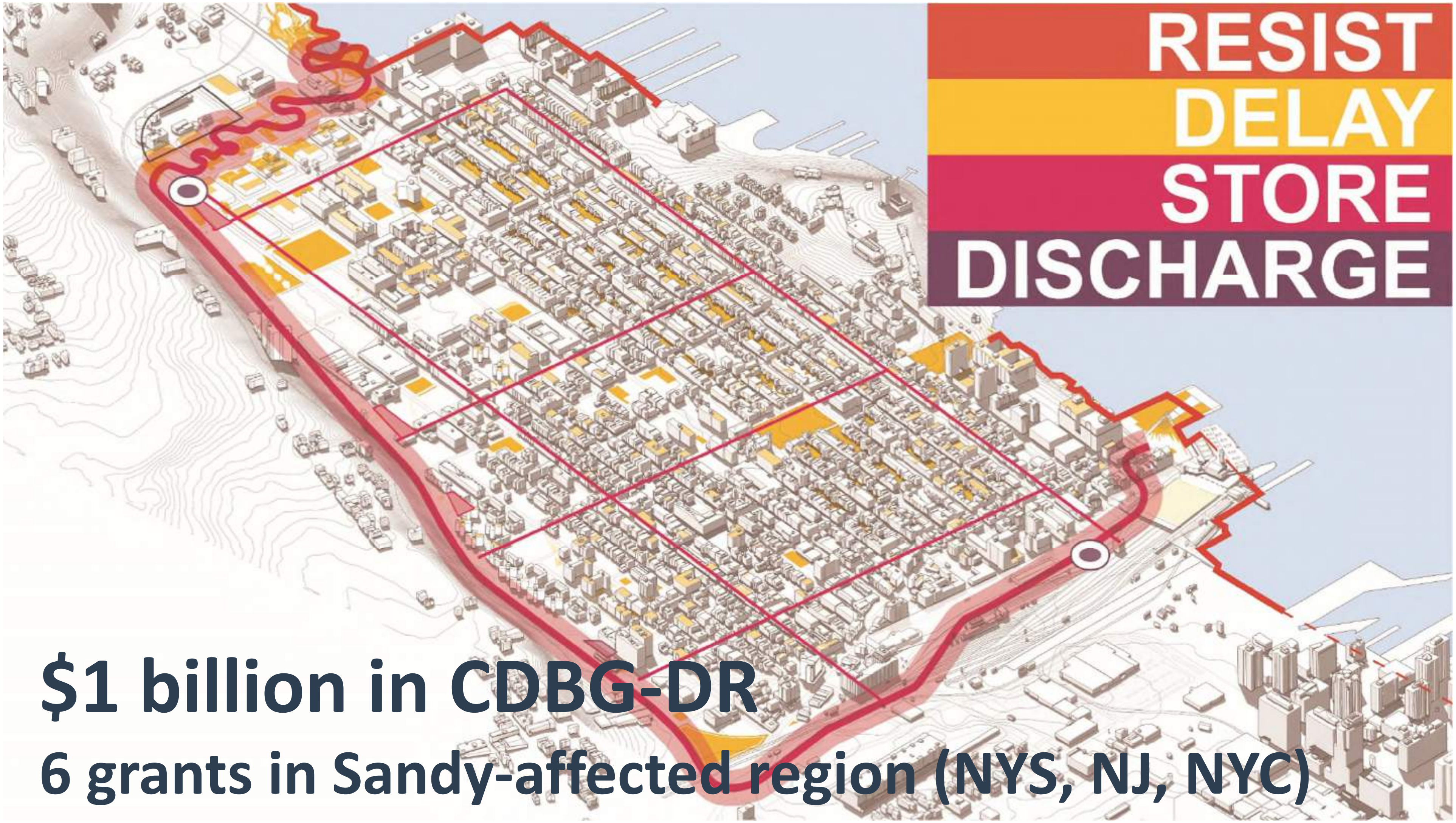
$240 million in planning grants

143 grants (regional & district scale); 80% of US

Sustainable Communities Plans

- Economic development and diversification plans
- Climate change and adaptation plans
- Increasing housing and transportation choices
- Modernizing zoning codes and land use provisions
- Affordable housing studies and plans
- Green infrastructure
- Fair Housing and Equity Assessments (FHEA)

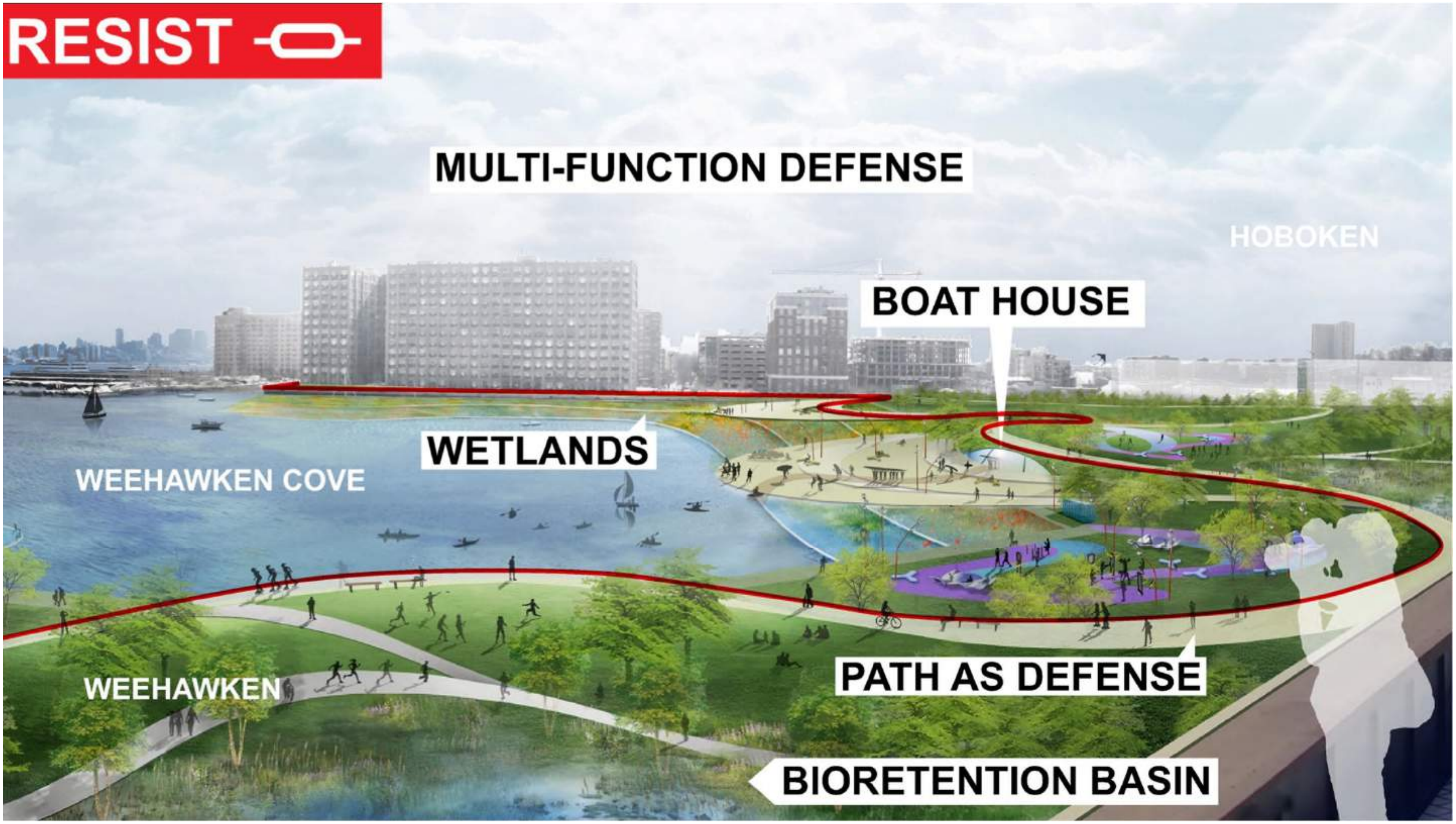
2014: **Rebuild by Design**



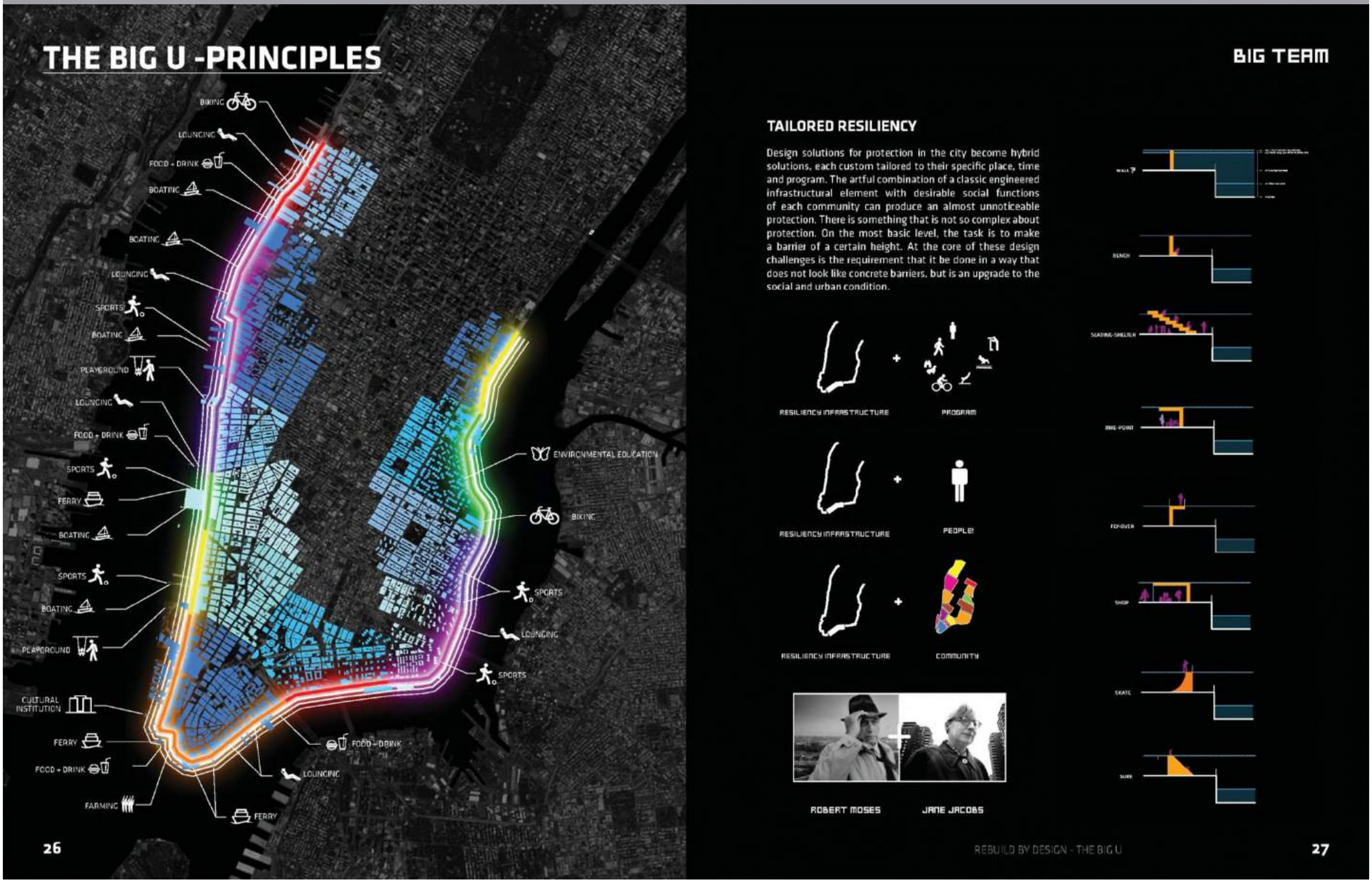
$1 billion in CDBG-DR

6 grants in Sandy-affected region (NYS, NJ, NYC)

Rebuild by Design



Rebuild by Design

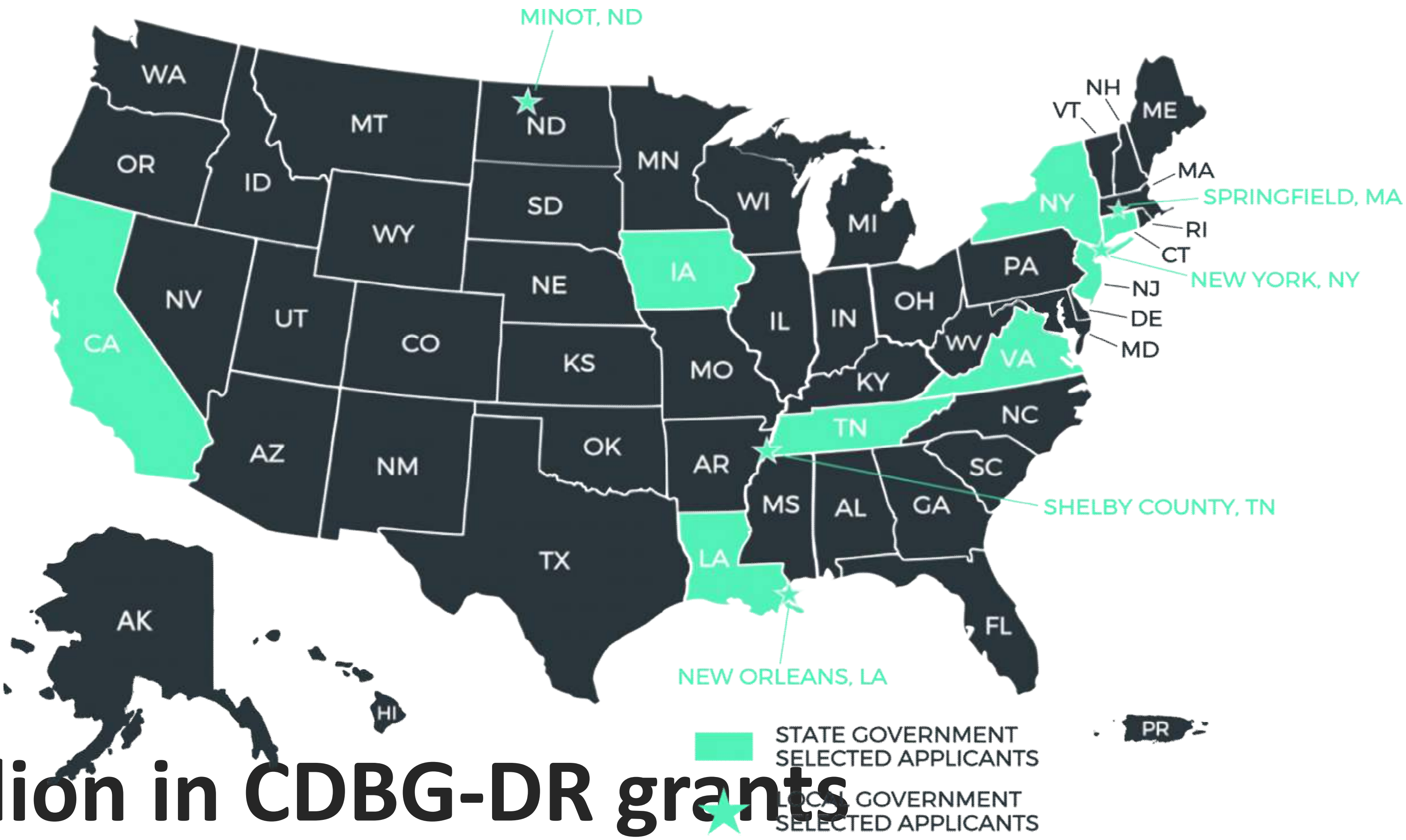


Rebuild by Design

THE EAST RIVER PARK BIKEWAY

The East River Bikeway and park service road undulate with the base of the berm, creating diverse biking and jogging experiences. Benches wrap around existing trees, creating intimate seating nooks and preserving the park's canopy.

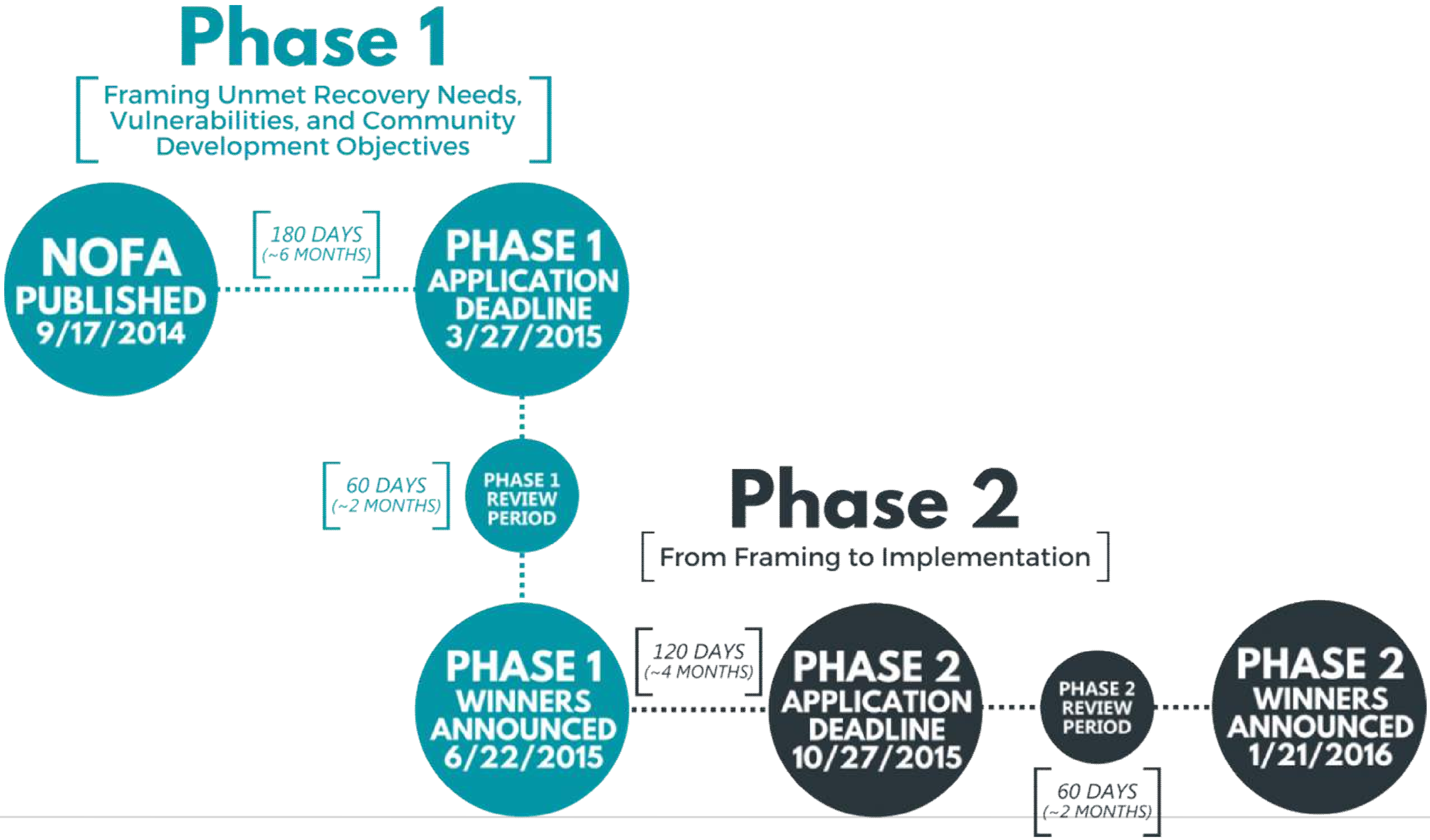
2016: National **Disaster Resilience** Competition (NDRC)



$1 billion in CDBG-DR grants

13 grantees: 8 states and 5 local governments

NDRC **Process**



NDRC **Goals**

1. Fairly allocate funds from PL 113-2 CDBG-DR pool
2. Apply science-based and forward-looking risk analysis
3. Institutionalize thoughtful, innovative, and resilient approaches
4. Provide resources to recover from disaster while making them more resilient to a range of shocks and stresses
5. Fully engage stakeholders
6. Leverage investments from local, state, federal and philanthropic partners

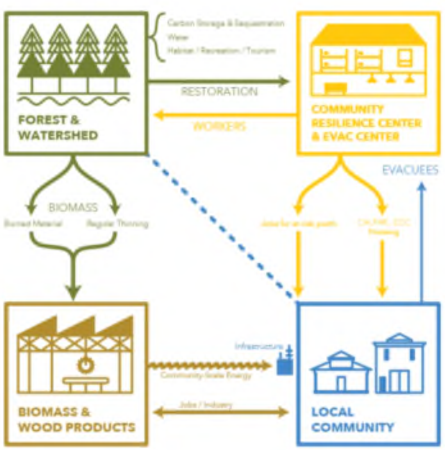
NDRC **Awards**

Applicant	CDBG-NDR Nationwide Funds	CDBG-NDR Set-Aside Funds	Total CDBG-NDR Award
State of California	$70,359,459		$70,359,459
State of Connecticut	$54,277,359		$54,277,359
State of Iowa	$96,887,177		$96,887,177
State of Louisiana	$92,629,249		$92,629,249
City of New Orleans, LA	$141,260,569		$141,260,569
State of New York		$35,800,000	$35,800,000
City of New York, NY	$45,800,00	$130,200,000	$176,000,000
City of Springfield, MA	$17,056,880		$17,056,880
State of Tennessee	$44,502,374		$44,502,374
Shelby County, TN	$60,445,163		$60,445,163
City of Minot, ND	$74,340,770		$74,340,770
State of New Jersey		$15,000,000	$15,000,000
Commonwealth of Virginia	$120,549,000		$120,549,000
Grand Total	**$818,108,000**	**$181,000,000**	**$999,108,000**

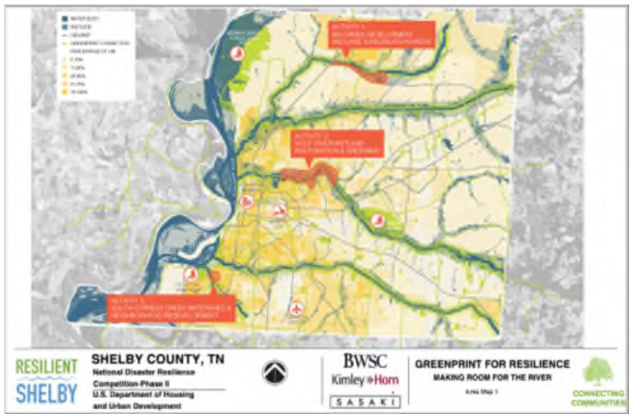
NDRC **Awards**

California | **Shelby County, TN** | **State of Louisiana**

California



Shelby County, TN



State of Louisiana

NDRC Progress in **Resilience Policy**

Activities featured :

- Resettlement away from vulnerable areas
- Housing elevation/retrofits
- Alternative energy generation/distribution
- (Lots of) green infrastructure
- Local economic development
- Workforce training
- Expanded transportation networks
- New parks/recreational areas
- Innovative financing structures
- Enhanced local planning
- Energy-efficiency
- Evaluation/monitoring

Major policy achievements:

- Broad understanding of “resilience”
- Data-driven planning
- Deep citizen engagement in process/visioning
- Long-term commitments made by all applicants
- Alignment with other plans
- Connection to previously-funded regional sustainability plans
- Diversity of state/city agencies comprising teams
- Focus on metrics … how to measure resilience
- Widespread use of green infrastructure as solution
- Adoption of “single investment, multiple benefit” ethos

2010+: HUD **Priority Goal for Energy**

1.2 million green and healthy homes

Via HUD investments and voluntary partnerships

(Better Buildings Challenge, Renew 300)

2016+: Secretary’s Goals for **Climate**

New ConPlan rule (disaster/climate considerations); vulnerability mapping; equitable relocation principles


HUD.GOV/resilience
U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
COMMUNITY PLANNING DEVELOPMENT

Chugach Mtns
Near Portage Glacier
Spring 1976

Climate Change Consequences

Climate sets the stage upon which the evolutionary and ecological play is enacted

Thinking About Water

Water has always appeared available,
we don't often think directly about what services this vital resource provides-
Water is rare, in northern/polar deserts.

Life becomes possible and is sustainable in otherwise extreme and variable northern environments.

Kugluktuk, Nunavut
May 1998

Agricultural Research Service

Accelerating Climate Change:

A Warming World and Consequences for Sustainability and Safety of Arctic Water and Food Resources

Conference on Water Innovations for Healthy Arctic Homes
Anchorage, Alaska/ September 2016

Eric P. Hoberg

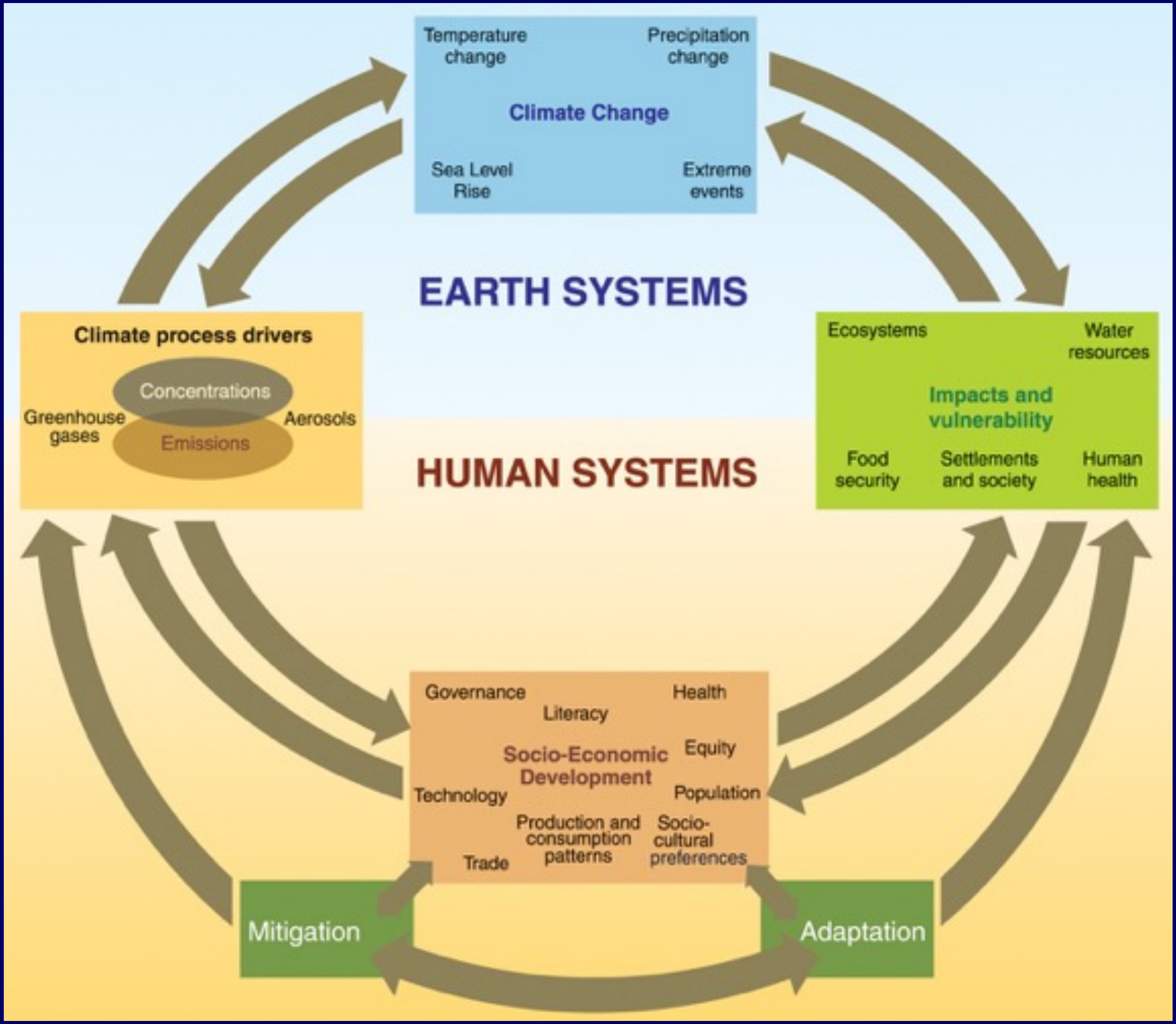
US National Parasite Collection
Agricultural Research Service, US Department of Agriculture
and
Smithsonian Institution

Climate and Biodiversity

Climate- mediates distribution and persistence of permissive environments

Climate- alternating episodes of perturbation and stability mediate faunal assembly/ emergent disease

Climate interacts with evolution, ecology and biogeography determining the structure of the biosphere



IPCC AR4 Synthesis, 2007

Phases of Water

Pallasjärvi, Finland
June 2004

Phases of Water

Water and phases of water are central to living in circumpolar environments.

Phenology/ Phases of Water Determine-

- Drinking sources, suitability, availability, safety
- Travel pathways (duration of ice versus liquid)
- Integrity of aquatic ecosystems
- Access, availability, security for food resources

Climate – Water Challenges

- Lack of consistent access to potable drinking water/ sanitation infrastructure
- Increasing exposures to contaminated surface water resources
- Circulation of pollutants and pathogens in traditional diets drives loss of access to reliable water-based food resources

Anticipating Climate Warming

Pallasjärvi, Finland
June 2004

Anticipating Climate Warming

- High sensitivity to accelerating warming
- Declining snow fall, reduced precipitation in a dry environment
- Reduced duration- snow and ice cover
- Frequency spring floods/ storm surges
- Accelerated melt, glaciers/ permafrost
- Declining lake abundance, draining wetlands on discontinuous permafrost

Increasing Temperature

- Broadening seasonal windows for circulation and exposures to pathogens
- New permissive conditions/ development
- Geographic range expansion/ invasion

- Extended persistence of pathogens
- Tipping points & thresholds in transmission
  - Shifts in years, not months
- Potential for extinction and extirpation

Consequences Climate Warming

- Unpredictable water availability
  - Fragile infrastructure water/sanitation
- Long range atmospheric transport organic pollutants
- Bioamplification through food-chains for mercury and POP’s
- Increasing anthropogenic stressors
- Cumulative and synergistic effects

Influence of Climate/ Water

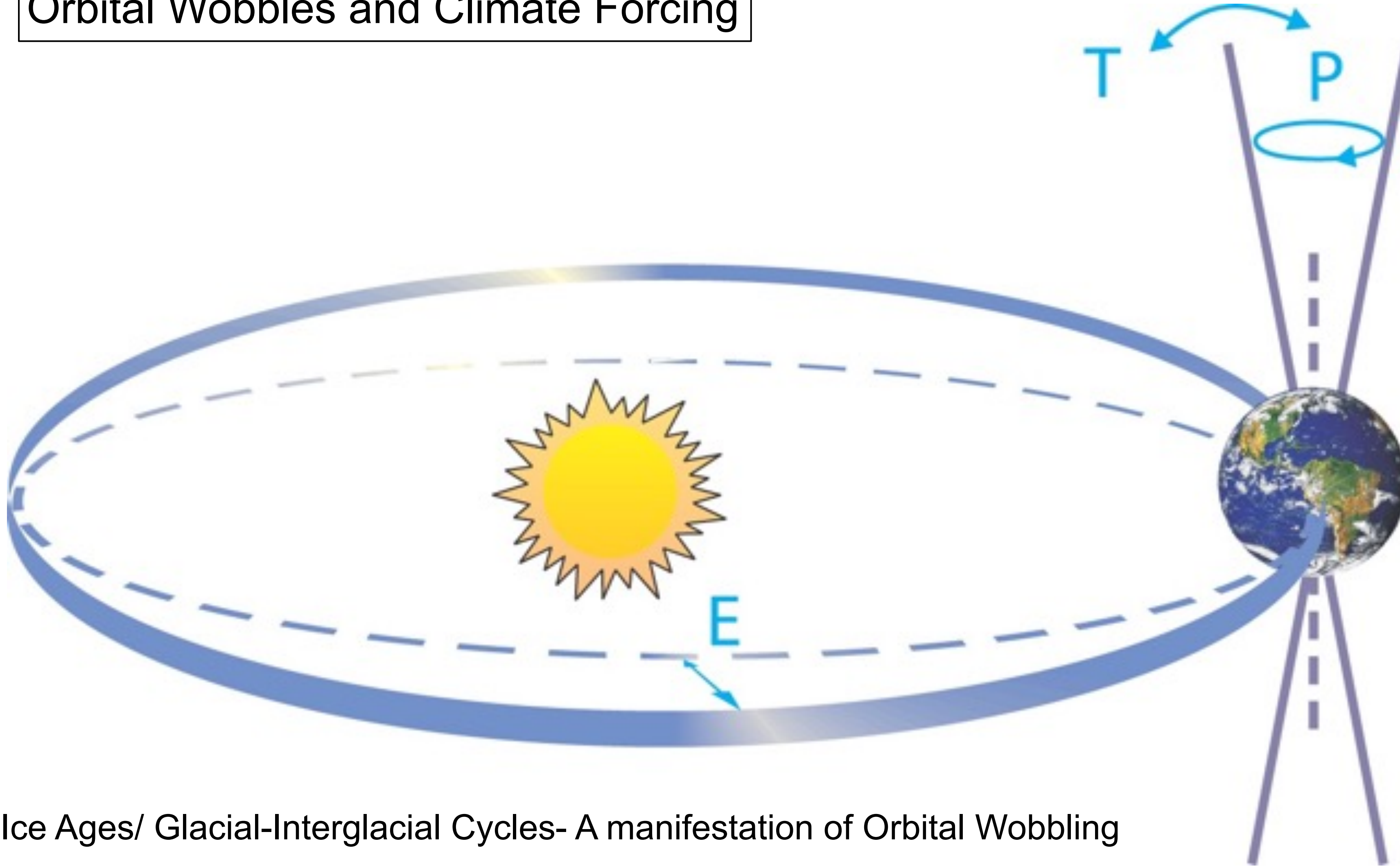
- Spatial/ Temporal distributions of wildlife/ migration, habitat use
- Wildlife numbers, population structure
- Access to wildlife resources
- <u>Pathogens are part of equation</u>
- Reduced reliance on wildlife resources?
- Cascading effects on a subsistence culture in northern communities?

Deline, NW Territories/ S. Kutz Photo

Wobbling Climate = Complexity

- Geological scale- (orbital dynamics)
  - glacial-interglacial
  - Trends in regional geography/ faunal dynamics
- Millennial scale (orbital/ solar dynamics)
- Decadal Oscillations/ Ephemeral Events
  - Ocean-atmosphere interactions, volcanism
  - ENSO, PDO, NAO (Regime Shifts)
  - Shifting balances in permissive environments
- Anthropogenic, directional warming

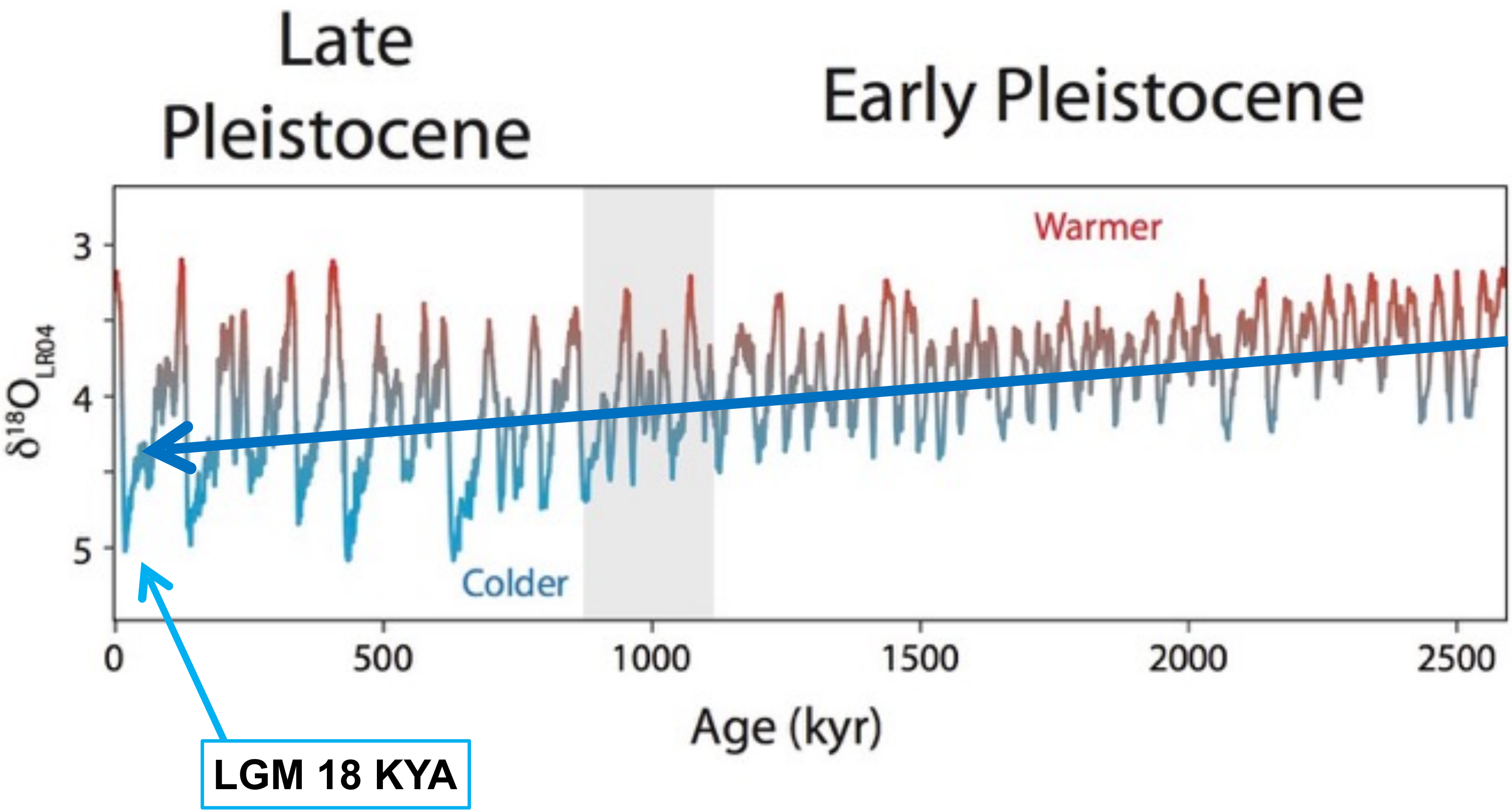
Orbital Wobbles and Climate Forcing



Ice Ages/ Glacial-Interglacial Cycles- A manifestation of Orbital Wobbling

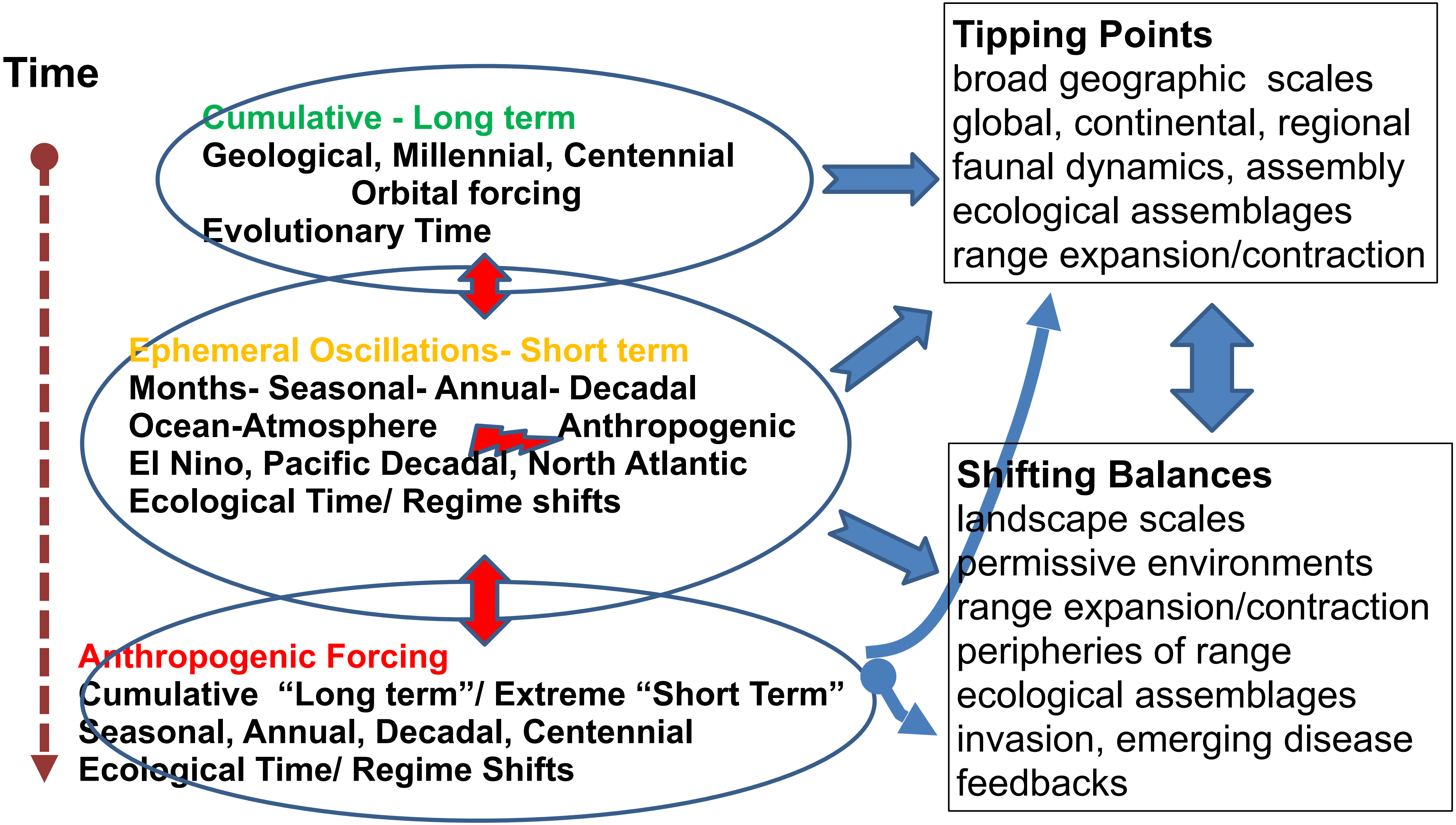
IPCC AR4 WG1 Chpt 6. (2007)

Quaternary Climate Oscillations, 2.5 MY/ Milankovitch Cycling



- Environmental cooling from late Pliocene
- Filter bridge- Northern intercontinental expansion and exchange
- Glacial-Interglacial episodes define Quaternary history (> 20)
- High amplitude, 100 KY cycles after 1 MYA (sea levels)

Wobbling Climate Drivers- Cycles Within Cycles/ Ecological Collision



Layered, multifactorial, hierarchical, across evolutionary/ ecological time.
Interacting with developmental rates, thresholds, tolerances, resilience.

Oscillating Climate Drivers

- Ecosystems in episodic collision
- Dynamics of faunal mixing (Mosaics)
  - Opportunity for host switching
- Equivalence of mechanisms/ outcomes
  - Spatial- Continental to Landscape
  - Temporal- Evolutionary to Ecological time
- Establishes historical foundation

Northern Biosphere
In Transition

Arctic Coastal Plain
Chukotka –
August 1981

Themes for a Northern Fauna

- Dynamic climate variation over time
- Crucible of Ecological Perturbation
- Episodic, cyclical or recurrent processes
  - Waves of faunal expansion / isolation
- Invasions on temporal scales linking evolutionary to ecological time
- Spatial scales from landscapes to regions
- Faunal mosaics in space and time

Natl. Geographic Magazine

A Contemporary Framework-

Anthropogenic Climate Drivers- Accelerating Change

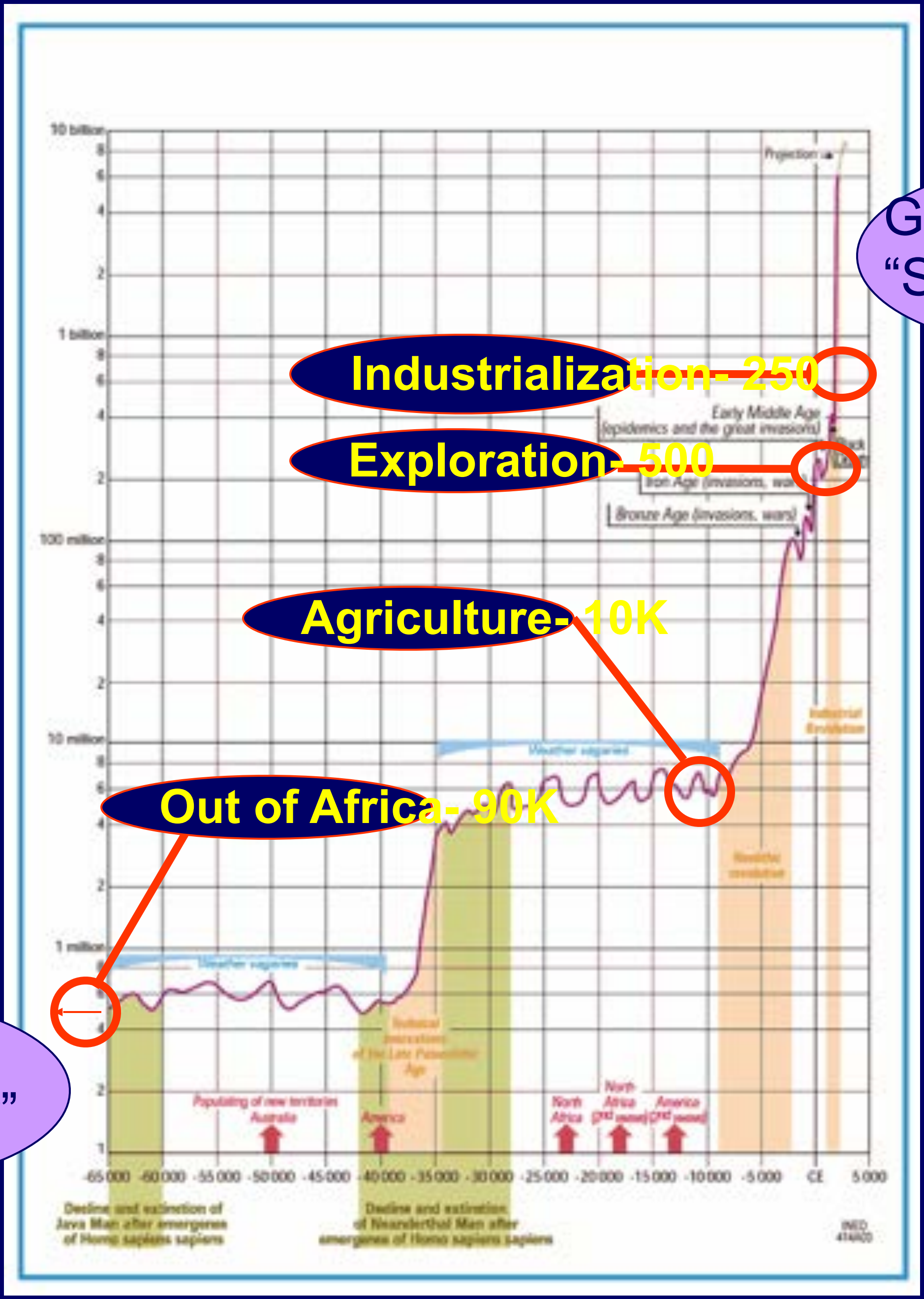
- Novel environments/ Invasion
- Changing geographical distribution of environments/ Habitats in transition
- Rapid changes in faunal distribution
- Secondary contact zones (recombination)
- Accelerated host switching
  - introduction of novel pathogens
- Development of Geographic Mosaics
- Ephemeral emergence for disease

Human Dimensions

Inukshuk
Coppermine River
Nunavut

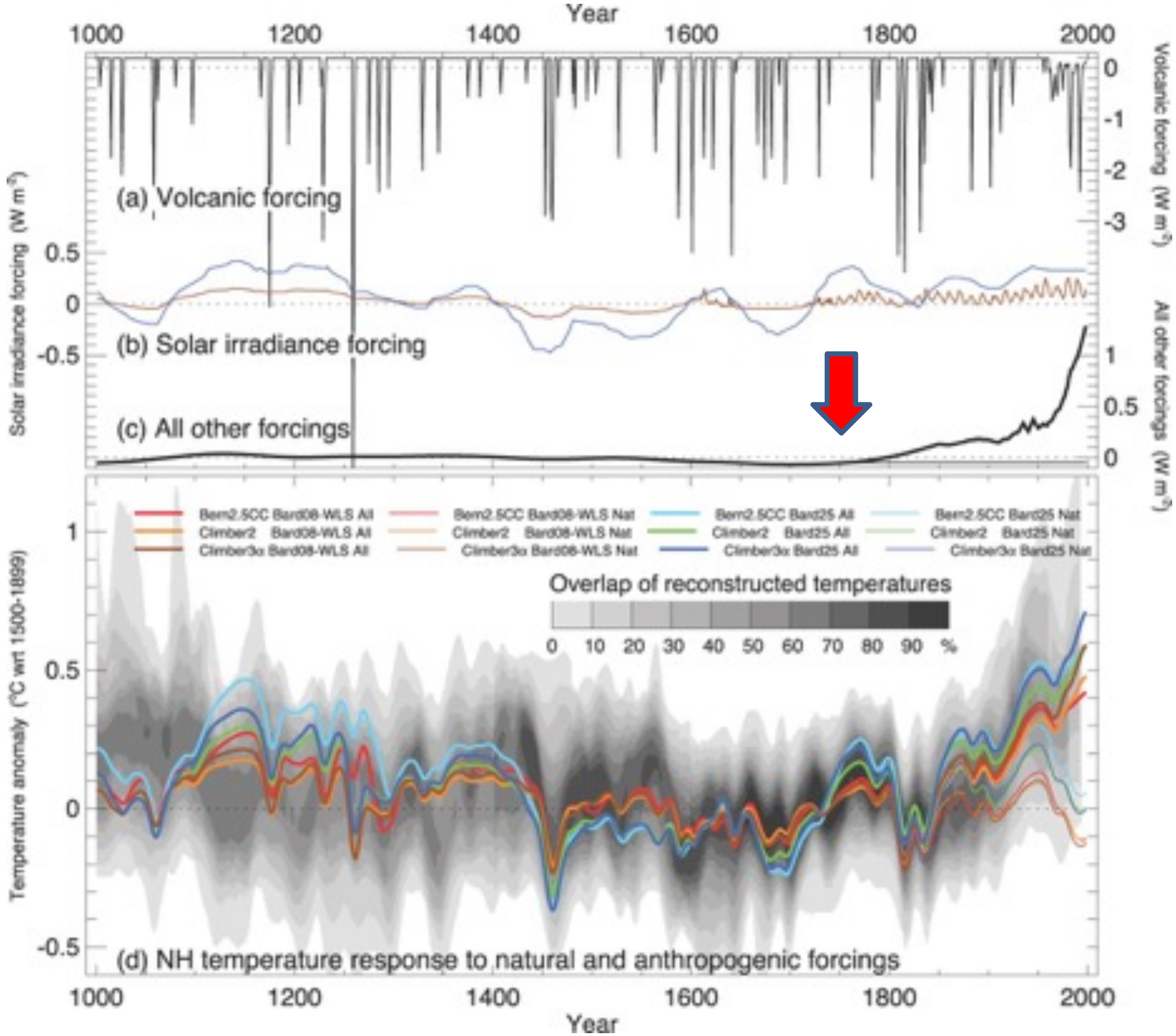
-Tipping Points-
-Thresholds-

Convergence
of
Earth
&
Human History

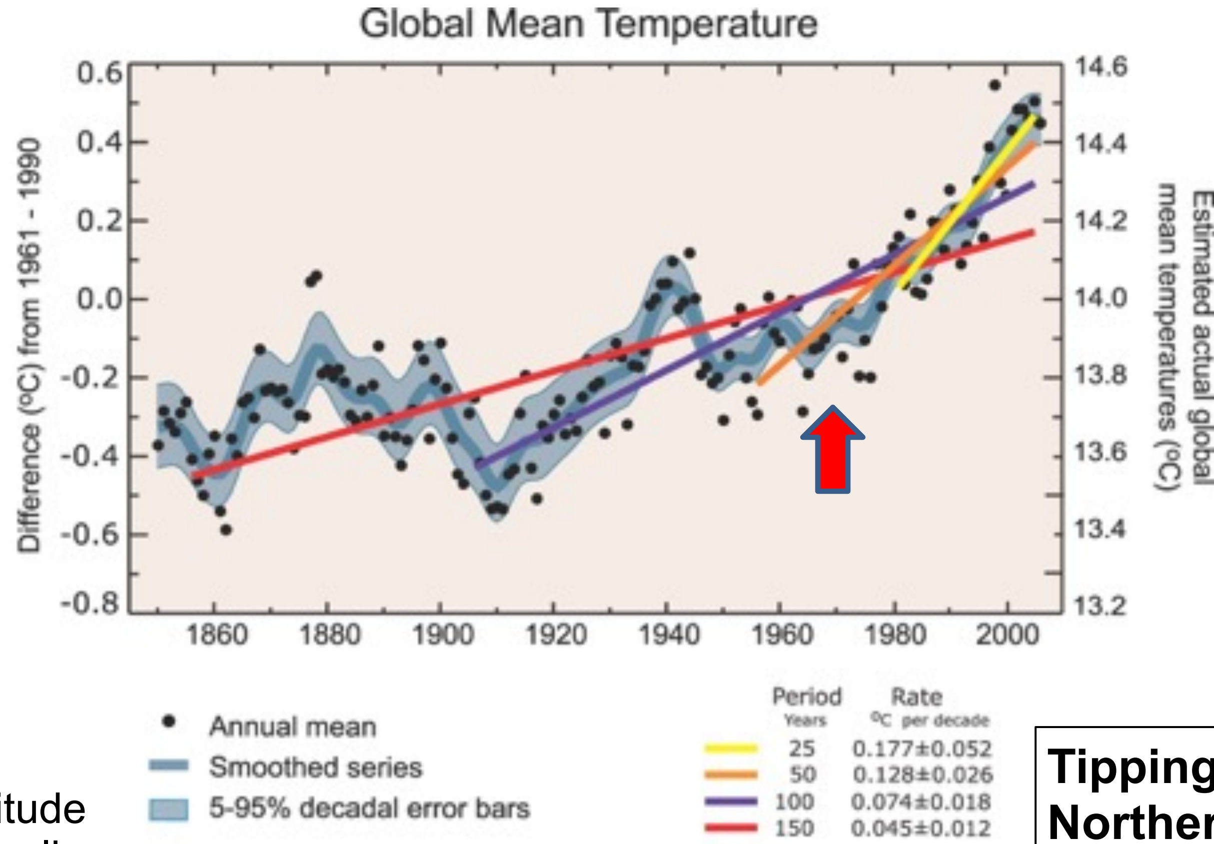


Modified from- Institut national d' études Démographiques (2008)

Climate/ Temperature Forcing Past 1KY

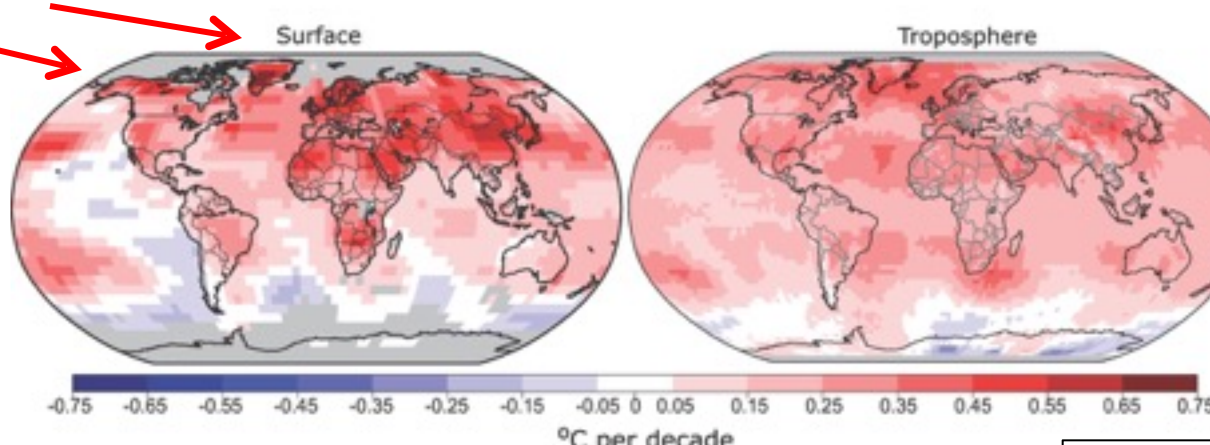


IPCC AR4 WG1 Chpt 6. (2007)



Tipping Point 1970's
Northern Systems

Northern High Latitude
Temperature Anomalies



Rates of temperature increase > 2 times global average in past 50 yrs

IPCC AR5 WGI (2013)

Cumulative knowledge from a century of biodiversity exploration

Brooks Range, Alaska 1949

Photo: R.L. Rausch; Courtesy U Ala

Arctic Parasite Context-

- Viruses, Bacteria, Protozoa, Fungi, Metazoa
- 40-50% of global diversity/ 75% trophic links
- 7100 spp. metazoan parasites in vertebrates?
  - Validate diversity through survey and inventory
  - Diversity of viral and bacterial pathogens?
- Considerable cryptic diversity?
- Absence of long term baselines
- Highly responsive to perturbation

Arctic Parasite Stories-

- Key ecological drivers, shaping ecosystems
- Disease agents, wildlife/ humans (zoonoses)
- Food safety, food security, sustainability
- Historical ecological/ biogeographic indicators
- Indicators of ecological stability and change
  - Conditions on distant flyways/ staging areas
  - Altered Phenology, Mismatches, Trophic shifts
  - Invasions, Faunal Mixing, Emergence
  - Changing Interfaces and Ecotones

Pathogens & Climate Change

- Long term/ Cumulative “in situ” processes
  - Responses to trends in warming
  - Decadal and longer
  - Extension of growth season; tolerance, development & generation time; amplification; emerging disease
  - Tipping points for changing dynamics of transmission
  - Latitudinal & altitudinal range shifts
  - Host-switching? Sympatry, “Ecotone” or Border effects
  - Subtle effects- challenge to identify

- Short-term/ Ephemeral “external” processes
  - Responses to extreme weather events
  - Temperature anomalies/ humidity
  - Explosive emergence of disease

Outcomes of Climate Warming

- Northern biotic expansion
- Ecosystems in collision/ faunal mixing
- Breakdown in ecological isolation
  - Host switching by parasites at interface newly emerging ecotones (contact zones)
- Shift in permissive environments
  - Altered developmental thresholds
  - Accelerated development/ amplification
  - Extinctions related to resilience

Climate - Water - Pathogens

- Northern expansion over time/ potential for invasion or introduction
- New pathogens/ *Icthyophonus*
- Increasing abundance of pathogens now limited by temperature
- *Vibrio* bacteria distribution

Climate - Water - *Vibrio*

- 50-100 years, shifting distribution
  - 15 C threshold for *Vibrio* development
- Rising sealevel/ temperature
  - Changing precipitation/ runoff, salinity
- *Vibrio* habitat increases 60% in Alaska
  - Naturally occurring pathogen coastal zone
  - Gastroenteritus, septecemia

Kugluktuk, Nunavut- April 1994

Human-Climate Intersection

- Increasing population pressure
- Irreversible infrastructure
  - Changing access (e.g., mineral extraction)
  - Permanent road systems
- Eutrophication in rivers/lakes exacerbated by reduced flows
- Impacts on availability aquatic-based foods (fishes, invertebrates)

Future Of Accelerating Perturbation

Jokül **Sarlon**
Southern Iceland
2004

Things We Know?

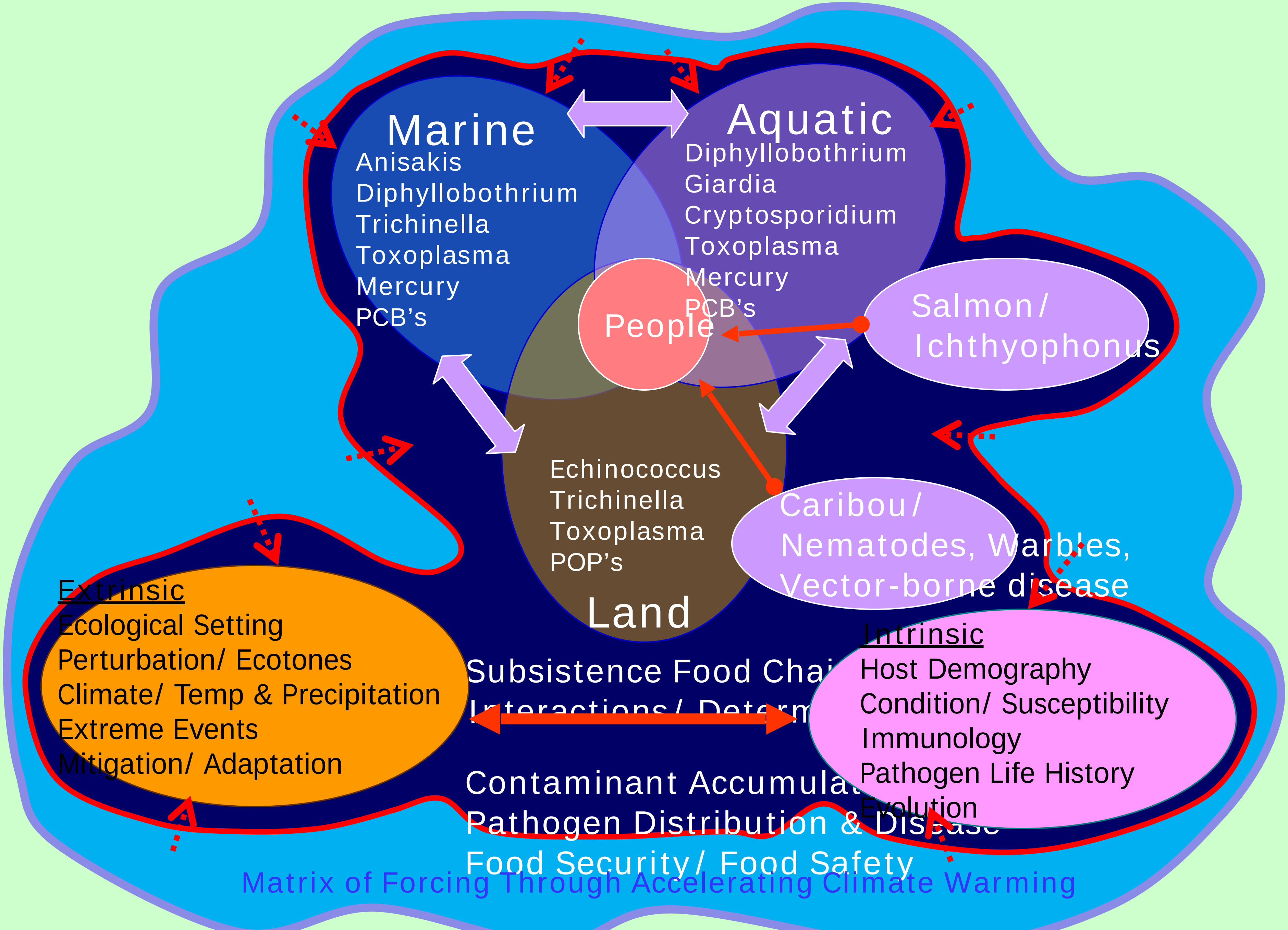
- Climate change is accelerating
- Increasing abundance of pathogens
- Climate has direct influence on distribution for pathogens/ diseases
- Host-Species distributions change
- Switching to new hosts drives disease
- Aquatic, Marine, & Terrestrial systems

Things We Need to Know?

- Pathogen diversity
- Distribution- hosts & geography
- Effects on hosts
- Potential for interaction with climate
  - development, thresholds, tipping points,
  - Resilience, tolerances

Things We Don’t Know?

- Challenge to predict dynamic change
- Specific biological parameters
- Detailed data for pathogen distribution
- Unanticipated cascades
- Consequences for perturbation of key vertebrates/invertebrates



Dudley, Hoberg et al. EcoHealth 2015

BioDiversity Information?

- Ecosystems in collision
- Environments in Rapid Transition
  - Indicators of loss, introduction, stability?
  - New associations/ emergent disease
- Permanent Record of Faunal Structure?
- Baselines to Assess Stability & Change
  - What is in an environment?
  - What is nearby and can invade?
  - Understanding the players = identification of pathways
- Survey, monitoring & archives

Transboundary Pathways

Landscapes → Information Webs

Integrating Specimens - Observations

Ecosystems - Faunas – Species – Populations

Informatics Cross-Disciplinary Synergy

Archives for Biodiversity – Geography - Genetics - Genomics

Baselines, Surveillance, Temporal-Spatial Modeling

Using/Developing Information Linking TEK to Research Networks

Physical Processes Biological Outcomes

Tracking/ Anticipating/ Mitigating

Change Over Space and Time

Climate Change Cascades

Climate change can modify the interface for people & environment.

Exposure to pathogens through water-borne & food-borne pathways will be altered.

Pathogens & diseases in key mammalian, avian & fish species can influence availability, sustainability & suitability of food resources.

Pathogens & emergence of diseases can disrupt structure for aquatic, terrestrial & marine ecosystems.

Climate Change Predictions

Climate change will eliminate ecological barriers & constraints on development & distribution for pathogen transmission.

-creates new conditions-

Maps for distributions of hosts, pathogens & diseases will be redrawn.

Emergence of diseases & unanticipated "cascades" can influence terrestrial, aquatic and marine ecosystems.

Matakiel Is., Sea of Okhotsk, August 1988

The Impact of Water and Sanitation Services on Health

Tom Hennessy, MD, MPH
Director
Arctic Investigations Program
National Center for Emerging and Zoonotic Infectious Diseases
US Centers for Disease Control and Prevention (CDC)

Anchorage, Alaska
thennessy@cdc.gov

SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD
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SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD

HOME ABOUT SECRETARY-GENERAL GOALS TAKE ACTION KEY DATES MEDIA WATCH AND LISTEN

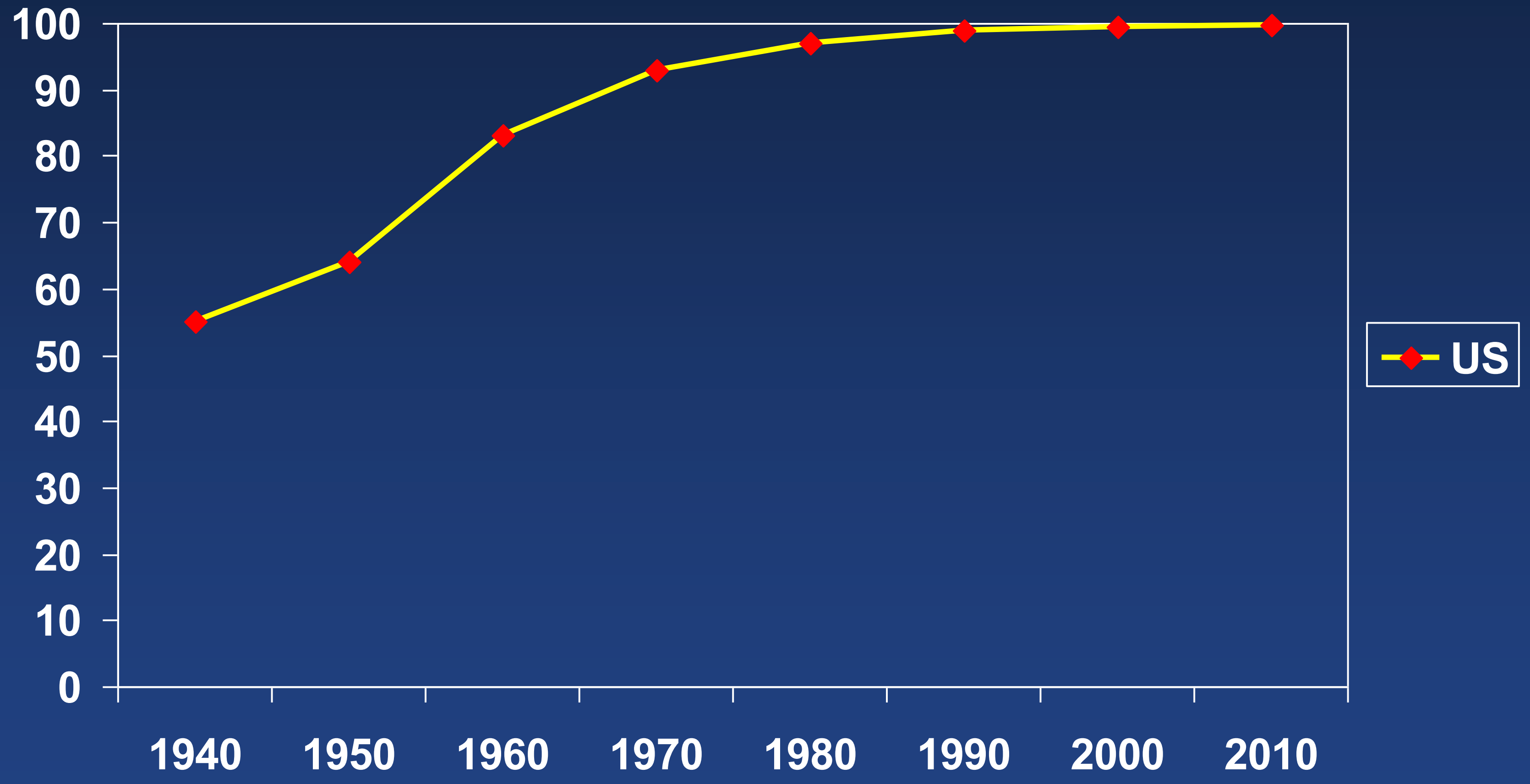
Goal 6: Ensure access to water and sanitation for all

Is water and sanitation service only a problem of the developing world?

Many Arctic and Subarctic residents don't have adequate access to in-home running water and sewer

Russia, Alaska, Canada, Greenland

Percentage of US homes with complete plumbing, 1940 – 2010, US Census



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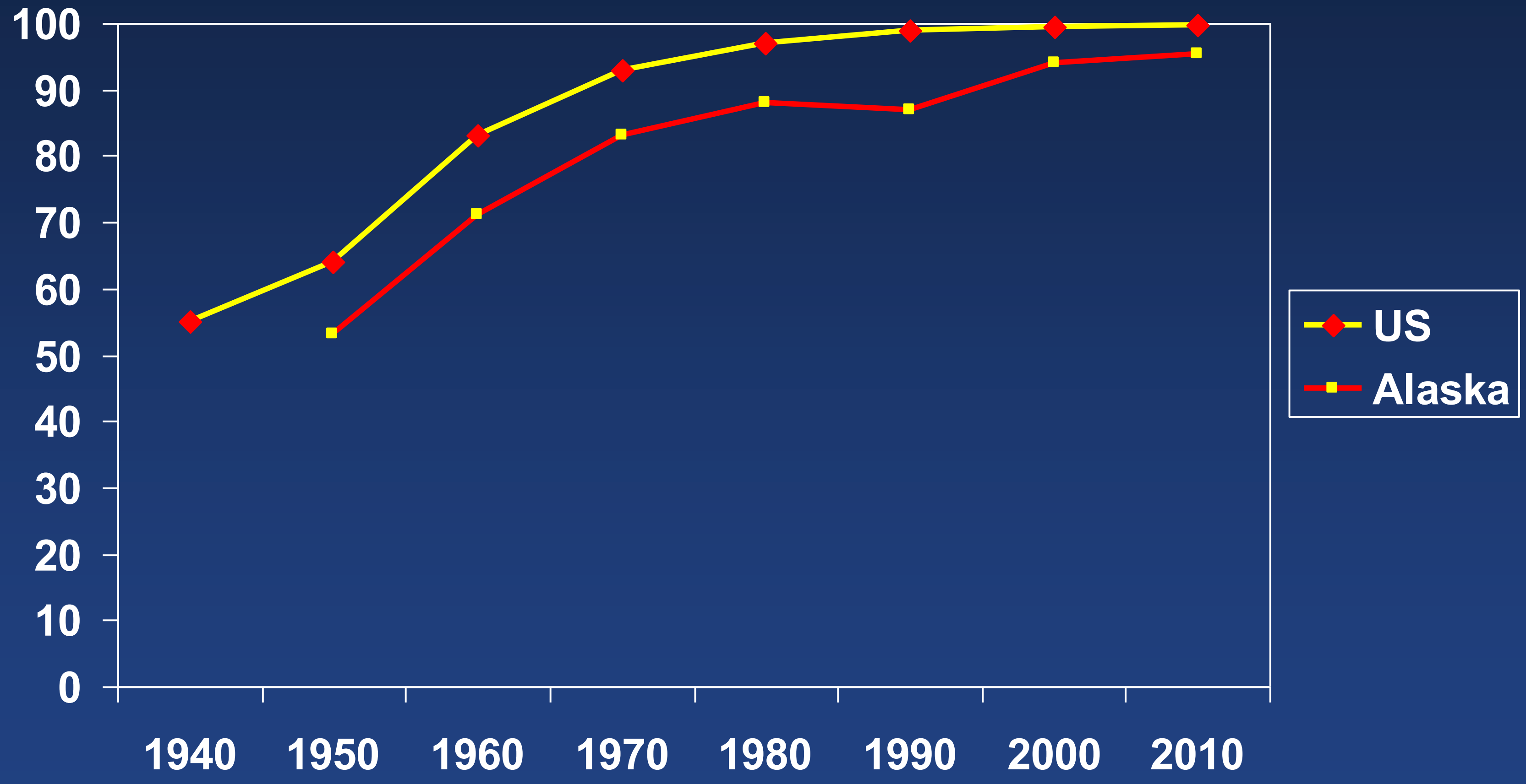

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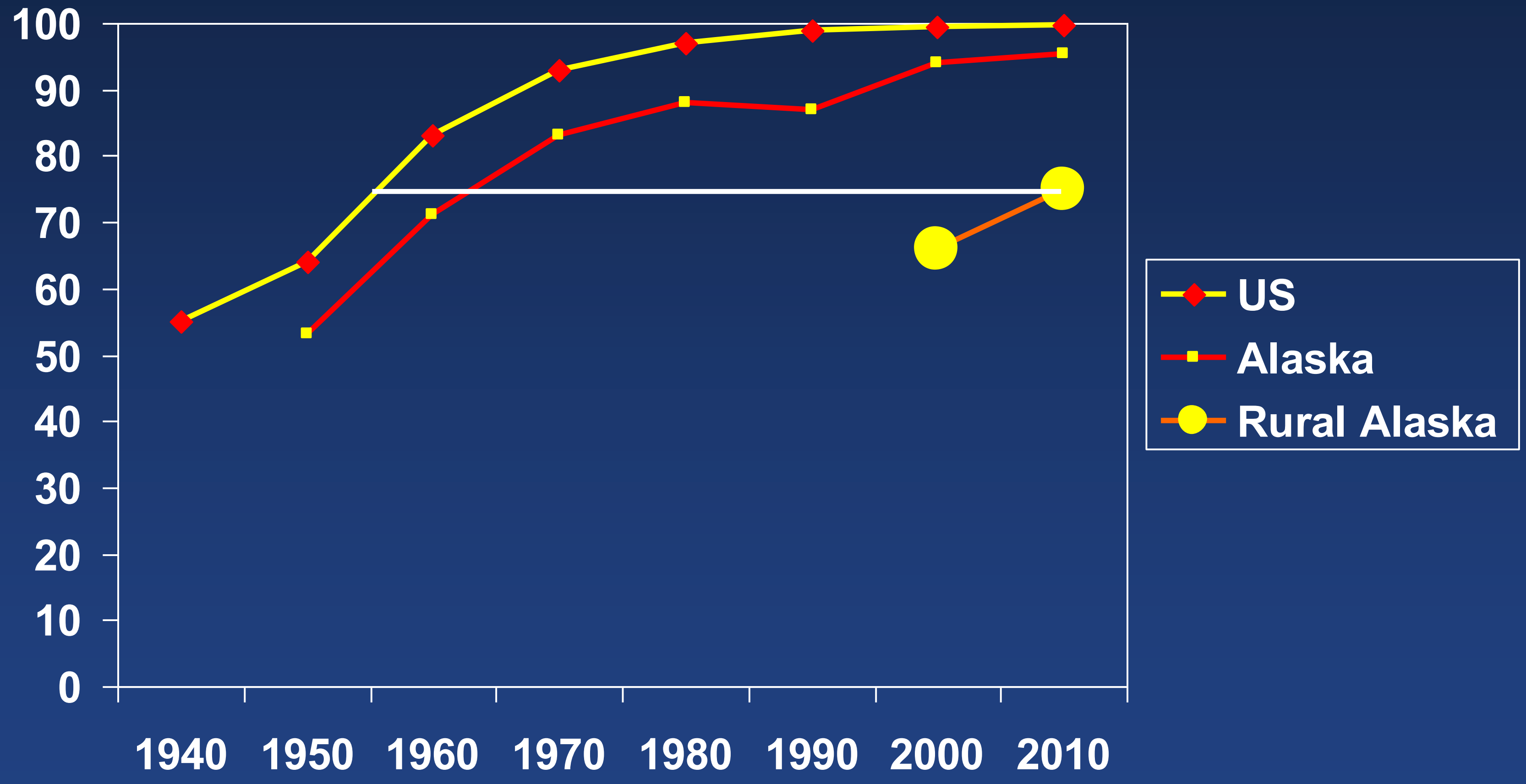
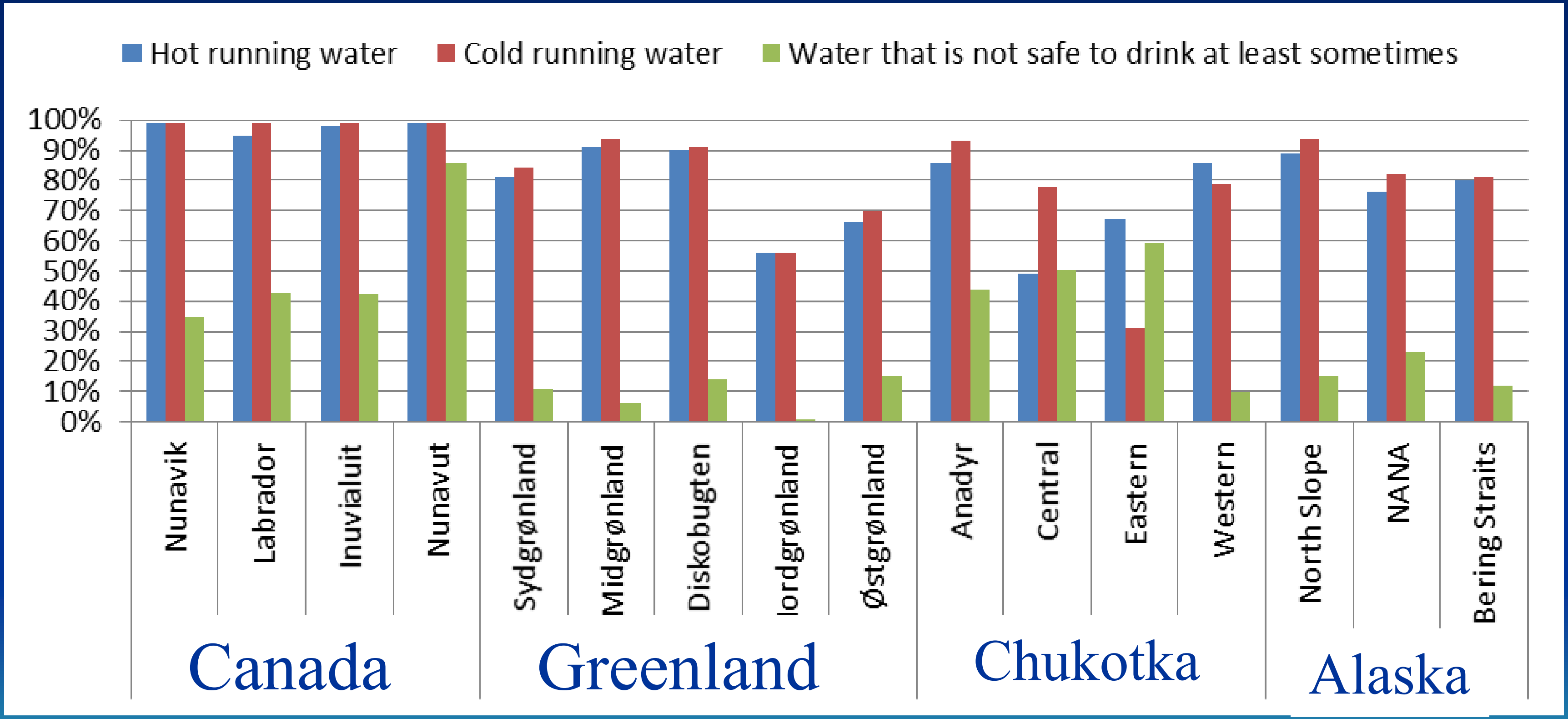


Sewer Service, Russian Arctic UN Development Report, 2006

In-Home Running Water Service, Survey of Living Conditions in Arctic, 2006



Main Message #1

- The Sustainable Development Goal for water and sanitation has not been met in the Circumpolar North
  - Alaska, Canada, Greenland, Russia

ONE ARCTIC

ARCTIC COUNCIL

U.S. CHAIRMANSHIP

2015–2017

Arctic Council Water/Sanitation Project

- "Improving Health through Safe and Affordable Access to Household Running Water and Sewer in Arctic and Sub-Arctic communities."
- Objectives:
  a) Promote innovations in water and sewer technologies and services provision.
  b) Document the status of water and sewer service and associated health outcomes.
  c) Describe climate-related vulnerabilities and adaptation strategies for community water and sewer systems and source water protection.
     a) Water and sanitation survey, open until Sep 30, 2016
     b) Jonathan Bressler in Climate Change session

http://www.artek.byg.dtu.dk/

Special ESPR issue on Sanitation in Cold Climate Regions

The journal Environmental Science and Pollution Research (ESPR) will be publishing a special issue focusing on Sanitation in Cold Climate Regions.

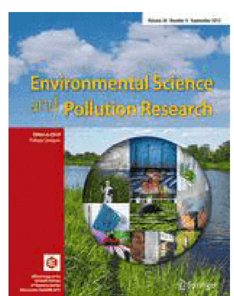
The special issue will feature both critical reviews and research papers and will include but not be restricted to these topics:

- Waste water
- Solid waste
- Water supply
- Health
- Safety
- Environmental impacts
- Treatment
- Infrastructural issues

The submission deadline for papers has been set as 31st of October 2016. Earlier submissions are encouraged, and papers will be published online as soon as they have been accepted for publication.

Download this document for information on how to submit your contribution to the ESPR special issue on Sanitation in Cold Climate Regions.

For further information about this special issue, please read this invitation letter or contact Associate Professor Pernille Erland Jensen.



Updated by Ingrid Vernimmen on 15 August 2016

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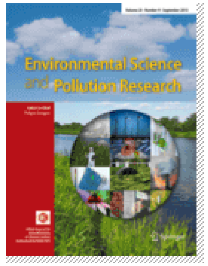

Environmental Science and Pollution Research

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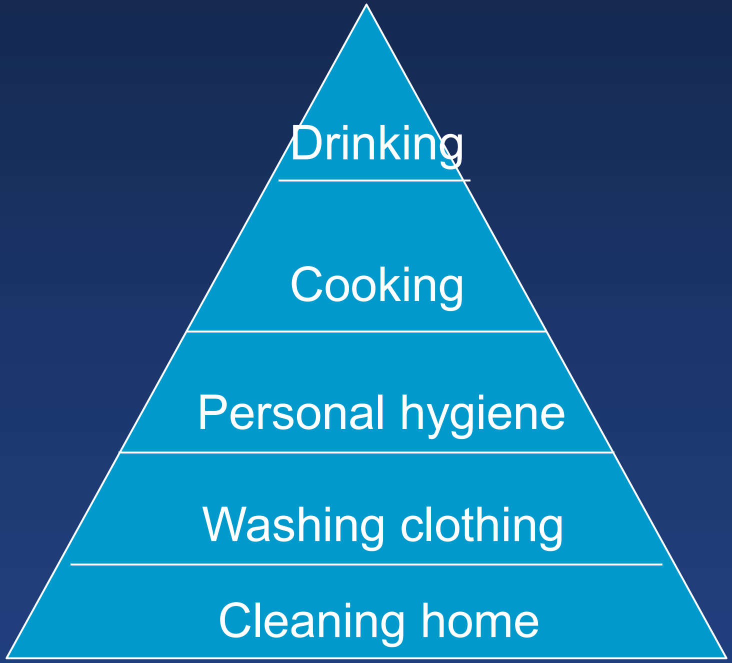
ADDITIONAL INFORMATION

Hierarchy of Water Requirements

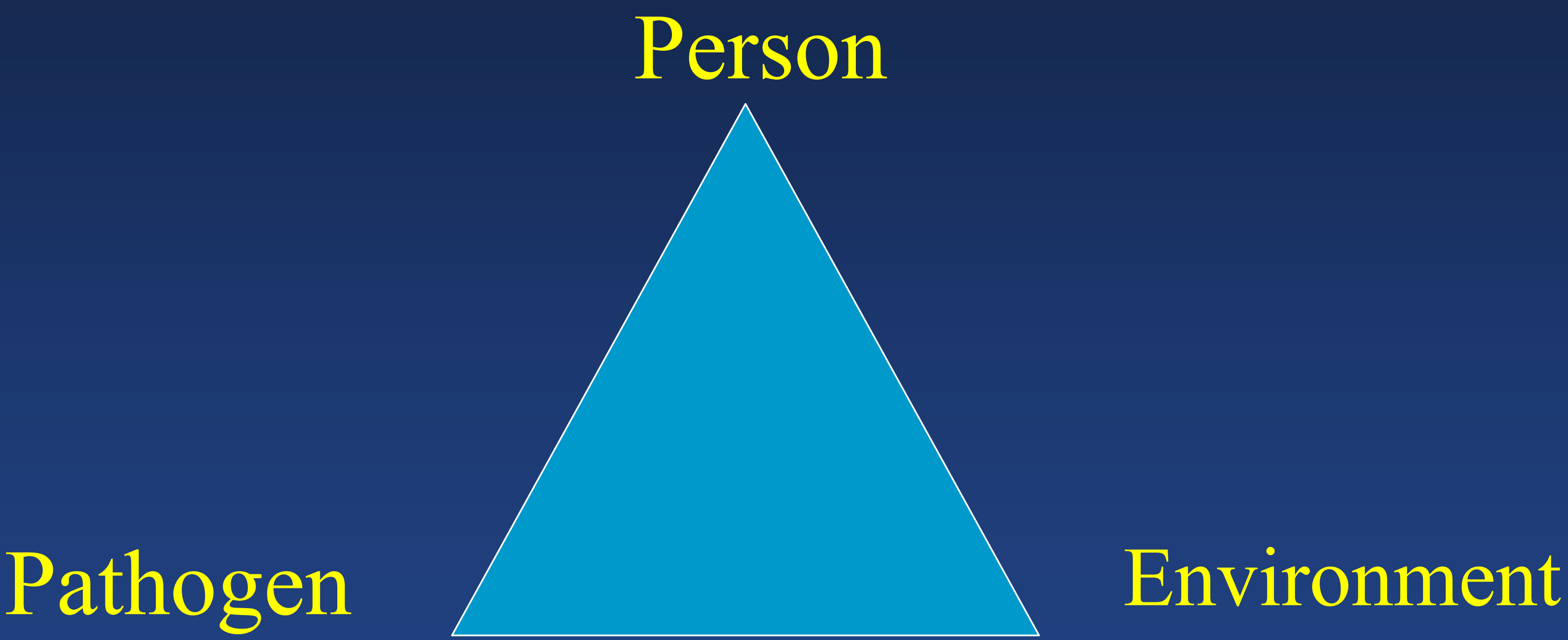


Factors Linking Water to Health

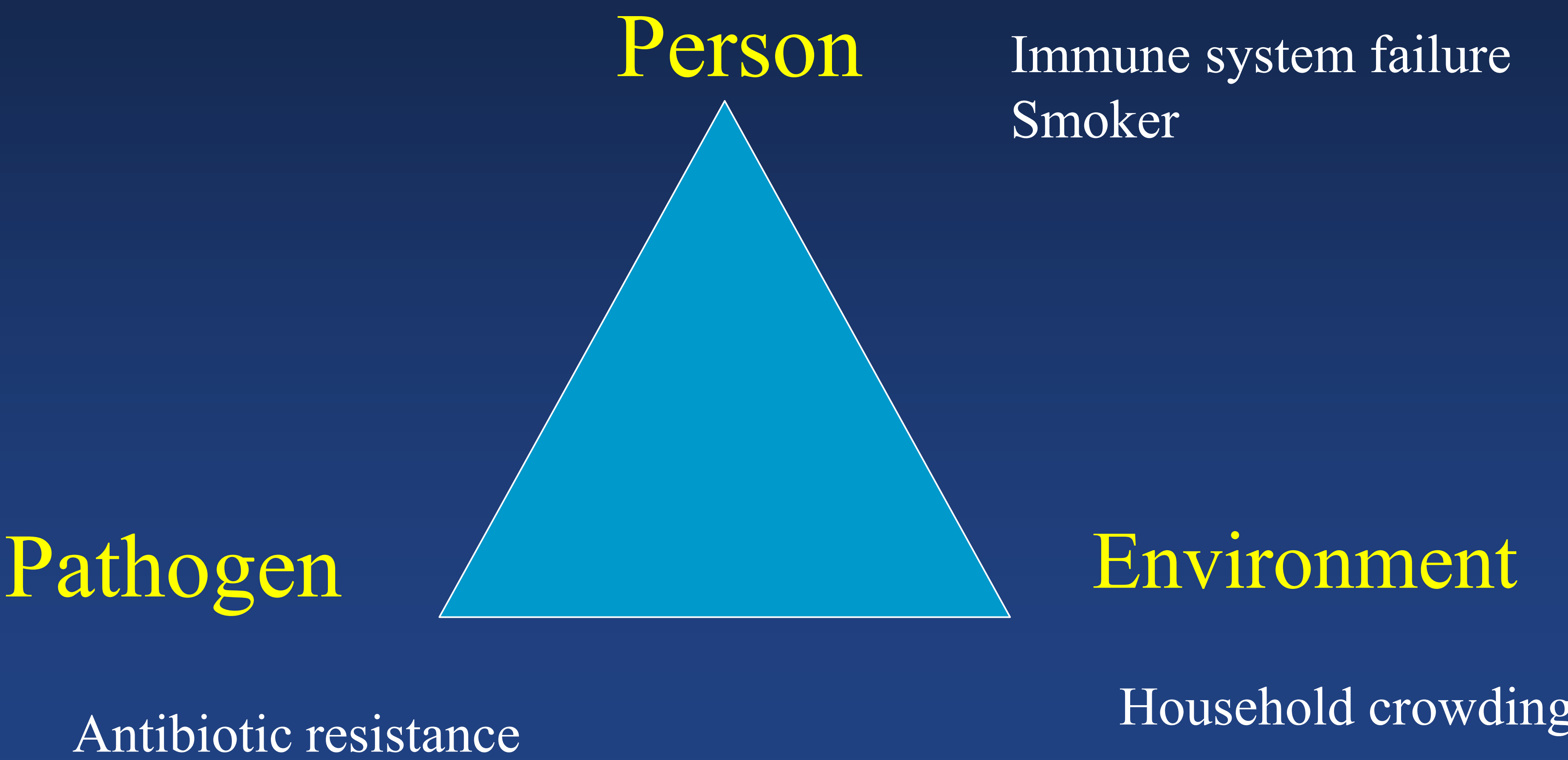
- Water Quality
  - Prevents illness from drinking water
    - – Water-borne diseases
      - Cholera, Typhoid fever, dysentery
- Adequate water Quantity
  - Drink, cook, wash: hands, body, clothes
  - Prevents infections spread person-to-person
    - – Water-washed diseases
      - Trachoma, respiratory infections, skin infections

CDC

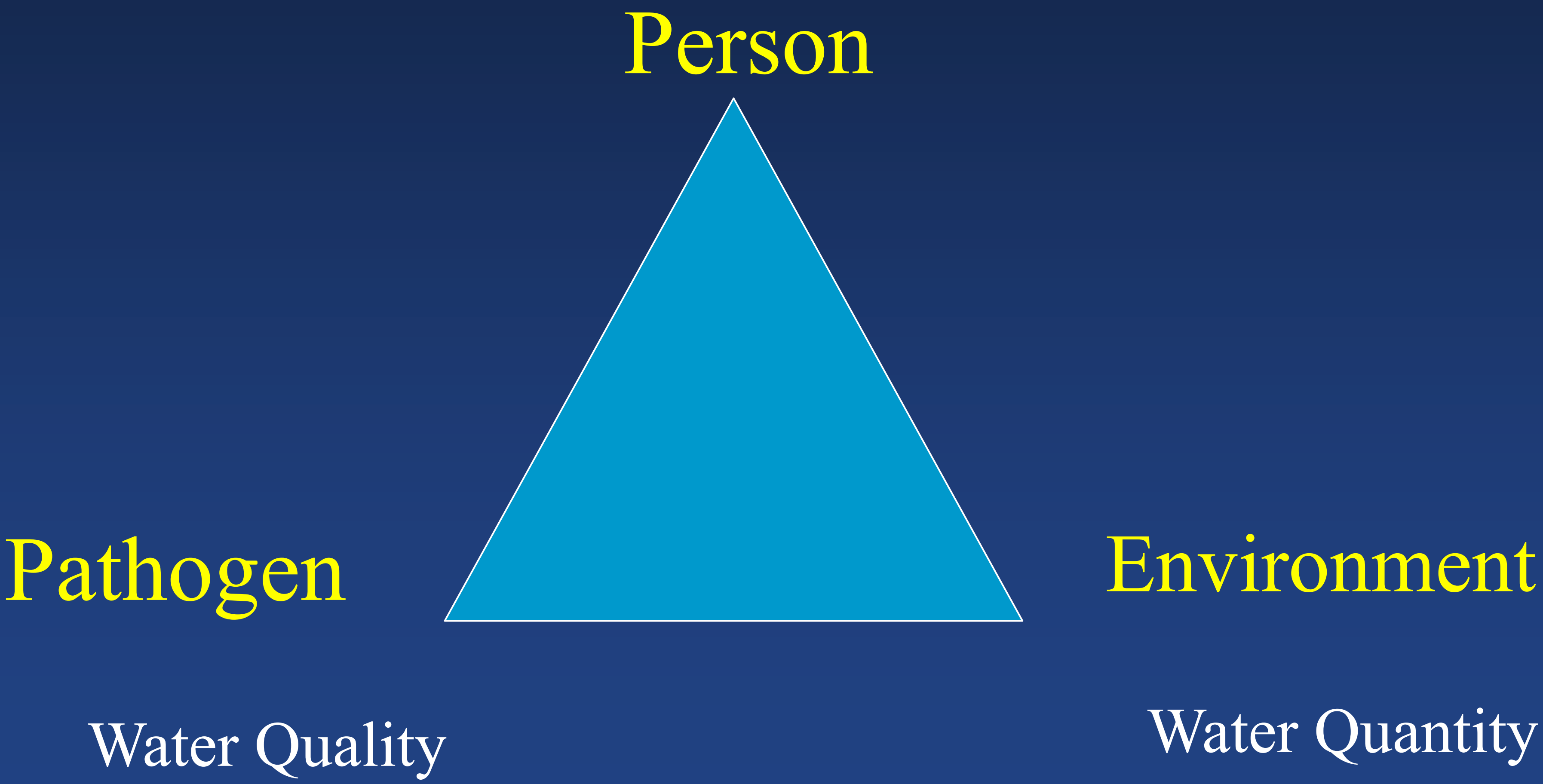
The Infectious Disease Triangle



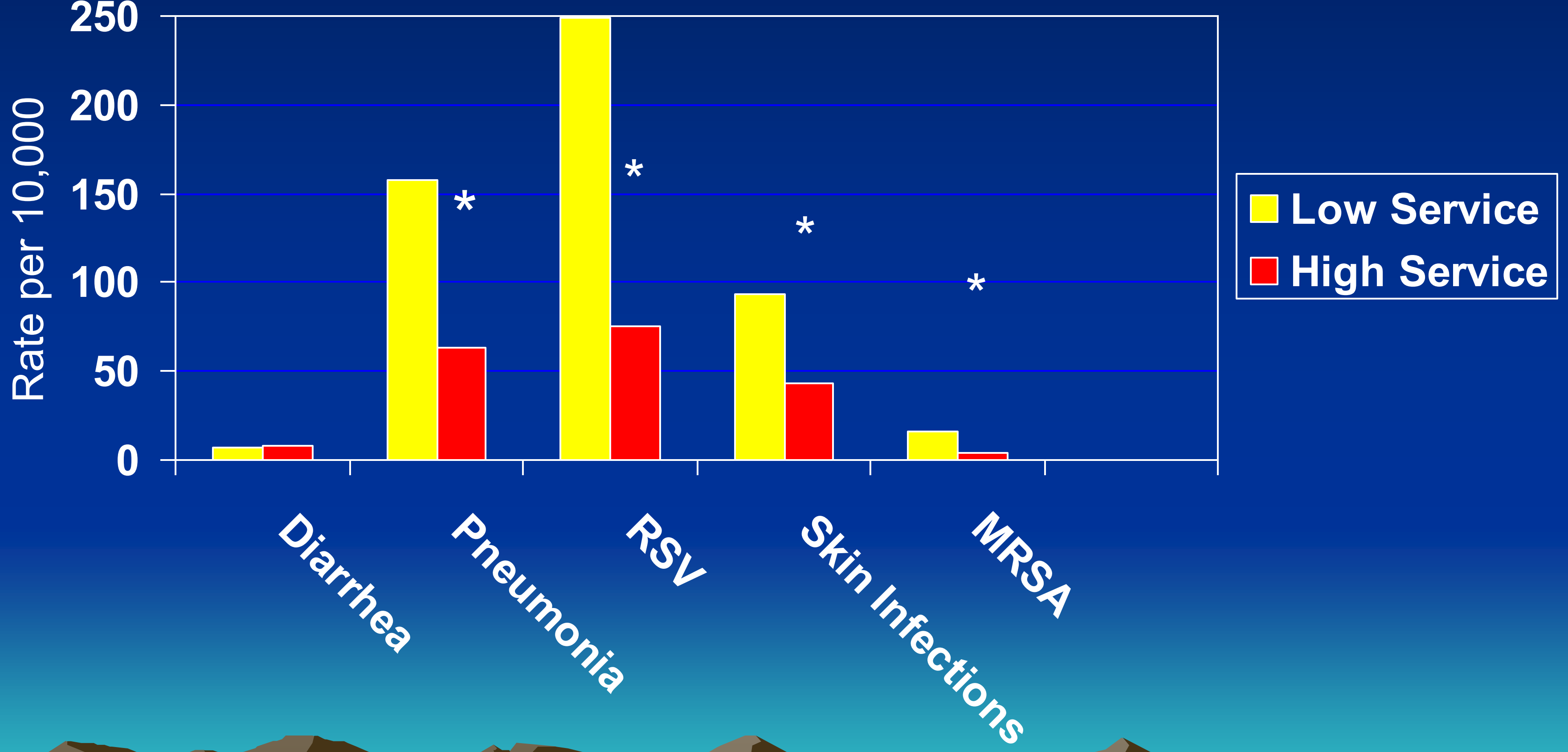
The Infectious Disease Triangle



The Infectious Disease Triangle



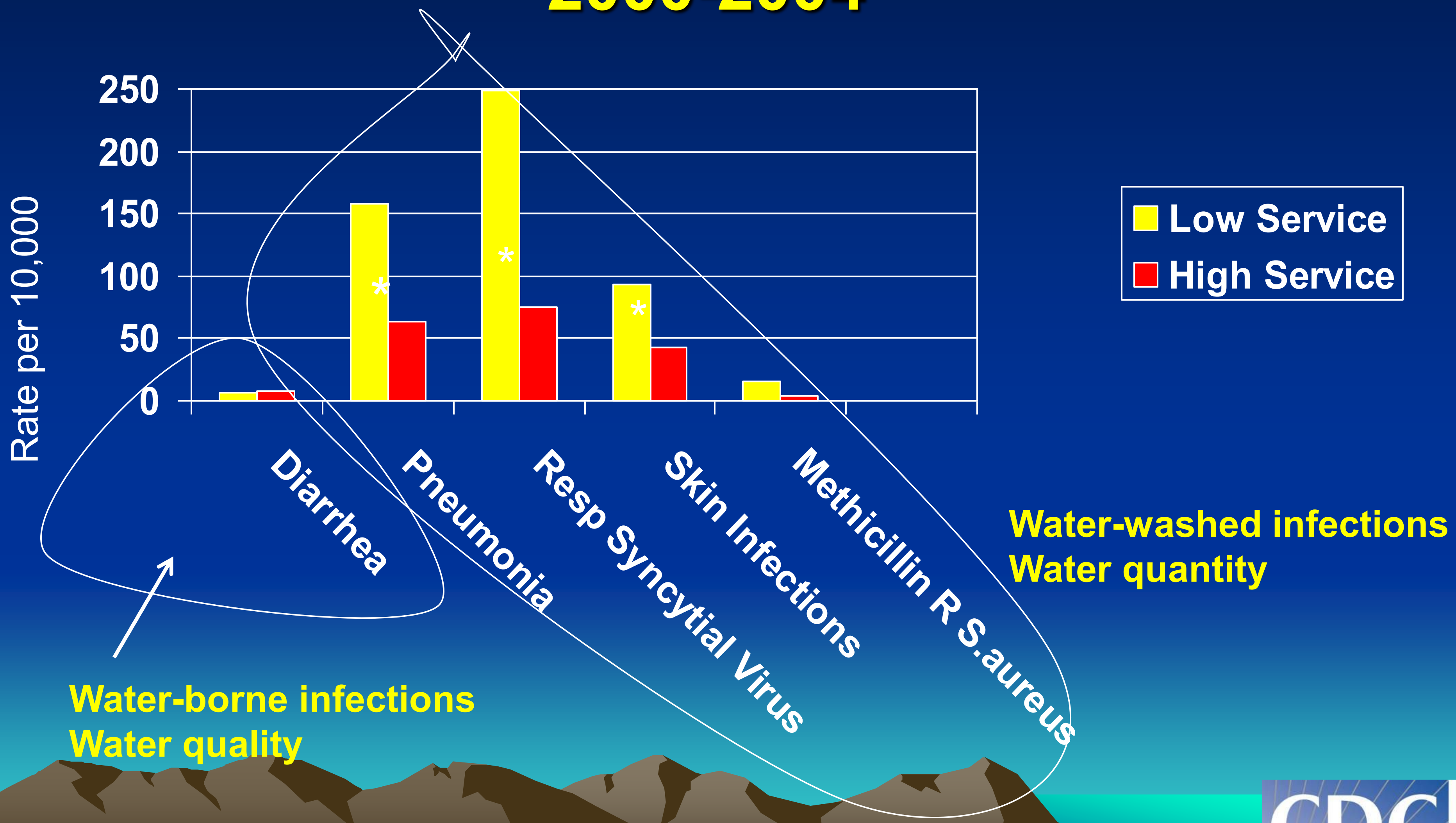
Hospitalization Rates for "High" and "Low" Water Service Regions, Alaska, 2000-2004



*$p < 0.05$

Hennessy, AJPH, 2008

Hospitalization Rates for "High" and "Low" Water Service Regions, Alaska, 2000-2004

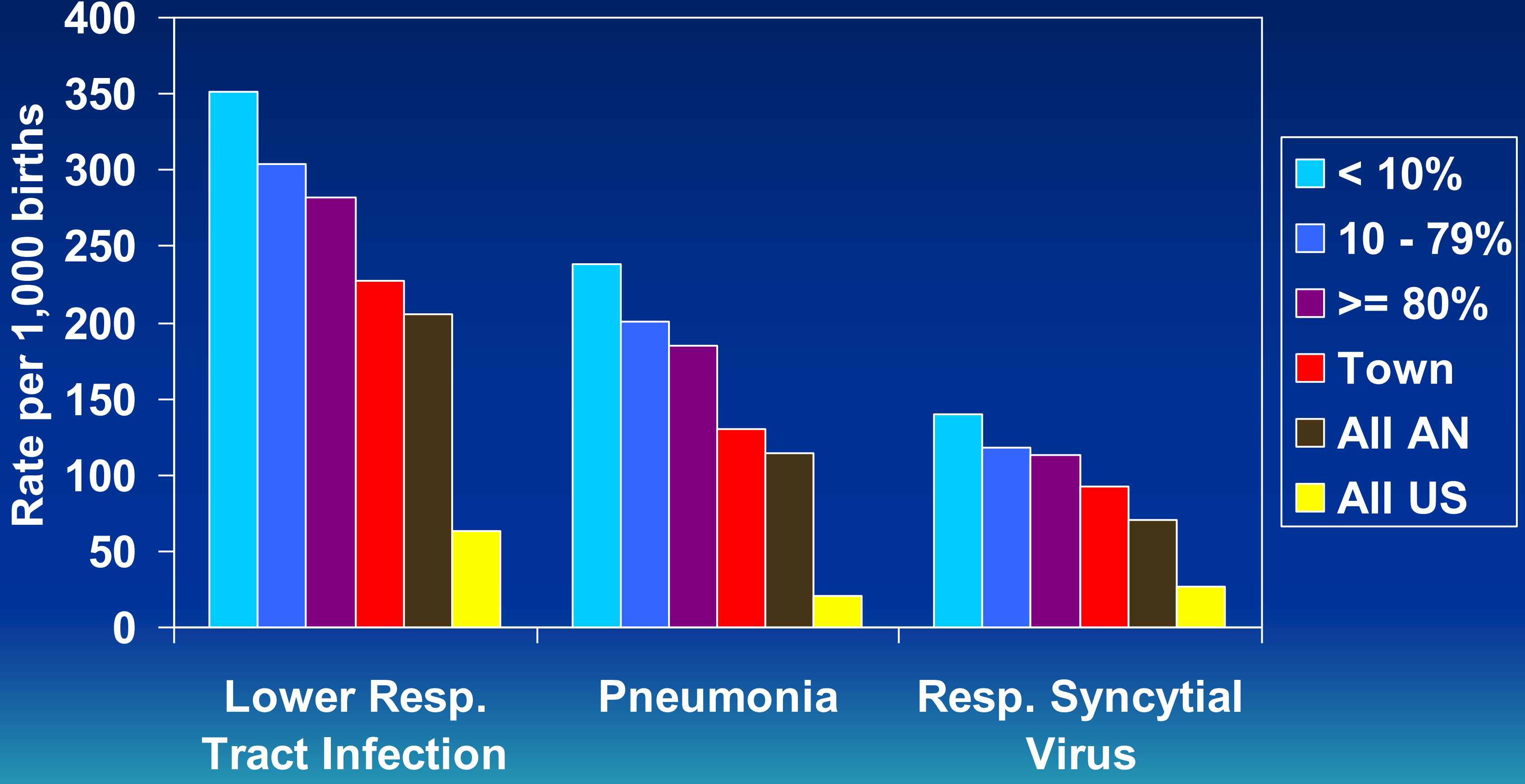


Main Message #2

- For health, water quantity is as important as water quality.

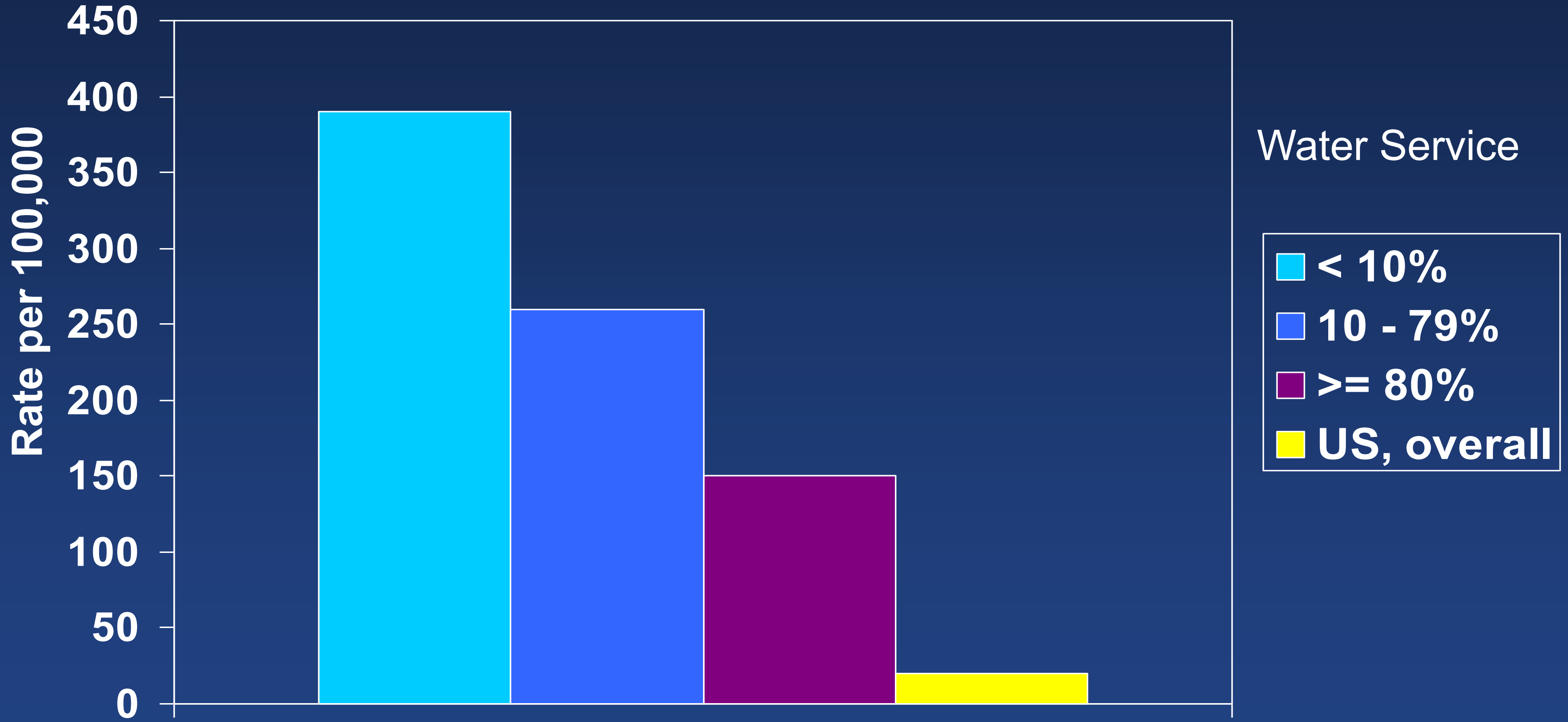
HHS CDC Centers for Disease Control and Prevention

Hospitalization rates for Alaska Native infants, according to percent of homes with water service 1999 - 2004*



* Hennessy, AJPH, 2008

Serious Infections with Pneumococcus in Children < 5 years old, Southwest Alaska, 2001- 2007



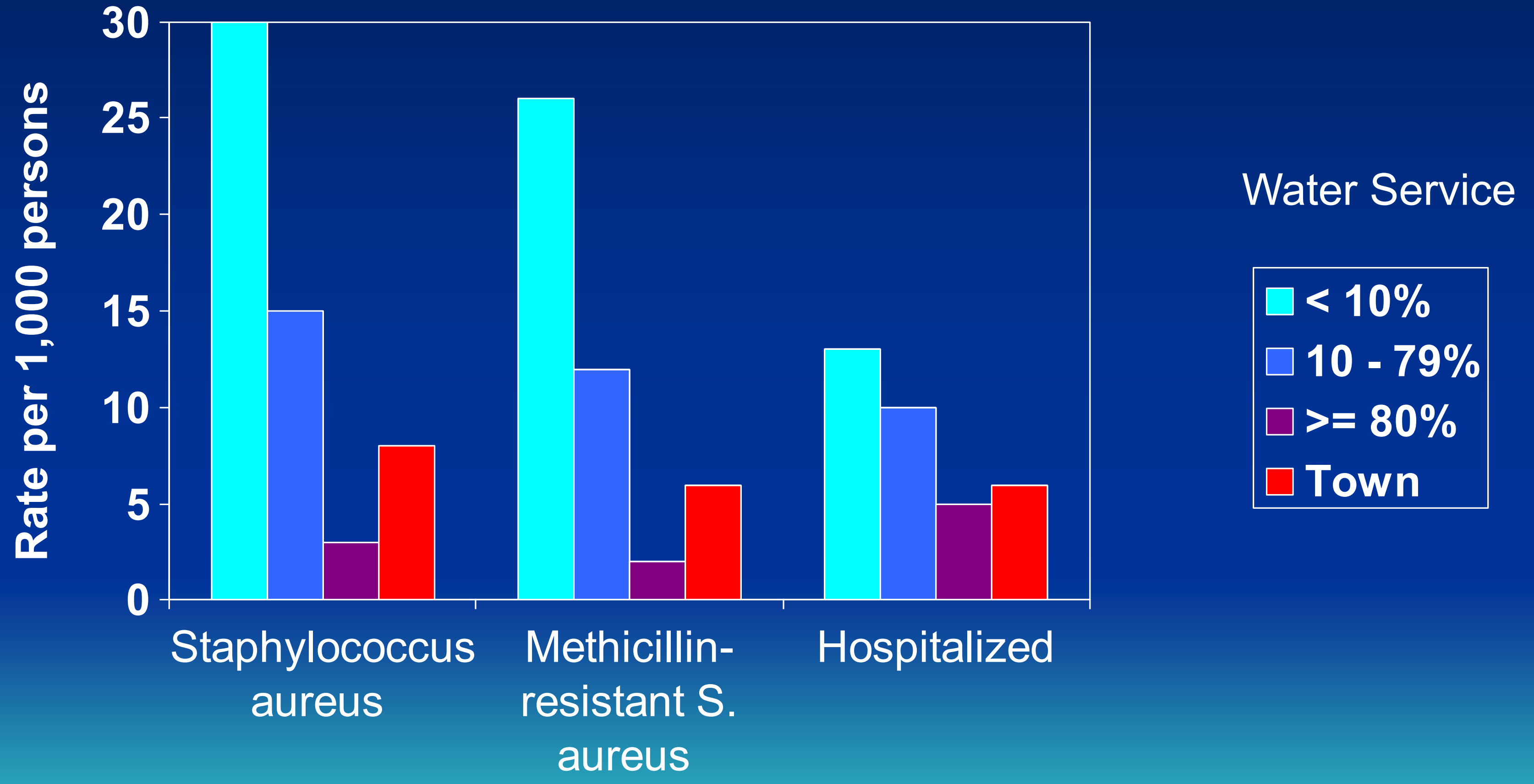
* Wenger, 2010, Pediatric Infectious Diseases

How water helps to prevent Respiratory Infections

- Transmitted by
  - Cough/sneeze droplets
  - Contaminated hands or surfaces
- Transmission prevented by
  - Hand washing, surface cleaning
- Other factors play a role
  - Crowding, vaccinations, cough/sneeze hygiene, breastfeeding

CDC

Skin infection rates, all ages, by village water service, Southwest Alaska, 1999 - 2000



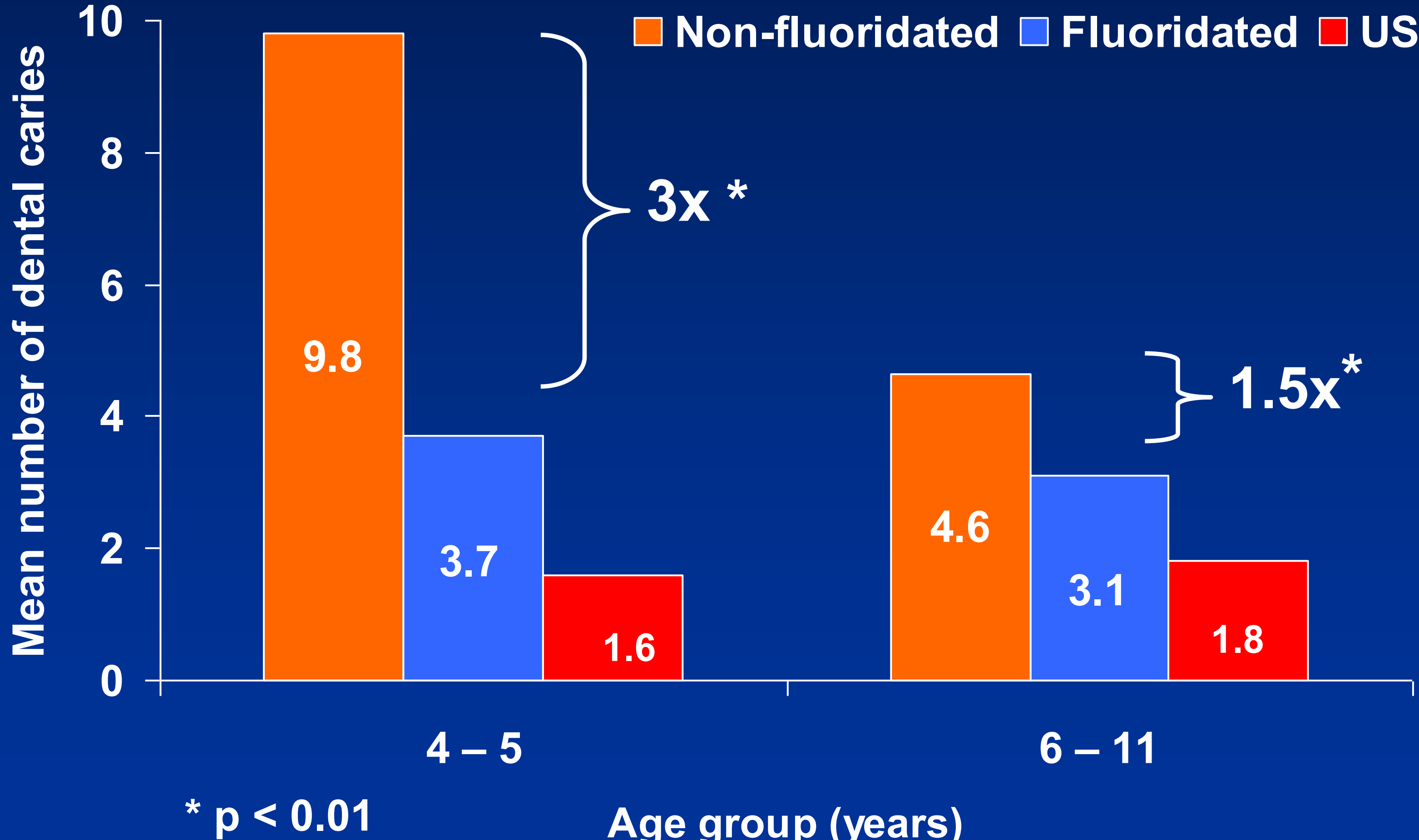
AJPH, 2008

How water helps to prevent Skin Infections (Boils and Impetigo)

- Spread by
  - Person to person contact
  - Self inoculation
  - Contaminated surfaces or objects (laundry, sauna benches)
- Spread prevented by
  - Hand and body hygiene
  - Cleaning home environment and saunas
  - Laundry (bleach, hot water)
- Other factors
  - Crowding, long lasting colonization of skin,
  - Antibiotic use

CDC

Number of Cavities in Primary Teeth by Village Water Fluoridation Status, Alaska



* p < 0.01

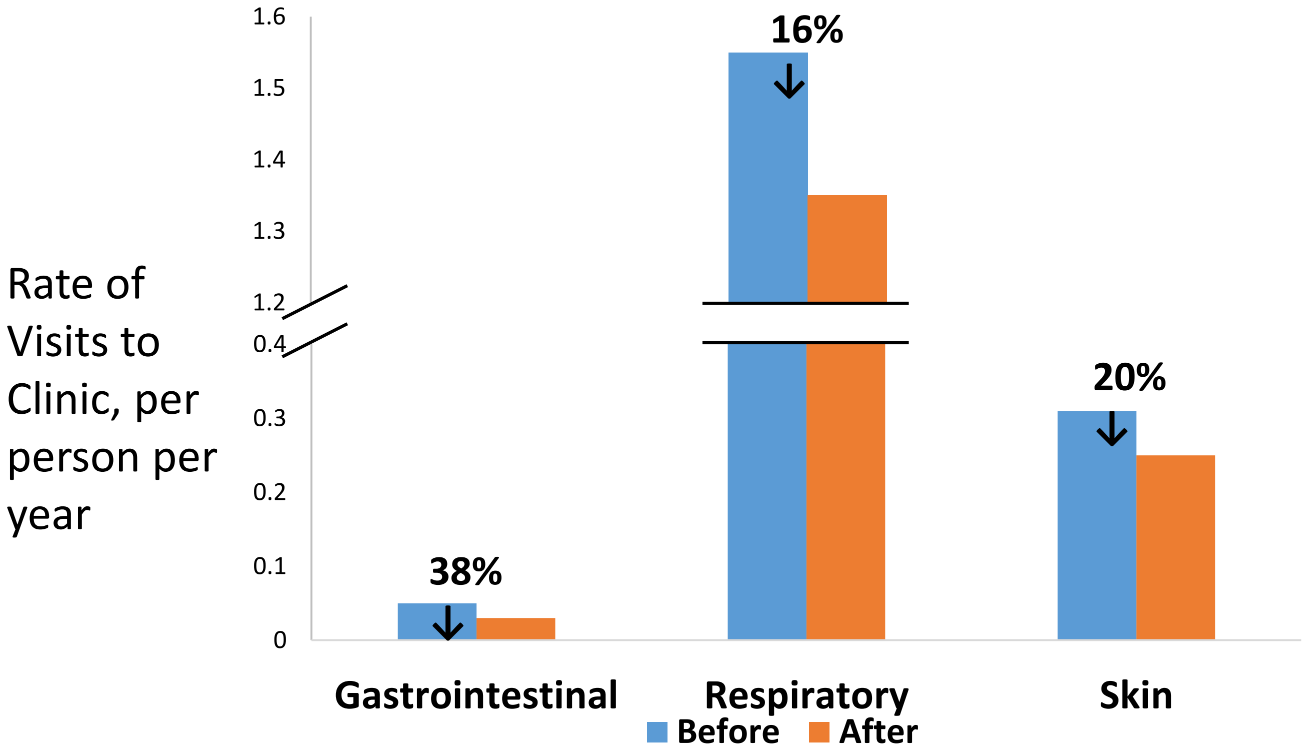
MMWR, Sept 2011

How water helps to prevent Dental Cavities

- Caused by excess *Strep. mutans* bacteria
  - Produces acid and destroys tooth enamel
- Prevented through
  - Water for brushing teeth
  - Fluoridated water
    - only available in piped distribution systems
  - Good tasting water may decrease soda drinking
- Other factors
  - Dietary sugar, use of toothpaste, strength of tooth enamel, access to dental care

CDC

Clinic visits for Water-related Infections Before and After Installation of Running Water, 4 villages in southwest Alaska, 2007 -2013



How water helps to prevent Gastroenteritis (Diarrhea)

- Germs spread through
  - Contaminated water or food
  - Person to person
- Transmission prevented through
  - Providing and protecting drinking water
  - Cleaning food preparation surfaces, utensils, dishes
  - Hand hygiene
- Other factors
  - Contaminated food, cooking temperatures, cross-contamination, storage of foods

CDC

Main Message #3

- The health benefits of running water includes prevention of:
  - Respiratory infections
  - Skin infections
  - Dental cavities, and
  - Diarrhea

How much disease can we prevent by adequate water service?

How much disease can we prevent by adequate water service?

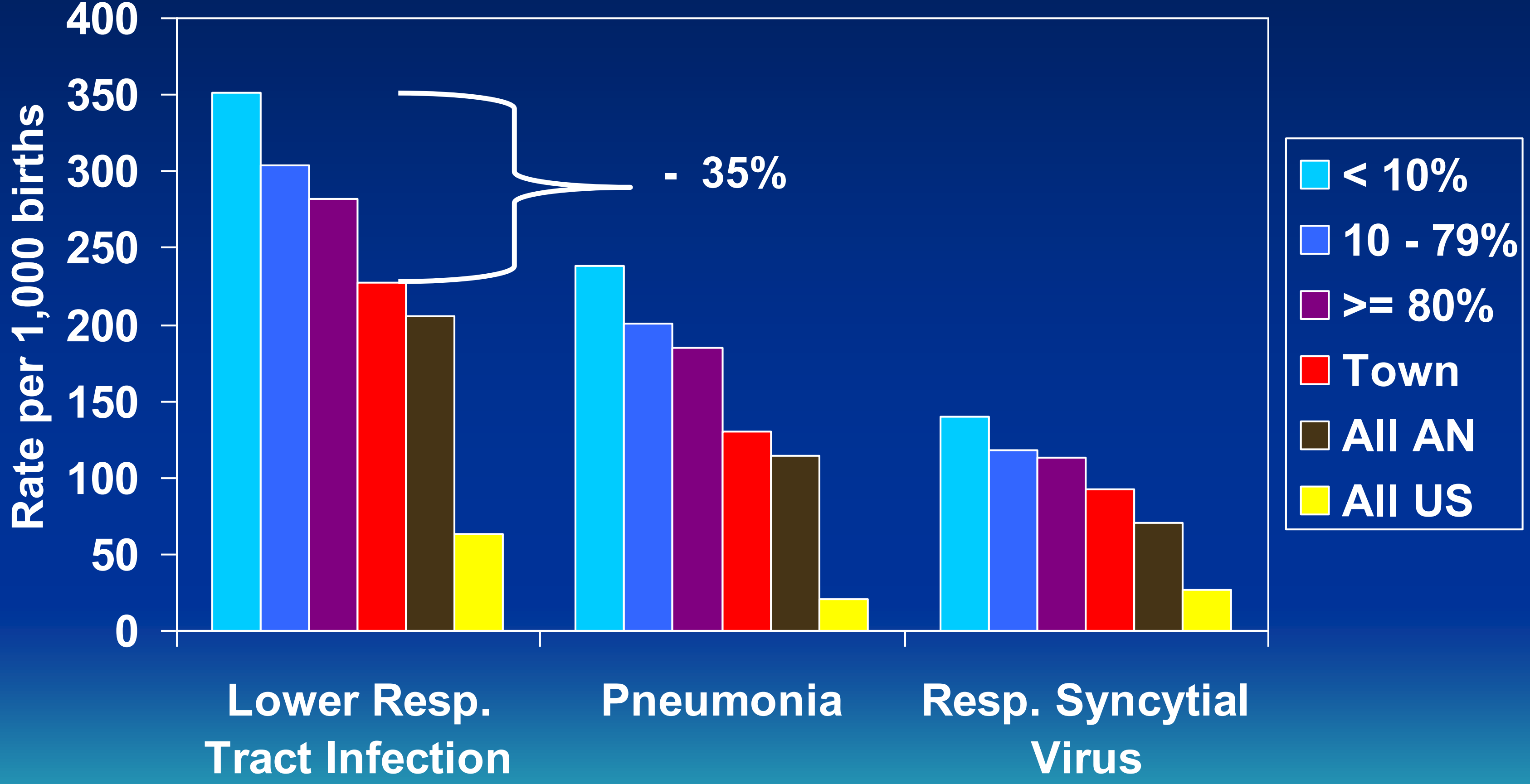
- Karachi, Pakistan
  - 606 households
  - Randomized trial of soap and handwashing promotion efforts
  - 50% drop in pneumonia, diarrhea, impetigo
    - Luby, et al. *Lancet 2005*

CDC

How much disease can we prevent by adequate water service?

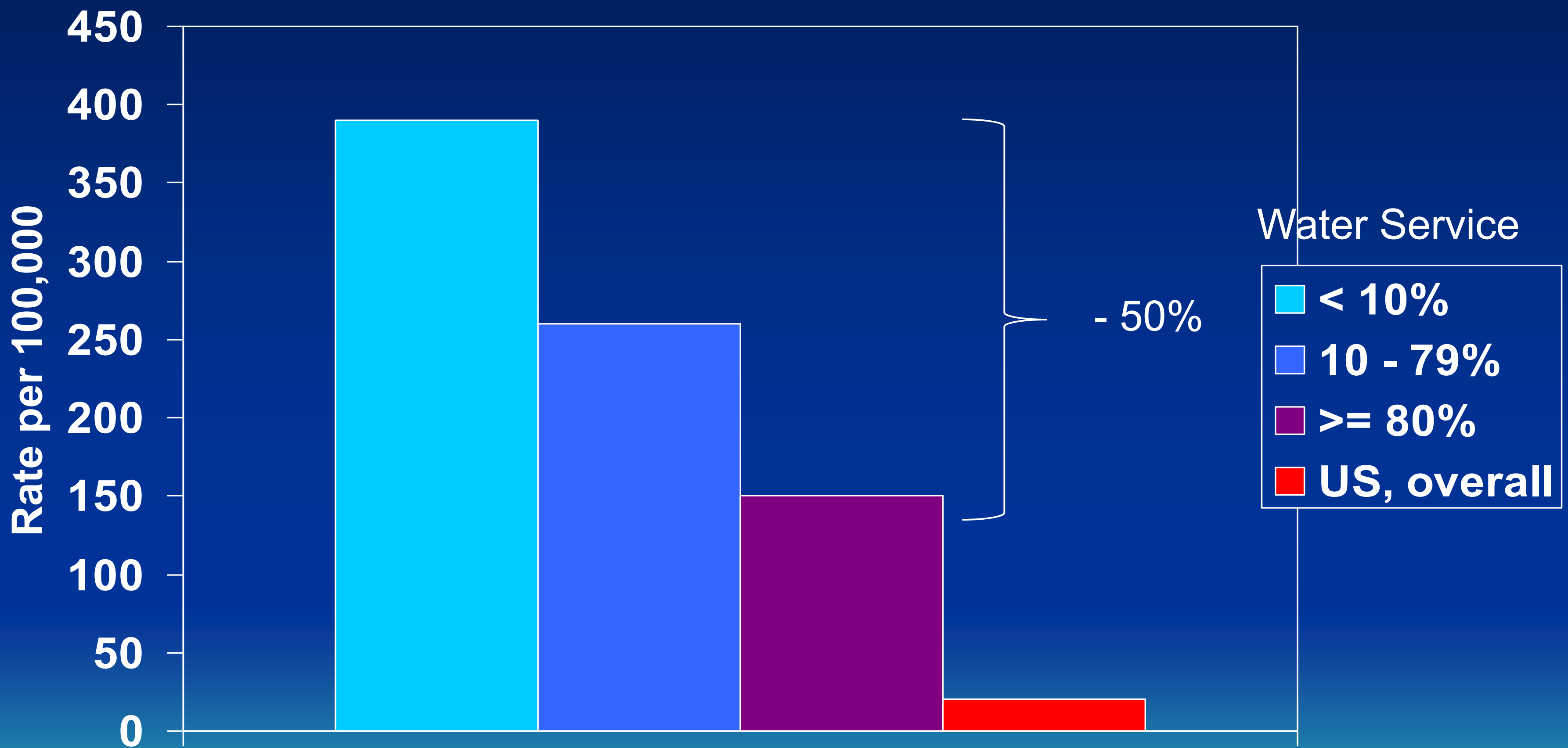
- Karachi, Pakistan
  - 606 households
  - Randomized trial of soap and handwashing promotion efforts
  - 50% drop in pneumonia, diarrhea, impetigo
    - Luby, et al. *Lancet 2005*
- **Rural Alaska villages**
  - **Compare rates**
    - **Served vs. unserved villages**
    - **Before and after water service**

Respiratory Hospitalizations in Children



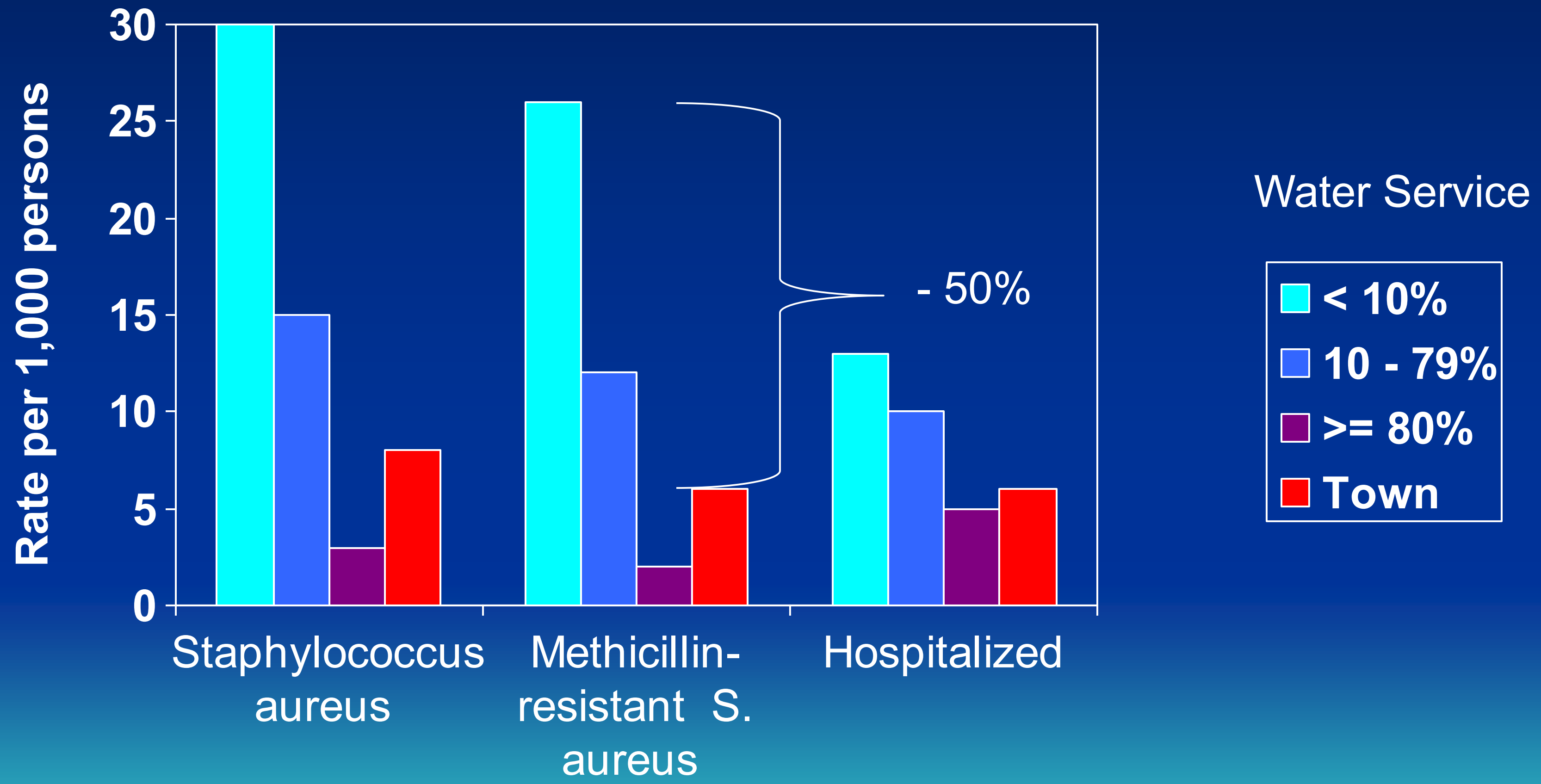
* Hennessy, AJPH, 2008

Serious infections with *Streptococcus pneumoniae* in children

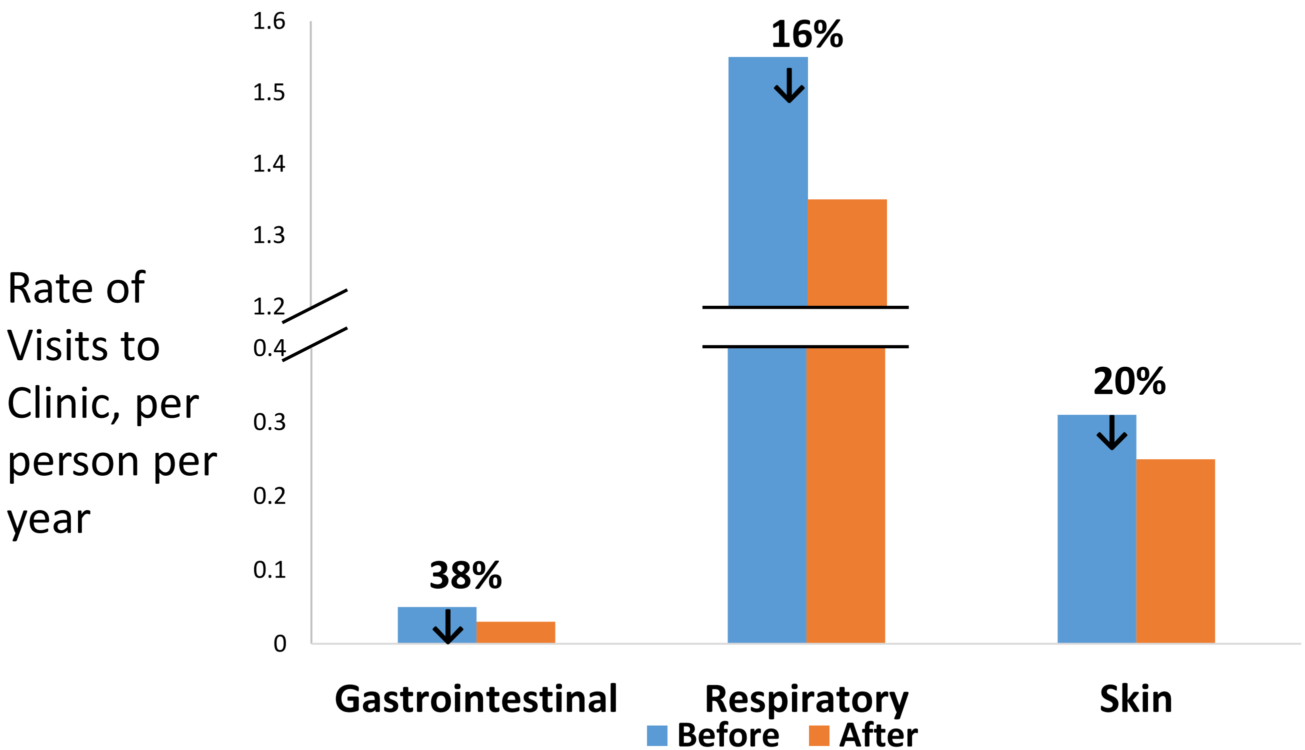


* J Wenger, 2010, Pediatric Infectious Diseases

Skin infections, All Ages



Clinic visits for Water-related Infections
Before and After Installation of Running Water,
4 villages in southwest Alaska, 2007 -2013



Main Message #4

- We can prevent a lot of illness and suffering by providing adequate water and sanitation.
  - 35% to 50% fewer infections

How much water is enough to improve health?

World Health Organization

WHO/SDE/WSH/03.02
English only

Domestic Water Quantity, Service Level and Health

Authors:
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Loughborough University, UK
Jamie Bartram
Co-ordinator, Water, Sanitation and Health Programme, World Health Organization, Geneva, Switzerland

http://cdrwww.who.int/water_sanitation_health/diseases/WSH03.02.pdf

Table S1: Summary of requirement for water service level to promote health

Service level	Access measure	*Needs met*	Level of health concern
No access (quantity collected often below 5 l/c/d)	More than 1000m or 30 minutes total collection time	Consumption – cannot be assured Hygiene – not possible (unless practised at source)	Very high
Basic access (average quantity unlikely to exceed 20 l/c/d)	Between 100 and 1000m or 5 to 30 minutes total collection time	Consumption – should be assured Hygiene – handwashing and basic food hygiene possible; laundry/ bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50 l/c/d)	Water delivered through one tap on-plot (or within 100m or 5 minutes total collection time	Consumption – assured Hygiene – all basic personal and food hygiene assured; laundry and bathing should also be assured	Low
Optimal access (average quantity 100 l/c/d and above)	Water supplied through multiple taps continuously	Consumption – all needs met Hygiene – all needs should be met	Very low

Is 50 Liters or 13 gallons per person per day needed to protect health?

- Could we conserve water?
  - Low-flow faucets
  - Water recycling
  - Separating or dry toilets
- Is all water needed in home?
  - Community facility for
    - laundry, shower / bathing, sauna
  - Home: drinking, toilet, cooking, handwashing, home cleaning

CDC

Handwashing Basin in Alaska Home

What is the "Return on Investment" for Providing Water and Sewer Service?

What is the Return on Investment for Water/sewer services?

- Direct health costs
  - Use rate differences to calculate costs of
    - Excess hospitalizations, clinic visits
  - Quality of Life measures
    - Quality Adjusted Life Years

CDC

Return on Investment, continued

- Indirect costs
  - Being ill or caring for an ill family member
    - Missed work – loss of income or job
    - Missed school – lower educational success
    - Less subsistence or cultural activity
  - Hauling water and waste
    - Opportunity cost of time
    - Reduced tourism or business opportunities
  - Water insecurity
    - Stress, mental health effects

The Human Cost

- A child born in November, returns to a village that has no running water…

- A child lives in a village with no running water, or where water has an unpleasant taste…

Main Message #5

- **Water and sewer service is a fundamental issue of health and social justice.**
- **The costs connected with lack of service are mostly unmeasured.**
- **These costs are being paid by the people living in communities without water service and also by the rest of society.**

Healthy Alaskans 2020 (HA2020)

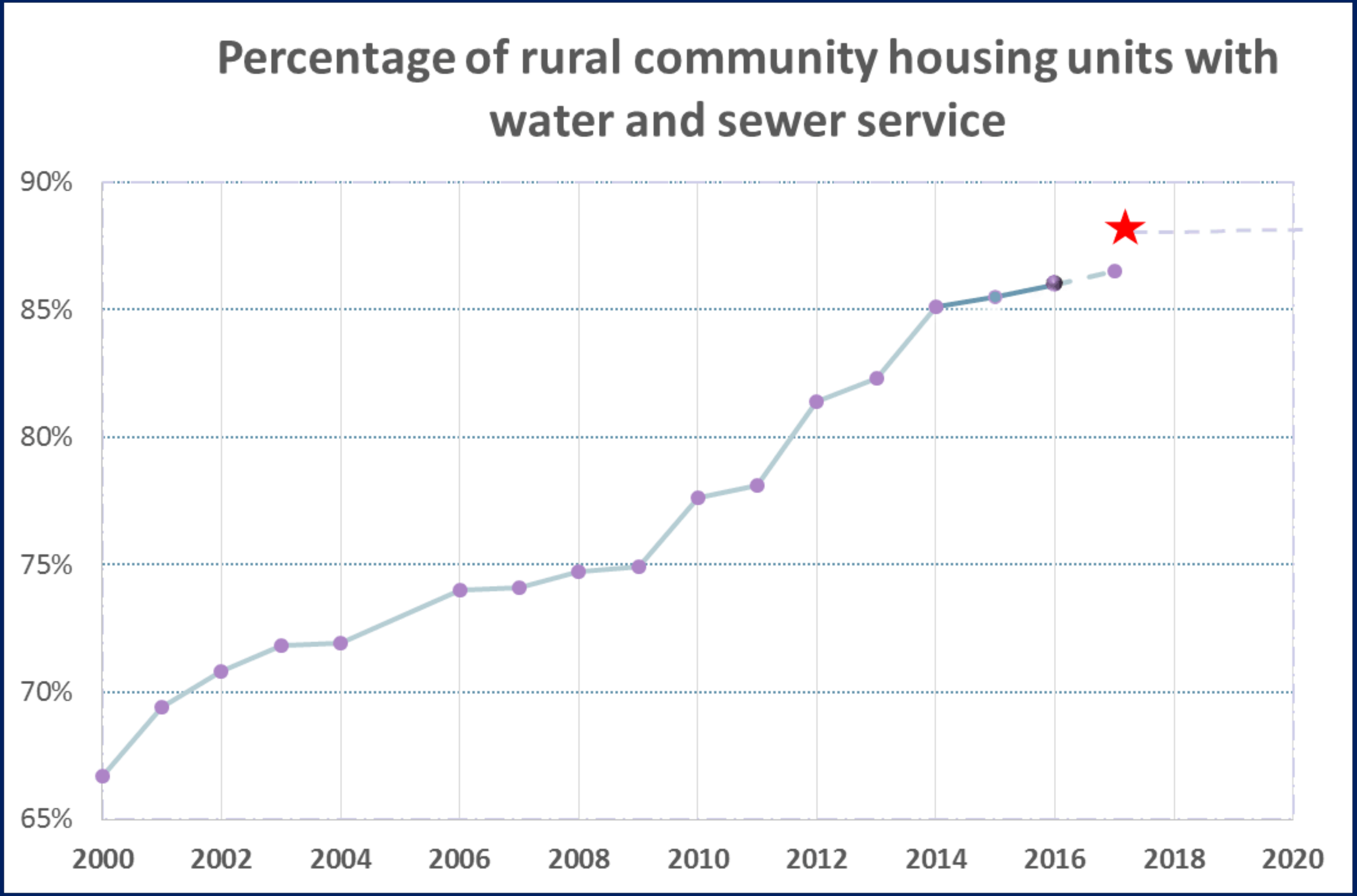
- **Public health initiative to improve health and ensure health equity**
- **25 health priorities**
  - Measureable targets to reach by 2020
  - Provides strategies and specific actions
  - Identifies key partners across the state to engage in the work

HA2020 Dashboard

Increase the proportion of Alaskans with access to in-home water and wastewater services

Indicator	Progress	Baseline (2010)	HA 2020 Target
19: Percentage of rural community housing units with water and sewer services		78%	87%

Healthy Alaskans 2020: Rural Sanitation Target



Thank you!

UNIVERSITY OF ALBERTA
SCHOOL OF PUBLIC HEALTH

This is PUBLIC HEALTH

Pathogen risk management considerations for safe household water uses

Nicholas ASHBOLT
(Ashbolt@UAlberta.ca)

Alberta Innovates Health Solutions

AI-HS Translational Health Chair in Water

WIHAH 2016, Hilton Anchorage, Alaska September 21st, 2016

Points to be addressed

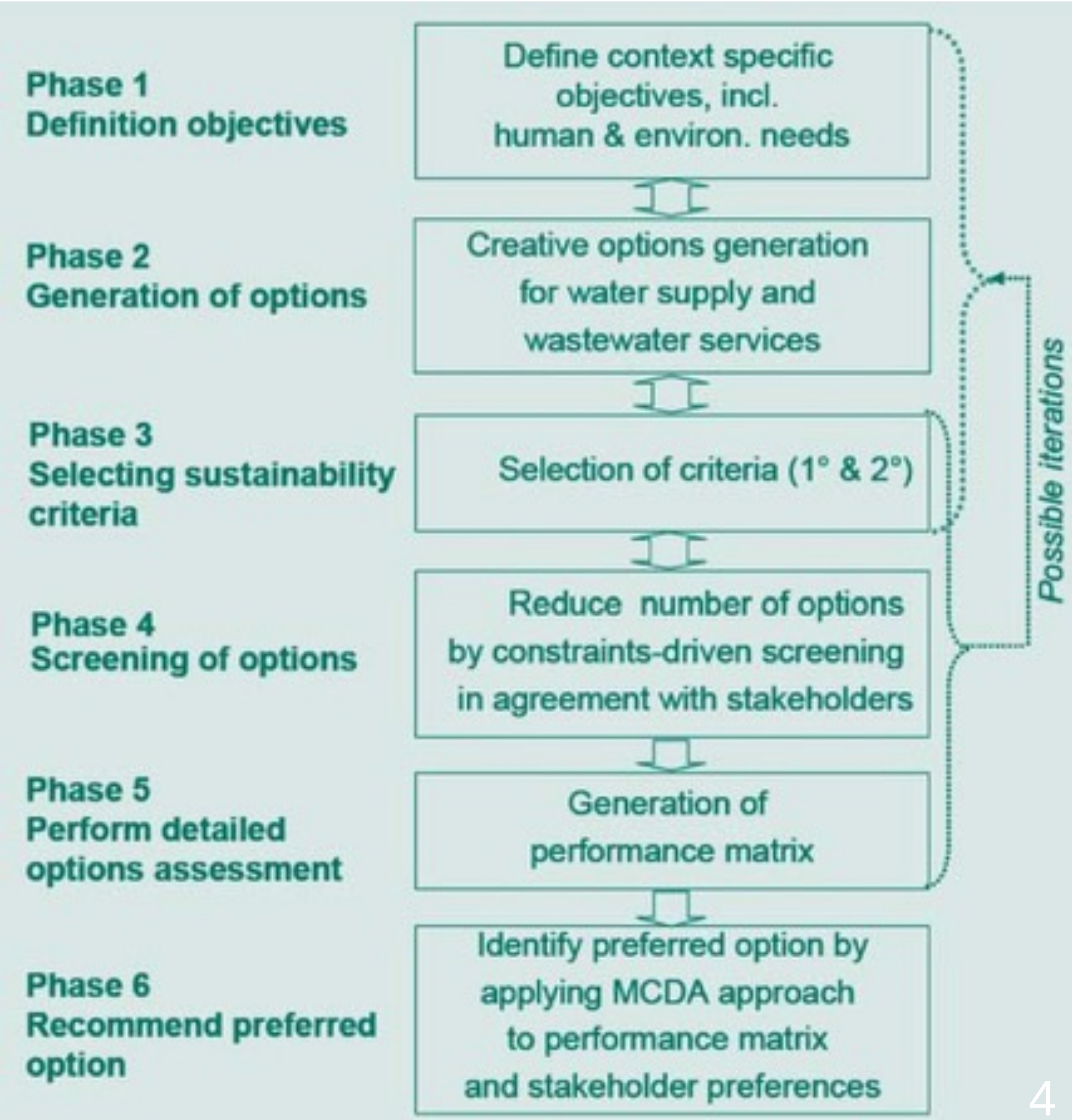
- Remote & Arctic community water services (not ≅ central water & sewage):
  - Need for decentralized (household) services
    - Given the pathogen pathways of concern
  - One-Health concept, climate adaptive
  - Management of microbial issues within a waterscape-system's framework

Our common goals - Larry Hartig

- Critical to address **<u>human health</u>**, but also
- Climate change (threatening all systems)
- Engineering issues (fit-for-purpose)
- Operational needs (training/maintenance) &
- **<u>Regulations</u>** (how, what, why); and

How to integrate within waterscape narrative

Sustainable water services selection

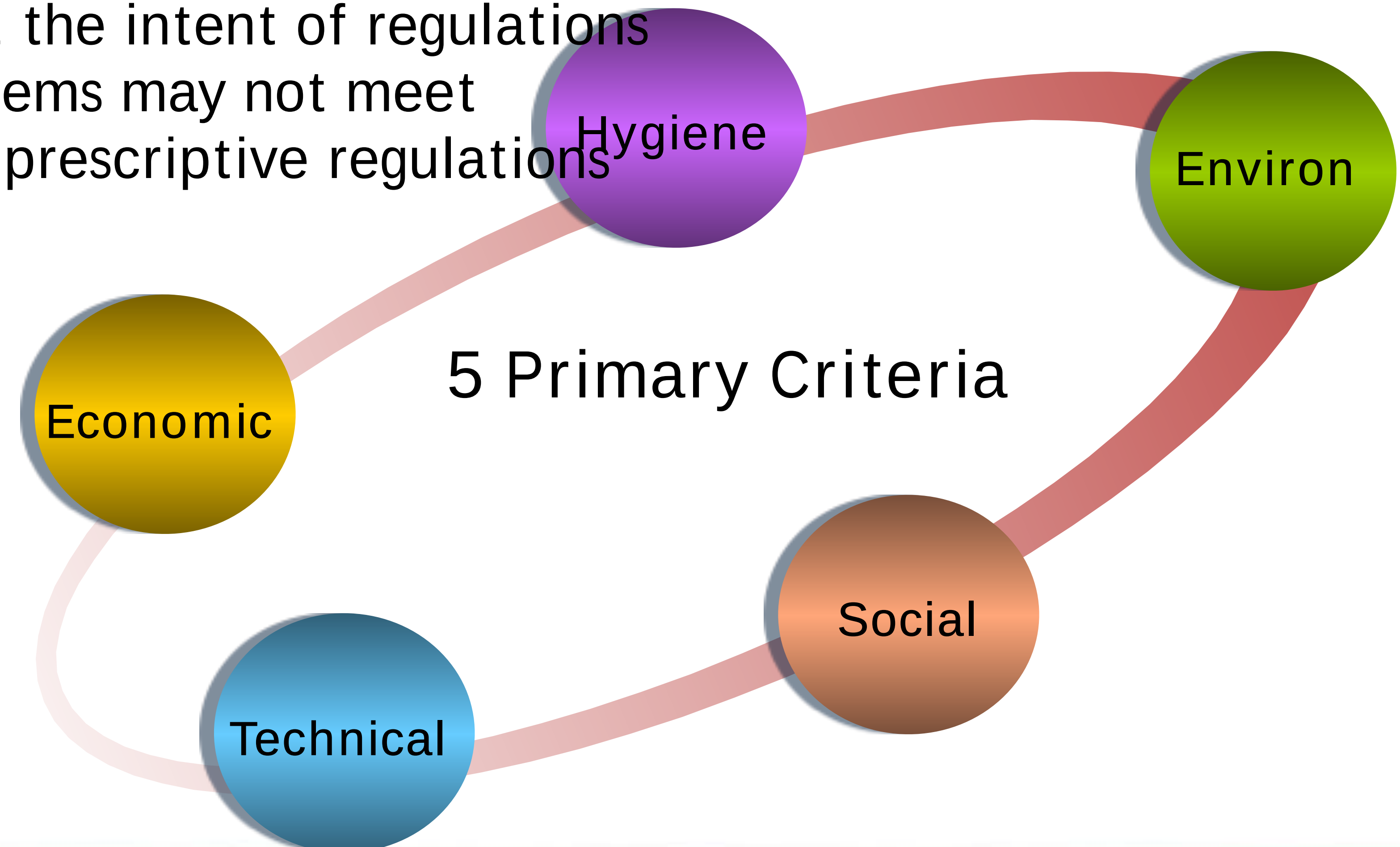


- Stakeholder-driven, so 'pulled' by citizens
- Meeting core sustainability principals
  - Resource recovery ecologically-based
  - Adaptable, & based on risk assessments

Water Services Association of Australia 2008 Framework

Sustainable systems achieved by trade-offs between key criteria with stakeholders

To meet the intent of regulations
i.e. systems may not meet
current prescriptive regulations



‘Honey’ buckets, Atmautluak

http://watersewerchallenge.alaska.gov/photogallery.html

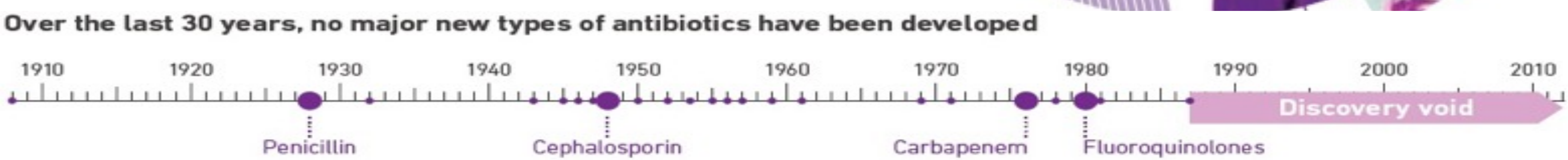
Covered Wastewater Haul & dump!

http://watersewerchallenge.alaska.gov/photogallery.html

Even this ‘preferred’ sewage management has major chemical, pathogen & antimicrobial resistant gene impacts

Antimicrobial Resistance (AMR) via water

- 3rd gen cephalosporin- resistant *E. coli* & MRSA estimated deaths 3.3 per 100,000 in EU in 2015
- Globally 700,000 AMR-deaths, likely 10 million by 2050*
- **Unclear fraction due to water food exposure pathways****



*Hoffman *et al.* (2015) Bull WHO 3, 66
**Ashbolt *et al.* (2013) Env Health Pers 121, 993-1001

Water needs for Arctic health

- Residents may use 1 to 5 gallons per capita per day for all current household uses (drinking, cooking, washing)
  - significantly below recommended by Institute of Medicine / WHO for water-wash disease control (~13 gal/person.d)*
- But supplying more water to homes may not be the answer nor do washeterias necessarily help consumers' health
  - **Because it is costly, generates more wastewater pollution and communal facilities increase respiratory disease transmission (the largest water-related health concern)**

*Howard & Bartram (2003). *Domestic Water Quantity, Service, Level and Health; WHO/SDE/WSH/03.02*

Climate change: loss of permafrost

- Resulting in serious erosion, flooding, and destruction of homes, buildings, and roads from differential settlement, slumping, and/or collapse of underlying base sediments
- Loss of clean lake water for drinking and hygiene, saltwater intrusion, and sewage contamination that could cause respiratory, gastrointestinal and skin infections

Need more adaptive infrastructure, not just resilient

– i.e. most infrastructure only within homes

Lasting change requires trust

How customers want to feel

What customers need

How we must deliver it

What the service must offer

Understanding water health issues

- Community diseases result from:
  - **Inadequate water and sanitation**
    - waterborne & water-based pathogens
  - **Lack of body and clothes washing**
    - skin infections (primarily bacterial and fungal)
  - **Respiratory infections**
    - person-to-person in group settings + water-based
    - such as reduced with Kivalina washeteria closures [1]
- **Solutions must address aboriginal societal needs [2]**

4 village study* rates
Pre & Post intervention

GI illnesses
2% & down 38%

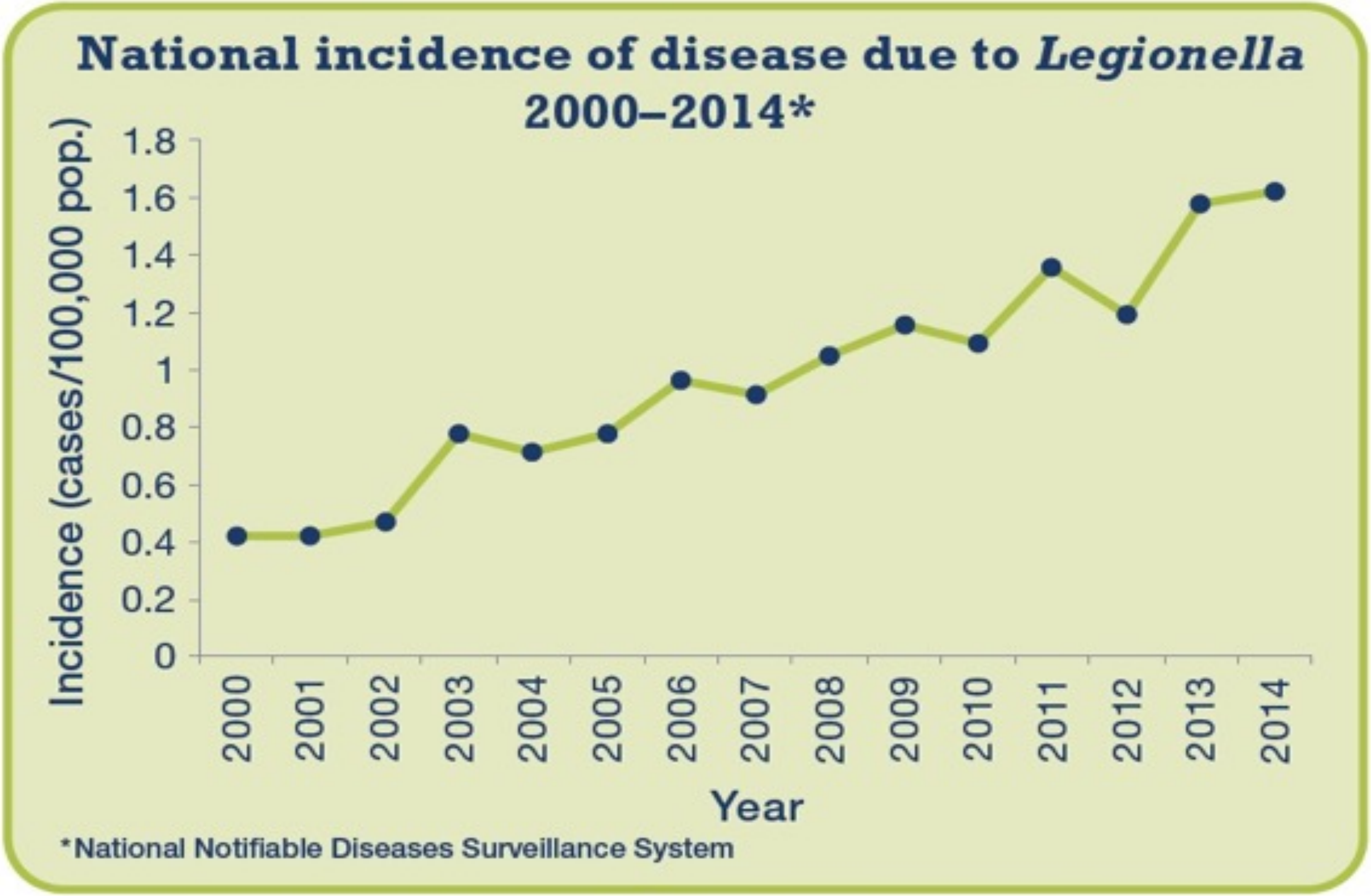
skin illnesses
17% & down 20%

Resp'y illnesses
83% & down 16%

*Thomas *et al.* (2016) Impact of In-home Water Service on the Rates of Infectious Diseases, WIHAH

[1]Thomas *et al.* (2013) Int J Circumpolar Health 72: 480-4
[2]Daley *et al.* (2015) Social Sci & Med 135: 124-132

U.S. reported cases of Legionnaires' disease have increased nearly 300% since 2000



In-building water issue via aerosols e.g. showers

CDC (2016) Developing a Water Management Program to Reduce *Legionella* Growth & Spread in Buildings

Circumpolar-relevant water pathogens

- **Enteric** waterborne (**human & zoonotic**) diseases
  - *Hepatitis A* liver disease, *Norovirus* gastro, *Shigella* dysentery
  - *Giardia* giardiasis, enteritis *Yersinia & Campylobacter* spp.
  - *Echinococcus multilocularis* (lung disease) via foxes/voles
- **Water-based** (saprozoic) diseases
  - Non-tuberculous mycobacteria (wound/lung), *Helicobacter pylori*?
  - *V. parahemolyticus/vulnificus* gastro via seafood if seawater > 15 °C
- **Person-to-person** spread & **Water-Washed** infections:
  - *Norovirus, Cryptosporidium, Staph aureus, P. aeruginosa* & **helminths**
  - TB, *Strep. pneumoniae, Haemophilus influenzae* along with various multi-drug resistant bacterial and fungal pathogens

Parkinson & Evengård (2009) *Glob Health Action 2: 1-3*
Dudarev *et al.* (2013) *Int J Circumpolar Health 72*: 1-10

Waterborne sequelae – poorly understood

- **Auto-immune diseases**
  - Diabetes, Heart disease, Liver damage, & Reactive arthritis (enteric viruses, campylobacters)
- **Carcinogens**
  - *Helicobacter pylori,* **cyanotoxins**
- **Renal disease**
  - *E. coli* O157:H7, *Microsporidium* spp.
- **Nervous system disorders**
  - *Campylobacter jejuni*, various *Enterovirus* spp.
- **Heart and liver disease**
  - Adenovirus, Coxsackievirus, **cyanotoxins**

Cyanobacteria that produce cyanotoxins

Managing pathogens via a one-health approach, 2 examples:

- Containment of sewage/stormwater runoff to native animals: for *Toxoplasma gondii*, *Giardia, Echinococcus, etc.* yet
  - **Antimicrobial resistance (AMR) genes/bacteria & CEC not adequately controlled by sewage treatment and disinfection**
- Antimicrobial treatment for *Helicobacter pylori* infection: 58% people positive to below 9% by treatment (Aklavik NWT study) [1] however..

One Health approach include interactions between and among humans, animals, plants, parasites, microbes, and chemical contaminants in terrestrial, aquatic, & marine ecosystems

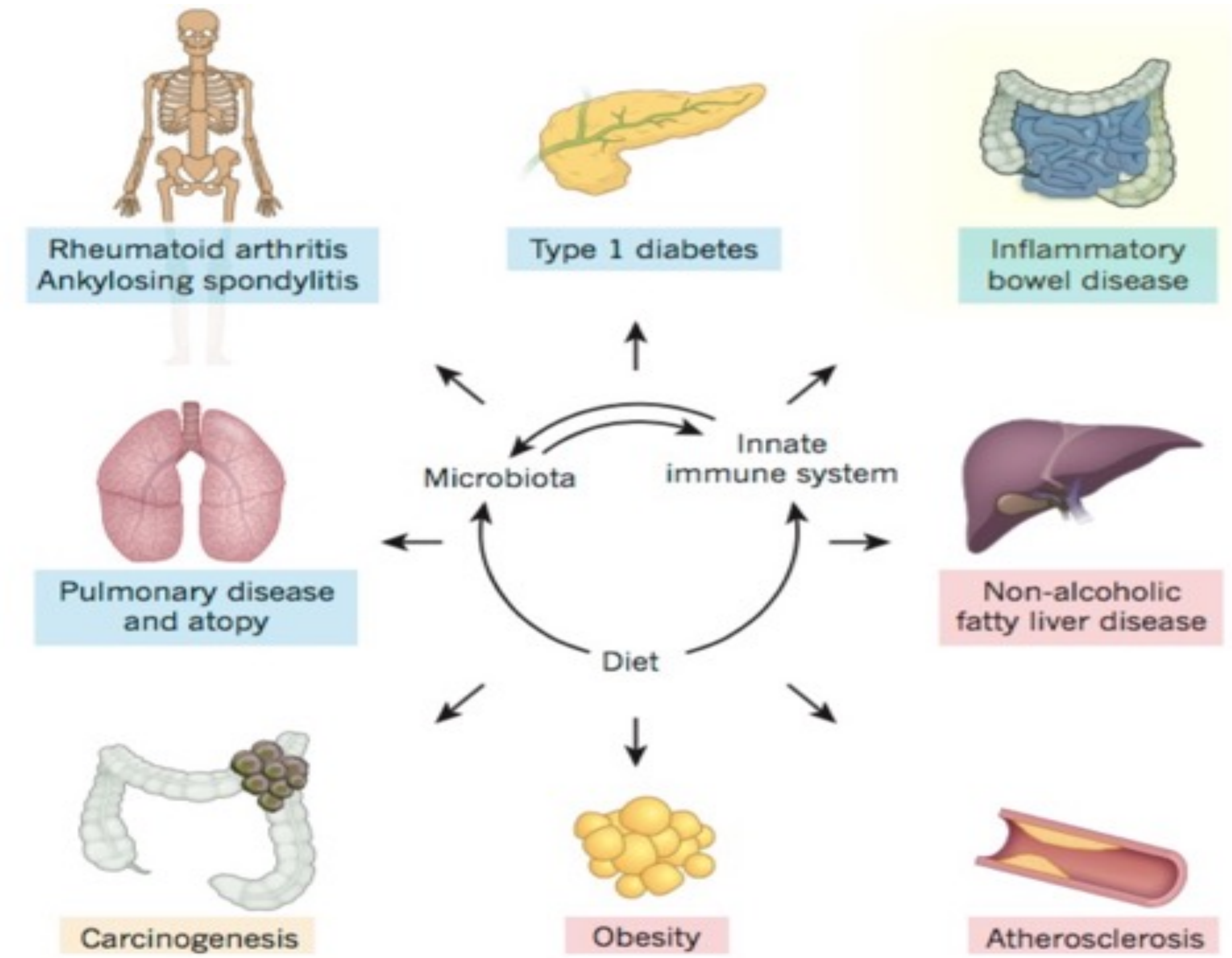
[1]Carraher *et al.* (2013) *Int J Circumpolar Health 72*:21594

Cheung *et al.* (2014) BMJ Open 4:e003689

***Helicobacter pylori*, ulcer & cancer bug, is it waterborne?**

- CDC estimate 2/3 of all humans **harbor** *H. pylori*
  - < 20% in developed regions, e.g. generally in USA
  - **50-80% in Indigenous Peoples of Arctic regions**
- Most infections do not cause illness, but
  - Major risk factor for peptic ulcer disease
  - 1994 *H. pylori* classified as a **carcinogen** (mucosa-associated lymphoid tissue [MALT] lymphoma)
  - But also reduces risk of esophageal adenocarcinoma

Microbiome–innate-immune-system interactions



- Many inflammatory disorders are influenced by alterations in the crosstalk between innate immunity and our microbiome
- These include metabolic (red boxes), neoplastic (orange box) and autoimmune or autoinflammatory (blue boxes) disorders

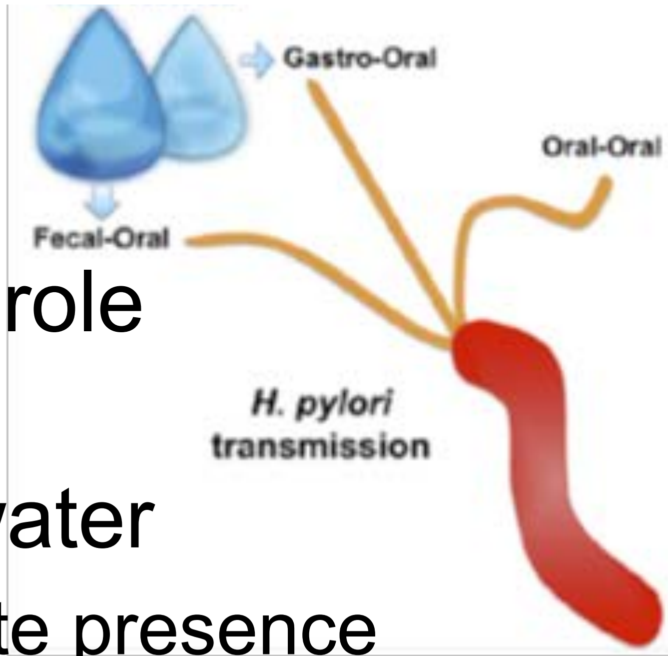
Thiass *et al.* (2016) *Nature 535*(7610): 65-74

So not necessarily good to treat all *Helicobacter pylori* cases

- Based on an international experts' review of evidenced-based benefits and harms for screening & treatment of *H. pylori* in high-prevalence countries
  - In Arctic countries where *H. pylori* prevalence exceeds 60%, treating *H. pylori* infection should be limited to peptic ulcer disease and mucosa-associated lymphoid tissue lymphoma and
  - **test-and-treat strategy may not be beneficial for those with dyspepsia***

*McMahon *et al.* (2015) Epi Inf 144: 225-233

Waterborne *H. pylori?*

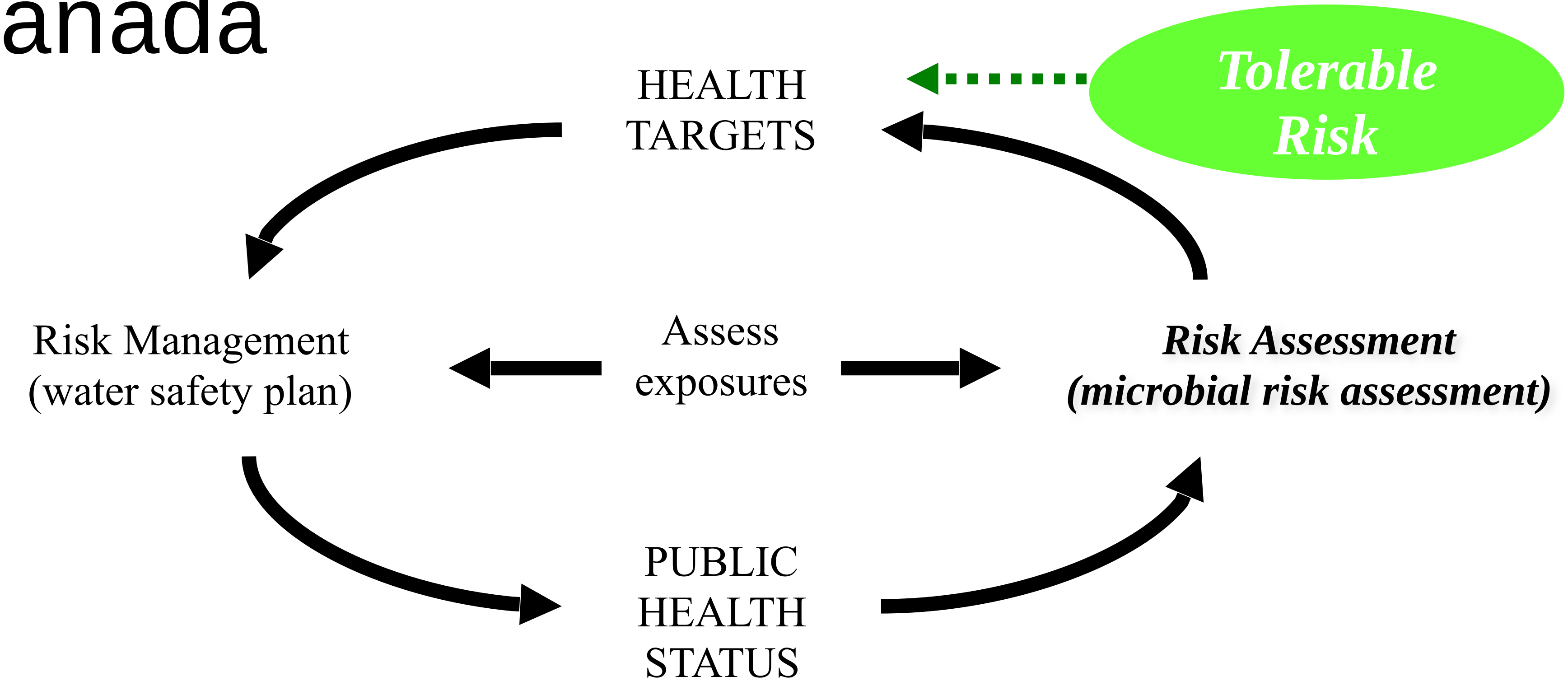


- Contaminated water plays a key role
- *H. pylori* survives in a viable but non-culturable (VBNC) state in water
  – Traditional culture does not estimate presence
- Rafik Dey in my group has demonstrated intracellular growth within free-living amoebae
  – Hence detect infectious VBNC forms & natural site for growth within biofilms (of chlorinated drinking water)

Aziz (2016) *J Adv Res 6*, 539-547

WHO Risk-based water safety plans

Basis of regulations now in Alberta, Canada



Fewtrell & Bartram (2001) Water Quality: Guidelines, Standards and Health. Risk Assessment and Management for Water Related Infectious Diseases, WHO

Pathogen control starts with a toilet

Loowatt-toilet (http://loowatt.com)

Vacuum toilet components

Flush water needs
0 – 1 pint – 0.26 gallons

Air-water forced toilet

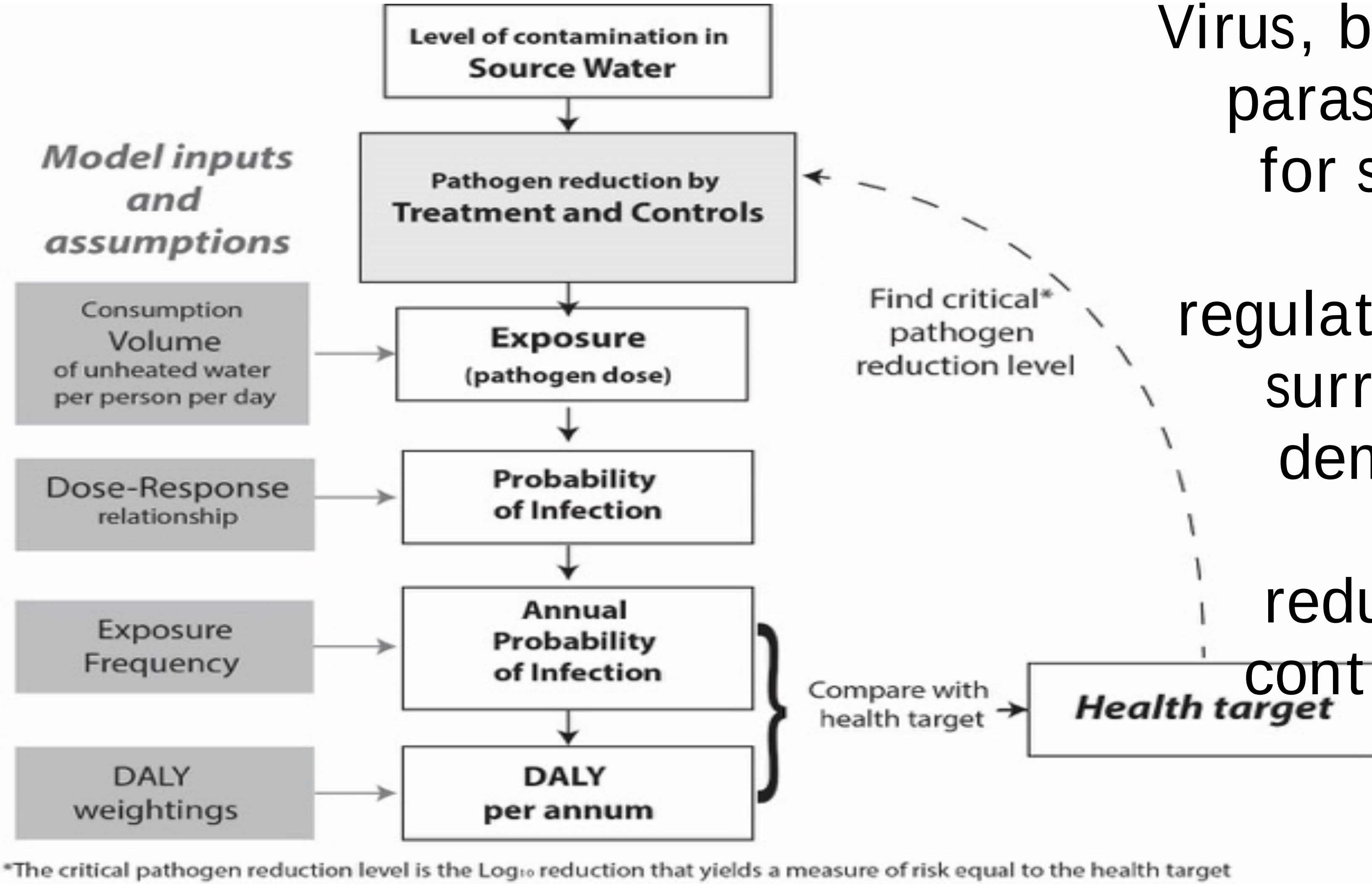
Blackwater energy recovery: socio-economic driver for alternative systems

- Household-scale
  - Possible, but community energy & nutrient recovery better
- Community-scale
  - Full-cost recovery & net energy generation
  - Also provides local economy with jobs

Blackwater sewer (daily pulsed flow, not heated?)

Wood *et al.* (2015) *J Environ Manage 150*: 344-54

Risk-defined treatment requirements



Virus, bacteria & parasite levels for safe uses. Drives regulations then surrogates to demonstrate pathogen reductions at control points are met

Petterson & Ashbolt (2016) J Wat Health 4(4): 571-589
WHO (2016) *Quantitative Microbial Risk Assessment*, Geneva

World Health Organization

Results of Round I of the WHO International Scheme to Evaluate Household Water Treatment Technologies

http://apps.who.int/iris/bitstream/10665/204284/1/9789241509947_eng.pdf

- Criteria based on quantitative microbial risk assessment of surface drinking waters

Performance classification	Bacteria (log_{10} reduction required)	Viruses (log_{10} reduction required)	Protozoa (log_{10} reduction required)	Interpretation (assuming correct and consistent use)
★★★	≥ 4	≥ 5	≥ 4	Comprehensive protection (very high pathogen removal)
★★	≥ 2	≥ 3	≥ 2	Comprehensive protection (high pathogen removal)
★	Meets at least 2-star (★★) criteria for two classes of pathogens			Targeted protection
–	Fails to meet WHO performance criteria			Little or no protection

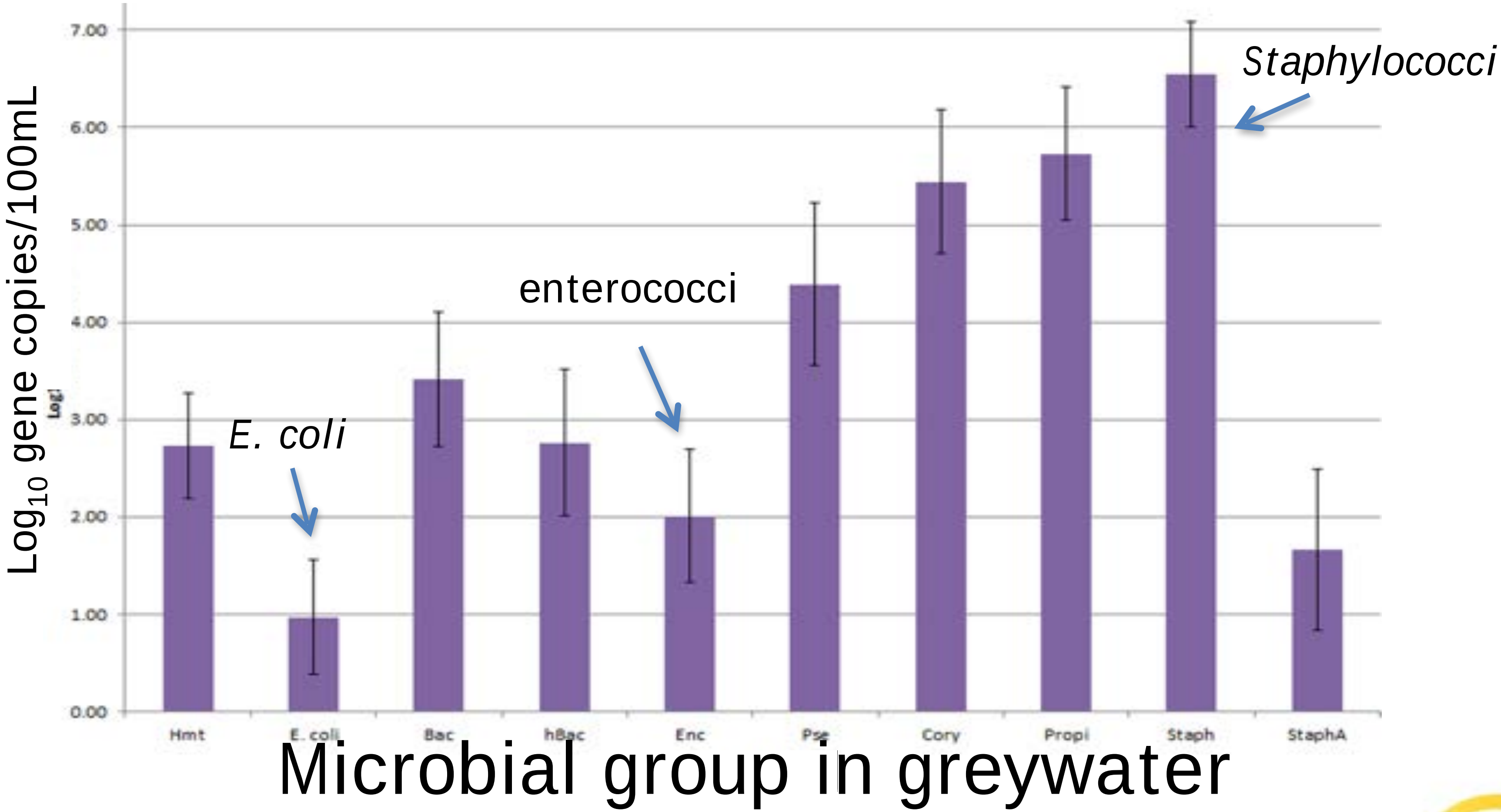
This is PUBLIC HEALTH

Pathogen log reduction targets for non-potable household uses

Water Source	Use	Pathogen log_{10} reduction target to meet < 1 infection / 10,000.y			How?
		Viruses	Bacteria	Parasites	
Roof	Drinking	?	3.5	?	MF + UV
Roof	Washing	?	3.5	?	MF + UV
Snow-melt	Drinking	4.0	3.5	4.0	MF + UV
Snow-melt	Clothes washing	3.0	3.0	3.0	MF + UV
Shower/clothes	Showering	7.0	4.5	5.5	UF + UV
Shower/clothes	Clothes washing	6.0	3.5	4.5	UF + UV

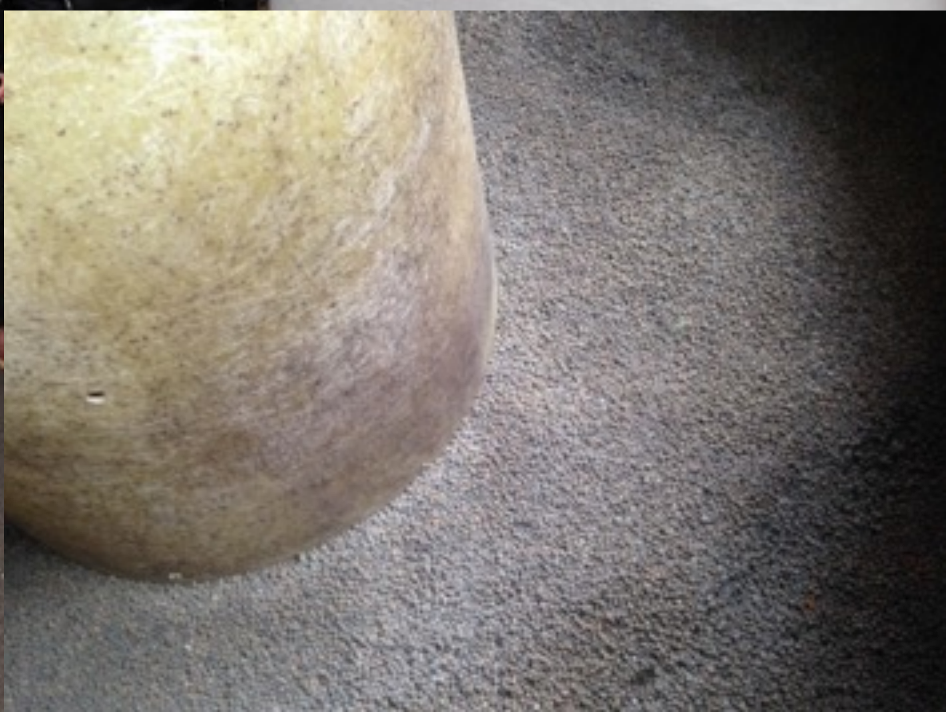
Adapted from: Sharvelle, S.; Ashbolt, N.; Clerico, E.; Hultquist, R.; Leverenz, H. L.; Olivieri, A. I(2016). *Risk Based Framework for the Development of Public Health Performance Standards for Decentralized Nonpotable Water Systems.* Water Environment Research Foundation Alexandria, VA

Bacterial genera in laundry greywater – identifying surrogate



Zimmerman *et al.* (2014) *Env Sci Tech 48: 7993-8002*

Alternative systems: suitable for Arctic?



pld (pathogen log reduction target –

Greywater/treatment (48 gpd)
4-7 LRT by unsaturated filter, UV, or Cl_2

Electrochemica
l

Electrochemical blackwater treatment & recovered flush water loop 4 LRT

odel & political will for:

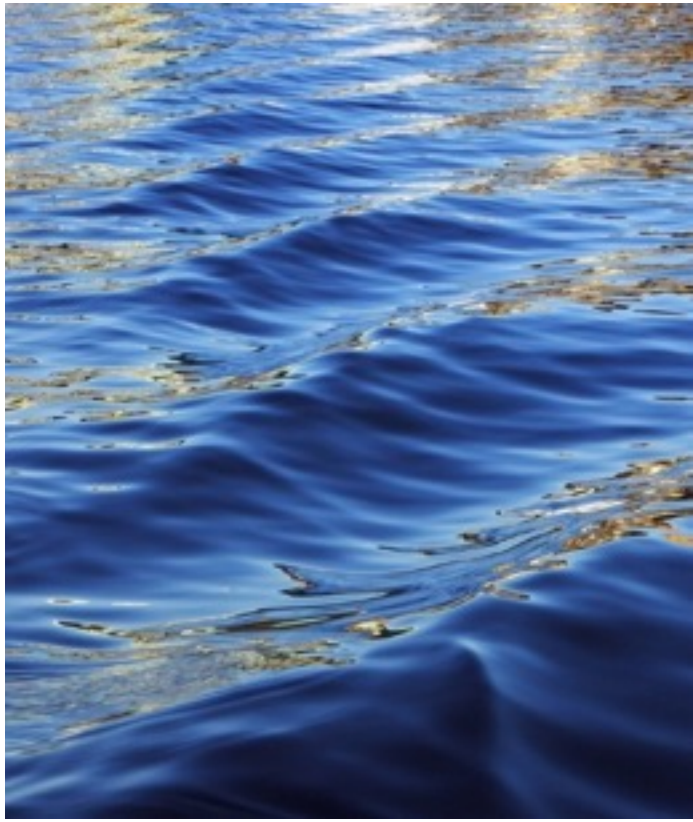
t of drinking water and re-
clothes greywater & separate

modeled water safety plan

Key take home points

- **'Traditional' centralized water services should not be our aspirational goal for most small Arctic communities (nor elsewhere)**
  - Need a systems' & community view to identify alternatives
  - Including energy, heat, fertilizers + water fit-for-purpose
  - Manage system within a proactive water safety plan
  - Demonstration at scale (e.g. Alaskan water/san challenge) to identify sustainable/adaptable water service options

Reuse Regulations and Challenges of Regulating On-site Systems



WATEREUSE

There is not a National Regulation for Water Reuse

- In the gap between CWA and SDWA
- All water is recycled
  - De facto
  - Intentional
- Regulations tend to be for centralized systems

Graphic credit: www.healthywaterways.org

What is Water Reuse?

Non-Potable Reuse (NPR) or
“Direct Reuse” (Purple Pipe)

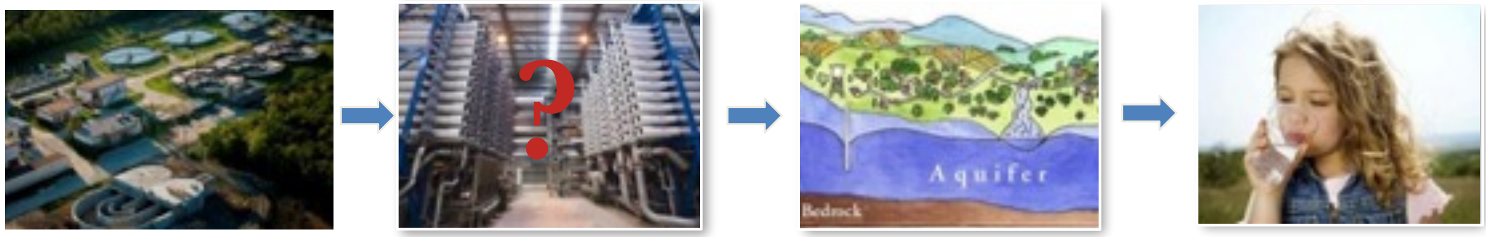
“De Facto” Potable
Reuse

WATEREUSE

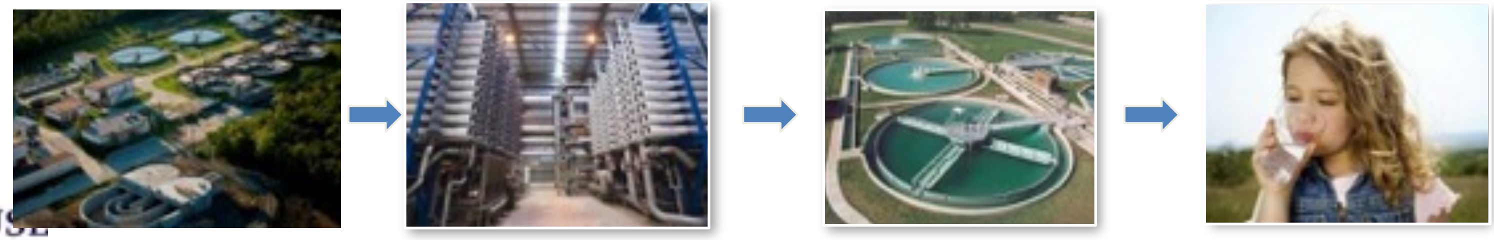
What is Water Reuse?

Non-Potable Reuse (NPR) or “Direct Reuse” (Purple Pipe)

Indirect Potable Reuse - Surface Water Augmentation



Indirect Potable Reuse - Groundwater Recharge



Direct Potable Reuse

"Reuse" is Starting to Mean New Things Too…

- Stormwater Reuse
- On-site, Decentralized Reuse
  - Neighborhood
  - Multi-Story
  - Campus
  - Household
- Commercial & Industrial Reuse
  - Using reclaimed water
  - On-site recycling

However, most reuse regulations focus on use of domestic wastewater as a source of supply

Reuse Regulations Driven by Local Water Rights and Water Quality Rules

- Prior Appropriation
- Riparian Rights
- Case Law
- Management of Aquifers (Quality & Quantity)
- Potable Reuse Regulations Based on SDWA Risks
  - No greater than 1 per 10,000 persons exposed annually
  - 70 kg person drinking 2 liters/day

Drivers Toward Decentralized Water Management

Operationa
l
Technology
and
Informatio
n

Automatio
n and
Computing
Capacity

Locally
Available
and
Controllabl
e

Holistic
Pollution
Prevention

Impediments to Decentralized Water Management

Regulatory Framework → Optics & Perception → A&E Capacity → Profitability → Qualified Operators

WATEREUSE

Decentralized Reuse is Gaining Ground Nationwide

- Greywater Ordinances
- Non-Potable Water Ordinances (SFPUC)
- NSF 350 and 350-1: Onsite Residential and Commercial Reuse Systems
- But, no Greywater to Potable Water
- Biggest challenge for potable is assurance of water quality

Status of Greywater Regulations

Table 4.1. State Analysis of Graywater/Wastewater Regulations

States without Formal Graywater Regulations			States Allowing Graywater Reuse		
States allowing wastewater reclamation that define graywater as wastewater (4.1.1)	**States not defining graywater (4.1.2.1)**	**States treating graywater as septic (4.1.2.2)**	**States permitting graywater using a tiered approach (4.2.1)**	**States regulating graywater reuse without a tiered approach (4.2.2)**	**States allowing residential irrigation only (4.2.3)**
Alabama	Illinois	Connecticut	Arizona	Florida	Hawaii
Alaska	Kansas	Kentucky	California	Georgia	Idaho
Arkansas	North Dakota	Maryland	New Mexico	Montana	Maine
Colorado	Ohio	Michigan	Oregon	Massachusetts	Nevada
Delaware	South Carolina	Minnesota	Washington	North Carolina	
Indiana	Tennessee	Nebraska		South Dakota	
Iowa		New Hampshire		Texas	
Louisiana		New Jersey		Utah	
Mississippi		New York		Virginia	
Missouri		West Virginia		Wisconsin	
Oklahoma				Wyoming	
Pennsylvania					
Rhode Island					
Vermont					

Table from "Treatment, Public Health, and Regulatory Issues Associated with Greywater Reuse. *Guidance Document.* By Sybil Sharvelle et. al. for WERF

WATEREUSE

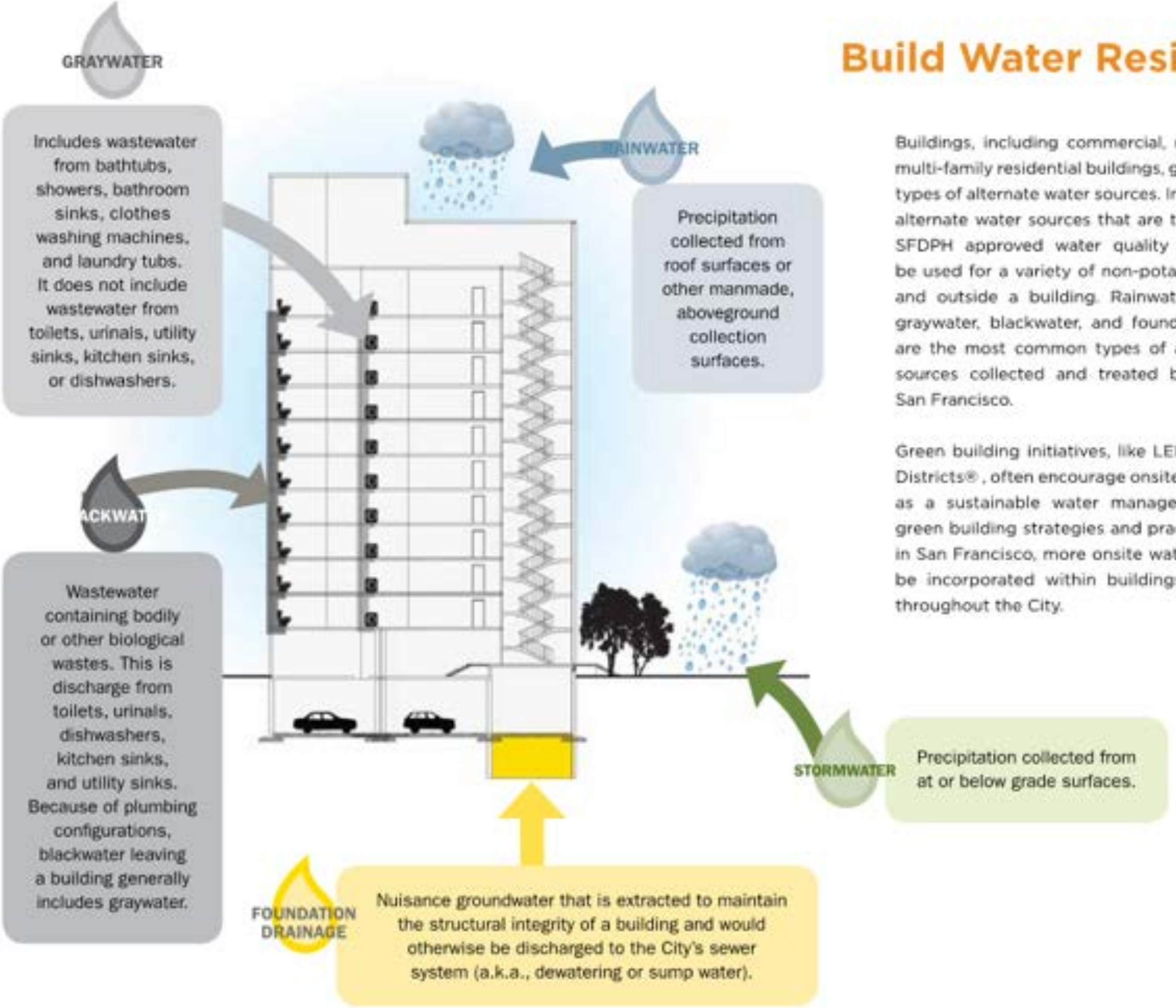
SFPUC Non-Potable Water Ordinance

- Developed in context of watershed management
- On-site vs. centralized capacity
- Integrated across departments
- Supported by Guidance Manual
- Clear, concise on-line information
- Mandated implementation for all buildings 250,000 square feet and larger

San Francisco
Water
Power
Sewer

Services of the San Francisco Public Utilities Commission

SFPUC Non-Potable Water Ordinance



Build Water Resilience

Buildings, including commercial, mixed-use, and multi-family residential buildings, generate several types of alternate water sources. In San Francisco, alternate water sources that are treated to meet SFDPH approved water quality standards can be used for a variety of non-potable uses within and outside a building. Rainwater, stormwater, graywater, blackwater, and foundation drainage are the most common types of alternate water sources collected and treated by buildings in San Francisco.

Green building initiatives, like LEED® and 2030 Districts®, often encourage onsite water systems as a sustainable water management tool. As green building strategies and practices progress in San Francisco, more onsite water systems will be incorporated within buildings and districts throughout the City.

WATEREUSE

SFPUC Non-Potable Water Ordinance

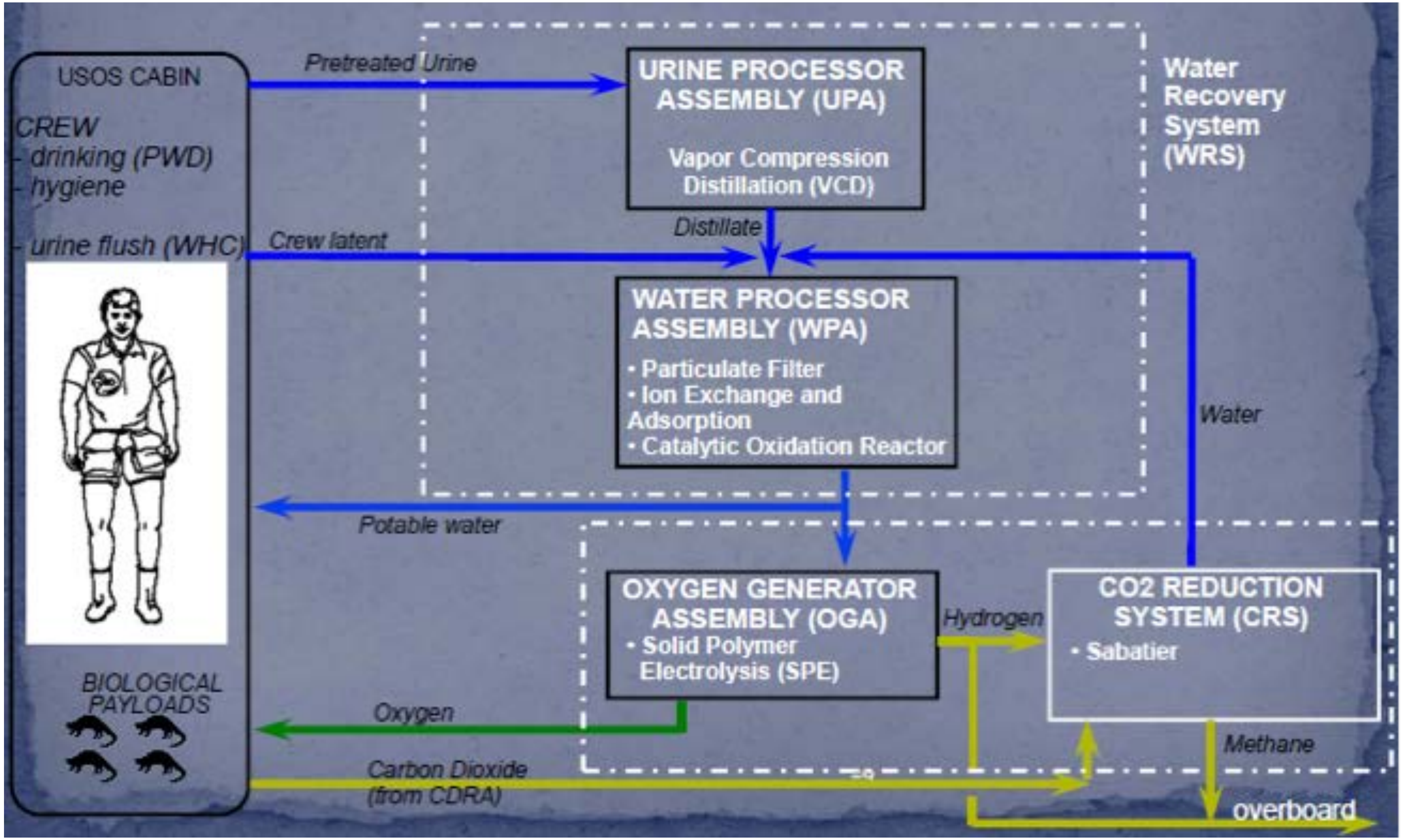
- Sources cannot include dishwasher or kitchen sinks.
- None of recycled water would come into direct contact with people
  - Toilet & urinal flushing
  - Landscape irrigation
- Can’t be used for washing food or clothing
- Doesn’t do rural Alaska much good.

NSF/ANSI 350 Only Goes So Far

- Very onerous process to get certified
- Sources cannot include dishwashers or kitchen sinks
- Limited on-site uses
  - Urinal & toilet flushing
  - Landscape irrigation
- Doesn't do rural Alaska much good

WATEREUSE

Why don't we just do what NASA does, and drink our own recycled urine?



WATEREUSE

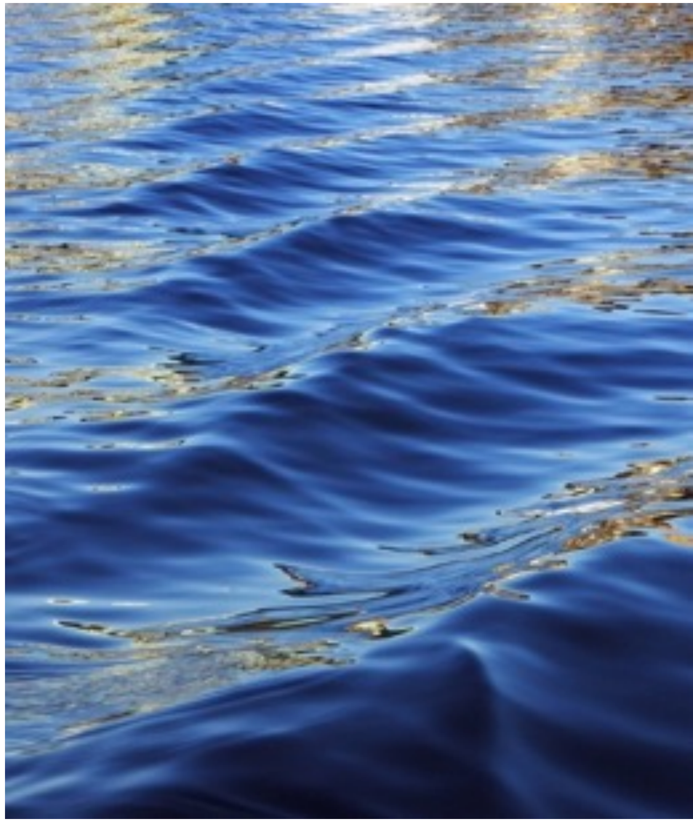
So what principles can we apply for on-site systems in rural Alaska?

- Exposure risk assessments
  - Centralized systems: cancer and gastrointestinal pathogens
  - Decentralized systems: Same, but also skin maladies
- Low complexity / loosely coupled systems
- Risk mitigation
  - Redundant treatment
  - Real time monitoring
  - Storage & re-processing of off-spec water
  - Homeowner basic training & best practices
  - System testing program (like backflow prevention)

Thank you!

Guy Carpenter
President, WateReuse Association

Senior VP, Strategic Operations
gcarpenter@aqua-tecture.net
424-832-7017



WATEREUSE

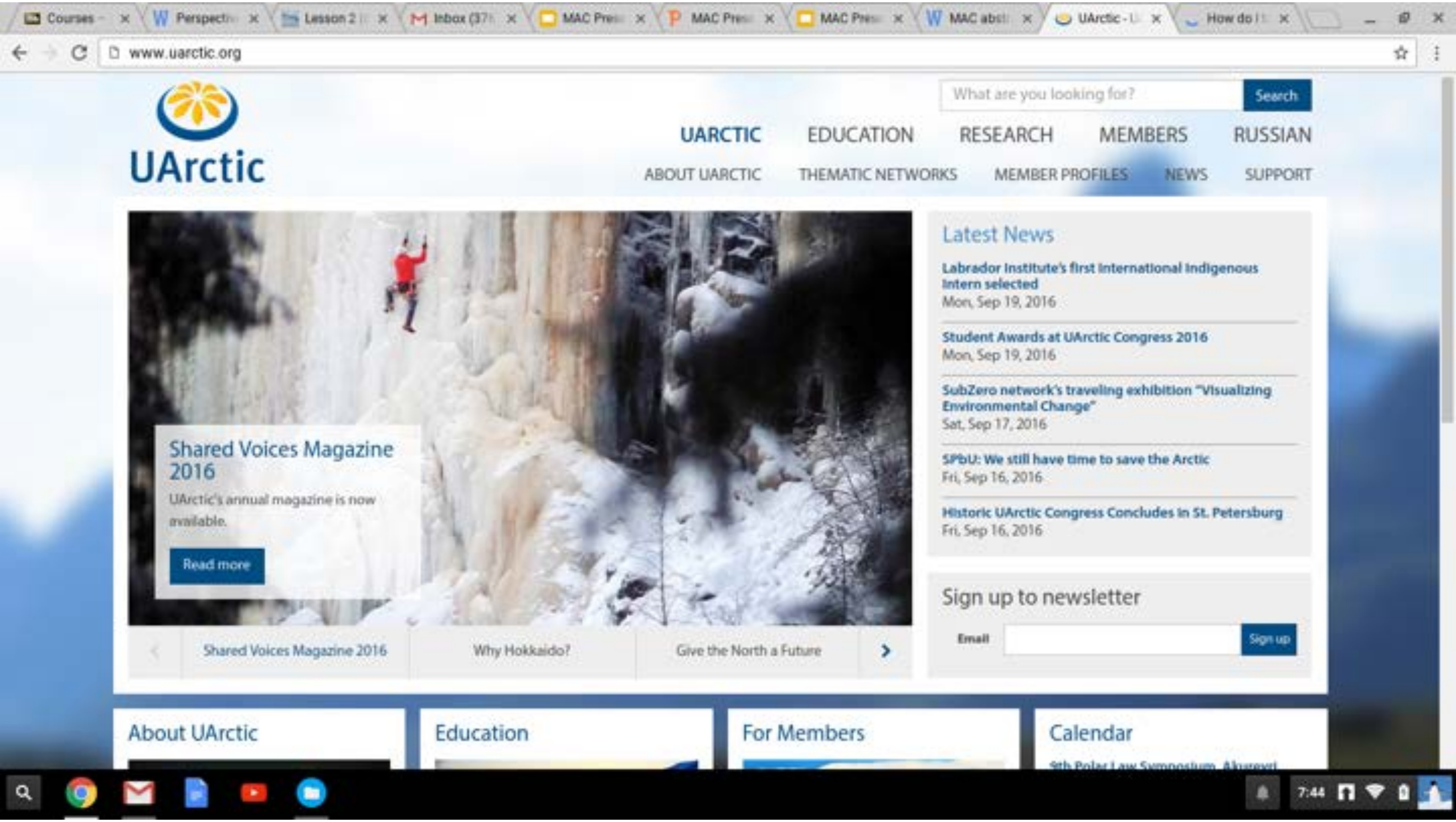
Water Security in the Arctic

Perspectives from the Model Arctic Council

University of Alaska Fairbanks | March 2016

MAC Objectives

- ➔ develop students' knowledge of the Arctic as a region, of circumpolar politics, and of northern Indigenous peoples
- ➔ increase students' understanding of Arctic Council objectives and processes
- ➔ prepare students to assume leadership roles in the circumpolar north
- ➔ enhance student and faculty collaboration among UArctic institutions.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Shared Voices Magazine 2016
UArctic's annual magazine is now available.
Read more
Shared Voices Magazine 2016
Why Hokkaido?
Give the North a Future
Latest News
Labrador Institute's first International Indigenous Intern selected
Mon, Sep 19, 2016
Student Awards at UArctic Congress 2016
Mon, Sep 19, 2016
SubZero network's traveling exhibition "Visualizing Environmental Change"
Sat, Sep 17, 2016
SPbU: We still have time to save the Arctic
Fri, Sep 16, 2016
Historic UArctic Congress Concludes in St. Petersburg
Fri, Sep 16, 2016
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For Members
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7:44

SDWG: Arctic WASH Project

Stephen Penner
MAC Role: Arctic Athabaskan Council

Denah O'tanah! We are the people of the land.

non Indigenous person to act in the place of an Indigenous organization

Greater understanding of positionality and place = positive experiential learning.

Sharon Hildebrand
MAC Role: U.S. Representative

http://youtu.be/rb3yliN0Wz0

Carolyn Kozak
MAC Role: U.S. Representative

Over 5,000 Alaskans Unserved

Complex Challenges

Fail Attempts

Value of
Simulation

FAIRBANKS DECLARATION (excerpt)

Affirm three central themes for the Improving Health Through Safe and Affordable Access to Household Running Water and Sewer (WASH) project: social justice, economic sustainability, and environmental protection,

Confirm a report on climate change vulnerabilities and adaptation strategies is needed pertaining to Arctic community water and sewer systems, including source water protection, to be presented to the Arctic Council following the September 2016 Sustainable Development Working Group meeting,

Confirm participation by the Member States and permanent participants at the Water Innovations for Healthy Arctic Homes (WIHAH) conference in Anchorage, Alaska, September 18-21 2016, Reaffirm the need to establish metrics and best practices for monitoring implementation, led by the Arctic Council Permanent Participants,

Reaffirm the need to establish metrics and best practices for monitoring implementation, led by the Arctic Council Permanent Participants

LEARNINGS FROM MAC

The effects of climate change are felt more acutely by those who are the most remote.

Time for research and time for action

We are stronger when we SHARE

THE ARCTIC IS WHERE TEK COMES CLOSEST
TO THE WESTERN SCIENTIFIC PARADIGM

CONSENSUS IS TOUGH PILL TO SWALLOW BUT IT DOES LEAD TO PROGRESS

EMPOWERMENT FROM MAC

AMAZING NEW COHORT TO CARRY THE MESSAGE OF THE ARCTIC TO THE SOUTH

Taking action on matters of importance to Arctic communities

Questions

Sharon Hildebrand
Carolyn Kozak
Stephen Penner

Masee' – Thank you

Household Water Treatment and Safe Storage:
Experience from the Developing World
Lessons for Rural Alaska?

Rob Quick, MD, MPH

CDC

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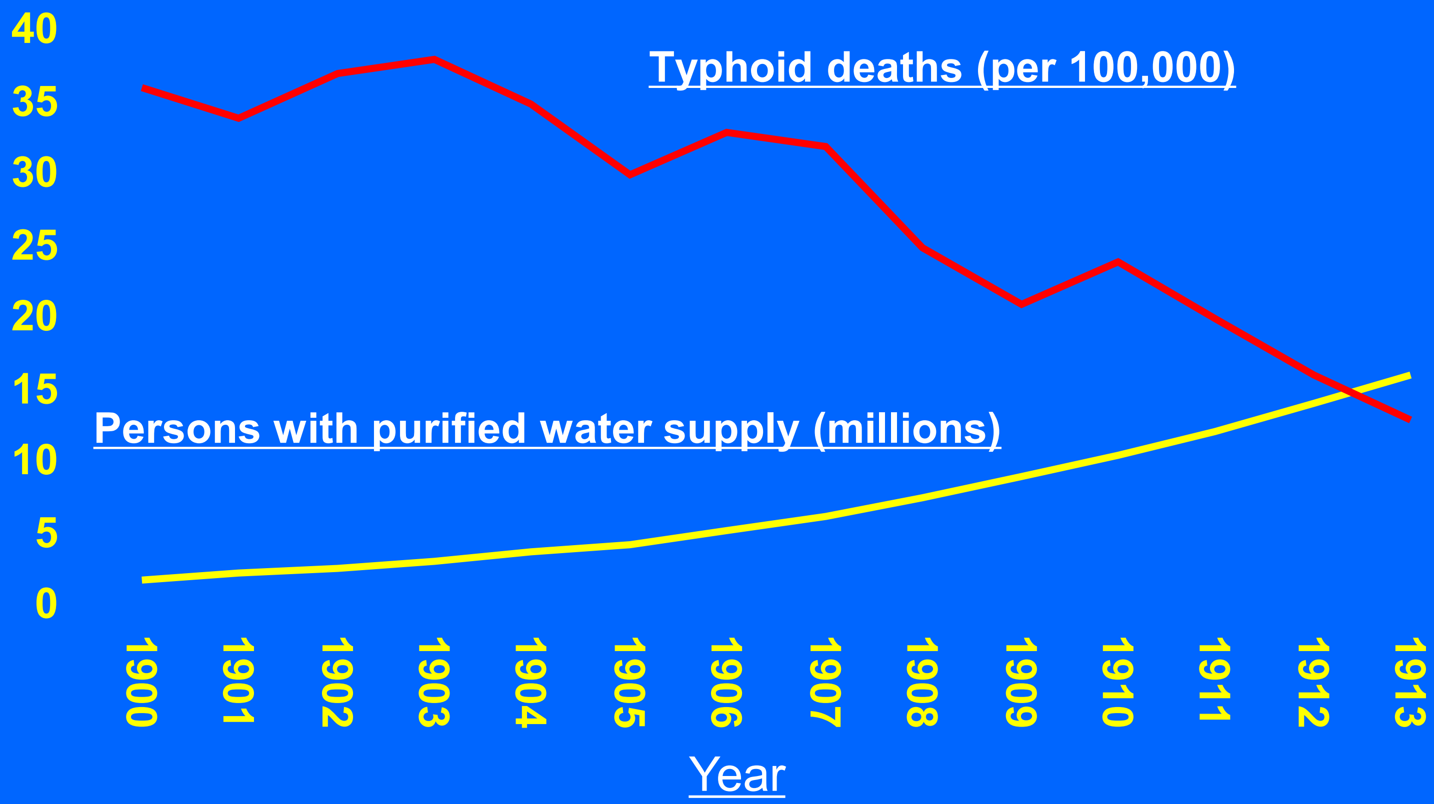
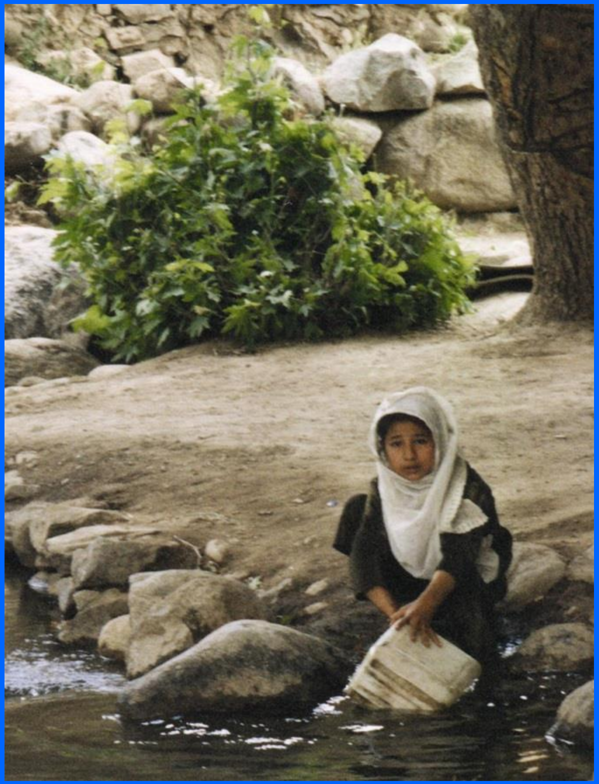
Growth of Water Purification and Decline in Typhoid Fever Deaths, United States Cities 1900-1913



Adapted from: Johnson GA. The typhoid toll. Journal of the American Water Works Association 1916; 3: 249-326

Health and Access to Safe Water in the Developing World

- Over 500,000 diarrhea deaths per year
- Over 660 million people lack access to "improved water supplies"
- At least 1.8 billion lack access to safe water
- "Improved" water supplies are not necessarily safe



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Household Connections Are Not Necessarily Safe

- Irregular treatment
- Inadequate maintenance
- Clandestine connections
- Power outages

Community Water Supplies Are Not Necessarily Safe

- Contamination of ground water
- Recontamination of clean water through transport and storage

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Barriers of Time and Effort: Daily Burdens

- Obtain food
- Collect water
- Buy or collect fuel
- Build fire
- Cook
- Care for children
- Wash clothes
- Clean house
- Care for livestock
- Tend garden crops
- Engage in economic activities

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Barriers of Money: Daily Expenses

- Food
- Cooking supplies
- Water
- Fuel
- Cleaning supplies
- Seeds, fertilizer
- Transportation
- Clothing
- Medicine/health care
- School supplies
- Durable goods

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The Water People Want

- In the home
- Clean
- 24/7

The Challenge of Providing Water Infrastructure

- Huge expense (China: $125 billion over 10 years)
- Time consuming
- Requires political stability/good governance
- Compromised distribution systems
- Maintenance/repair challenges
- The population at greatest need earns less than $2 per day
- Inadequate systems to collect money from population in need

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A Short to Medium Term Alternative: Household Water Treatment and Safe Storage (HWTS)

Household Water Treatment and Safe Storage

Water treatment with dilute sodium hypochlorite

Safe water storage

Behavior change methods: social marketing and community mobilization

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Evidence Base

- Improve water quality in the laboratory
- Improve water quality in field settings*
- Prevent disease
  - 2006 Cochrane review**
    - Review of 33 reports
    - HWTS interventions reduce diarrhea risk by >30%
- Improve water quality and prevent disease at scale in a "real world" setting

*Wright J, et al; TMIH 2004; Vol 9: p. 106-17

Clasen T, et al. BMJ 2007; doi:10.1136/bmj**.39118.489931.BE

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HWTS Field Trials

Reduces diarrhea risk by 25-85%

Bolivia*	1994	44% overall; 53% in infants
Uzbekistan*	1996	85% overall
Zambia*	1998	48% overall
Guatemala*	2001	25% overall
Madagascar*	2001	90% against cholera
Kenya*	2001	55% in children <5 years old
Madagascar*	2002	63% overall
Pakistan*	2002	73% overall
Uganda*	2003	25% in HIV-infected persons

*publication available

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Proven Technologies: Chemicals

- Chlorine solution
- Flocculent-disinfectant
- Aquatabs
- Chlorine dispensers

Proven Technologies: Filters

- Biosand
- LifeStraw Family
- Silver impregnated ceramic pot, situated in nested buckets with a tap

Proven Technologies: UV Light

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Proven Technologies: Boiling

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Unproven Technologies Abound

- Unproven technology = insufficient evidence for effectiveness and feasibility
- Many examples of unproven technologies
  - Chemical ($AgNO^2$, halogen beads)
  - Filters (hollow fiber)
  - Community systems (reverse osmosis)
- Innovation is necessary and good, but testing is essential

Estimated Scale of HWTS

- Based on JMP surveys from 67 countries (1.1 billion people)*
- Reported HWTS use by 33% (18% in Africa)
  - Boiling: 21% (4.5% in Africa)
  - Chlorine: 6%
  - Filtration: 4%
  - Solar disinfection: 0.2%
- Direct observation
  - E. coli detection in water reported to be boiled: 40-60%
  - Chlorine residual detection in water reported to be chlorinated: 5-30%

Rosa, et al. Am. J. Trop. Med. Hyg., 82(2), 2010, pp. 289–300

Why Don't People Treat Their Water?

- Hardware (ie, technology) problems
  - Poor match with population
  - Performance problems
  - Inadequate attention to maintenance and repair
  - Short lifespan
- Software problems
  - Insufficient training of implementers and target populations
  - Inadequate attention to behavior change process

Why Don’t People Treat Their Water?

- Barriers
  - Cost
  - Lack of time
  - Inconvenient
  - Taste/smell issues
  - Too complicated
- Low demand
  - Lack of awareness of need for treatment
  - Belief that water doesn’t need treatment
  - Ingrained practices/habits

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Why Do People Adopt Interventions? Lessons from Diffusion Research

- Relative advantage
- Compatibility
- Triability or testability
- Potential for reinvention
- Observed effects

Rodgers, *Diffusion of Innovations*

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Social Entrepreneurs/ Community Health Promoters

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HWTS Integration in Schools

HWTS Integration in Health Facilities

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HWTS Integration with Antenatal Services

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"Consumer" Choice: An Evaluation of Technology Preferences

- Location: rural western Kenya
- Population: random sample of 400 households
- Technologies:
  - "WaterGuard" chlorine solution + improved container

  - "PUR" flocculent-disinfectant sachets, 2 buckets, cloth

  - Silver-impregnated ceramic pot

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Study Design

- Baseline survey
  - Technology preferences
- Randomized into 3 groups
  - Each group randomly assigned one of 3 technologies
  - Used technology for 2 months
  - Technologies switched every two months
  - Each group each of 3 technologies x 2 months
  - Water quality tested for each technology in each household
- End of study: each participant chose technology they preferred

Outcomes Measured for Each Technology

- Reported use
- Microbiological performance
- Reported technology preferences
  - Baseline
  - End of study
- Technologies chosen by participants at end of study

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Technology Use

Technology	Reported use
WaterGuard	76%
PUR*	62%
Ceramic pot	73%

*p<0.05 compared to WaterGuard

Technology Performance: Undetectable E. coli in Treated Water

Technology	Improved water supply	Unimproved water supply
WaterGuard	53%	66%
PUR*	34%	54%
Ceramic pot*	43%	51%

*p<.05 compared to WaterGuard

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Technology Preferences

	Baseline prefer	**Exit prefer**	**Exit choose***
WaterGuard	35%	21%	14%
PUR	18%	35%	40%
Ceramic pot	47%	44%	44%

*2% preferred soap to any technology

Western Alaska vs. Western Kenya

A Brief Comparison

Western Alaska

- Rural and remote
- Small populations
- Economy: service and subsistence
- Poverty rates: high
- Cost of living: high
- Few roads
- Expensive electricity
- Health services: good

Western Kenya

- Mostly rural
- Large populations
- Economy: informal and subsistence
- Poverty rates: high
- Cost of living: high
- Few roads
- Little or no electricity
- Health services: poor

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A Brief Comparison

Western Alaska

- Water:
  - Accessible
  - Surface sources
  - Transport and store in home
- Maintenance challenges:
  - Cold climate
  - Climate change
- Cultural links to water
- Access to financing (government, other?)

Western Kenya

- Water:
  - Scarce
  - Surface and ground
  - Transport and store in home
- Maintenance challenges:
  - Heat, dust, low water table
  - Climate change
- Cultural links to water
- Little access to financing (NGOs, development agencies)

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Lessons

- Choose proven, field-tested technologies
  - Durability
  - Feasibility
  - Microbiologic effectiveness
  - Affordability
  - Sustained, consistent use
- Conduct formative research in target population
  - Current practices
  - Understanding of cultural ties to water
  - Understanding of need for water treatment
  - Technology preferences (ie, provide menu of options)

Lessons

- Community participation/ownership is vital
  – Demand for safe water supply
  – Consistent household use
  – Maintenance/repair
- Integration in health services and schools can help
- A realistic financing plan is necessary
  – Cost recovery is desirable
  – The poor may not be able to pay
  – Alternative financing strategies may be necessary
- Policy support is important
  – Local to regional to national

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Final Word

"The problems seem overwhelming. But these are all solvable problems. We just need a bigger and better response."

--William H. Foege, MD, MPH

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Thank You






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Arctic WASH contributions from the Kingdom of Denmark - Greenland

Pernille Erland Jensen and Kristian Hammeken
Centre of Arctic Technology
Department of Civil Engineering
Technical University of Denmark

Outline

- Greenland
- A retrospect
- Present situation

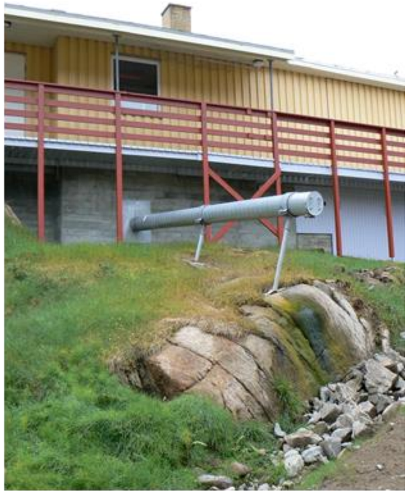
- International conference in April
- Programs

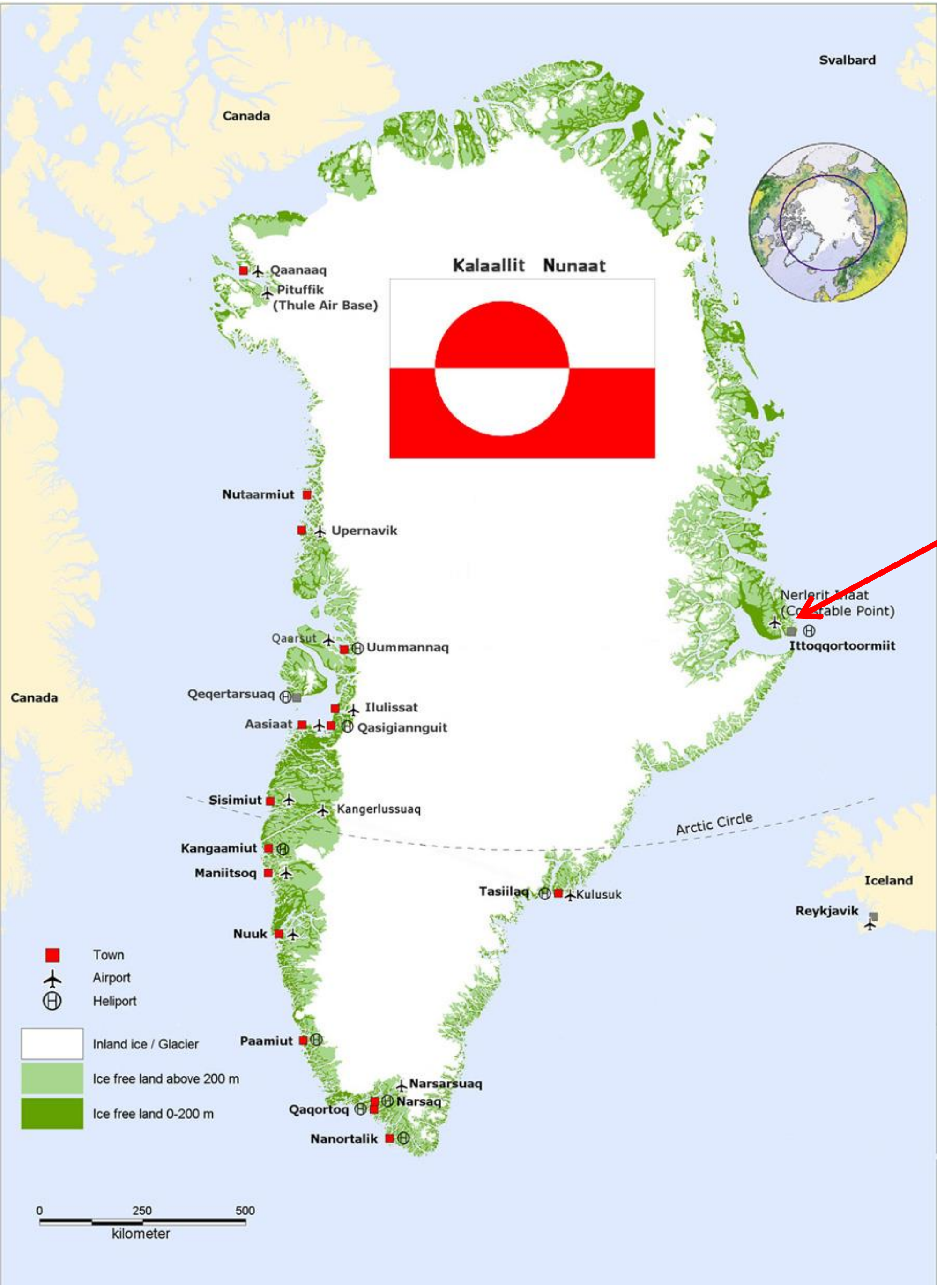
Greenland

- Largest non-continental island in the world
  - 1.3 times Alaska
- Lowest population density worldwide
  - 56,000 inhabitants
  - 0.03 or 0.14 persons/km^2 (Alaska: 0.49/km^2)
- Climate Sub-Arctic to Arctic
- Long distances and no roads to connect towns and settlements
- Fish industry – no mines or oil now
- 17 towns (380-17000 inhabitants)
- 56 settlements (25-500 inhabitants)

Present situation

- Sewers and access to improved water in major part of towns
- Honey buckets in major part of settlements and minor part of towns – very variable water resource situation from place to place.




Kalaallit Nunaat
Svalbard
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(Thule Air Base)
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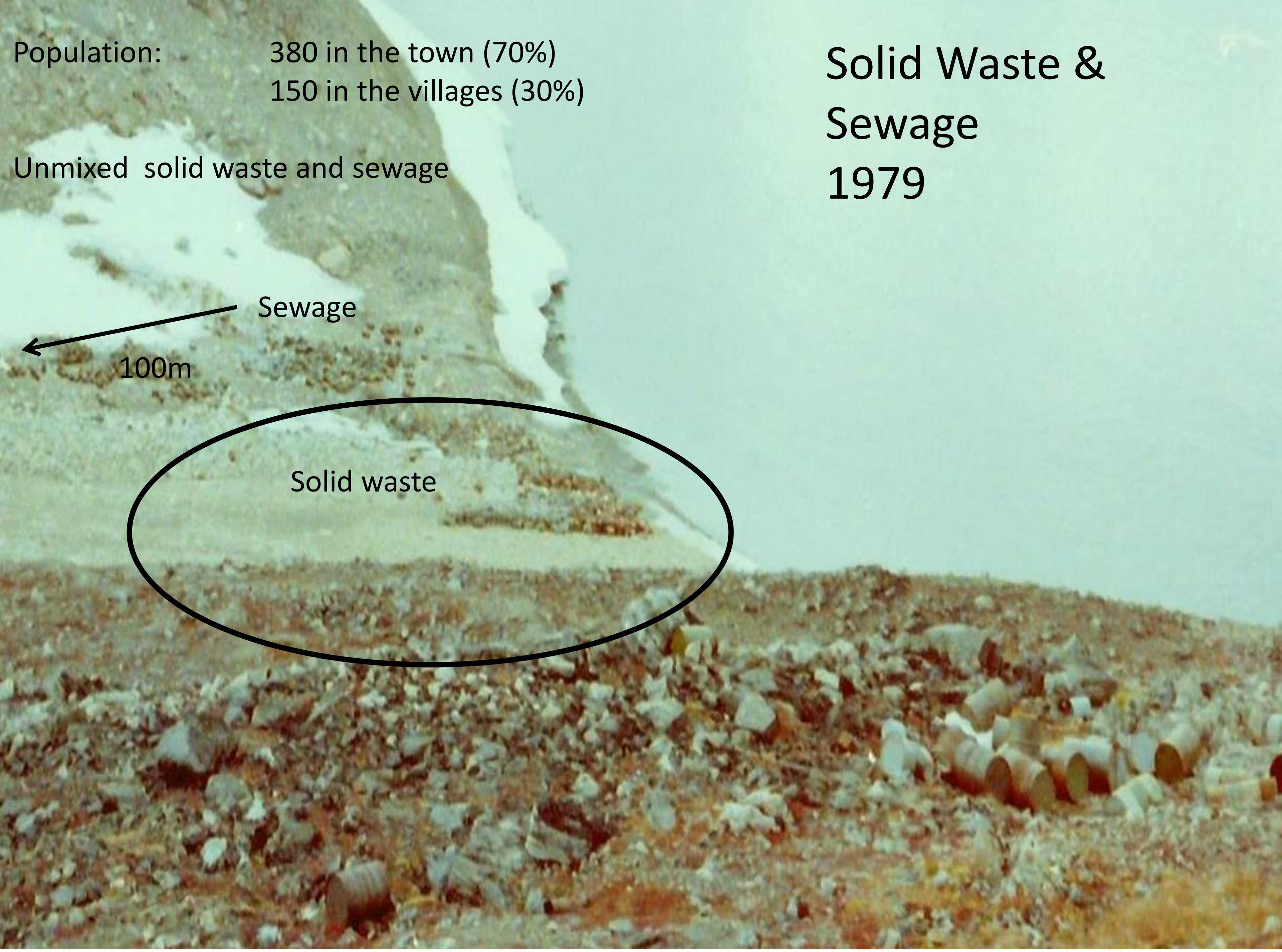
kilometer

WIHAH
ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21
WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

ARCTIC TECHNOLOGY CENTRE DTU

My home as kid

Ittoqqortoormiit playing kids


Population:
380 in the town (70%)
150 in the villages (30%)
Solid Waste &
Sewage
1979
Unmixed solid waste and sewage
Sewage
100m
Solid waste


Solid Waste
& Sewage
2015
Population:
460 in town (100%)
0 in the villages (0%)
Mixed solid waste and
Sewage
Honey bags
Solid waste

Ittoqqortoormiit Watersupply – 1980-81

Ittoqqortoormiit Watersupply - 2015

International conference in April

ARTEK Event 2016

Calendar

ARTEK Events http://www.artek.byg.dtu.dk/

What is the ARTEK Event?

ARTEK Event is an international technology conference arranged by the Arctic Technology Centre. It is held every 2nd year in Sisimiut and was held the first time in 2005. Next time will be in April 2016.

ARTEK EVENT 2016

The ARTEK Event 2016 has the topic Sanitation in Cold Climate Regions and has it's focus on management of municipal and industrial waste and protection of water resources in the Arctic. The conference takes place 12 - 14 April in Sisimiut.

Background

The Arctic is undergoing substantial changes towards denser populations, introduction of modern industries, opening of shipping lanes and increases in the standard of living, leading to modern consumption rates. At the same time, climate changes are predicted to significantly impact the ecosystems in the Arctic.

The development in the Arctic creates new challenges in relation to waste and wastewater handling, pollution control, human health, management of contaminated land and protection of the water supply. There is a need for research and development of affordable, robust and sustainable engineering solutions that fulfill supply and environmental demands within the constraints of the Arctic climatic and infrastructural conditions.

The Artek Event 2016 offers the opportunity for participants from the industry, the public sector, the science community and
other stakeholders to present, discuss and exchange ideas and experience on the management of municipal and industrial waste and protection of water resources in the Arctic.

Topics include, but are not restricted to:

- Arctic context
  Stand-alone/decentralized systems, island operated systems, small systems for cluster homes, remote and very small communities, cold climate issues, health issues and transportation challenges.
- Municipal wastewater
  Environmental impacts, treatment (passive and active), separation and composting toilets, un-sewered communities, sewering in cold climate and sludge management.
- Drinking water
  Supply, safety, resources, quality, storage, distribution and treatment.
- Extractive industries
  Wastewater and solid waste, impacts, treatment methods, toxic and radioactive element removal, cyanide treatment, acid mine drainage treatment and prevention, processing chemicals impacts and treatment.
- Municipal solid waste and waste from food, fish and other industries
  Characteristics and volumes, sorting, reuse, incineration, composting, anaerobic digestion, deposition, from waste to energy potential and energy technologies.

-> Book of Abstracts

-> Official conference webpage

ARTEK EVENT 2014

ARTEK Event 2014 took place in Sisimiut from 7-9 April and had the topic Urbanisation and infrastructure in the Arctic.

Conference proceeding 2014

ARCTIC TECHNOLOGY CENTRE

http://www.artek.byg.dtu.dk/

DTU

ARTEK Event 2016

- Presentations
- Pictures
- WASH - an Arctic Council endorsed project
- Special ESPR issue on Sanitation in Cold Climate Regions

Calendar

ARTEK Event 2016

Thank you for a great ARTEK Event 2016 in Sisimiut, Greenland.

With over 100 participants and 55 presentations, the attendance for the ARTEK Event 2016 was by far the largest ever.

The conference attracted participants from all Arctic countries: USA, Canada, Russia, Finland, Iceland, Norway, Sweden and Denmark – including participants from Greenland and the Faroe Islands. The broad interest provided an opportunity to get acquainted with new technological solutions as well as new potential partners.

On this site you will find:

- Presentations and pictures from the conference.
- Information about the Arctic Council-endorsed project, "Improving Health through Safe and Affordable Access to Household Running Water and Sewer (WASH)", which ARTEK Event 2016 is a part of.
- Information about the special issue in the journal Environmental Science and Pollution Research (ESPR) on Sanitation in Cold Climate Regions.

Updated by Sabina Askholm Larsen on 3 June 2016 http://www.artek.byg.dtu.dk/

ARTEK Event 2016

- Presentations
- Pictures
- WASH - an Arctic Council endorsed project
- Special ESPR issue on Sanitation in Cold Climate Regions

Calendar

Special ESPR issue on Sanitation in Cold Climate Regions

The journal Environmental Science and Pollution Research (ESPR) will be publishing a special issue focusing on Sanitation in Cold Climate Regions.

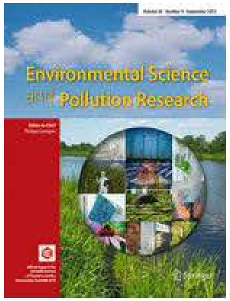
The special issue will feature both critical reviews and research papers and will include but not be restricted to these topics:

- Waste water
- Solid waste
- Water supply
- Health
- Safety
- Environmental impacts
- Treatment
- Infrastructural issues

The submission deadline for papers has been set as 31st of October 2016. Earlier submissions are encouraged, and papers will be published online as soon as they have been accepted for publication.

Download this document for information on how to submit your contribution to the ESPR special issue on Sanitation in Cold Climate Regions.

For further information about this special issue, please read this invitation letter or contact Associate Professor Pernille Erland Jensen.



Updated by Ingrid Vernimmen on 15 August 2016

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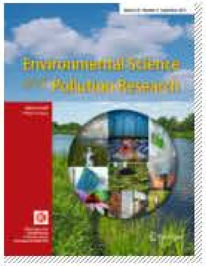

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ADDITIONAL INFORMATION

ARTEK – Education

BEng Arctic Technology

- Three semesters in Sisimiut (GL)
- Three semesters DTU (DK)
- One semester internship in Greenland
- Thesis on Arctic topic
- Civil engineers, five specializations: Building design, Installations, Environment, Construction and Planning

- 20-25 students each year enroll
- Studying now total 90
- Graduated 70+

Center for ARKTISK TEKNOLOGI

DTU

The Arctic Semester in Greenland

An opportunity for Master students to experience the challenges of engineering north of the Arctic Circle

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- Exchange Semester

The Cold Climate Engineering partners

Unis, Svalbard

DTU Campus, Sisimiut, Greenland

Nordic Master in Cold Climate Engineering

www.coldclimate-master.org

Arctic studies from space

DTU + Aalto

Arctic studies at sea

NTNU + Aalto

Arctic studies on land

DTU + NTNU

Qujanaq

A BEND IN THE RIVER

TRANSITIONING TO A TIME OF *PERMANENT* CHANGE

john matthews • johoma@alliance4water.org
anchorage, alaska, usa • 19 september 2016

HOPE IN A TIME OF GREAT TRANSITIONS

Qinghai Province, Tibetan Plateau, China

AGWA Alliance for Global Water Adaptation
alliance4water.org

WHY IS AGWA HERE?

AGWA focuses on long-term sustainability — how do we

technical knowledge: science, engineering, finance, economics — synergies, best practices

enabling policy: can we help high-level decision makers understand and assist?

Co-chairs: World Bank and Stockholm International Water Institute (SIWI)

Membership: global, ~950 individuals

http://alliance4water.org
http://AGWAguide.org

AGWA Alliance for Global Water Adaptation alliance4water.org

WHAT ARE THE CLIMATE CHALLENGES?

climate extremes / disasters|
super droughts & floods|
tropical cyclones|

Resilience: return to normal

Resilience: Tracking change

|steady, creeping climate change
|climate "weirding"
|transformation

traditional & purely technical solutions are no longer real solutions

FOR HUMANS, CLIMATE CHANGE IS ABOUT WATER

FOR WATER, CLIMATE CHANGE IS ABOUT INFRASTRUCTURE & ECOSYSTEMS

TOGETHER, WE HAVE A CRISIS IN HOW WE MAKE DECISIONS ABOUT WATER

CLIMATE CHANGE CHALLENGES HOW WE MAKE LONG-TERM SOLUTIONS

To manage water reliably, we have always looked *backward* for guidance.

That era is over too. The past doesn’t tell us much about the future anymore.

Our challenge is to envision a range of probable futures.

Janus, the Roman god of transitions and journeys — looking into the future & past

WE CARELESSLY MADE 100 (200, 300) YEAR DECISIONS

SCIENCE & ENGINEERING CAN’T PROVIDE PRECISE, ACCURATE DETAIL ABOUT WHAT WILL HAPPEN — OR HOW QUICKLY

IF NECESSARY, WE CAN MAKE SHORTER DECISIONS THAT HELP US KEEP OPTIONS OPEN

HOW WE USUALLY MAKE LONG-TERM WATER DECISIONS

Decision maker

PROBLEM / NEED

Not just the climate is changing. Our needs are too.

Technical analyst

SOLUTION

CLIMATE VULNERABILITY

Users, stakeholders

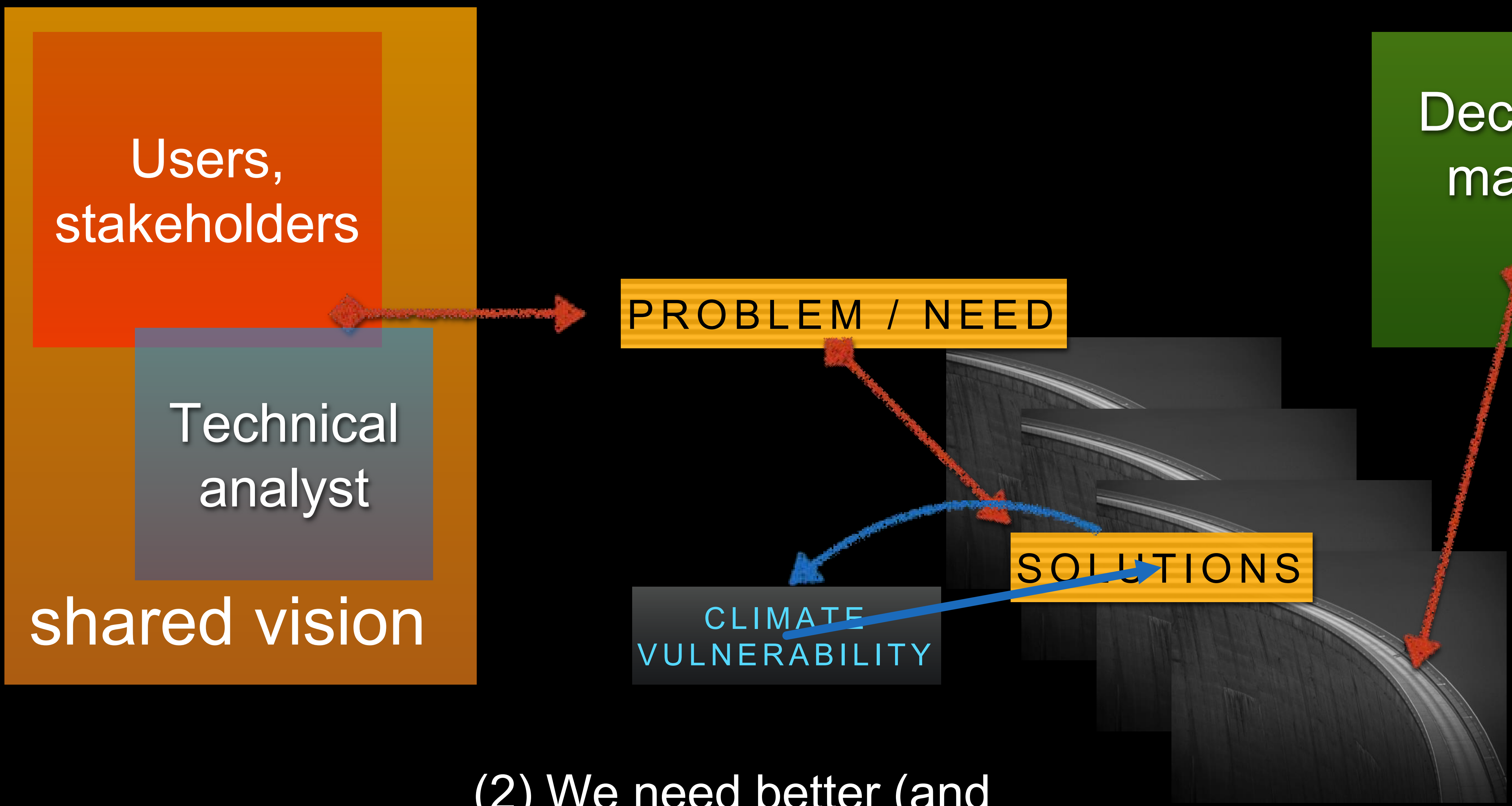
(1) users & stakeholders need to be involved much earlier.

(2) We need better (and probably multiple) solutions.

HOW DO WE GET THERE?

http://AGWAGuide.org/EEDS

(1) users & stakeholders need to be involved much earlier.



(2) We need better (and probably multiple) solutions.

HOW WE DEFINE VULNERABILITY DEFINES OUR SOLUTIONS

TOP-DOWN ASSESSMENT

MOST ADAPTATION SINCE ~1995

1. Use GCMs to define the water risks
2. Inform stakeholders of GCM output
3. Hope the GCMs are correct

4. Test & compare alternate solutions, pathways
3. Develop robust, flexible solutions
2. Use GCMs and other climate data to explore risk tolerance
1. Have stakeholders, decision makers define problem

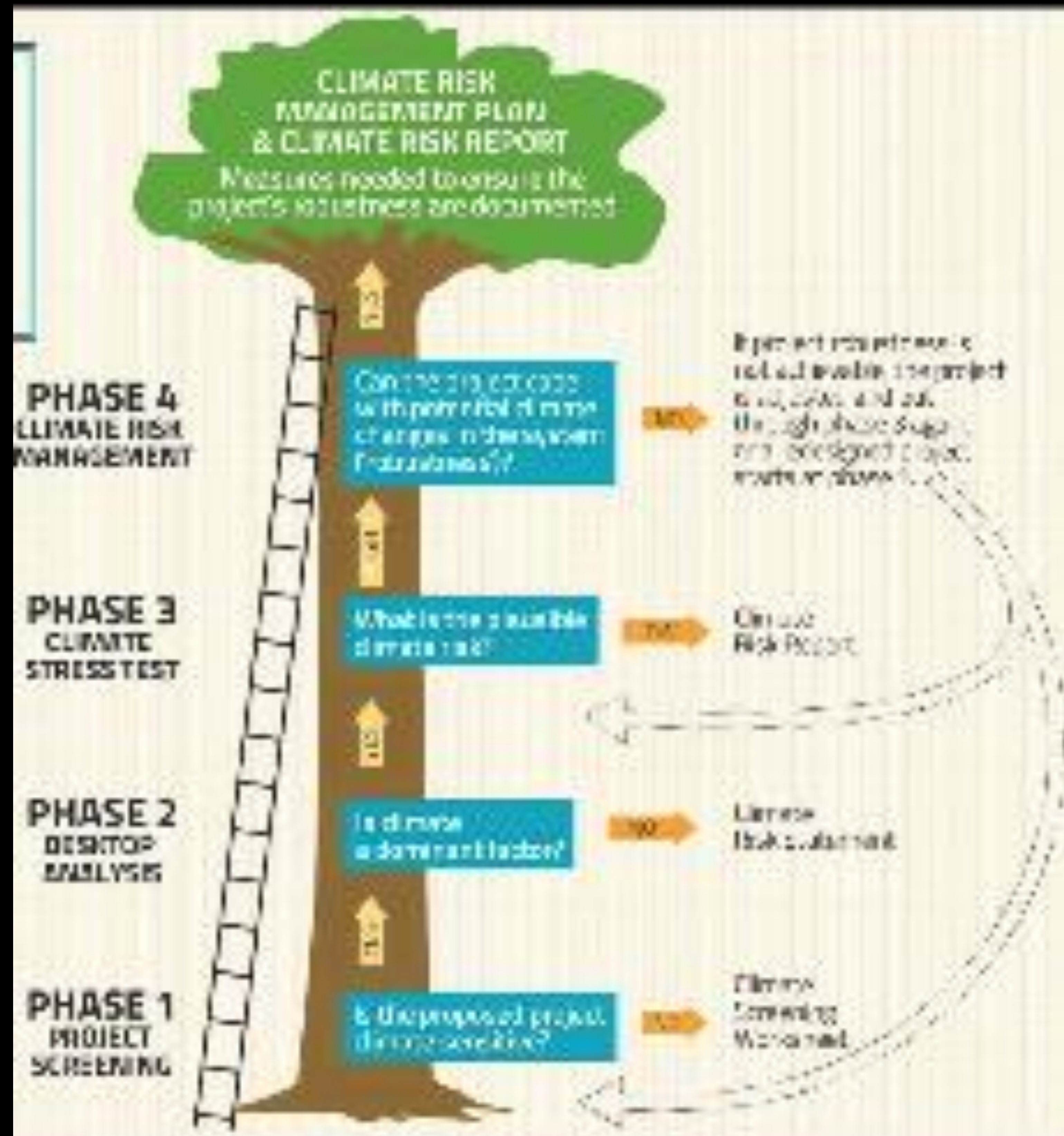
SINCE ~2010

BOTTOM-UP ASSESSMENT

THE TRANSITION HAS BEGUN

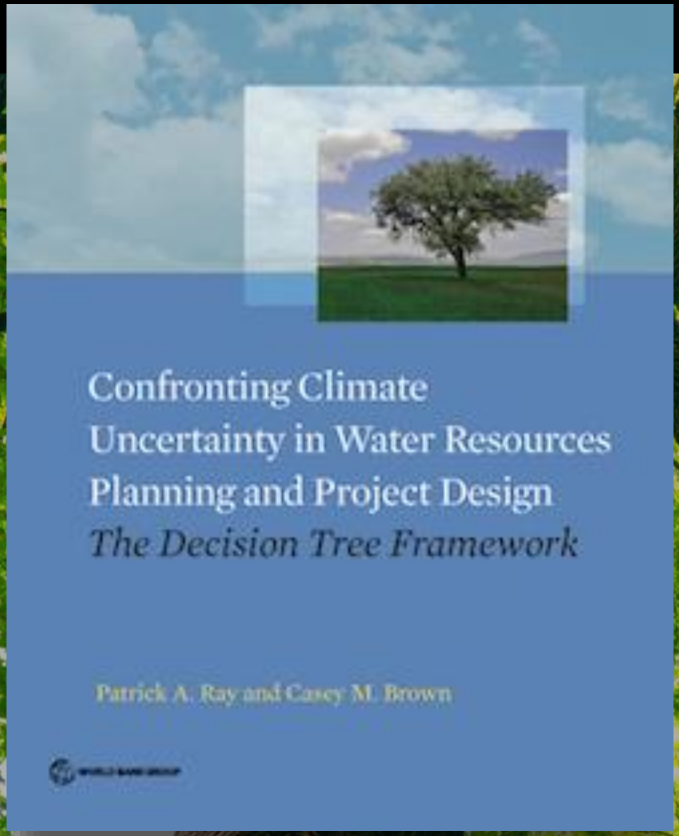
Bottom-up approaches:

- Use existing decision making processes
- Define problems broadly, for broader solutions
- Work with rather than against uncertainty
- Helps the technical analyst to bridge knowledge & governance gaps



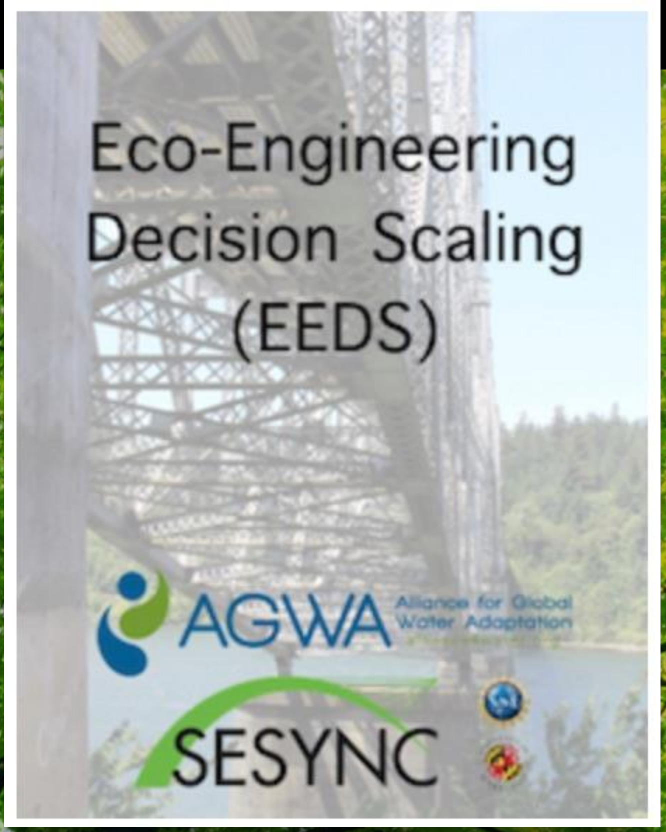
Ray/Brown, Confronting Climate Uncertainty, World Bank.

THREE METHODOLOGIES, ONE CORE APPROACH



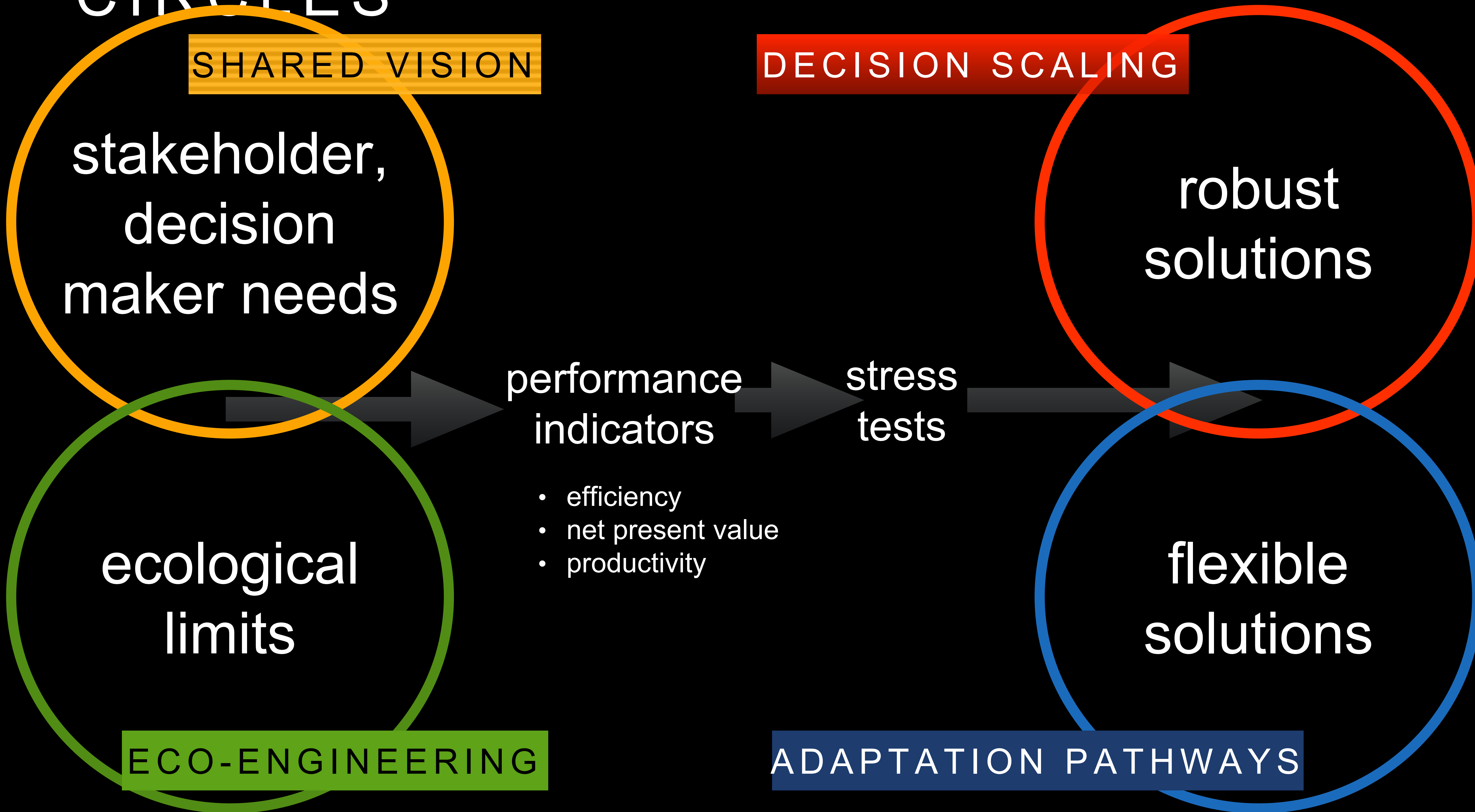
crida
COLLABORATIVE RISK INFORMED DECISION ANALYSIS

Publishing 1 November 2016:
US Army Corps of Engineers, Rijkswaterstaat (NL), Deltares, University of Massachusetts @ Amherst



http://AGWAguide.org/risk/

CRIDA: CONNECTING FOUR CIRCLES



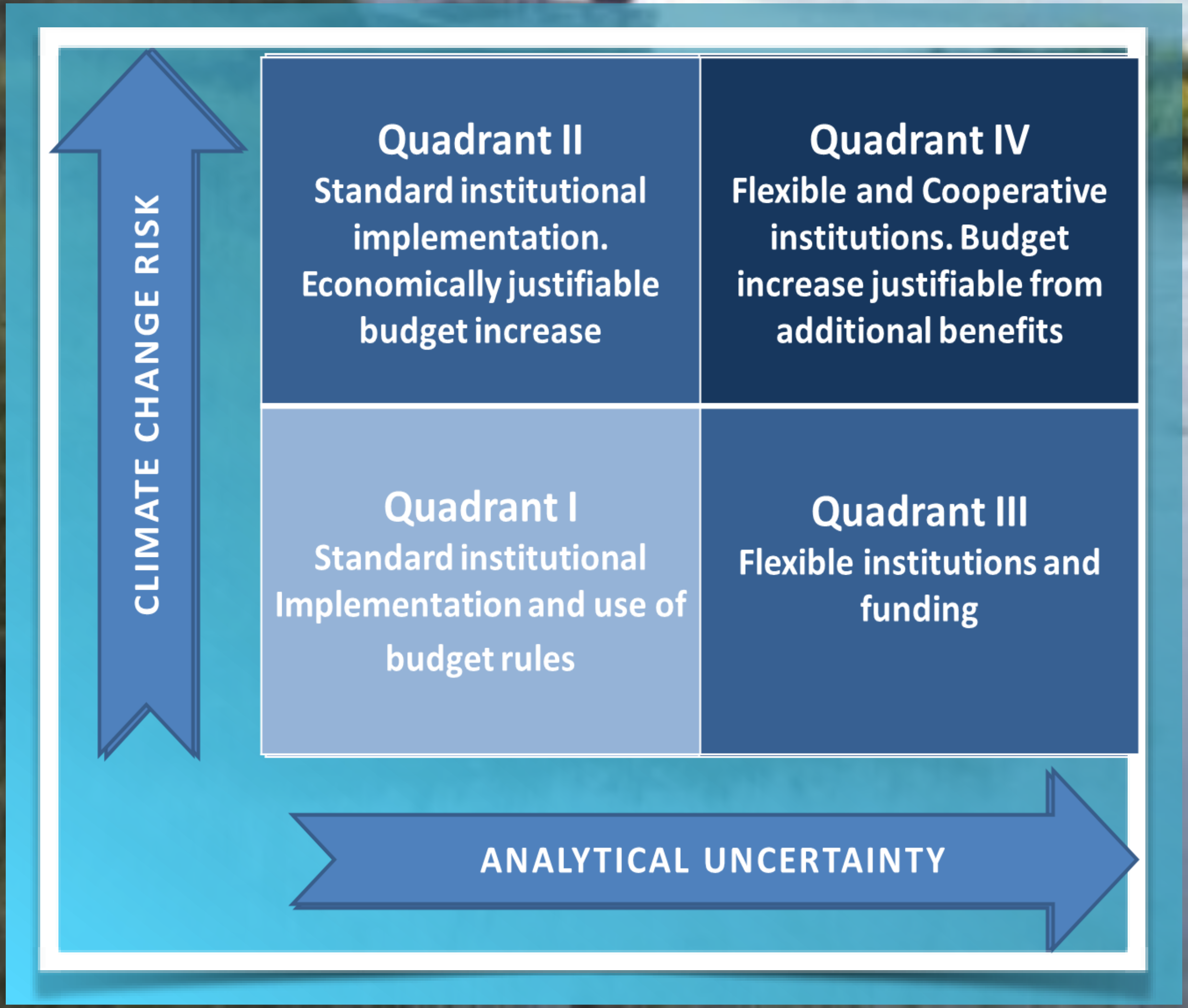
http://AGWAguide.org/risk/

SETTING STRATEGY: THE LEVEL OF CONCERN

Users, stakeholders

Technical analyst

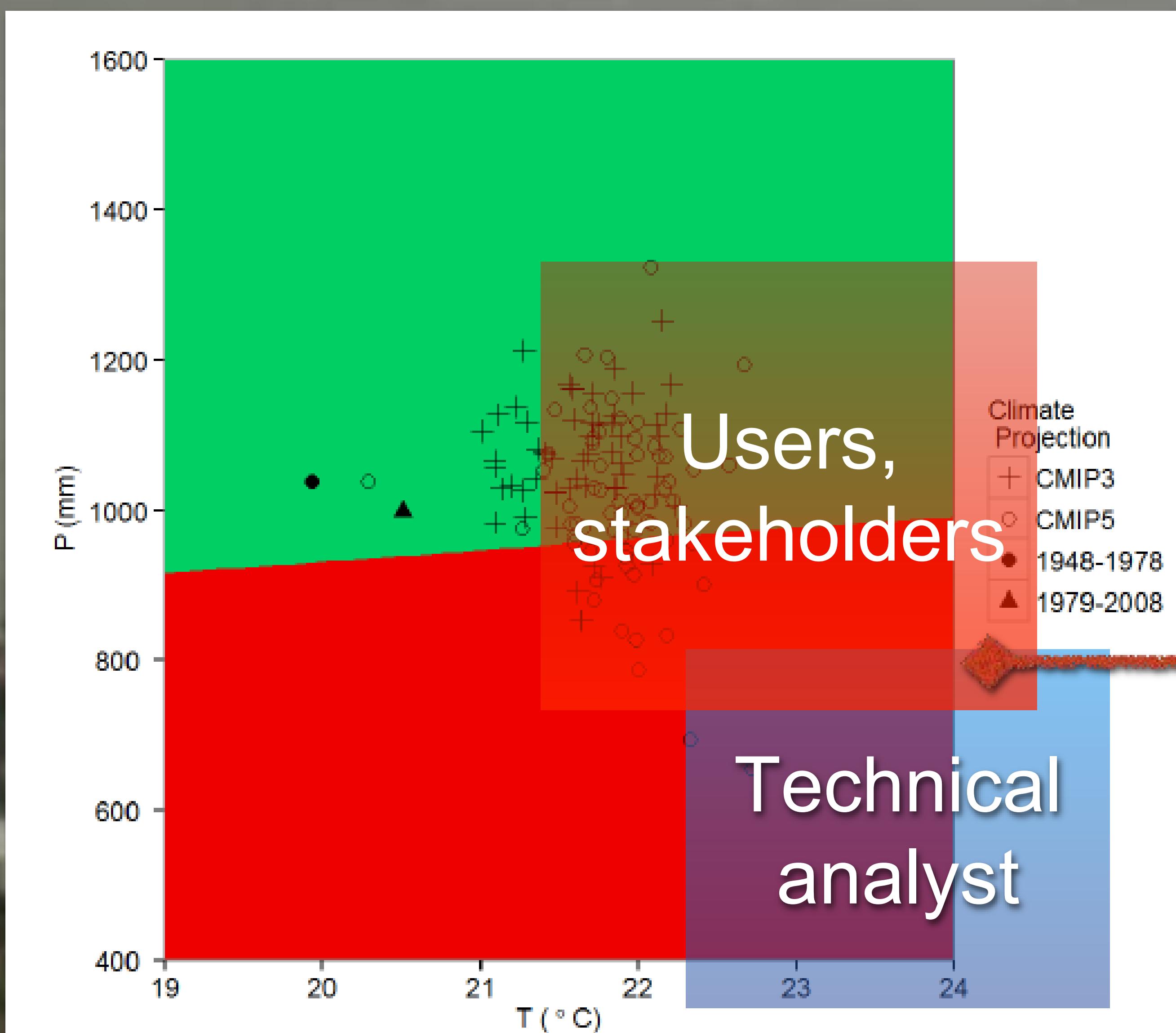
Decision maker



Two key elements are then used to act on this strategy

KEY ELEMENT 1

DECISION SCALING: DEFINING ROBUST SOLUTIONS



- Users / stakeholders define system failure
- Can mix many forms of climate data: GCMs, modeled data, paleo data, TEK, hypothetical situations

PROBLEM / NEED

"PERFORMANCE INDICATORS"

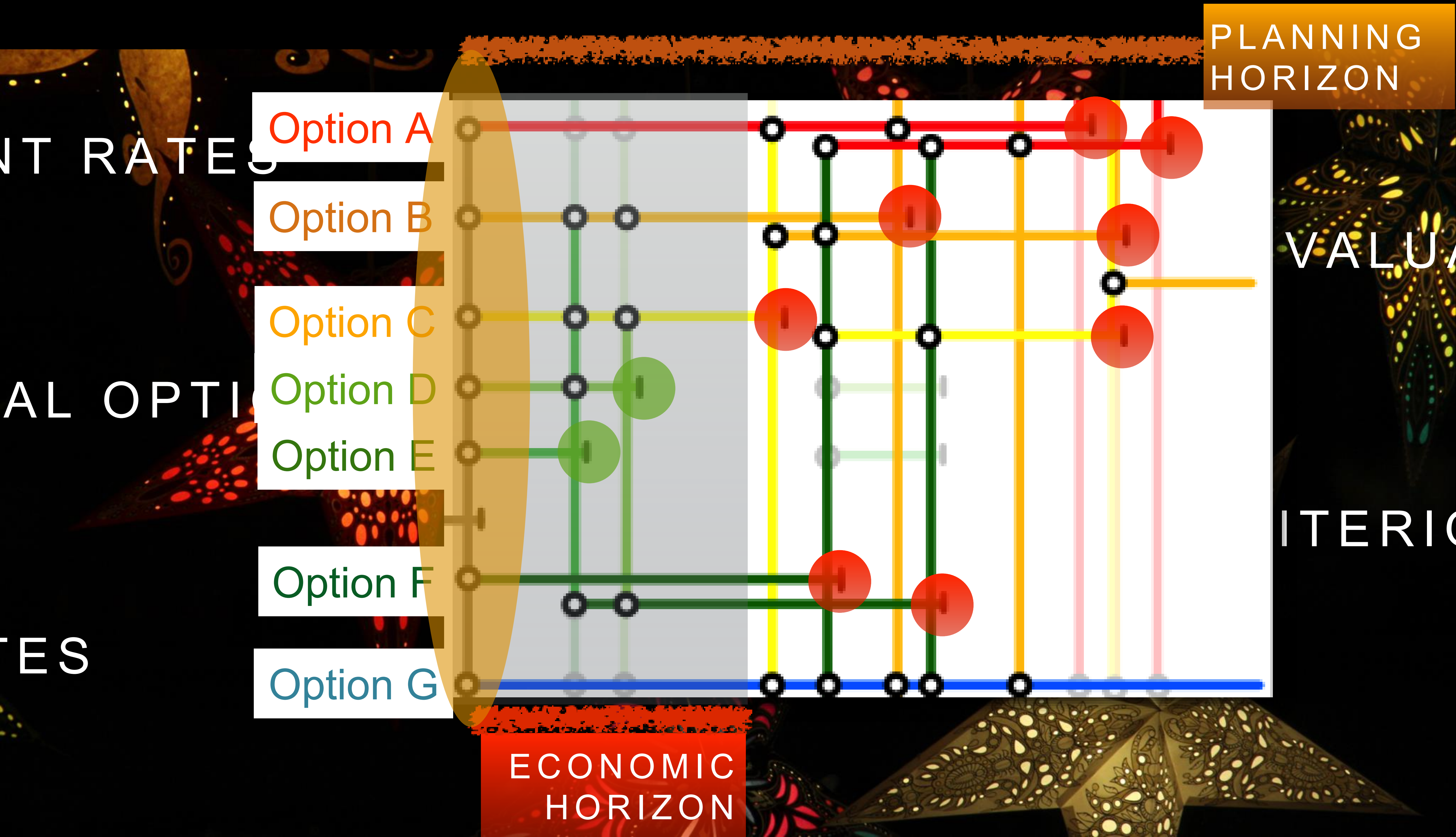
"STRESS TEST"

RISK TOLERANCE

HTTP://AGWAGUIDE.ORG/EEDS/#DS
HTTPS://YOUTU.BE/WORTE_2H_R8

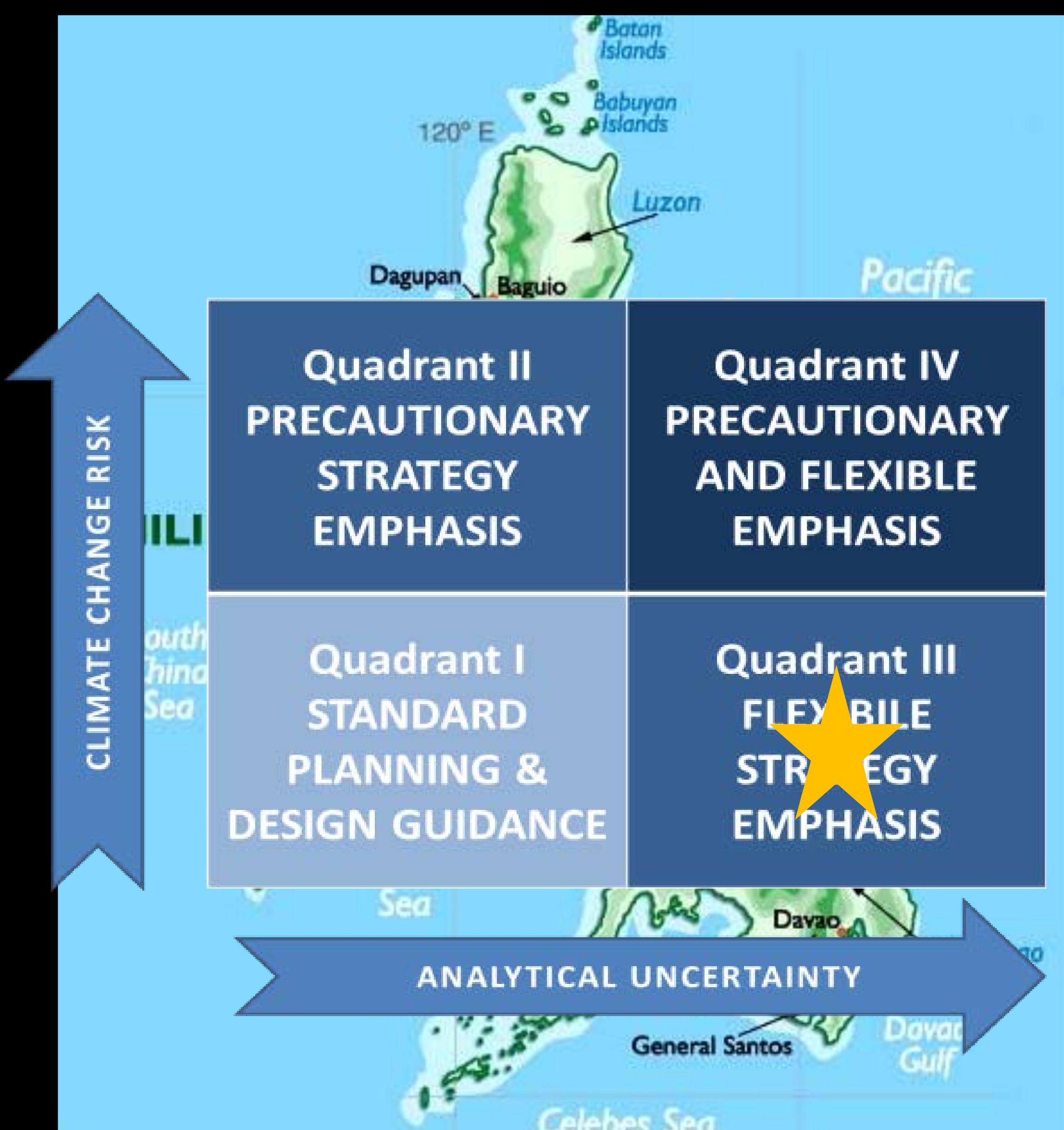
ELEMENT 2

ADAPTATION PATHWAYS: DEFINING FLEXIBLE SOLUTIONS

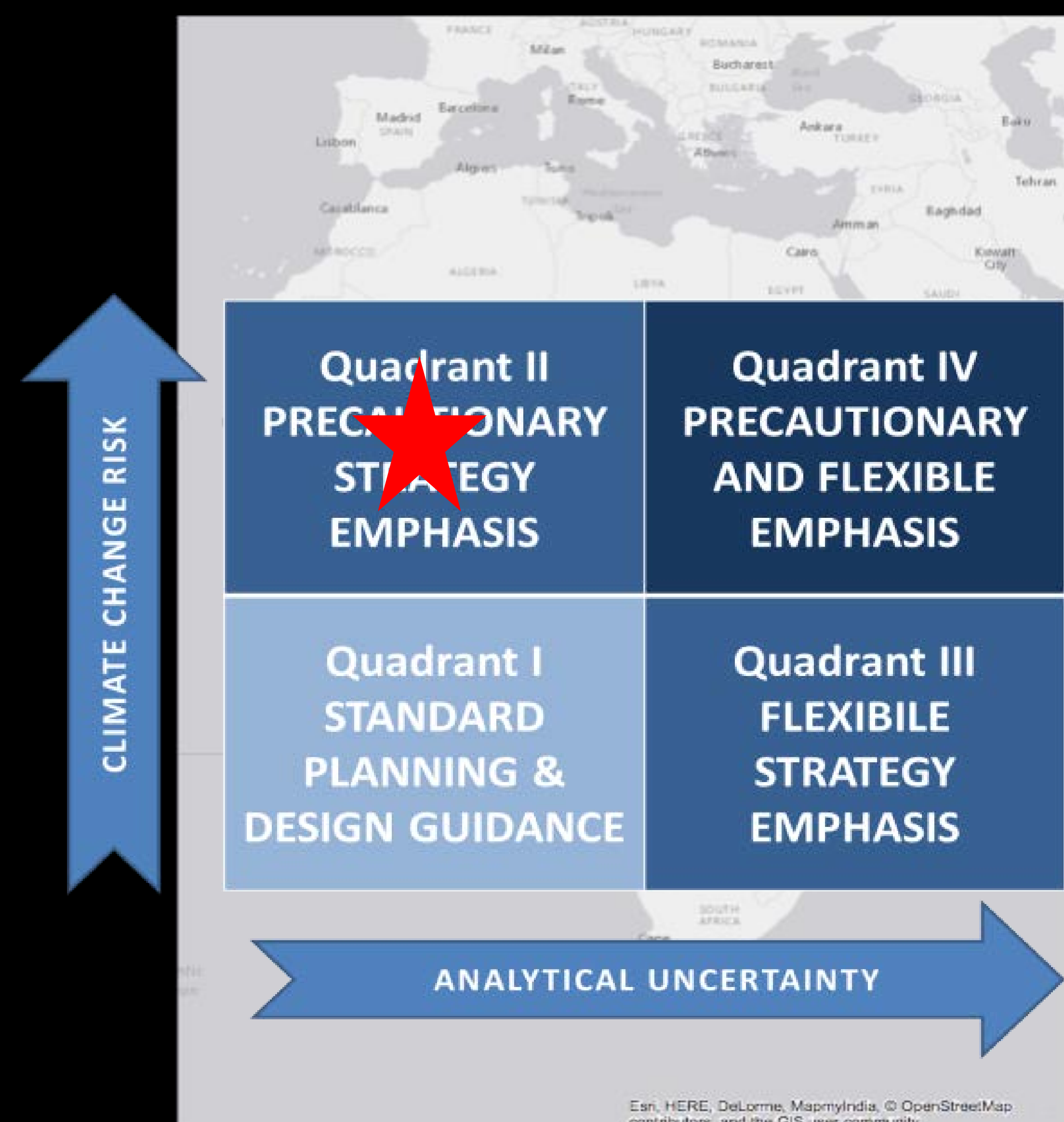


TWO EXAMPLES: MILLENNIUM CHALLENGE CORPORATION

Water Supply in Central Cebu, Philippines



Ioland Water Treatment Plant, Zambia

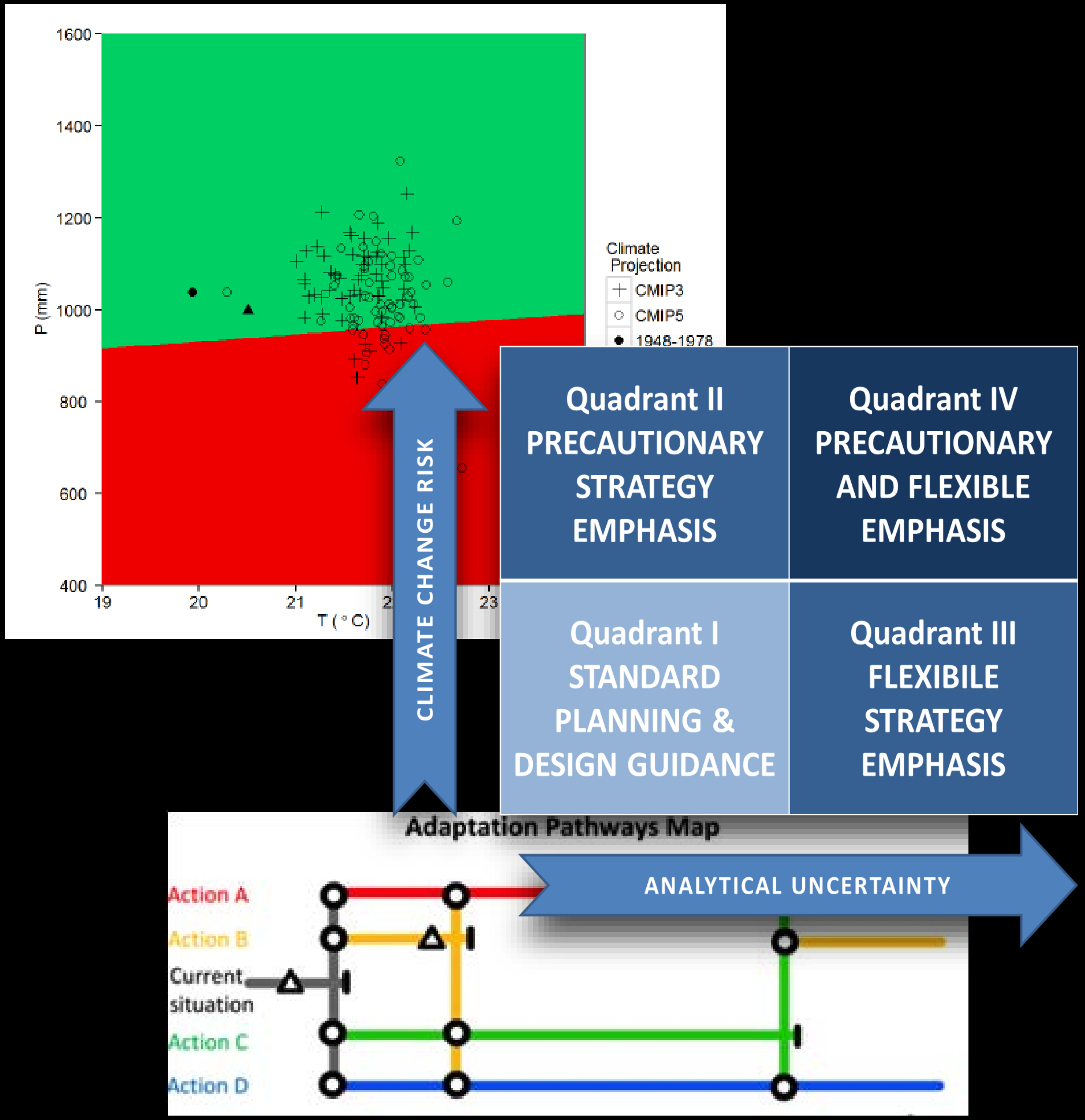


HTTPS://YOUTU.BE/WORTE_2H_R8

WHAT DOES CRIDA ADD TO TRADITIONAL PLANNING?

Publishing November 2016

- A "mother document" to guide adoption
- Early, repeated engagement with users & stakeholders for a shared vision
- Strong linkages between technical, user, and decision maker groups
- A broad vulnerability assessment
- Guidance on the strategic direction
- Adaptation pathways for flexibility
- Guidance on economic evaluation & institutional capacity

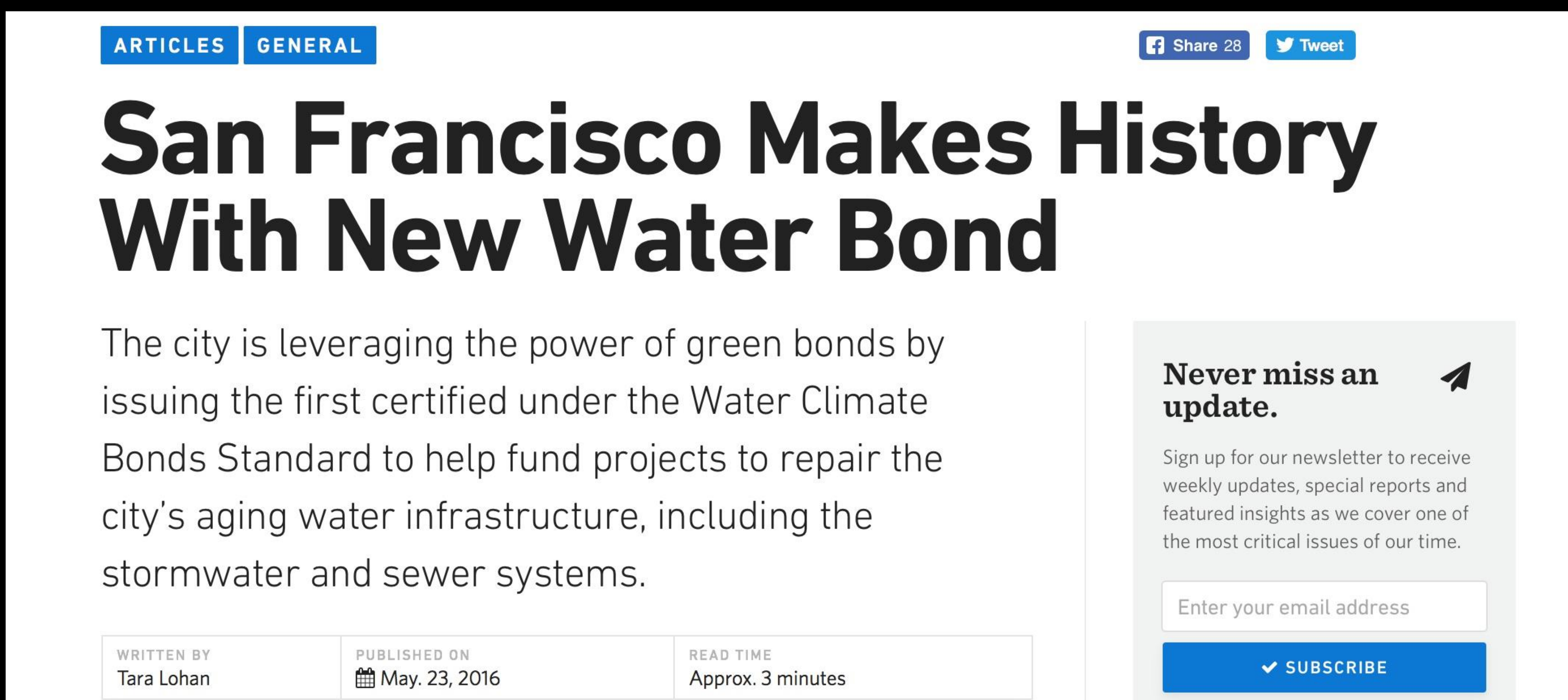


http://AGWAguide.org/risk/

FINANCING RESILIENCE

Launched May 2016: Water Climate Bond Standard

http://AGWAGuide.org/greenbonds/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San Francisco Makes History With New Water Bond

The city is leveraging the power of green bonds by issuing the first certified under the Water Climate Bonds Standard to help fund projects to repair the city's aging water infrastructure, including the stormwater and sewer systems.

WRITTEN BY	PUBLISHED ON	READ TIME
Tara Lohan	May. 23, 2016	Approx. 3 minutes

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State of Alaska's R&D Project:
The Alaska Water & Sewer Challenge

Bill Griffith / Fatima Ochante
Village Safe Water Program
Alaska Department of Environmental Conservation

Progress in Alaska Village Sanitation

- 30 years ago, fewer than 25% of rural Alaska households had running water and flush toilets.
- In 1996, 55% of rural homes had piped or covered haul service.
- Today, approximately 85% of rural homes have indoor plumbing (over 90% if regional hubs are included in the calculation).

However…

- Conventional, community-wide piped systems and truck haul systems are expensive to construct, maintain and replace.
- Many communities cannot afford the high operation and maintenance costs associated with piped or haul systems.
- Available funding is not adequate to serve remaining homes and make needed improvements.
- Innovative approaches were needed in order to address health problems associated with water and sewer system deficiencies.

Comparison of Health Benefits vs. Cost and Complexity of Different Water and Sewer Service Types

January 2016

Health benefits of household water and sewer service (+ to −)

Expense and degree of difficulty of maintaining and operating household equipment (− to +)

≥ 25 gallons per person per day

Service Level IV: Unlimited water use (assuming flat billing rate)
- Kitchen sink
- Bathroom sink
- Flush toilet
- Shower
- Laundry hookup

Piped water and sewer service: Approximately 34,000 homes in villages

Individual water well and septic system: Approximately 1,000 homes in 20 villages

Target: 15-20 gallons per person per day

Service Level III: Greywater reuse systems
- Kitchen sink
- Bathroom sink
- Flush toilet
- Shower
- Laundry hookup

- Alaska Water and Sewer Challenge systems
- YKHC demonstration system

(most complex)

App. 4 gallons per person per day

Service Level II: Flush tank and haul systems (typically by trailer)
- Kitchen sink
- Bathroom sink
- Flush toilet
- Shower
- Laundry hookup

Approximately 550 homes in 8 villages served by existing flush tank and haul systems

(most costly)

1 - 10 gallons per person per day

Service Level I: Kivalina demonstration project

Bathroom sink

Dry, separating toilet

No shower

No laundry hookup

9 homes served by ANTHC demonstration system in Kivalina

App. 2.5 gallons per person per day

No Service
- No running water or sewer
- No flush toilet
- No shower
- No laundry hookup

Approximately 3,800 homes in villages throughout Alaska, including 30 unserved villages

State of Alaska Water & Sewer Challenge

The Problem

"Honey bucket," a plastic bag lined bucket that collects urine and feces.

Plastic bags of feces from honey buckets are disposed of in a sewage lagoon.

- Over 3,300 rural Alaska homes lack running water and a flush toilet. Many more depend on aging and deteriorating piped and haul systems.
- Lack of in-home water and sewer in Alaska contributes to severe skin infections and respiratory illnesses. Residents of Southwest Alaska suffer rates of invasive pneumococcal disease that are among the highest in the world.
- To address this public health problem, agencies have funded conventional, community-wide piped and truck haul systems. These systems work, but they are expensive to construct, and many communities cannot afford the high operating costs.
- Funding to build systems has declined severely while costs have risen sharply. The deficit between available funds and needs is over $1 billion.
- Capital and operating costs of traditional approaches have become unsustainable. An innovative approach is needed.

The Solution

The Alaska Department of Environmental Conservation, in coordination with tribal, state, and federal agencies, has initiated a project to spur widespread research to develop innovative and cost effective water and sewer systems for homes in remote Alaska villages. The project focuses on decentralized water and wastewater treatment, water re-use, and minimization. These approaches have a high potential for use in individual homes and housing clusters. **Our goal is to significantly reduce the capital and operating cost of in-home running water and sewer in rural Alaska, so every home can have service.**

www.WaterSewerChallenge.alaska.gov

(Revised September 2016)

State of Alaska Water & Sewer Challenge

The Project

- **Phase 1 (COMPLETED)** Engineers, social scientists, innovators, and people with rural Alaska experience formed joint venture teams.
- **Phase 2 (COMPLETED)** Funding awarded to select teams to research and develop new and sustainable in-home water and sewer systems.
- **Phase 3 (ONGOING)** Development of working prototypes and lab testing of pilot systems.
- **Phase 4 (2017-2019)** Field test systems in rural homes.
- **Phase 5 (2020+)** Select successful systems that will be affordable to build, operate, and maintain.

Hauling household sewage around Atmautluak.

The Teams of Phase 3

DOWL Alaska

DOWL Alaska proposes a graywater re-use system located in a small vestibule attached to the house. The vestibule minimizes space requirements and avoids expensive heat trace to an outside holding tank. DOWL's prototype is at the Cold Climate Housing Research Center in Fairbanks. DOWL is also testing a Point-of-Use filter for drinking water.

Summit Consulting

Summit proposes an entirely in-home system designed to minimize water and wastewater hauling. Raw water is treated by multi-stage cartridges, an ultrafiltration membrane and disinfection to produce drinking water. Graywater is treated by a biological process and then disinfected. Summit's system is at their main office complex outside Tok.

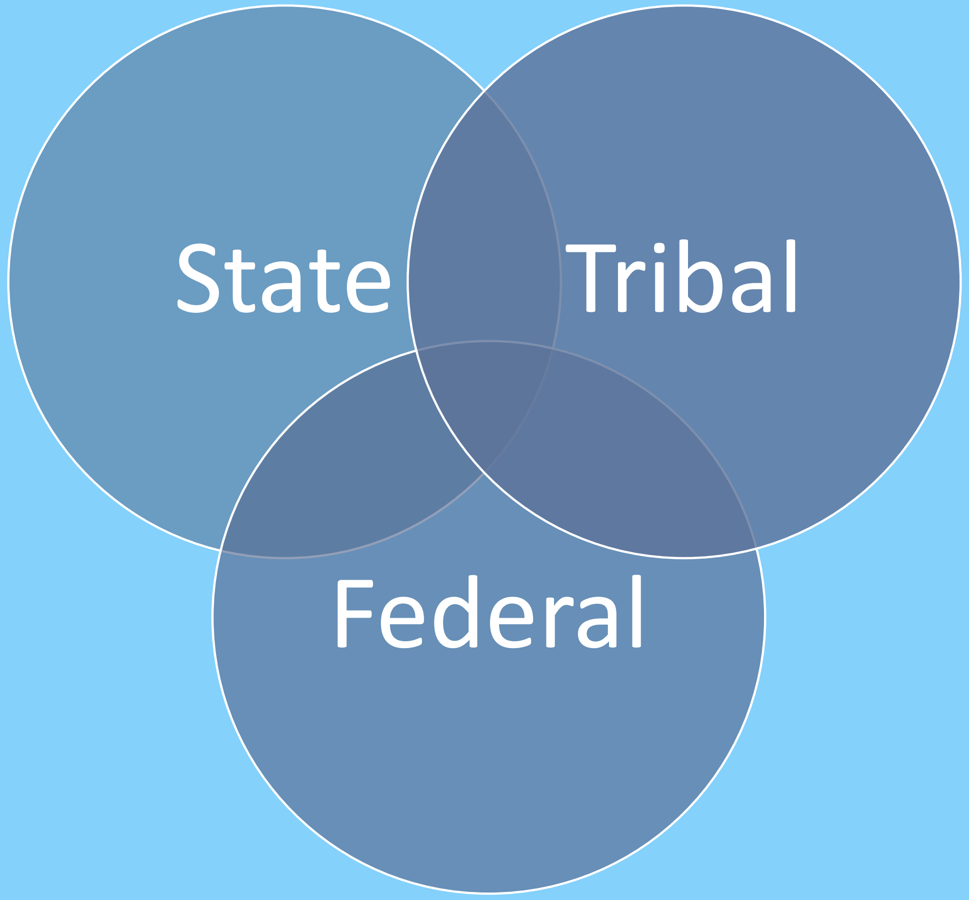
University of Alaska Anchorage

UAA proposes to treat both graywater and some blackwater, as well as a modular approach that allows home-owners to select in-home components that fit their lifestyles and space available. Membrane treatment and high dose ultraviolet disinfection are used to produce non-potable wash water. UAA's system can be found on campus in Anchorage

Alaska Water and Sewer Challenge

- State-funded research and development project projected to last 5 – 7 years
- Focus is on “decentralized” approaches – household based systems that utilize water re-use technologies
- Private sector driven – with ownership of intellectual property retained by project teams
- Goal is to significantly reduce the capital and operating costs of in-home running water and sewer in rural Alaska homes
- Funding to date is $4 million in state and federal funding. Additional funding will be required to complete the project

Multi-Agency Steering Committee



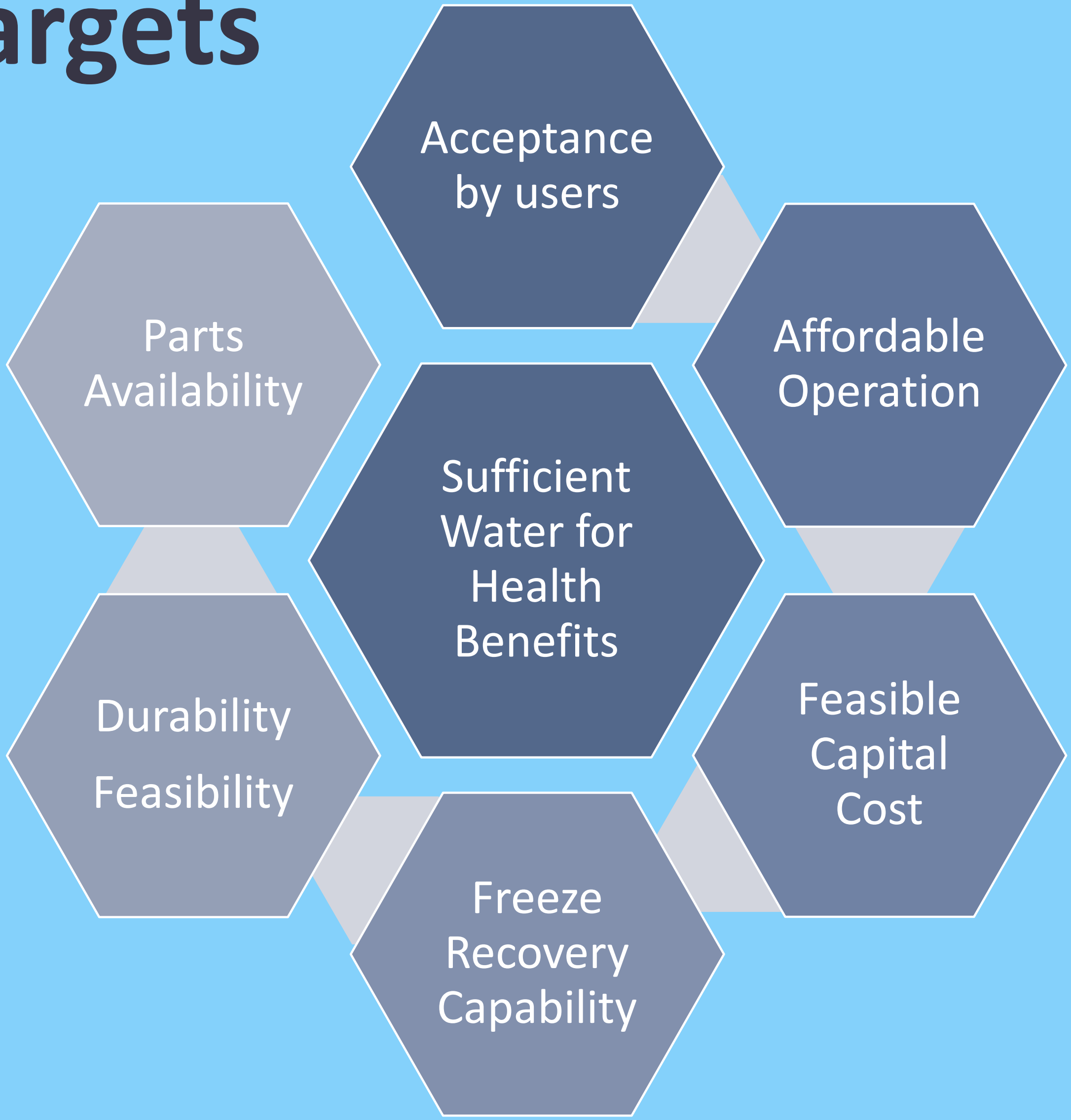
Project Timeline

Phase	Approximate Timeframe	Duration (months)
Team Formation	Fall 2013 – Spring 2014	9
Proposal Development + Presentation	Fall 2014 – Summer 2015	8
Prototype Development + Pilot Testing	Fall 2015 – Summer 2017	21
Field System Development + Testing	Fall 2017 – Summer 2019	21
Technology Refinement + Improvement	2020 and beyond	?

Phase III: 2015 - 2017
Prototype Development and Testing

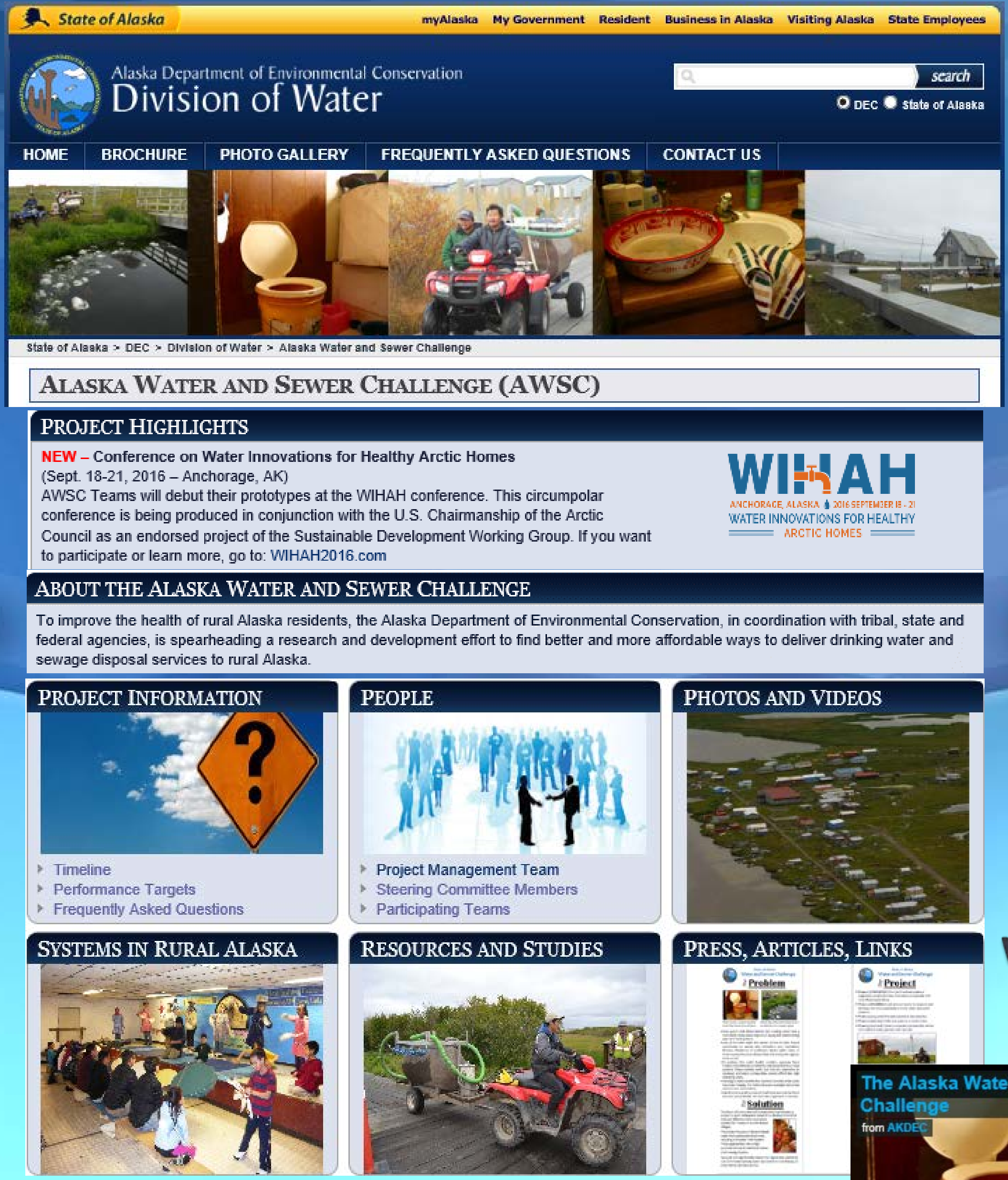
- Three proposals funded for prototype development and testing.
- Targets and testing requirements have been provided.
- Engineering plans will be reviewed and approved.
- The results of testing phase will be presented to the Steering Committee.
- Systems that demonstrate promising results will be selected for field system development and testing.

Performance Targets



Village Input

- End users provide the most valuable feedback for appropriate technology design
- ADEC partnership with rural communities to better inform the development of future home-based systems
- Teams are required to work with communities from different regions



<u>Project Contacts</u>:

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fatima.ochante@alaska.gov

www.WaterSewerChallenge.Alaska.gov

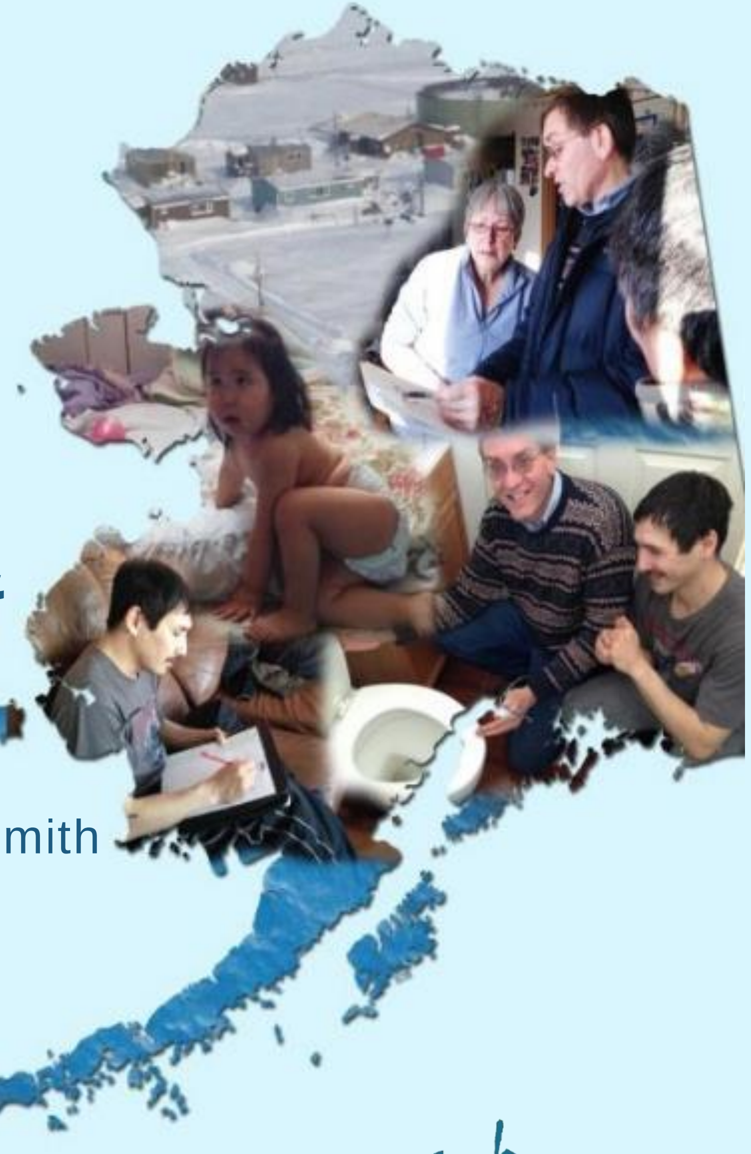
Project Website

Alaska Water & Sewer Challenge

AK

WIHAH Conference
September 19-21, 2016

Designing a Household Water & Wastewater System for Underserved Villages in Alaska



Chris Schulz & Janelle Rogers, CDM Smith
Chase Nelson & Mitch Titus, DOWL
Bruno Grunau, CCHRC
Laurie Krieger, Manoff Group

DOWL WWW.DOWL.COM INSPIRATION • INNOVATION • INTEGRITY

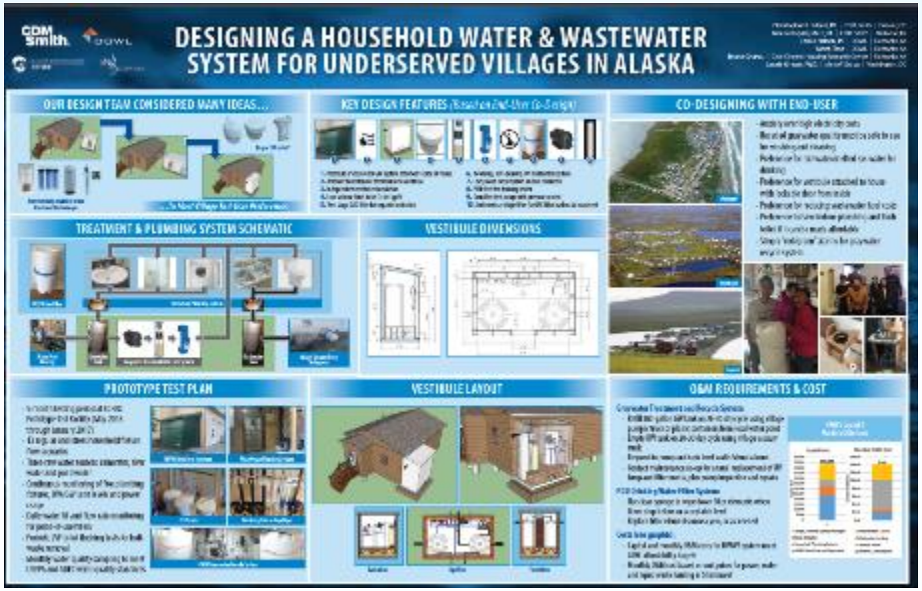
CDM Smith

COLD CLIMATE HOUSING RESEARCH CENTER CCHRC

THE MANOFF GROUP

Presentation Topics

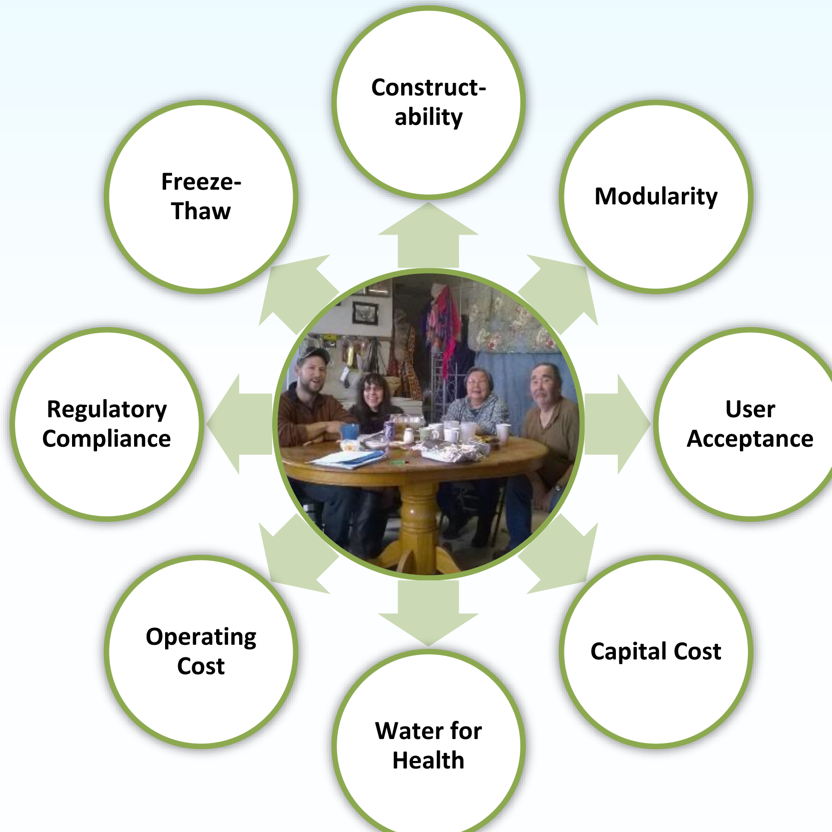
- AWSC design-think process
- Village trips and co-designing with end-users
- Key design features and system schematic
- Vestibule layout and dimensions
- HWWS prototype test plan and preliminary results
- O&M requirements and costs



AWSC Design-Think Process

What We Mean by Design-Thinking

Old Way (*design and then try to get buy-in*)	New Way with Design Thinking (*End users tell us what they want*)



We developed initial design concepts using "off-the-shelf" (chemical-free)components...


Storage Tanks


POE UV/Filter


POU Filter

Activated Media


Ozone Generator


Feed Pump

PEX Plumbing

UV Disinfection

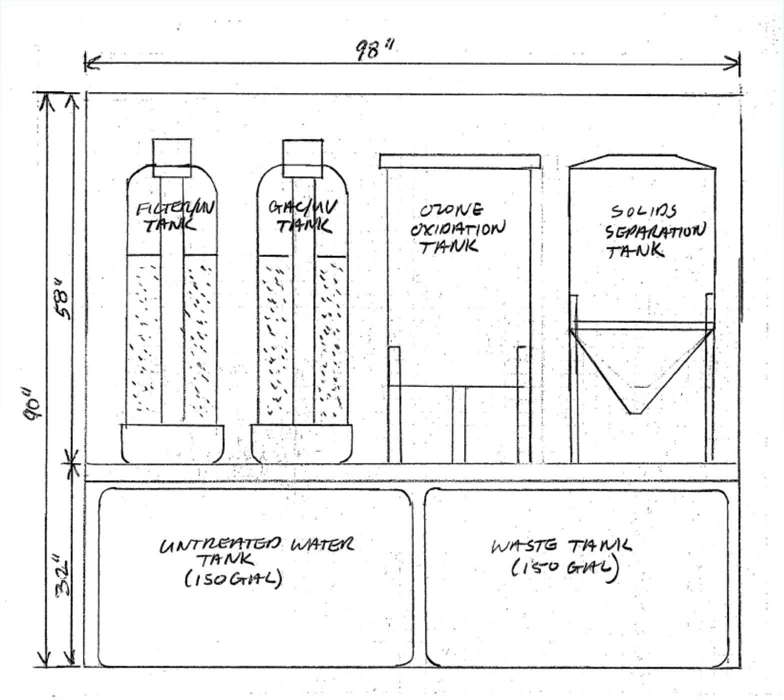

GAC Filter

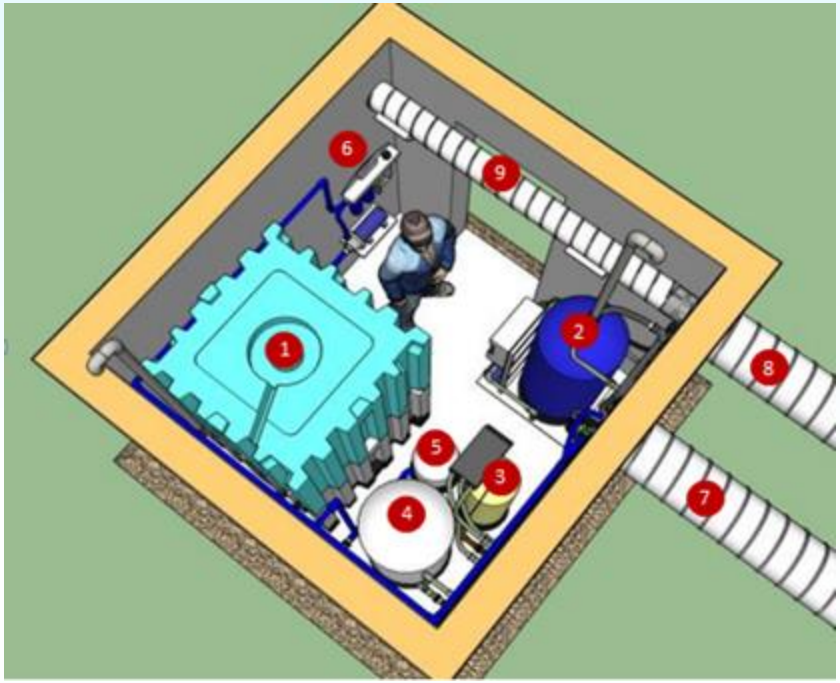

Saniflo Pump

Hydropneumatic Tank


Membranes

…configured in different ways to meet ADEC design requirements





We considered low-volume flush and odor-free bag toilets....

Separett Bag

Pedal LVF

Push Button LVF

…to replace unsanitary honey buckets

We compared POE treatment and plumbing system for drinking water...

POE UV/Filter

Dual Tap Sink

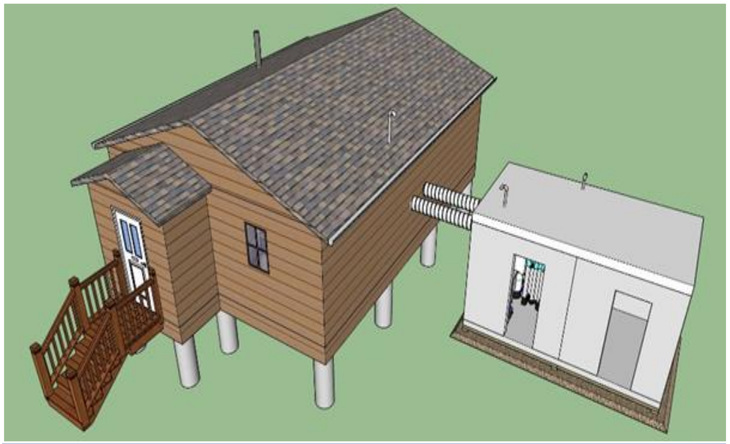
...against counter-top POU filters without plumbing

POU Kohler Filter

POU Bucket filter

...and we evaluated attached vs. detached buildings for housing the HWWS equipment

Detached HWWS

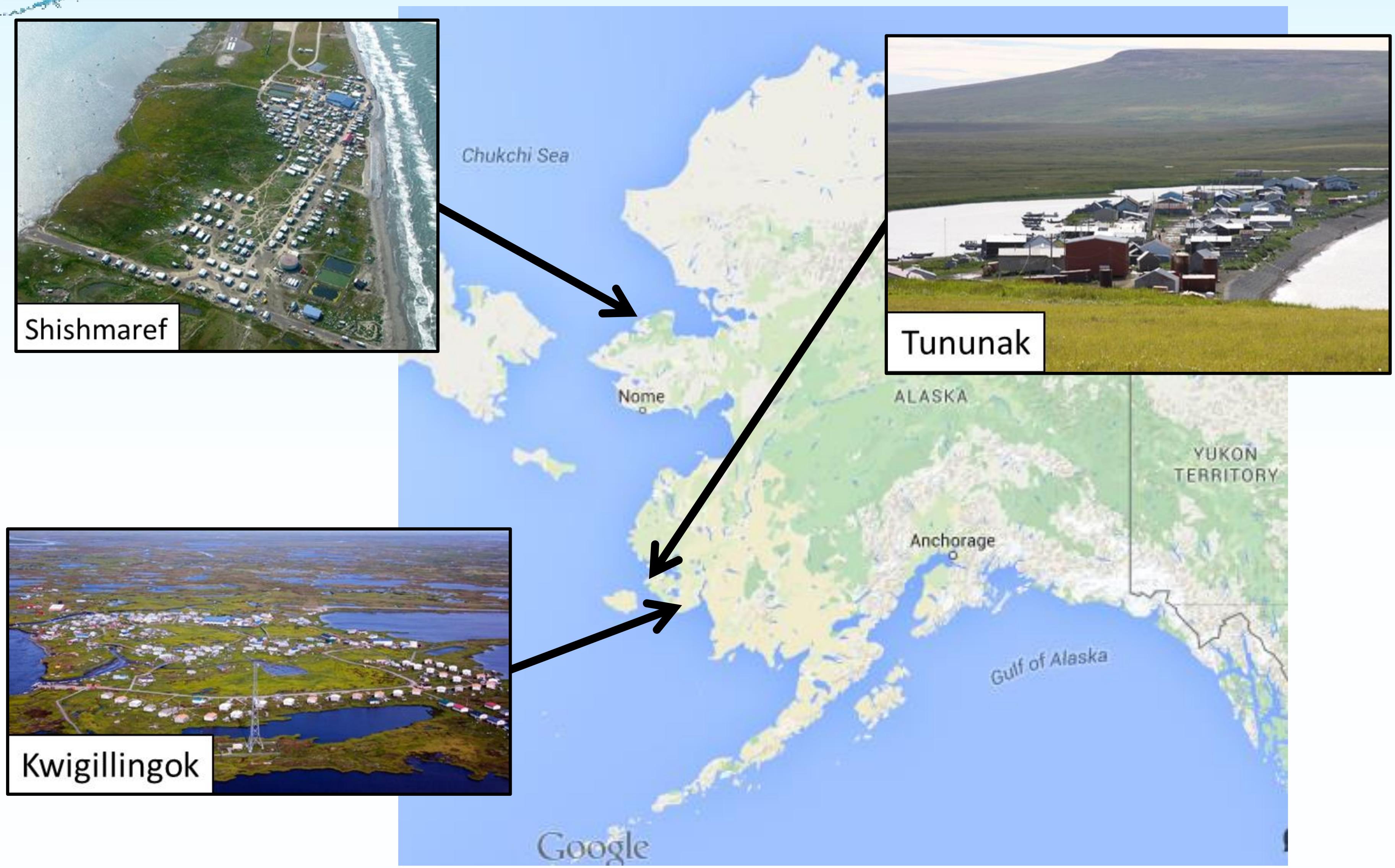


Detached HWWS with Storage

Attached HWWS

Village Visits and Co-Designing with End-Users

In March 2015 and March 2016 the DOWL Team travelled to three villages



We visited numerous homes and talked with potential end-users

- Interviewed 64 residents in three villages, plus a 6 person focus group in Shishmaref and 19-person community meeting in Tununak

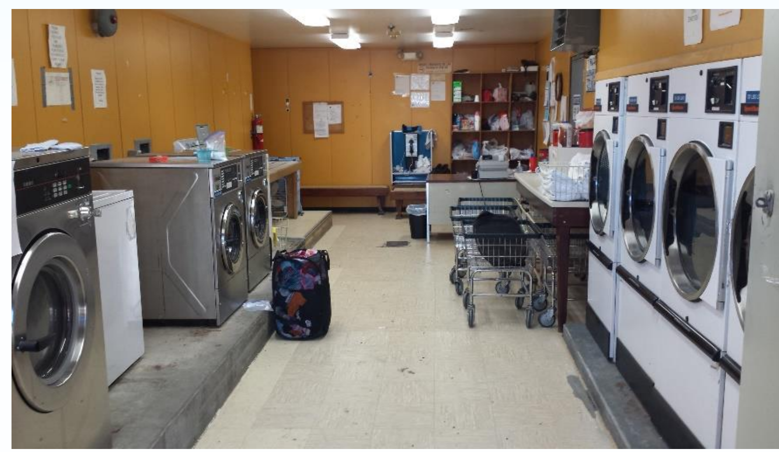
We observed existing "pump and haul" systems

Key Village Findings—Drinking Water

- Strong preference for drinking with ice melt or rain water – several people used Brita filters
- Dislike of chlorine and chlorine taste
- Preference for POU filter instead of separate tap

Key Village Findings—Washing and Cleaning

- Community treated water used for cleaning and dish washing
- Household greywater stored in outdoor tank (for village hauling) or thrown on ground
- Washeteria used for laundry and showers (if available in village)
- Reuse of greywater a concern—understood cost benefits but must be safe



High cost of electricity is big concern ($0.65/kWhr in Shishmaref)

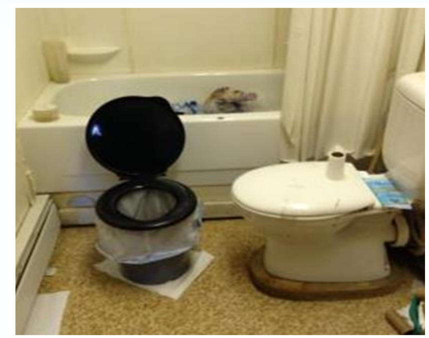
Key Village Findings—Toilets and Wastewater Collection

- Observed variety of toilets & honeybuckets
- Villages charge monthly fee for collection of honeybucket waste bags
- Hauling of wastewater expensive and unreliable in some villages

Macerator Toilet

Honeybucket

Toilet flushing with used sink water



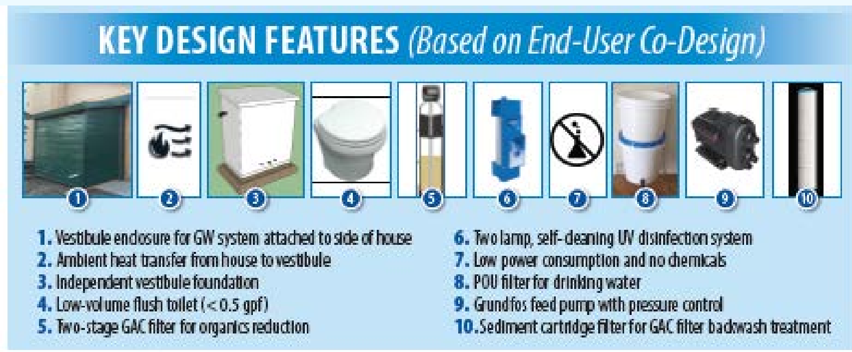
Honeybucket used instead of toilet due to high electricity costs

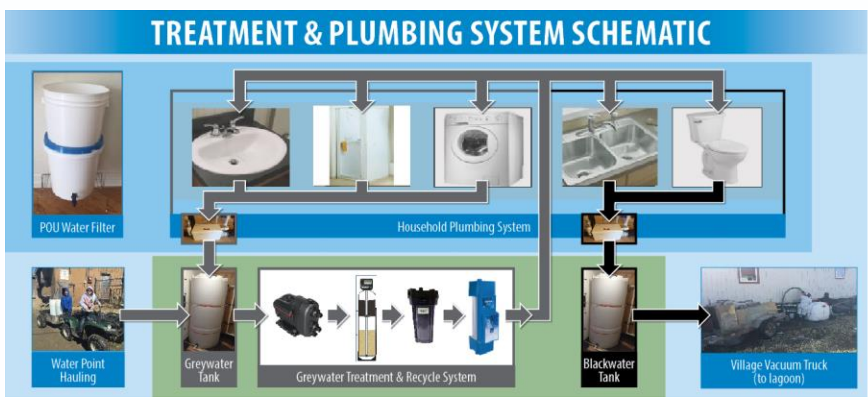
Summary of End-User Input for Co-Designing HWWS

- Attach vestibule to house with lockable door
- Use POE filter for treating rainwater/melted ice-water
- Use indoor plumbing and LVF toilet
- Recycled greywater quality must be safe to use
- System must be freeze-proof
- System must not damage house structure

Focus Group in Shishmaref

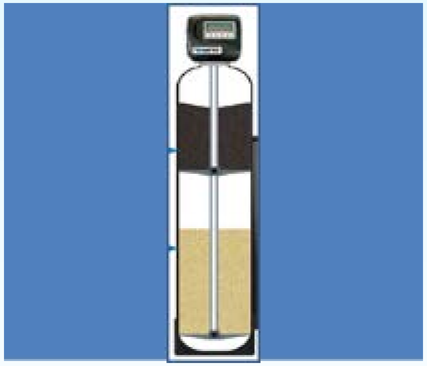
Key Design Features and System Schematic





Key Design Features—Greywater Recycle and Drinking Water Treatment Components

Grundfos Feed Pump



Two-Stage GAC Filter

Activated Media Disinfection unit

Two-Lamp,Self-Cleaning UV System

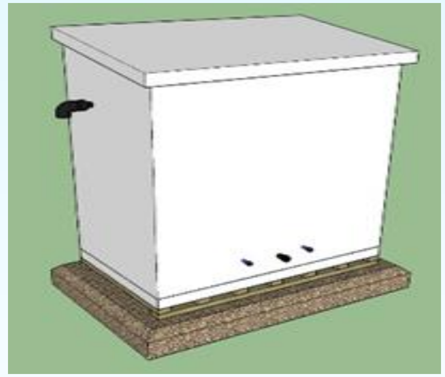
Sediment Cartridge Filter

PE Vertical Tanks

POU Drinking Water Filter

Key Design Features—Vestibule and Household Plumbing Components

Vestibule Attached to Side of house



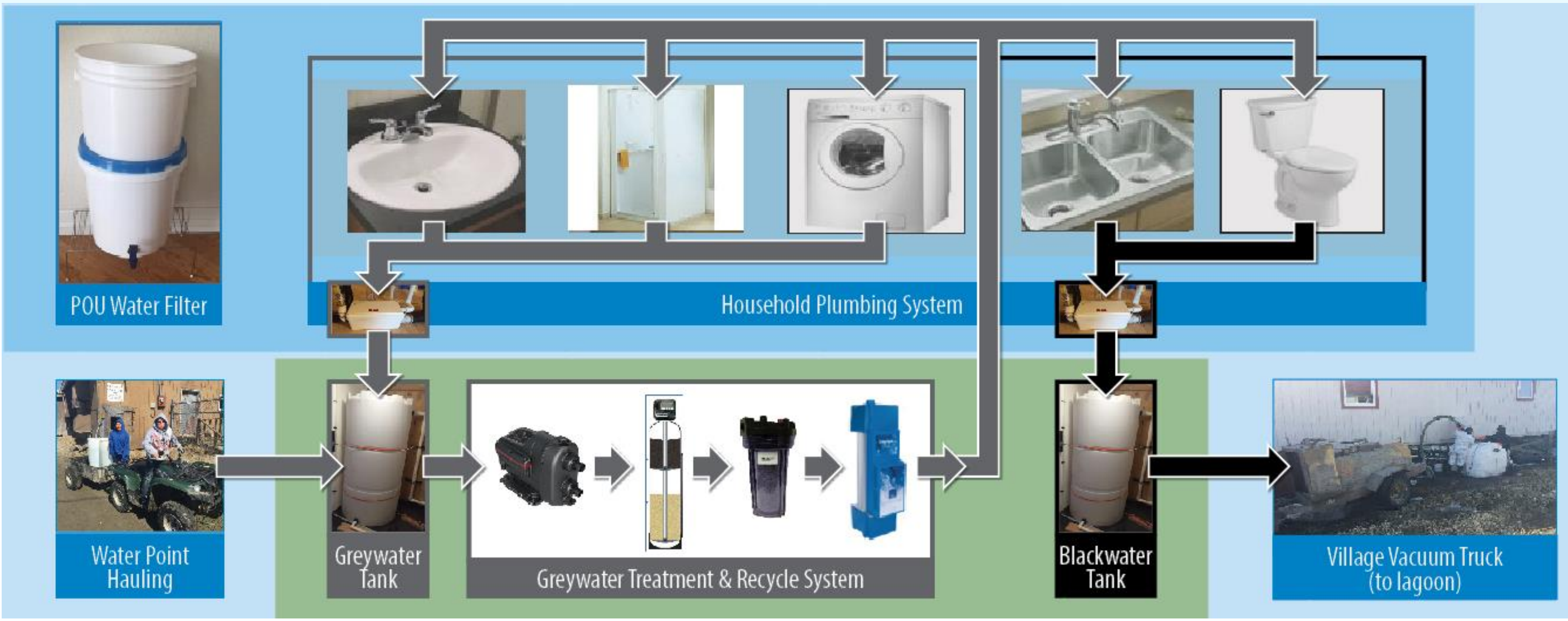
Independent Vestibule Foundation

LVF toilet (< 0.5 gpf)

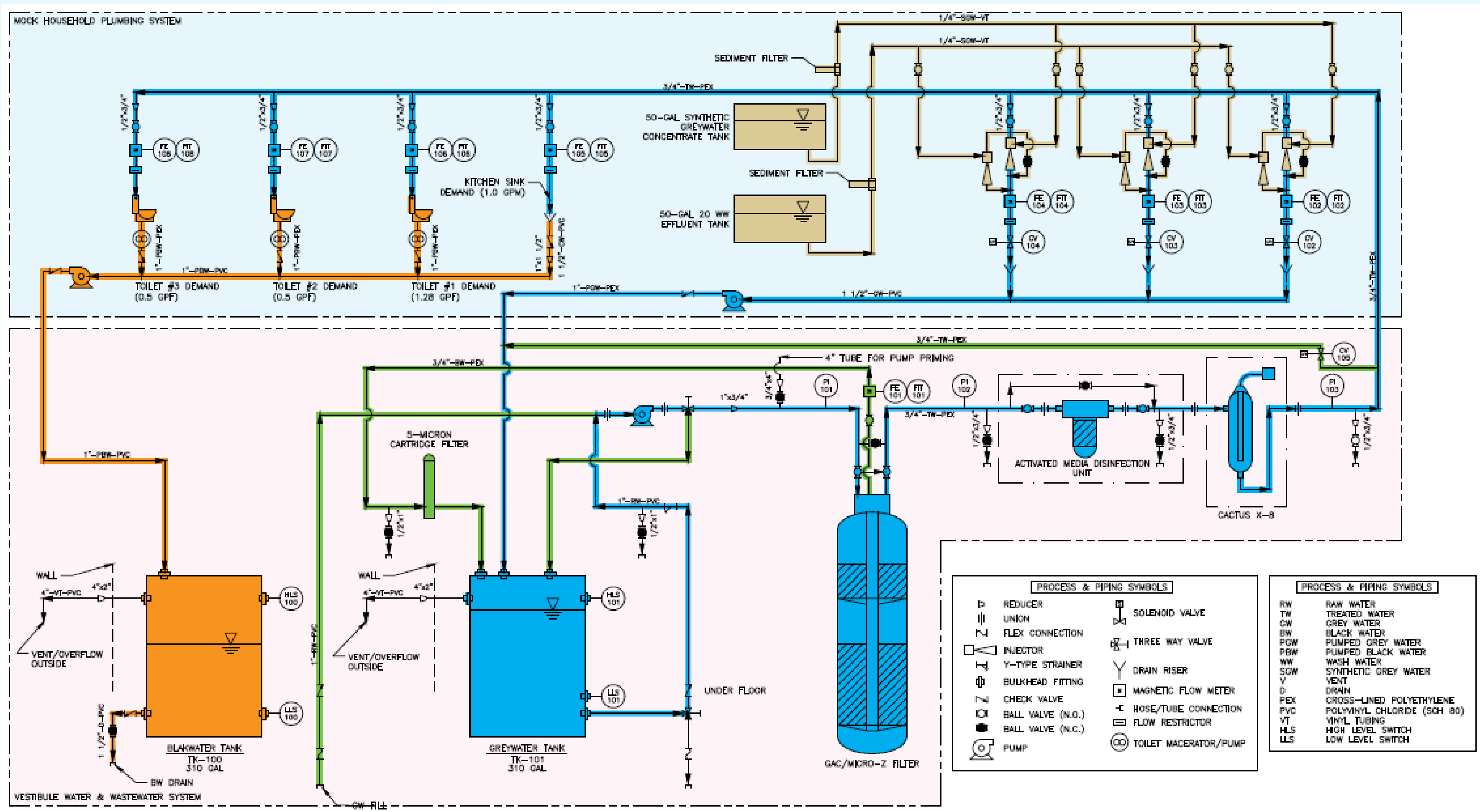
Accordion-Type Flexible Joint

Saniflo Return Pump

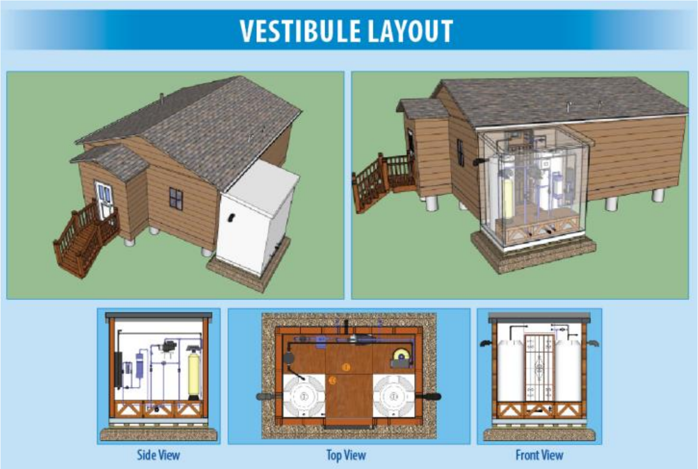
HWWS Simplified Process Schematic

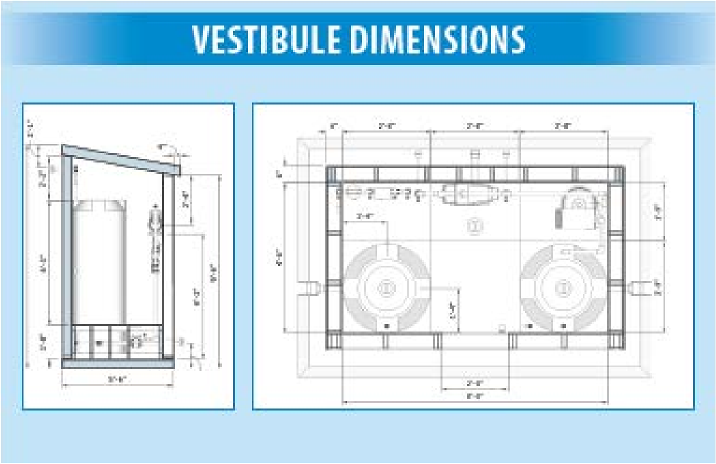


Prototype HWWS Process and Instrumentation Drawing (see Poster)

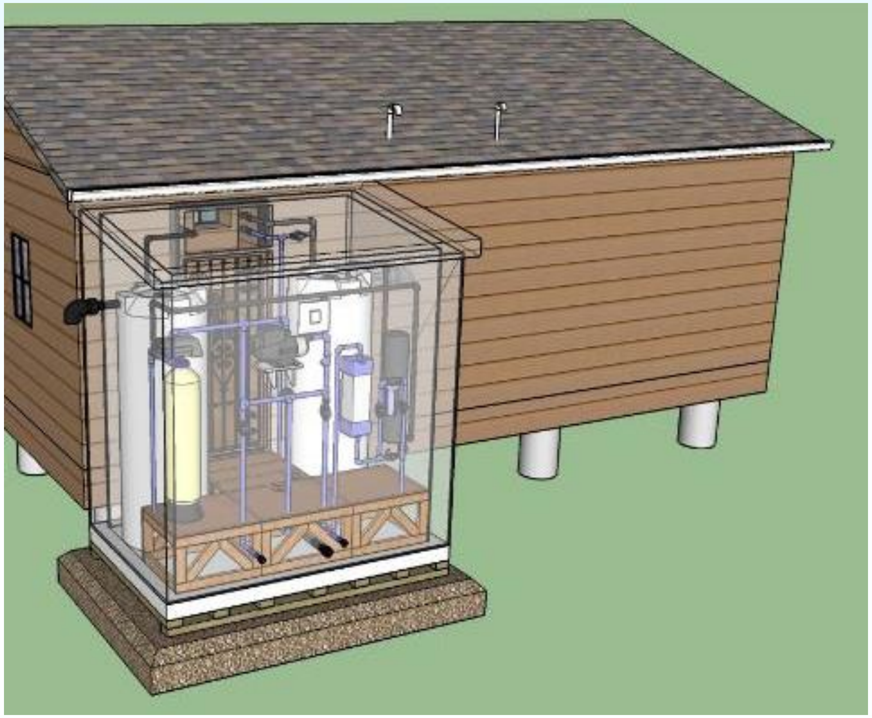


HWWS Vestibule and Mock Plumbing Layout and Dimensions

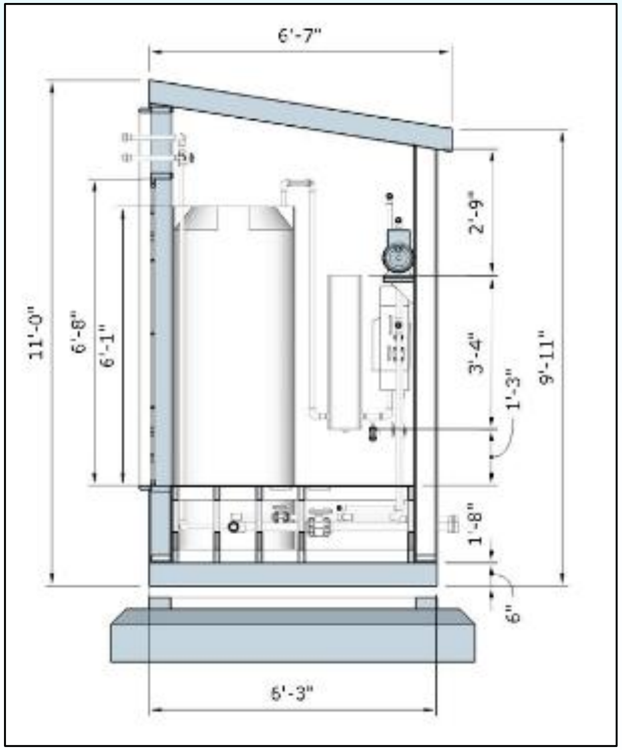


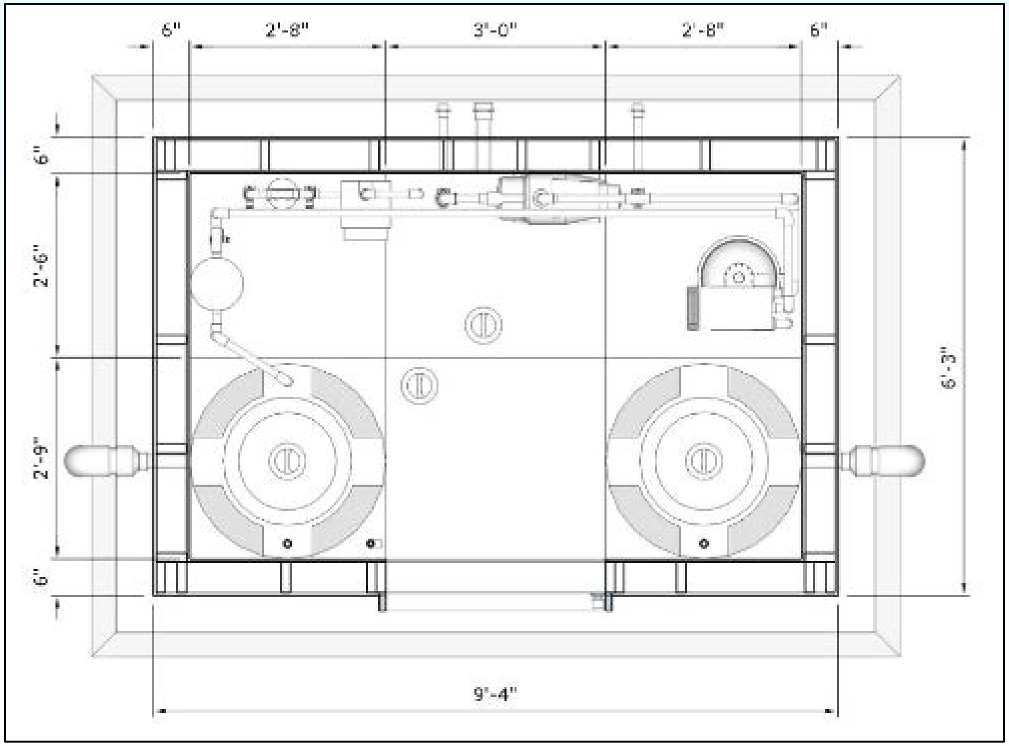


Vestibule Layout

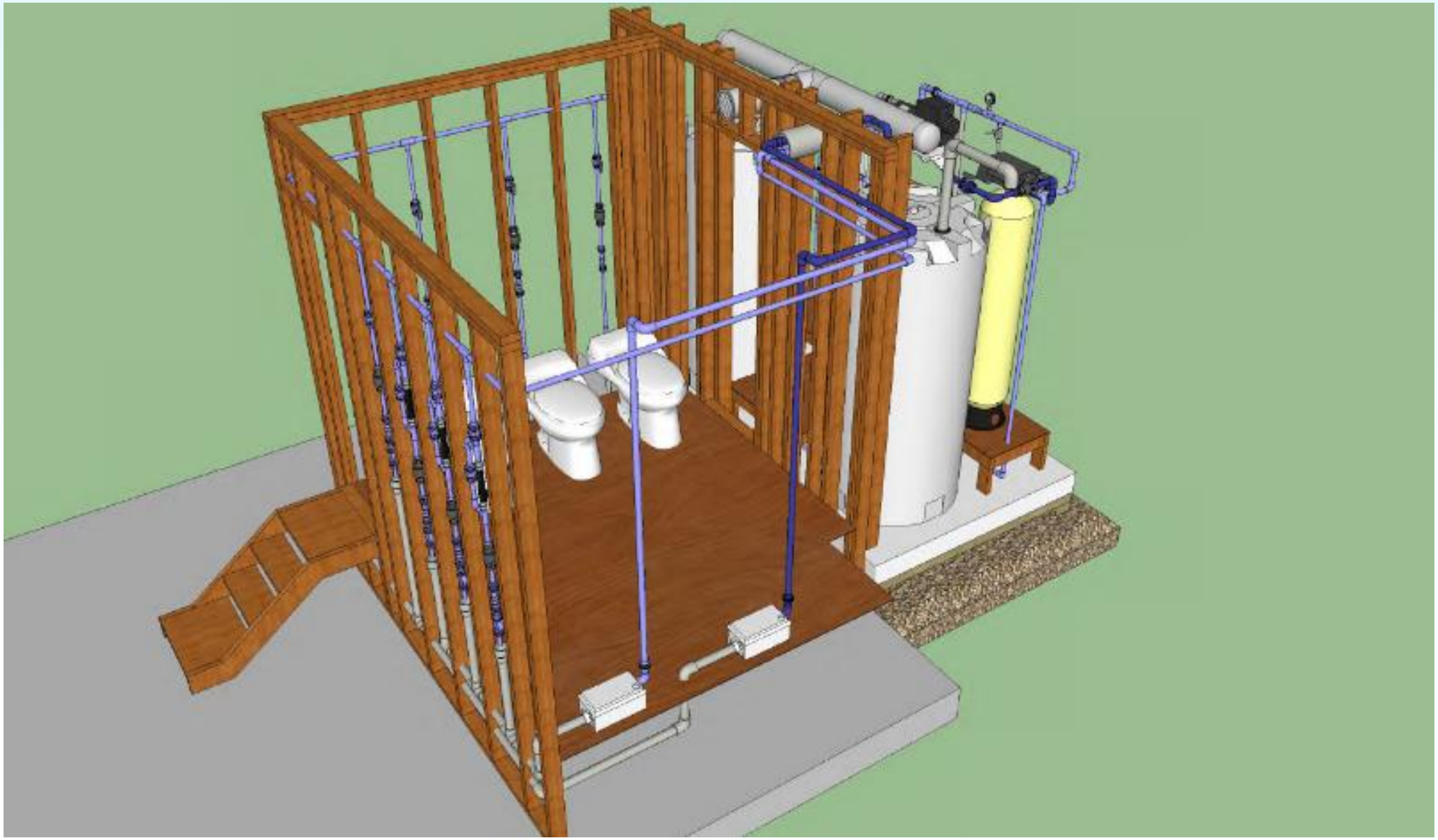


Vestibule Dimensions

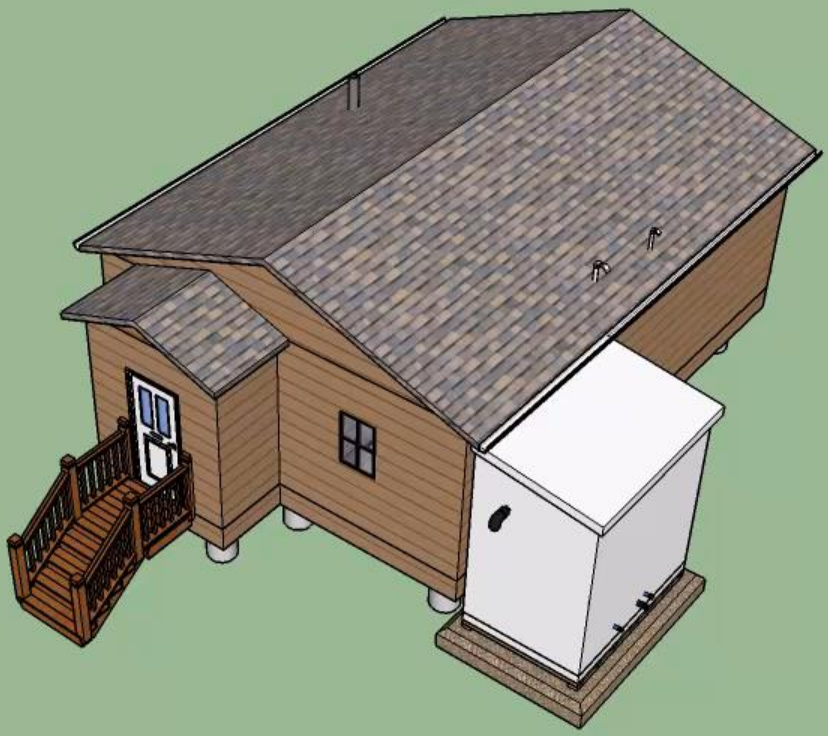




Mock Household Plumbing System



HWWS 3-D Virtual Tour



HWWS Prototype Test Plan and Preliminary Results

PROTOTYPE TEST PLAN

- 9-month testing period at CCHRC Prototype Test Facility (May 2016 through January 2017)
- 13 regular and stress household fixture flow scenarios
- Three raw water sources: rainwater, river water and pond water
- Continuous monitoring of five plumbing fixtures, BW/GW tank levels and power usage
- Daily water fill and flow rate monitoring for point-of-use filters
- Periodic LVF toilet flushing tests for bulk waste removal
- Monthly water quality sampling to meet USEPA and ADEC water quality standards

HWWS Prototype Test Plan

9-month testing period at CCHRC Prototype Test Facility (May thru January 2016)

13 stress flow scenarios for five household fixtures

Three raw water sources: rainwater, river water and pond water

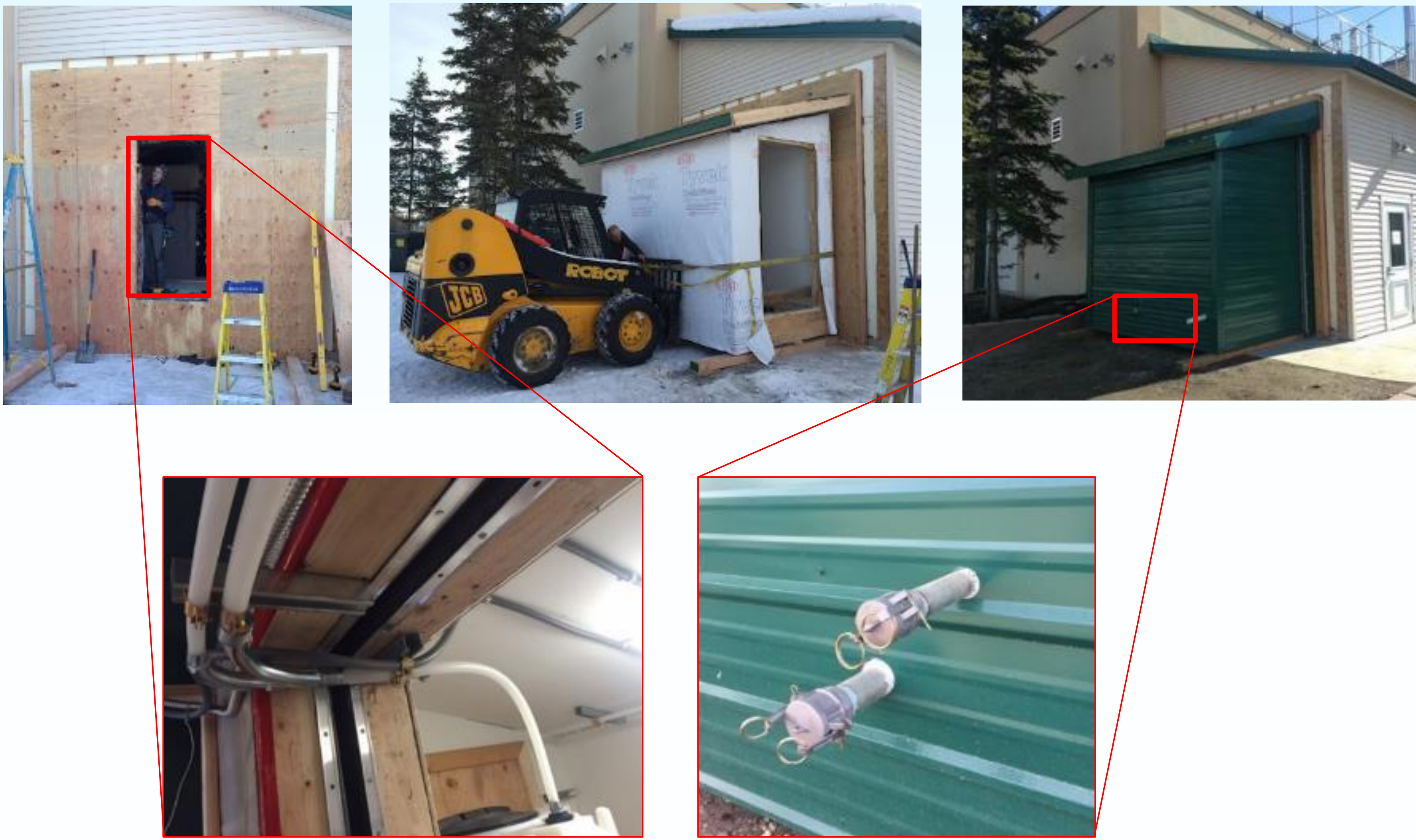
Continuous monitoring of fixture flows BW/GW tank levels and power usage

Daily water fill and flow rate monitoring for POU filters

Periodic LVF toilet flushing tests for bulk waste removal

Monthly water quality sampling to meet NSF-350 and drinking water quality standards

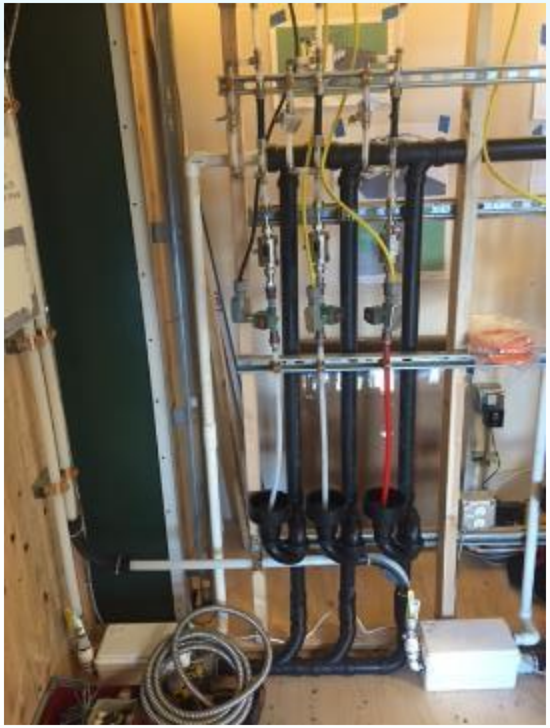
HWWS Prototype Vestibule Construction



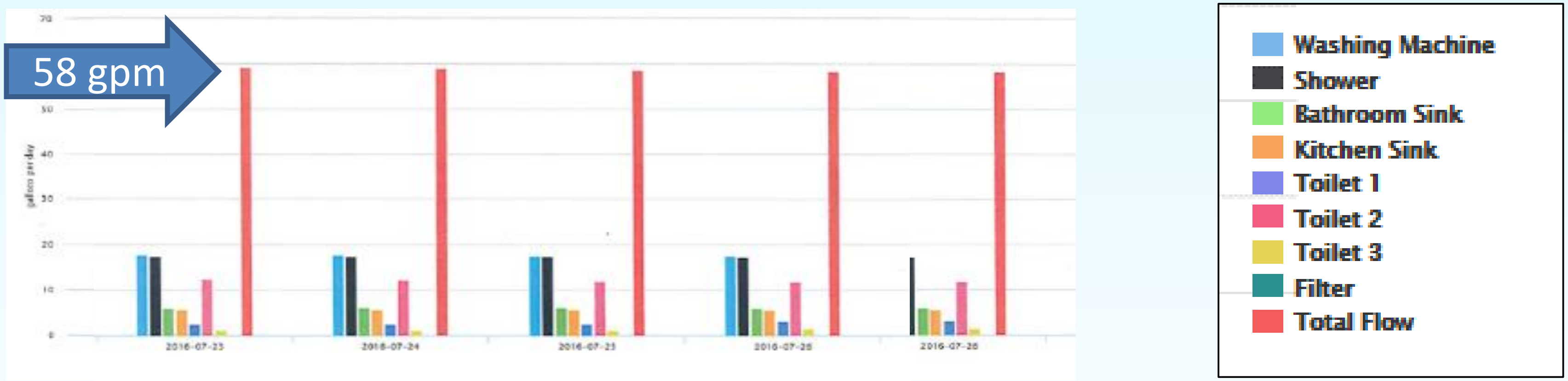
HWWS Equipment Inside Vestibule (see 360 photo on I Pad)

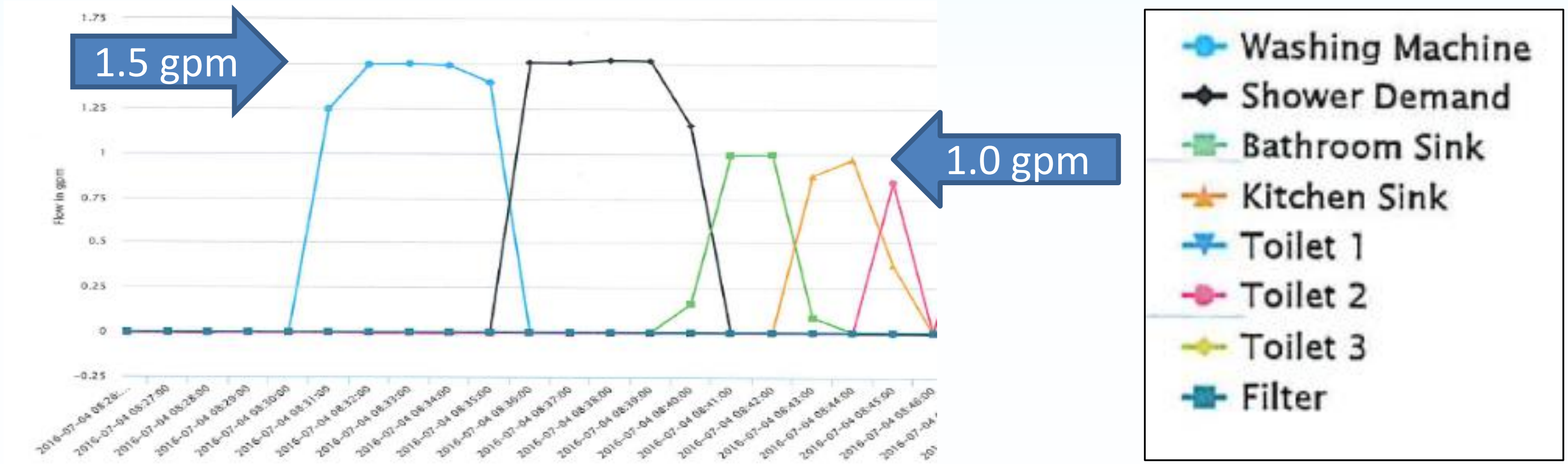
Mock Household Plumbing Structure (see 360 photo on iPad)

Mock Household Plumbing System



HWWS Typical Daily Water Usage Trends





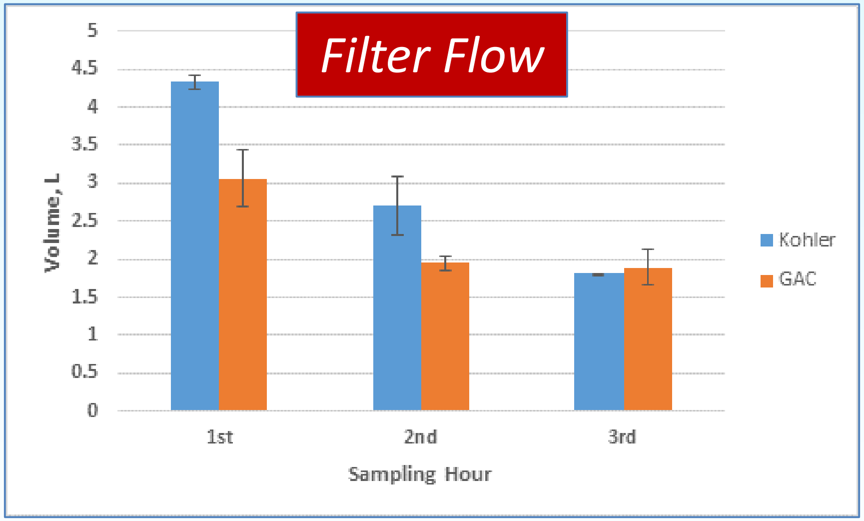
Mock plumbing flows meet daily water usage target of 60 gpd

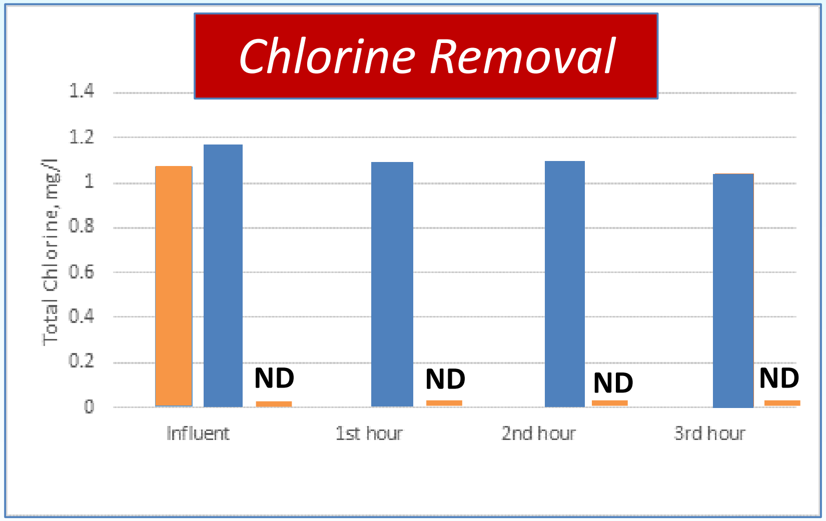
POU Filter Microbial Challenge Test Results (single filter element)

Water Depth Above Filter Cartirdge - inches	Flow L/Hr	Kohler Clarity Filter		Stacked Bucket Filter	
		E. Coli Log Reduction (Log)	Outlet E.Coli concentration (CFU/100 mL	E. Coli Log Reduction (Log)	Outlet E.Coli concentration (CFU/100 mL
10.5	3.4	NA	<1	> 6.6	<1
7	2.3	NA	<1	> 6.6	<1
3 (5 liters)	0.9	> 7.1	<1	> 6.6	<1
1.8 (3 liters)	0.5	> 7.1	<1	> 6.6	<1
0.9 (1.5 liters)	0.3	> 7.1	<1	> 6.6	<1

Both POU filters achieved complete (100%) bacteria removal

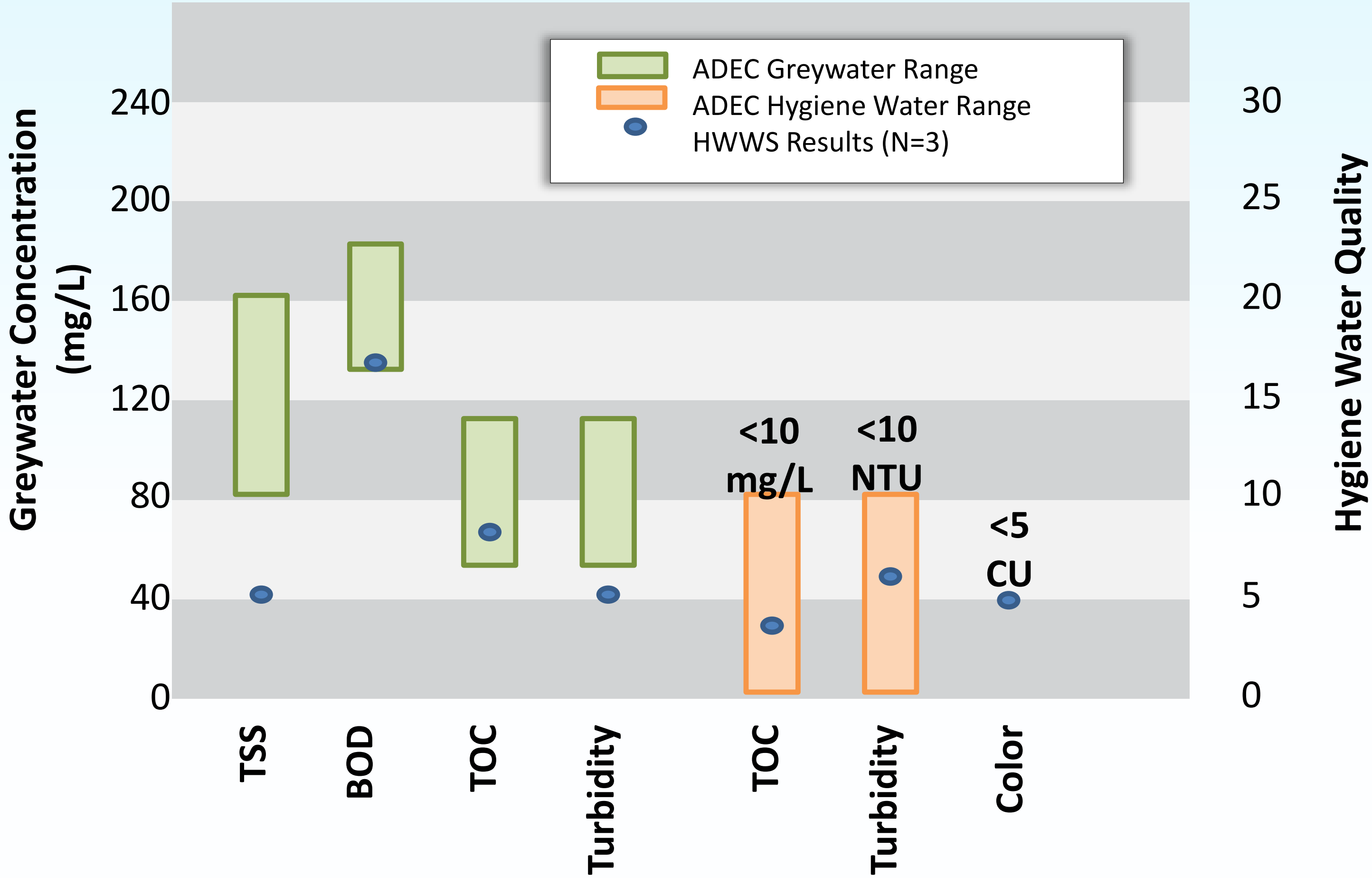
POU Filter Flow and Chlorine Removal Test Results (double filter element)





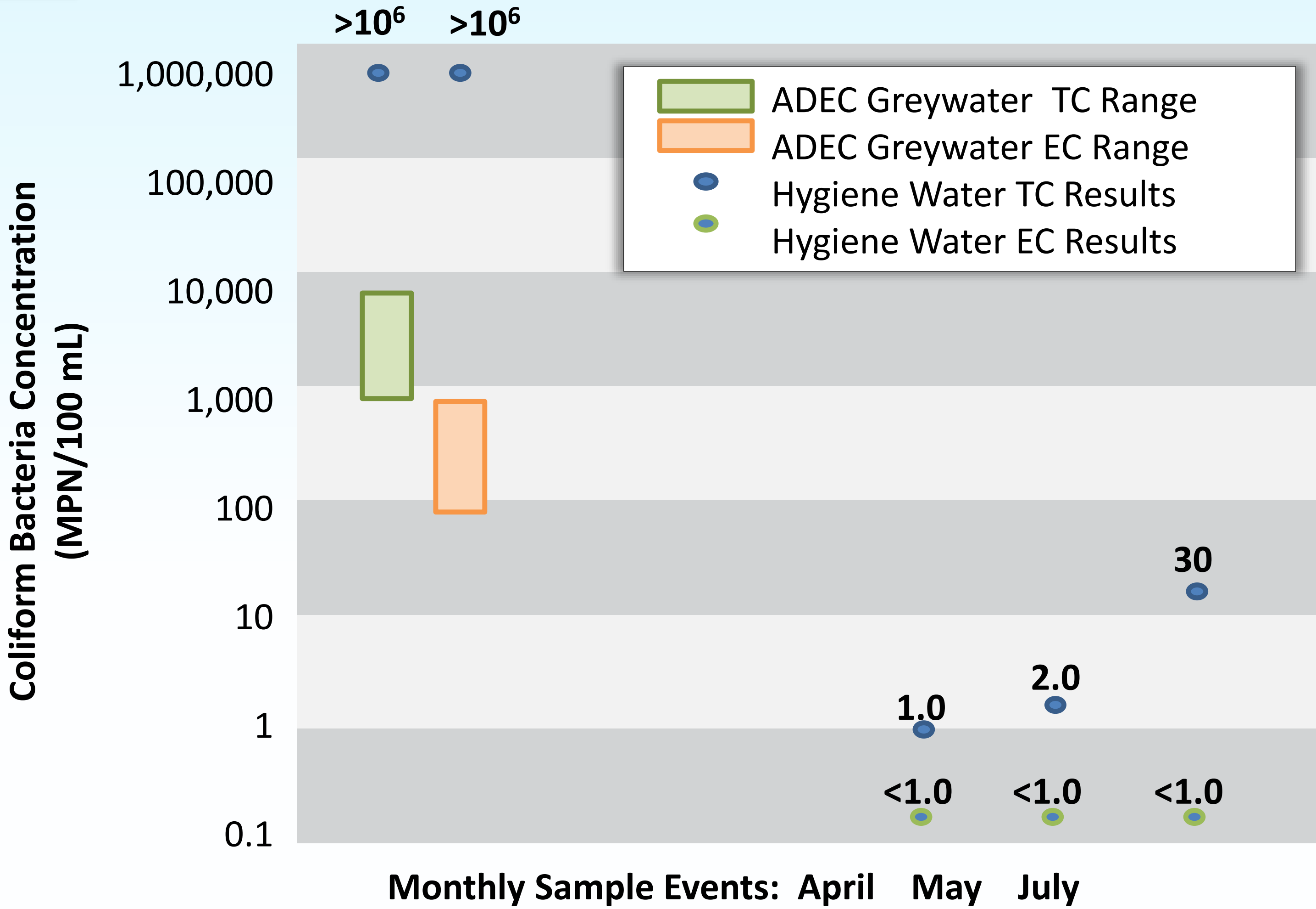
Dual filters with GAC packing achieved 100% chlorine removal

Greywater and Hygiene Water Preliminary Water Quality Results (Physical and Chemical)



Greywater targets hard to hit, but hygiene WQ targets still met

Greywater and Hygiene Water Preliminary Water Quality Results (Coliform Bacteria)



Very high microbial growth rates in GW tank impacted hygiene WQ

O&M Requirements and Cost

O&M REQUIREMENTS & COST

Greywater Treatment and Recycle System:

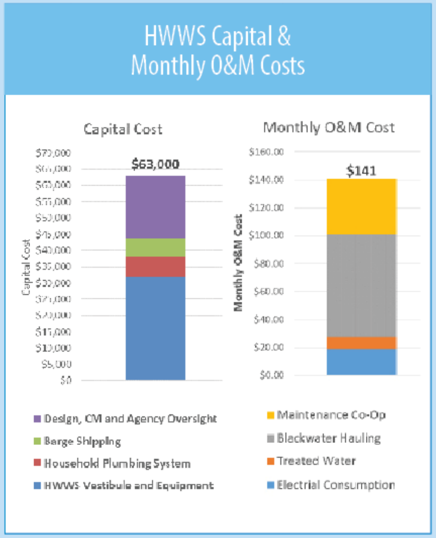
- Refill 300-gallon GW tank on 20-30 day cycle using village pumper truck or plastic containers from local water point
- Empty BW tank on 20-30 day cycle using village vacuum truck
- Respond to pump and tank level audio/visual alarms
- Contact maintenance co-op for annual replacement of UV lamp and filter media, plus pump inspection and repairs

POU Drinking Water Filter System:

- Use clean sponge to wipe down filter elements when flows drop below an acceptable level
- Replace filter elements once a year, or as needed

Costs (see graphic):

- Capital and monthly O&M costs for HWWS system meet ADEC affordability targets
- Monthly O&M cost based on unit prices for power, water and liquid waste hauling in Shishmaref



Household O&M Requirements
Greywater and Blackwater Systems

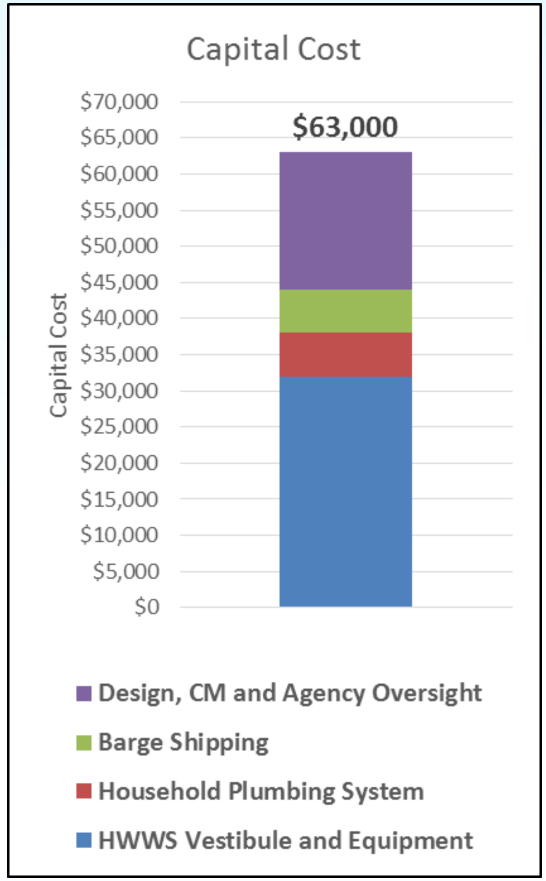
- Refill 300-gallon GW tank and empty BW tank on 20-30 day cycle
- Check sediment filter weekly and clean as needed
- Respond to pump and tank level audio/visual alarms
- Maintenance co-op:
  - Annual HWWS inspection and as needed repairs
  - Annual replacement of UV lamp, cartridge filter and GAC filter media

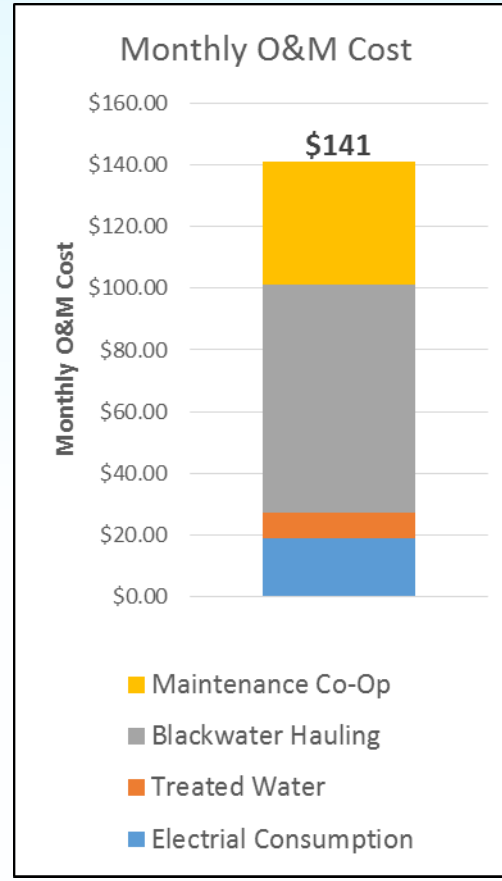
Household O&M Requirements
POU Drinking Water Filter System

- Use clean sponge to wipe down filter elements when flows drop below an acceptable level
- Replace filter elements once a year, or as needed

Capital and O&M Costs

- Capital and monthly O&M costs for HWWS system meet ADEC affordability targets
- Monthly O&M cost based on unit prices for power, water and liquid waste hauling in Shishmaref





THANK YOU

ALASKA WATER + SEWER CHALLENGE

Water Innovations for Healthy Arctic Homes

September 19-21, 2016

Summit Consulting Services

www.summitwsc.com

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The Phase III Team

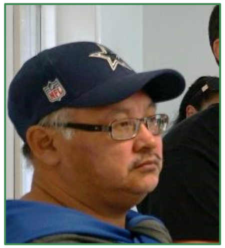












Summit

Agnew::Beck Consulting

Kongiganak

Kivalina

Re-Locate

The Cabin Lab

Quick Tour

The Entry Way

http://on.bubb.li/433755aponfyrl4n7h3mx56/

The Kitchen
http://on.bubb.li/433755aalfovrbla7vbdcjb/

The Bathroom

http://on.bubb.li/433755alx558y70ppj8l8l4/

Design Highlights

-Fits within the home

-Treats water for drinking

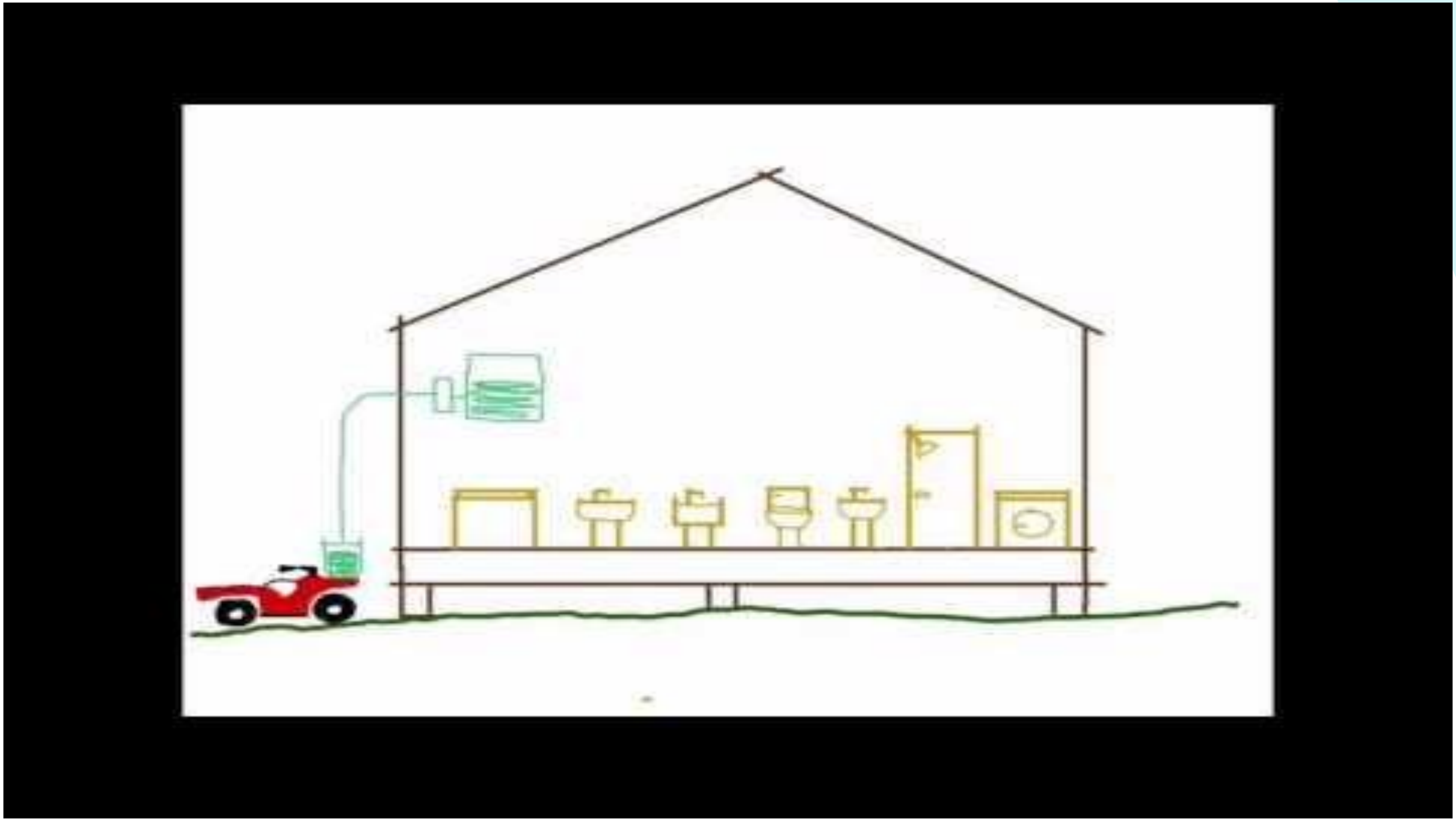
-Treats wash water using an Aqua2Use greywater treatment system

-Includes two toilet options

-Includes freeze-thaw protection

-Designed to be installed and maintained with local labor

Drinking Water



Drinking Water Treatment

Washable
Silver Zeolite
Filter

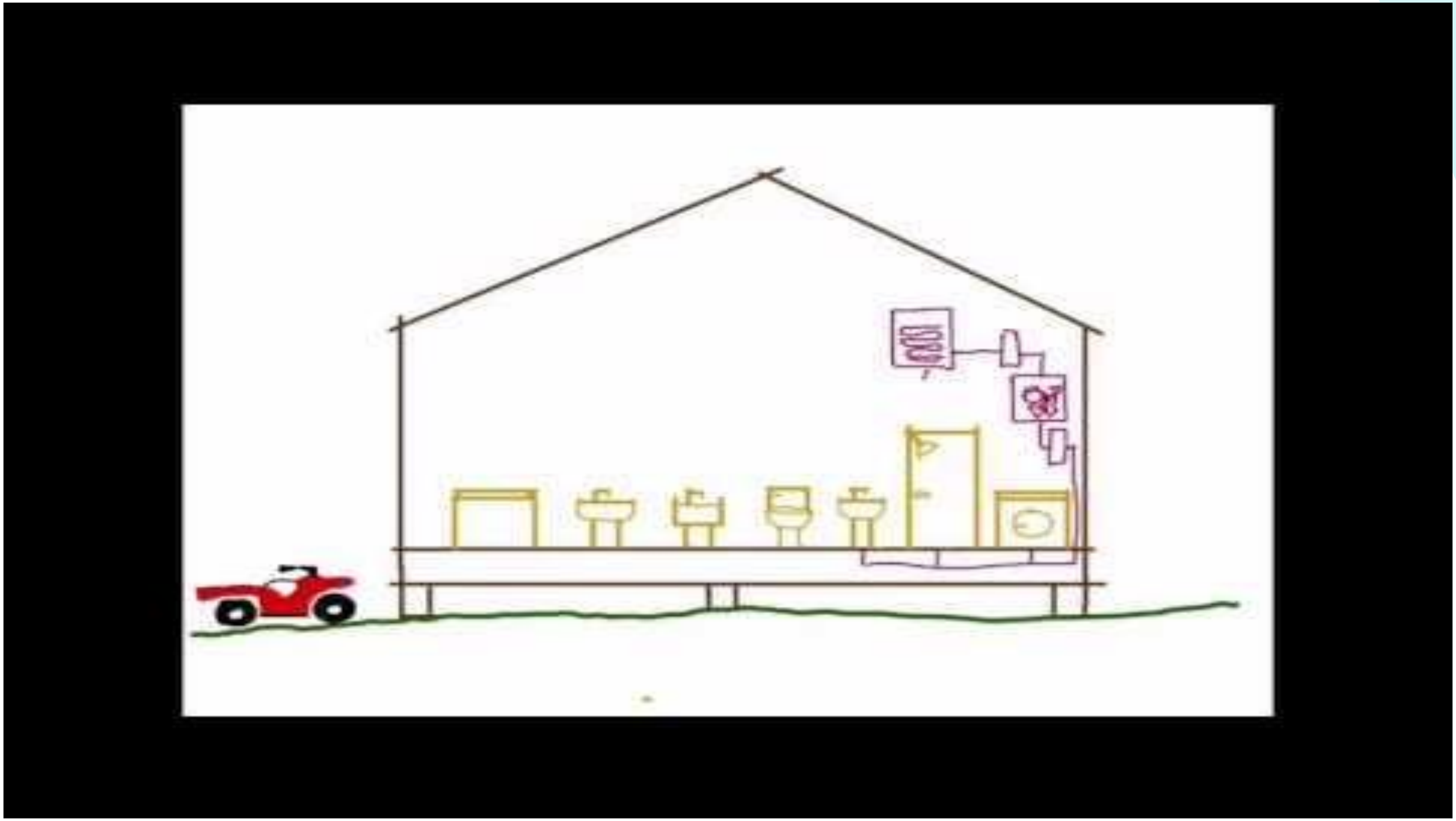
1 Micron
Cartridge
Filter

Ultrafiltration
Membrane

Quantum
Silecte
Disinfection

Carbon
Polishing Filter

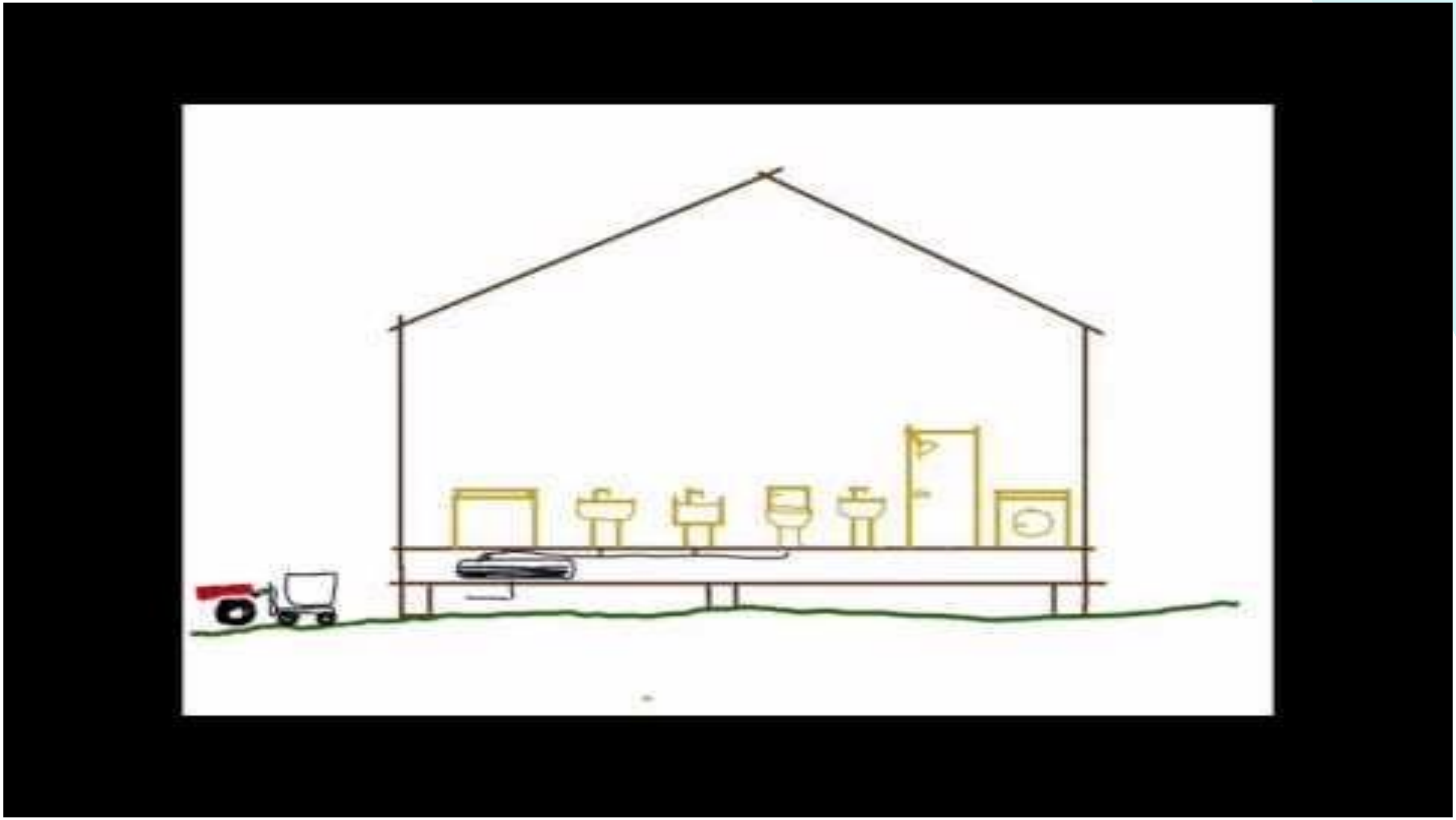
Wash Water



Wash Water Treatment

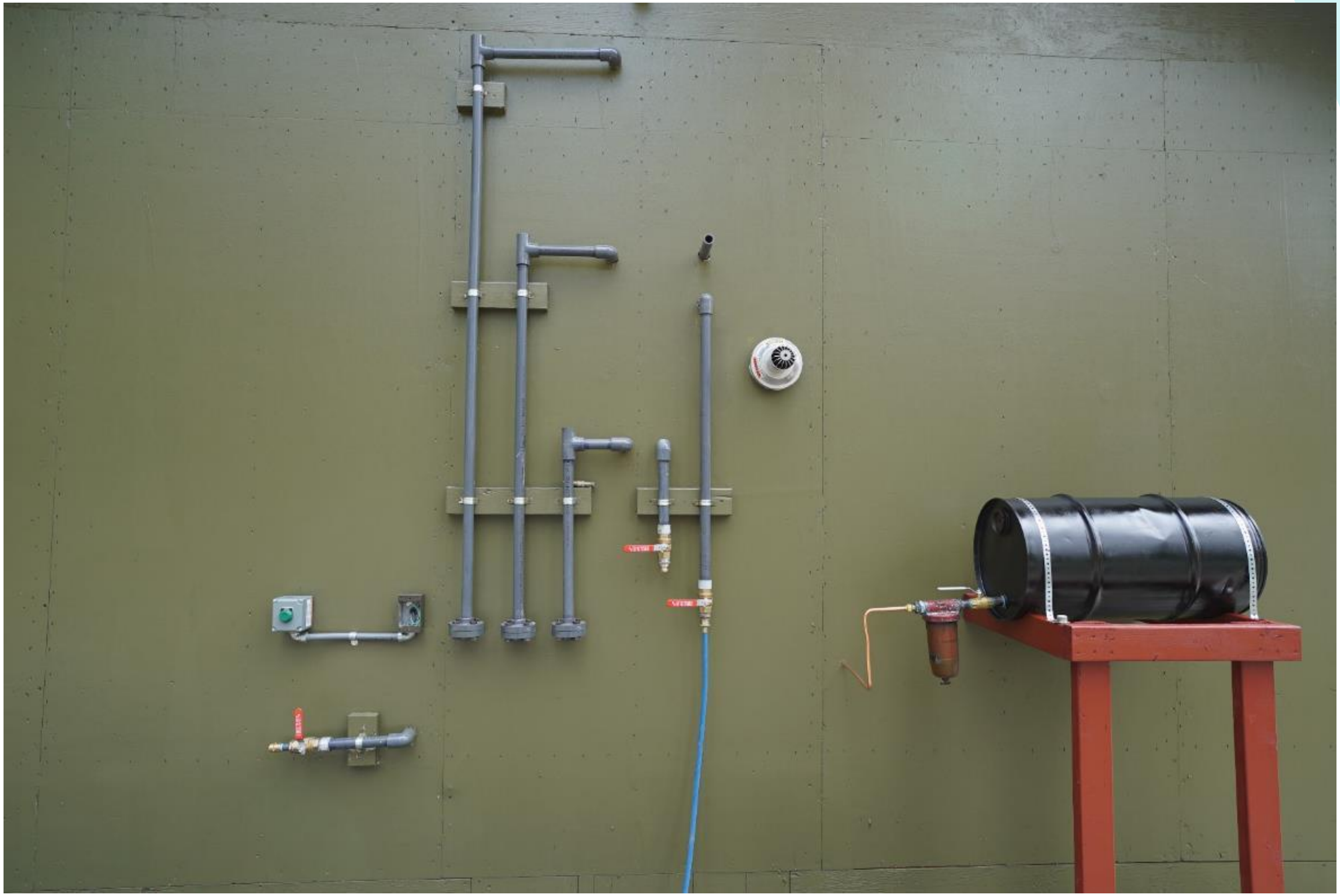
Wash Water Treatment (alt)

Waste Water

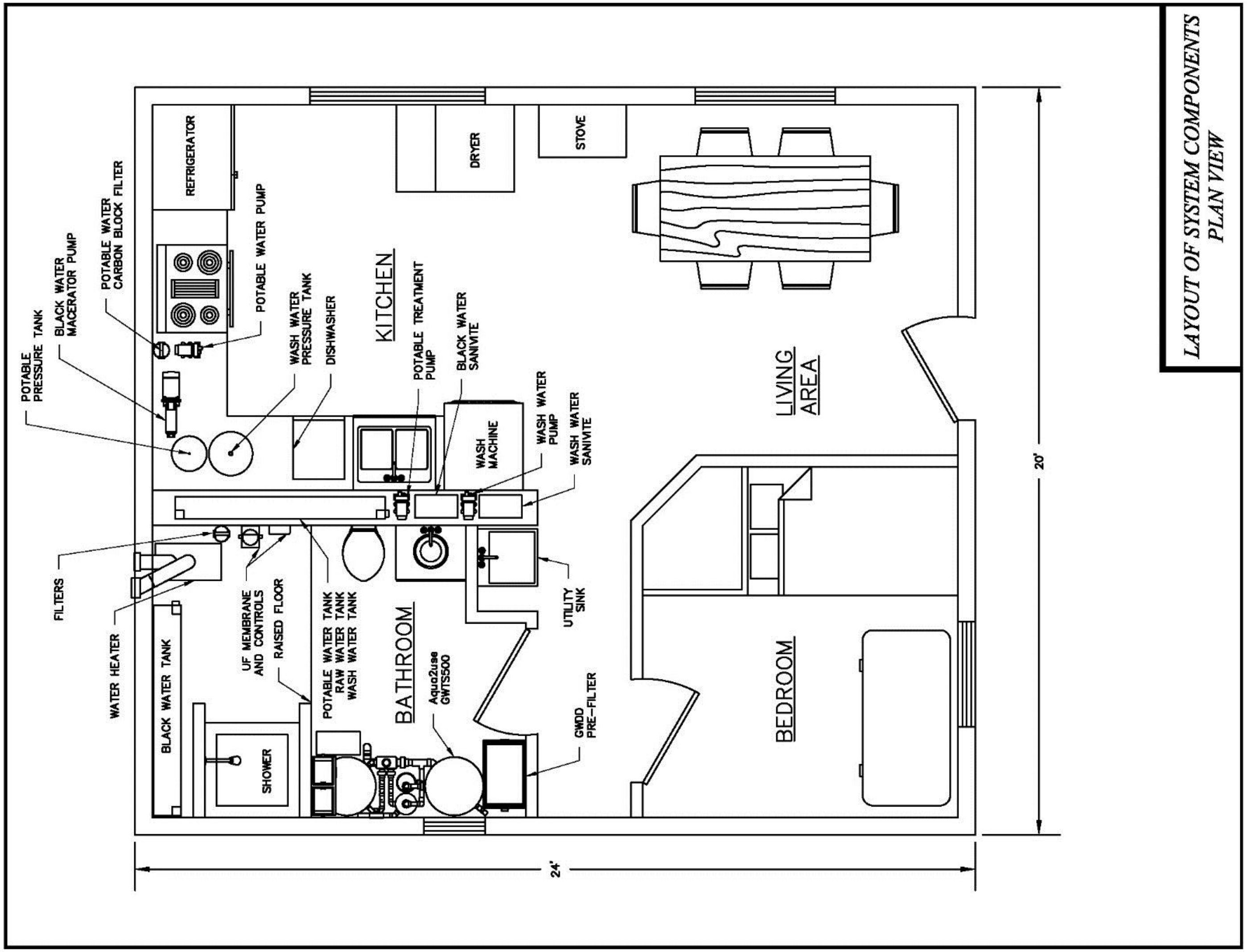


Toilet Options

Water in, water out



Floor Plan

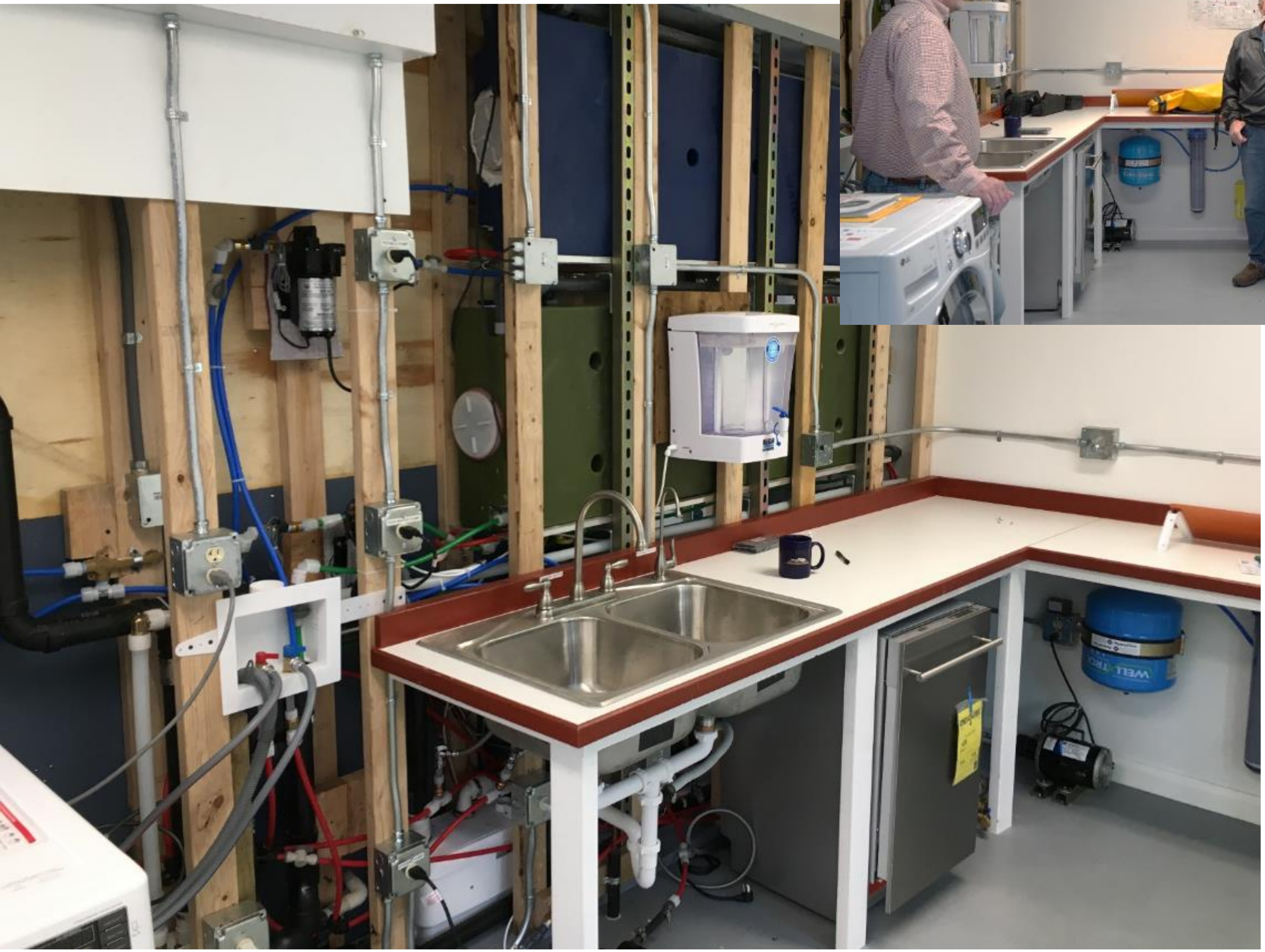


LAYOUT OF SYSTEM COMPONENTS
PLAN VIEW
REFRIGERATOR
DRYER
STOVE
KITCHEN
LIVING AREA
BEDROOM
BATHROOM
POTABLE PRESSURE TANK
BLACK WATER MACERATOR PUMP
POTABLE WATER CARBON BLOCK FILTER
POTABLE WATER PUMP
WASH WATER PRESSURE TANK
DISHWASHER
POTABLE TREATMENT PUMP
BLACK WATER SANIVITE
WASH MACHINE
WASH WATER PUMP
WASH WATER SANIVITE
FILTERS
WATER HEATER
BLACK WATER TANK
UF MEMBRANE AND CONTROLS
RAISED FLOOR
POTABLE WATER TANK
RAW WATER TANK
WASH WATER TANK
Aqua2use GWTS500
UTILITY SINK
GWDD PRE-FILTER
SHOWER
20'
24'

Kitchen + Bathroom

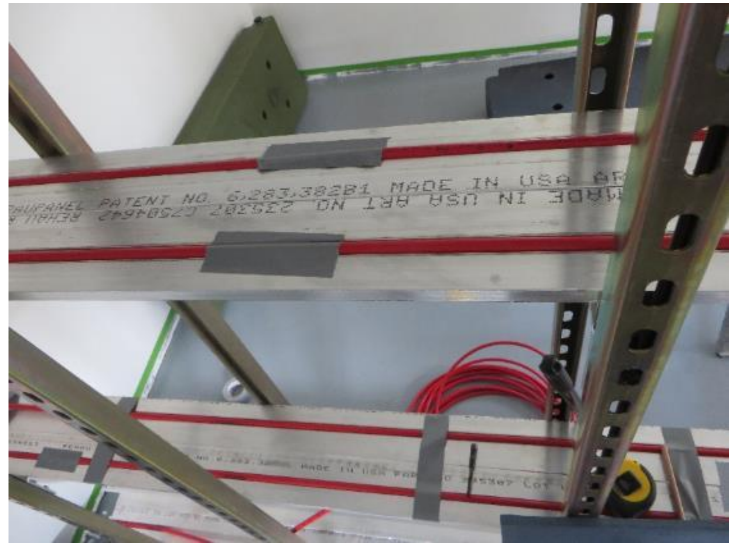
Bathroom

Kitchen



Front Room

Freeze – Thaw Protection



What we have heard from end users

System needs to fit within the home

Water must be clean

Reduce water hauling

Easy to modify

Make it kid proof

Limit condensation

End user input to system design

Utility sink

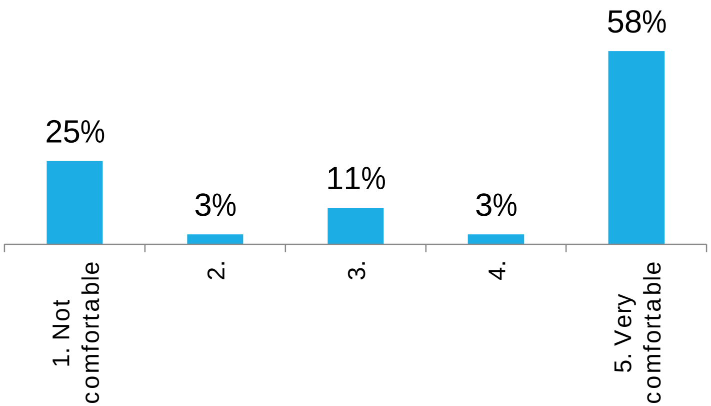
Two toilet options

Integration with rain water catchment

Kid-proofing options (color coding, tap placement)

Reusable filters

Comfort with water reuse



Comfort with recycled water use for handwashing

Daily Water Flows (Range)

Raw water used: **10 – 17 gallons**

Drinking water used: **3 gallons**

Wash water in circulation: **57 gallons**

Wastewater produced: **9.5 – 16.5 gallons**

The raw water consumption and wastewater produced vary by the type of toilet used.

Financial Costs

Capital cost: **$125,000 per home***

Monthly operation cost:

$183 for dry toilet / $243 for flush toilet

Item	Monthly cost Dry Toilet (A)	Monthly cost Flush Toilet (B)
Electricity	$13.30	$10.76
Consumables	$17.92	$13.67
Water at $.10/galloon	$20.10	$34.17
Wastewater haul at $.25/gallon	$71.25	$123.75
Co-op	$40	$40
Replacement parts (Avg.)	$20.83	$20.83

Testing Results

Raw Water	8/17/2016	8/29/2016
Nitrate (mg/L)	0.3	NT
Total Coliform (MPN/100ml)	7.4	2
E-Coli (MPN/100ml)	0	0
All other parameters No Detect		

Drinking Water	8/17/2016	8/29/2016
Total Coliform (MPN/100ml)	0	0
E-Coli (MPN/100ml)	0	0

Testing Results

Synthetic Gray Water	Desired Range	8/17/2016	8/29/2016
Total Coliform (MPN/100ml)	100-1,000	>2,400	>2,400
E-Coli (MPN/100ml)	1,000-10,000	1,700	>2,400
pH	6.5-8.5	8-9	8.4
TOC (mg/L)	50-100	1,890	430
COD (mg/L)	250-400	490	1,000
TSS (mg/L)	80-160	24	525
TURBIDITY (NTU)	50-100	34	63
BOD_5 (mg/L)	130-180	169	1,220
PHOSPHORUS (mg/L)	1-3	8.4	14
TKN (mg/L)	3-5	4.01	5.97

Testing Results

Wash Water	Desired Range	8/17/2016	8/29/2016
Total Coliform (MPN/100ml)	none	81	180
E-Coli (MPN/100ml)	none	No detect	No detect
pH	6.0-9.0	8	8
TSS (mg/L)	<30	2	4.8
Color, apparent	Test only	10	20
TURBIDITY (NTU)	<10	No Detect	5.5
BOD_5 (mg/L)	<25	10.7	23.8
Odor	Non-offensive	present	present
Oily Film and Foam (mg/L)*	Non-detect	Not Tested	1.29

* Tested as methylene blue active substances assay (MBAS)

Operations + Maintenance Issues

Homeowner tasks

Co-op – system support

End user requests: re-usable parts, maintenance support and locally available parts.

Concerns: soap smell, kid proofing

⊕ CLEAN WATER AND SAFE WASTE DISPOSAL SOLUTION

PORTABLE

The biggest drawback of a typical piped water and sewer system is that they are not portable. Some Alaskan communities are vulnerable to flooding and erosion; therefore, some funding agencies have been reluctant to invest in infrastructure. The PASS systems can be assembled and reassembled if a community has to relocate.

ALTERNATIVE

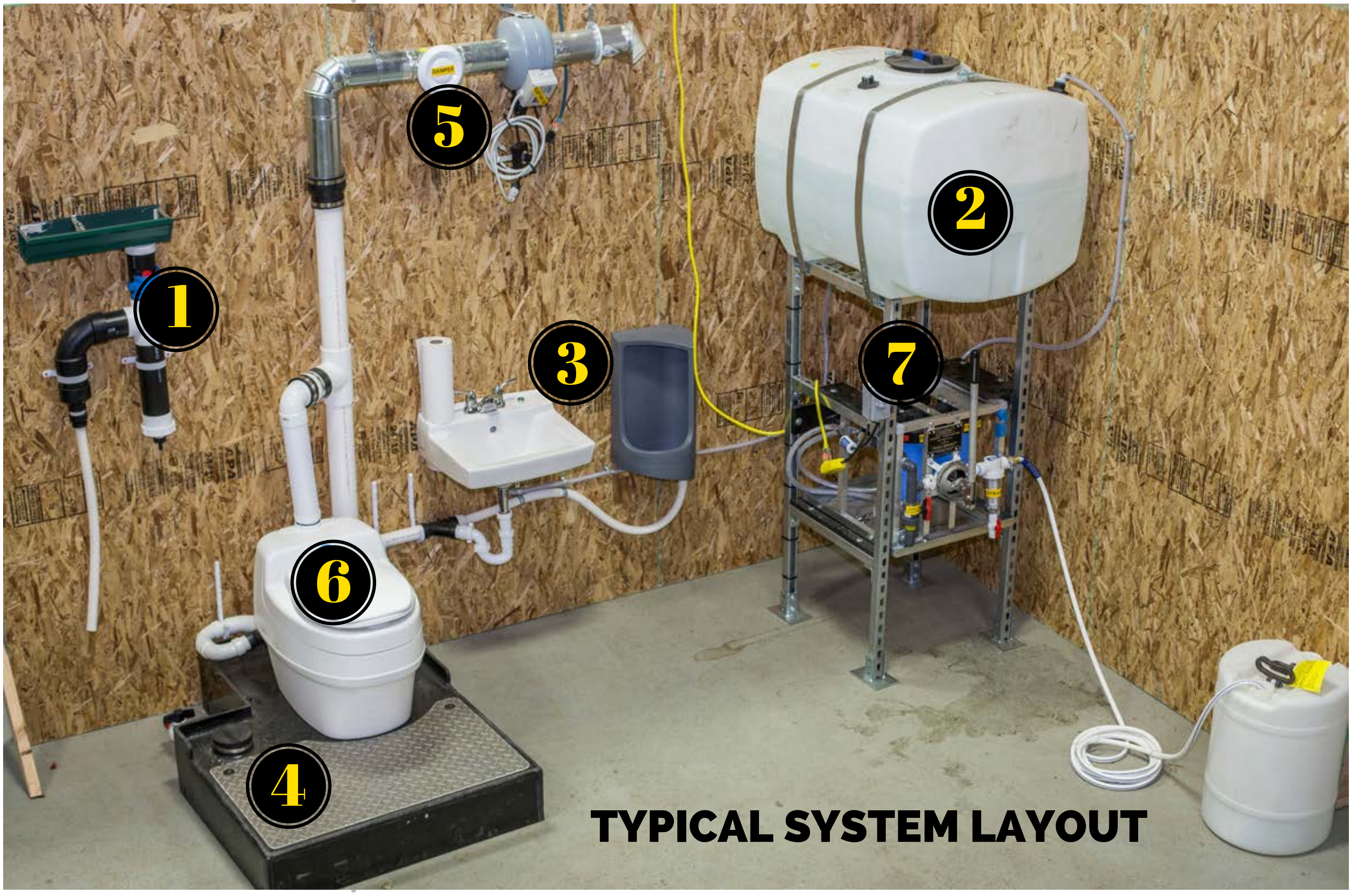
The Alaska Native Tribal Health Consortium and the Cold Climate Housing Research Center have designed and implemented a low cost sanitation alternative for communities that are affected by climate change. The PASS systems are approximately $26,000 per household as compared to a traditional piped system that costs approximately $168,000 per household.

SANITATION

The PASS was implemented in nine homes in Kivalina, Alaska. Kivalina has been operating on a self-haul system. This exposure to raw sewage places community members at risk for waterborne pathogens. The innovative systems vastly improve hauling by limiting exposure to waste, minimizing odor, and reducing frequency and weight of hauls.

SYSTEM

The system is entirely homeowner-based, designed to address the most basic sanitation needs, and can be moved with the community. The systems are stand-alone models; as homes are moved to the new village site away from the eroding coastline, residents can bring their clean water and safe sewer systems with them.



1. RAIN CATCHMENT

For an 800-square-foot home with a catchment area of approximately 1,200 square feet, it is possible to recover nearly 3,000 gallons or more of rain each year to supplement the quantity of water hauled to the home.

2. WATER STORAGE TANK

The 100-gallon, gravity-fed tank does not require electricity.

3. LOW-FLOW SINK AND WATERLESS URINAL

The sink and urinal conserves water while providing for hygiene and sanitation needs.

4. GREY WATER TANK

The grey water tank purges into the seepage pit below when full.

5. INTEGRATED VENTILATION

An energy-efficient combined ventilation system dries the waste, reduces odors, and ventilates the home.

6. SEPARATING TOILET

Waste is separated into liquid and solid components where the liquid is disposed of into a seepage pit and dried solids are disposed of in the landfill.

7. WATER TREATMENT SYSTEM

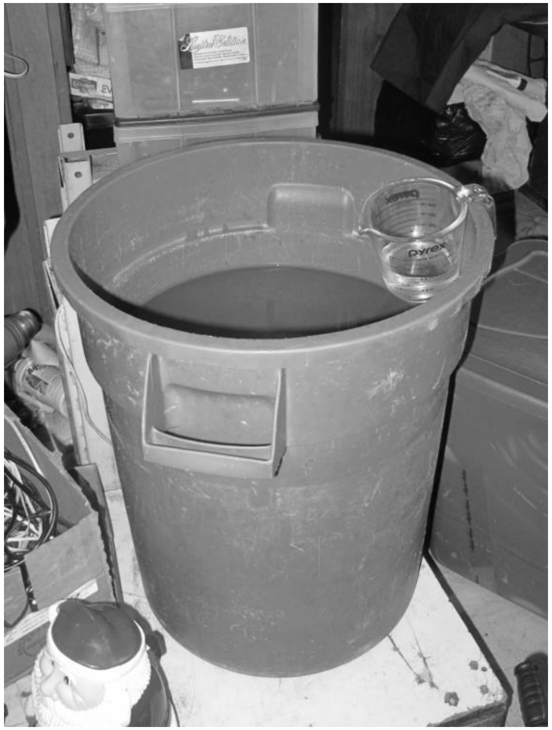
The water treatment system incorporates membranes and chlorination for point-of-use treatment to ensure the water is safe to drink despite its condition upon entering the system.

Community Perspectives on Water Insecurity in Rural Alaska

Dr. Laura Eichelberger, PhD, MPH
University of Texas at San Antonio

Water Insecurity

* ~20% households lack in-home plumbing.
* Many more others are water insecure:
  * Unreliable access to water
  * Poor sanitation
  * Water rationing
* System failures are common due to economic, environmental challenges.



Outline

* Define water insecurity and how anthropologists study this problem

* Report findings from research on
  * Dimensions of water insecurity
  * Social and environmental axes
  * Daily lived experiences: practices and concerns
  * Narratives of insecurity: “spoiled by technology”

Anthropology of water

Water as "total social fact" (Orlove and Caton 2010):

* enables life
* involves social interactions, social hierarchies, practices, and cultural meanings.
* culturally specific
* structured by infrastructure and policies

Anthropology of water

* **Waterscape**
  * Meanings people give to water in its different forms.
    * "Rain water is the most pure."
  * Social interactions and practices that are shaped by water, and which affect where it flows.
    * Water plant operators, utility managers, customers…
  * Political and economic factors that affect water
    * Policies
    * Affordability, poverty

My Research

* How does water insecurity affects daily life?
  * (practices around obtaining water and its uses)
* What are the affects on health and wellbeing, broadly defined?
* How people talk water insecurity?

Methods (Phase 1: 2008-09)

Northwest Arctic Borough
March 2008-June 2009

In-depth field research:

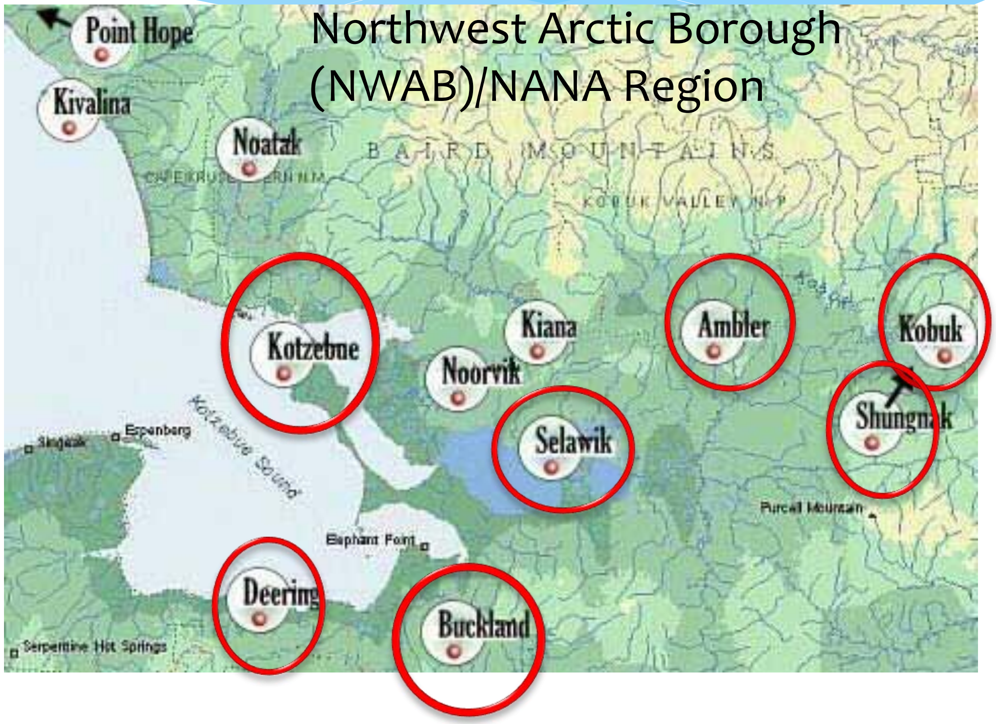
* 3 remote Iñupiaq villages
  * 2 with partial water/sewer service
  * 1 with “self-haul” (Buckland)
* Kotzebue (regional hub)

Participant observation

* CBPR: photovoice, community mapping
* Semi-structured interviews (N=101)
* Direct observation
* 21 surveys in Buckland

Archival research: history of

* Iñupiaq and village health
* Public health interventions
* Water/sewer development in remote Alaska



Methods (2015-16)

Follow-up Research:

* Ambler, Buckland, Kotzebue:
  * Follow-up key informant interviews
  * Participant observation

Preliminary Research:

* Newtok:
  * Participant observation
  * Open-ended, semi-structured interviews (N=16)

Enjoying traditional foods with Minnie Gray, Ambler 2016

Buckland (2008-2009)

“Warning: pond contains sewage. Stay out.”

- Iñupiaq, NW AK
- Population: 450+
  - (now 500+)
- Self-haul & honey bucket
- Yearly spring flood increased cross-contamination
- 15-year long piped water and sewer project
  - Completed by VSW &Summit
  - 2016: all but 2 households connected
  - Problems with affordability
    - Disconnections
  - Erosion

Newtok (2016)

- Population: 354 (2010 Census)
- Self-haul & honey bucket
- Relocating due to effects of climate change.
  - Flooding
  - Erosion
  - Melting permafrost
  - Severe storms

Treated Water Access & Sewerage

Buckland (2008-09)

- "Washeteria"
  - Central watering point
  - Showers ($2/7 minutes)
  - Laundry facilities:
    - 4 washing machines for 450+ pop.
    - $4/load
- Untreated sources: river, spring
  - Limited use
- Cross-contamination from honey buckets

Newtok (2016)

- "PHS" (water treatment plant)
  - Central watering point
  - No public showers (steam baths)
  - No laundry facilities (Danby washers @ home)
- Newtok School
  - Treated water, showers, laundry
  - Normal access limited to associate teachers
  - Emergency access: 10 gal/household/day
- Untreated sources: rainwater, ponds, spring
  - Frequent use
- Cross-contamination from honey buckets

Quantifying Water Insecurity

5 Factors	WHO: "Intermediate Access" (Howard & Bartram 2003)
* Amount	* 50 liters (13.2 gal)/person/day
* Distance	* Tap <100 meters away
* Time	* <5 minutes collection time
* Quality	* Acceptable quality with minimum risk to health
* Affordability	* (Affordability)

Quantifying Water Insecurity

	WHO Criteria[1] (Ref.)	Buckland[2] (2008-09)	Newtok[3] (2016)
N		N=21	N=11
Amount (gal/c/day)	13.2 gal	2.4 gal	2.3 gal
Distance	<100 meters	>100 meters	>100 meters
Time	<5 min	15-45 min.	15-45 min.

[1]Howard and Bartram 2003; [2]Eichelberger 2010; [3]Eichelberger *Unpublished* preliminary data

Social & Environmental Axes

Social and environmental circumstances that overlap to increase insecurity:

* Age
* Ability
* Social/Kin network
* Access to vehicle
* Climate vulnerabilities

(Eichelberger 2010)

"It's elders … I worry about. Who takes care of them when the boys go off to do subsistence?...

"We tell [the kids], 'Go pack water, dump honey buckets, do their dishes. Visit them,' we say. 'It just takes thirty minutes."

--Mother and Yup'ik teacher, Newtok

Daily Lived Experiences & Hidden Costs of Insecurity

- Daily life revolves around when & how to get water.
  - For most: requires kin relationships
  - Sharing water with those without
  - Paying others to haul
- Time-consuming
  - Travel to alternative sources
  - Opportunity costs: subsistence, cultural & economic activities, etc.

> "I have to run back and forth 5 or 6 times unless I borrow a larger bucket. I can do it in 15 minutes if I rush… 30 gallons will last you for one whole week if you're careful."
>
> - Mother, Buckland

Hidden Costs: Gender & Age

Particular affects for women and children.

* Time:
  * 4-8 hours for laundry at washeteria
* High health risk for children
  * Women travel with sick children
  * Lost time at work, school
  * Stigma/social isolation at school
    * Contribution to depression?

"There's a degree of likeness and dislike. Kids don't want to be partners with kids who smell."

After the flood in Buckland 2008

Social Roles & Reciprocal Relations

* "Every day we'd go listen to **stories from the elders, but they wouldn't tell us any until we'd do something**. Chop wood, packing water, packing ice. It was a daily thing."
* "**Everyone used to share and help each other**… But that was before we had to pay for the lights, the stove oil, and the water. Now we need money."

Water as "Total Social Fact"

Water as "total social fact" (Orlove and Caton 2010):

* enables life
* social interactions practices, and cultural meanings
* structured by infrastructure and policies

Traditional values and water access:

* **Sharing, hard work, cooperation**
* **Respect for elders**

Centralized water systems thus far have not reflected traditional values:

  * Paying for water
  * Disconnecting elders, others

Seining in Buckland, June 2008

Narratives of distress: Trade-offs for water security?

Desire for running water/sewer	"Spoiled" by technology
"Everyone deserves a hot bath and a good, cold drink of water. Our forefathers fought hard for this country and we deserve better… **It's like a Third World country here.**" -	* **"The lights, the toilet… it spoiled us,** but we can't go back and unravel it."
"Right now, in 2009, I have six honey buckets in front of my house. In 2009! …**My kids get sick every spring from it.** It's not good for U.S. people like us."	* "Modern technology is making us sick... Electricity, water, sewer, TV... **You don't have to do anything physical."**

Quyana

Villages of Ambler, Buckland, Newtok, & Selawik

Maniilaq Association
Northwest Alaska Native Association
Northwest Arctic Borough

ANTHC
VSW
CDC AIP
UAA ISER

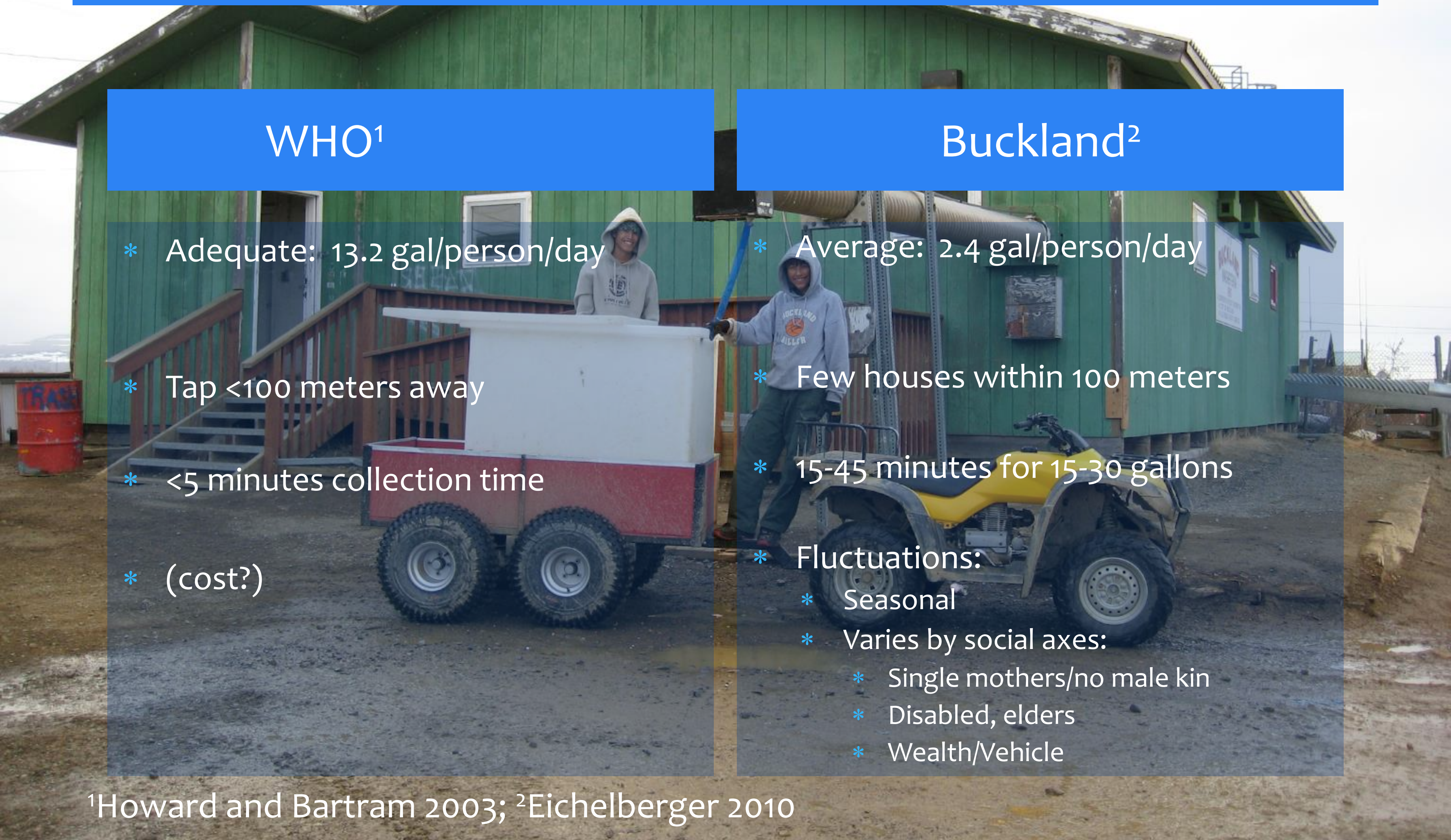
National Science Foundation
WHERE DISCOVERIES BEGIN

“Spoiled by technology”

* Decreased sharing
  * Replaced by bills
  * Paying someone to haul water

* Loss of traditional and subsistence knowledge

Access & Adequacy: Summary



WHO[1]

* Adequate: 13.2 gal/person/day
* Tap <100 meters away
* <5 minutes collection time
* (cost?)

Buckland[2]

* Average: 2.4 gal/person/day
* Few houses within 100 meters
* 15-45 minutes for 15-30 gallons
* Fluctuations:
  * Seasonal
  * Varies by social axes:
    * Single mothers/no male kin
    * Disabled, elders
    * Wealth/Vehicle

[1]Howard and Bartram 2003; [2]Eichelberger 2010

Practices: Uncertainty of Access

* Sharing
  * Allowing kin to use running water
  * Hauling water for kin

* Paying others to haul
  * Usually if weak kin network

* Collecting as much possible from natural sources
  * (difficult to quantify)

* Rationing:
  * Reusing water in washer, washbasin, bathtub
  * Using wipes instead of handwashing

Daily Life: Time

Buckland (2008-09)

* Hauling water:
  * 15-45 minutes for 5-30 gallons
  * Depends on access to vehicle
* Laundry: 4-8 hours
  * 4 washing machines for 450+ pop.
  * Most busy on weekends
  * Affects women more than men
* Health-related
  * Travel with children to hospital
  * Missed work, school

Newtok (2016)

* Hauling treated water:
  * 15-45 minutes: 5-30 gallons
  * Depends on access to vehicle
  * Multiple trips if doing laundry and/or hauling without vehicle
* Hauling water from other sources
  * Requires access to vehicle/boat
  * Having/paying others to haul

Practices: Risk Perceptions & Preventing Disease

* Preference for natural (untreated) sources
  * (Can also be cultural preference)
* Not bathing children under 1 year old
* Pouring gasoline into puddles to kill bacteria
* Avoiding traditional berry picking areas
* Removing shoes in home

Daily Life: Health & Stigma

* Avoiding particular areas, households, individuals
* Households with disease characterized as "lazy"
* Stigma: children socially ostracized
* There's a degree of likeness and dislike. Kids don't want to be partners with kids who smell."

Practices to Prevent or Treat Water-Wash Diseases

* Traditional medicines & lay epidemiology:
  * Ear aches:
    * Beluga oil
    * Cigarette smoke
  * Sore throats:
    * Beluga blubber
    * Duck oil
    * Sliced potato compress
    * Willow buds

* Order of use:

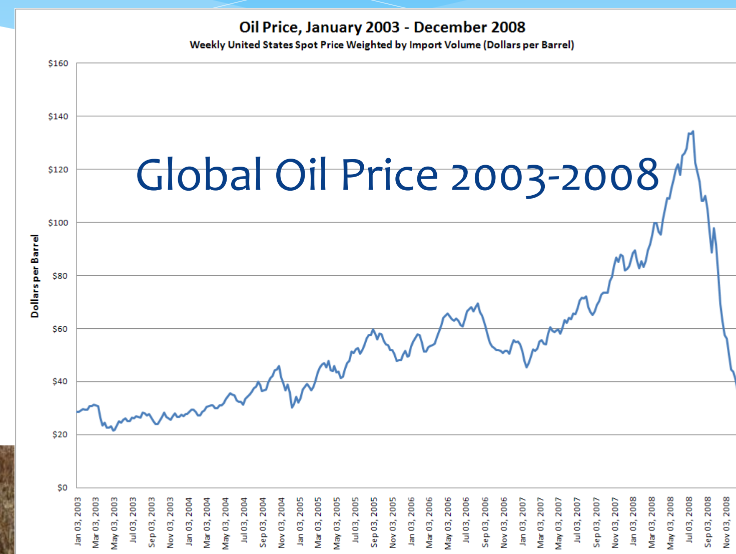
1) Traditional medicines
2) OTC/Prescription

* Save antibiotics after cessation of symptoms

* "Blubber is good for sore throats with white patches and things stuck in the throat because everything sticks to it and comes out."

Environmental Axes & Water-Energy Nexus

- Extreme cold
- Flooding
- Permafrost
- Turbidity
- Climate change



- Energy-intensive, extremely expensive
    - Dependent on state subsidies
- Vehicles to haul water

Social Axes of Insecurity

- Social circumstances that overlap to put individuals at risk for adverse health outcomes (Farmer 1996)
  - Age
  - Gender
  - Physical ability/disability
  - Socio-economic factors: Can you afford the water?
  - Social network: Is there someone who can haul water for you?

(Eichelberger 2010)

Social Axes: Buckland

Social circumstances that overlap to put individuals at risk for adverse health outcomes (Farmer 1996)

Wealth:

* No vehicle → 5-10 gallons/haul
* Vehicle → 18-400 gal/haul
* Flush-hold → 200-400 gal/haul

Gender: single mothers

* range: 5-60 gal
* w/o vehicle: 5-15 gal

Environmental Axes of Water Insecurity

Buckland

Washateria closures

* Spring ice jam flood
* Broken generator for pumping raw water
* Extreme cold
* Unknown reasons

No alternative sources for treated water

Newtok

PHS closures

* Limited pumping season (summer) & inadequate storage capacity for treated water
* No electricity ➔ PHS froze up (Still unrepaired)
* Storms
* Flooding
* Erosion: impending loss of water source

School provides emergency access: 10 gal/household/day

Social & Environmental Axes of Water Insecurity

	WHO Criteria (Ref.)	Buckland (2008-09)	Newtok (2016)
N		N=21	N=11
Average (gal/c/day)	13.2 gal	2.4 gal	2.3 gal
Social Axes			
Single mothers	13.2 gal	2.0 gal	
Flush-hold system	13.2 gal	4.8 gal	
No vehicle	13.2 gal	1.8 gal	
No male kin* at home	13.2 gal	1.0 gal	
Single mother without male kin*	13.2 gal	0.7 gal	
Climate Vulnerabilities		0 gal	1.8 gal

Sewerage

Buckland (2008-09)	Newtok (2016)

* Honey buckets
  * City hauled sewage to lagoon
  * ~1 mile from village
	* Honey buckets
	  * No sewage lagoon
	  * Households self haul
	  * Residents dispose of over 2 riverbanks bordering community
	    * ~20 feet from some homes

Education and Behavior Change Efforts to Maximize the Health Benefits and Sustainability of Water and Sanitation

AJ Salkoski, Sr. Program Manager

John Nichols, P.E. - Manager of Utility Operations, ANTHC

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Alaska Tribal Health System

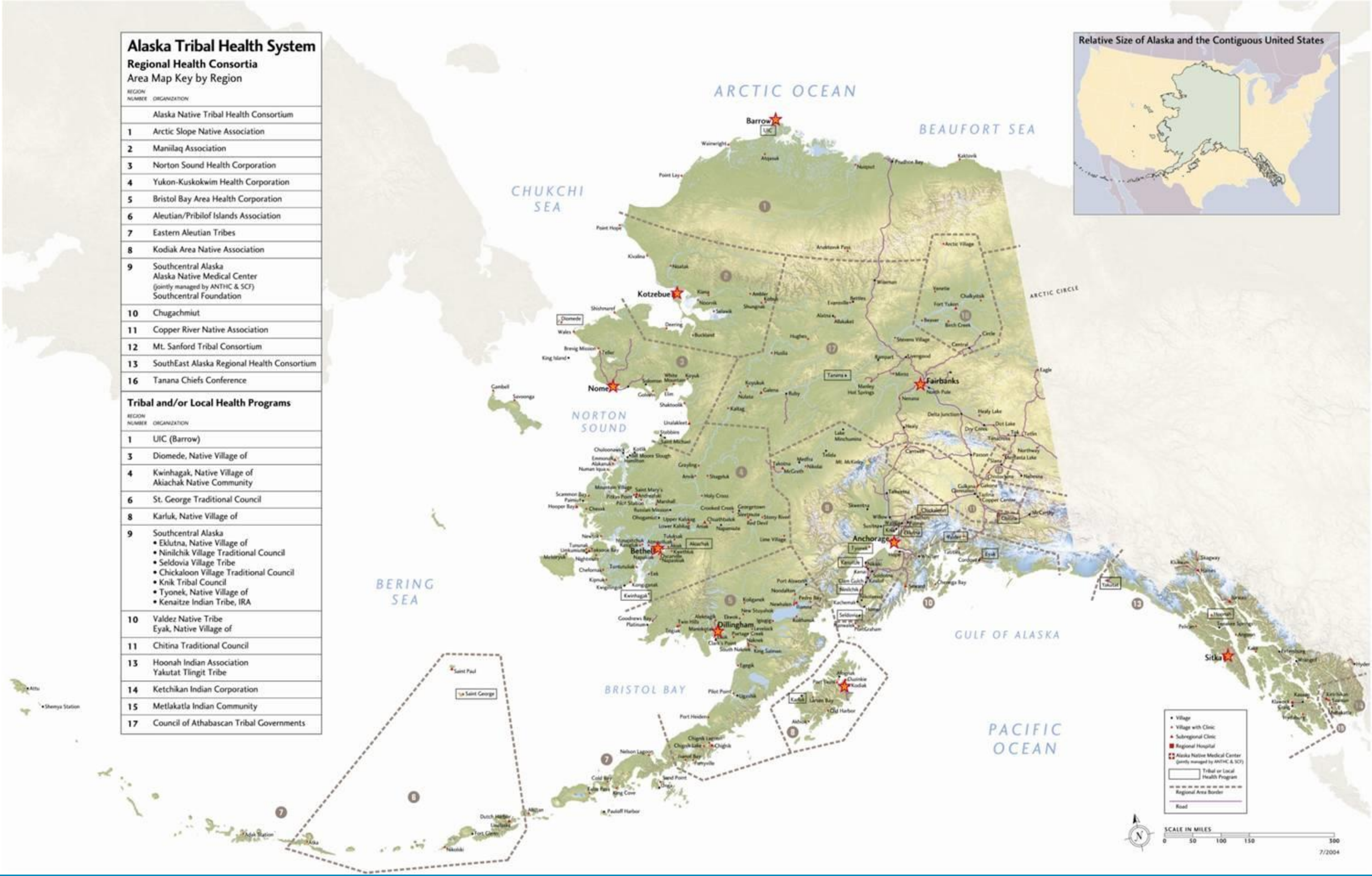
Regional Health Consortia

Area Map Key by Region

REGION NUMBER	ORGANIZATION
	Alaska Native Tribal Health Consortium
1	Arctic Slope Native Association
2	Maniilaq Association
3	Norton Sound Health Corporation
4	Yukon-Kuskokwim Health Corporation
5	Bristol Bay Area Health Corporation
6	Aleutian/Pribilof Islands Association
7	Eastern Aleutian Tribes
8	Kodiak Area Native Association
9	Southcentral Alaska Alaska Native Medical Center (jointly managed by ANTHC & SCF) Southcentral Foundation
10	Chugachmiut
11	Copper River Native Association
12	Mt. Sanford Tribal Consortium
13	SouthEast Alaska Regional Health Consortium
16	Tanana Chiefs Conference

Tribal and/or Local Health Programs

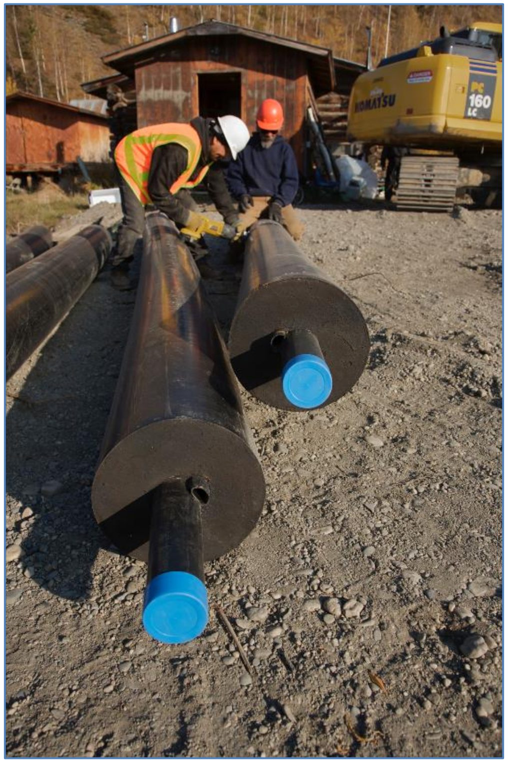
REGION NUMBER	ORGANIZATION
1	UIC (Barrow)
3	Diomede, Native Village of
4	Kwinhagak, Native Village of Akiachak Native Community
6	St. George Traditional Council
8	Karluk, Native Village of
9	Southcentral Alaska • Eklutna, Native Village of • Ninilchik Village Traditional Council • Seldovia Village Tribe • Chickaloon Village Traditional Council • Knik Tribal Council • Tyonek, Native Village of • Kenaitze Indian Tribe, IRA
10	Valdez Native Tribe Eyak, Native Village of
11	Chitina Traditional Council
13	Hoonah Indian Association Yakutat Tlingit Tribe
14	Ketchikan Indian Corporation
15	Metlakatla Indian Community
17	Council of Athabascan Tribal Governments



ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Alaska Native Tribal Health Consortium

Alaska Native
Medical Center



Environmental Health
and Engineering

Community Health
Services

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM


OUR VISION: Alaska Native people are the healthiest people in the world.

Welcome to the Real World!

- From engineering school to Public Works Director, City of Dillingham, Alaska.
- Balance water utility budget without rate increase.
- Collecting from non-paying customers =
  - Balanced budget, no rate increase, and….
  - Social and political uproar
- Must proactively connect with customers and community leaders
  - No engineering guidance on this topic

Project Meq-Egtaq
(“Nice Water” – Yupik)

Provision of infrastructure complemented with education activities to have greatest impact

Promotion Program

- Formative research informed program design.
- Developed to improve uptake of modern water services for human consumption and hygiene practices.
- Individual and community-level interventions.
- Key messages:
  - Chlorine safety and reasons for use.
  - Strategies to minimize chlorine taste.
  - Free and liberal use of treated.

Results

- Significant increases in drinking treated water.
- Average daily per capita water use increased from a level of “very high health concern” to one of “very low health concern” at project’s end.
  - 1 gpcd to 25.3 gpcd

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

Project Meq-Egtaq

National Tribal Water Center

Mission: to serve as a culturally appropriate resource to maximize the health and wellbeing of AIAN people through water and sanitation.

Background: established to fill gaps in the traditional IHS service delivery model; complement and enhance existing services, not replace

NTWC

Example Projects

- "Our Water" Toolkit
  - Resources for education and action planning; aims to connect and support tribes in their efforts to ensure sustainable access to safe water and maximize the benefits of healthy water practices.
  - Draft to be completed September 30^{th}.
- Water Is Life
  - Education and awareness campaign that aims to increase community pride in ownership of water and sanitation systems.
  - Pilot stage – has had positive results (Russian Mission, red to black)
- Project Coyote Water
  - Identification of unregulated water use data and water-issues of greatest concern to tribes.
  - Report sent to Tribes in July; Will provide information to Tribes and agencies to guide future monitoring or funding opportunities.

NTWC

Portable Alternative Sanitation System (PASS)

Pilot Project – Kivalina, AK

User Education

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

Training Methods

- Onsite orientation.
  - Best trainer was onsite plumber!
- Comprehensive user manual.
- Training video.
- Regular check-in calls.

Kivalina-Related Pics

Lessons Learned

- Onsite training is the most valuable.
  - When asked what could be improved for training, one person said, “Nothing really. [You are] doing good about flying out here. You're not somewhere in your office.”
  - Another said that they had no problems or concerns, they felt “indoctrinated” by the time the trainers left.
- Training needs to be mandatory for residents.
- Simple is best.
- Repetition and follow-up are key.
- Connect community members.
- Good training requires good investment.

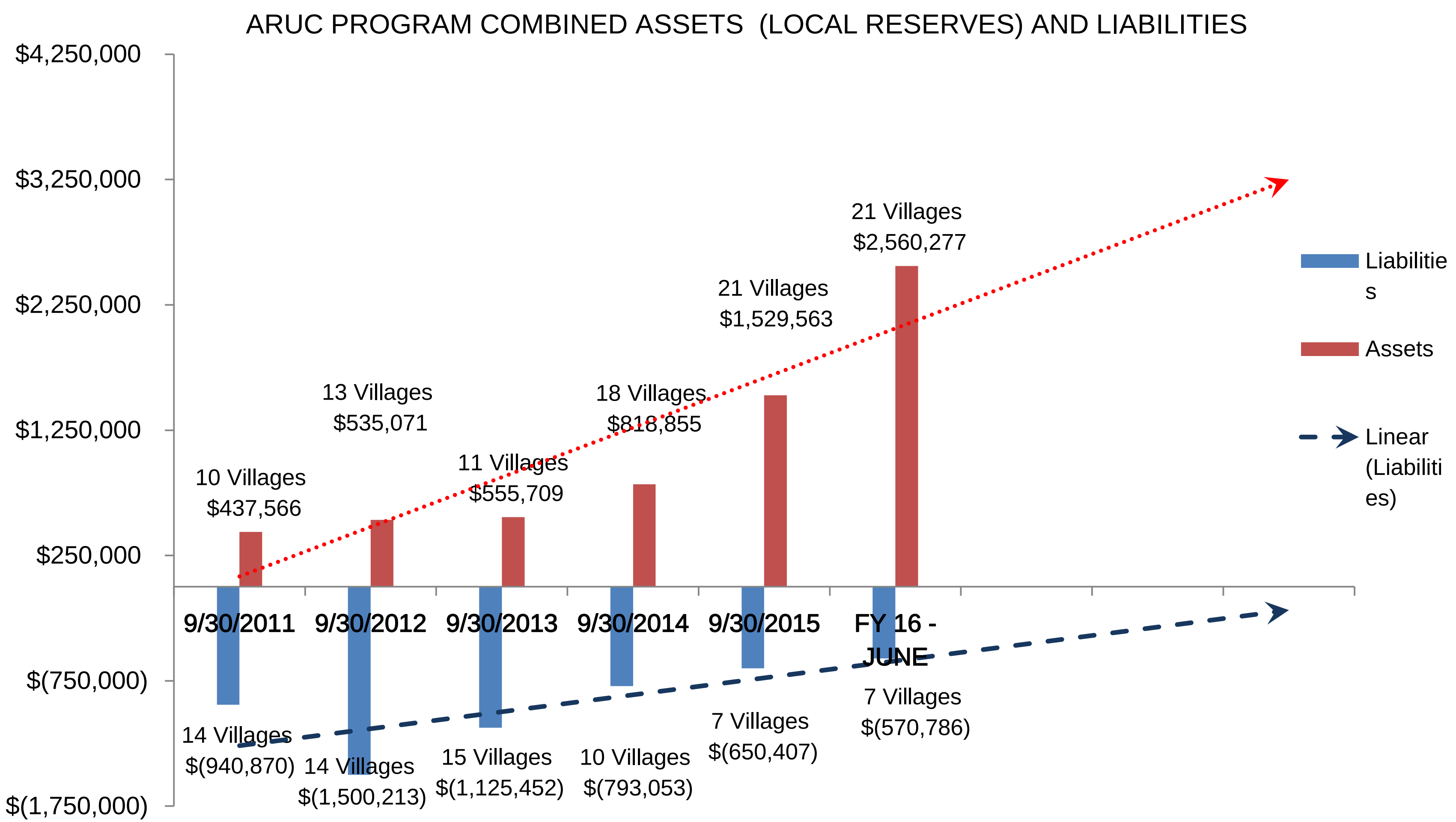
Alaska Rural Utility Collaborative

- Began managing ARUC in 2008.
- Full service management service
- 27 member communities
- Rates rise & fall with expenses independently in each community.
- Dillingham experience valuable

ARUC

Alaska Rural Utility Collaborative

Result of Connecting with Customers: Improved Financial Sustainability



ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Disciplines for Successful Utility Design:

- Civil engineering
- Mechanical engineering
- Electrical engineering
- Structural engineering

Disciplines for Sustainable Utility Design:

- Civil engineering
- Mechanical engineering
- Electrical engineering
- Structural engineering
- **Social engineering**

If it is worth building, it is worth building to last.

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

Thank You!

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

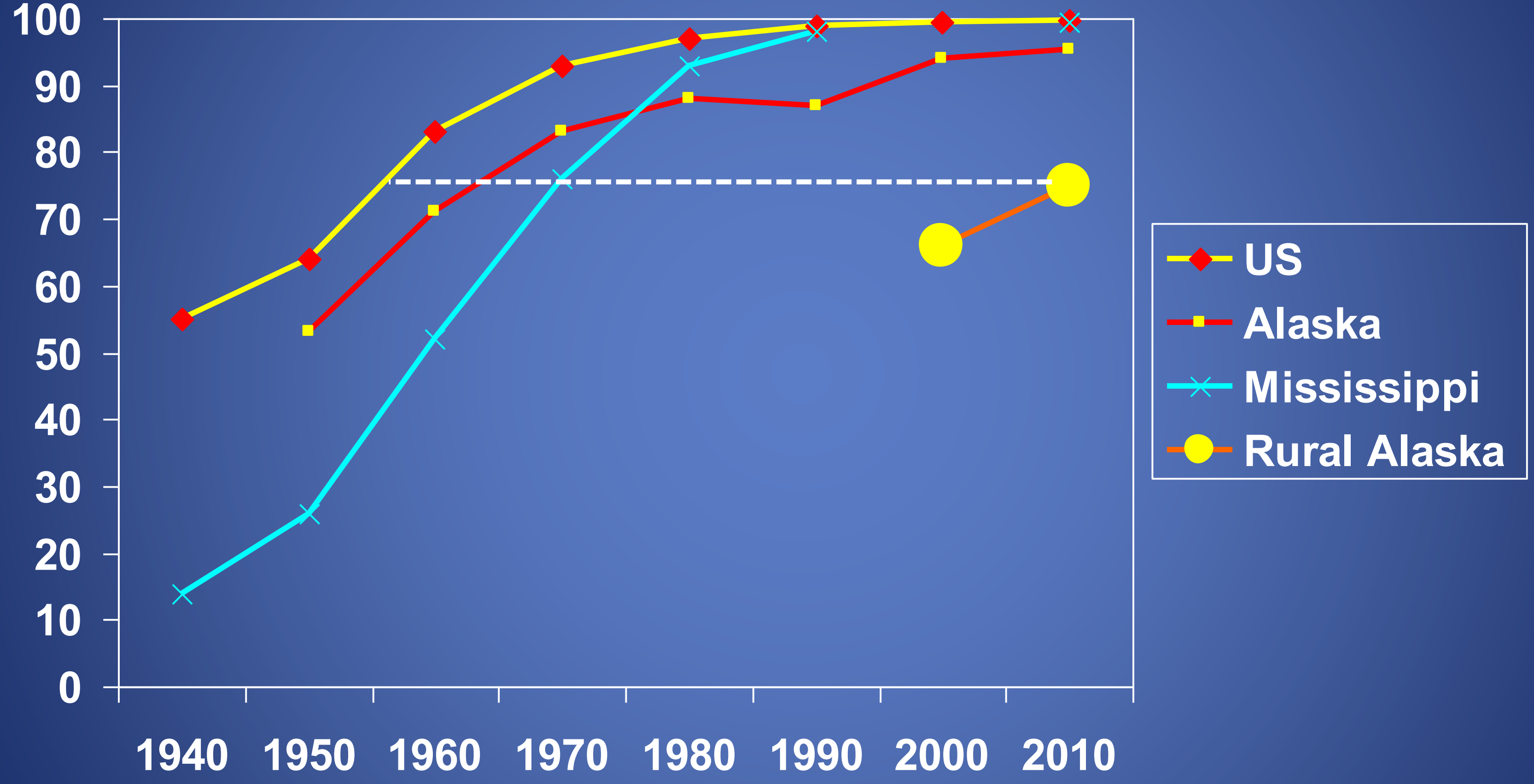
Impact of In-home Piped Water on Rates of Infectious Disease - The Four Village Study

Water Innovations for Healthy Arctic Homes
September 18-21,2016

Timothy Thomas: ANTHC
Troy Ritter: ANTHC
Dana Bruden: CDC/AIP
Mike Bruce: CDC/AIP
Korie Hickel: ANTHC
Tom Hennessy: CDC/AIP

Alaska Native Tribal Health Consortium
Centers for Disease Control and Prevention/Arctic Investigations Program

Proportion of US homes with complete plumbing (i.e. 'served'), 1940 - 2010

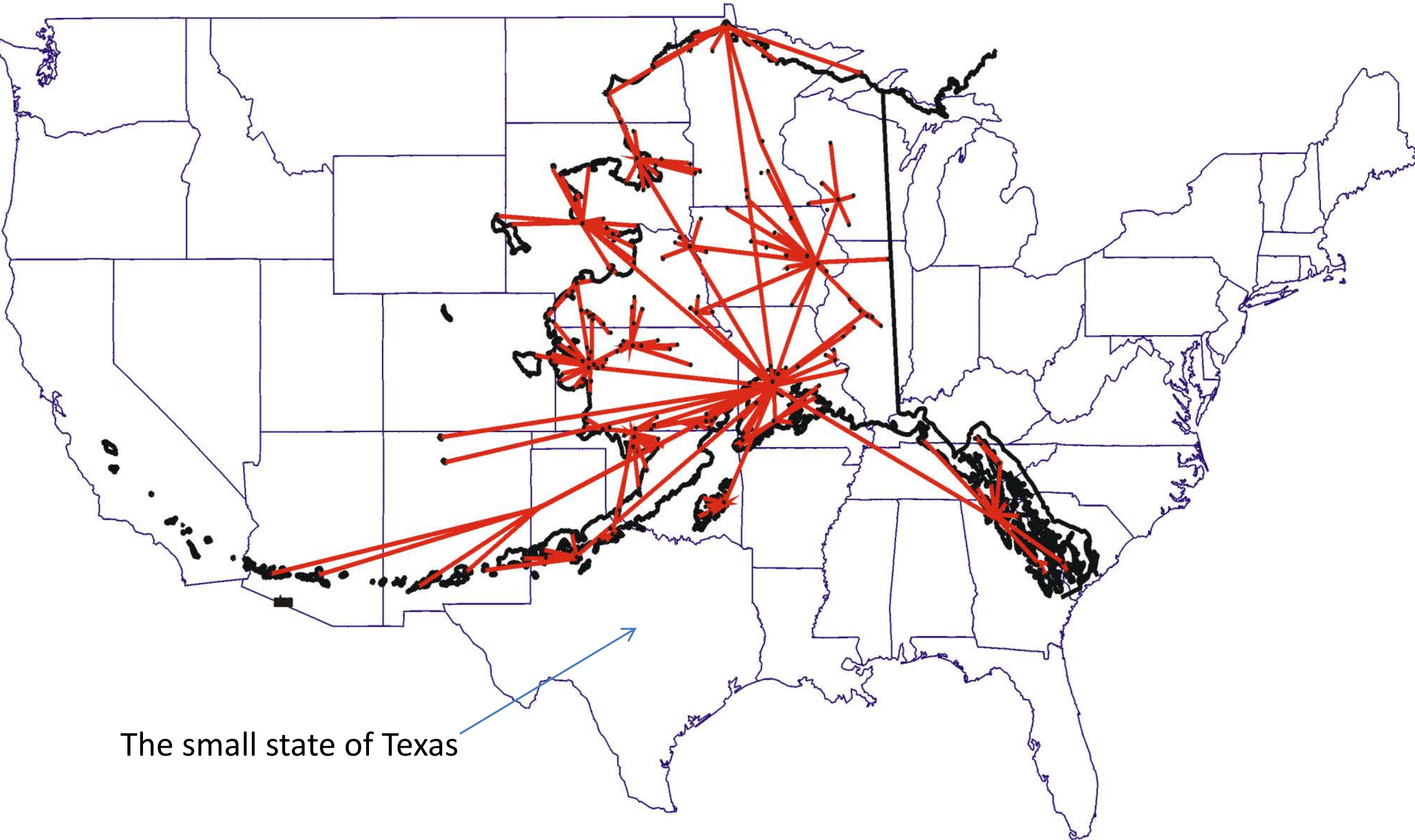


4,500 homes (~20,250 people) in 43 communities do not have adequate sanitation facilities (in-home piped water and sewage)

Over $685M in unmet need

THE ALASKA NATIVE HEALTH CARE SYSTEM REFERRAL PATTERN

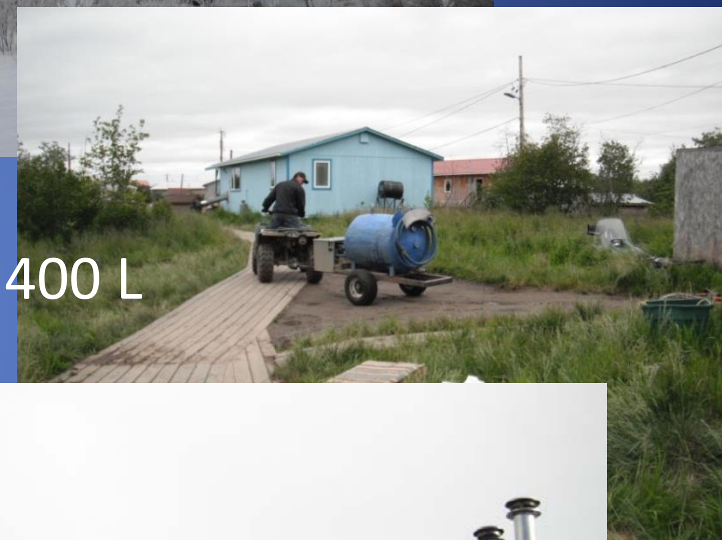
Same Scale Comparison - Alaska Area to Lower 48 States






1 gallon = 3.8 liters

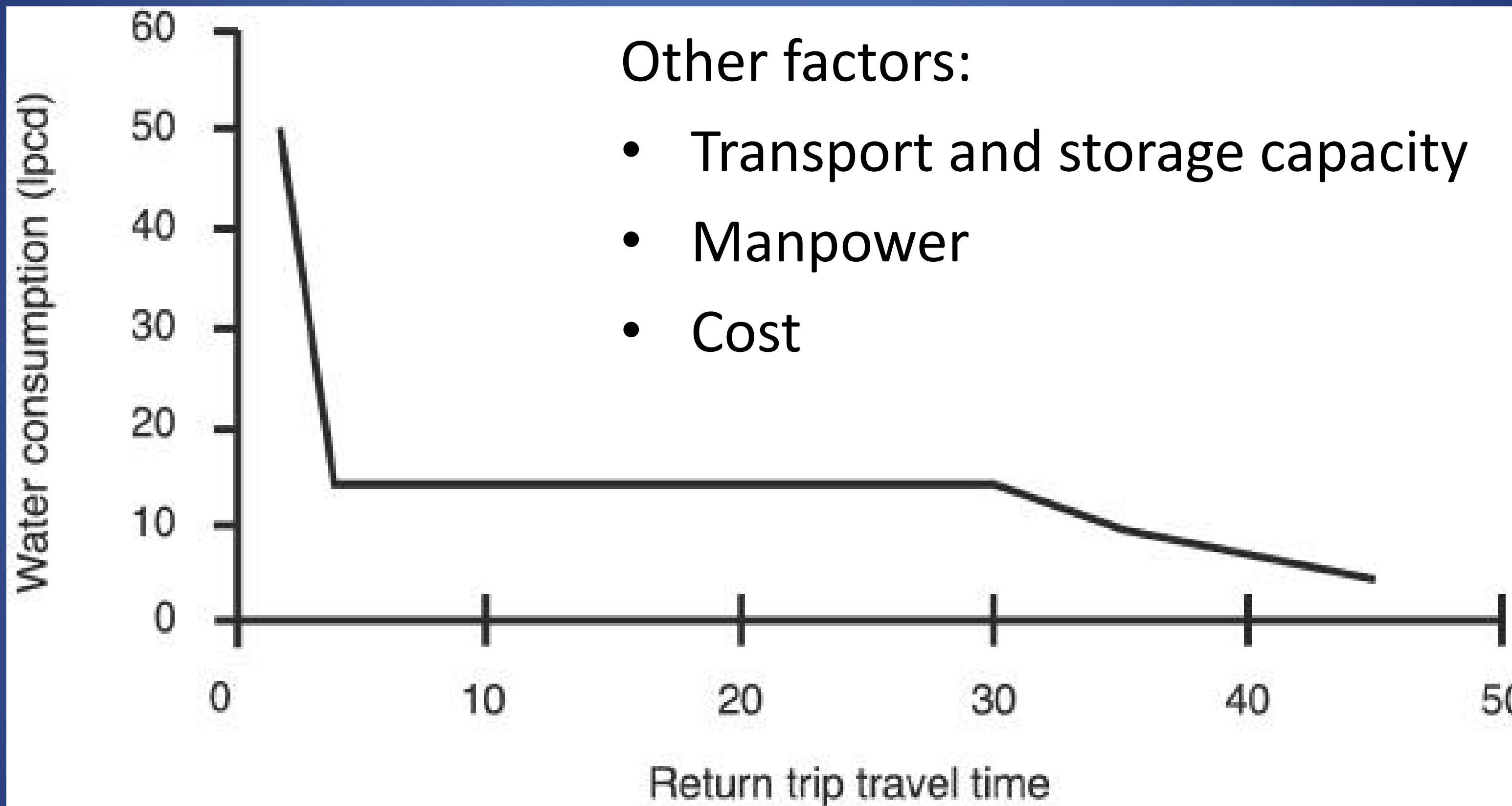
8000 L



400 L

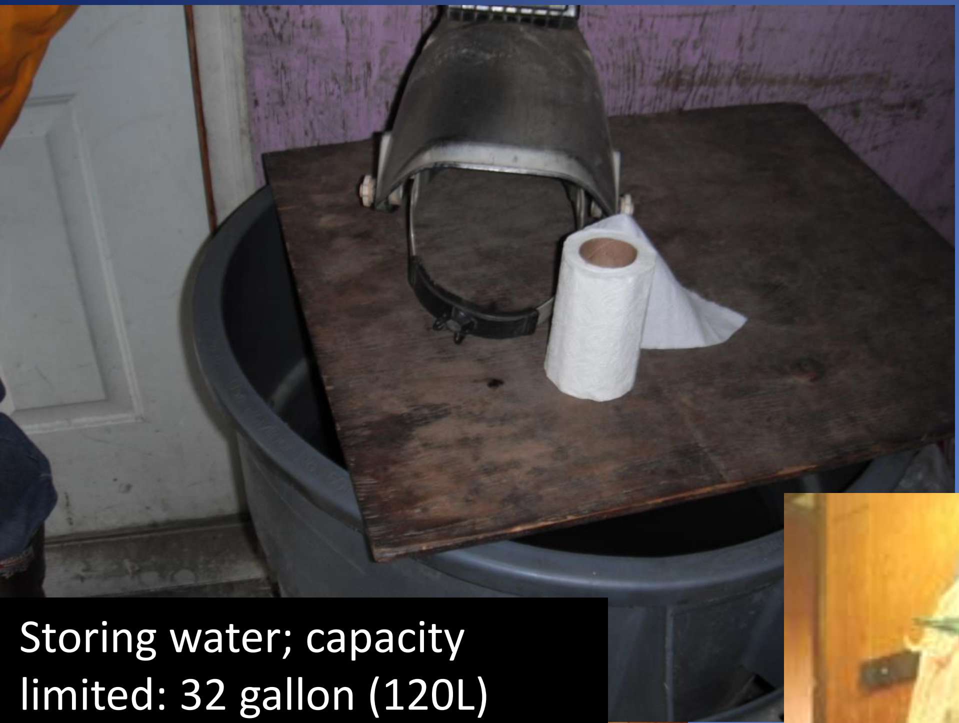
20 L

Water consumed in relation to the time it takes to collect



Cairncross S. 1987: The Benefits of Water Supply

No pipes means:



Storing water; capacity limited: 32 gallon (120L) plastic container

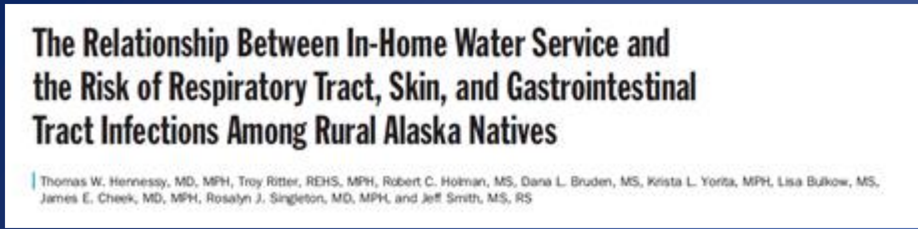
The Honey bucket

Conserving water: Many people washing hands in the same water

Water-related Infections

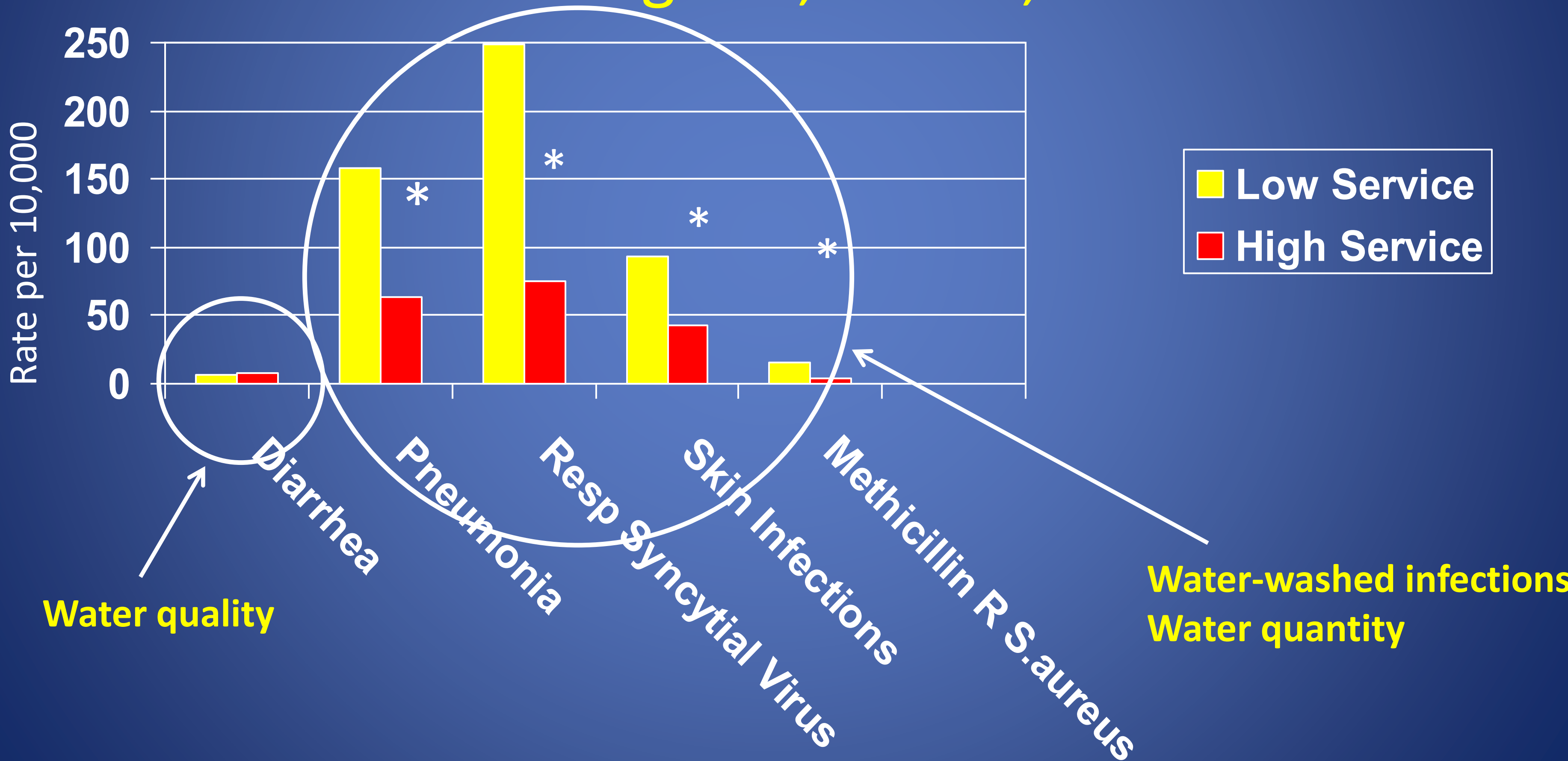
- Water-borne
  - Pathogen ingested with water
    - Cholera, other enteric infections
    - Water-quality issue
- Water-washed
  - Person-to-person transmission
  - Lack of water for hygiene
    - Skin infections, trachoma, enteric infections
    - Water quantity issue

* "Drawers of Water"; White, Bradley, White; U of Chicago Press, 1972


The Relationship Between In-Home Water Service and the Risk of Respiratory Tract, Skin, and Gastrointestinal Tract Infections Among Rural Alaska Natives

Thomas W. Hennessy, MD, MPH, Troy Ritter, REHS, MPH, Robert C. Holman, MS, Dana L. Bruden, MS, Krista L. Yorita, MPH, Lisa Bulkow, MS, James E. Cheek, MD, MPH, Rosalyn J. Singleton, MD, MPH, and Jeff Smith, MS, RS

Hospitalization Rates for “High” and “Low” Water Service Regions, Alaska, 2000-2004



* P < 0.05

Hennessy et al; AJPH Nov 2008

Prospective studies

- Studies needed to evaluate role of water quantity on water-wash infections;
  - Most have focused on diarrheal illness
- *Ryan et al, 2001*: Hand washing campaign among US Navy recruits:
  - 45% reduction in outpatient respiratory illness
- *Luby et al, 2005*: Communities in Karachi, Pakistan randomized to soap and hand washing vs none:
  - 50% reduction in pneumonia, children < 5 years
  - 53% reduction in diarrhea, < 15 years
  - 34% reduction in impetigo, < 15 years

Four village study

- Four villages (A-D) in western Alaska received funding and met requirements for completion of piped water installation 2007/2008
- Opportunity to conduct a prospective cohort study
- Objective:
  - Assess rates of water-wash and water-borne
    - acute gastrointestinal (GI), respiratory and skin infections
    - before and after installation of in-home sanitation services
- Study approved by:
  - CDC, Alaska Area IRB
  - Alaska Native Tribal authorities and participating villages

Participants

- All households in 4 villages invited to participate
- Consented to:
  - Review of medical records from village clinic and regional hospital
  - Recording of who lives in house

Intervention/Timeline

- "Intervention":
  - Installation of pipes to homes
  - Plumbing inside home
  - Education/Promotion of water use
- Study started in 2008
- Last village received piped water in April 2010
- Village A: Only half of the homes were piped

Health Outcomes

- Review of electronic medical record
  - Village clinic and hospital visits
  - ICD-9 codes for acute GI, respiratory and skin infections

Water Use

- Pre-pipe installation
  - Households recorded number and volume of water hauls over one month
- Post-pipe installation
  - Monthly water meter readings
- Obtained number of household occupants
  - Calculated liters (gallons)/capita/day

Analysis

- Calculated annual illness event rates for each community for GI, respiratory and skin infections
  - 3 years before and 3 years after pipes installed
- Excluded visits with same ICD-9 code within 14 days
- Age adjusted rates for post-installation period
- Rates presented overall and by age group
- Generalized estimating equations used to account for repeated observations on same individual over time

4 villages (US 2010 census)

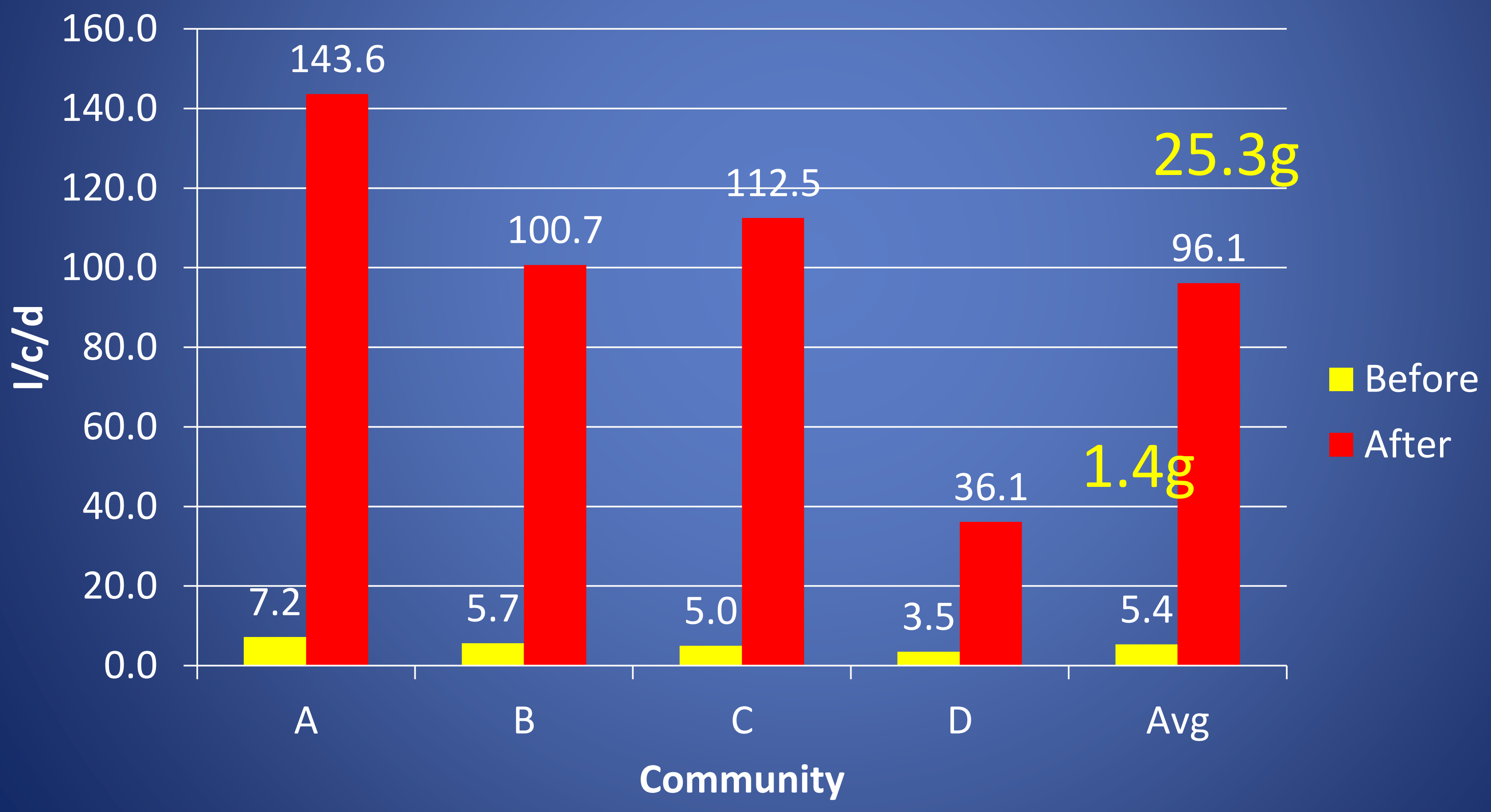
Community	A	B	C	D	USA
Population	627	346	243	187	308M
No. of Households	150	90	76	43	
% Alaska Native/ American Indian	**95**	**93**	**95**	**91**	**1.2**
% < 5 yrs of age	**10**	**10**	**14**	**12**	**6.3**
Avg. Persons Per Household	**5**	**4**	**4**	**5**	**2.6**
Per capita income ($)	**13,224**	**12,501**	**9,122**	**15,308**	**28,051**
% Households below federal poverty threshold	**24**	**28**	**44**	**15**	**14.9**

Study participants

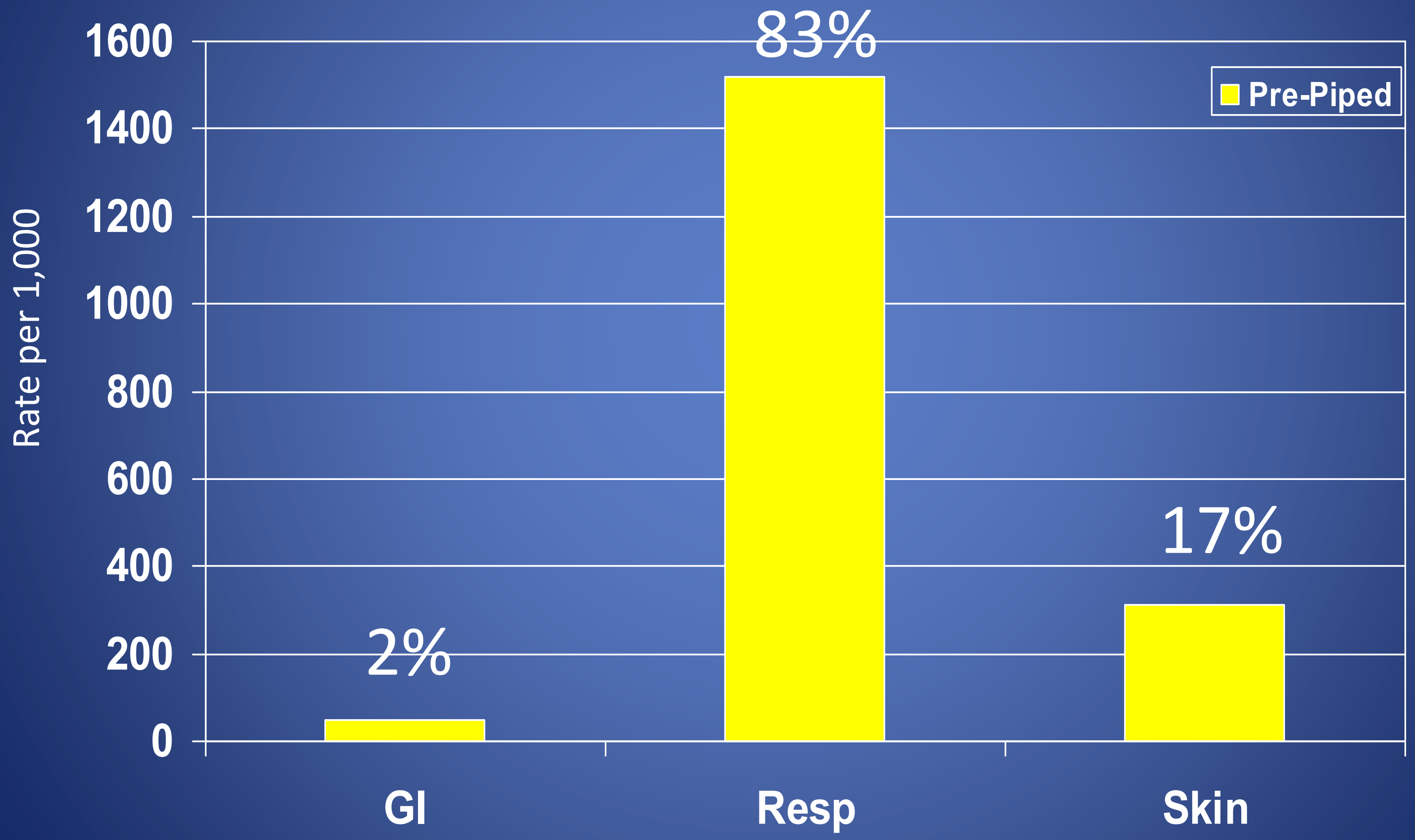
Population	Total
2010 Census	1403
Enrolled (% of total)	1048 (75%)
Outcome data (pre)	1010
Outcome data (post)	975

Mean household water use litres/capita/day (l/c/d) pre- and post-installation

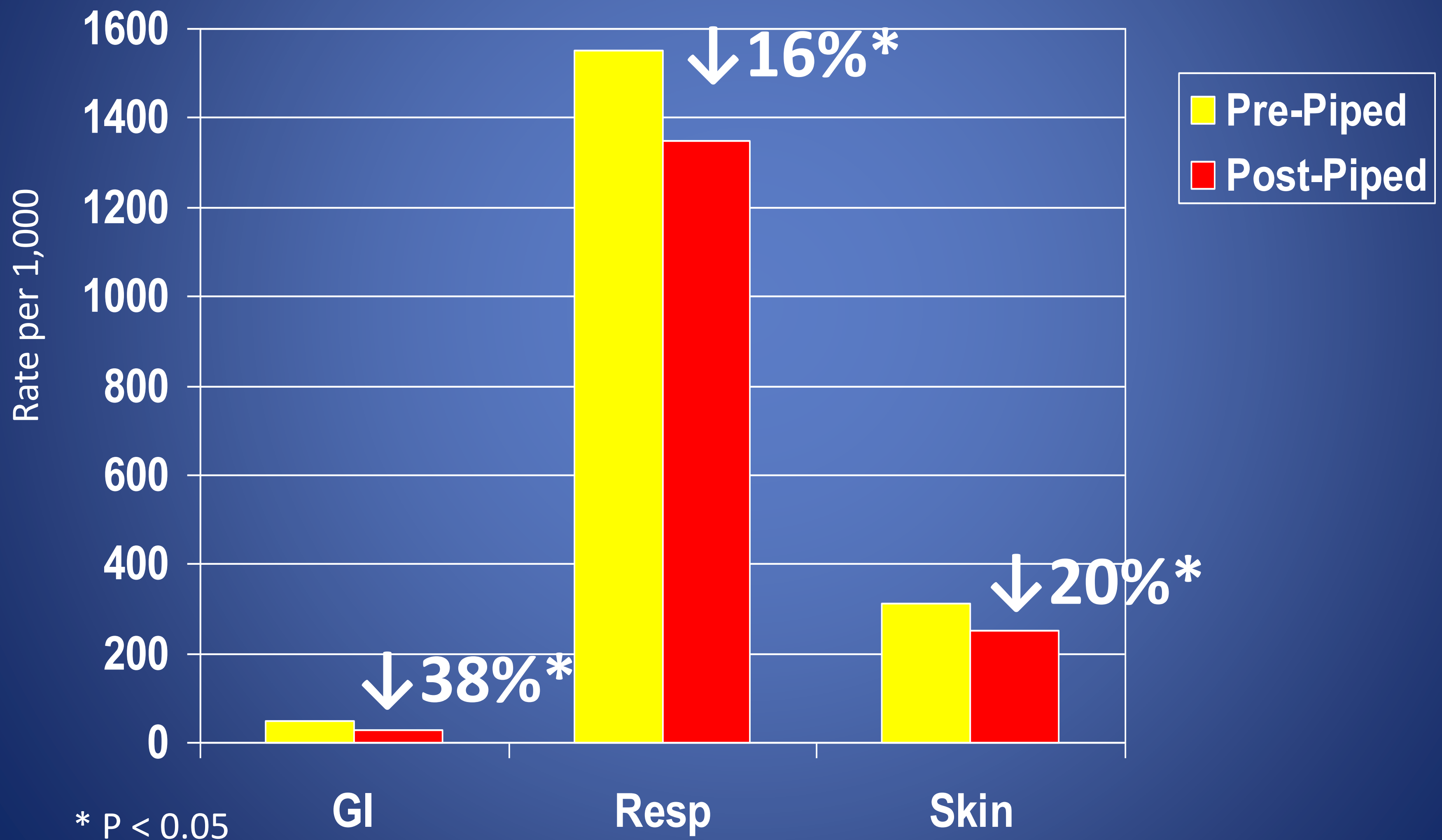
1 gallon = 3.8 litres
10 gallons = 38 litres
20 gallons = 76 litres



Annual Gastrointestinal, Respiratory and Skin infection Rates (per 1000) Pre-Piped Water for All Homes that received Piped Water (n=835)

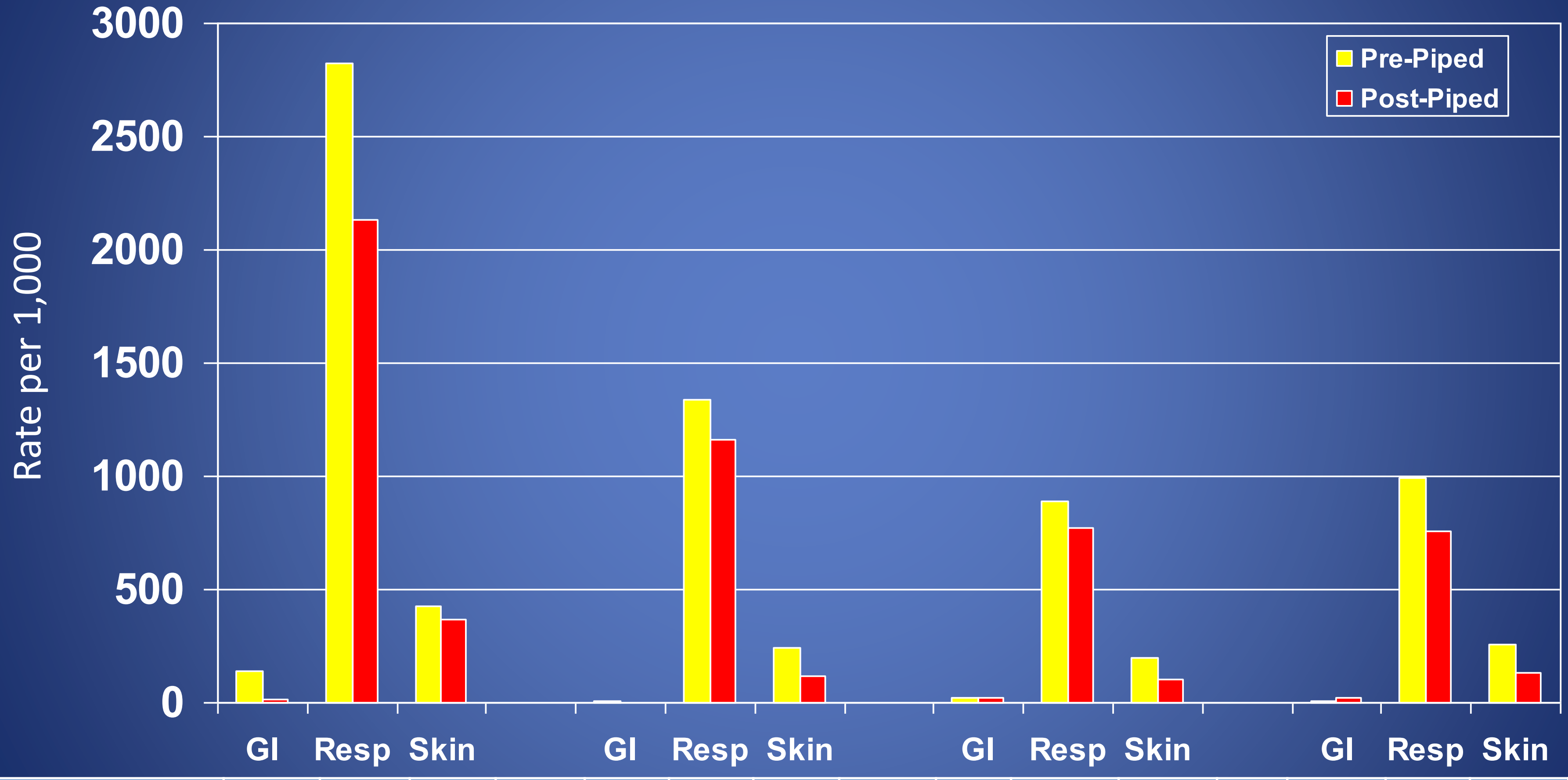


Age adjusted Annual Gastrointestinal, Respiratory and Skin infection Rates (per 1000) Pre- and Post-Piped Water for All Homes Installed with Piped Water



* P < 0.05

Age-adjusted Annual GI, Respiratory and Skin infection Rates (per 1000) Pre- and Post-Piped Water for All Homes Installed with Piped Water by Age Group



Percent Δ	91	24	14		---	13	50		---	13	50		---	---	50
Age group	< 10 yrs				10-19 yrs				20-35 yrs				35-49 yrs		

Summary

- People in self-haul villages in Alaska are using extremely low quantities of water
  - minimum for refugee camp
- Dramatic (and expected) increase in use of water post installation
- Provision of adequate QUANTITY of water results in a decrease in infections:
  - Gastrointestinal: increased hand washing, increased washing of dishes and other surfaces, decreased risk of contamination of hauled water,
  - Respiratory: increased hand washing, cleaning of surfaces.
  - Skin: increased bathing, laundry, hand washing

Impact beyond the four villages

- 4,500 homes in Alaska (est. 20,250 people) without piped water;
  - 5,100 fewer respiratory infections/year
  - 1,300 fewer skin infections/year
  - 400 fewer gastrointestinal infections/year

- Note: We removed visits within 14 days for same infection, so even greater reduction in burden on clinics and hospitals – 9,000 clinic visits/year

- Over 220,000 rural homes in United States lack complete plumbing

Limitations

- Did not observe changes in behavior
  - Post-installation surveys indicated increased bathing and handwashing
- Declines in rates may be due to other factors:
  - Increased immunization
  - Seasonal and yearly variation
  - Other factors
  - Un-piped homes of Village A serve as a control
- Some respiratory infection codes non-specific
  - Analysis with more specific code might demonstrate greater reduction
- Transmission of respiratory infections can also occur through other mechanisms such as droplet spread and thus less likely to be impacted by provision of water

Conclusions

- People in self-haul villages in Alaska are using extremely low quantities of water
- Provision of adequate QUANTITY of water results in a decrease in gastrointestinal, respiratory and skin infections
- Findings reinforce the earlier studies in Alaska
- Funding and innovation required to provide increased quantity of water to rural Alaska villages

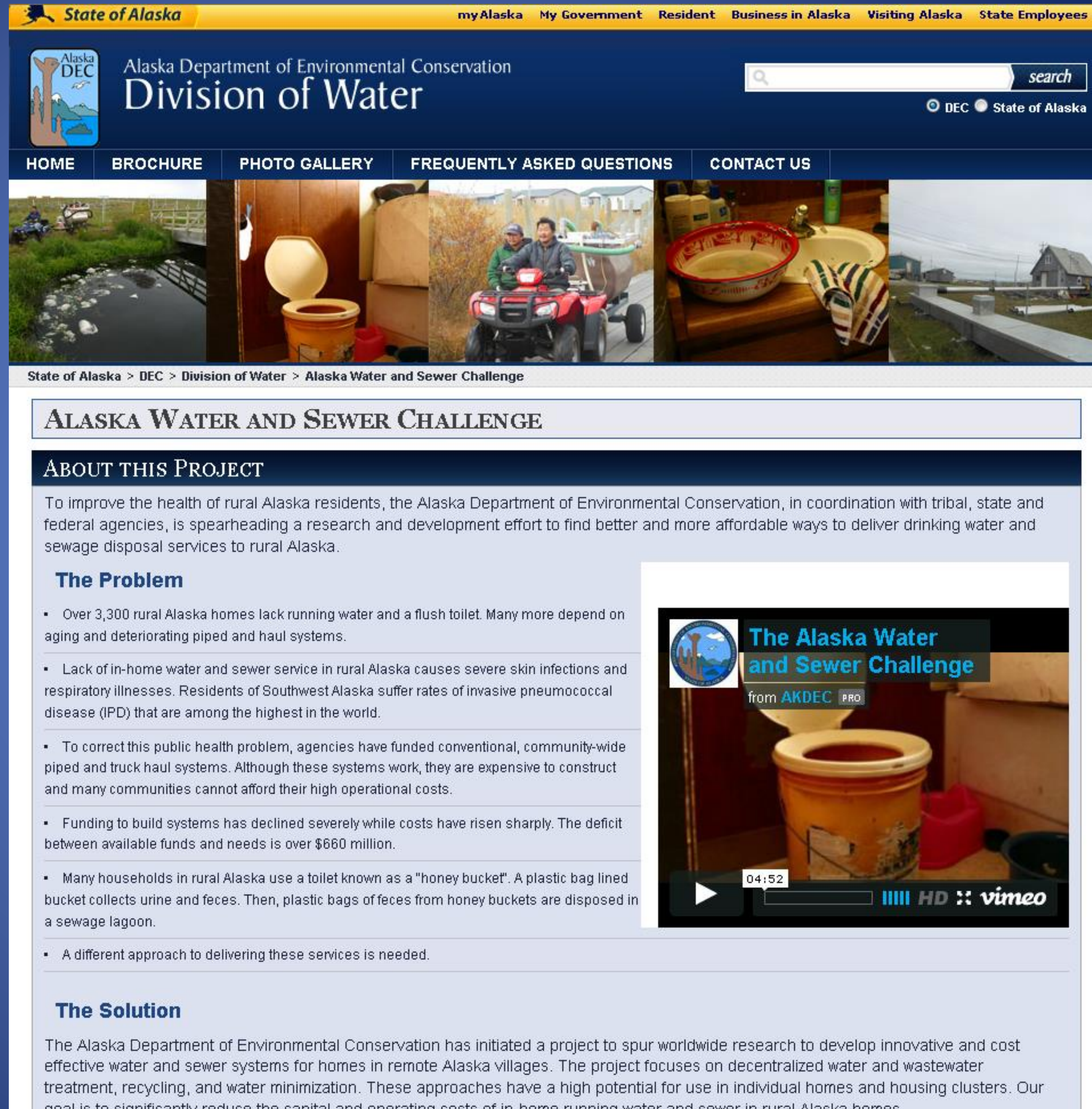
Quyana Apyutengqertuci?

Alaska Department of Environmental Conservation (http://watersewerchallenge.alaska.gov/)

Project to spur worldwide research to develop innovative and cost effective water and sewer systems.

Focus on decentralized water and wastewater treatment, recycling, and water minimization.

Selection of teams to be funded is in progress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Division of Water

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Alaska Water and Sewer Challenge

About this Project

To improve the health of rural Alaska residents, the Alaska Department of Environmental Conservation, in coordination with tribal, state and federal agencies, is spearheading a research and development effort to find better and more affordable ways to deliver drinking water and sewage disposal services to rural Alaska.

The Problem

- Over 3,300 rural Alaska homes lack running water and a flush toilet. Many more depend on aging and deteriorating piped and haul systems.
- Lack of in-home water and sewer service in rural Alaska causes severe skin infections and respiratory illnesses. Residents of Southwest Alaska suffer rates of invasive pneumococcal disease (IPD) that are among the highest in the world.
- To correct this public health problem, agencies have funded conventional, community-wide piped and truck haul systems. Although these systems work, they are expensive to construct and many communities cannot afford their high operational costs.
- Funding to build systems has declined severely while costs have risen sharply. The deficit between available funds and needs is over $660 million.
- Many households in rural Alaska use a toilet known as a "honey bucket". A plastic bag lined bucket collects urine and feces. Then, plastic bags of feces from honey buckets are disposed in a sewage lagoon.
- A different approach to delivering these services is needed.

The Alaska Water and Sewer Challenge
from AKDEC PRO
04:52 HD vimeo

The Solution

The Alaska Department of Environmental Conservation has initiated a project to spur worldwide research to develop innovative and cost effective water and sewer systems for homes in remote Alaska villages. The project focuses on decentralized water and wastewater treatment, recycling, and water minimization. These approaches have a high potential for use in individual homes and housing clusters. Our goal is to significantly reduce the capital and operating costs of in-home running water and sewer in rural Alaska homes.

Illness episodes per person-year (ppy) Villages B-D (all homes received water)

		Villages				
Infection type	Period			**B**	**C**	**D**
N (Pre)				296	152	179
Respiratory	Pre			1.81	0.93	1.49
	Post			1.73	0.82	0.92
	P			**0.03**	**0.03**	**<0.0001**
Skin	Pre			0.27	0.31	0.22
	Post			0.17	0.12	0.16
	P			**0.0001**	**<0.0001**	**0.049**
Gastro-intestinal	Pre			0.06	0.03	0.03
	Post			0.02	0.02	0.04
	P			**0.0003**	0.57	0.30

Post water introduction rates adjusted by age class

Illness episodes ppy
Village A only

		Villages				
Infection type	Period	**A (water)**	**A (no water)**	B	C	D
N (Pre)		219	161			
Respiratory	Pre	1.68	1.88			
	Post	1.46	1.76			
	P	0.06	0.08			
Skin	Pre	0.44	0.44			
	Post	0.51	0.36			
	P	0.18	0.06			
Gastro-intestinal	Pre	0.06	0.06			
	Post	0.04	0.06			
	P	0.2	0.8			

Post water introduction rates adjusted by age class

Study participants, by village (A-D), and overall.

	Villages					
Population	**A**	**B**	**C**	**D**	All Homes With Water	**Total**
2010 Census	627	346	243	187	1087	**1403**
Participants Enrolled (%)	405 (65%)	296 (86%)	152 (63%)	179 (96%)	835 (77%)	**1010 (72%)**
Households Enrolled (%)	102 (68%)	71 (79%)	53 (70%)	39 (91%)	217* (70%)	**265 (74%)**

* 48 homes in Village A never received water

Water Infrastructure and Well-being: What Does the Data Tell Us?

Water Innovations for Healthy Arctic Homes Conference
September 19-21, 2016

Melanie O’Gorman and Stephen Penner
University of Winnipeg, MB, CANADA

Water Rights and An Economic Perspective

- We know there is a legal basis – also likely the case that there is an economic basis for such infrastructure.
- Economic analysis is needed to confront government and public apathy towards the issue.

→ Economic counter-argument may persuade the government to act sooner.

- Economics first comes to mind when we consider the costs of water infrastructure and indoor plumbing.
  - $4.7 billion! (Neegan Burnside Ltd. (2011))
  - Economics can also be used to quantify the benefits of providing them.

What are the economic benefits of improved water infrastructure?

- Improved health, including reduced incidence of water- and sanitation-related illness (such as respiratory tract, skin and gastrointestinal tract infections)
  - **Averted health care costs**
- Fewer absences from work - and increased labour earnings - due to illness.
- Children's attendance at and performance in school
- Environmental benefits of proper sanitation infrastructure, including reduced groundwater contamination, improved soil quality and improved health of aquatic life
- Inherent value of access to safe drinking water

Documenting Health impacts of a lack of water infrastructure

- We investigate the relationship between access to safe water and general health conditions in First Nations communities in Canada using 3 datasets:
- The Aboriginal Peoples Survey (2001, 2006) – off-reserve data (n=621,000)
- The Regional Health Survey (2008) – on reserve data (n=11,000)
- St. Theresa Point First Nation data (2016)

(n=142)

The Model

$$Hi = \alpha + \beta Xi + \delta W + \varepsilon$$

- H_i represents a number of health indicators for individual i
- W = 1 if household consider water safe to drink, 0 otherwise
- X_i includes age, sex, household’s income, province, education, employment, alcohol, smoking

On Reserve Analysis

- On-reserve data – from the Regional Health Survey
- Survey administered by First Nations Information Governance Centre (FNIGC) and Regional Partners
- Information for 2002 and 2008

Summary Statistics for Dependent Variables		
	2002	2008
Proportion in excellent, very good or good health	79.90%	77.20%
Proportion having stomach and intestinal problems	7.70%	9.90%
Proportion reporting that they feel depressed (2002) /distressed (2008)	29.90%	50.80%

Impact of Water Source on Self-rated Health

Odds of good health – relative to having water delivered by truck (2008 data)				
Including explanatory variables:	Age* and Gender*	Age*, Gender* and Defence*	Age*, Gender*, Defence* + Res. School*	Age*, Gender*, Defence* + Res. School*, Good Community Progress*
Piped	1.102	1.088	1.107	1.109
Well	0.830	0.833	0.58	0.862

Impact of Water Source on Gastrointestinal Problems

Odds of being told you have a stomach problem – relative to having water delivered by truck (2008 data)			
Including explanatory variables:	Age*, Gender*	Age*, Gender*, Defence*, Remote	Age*, Gender*, Defence*, Remote*, Res School*
Piped	0.688	0.816	0.807
Well	1.021	0.996	0.983
*** Independent variables are statistically significant at the 1%, 5% or 10% levels.**			

Impact of water infrastructure on health costs

- Piped water associated with a roughly 20% decrease in stomach/intestinal problems relative to trucked water.
- The cost of infectious and parasitic diseases in 2008 was estimated at $2.92 billion (Economic Burden of Illness in Canada (2014)).

→ Includes the costs of hospitalization and physician care, drug costs, mortality and morbidity costs

- Benefit of piped water on reserve could be estimated at $583 million for 2008.

Impact of Sanitation on Self-rated Health

Odds of good health for those with sanitation relative to those without sanitation (2008 data)	
Including explanatory variables:	Age* and Gender*
Sanitation	1.383
* Independent variable is statistically significant at the 1%, 5% or 10% level.	

Impact of Water Source on Mental Health

Odds of distress – relative to having water delivered by truck (2008 data)				
Including explanatory variables:	Age*, Gender*, Res. School*	Age*, Gender*, Res. School* and Defence*	Age*, Gender*, Remote + Res. School*	Age*, Gender*, Defence* + Res. School*, Good Community Progress*
Piped	0.581	0.864	0.866	0.862
Well	0.840	0.840	0.823	0.840
* Independent variables that are statistically significant at the 1%, 5% or 10% levels.				

Impact of Running Water on Mental Health

Odds of distress relative to having no running water (2008 data)				
Including explanatory variables:	Age*, Gender*, Defence	Age*, Gender*, Res. School*	Age*, Gender*, Defence, Small*	Age*, Gender*, Defence, Good Community Progress*
Running water	0.601	0.591	0.581	0.587
* Independent variables that are statistically significant at the 1%, 5% or 10% levels.				

Current Situation in Manitoba

- Home to many long standing drinking water advisories
- As of **July 31, 2016, there were 132 Drinking Water Advisories in effect in 92 First Nations communities across Canada.**

First Nation	Community	System Name	Type of Advisory	Date Set (YYYY/MM/DD)	Date Revoked (YYYY/MM/DD)	Population
Canupawakpa Dakota	Canupawakpa Dakota	Canupawakpa Community Complex/DOCFS/DOPS	BWA	2015/06/03	None	101-500 people
Dakota Tipi	Dakota Tipi	Dakota Tipi Public Water System	BWA	2016/07/22	2016/07/27	101-500 people
Dakota Plains	Dakota Plains	Dakota Plains Public Water System	BWA	2016/07/21	None	101-500 people
God's Lake	God's Lake	God's Lake Austin Nazzie Pump House Public Water System	DNC	2014/04/14	None	0-100 people
Kinonjeoshtegon (Jackhead)	Kinonjeoshtegon (Jackhead)	Kinonjeoshtegon Public Water System	BWA	2016/07/07	None	0-100 people
Lake Manitoba	Lake Manitoba	Lake Manitoba Public Water System	BWA	2016/04/06	None	101-500 people
Long Plain	Long Plain	Long Plain Public Water System	BWA	2016/07/22	2016/07/27	1001-5000 people
Long Plain	Long Plain	Long Plain Public Water System (Cistern)	BWA	2016/07/22	None	101-500 people
Pauingassi	Pauingassi	Pauingassi Public Water System	BWA	2014/09/24	None	501-1000 people
Pinaymootang	Fairford	Pinay Gas Bar Semi-Public Water System (Non-Transient)	DNC	2012/08/24	None	unknown
Pinaymootang	Fairford	Pinaymootang Arena Semi-Public Water System (Non-Transient)	BWA	2015/08/17	None	unknown
Sandy Bay	Sandy Bay	Sandy Bay Public Water System	BWA	2016/07/21	2016/07/22	5001-10000 people
Shamattawa	Shamattawa	Shamattawa Public Water System	BWA	2015/11/06	2016/07/11	1001-5000 people
Wuskwi Sipihk	Indian Birch	Wuskwi Sipihk Public Water System	BWA	2014/04/24	None	0-100 people

St. Theresa Point First Nation

- St. Theresa Point is 610 kilometers Northeast of Winnipeg. The community is accessible by plane and boat in the summer and by winter road in the winter.
- Registered Population: 4187 as of March 2016
- Treaty: Adhesion to Treaty No. 5
- Band No. 298
- Area: Approx. 7,129 Acres
- Chief: Marie A. Wood

(Source: http://www.stpfirstnation.com)

Our Study

- To document daily implications of a lack of funding for water infrastructure. We ask:
  - What are the day-to-day impacts of inadequate infrastructure and indoor plumbing?
  - Are there health implications?
  - Is a lack of proper water infrastructure affecting schooling?
  - Are there still homes that need to be retrofitted?
  - How much are people spending on bottled water/filtration systems?
  - Are there any concerns with cisterns?
- This information may assist with acquiring increased Federal funding for infrastructure.

Access to Water

- 88% have a working flush toilet
- 4.8% use an outhouse
- 10.5% use a slop pail
- 87% have a working shower
- 74.2% have a septic tank

Water Source	
Pipe (home connected to main water line)	52.1%
Water tank (water delivered by truck)	35.2%
No running water	12.7%

What would you do with the extra time if you weren’t hauling water?

- “I would focus on my family, spending time with them”
- “I would clean my home and yard during the summer”
- “I would relax”
- “I would exercise”
- “I would look for a job”
- “I would play video games”
- “I would watch TV or visit friends”
- Most prominent response – “I would work”
- It was noted that while hauling water is hard work, it is an important cultural activity

Water and Health

- 30% of individuals say they've missed work or school because they or a family member was sick from a waterborne illness
- 18% say they've missed school or work for another water-related reason
- 33.3% feel chlorine is bad for their health

Self-rated health status	
Excellent	13.5%
Very Good	12.7%
Good	43.7%
Fair	27.0%
Poor	11.9%

Water and Health continued

- Methicillin-resistant Staphylococcus aureus (MRSA)
- Impetigo
- Lice
- Boils

How often is your water monitored?	
Every few months	24.8%
Twice a year	5.7%
Once a year	7.6%
Less than once a year	61.9%

Impact on Schooling

"The water situation does make a difference when you're talking about the quality of life of the students"

- Water pressure – at the school – very unpredictable.
  - It'll shut off sometimes for an hour or so
  - School is at the end of the line
- Skating rink – can't flood it – so it's not functioning
- Some students go to the washroom every hour – they have diarrhea
  - But they're still managing to come to class
- If water isn't working, school is shut down – this happens a lot

Impact on Schooling (continued)

- Some students don't come to school because they haven't been able to shower or do laundry
- Eye wash stations don't work – science classes can't do experiments
- If there is a fire – and everyone is using water so water pressure is low – it would be a disaster
- "Water has always been an issue"

What, in your view, is most important for improving the water/sanitation situation in your community?

- Most prominent answer - for all to be directly connected to main water line – 38% of respondents indicated this
- 29% of individuals indicated a general desire for clean water
- 10% of individuals demanded more water trucks
- Other responses:

•"I would like water to run in pipelines in each home for convenience like washing clothes or daily shower"

•"Water filtration systems"

•"Need more trained workers to work at the plant"

•"Community education on proper water use"

What, in your view, is most important for improving the water/sanitation situation in your community?

- “Improved water pressure”
- “Water that I could trust so I don’t need to boil it”
- “More retrofitting of homes”
- “Hooked to main water line instead of worrying about saving every last drop of water”
- “More frequent testing of water”
- **“If everyone got water from the main line – how would things change?”**

The View from Northern Quebec: Different Treaties/ Different Reality

- Reality on the ground is that water infrastructure in Eeyou Istchee is overseen by the Capital Works Department of Cree Nation Government (CNG).
- Three major Agreements: James Bay Northern Quebec Agreement (JBNQA), Les Paix des Braves, and New Relationship Agreement (NRA).
- Water infrastructure is funded through NRA.
- The NRA has a life-span of 50 years and is funded by the Governments of Canada and Quebec.

Eeyous Istchee Water Infrastructure- Modern and Service oriented

Left to right Water Treatment Facilities in Nemaska, Wemindji & Whapmagoostui

$ spent = H_20 Security

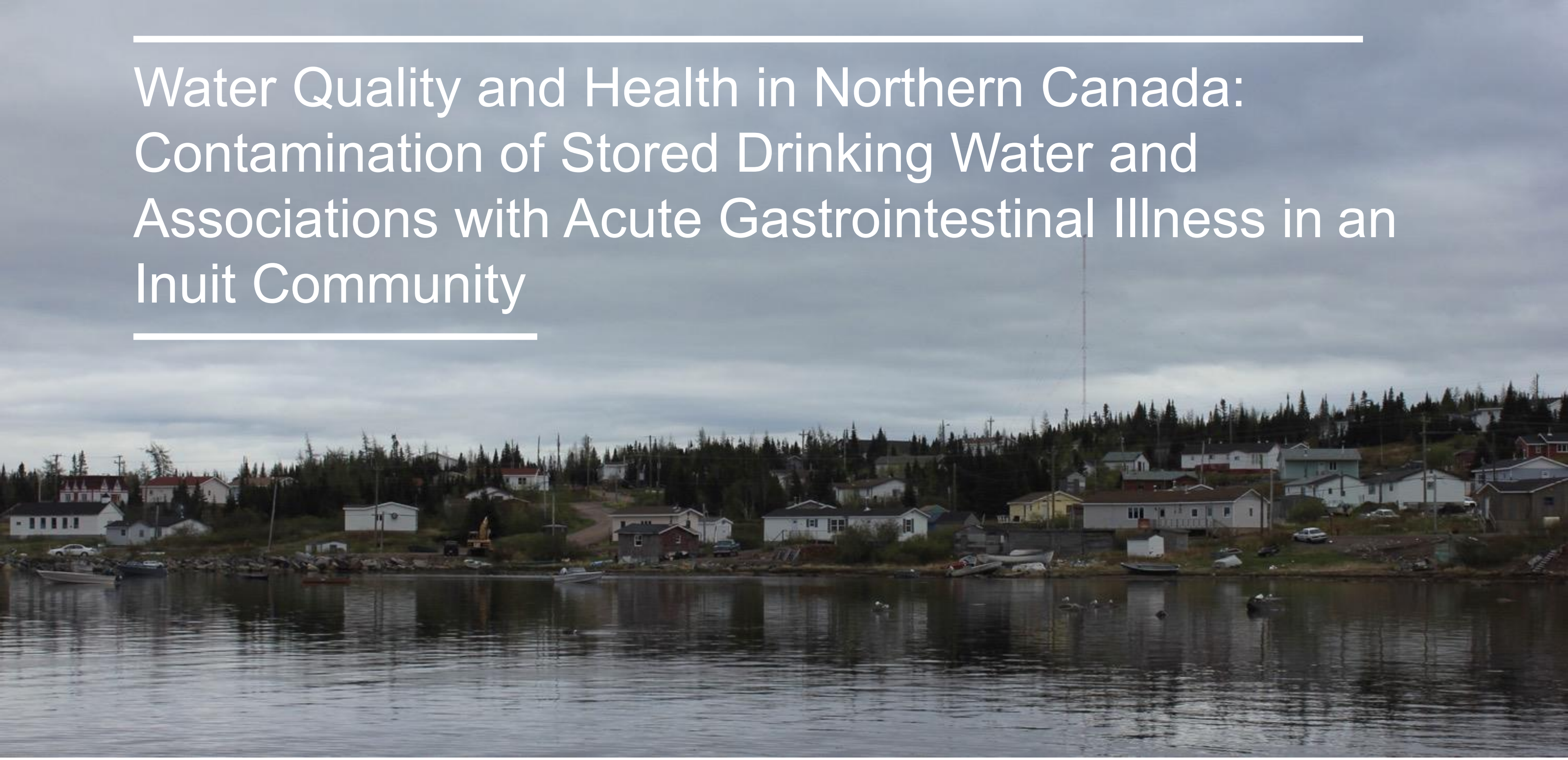
- CNG has spent **$165,763,703** since 2008 setting up and maintaining healthy water infrastructure.

Conclusions

- Absence of water infrastructure/indoor plumbing shows a statistically significant association with measures of health
  - Gastrointestinal problems, self-rated health, mental health
  - Largest impact appears to be on mental health
- St. Theresa Point case study demonstrates that effects of inadequate water facilities impact more than health
- Success in Northern Quebec indicate there are lessons to be learned!

Thank you

- Ian Clara of the Research Data Centre for assistance with the APS study
- Leona Star and Leanne Gillis of Nanaandawewigamig for assistance with the Manitoba RHS study
- Maria Santos of the FNIGC for assistance with the national RHS study
- Helen Fallding of the CHRR for assistance with all aspects of this project
- Shianne McKay and Morgan Vespa of the Centre for Indigenous Environmental Resources and Jack Wood of St. Theresa Point First Nation for assistance with planning the St. Theresa Point study
- Focus group and survey participants for their time and insight
- Pamela Mason for help with catering and transportation
- St. Theresa Point Chief and Council for spearheading the survey



Water Quality and Health in Northern Canada: Contamination of Stored Drinking Water and Associations with Acute Gastrointestinal Illness in an Inuit Community

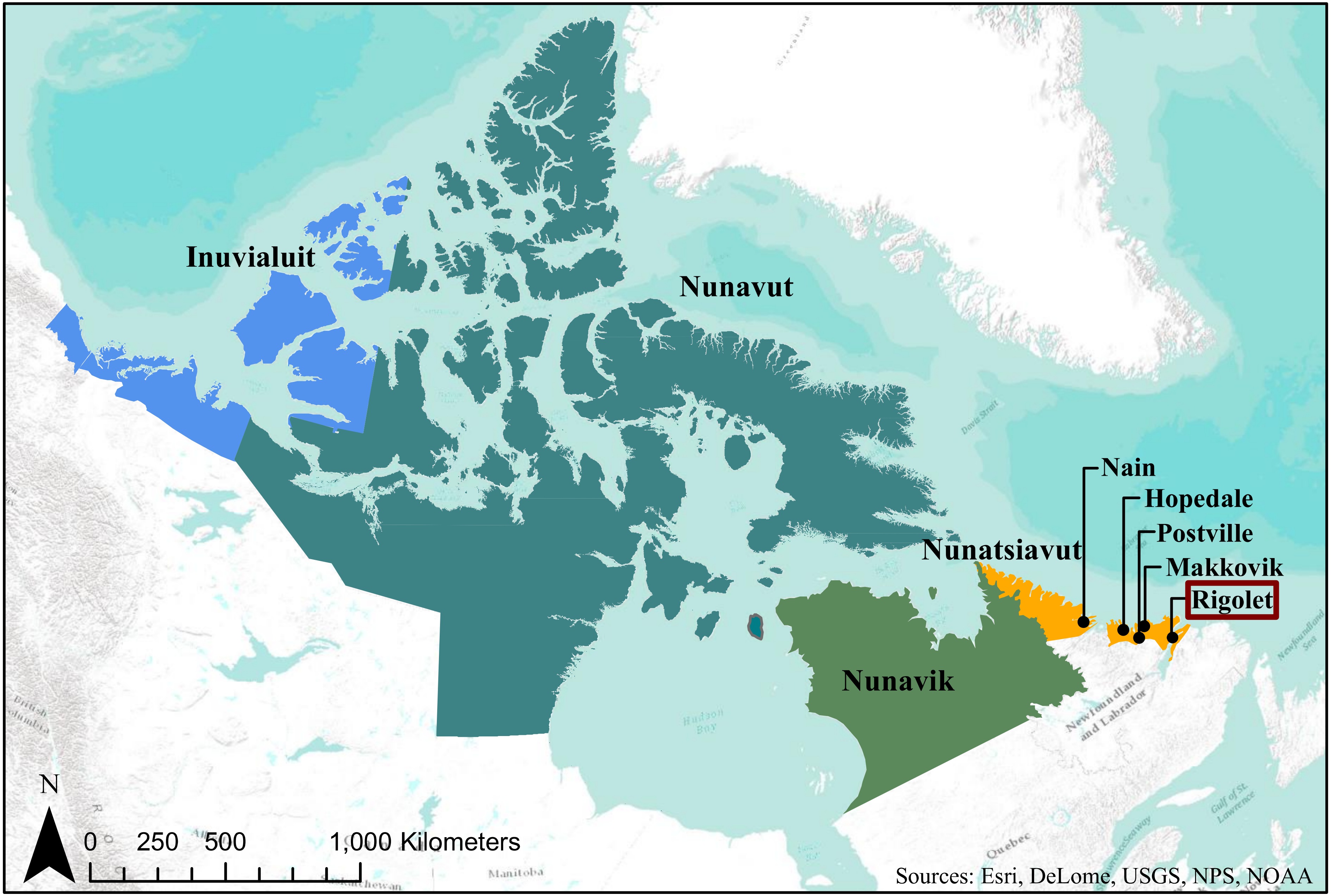
Carlee Wright

J. Sargeant, V. Edge, J. Ford, I. Shiwak, K. Farahbakhsh, RICG, IHACC Research Team, and S.L. Harper

WIHAH| September 2016

Background: Waterborne Disease in Northern Canada

- Inuit communities in the Canadian Arctic have one of the highest self-reported incidence rates of Acute gastrointestinal illness (AGI) in the world
- Concerns over drinking water supply
  - Safety of municipal tap water
  - Water is a potential source of AGI



Inuvialuit
Nunavut
Nunatsiavut
Nain
Hopedale
Postville
Makkovik
Rigolet
Nunavik
N
0 250 500 1,000 Kilometers
Sources: Esri, DeLome, USGS, NPS, NOAA

Background: Drinking Water in Rigolet

Tap water

Purchased water

Brook water

ADWS water Jan 2014

Background: Drinking Water in Rigolet

- ADWS: Residents collect own water
- Community member identified research question
  - Can storing water have negative health impacts?

Goal & Objectives

Goal

Understand household stored drinking water and its potential associations with self-reported AGI in Rigolet, Nunatsiavut

Objectives:

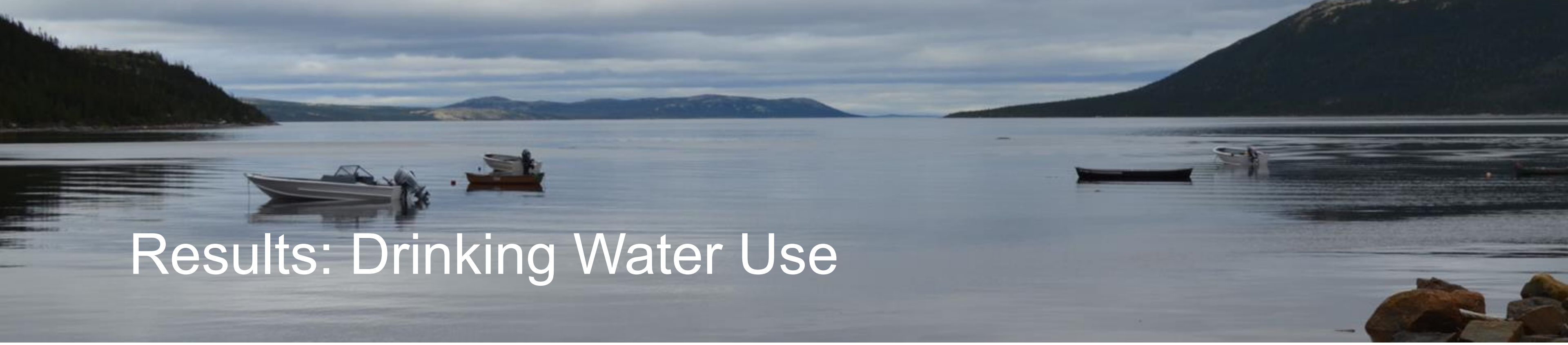
1. Describe drinking water sources and water-related practices, and how they differ across demographic groups
2. Determine the prevalence of *E. coli* and total coliforms in stored water containers, and identify risk factors for secondary water contamination; and
3. Examine potential associations between AGI and environmental and behavioural risk factors, *E. coli,* and total coliform levels in containers.

Materials & Methods

June 2014: Retrospective, cross-sectional census survey

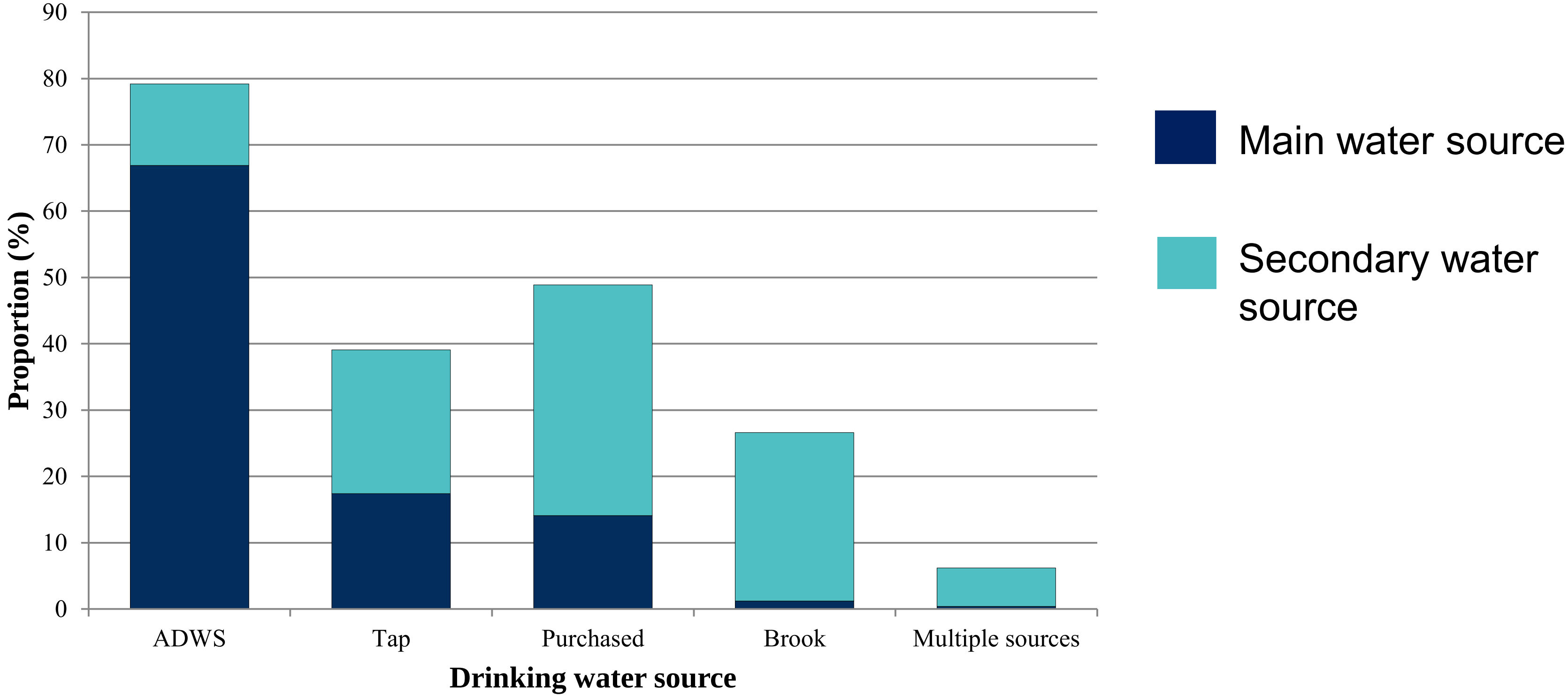
Questionnaire	Water Sampling
• Risk factors for secondary water contamination • Water-related risk factors for AGI • Self-reported AGI	• Sampled all identified water storage containers • Analyzed for total coliforms & *E. coli* • Data on container characteristics

Response rate: 92.8% (n=246)



Results: Drinking Water Use

- ADWS primary or secondary water source for 74.8% of people (95% CI 68.9%-79.9%)



Results: Total Coliforms in Stored Water

- Over 90% of households had stored water
- Samples from 104 containers
  - Total coliforms: 25.2% (95% CI 17.7%-34.7%)
  - *E.* coli: One sample positive
- 67.0% (95% CI 57.0%-75.6%) cleaned once/month or less

Results: Total Coliforms in Stored Water

- **Dippers**: Odds of total coliform presence in containers with dippers 13. ... ainers where no dipper was ... 06)

- **Transfer d** ... sence 3.4 times greater whe ... water, compared to if water ... r (p=0.028, 95% CI 1.15 – 1 ...

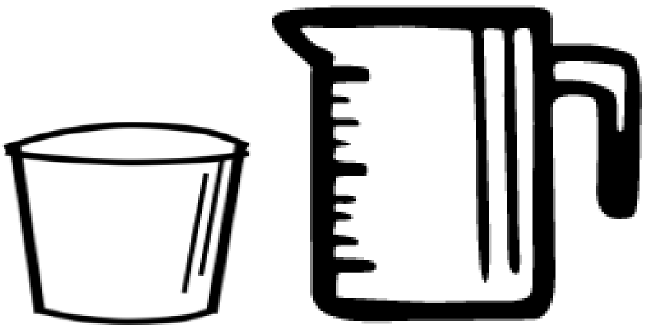
Results: Acute Gastrointestinal Illness

- Annual incidence rate 2.43 cases/person-year
  - 42 cases
  - 4 week period prevalence 17.2% (95% CI 12.9-22.5%)

- No significant water-related risk factors in June 2014

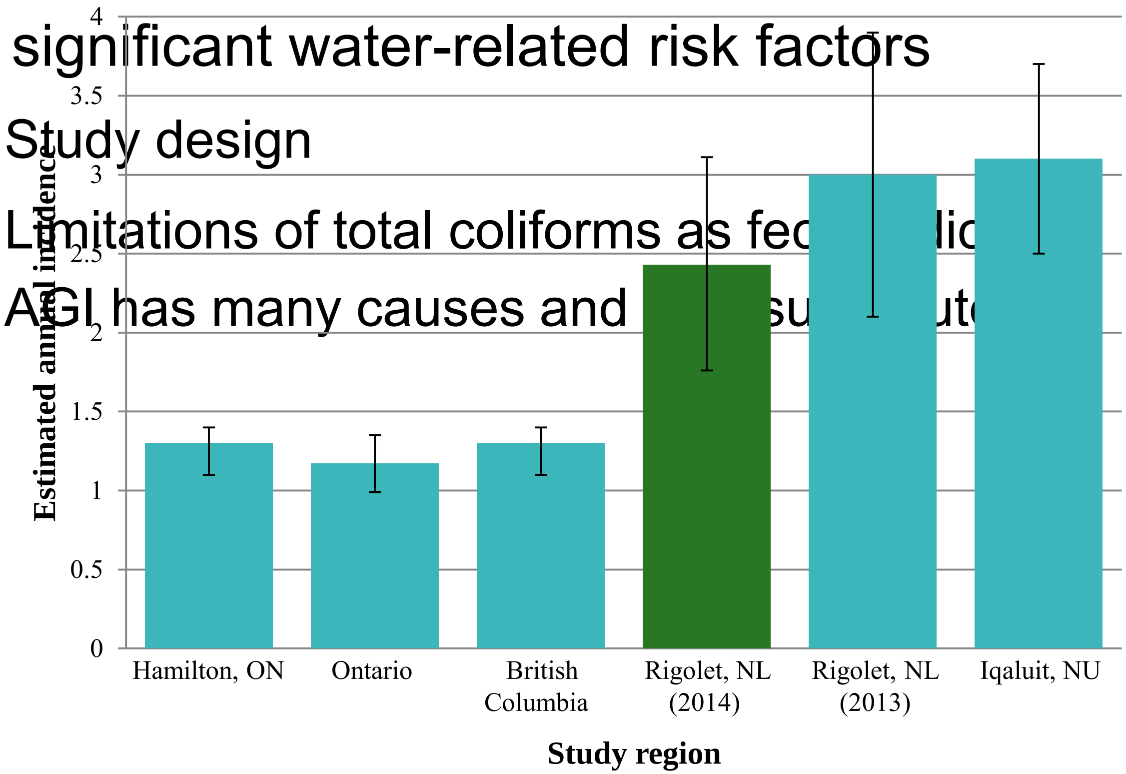
Discussion

- ADWS recently installed & widely used in community
  - Necessitates storage of drinking water
  - Infrequent cleaning → microbial regrowth
- Total coliforms detected in large proportion of samples
  - Recontamination after collection → transfer devices
  - Lack of chlorine in ADWS water



Discussion

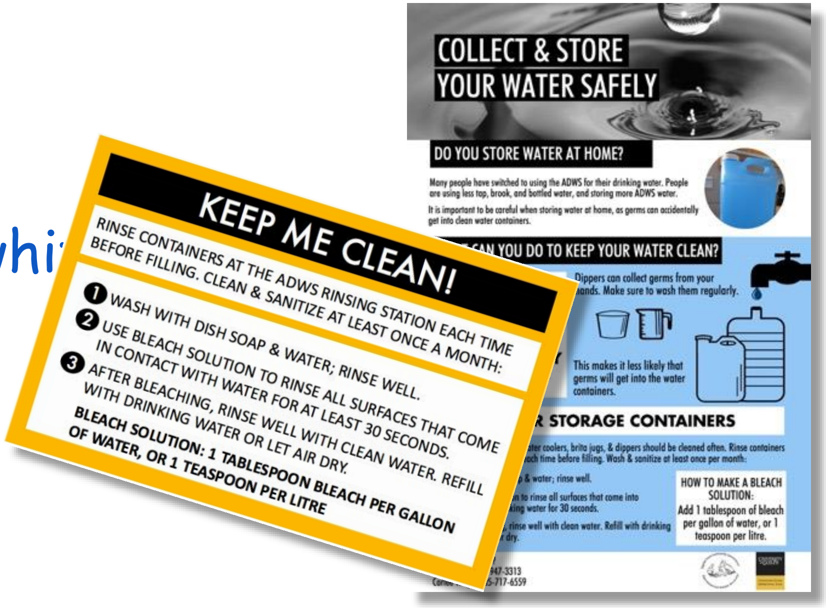
- Incidence rate of AGI similar to past research → significantly higher than in other studies in southern Canada & globally
  - No significant water-related risk factors
    - Study design
    - Limitations of total coliforms as fec … dic
    - AGI has many causes and … su … ut



Conclusions & Next Steps

- Various factors could contribute to high rates of AGI
- Minimize possible exposure to waterborne pathogens through simple interventions

rigoletwhi



Acknowledgements

- Rigolet Inuit Community Government
- Charlie Flowers, & Allan Gordon
- Rob Jamieson & Lisbeth Truelstrup-Hansen
- IK-Adapt
- Indigenous Health Adaptation to Climate Change (IHACC) Research Team

Rigolet Inuit Community Government
Rigolettimiut Inuit Nunalet Kavamanga

INDIGENOUS HEALTH adaptation to CLIMATE CHANGE

IK adapt

UNIVERSITY of GUELPH
CHANGING LIVES IMPROVING LIFE

Thank You!

Water Innovations for Health Arctic Homes, Anchorage, AK.
September 18th-21st, 2016

Vulnerability of northern water supply lakes to changing climate and Demand

Michael Bakaic
York University

The Question

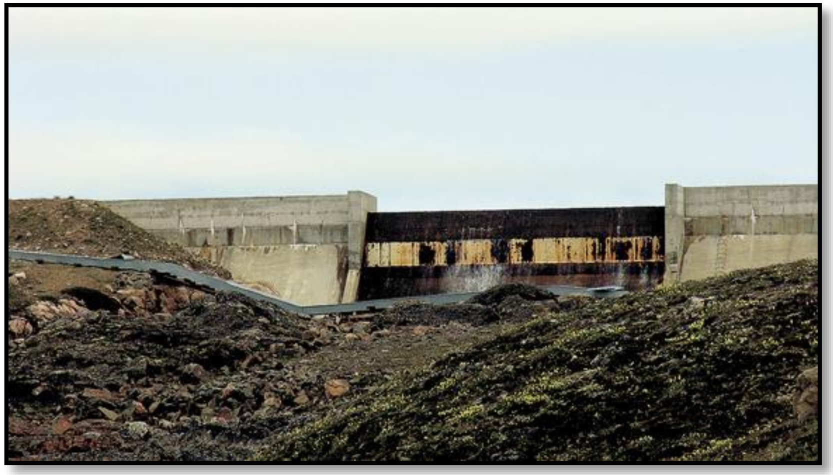
How much water do we have?

Factors

Climate

- Arctic amplification
  - Fluctuating Extremes
  - Higher evaporative stress
  - Lake Ice
  - Length Summer season
  - Freeze-up

Factors

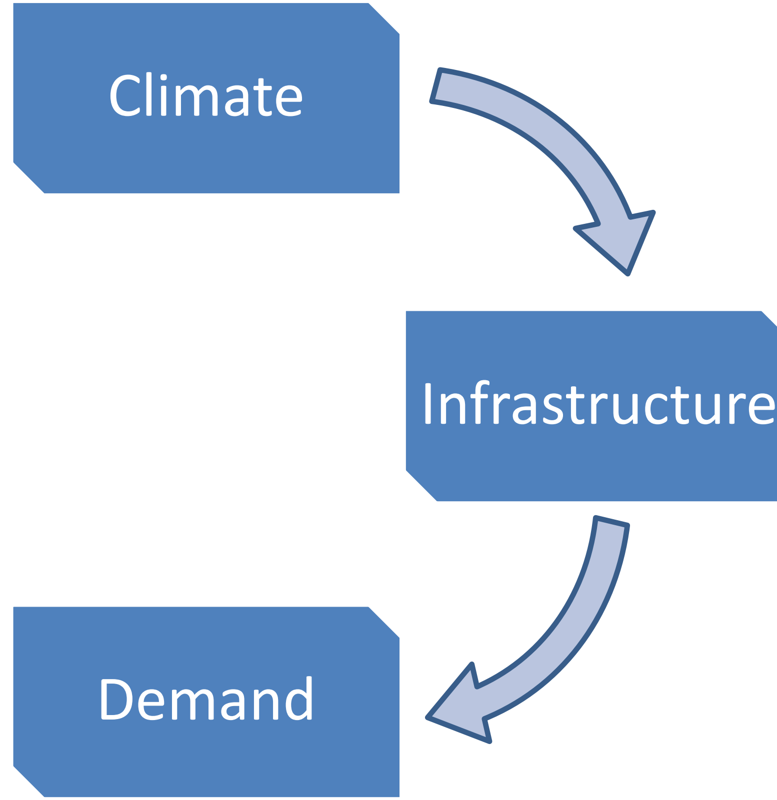


Climate → Infrastructure

- Arctic engineering
  - Permafrost
  - Longevity, O&M
  - Costly Engineered Solutions
  - Human Capacity

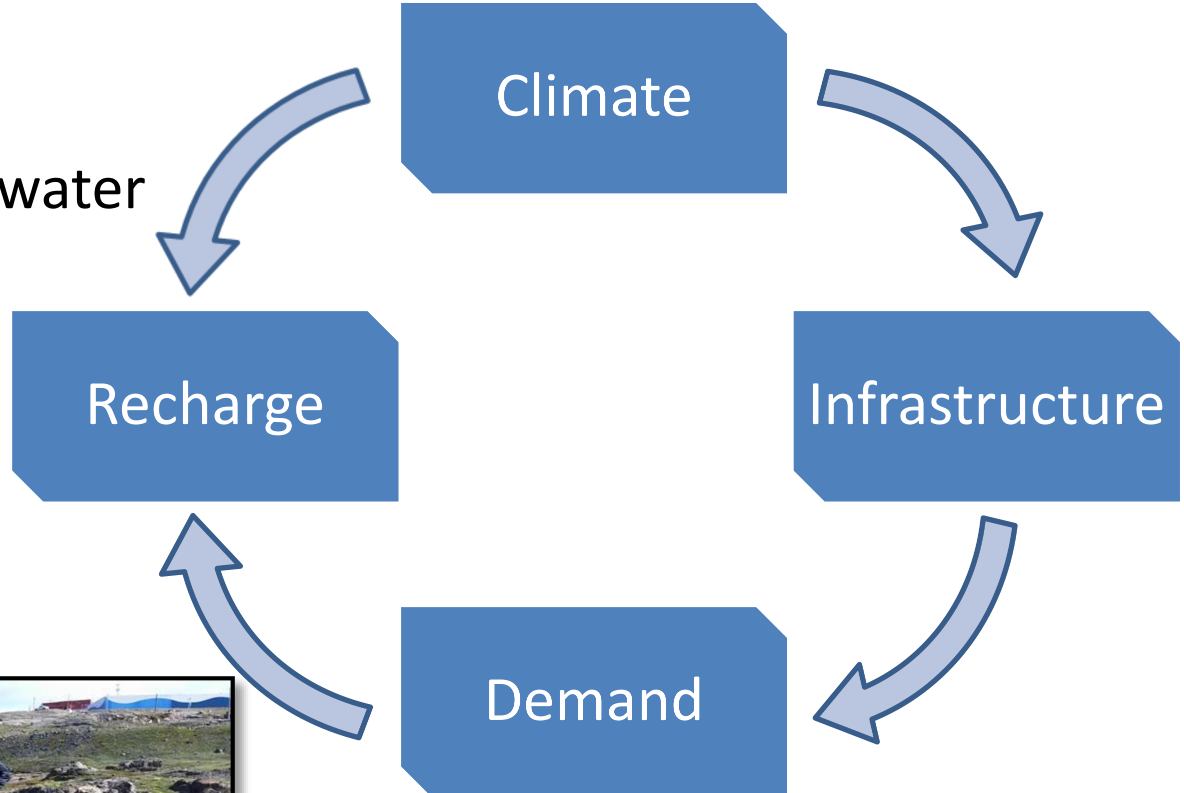
Factors

- Growing Demand
  - Population growth
  - Development
  - Distribution
  - Lifestyle improvements



Factors

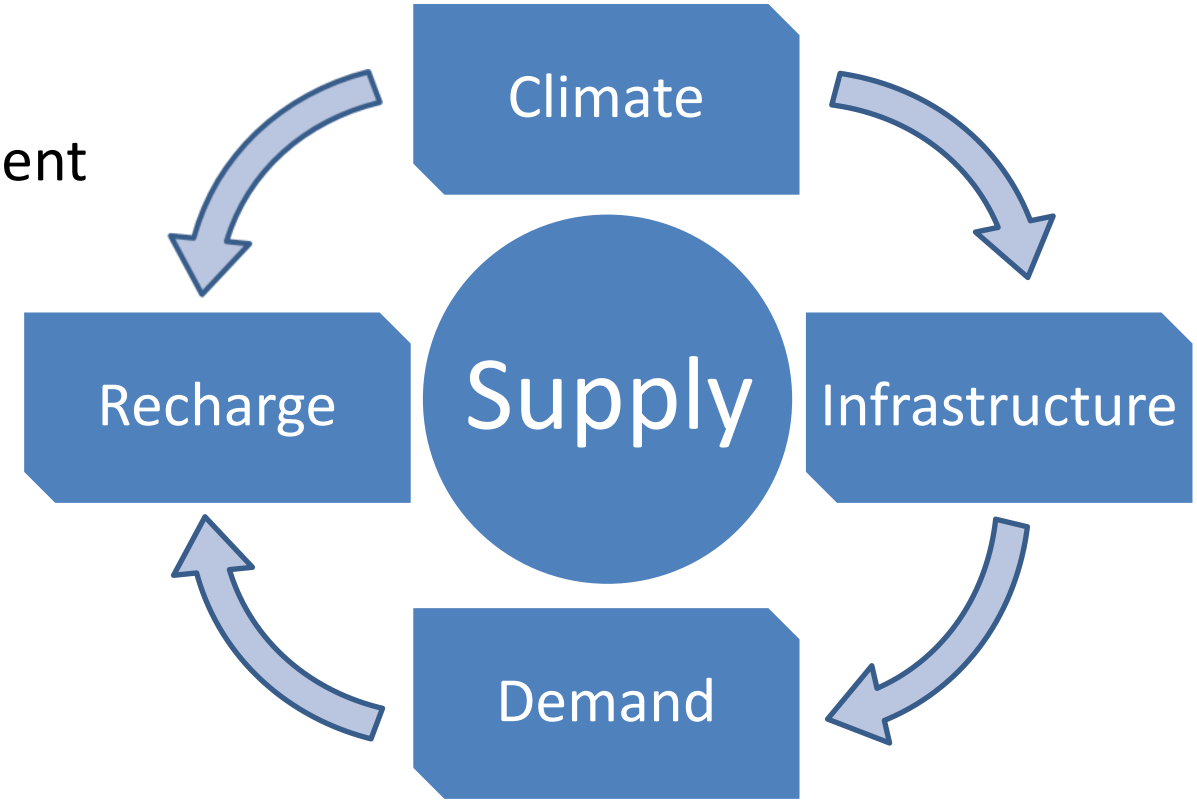
- Climate
    - Natural trajectory of water
- Demand
    - Reservoirs
    - Dams
    - Supplemental Supply



Water Resource Assessment

Answers Needed:

- Planning & Management
- Emergency Prep
- Water Safety
- Funding Priority



Hydrologic Modeling

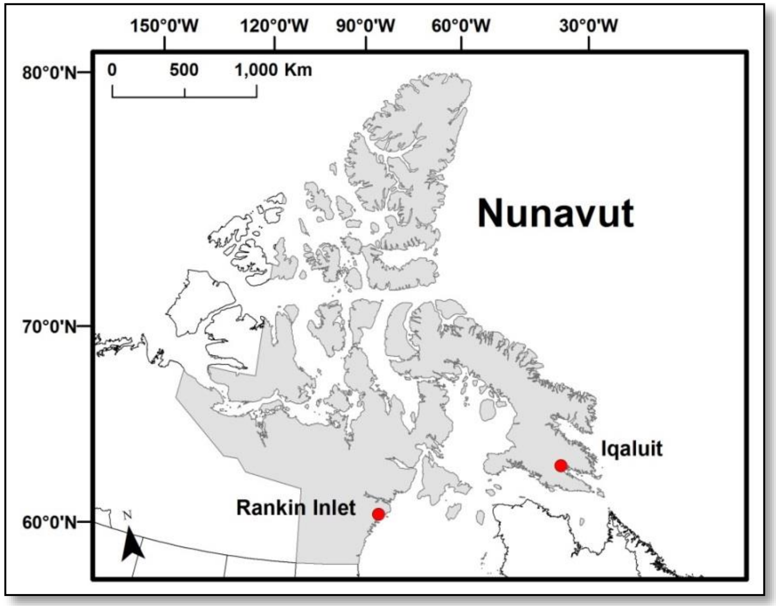
- Simulations of climate and demand scenarios
- Proposed infrastructure
- System evaluation
- Climate adaptation

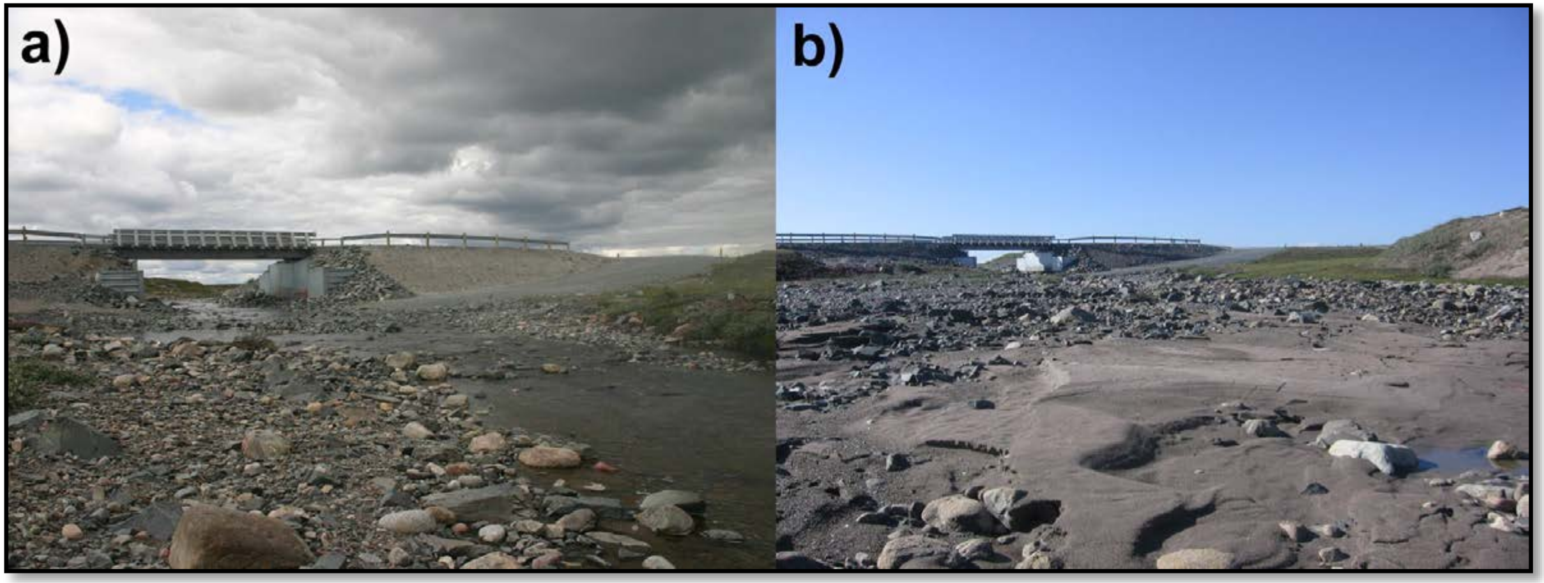
…… **account for the factors**

Water Resource Assessment

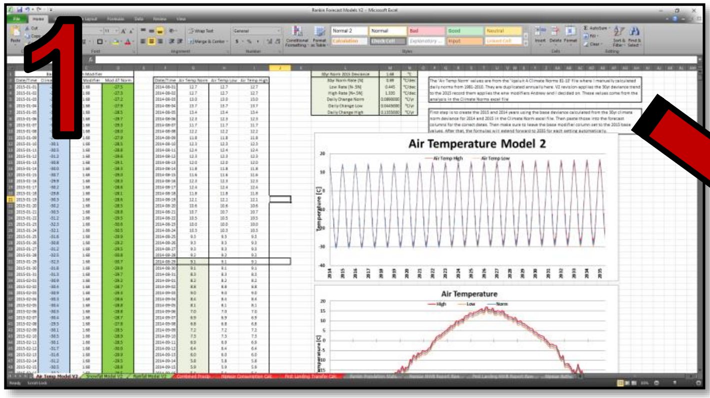
- Rankin Inlet and Iqaluit, NU
- High development pressures
- Diminishing supply
- Multiple proposed solutions

For example…

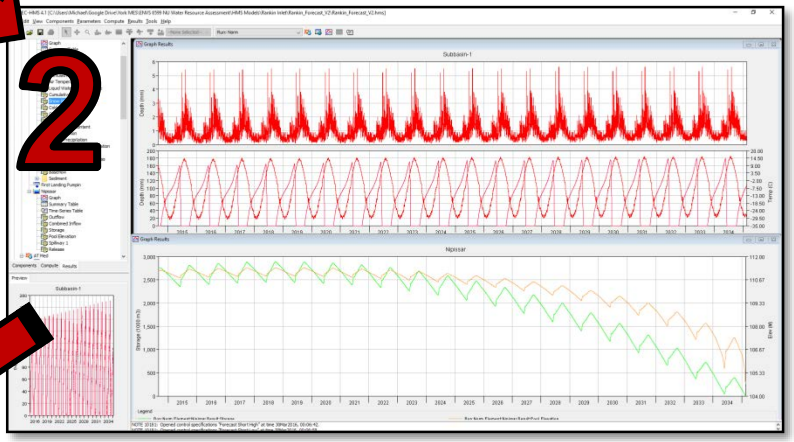




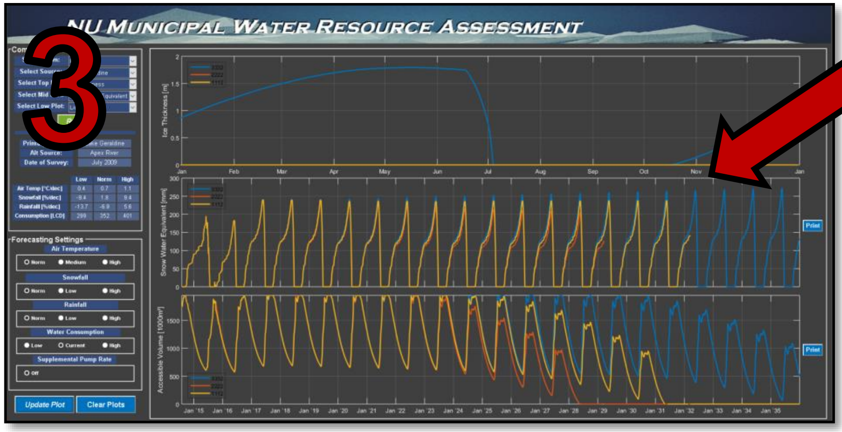
Process



Produce Climate & Demand Forecasts



Hydrological Simulation



Analysis Software

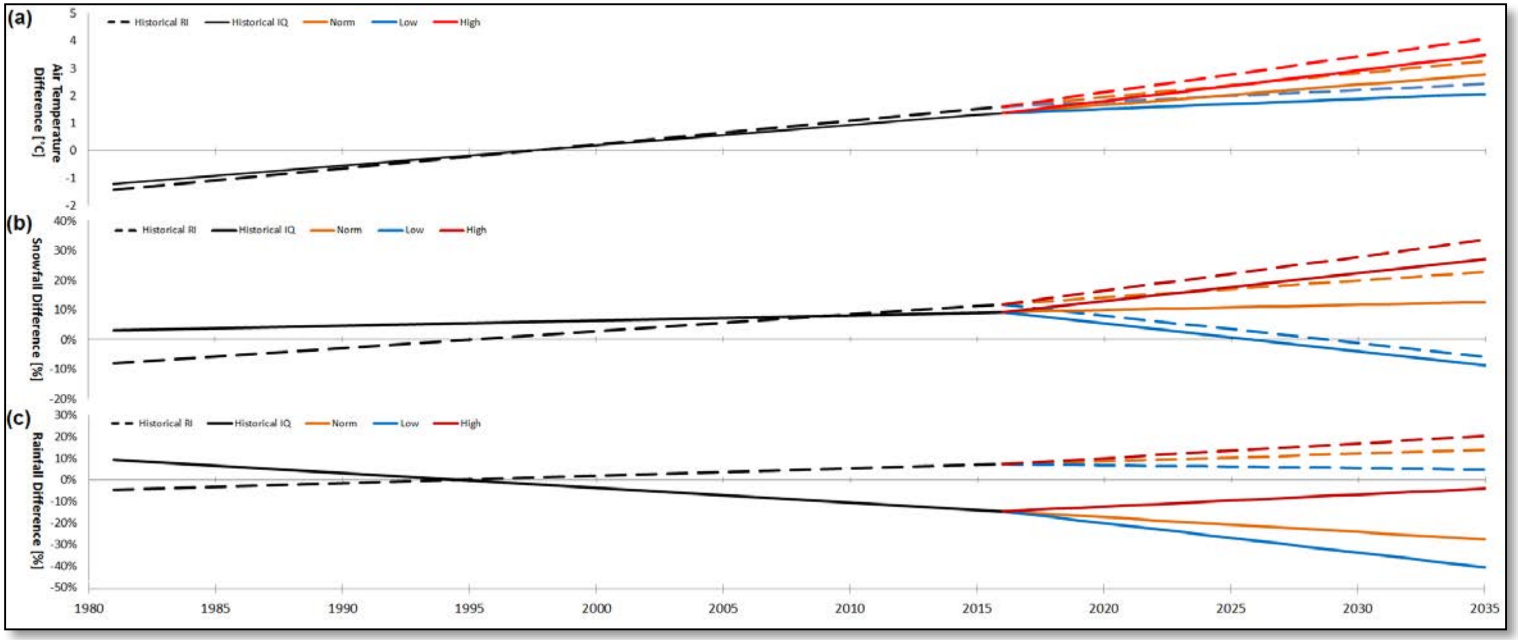
Climate Forecasts

- –3 Climate Parameters
- –Based on 30yr climate records
- –High/Norm/Low levels
- –Generate 27 climate forecast scenarios

Air Temp

Snowfall

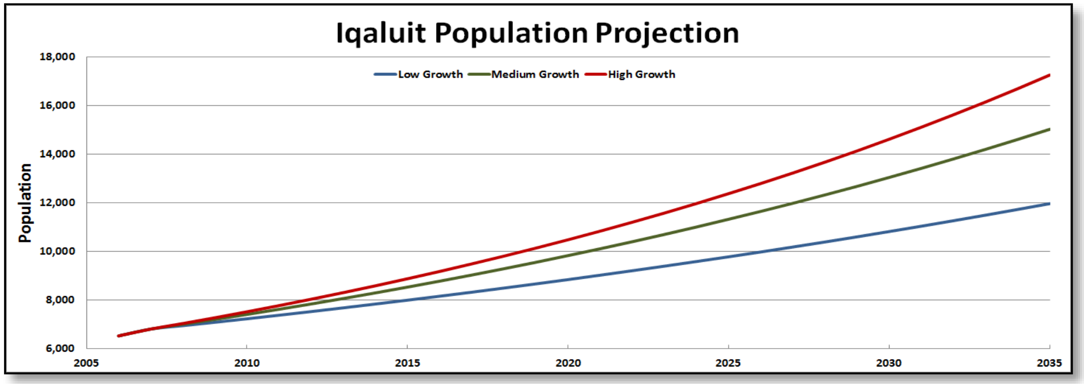
Rainfall



Demand Forecasts

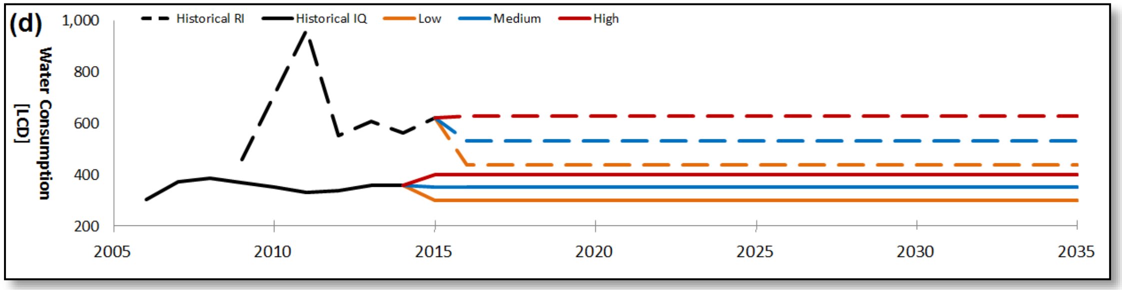
POPULATION GROWTH

- NU Stats Bureau projections
- High/Medium/Low



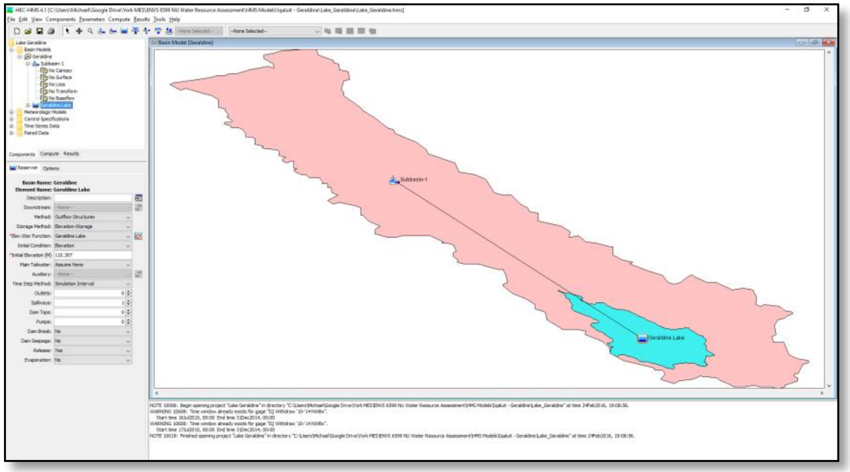
WATER CONSUMPTION

- NWB Annual Reports
- High/Medium/Low



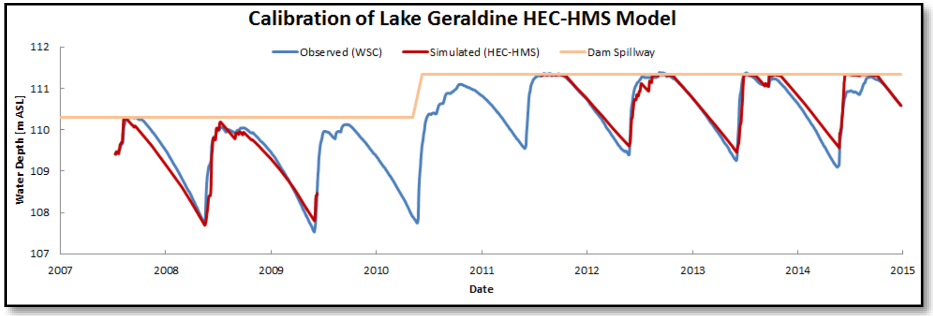
Simulation & Calibration

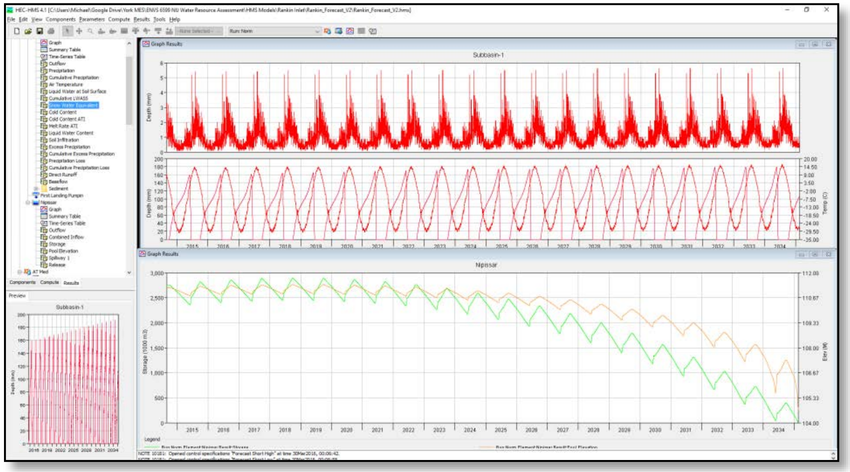
- Inputs:
  - Reservoir bathymetry
  - Watershed area
  - Dam/spillway configuration
  - Geological characteristics
  - Replenishment/reservoir specs
  - **81** combos of **Climate & Demand**



HEC-HMS Software Screenshot of Input Screen

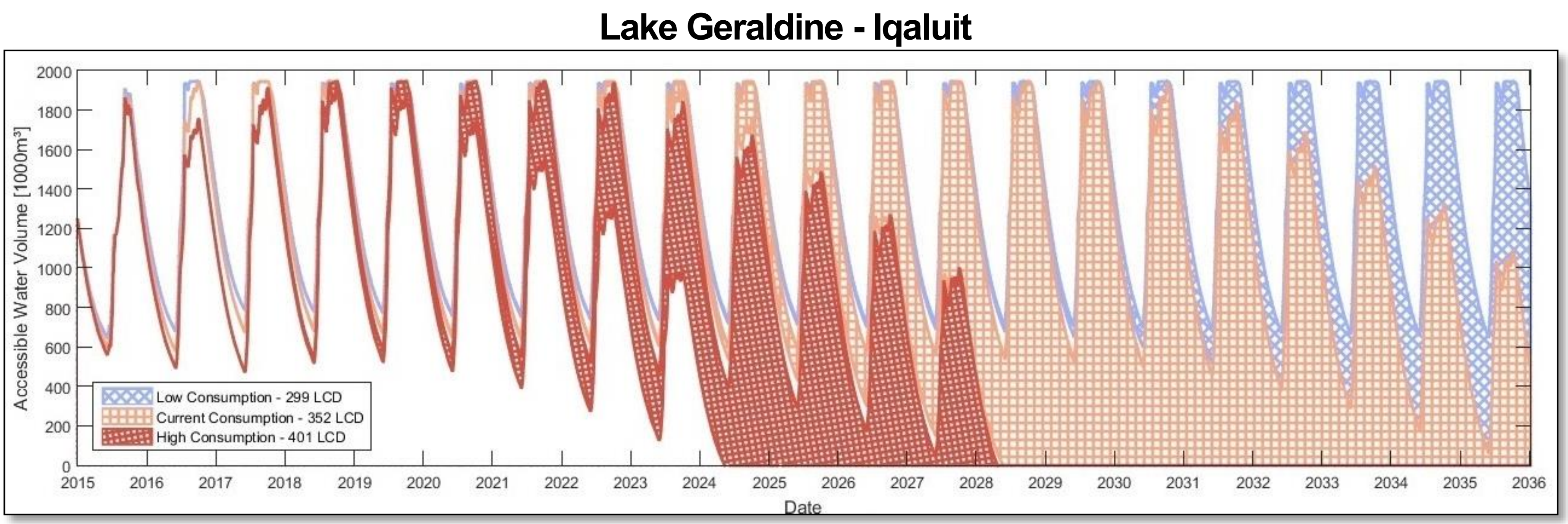
- Calibrated with WSC lake level gauge





HEC-HMS Software Screenshot of Results

Results



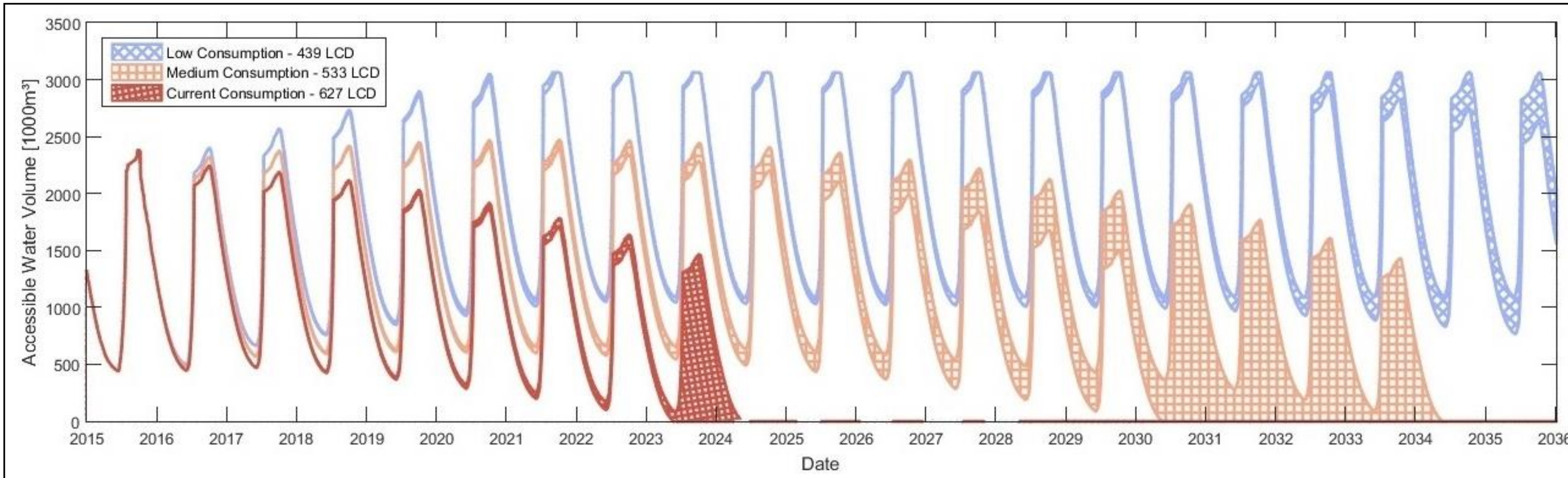
– **3** colour areas of **Demand**

– **27 Climate** scenarios **each** color

– High Consumption: Shortages in **2024**

Results

Lake Nipissar – Rankin Inlet



– **Current** Consumption: Shortages in **2023**

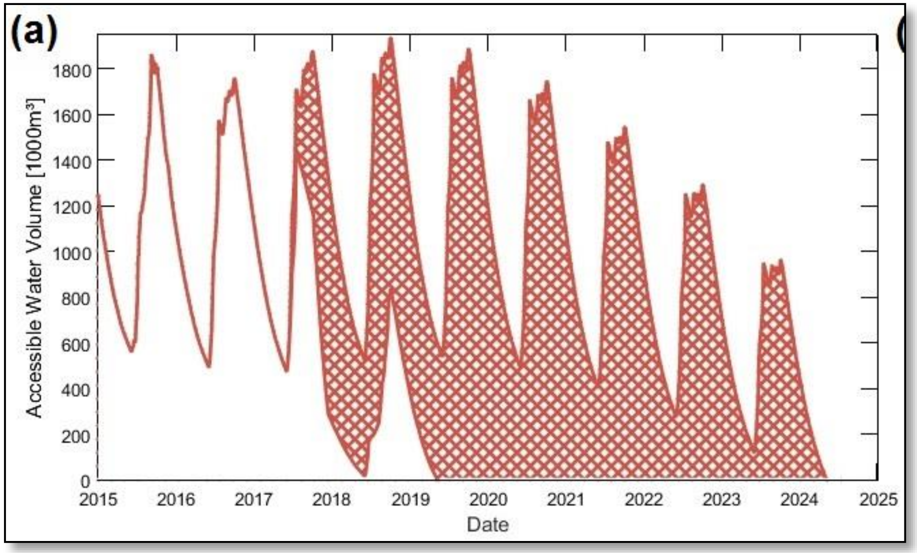
– Results include *seasonal replenishment pipeline*

Planning & Management Analyses

Lake Geraldine - Iqaluit

– Climate anomalies: 33yr precip low

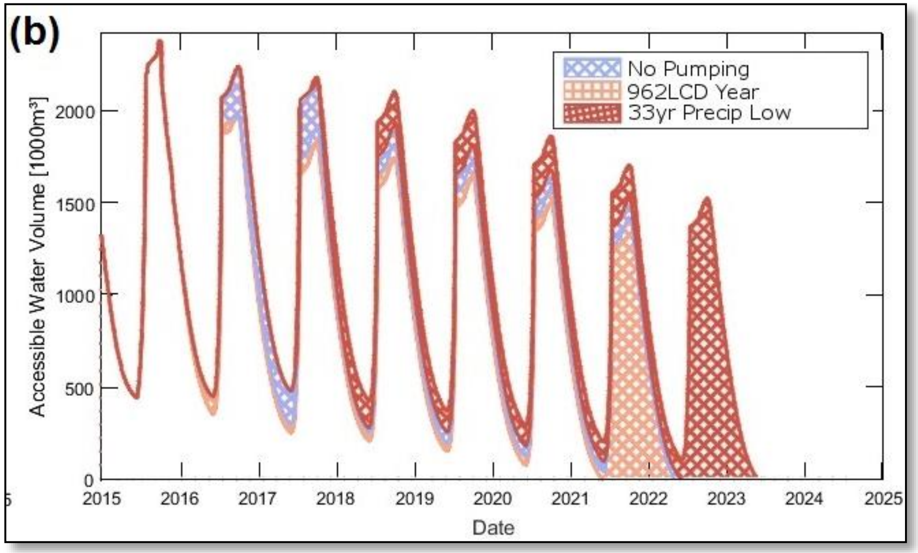
– Shortages in **2018**



Lake Nipissar – Rankin Inlet

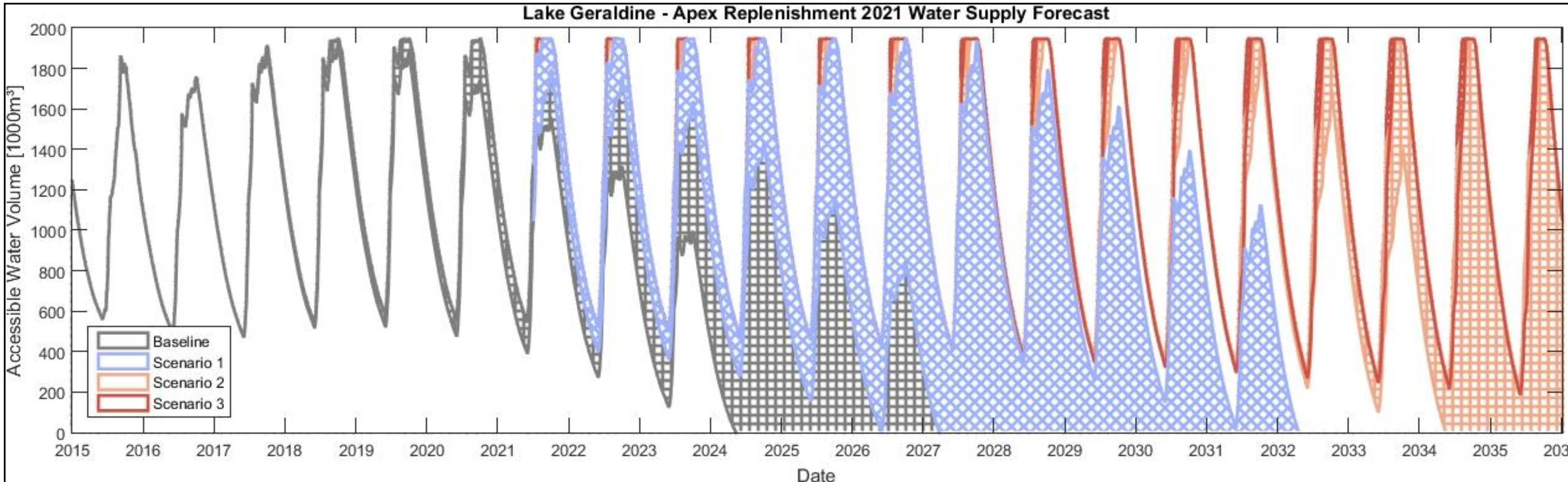
– Climate anomalies, pumping interruption, extreme consumptions

– Shortages in **2021**



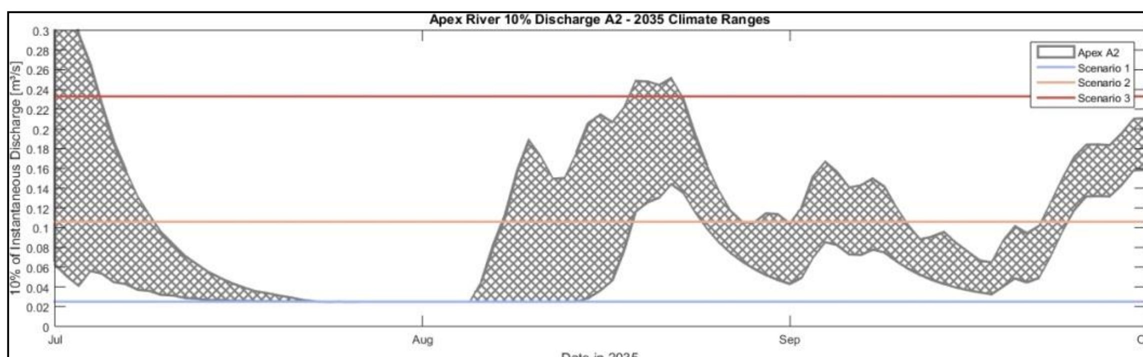
Apex Seasonal Replenishment

Lake Geraldine – Apex Replenishment



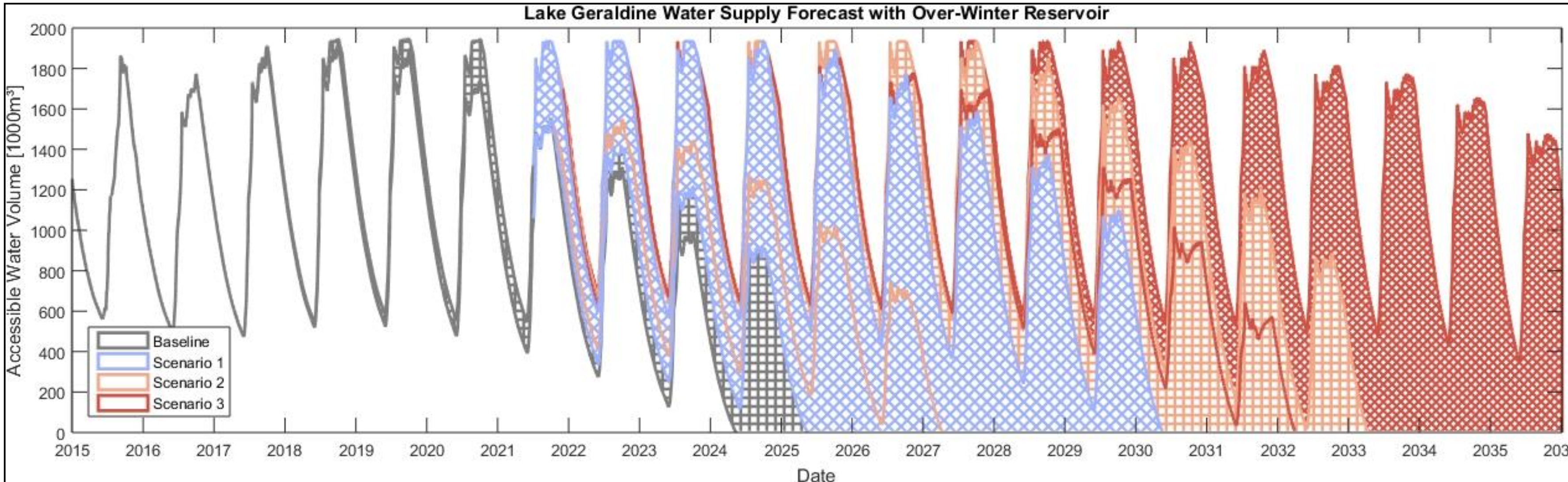
– Protocol can easily be expanded to evaluate infrastructure proposals

– Forecasting method reveals impact of Apex replenishment on Iqaluit water supply



Over-Winter Reservoir

Lake Geraldine – Over-winter Reservoir



– Protocol can easily be expanded to evaluate infrastructure proposals

– Scenario 1: 105,000m^3

– Scenario 2: 210,000m^3

– Scenario 3: 500,000m^3

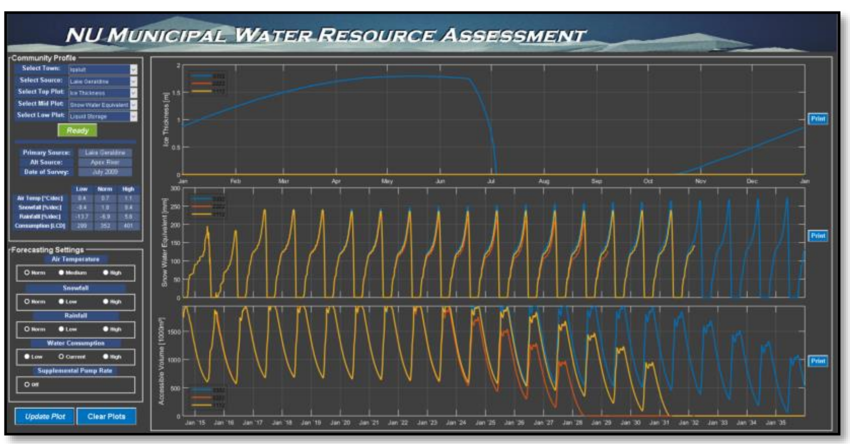
Water Strategy Development

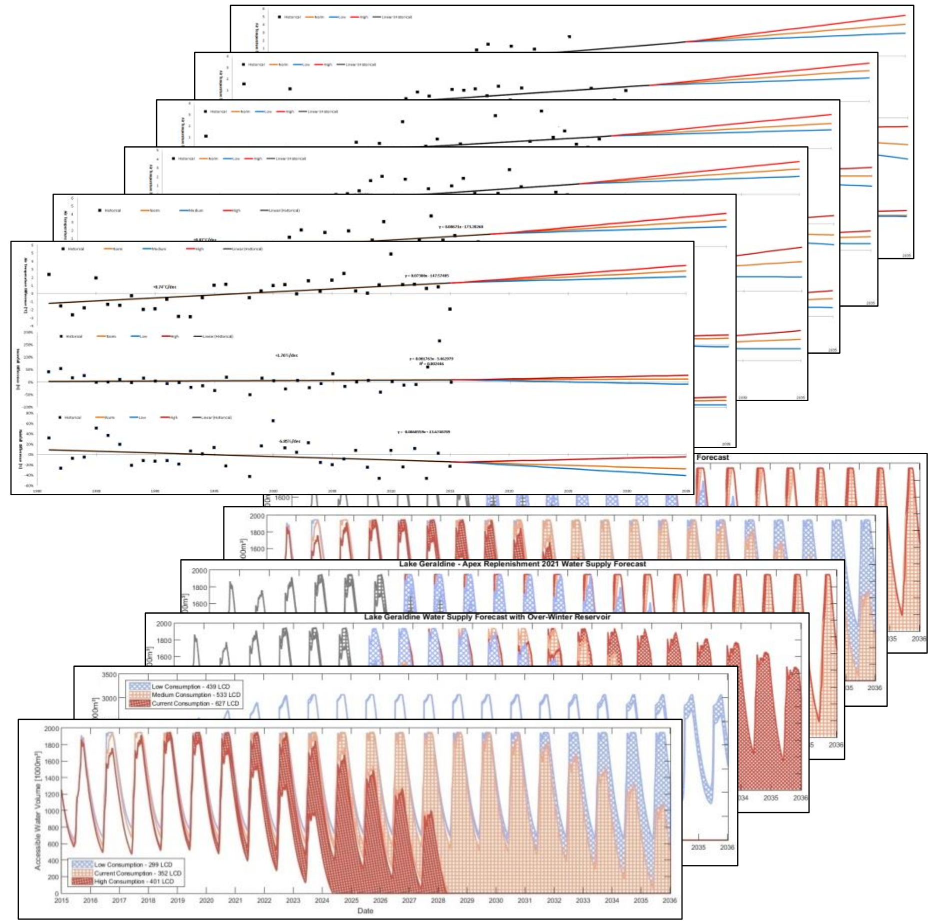
– Full suite of preliminary supply forecasts for all communities

– Deploy to evaluate current infrastructure proposals

– Advance understanding of Water Security for Northern regions

– Establish real-time monitoring & forecasting





Questions to YOU

- When was the last time your resources were assessed?
- How will climate change impact your water supply?
- **How long will your supply last?**
- Let us work together!

Michael Bakaic
mbakaic@yorku.ca
York University

References

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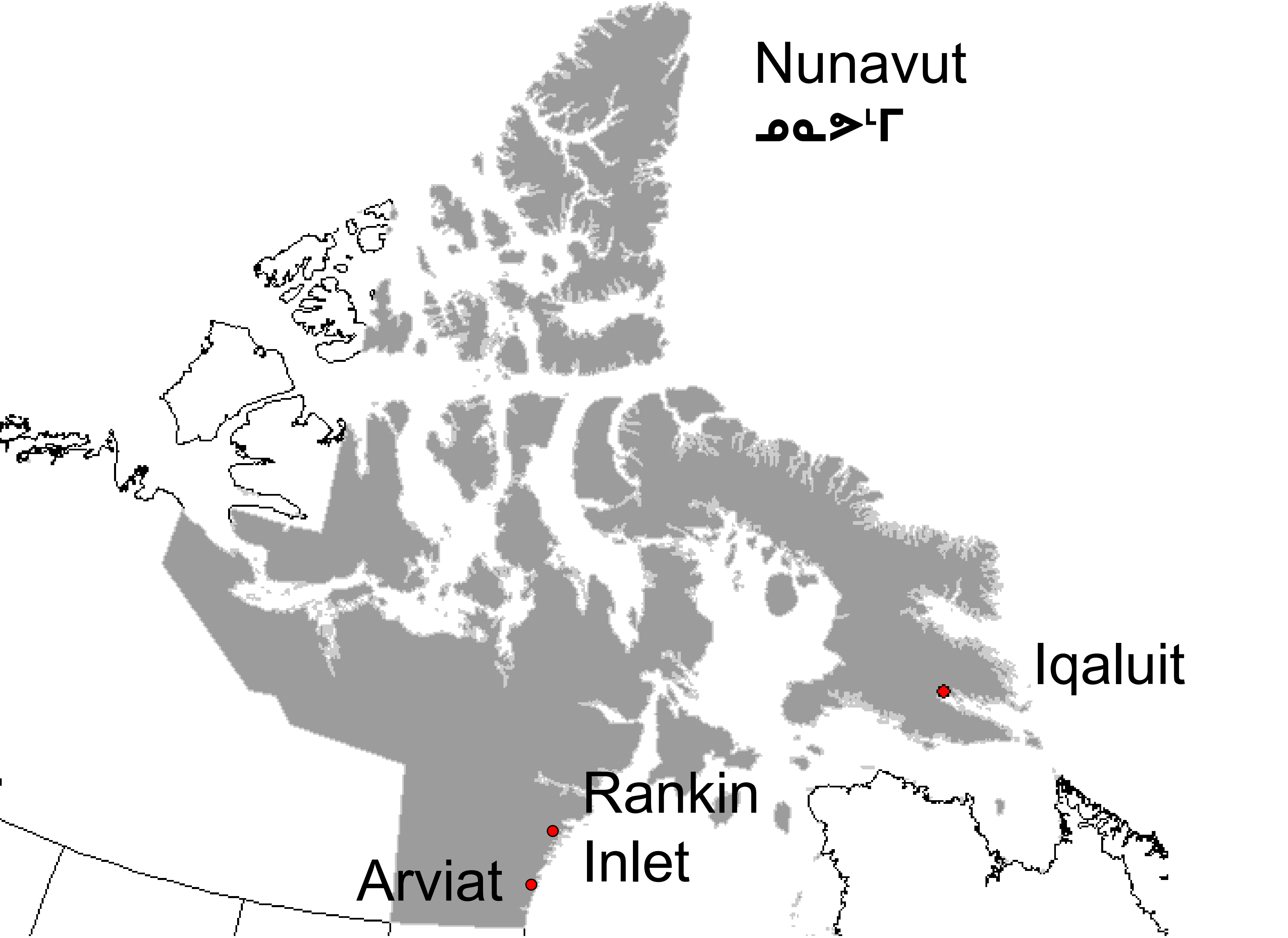
2. Nunavut Bureau of Statistics. (2014, Dec 7). *Population Projections.* Retrieved Dec 01, 2015, from Nunavut Bureau of Statistics: http://www.stats.gov.nu.ca/en/Population%20projections.aspx
3. Golder Associates Ltd. (2013). *Lake Geraldine Water Balance Assessment.* Golder Associates Ltd.
4. Stantec Consulting Ltd. (2014). *Seasonal Replenishment of Nipissar Lake, Rankin Inlet, Nunavut.* Yellowknife: Stantec Consulting Ltd.
5. Budkewitsch, P., Prevost, C., Pavlic, G., and Pregitzer, M. 2011a. Description of Water Depth Survey Datasets from Rankin Inlet, Nunavut. Ottawa: Geological Survey of Canada.
6. exp Services Inc. (2014). City of Iqaluit Supplementary Water Supply Study. Moncton.
7. Budkewitsch, P., Prevost, C., Pavlic, G., and Pregitzer, M. 2011b. Description of Watershed Outline and Water Depth Survey Datasets from Geraldine Lake - Iqaluit, Nunavut. Ottawa: Geological Survey of Canada.

Vulnerability of fresh water supply in Arctic Canada

Andrew S. Medeiros* and Michael Bakaic

York University, Department of Geography


Nunavut
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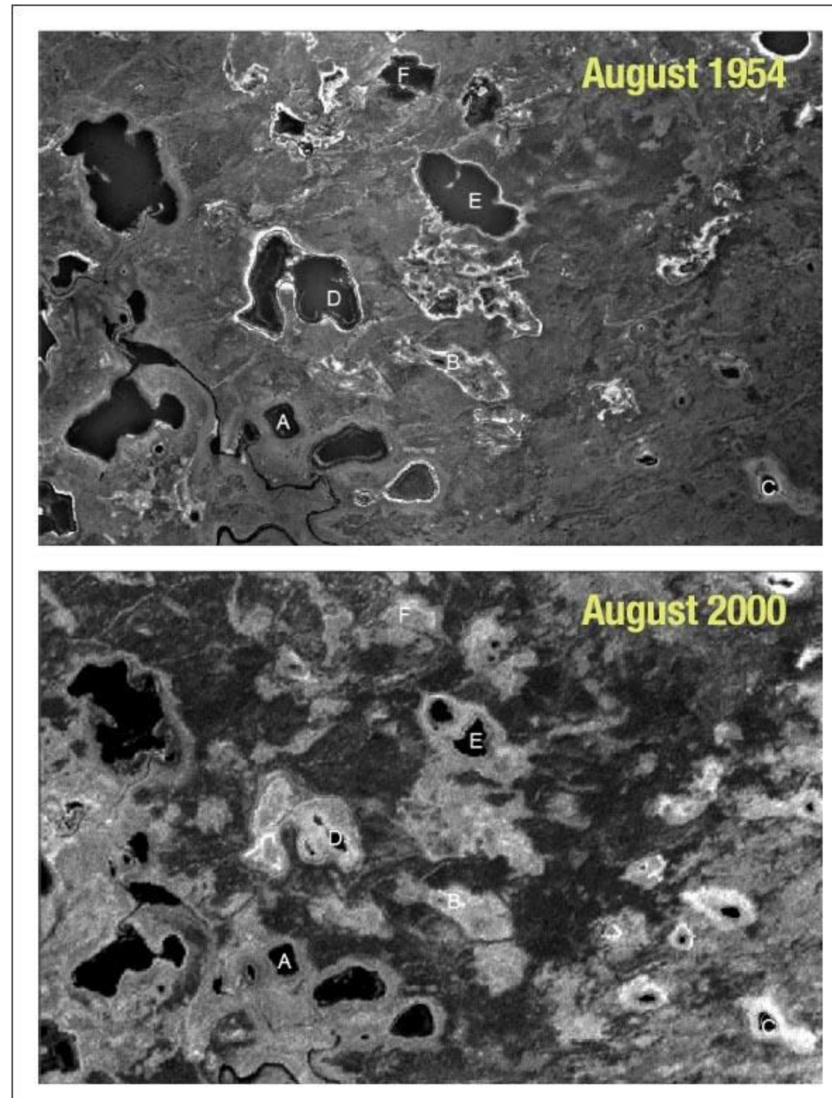
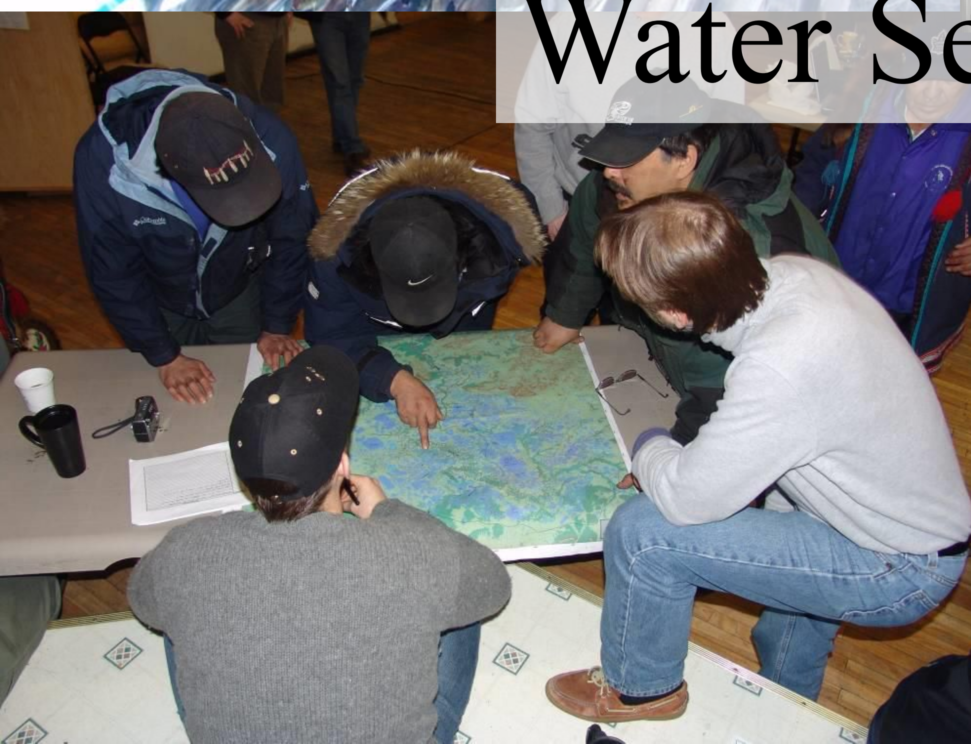
Iqaluit
Rankin Inlet
Arviat

Environmental Change and Arctic freshwater systems



Water Security



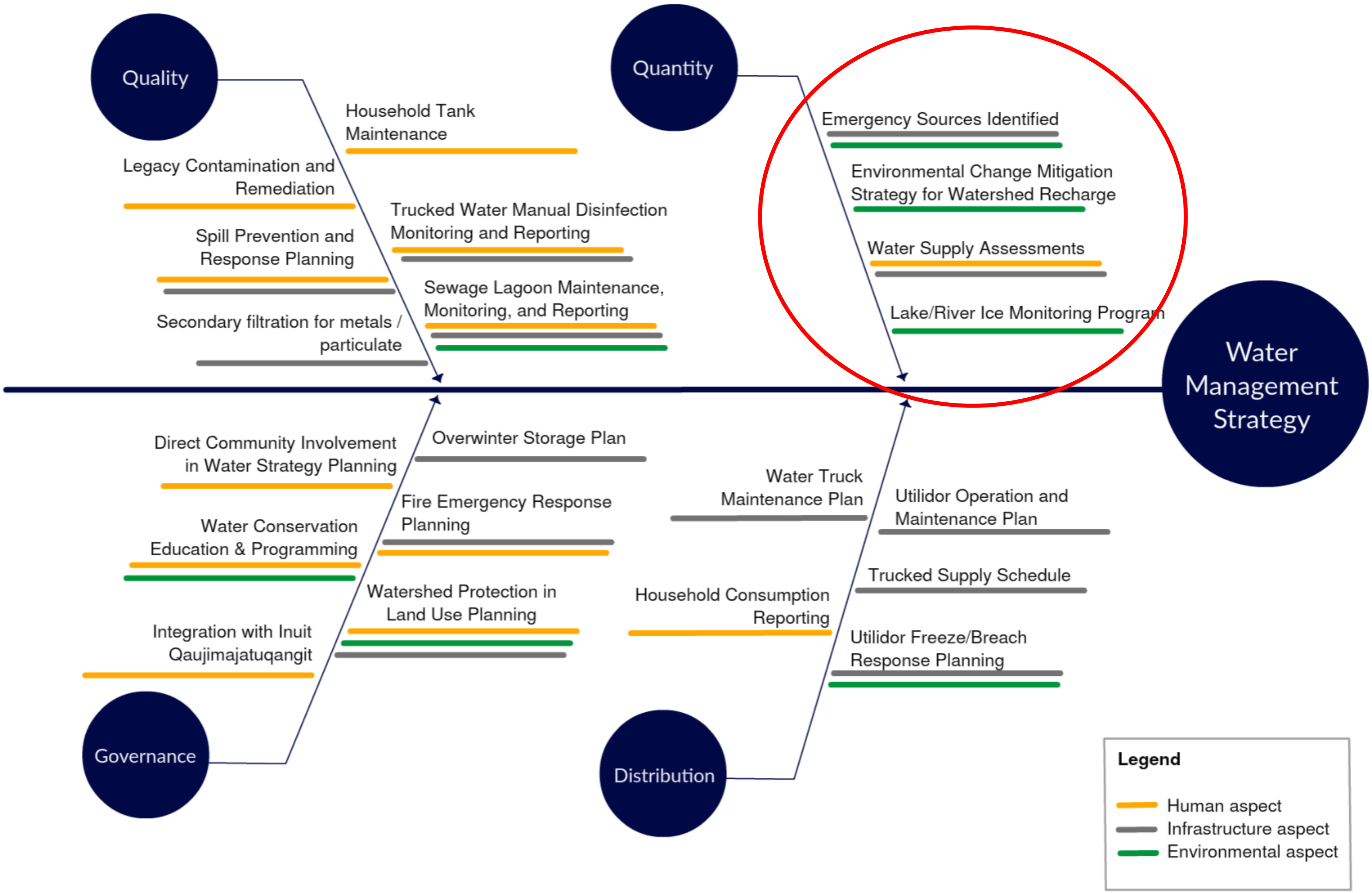
Water Security

Survey of Residents determined:

- Residents often drink untreated flowing water sources
  - Traditional Ecological Knowledge of water borne pathogens
  - Distrust of municipal water supply

- Concerns over **water quantity**
  - Demand exceeds long-term supply
  - Households often run out of water
  - Knowledgeable about municipal plans for water development

- Concerns over **water quality**
  - Identification of several areas residents would not consider drinking water from



Quality
Household Tank Maintenance
Legacy Contamination and Remediation
Trucked Water Manual Disinfection Monitoring and Reporting
Spill Prevention and Response Planning
Sewage Lagoon Maintenance, Monitoring, and Reporting
Secondary filtration for metals / particulate
Quantity
Emergency Sources Identified
Environmental Change Mitigation Strategy for Watershed Recharge
Water Supply Assessments
Lake/River Ice Monitoring Program
Water Management Strategy
Direct Community Involvement in Water Strategy Planning
Overwinter Storage Plan
Fire Emergency Response Planning
Water Conservation Education & Programming
Watershed Protection in Land Use Planning
Integration with Inuit Qaujimajatuqangit
Governance
Water Truck Maintenance Plan
Utilidor Operation and Maintenance Plan
Trucked Supply Schedule
Household Consumption Reporting
Utilidor Freeze/Breach Response Planning
Distribution
Legend
Human aspect
Infrastructure aspect
Environmental aspect


Water Quantity Issues

Water Risk Assessment

- **Problem**: Climate stress and increased populations causing widespread risk to water infrastructure and supply

Use estimates of water source volumes to:

→ Calculate input vs output

→ Determine water-balances

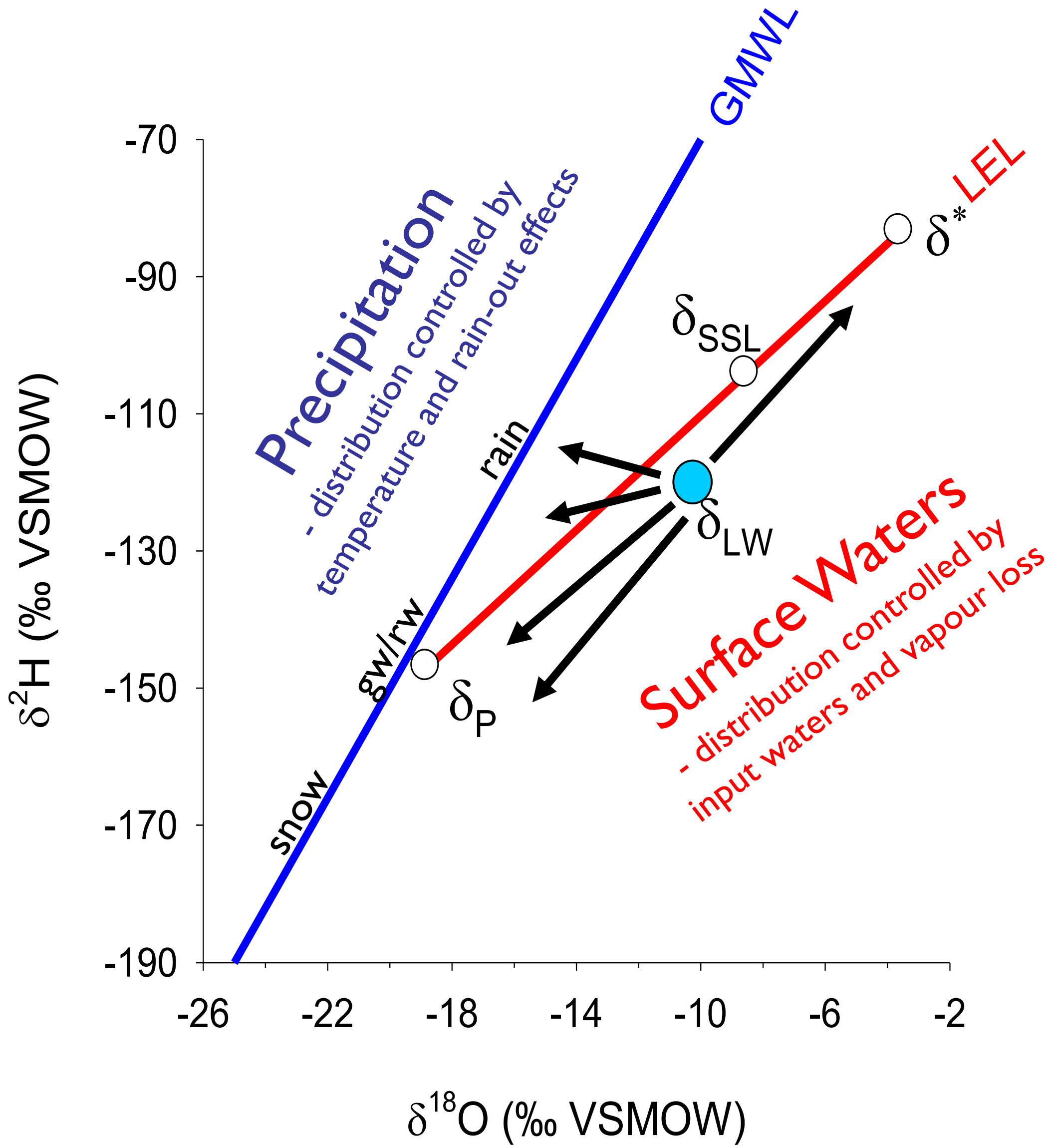
→ Model risk assessment scenarios

→ Provide adaptation recommendations

Indicators: Isotopes

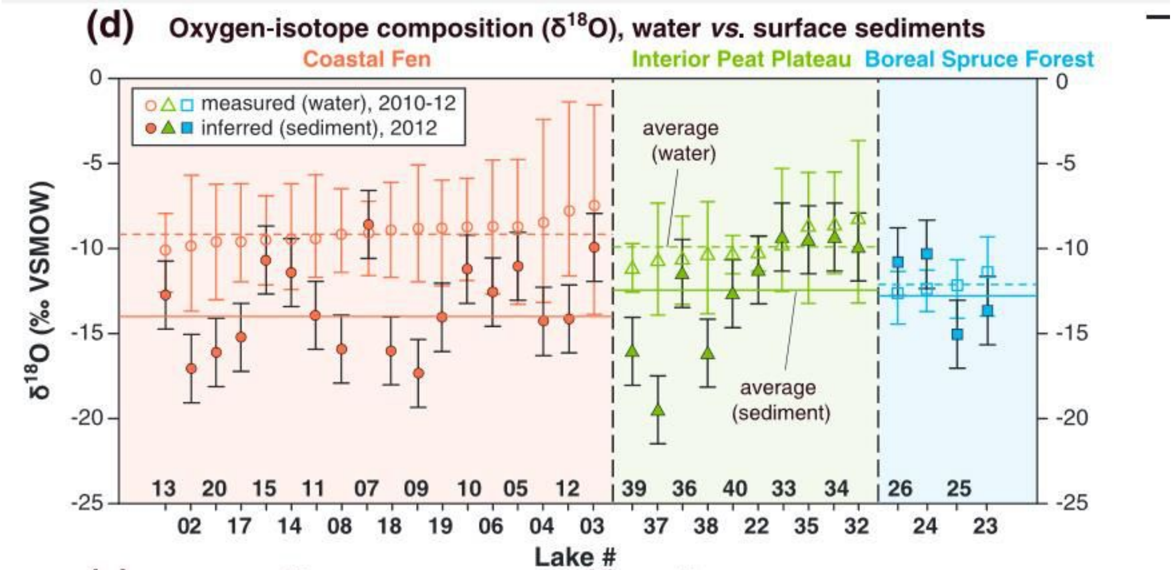
Lake-Water isotope Tracers

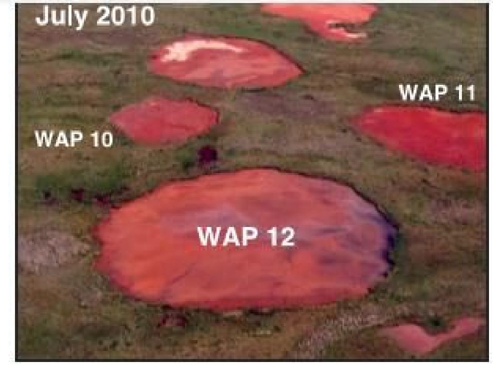
- $\delta^{18}O$, $\delta^{2}H$
  - Monitoring of Lake Water Balances
  - Hydrologic pathways

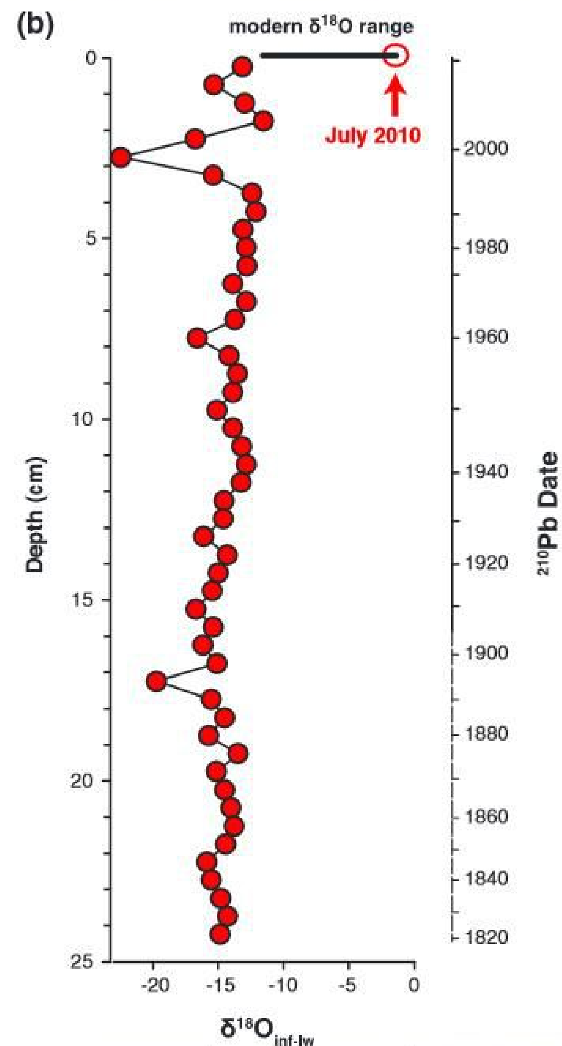


Evaporative Stress

Vulnerability



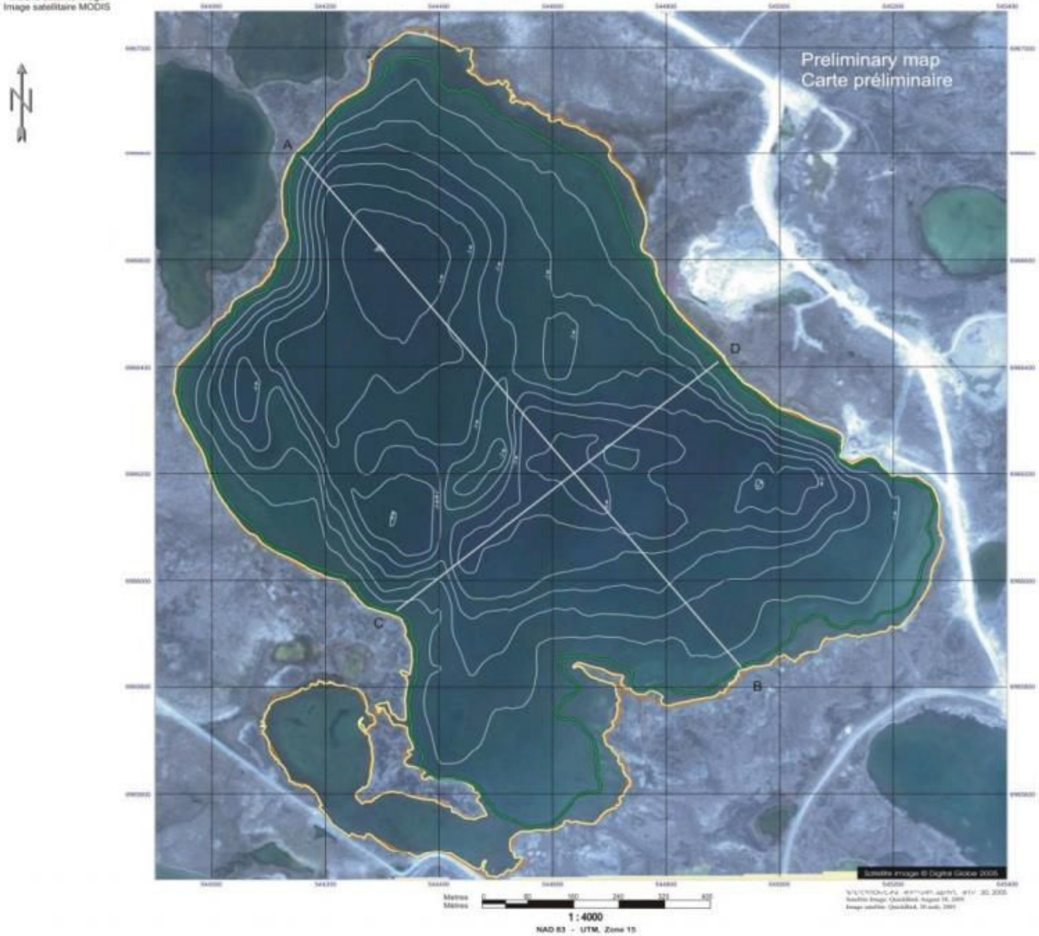




- Bouchard et al. 2013, Geophysical Research Letters, *40*(23), 6112-6117.

Running Out of Water

Rankin Inlet, Nunavut



Supplemental Water Supply?
Char River outlet - 2007

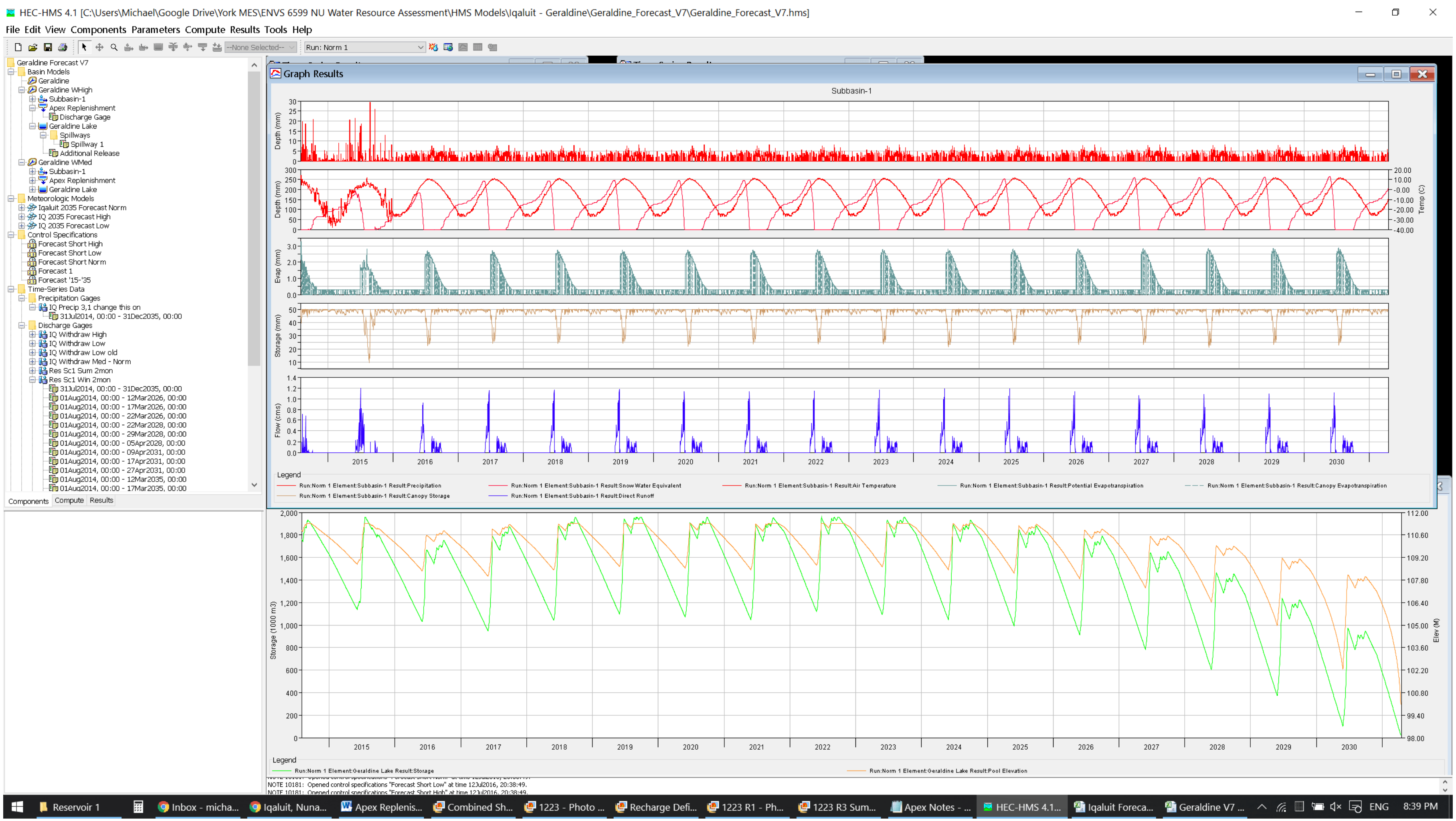
Char River outlet - 2006

- Cost: ~$5 million
- Extension of supply: 5 years

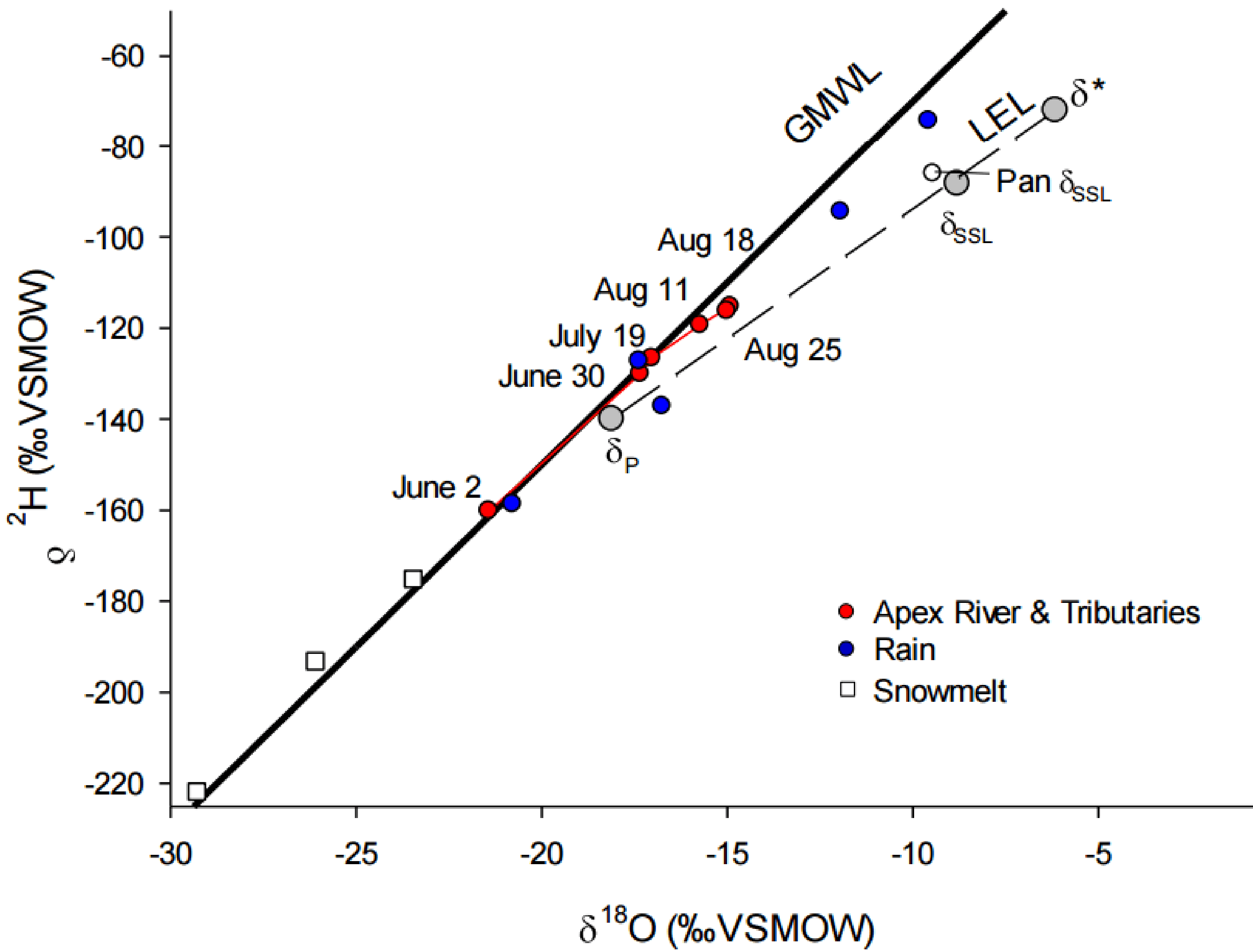
Alternative Water Supply?
The Apex River, Iqaluit, Nunavut

- Current Proposal
- Estimated cost: 6.4 million

Hydrologic Modelling



Water Balance Modelling

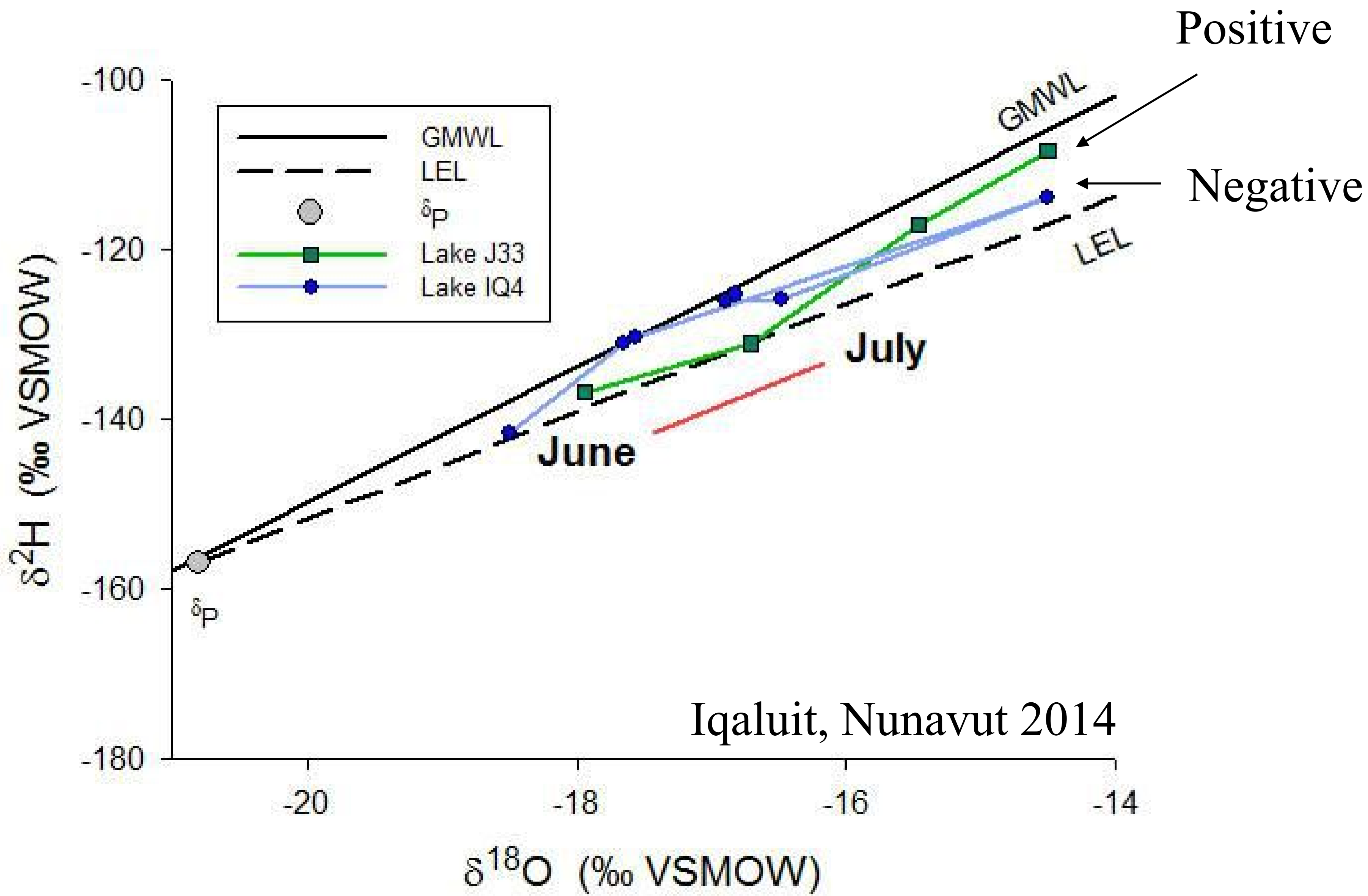



Summer Rainfall

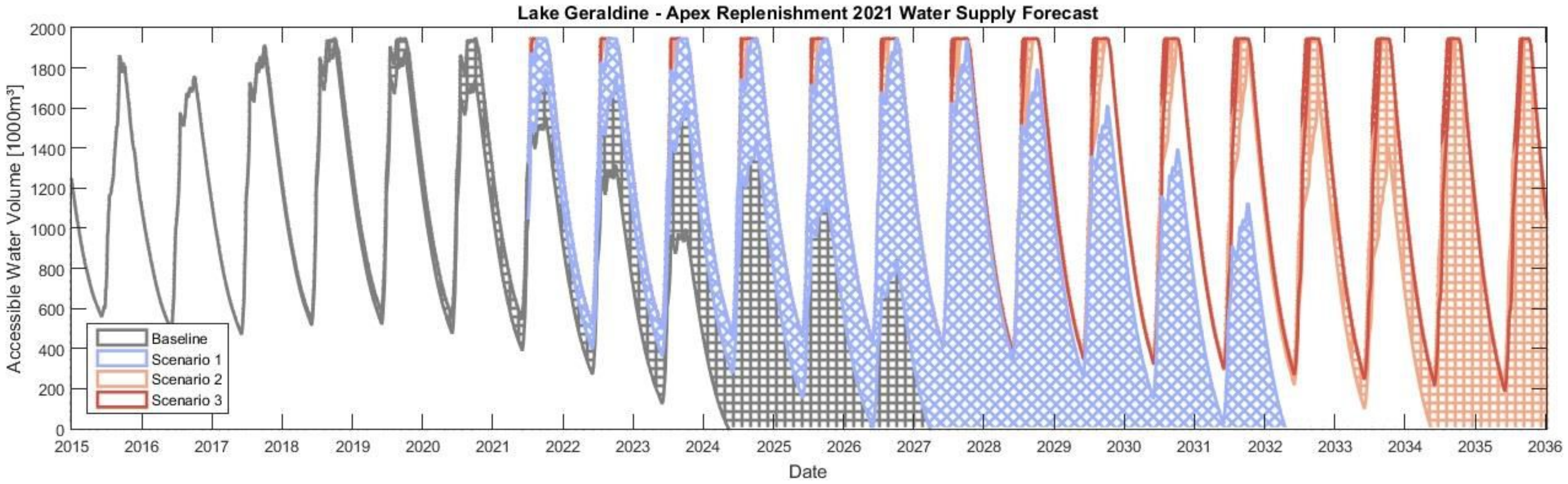
Evaporative Stress

Jessica Peters
BES Honours Thesis,
Wilfrid Laurier University

Isotope Hydrology: Seasonal Pattern



What do we find?



- Supplemental Water replenishment from local river provides 3-5 years worth of water
- Cost / Benefit question
- Alternative sources of water?

Water Risk Assessment

- **Problem**: Evaporative stress and increased populations causing widespread risk to water infrastructure and supply

Use estimates of water source volumes to:

→ Calculate input vs output

→ Determine water-balances

→ Model risk assessment scenarios

→ Provide adaptation recommendations

Government has no estimates of water volumes for 19 of 25 Nunavut communities

Solution: Basic Bathymetric Surveys and Water Sampling

- Simple measurements of depth
- Collection of water and sediment
- Isotope analysis + Hydrologic modelling
- Estimated cost per community: ~$10-15,000

→ Minor costs but not a funding 'priority'

Freshwater Policy?

- Nunavut Waters and Nunavut Surface Rights Tribunal Act – 2014
- Municipalities own and operate water infrastructure
- Maintenance and management from Department of Community and Governmental Affairs
- Permits and licensing from <u>Nunavut Water Board</u>
- **No territorial freshwater management policy framework exists**

Freshwater Policy

- Severe need to bring various government and non-government stakeholders together to address lack of freshwater policy or management
- Government of Nunavut has no person(s) in charge of freshwater policy or planning
- Climate change adaptation group has no freshwater adaptation strategy
- **Water Security is as important as food security**

Thank you!

- Undergraduate Honours Thesis Students: Cait Carew, Jessica Peters, Heather Haight, Anthony Todd
- Field Assistance: Ryan Scott, Chris Luszczek, Ray Biastoch
- University of Waterloo – Environmental Isotope Lab
- Northern Partners: Nunavut Research Institute, Nunavut Arctic College
- Collaborations: Suzanne Tank, Brent Wolfe, Roland Hall, Roberto Quinlan, Marc Amyot, Gwyneth MacMillan, Konrad Gajewski, Sarah Finkelstein, David Porinchu, and many many others..
- Funding: NSERC, PCSP, ACUNS / The W. Garfield Weston Foundation

Association of Canadian Universities for Northern Studies

Freshwater Policy

Climate Change and Community Water Security
Emerging Challenges and Strategies

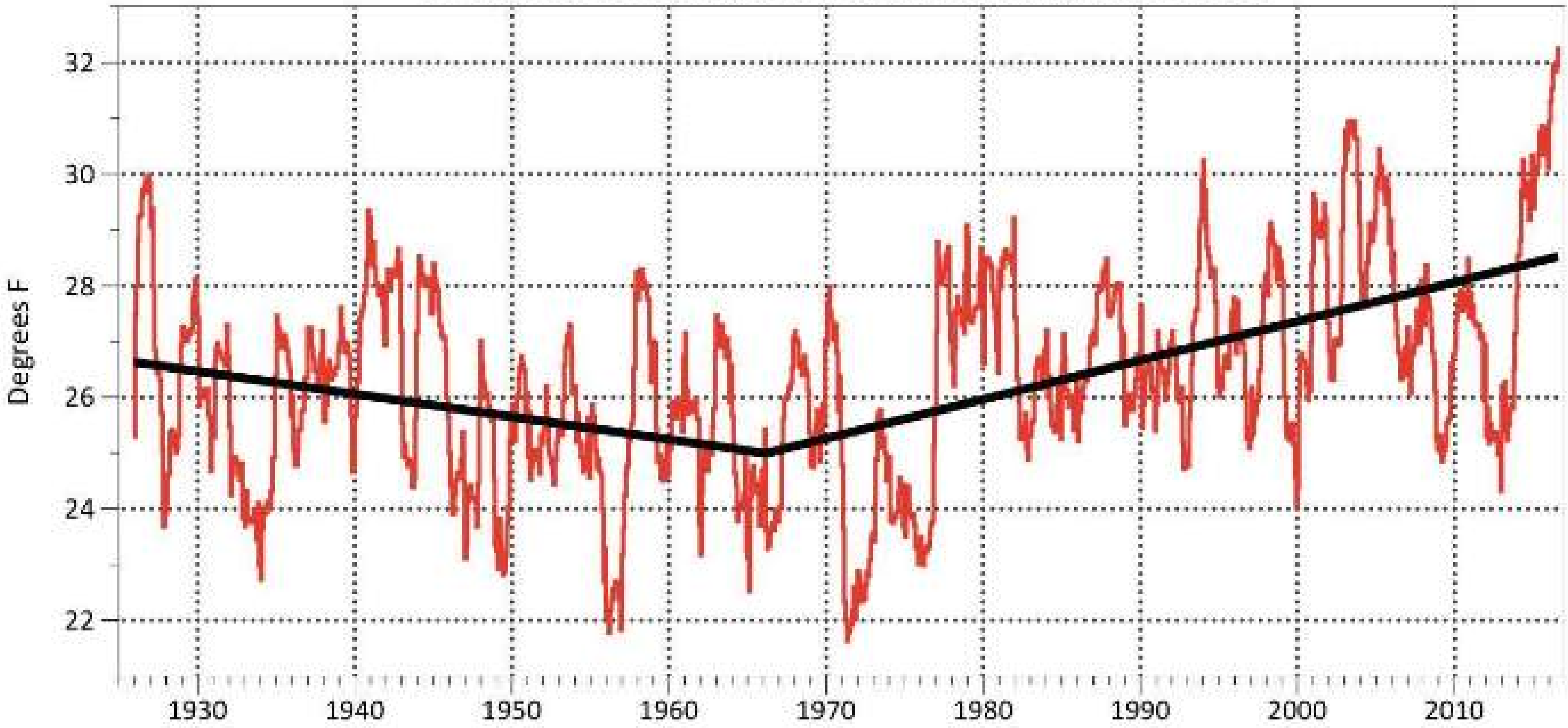
WIHAH – September 19 & 20 2016

Mike Brubaker

Alaska Native Tribal Health Consortium

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

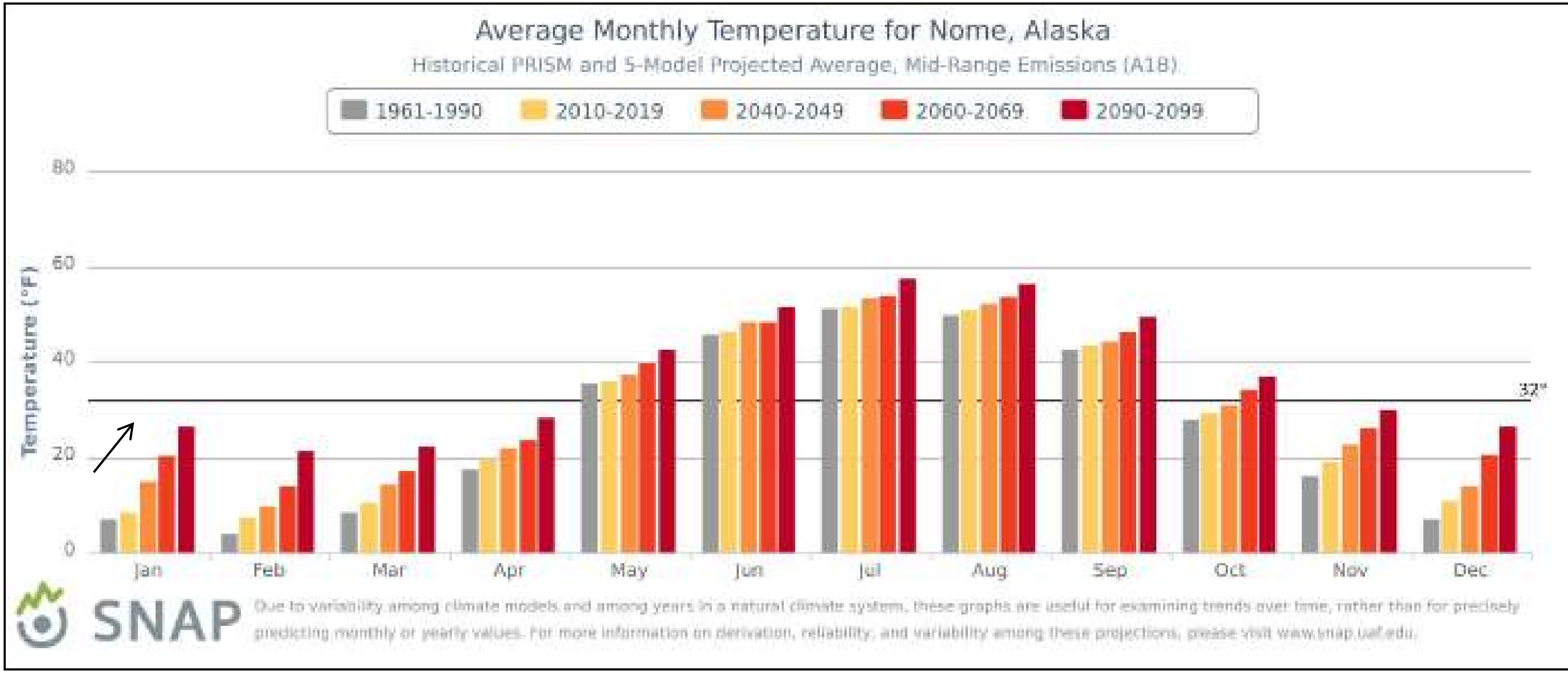
Alaska Statewide
12-Month Running Mean Temperature, 1926-2016



Data source: NOAA/NCEI
updated through Aug 2016

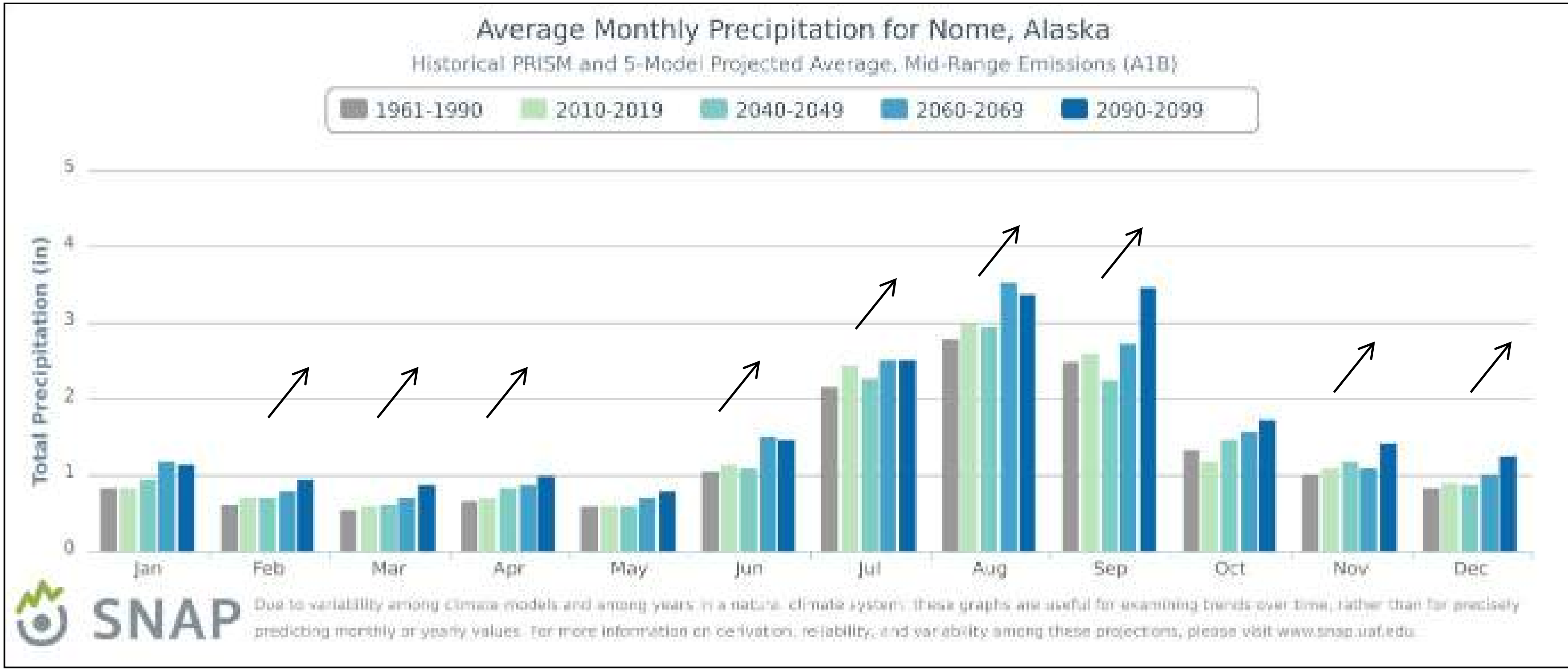
Courtesy Rick Thoman

What do we know about climate change trends? Warmer.



Comparing these two periods, 1961 – 1990, and 2010 – 2012, temperature has increased in every month. Biggest changes occurring in winter.

What do we know about climate change trends? Wetter.



Comparing these two periods, 1961 – 1990, and 2010 – 2012, precipitation has increased in nine of twelve months. Biggest change occurring in summer and fall.

How does climate change affect human health?

Disease

Behavioral Health

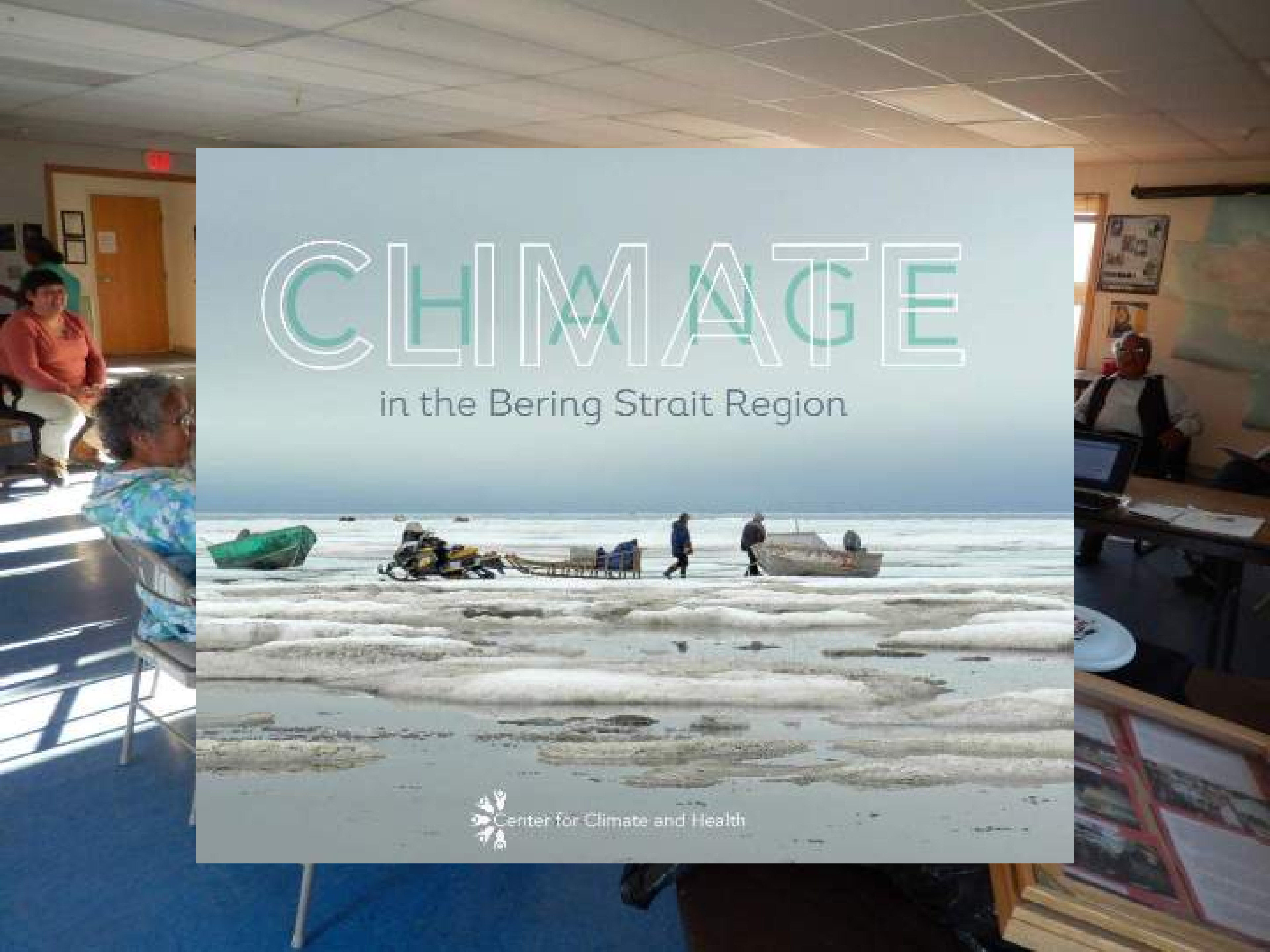
Food Security

Injury

Water Security

Center for Climate and Health

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM


CLIMATE
CHANGE
in the Bering Strait Region
Center for Climate and Health

How does climate change affect water security?

Damage or disruption to water infrastructure.

Changes to water source quality or availability.

Thaw related service line damage: Northwest Arctic Region - Selawik

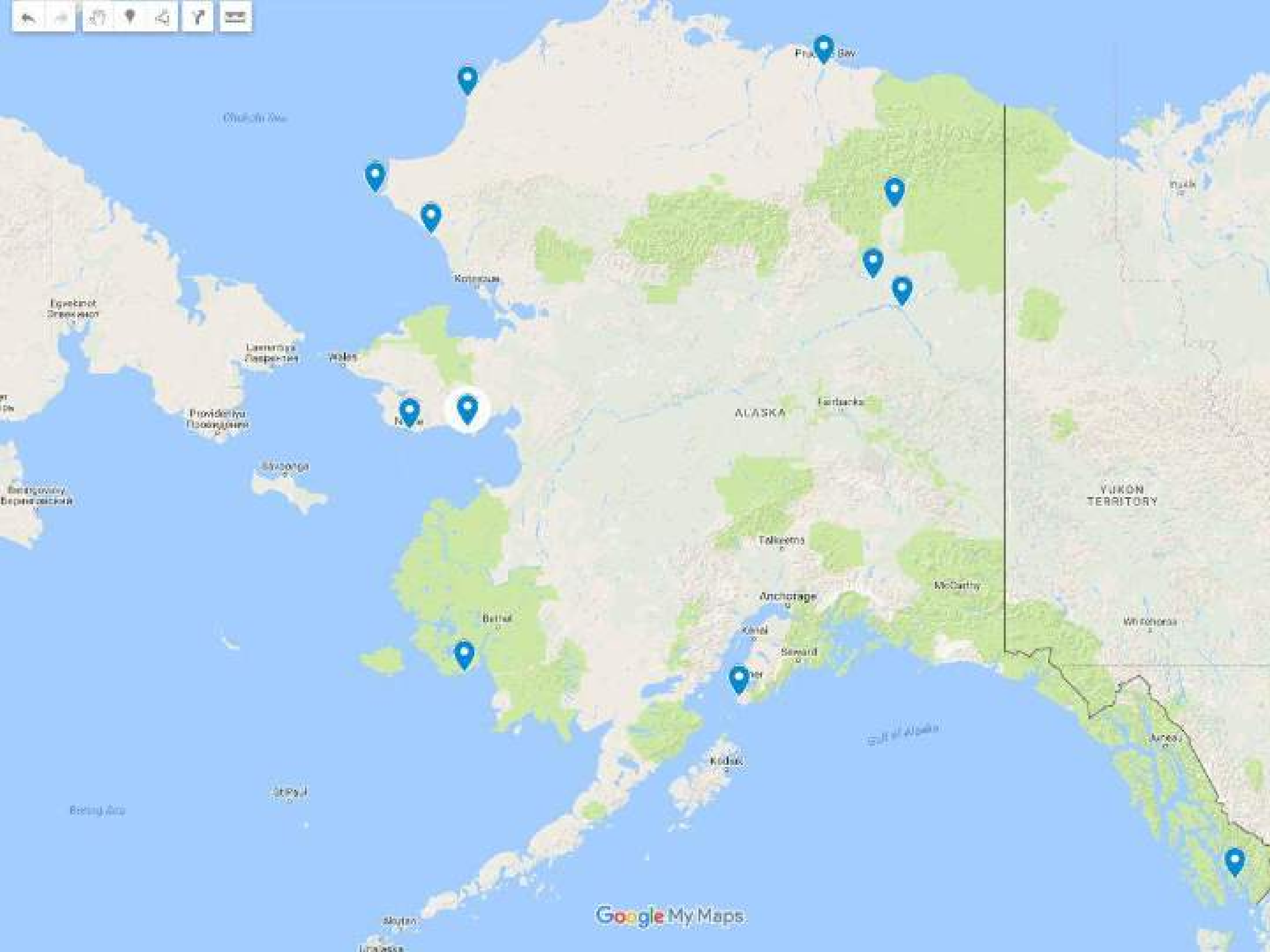
Thaw related septic system damage: Northwest Arctic Region - Selawik

Center for Climate and Health ©2011

Yukon-Kuskokwim Health Corporation

Community Water Source Type

lake water river water ground water



ALASKA
Fairbanks
Talkeetna
Anchorage
Kenai
Seward
Kodiak
Bethel
McCarthy
YUKON
TERRITORY
Whitehorse
Juneau
Wales
Kotzebue
Provideniya
St Paul
Bering Sea
Google My Maps

What are some drivers of lake change?

Decrease in snow pack.

Decrease in rainfall.

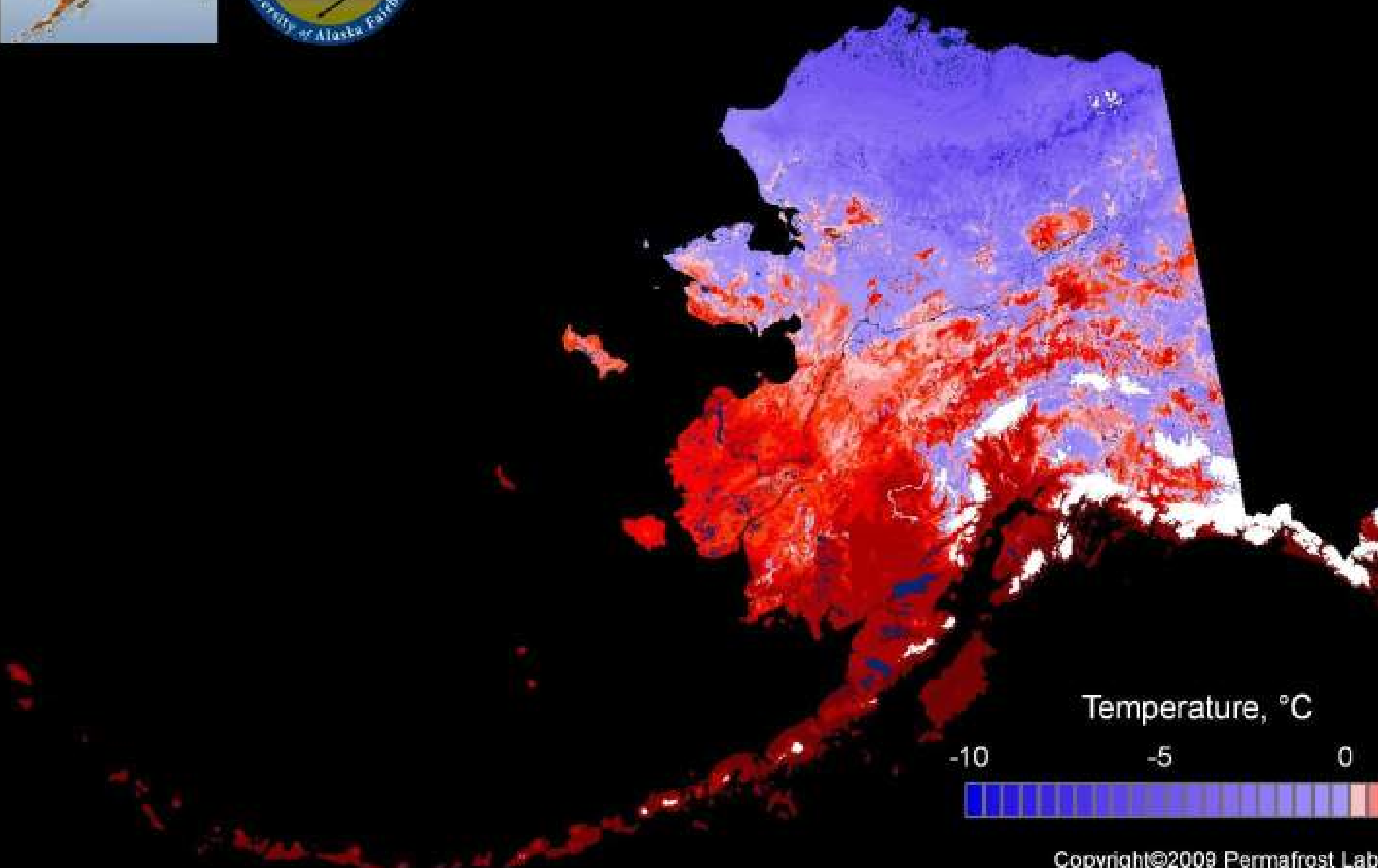
High summer temperatures.

Erosion

Thawing permafrost

Mean Annual Soil Temperatures at 1 m Depth
ALASKA 2050-2059

GIPL1.3 Permafrost Model



Lake Drying: North Slope Region – Deadhorse
(Cause - permafrost thaw)

Photo Courtesy of Vladimir Romanovsky

Source: LEO Network. Photo by Mike Sloan


Lake Drying: Interior Region - Fort Yukon
Cause - permafrost thaw(?) and drought

Lake Draining: Yukon / Kuskokwim Region – Kwigillingok

Cause - permafrost thaw (?) and erosion

Photo – Anchorage Daily News

Lake Draining: North Slope Region – Point Lay

Cause: permafrost thaw and erosion

Source: KTBA/GoogleEarth

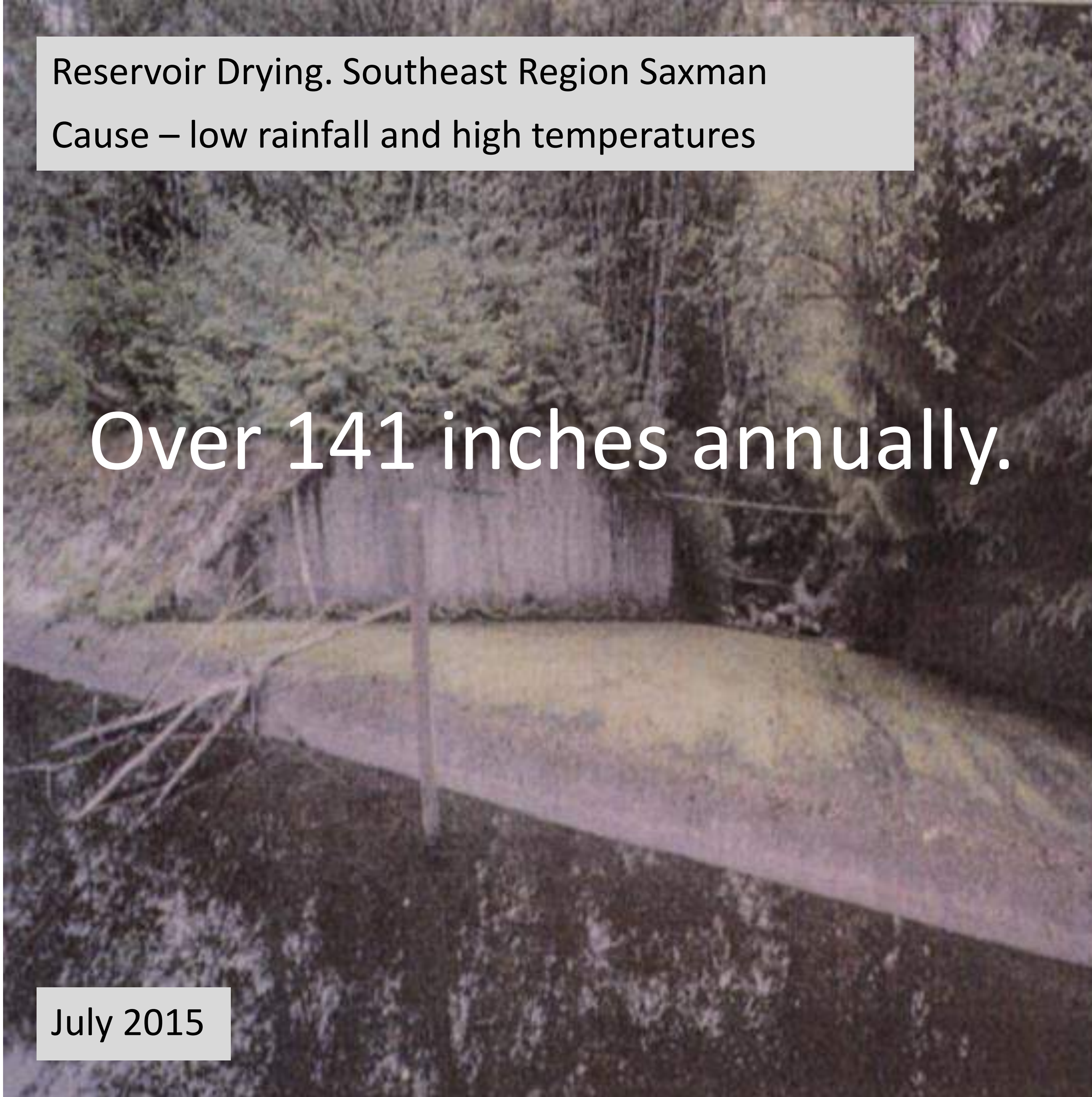
Source: LEO Network. Photo by Nancy Yeaton


River Drying. Southcentral Region - Seldovia
September 2015

Reservoir Drying. Southeast Region Saxman

Cause – low rainfall and high temperatures

Over 141 inches annually.



July 2015

Saxman tapping creek

KETCHIKAN (KDN) – The City of Saxman is using a $9,500 grant of emergency funds to add to its water supply.

Heavy rainfall usually has Saxman's water reservoir overflowing, but water levels fell far enough during the island's dry May to stop runoff, prompting the city to look for another source of potable water.

City Administrator Leona Haffner said Tuesday that she requested emergency funding from the Alaska Native Tribal Health

See 'Saxman water,' page 2

Sunday, May 11, 2014

City warns of water shortage

By **CHARLES L. WESTMORELAND**

JUNEAU EMPIRE

The City and Borough of Juneau posted a notice on its website Friday asking residents to begin conserving water due to lower-than-usual supplies for this time of year. Reservoir levels are standing at about 30 percent of usual capacity due to a string of high temperatures and low precipitation.

With reservoir low, Kodiak asks citizens to conserve water

By **Kayla Desroches, KMXT - Kodiak** - September 28, 2015

It's been a dry summer for Kodiak, which has lowered the Monashka reservoir. According to Rick Thoman, the climate science and services manager for the Alaska region of the National Weather Service, it's one of the driest seasons in Kodiak history. "Kodiak since June 1 has received just over ten inches of rain. That's just about half of normal for that time and is the second lowest of record…

What are some of the indirect effects of low water?

Increase in temperature.

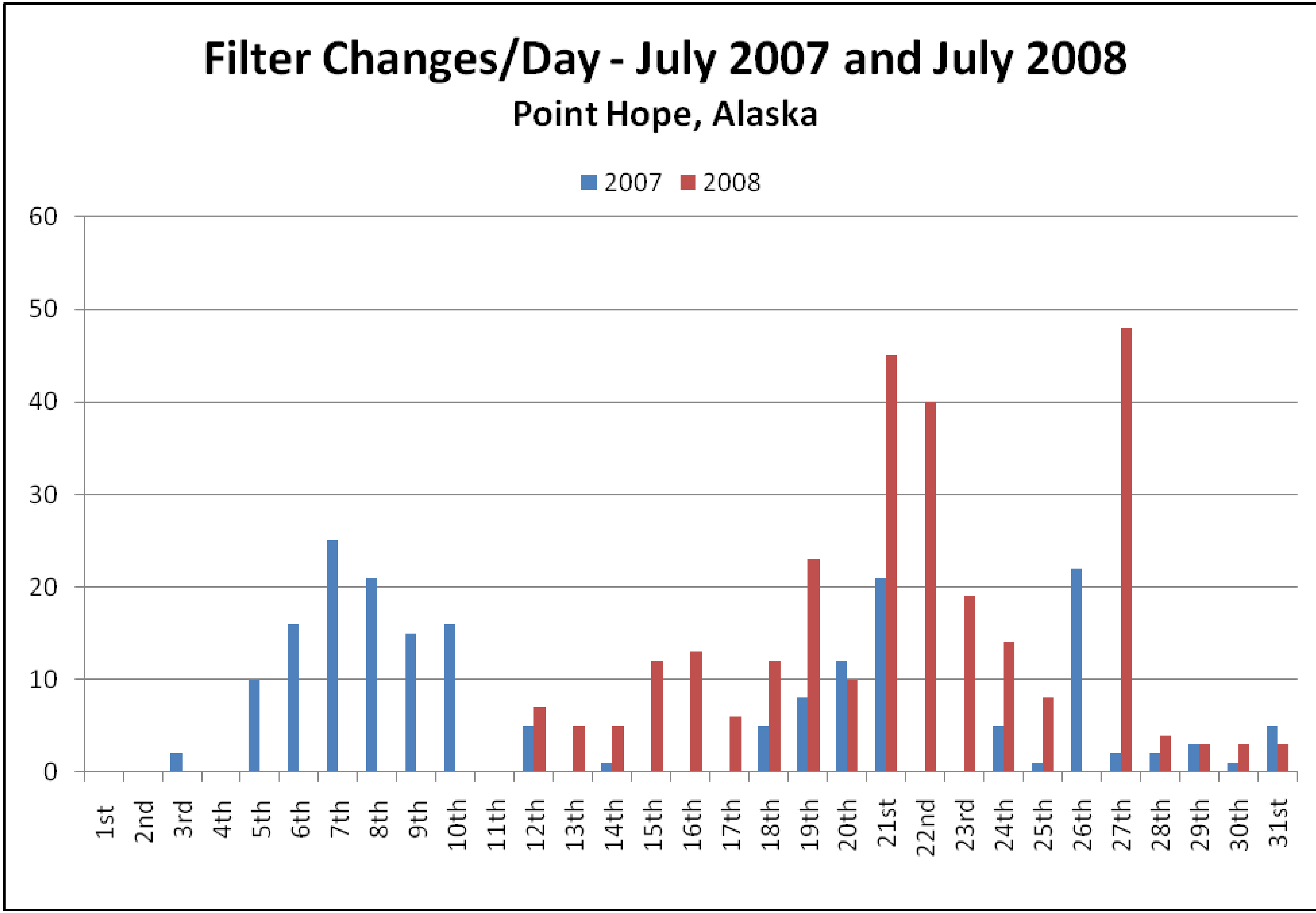
Decrease in available.

Increased growth of algae and other aquatic plants.

Lower water quality.

Increased cost of treatment.


Reservoir algae growth. Bering Strait Region - Shishmaref
Photo Courtesy Mike Black



Filter Changes/Day - July 2007 and July 2008
Point Hope, Alaska
2007
2008
60
50
40
30
20
10
0
1st
2nd
3rd
4th
5th
6th
7th
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19th
20th
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23rd
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26th
27th
28th
29th
30th
31st

What are some drivers of river change?

Decrease in snow pack.

High summer air temperatures.

Thawing permafrost

Erosion

Extreme rain or drought

Rapid plant growth

Emergence of new wildlife

Disruption of Barge Service Northwest Region

Cause: Low water level.

Fuel delivery - Noatak.

River freeze up - Arctic Village, Alaska

Cause – low water Chandlar River

River thaw feature and erosion, Interior – Chandlar River

August 2016.

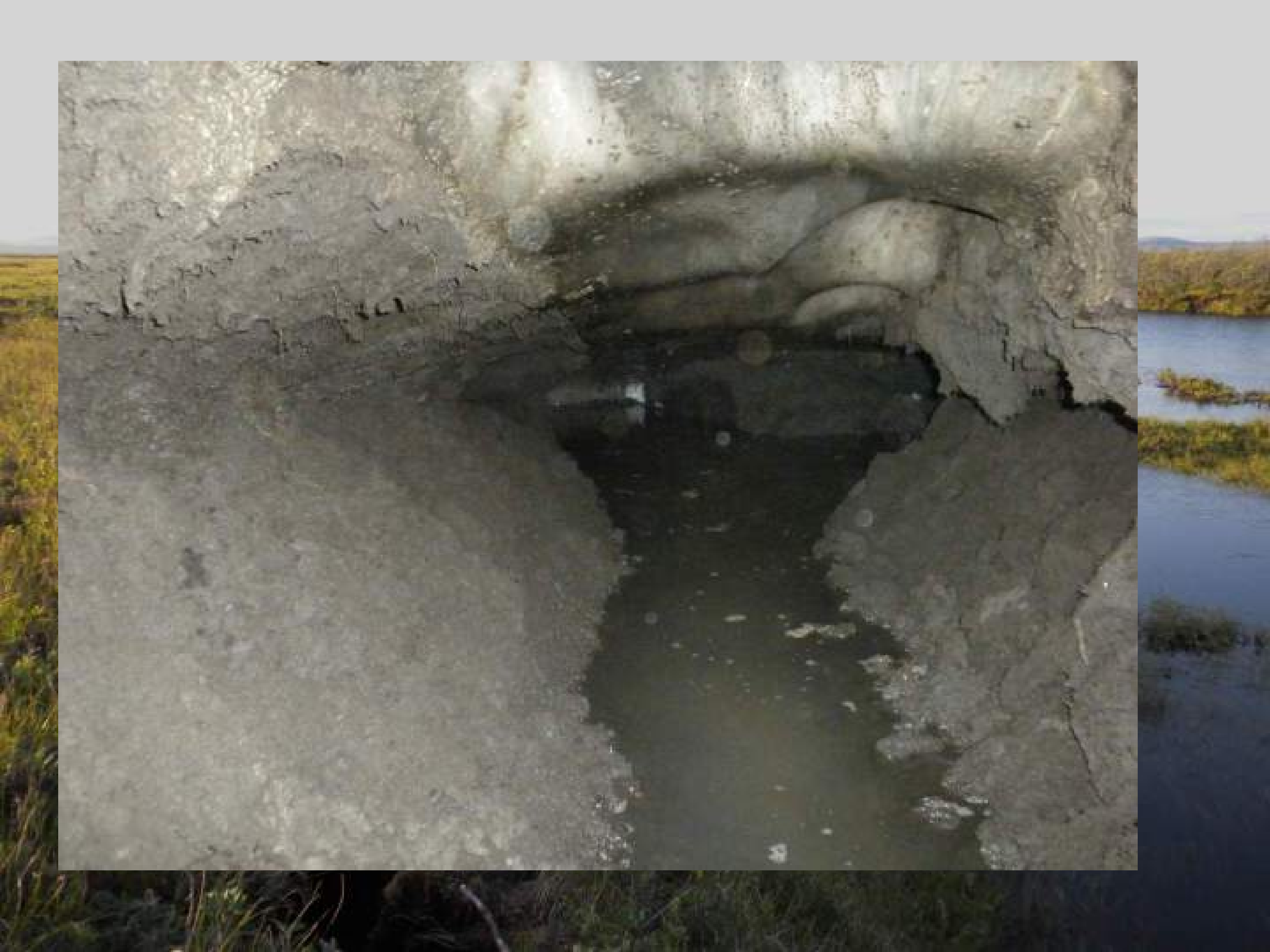

River thaw feature and erosion, Northwest Arctic - Selawik River

Community water well relocation Interior Region - Venetie

Cause: Erosion

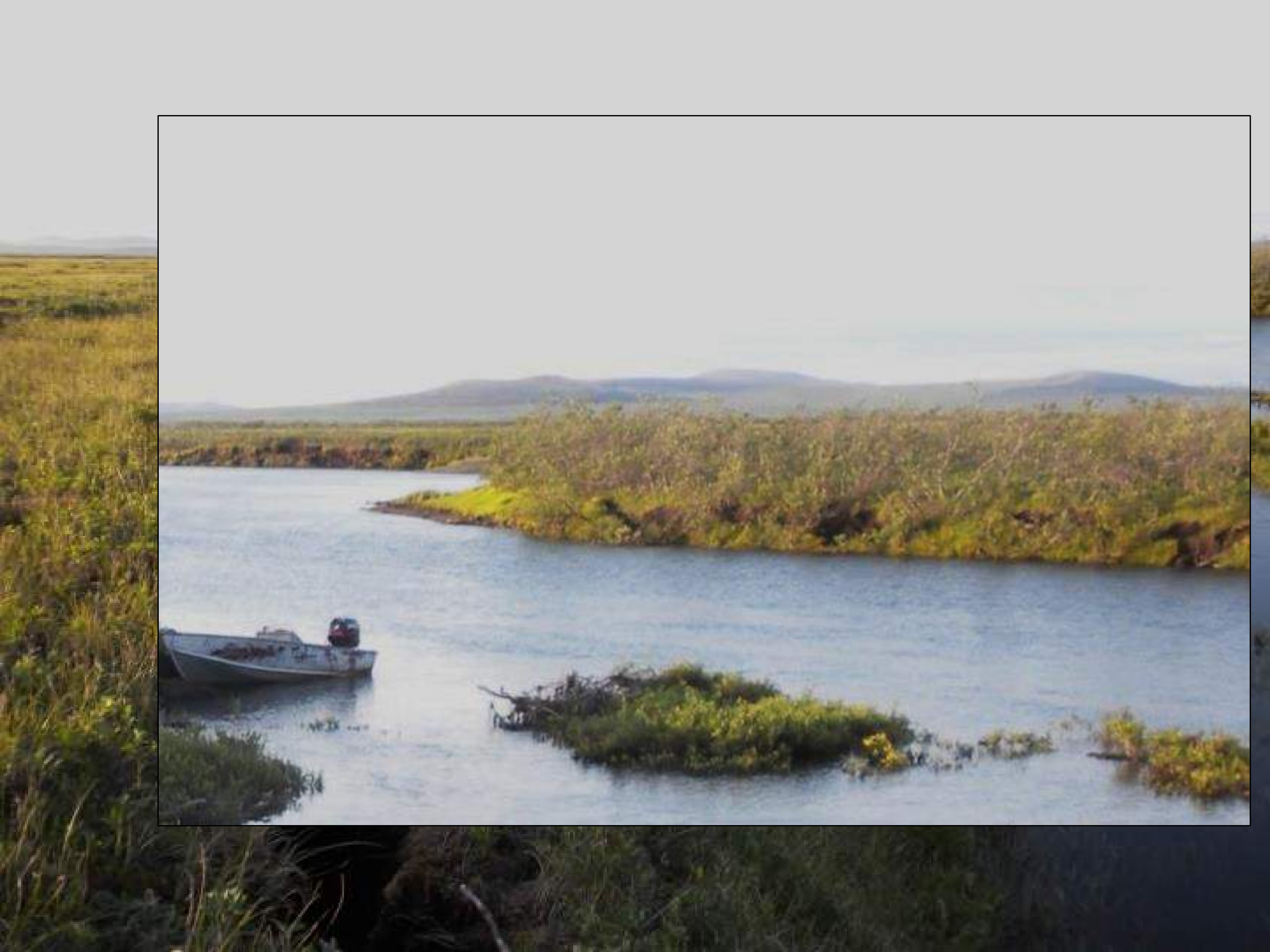
High turbidity: Norton Sound Region - Golovin.

Cause - permafrost thaw and erosion



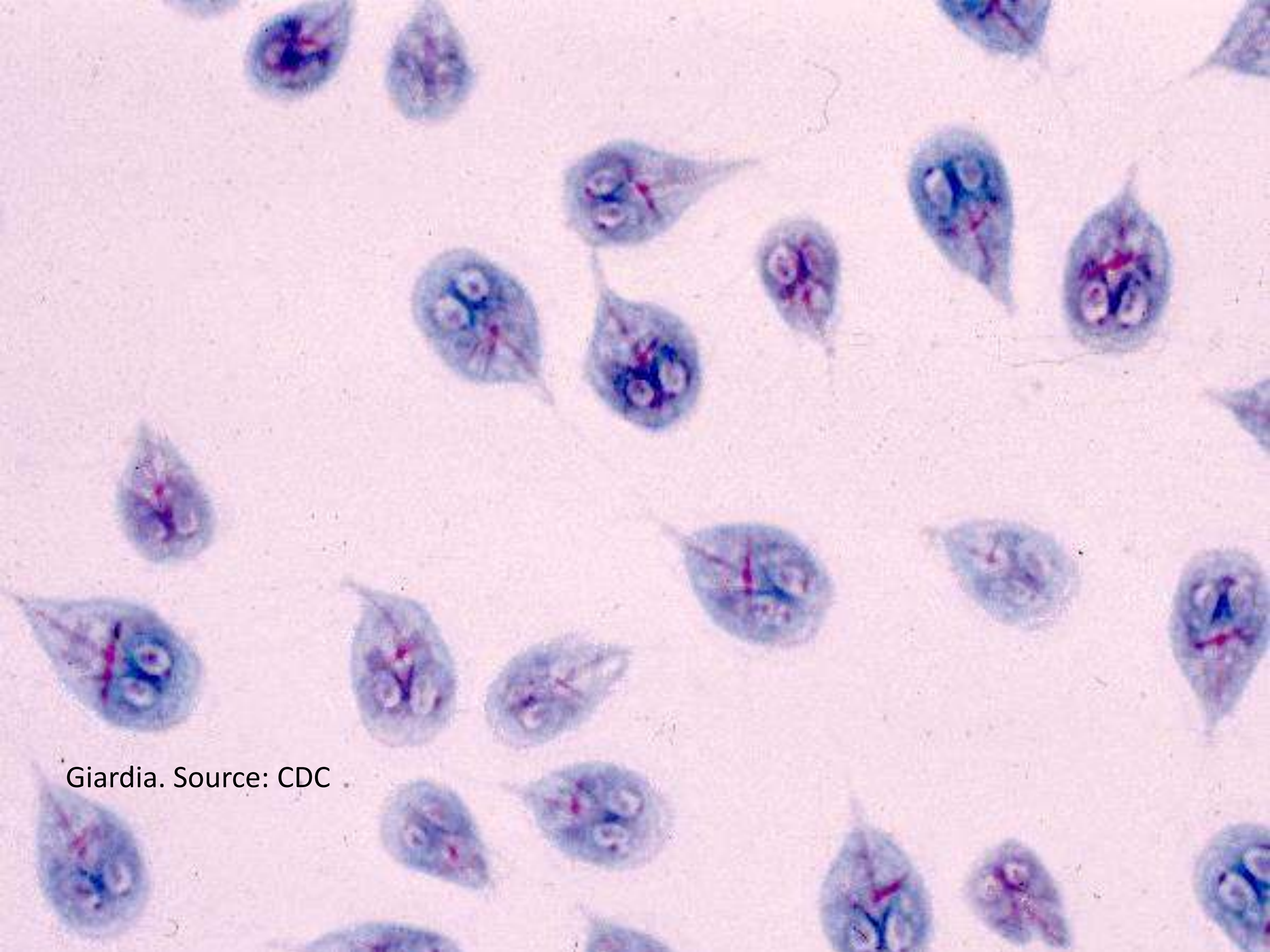
River bank thaw and erosion: Northwest Arctic - Kivalina, Alaska

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM




Source: ADFG

First evidence of beaver in Wulik River: Northwest Region - Kivalina


Giardia. Source: CDC

Water (Source) Security – Take Home

Alaska - less frozen and resilient and more thawing and fragile.

Surface water sources are climate vulnerable.

Lakes are changing and in some cases drying.

Rivers are becoming wider, shallower, and dirtier.

Both engineered and traditional sources are impacted.

The effects are statewide and have a variety of drivers.

Water source security can no longer be taken for granted.

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

mbrubaker@anthc.org

Survey on Water and Sanitation in the Arctic:
Access, Disease Surveillance, and Threats from Climate Change

Jonathan M. Bressler, MPH[1,2]

Thomas W. Hennessy, MD, MPH[3,4]

[1] Section of Epidemiology, Division of Public Health, Alaska Department of Health and Social Services, Anchorage, AK, USA

[2]Applied Epidemiology Fellow, Council of State and Territorial Epidemiologists, Atlanta, GA, USA

[3]Arctic Investigations Program, National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention (CDC), Anchorage, AK, USA

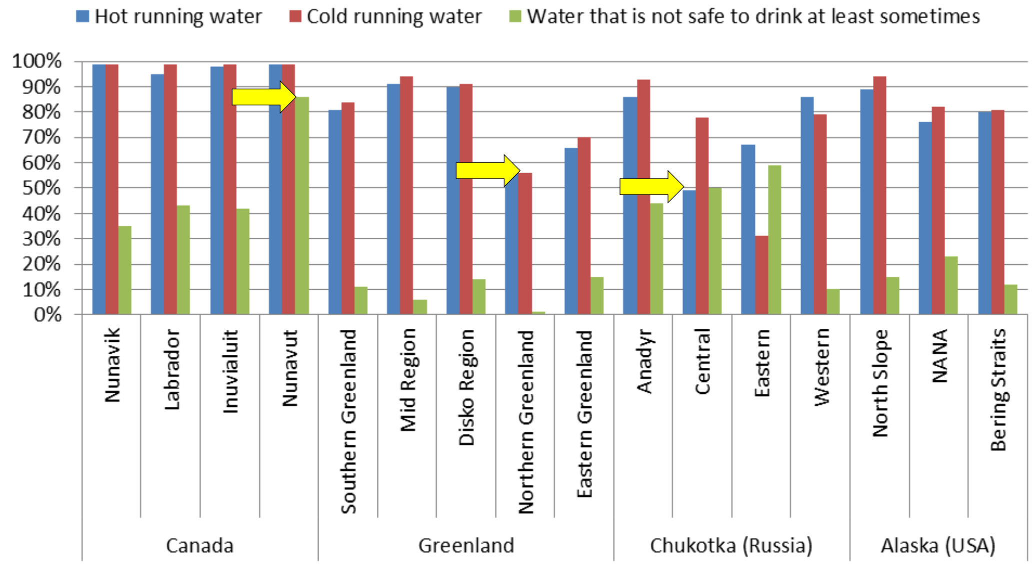
[4]Arctic Human Health Experts Group, Sustainable Development Working Group, Arctic Council

Sustainable Development Goal 6: Ensure access to water and sanitation for all

- **Millennium Development Goal #7: Ensure environmental sustainability**
  - Target 7.C: Halve proportion of world population without improved drinking water and basic sanitation by 2015.
  - Accomplished goal in 2010.
- **2010 UN General Assembly Resolution 64/292:**
  1. Recognized access to safe and clean drinking water as a human right.
  2. Called upon States and international organizations to provide resources and cooperate to achieve safe drinking water and sanitation for all.
- **Sustainable Development Goal #6: Ensure access to water and sanitation for all**
  - By 2030…
    - achieve universal access to safe and affordable drinking water for all.
    - achieve access to adequate sanitation and hygiene for all.
    - implement water resource management at all levels, and through trans-boundary cooperation.
  - Support and strengthen the participation of local communities in improving water and sanitation management.

Water and Sanitation in the Arctic

- *Survey of Living Conditions in the Arctic (SLiCA)*, 2001–2006*



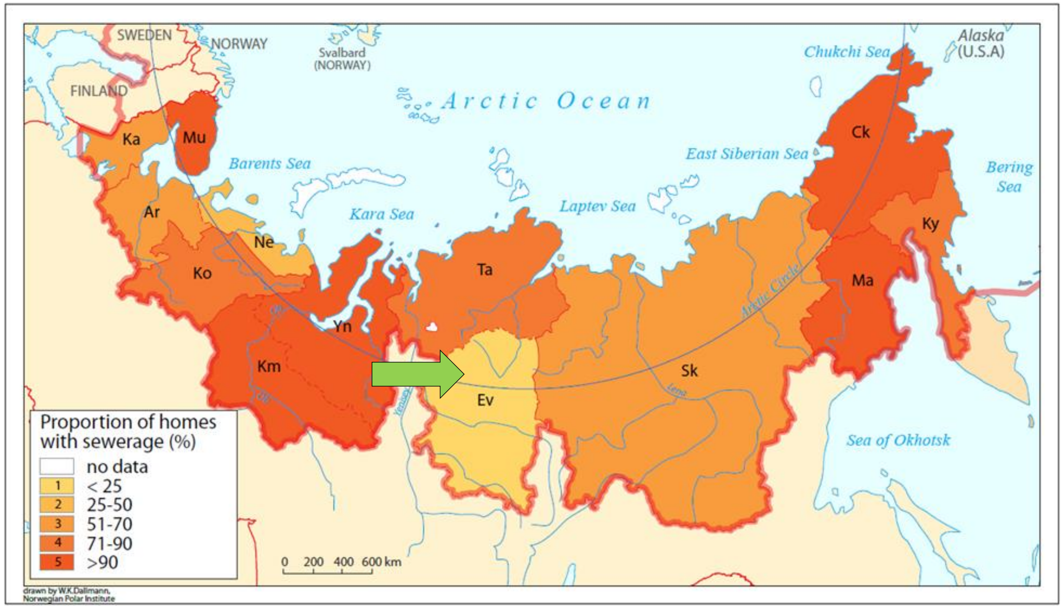
In-home water service in the Arctic by sample community

- Hot running water as low as 49% (Central Chukotka)
- Cold running water as low as 56% (Northern Greenland)
- Water that is sometimes unsafe to drink as high as 86% (Nunavut)

*Poppel B, Kruse J. Survey of living conditions in the Arctic.

Water and Sanitation in the Arctic

- *UN National Human Development Reports 2006/2007**



Proportion of homes in Arctic Russian regions with sewerage installation

- Some areas of Russia estimated to have under 25% of homes with household sewerage. (Evenkia)

*United Nations. National Human Development Reports 2007.

Water and Sanitation in the Arctic

- *Healthy Alaskans 2020* estimates that in 2010, **78% of rural Alaskan homes had water and sewer service**.[1]
  - Among all Alaskan homes, 95.6% have complete plumbing. [2]
  - Among all U.S. homes, 99.6% have complete plumbing. [2]

- Access to water and sewer is still inadequate, and SDG #6 for access to water and sewer service for all has not been achieved in the Arctic region.

- Higher water service has been associated with lower rates of water-washed disease in the Arctic, such as skin and respiratory tract infections.[3,4]

1. State of Alaska. Healthy Alaskans 2020. Leading Health Indicator #19.
2. US Census, American Community Survey.
3. Hennessy T, et al. The relationship between In-home water service and the risk of respiratory tract, skin, and gastrointestinal tract infections among rural Alaska natives. Am J Public Health. 2008;98:2072–8.
4. Gessner BD. Lack of piped water and sewage services is associated with pediatric lower respiratory tract infection in Alaska. J Pediatr. 2008;152:666–70.

Climate Change Threats to Water and Sanitation

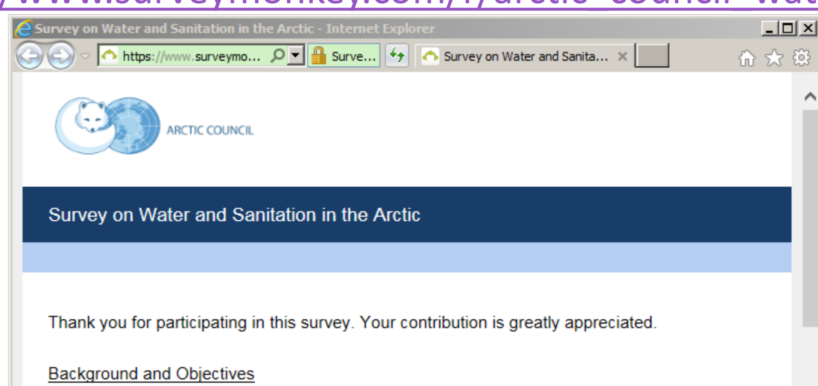
- Climate change poses threats to water and sanitation.
  - Accelerated erosion and increased storm intensity damages infrastructure.[1]
  - Permafrost melting and drainage of tundra ponds have caused loss of source water.[2]
  - Saltwater intrusion into wells have resulted from rising sea levels.[2]
  - Similar events have likely gone undocumented.

- Resources must be secured to maintain and improve water and sanitation services for the health of Arctic residents.

1. Warren JA, Berner JE, Curtis T. Climate change and human health: infrastructure impacts to small remote communities in the North. Int J Circumpolar Health. 2005;64:487–97.
2. Arctic Climate Impact Assessment (2005). Cambridge University Press.

Assessing the Current Status of Water and Sanitation in the Arctic

- Arctic Council project:
  - "Improving Health through Safe and Affordable Access to Household Running Water and Sewer in Arctic and Sub-Arctic communities."
  - Objectives:
    a) Promote innovations in water and sewer technologies and services provision.
    b) Document the status of water and sewer service and associated health outcomes.
    c) Describe climate-related vulnerabilities and adaptation strategies for community water and sewer systems and source water protection.
  - Last two objectives addressed in **Survey on Water and Sanitation in the Arctic**: https://www.surveymonkey.com/r/arctic_council_water_sanitation



Methods

ARCTIC COUNCIL

Survey on Water and Sanitation in the Arctic

- Three-part survey:
  - Access to water and sanitation services
  - Water- and sanitation-related disease surveillance
  - Climate or environmental changes affecting water and sanitation

- Distributed survey to professionals in health, water and sanitation; government authorities; and interested residents in the Arctic nations.

- Survey is open through September 2016.

Preliminary Results: Respondent Profile

Number of complete responses, by country and survey section

	Canada	Finland	Greenland	Iceland	Norway	Sweden	Russia	US (Alaska)
Total	**5**	**3**	**3**	**1**	**1**	**3**	**0**	**32**
Water & Sanitation	5	3	1	1	1	3	0	30
Disease Surveillance	1	0	1	1	1	1	0	7
Climate	3	0	1	1	1	1	0	12

Number of complete responses, by country and professional affiliation

	Canada	Finland	Greenland	Iceland	Norway	Sweden	US (Alaska)
National government authority			1	1	1		1
Local government authority	3	3	1			3	6
Tribal or indigenous organization							11
Community member							8
Other expert or interested party	2		1				6

Preliminary Results: Water & Sanitation

- Most respondents reported >90% access to improved water and sanitation in homes, schools, and health centers in their area.
  - However, responses describe mainly large national or provincial populations, while some small towns and villages have no services.
  - Responses are unreliable due to approximation, likely misunderstanding of definitions, and lack of empirical evidence provided for data.

Preliminary Results: Water & Sanitation

Water service used by most of population, according to respondents

	Canada	Finland	Greenland	Iceland	Norway	Sweden	US (Alaska)
Total respondents	**5**	**3**	**1**	**1**	**1**	**3**	**30**
Centralized piped distribution	4	3	1	1	1	3	13
Vehicle or self-haul with plumbing							2
Self-haul without plumbing							5
Private well							3
Other	1						

Sanitation service used by most of population according to respondents

	Canada	Finland	Greenland	Iceland	Norway	Sweden	US (Alaska)
Total	**5**	**3**	**1**	**1**	**1**	**3**	**30**
Centralized piped distribution		2		1	1	3	12
Vehicle or self-haul with plumbing	4						1
Private septic							2
Pit latrine							2
Composting, electric, or chemical toilet							
Honey bucket							4
Other							

Preliminary Results: Water & Sanitation

Water quantity and wastewater treatment standards according to respondents

	Water quantity standard	Is quantity standard met?	Are there a wastewater treatment standards?	Are treatment standards met?
Canada	90 L/p trucked 225-250 L/p piped	Yes (2) No (2)	Yes (3) No (1)	-- No (4)
Finland	120 L/p	Yes (2) --	Yes (2) --	Yes (2) --
Greenland	No standard	N/A	No response	N/A
Iceland	No standard	N/A	Yes (1) --	Yes (1) --
Norway	200 L/p	Yes (1) --	Yes (1) --	Yes (1) --
Sweden	No standard	N/A	Yes (2) --	Yes (2) --
US (Alaska)	Responses varied	Yes (43) No (6)	Yes (20) No (3)	Yes (12) No (7)

L/p = liters per person per day

Notable Water & Sanitation Information

- Canada-Nunavut Agreement on the Transfer of Federal Gas Tax Revenues under the New Deal for Cities and Communities 2005 – 2015
  - “The infrastructure found in the majority of communities in Nunavut are beyond their useful lifecycle and many are inefficient, expensive to operate, and potentially hazardous to the community and the environment. These deficiencies are particularly evident in critical components such as water, wastewater, and solid waste infrastructure, where renovations/repairs are desperately needed to keep pace with expanding communities.”

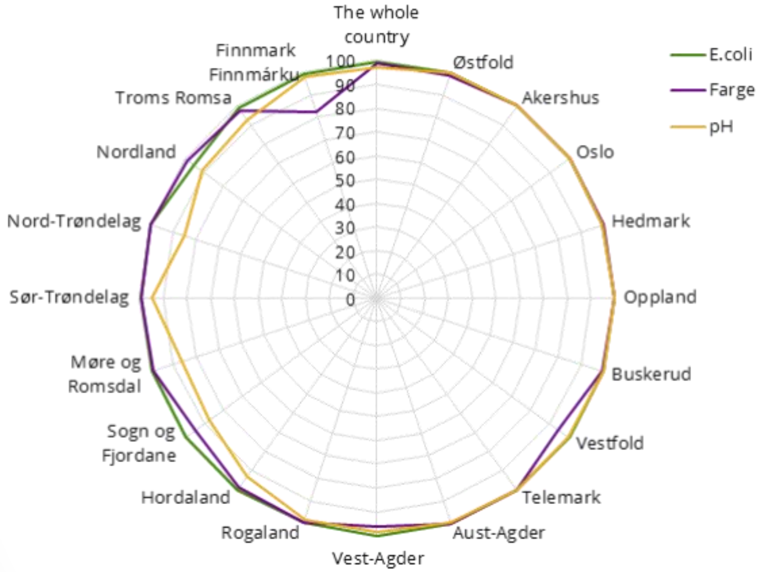
- Northwest Territories 2013 Water Quality Summary
  - Annual summary of water quality in public systems throughout province

Community	Water Source	Certified Operator	Treated Water Bacteria Tests (% of compliance, 48 required, 216 for Yellowknife)			Treated Water Chemical Tests (1 required)			Community	Plant Classification	Water Treatment Process
			2013	2012	2011	2013	2012	2011			
Aklavik	Mackenzie River (Peel Channel)	✓	100%	100%	88%	✓	✓	✓	Aklavik	Class II	Conventional (Coagulation, Flocculation, Storage
Colville Lake	Colville Lake	×	*63%	*35%	*7%	✓	✓	✓	Colville Lake	Small System	Cartridge Filtration, Chlorination, Storage
Déline	Great Bear Lake	✓	100%	100%	100%	✓	✓	✓	Déline	Small System	Cartridge Filtration, UV, Chlorination, Stor
Dettah	Yellowknife River		59%	27%	27%	N/A			Dettah	N/A	Chlorination
Behchokǫ̀ (Edzo)	West Channel	✓	77%	100%	100%	✓	✓	✓	Behchokǫ̀ (Edzo)	Class II	Conventional (Coagulation, Flocculation, Storage
Behchokǫ̀ (Rae)	Marian Lake	✓	77%	100%	100%	✓	✓	✓	Behchokǫ̀ (Rae)	Class II	Conventional (Coagulation, Flocculation, Storage
Enterprise	Town of Hay River		N/A						Enterprise	N/A	see Town of Hay River
Fort Good Hope	Mackenzie River	✓	100%	100%	95%	✓	✓	✓	Fort Good Hope	Class I	Membrane filtration, Chlorination and Stor
Fort Liard	Groundwater Well	✓	100%	100%	100%	✓	✓	✓	Fort Liard	Class I	Potassium Permanganate Assisted Green
Fort McPherson	Deep Water Lake	✓	100%	100%	100%	✓	✓	✓	Fort McPherson	Class II	Conventional (Coagulation, Flocculation,

Notable Water & Sanitation Information

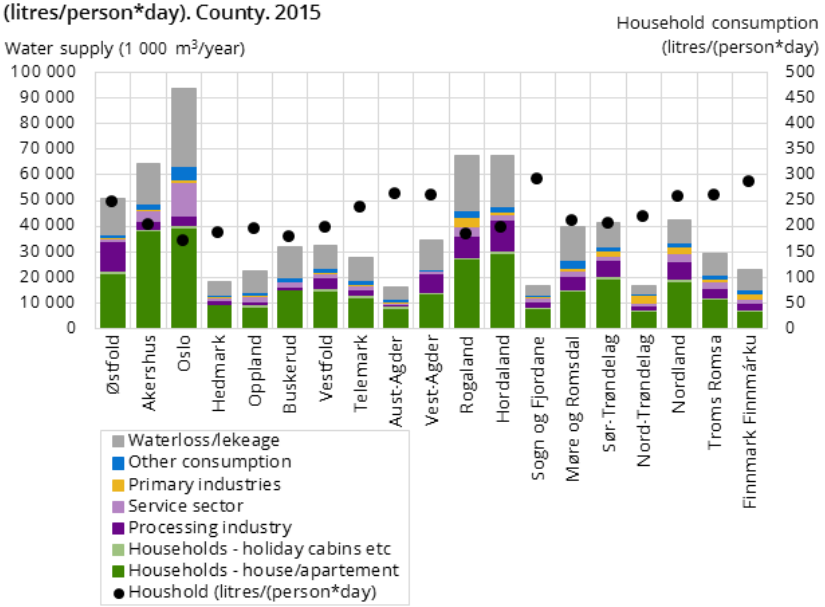
- Report on Municipal water supply in Norway, 2015
  - Only in municipalities, not rural areas

Figure 1. Per cent inhabitants connected to public waterworks supplied with safe drinking water with regard to E.coli, colour and pH. 2015



Source: Statistics Norway.

Figure 2. Water supply by sector (1 000 m³/year) and spesific household consumption (litres/person*day). County. 2015



Source: Statistics Norway.

Preliminary Results: Disease Surveillance

- Most *water-borne* infections are reported to public health authorities, but few *water-washed* infections are reported.
  - Skin and lower respiratory tract infections rarely reportable.
- Responses vary on which specific infections are reported.
  - *Influenza* and *pneumoniae* infections reportable in Alaska and Canada.
  - *Influenza* not reported in Sweden unless H1N1.
  - *Hep A, Typhoid, Cholera, Shigellosis, Campylobacter, Salmonella, Giardia, Legionella, Cryptosporidia,* and *Vibrio* reportable in Canada, Iceland, Norway, Sweden, and US (Alaska)

- Other existing data systems according to respondents
  - **Population registries** in Greenland, Iceland, Sweden and United States
  - **National patient registries** in Greenland and Sweden
  - **Electronic health records** in Canada, Greenland, Iceland, Sweden and United States
  - **Other data systems** in Norway (MSIS; outbreak alert) and Sweden (emergency calls; syndromic surveillance)

Preliminary Results: Climate Change

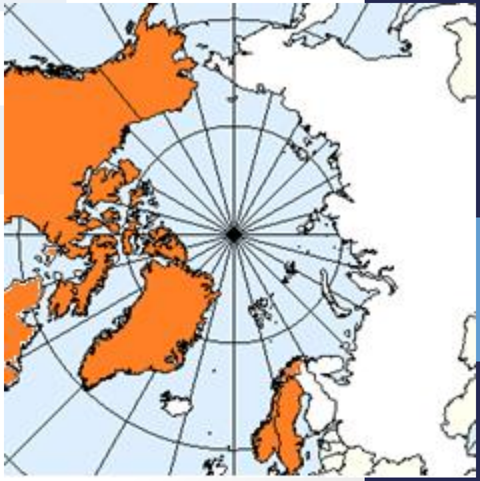
- **Decreases in source water <u>quantity</u>** were reported in Alaska, Canada, Greenland and Sweden.

	Respondents reporting water quantity decrease
Total respondents	**20**
Decrease in groundwater supply	4
Loss or decrease of tundra pond water or other surface water	8
Change in the course of a river that reduced access to water	6
Other decrease in quantity or volume not described here	4
No decrease in water quantity has been observed	1
Respondent was unaware of any decreases in water quantity	6

Preliminary Results: Climate Change

- **Decreases in source water *quality*** were reported in Alaska, Canada, Greenland, Norway and Sweden.

	Respondents reporting water quality decrease
Total respondents	**20**
Increased salt content, dissolved solids, or other contaminants in groundwater	3
Flooding of coastal areas by storms, causing contamination of surface water with seawater	3
Increased salt and bromide content in river intakes due to sea-level rise	0
Excessive algal, bacterial, fungal, insect, or other biological growth in source water	2
Other decrease in quality not described here	5
No decrease in water quality has been observed	3
Respondent was unaware of any decreases in water quality	6

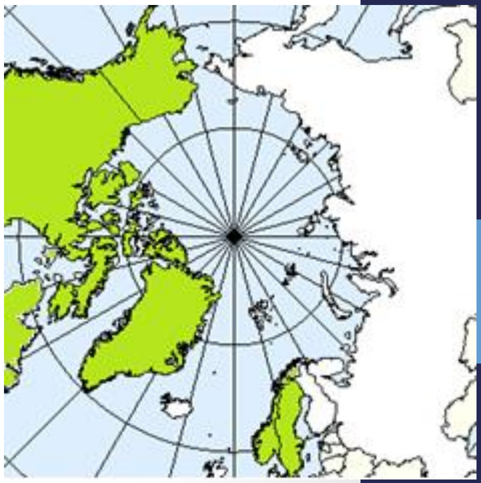


- Other decreases in water *quality* described:
  - Change in water color

Preliminary Results: Climate Change

- **Damage to water or sanitation infrastructure** was reported in Alaska, Canada, Greenland, Norway and Sweden.

	Respondents reporting infrastructure damage
Total respondents	**20**
Damage to infrastructure due to high overland water flow (runoff) after intense storms.	5
Damage to infrastructure from riverbank erosion after intense rainstorms.	6
Damage to structure founded on frozen soil due to thawing permafrost	8
Damage to other water infrastructure due to event(s) not described here.	3
No damage to water infrastructure has occurred.	0
Responded was unaware of any damage to water infrastructure.	8



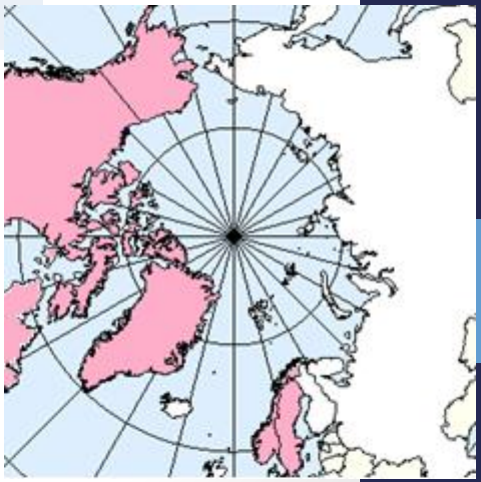
Preliminary Results: Climate Change

- Other infrastructure damage described:
  - Leaking water reservoir due to berm instability (thawing). (Nunavut)
  - ANTHC Climate Change Assessment Reports (Alaska): http://anthc.org/what-we-do/community-environment-and-health/center-for-climate-and-health/climate-health-3/
    - Describe flooding, erosion, water quality and quantity decreases, infrastructure damage, health effects, etc.
  - Failure of buried water distribution and collection systems, requiring temporary installation of tanks until an above-ground system can be built. (Alaska)
  - Dam safety incidents due to power cuts during intense storms, land collapse, rising water level. (Finland)

Preliminary Results: Climate Change

- **Climate-related maintenance issues** were reported in Alaska, Canada, Greenland, Norway and Sweden.

	Respondents reporting maintenance issues
Total respondents	**20**
Use of dirty, contaminated, or unsafe water due to high cost of repairing or replacing damaged structures or contaminated water sources.	4
Increase in cost of operations and maintenance.	9
Other operations or maintenance issue(s) caused by climate change not described here.	5
No climate- or environment-related maintenance issues have occurred.	0
Respondent was unaware of any climate- or environment-related maintenance issues.	7

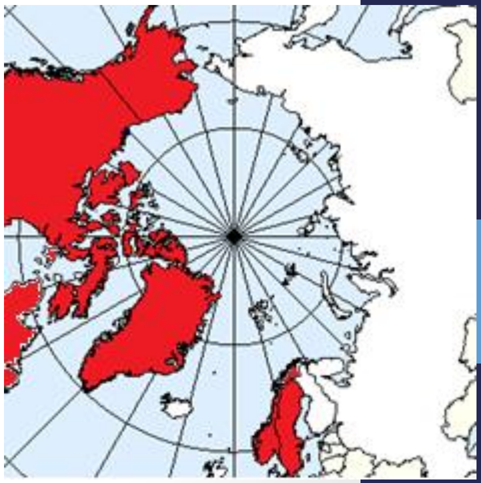


Preliminary Results: Climate Change

- Other maintenance issues described:
  - Need for installation of flexible service lines to minimize damage following buildings shifting due to freeze/thaw cycles and melting permafrost. (Alaska)
  - Stalling or incompletion of infrastructure projects due to lack of funding. (Alaska)

Preliminary Results: Climate Change

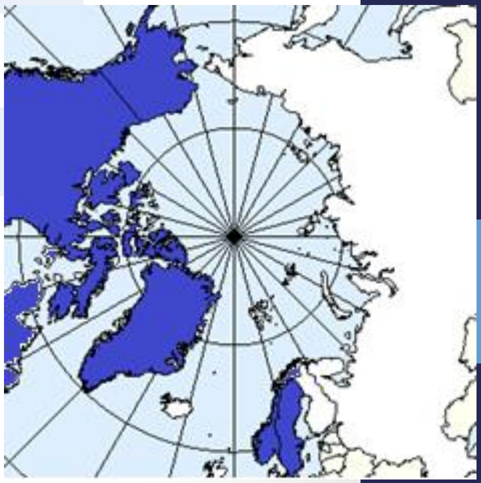
- **Climate change has affected planning** of infrastructure in Alaska, Canada, Greenland, Norway and Sweden.
- Examples of planning changes due to climate change threats:
  - Lining reservoirs since relying on permafrost is no longer realistic. (Nunavut)
  - Chemical and UV treatment upgrades. (Sweden)
  - Protective walls in treatment plant to prevent contamination from floods. (Sweden)
  - Some communities to receive funding for decentralized in-home water and sanitation systems to ease relocation following erosion, etc. (Alaska)
  - Planned research to address climate change-caused infrastructure problems. (Greenland)
  - Climate change adaptation plans for some countries.



Preliminary Results: Climate Change

- **Water treatment has been affected** in Alaska, Canada, Greenland, Norway and Sweden.

	Respondents reporting effects on water treatment
Total respondents	**20**
Rise in bromide concentration requiring treatment of water source.	1
More difficult to appropriately treat water after increase in turbidity, pathogens, or natural contaminants in the water.	6
More frequent or severe algal blooms affecting water treatment.	0
Other treatment issue(s) not described here.	5
Water treatment has not been affected by climate change.	2
Respondent was unaware if water treatment had been affected by climate change.	8



Preliminary Results: Climate Change

- Other treatment issues described:
  - Storm water entry into sewage plants reduces the effectiveness of water treatment. (Norway)
  - More rapid clogging of filters. (Alaska)
  - Greater organic loads in source water requires stronger chemical treatment, resulting in more disinfection byproducts. (Alaska)

Preliminary Results: Climate Change

- Respondent from Iceland reported only being **unaware of climate-related changes** to water and sanitation infrastructure.
  - Quantity or quality decreases and damage might have occurred without respondent's knowledge.
  - Other climate-related incidents have likely occurred in all Arctic nations that have not been noted.

- No responses on climate change were received from Russia or Finland.

Preliminary Conclusions

- The picture of water and sanitation access in the Arctic is incomplete, but clearly Sustainable Development Goal #6 has not yet been achieved in many areas of the circumpolar north.

- Reportable water- and sanitation-related diseases are not consistent across the region.
  - **Water-borne** infections are usually reportable to public health officials, while few **water-washed** infections are.

- Climate change has caused decreases in water quality and quantity, infrastructure damage, maintenance and treatment issues, and has affected planning in almost all Arctic countries.

- As remote communities build infrastructure to increase access to water and sanitation, they must also address how climate change may damage or burden that infrastructure.

Limitations

- Survey not comprehensive.
- Reported numbers in the survey are unconfirmed, and some responses and data for the same areas are discordant.
- Unclear definitions may affect responses.

- However…
  - Survey results clearly show that areas of very low water and sanitation service exist in the Arctic.
  - Responses indicate previously unrecognized climate-related issues that will affect water and sanitation access in the future.
  - A comprehensive picture of water and sanitation issues in the Arctic is needed.

Lessons Learned

- The amount of numerical water and sanitation data requested was excessive and mostly uninformative.
  - Few respondents had access to empirical data on number served with water/sewer services.
  - Length of section likely detracted from survey completion.

- Translation into other languages in the Arctic region may improve survey completion and response.
  - Russian language version may have attracted greater response from Russia.

The survey is still open!

- Experts and officials representing Arctic and Sub-Arctic areas are encouraged to complete the survey.
- Survey results will be published and reported to the Arctic Council, and included in summary proceedings of the WIHAH conference.

- Responses will be collected through the end of September 2016.
- Survey URL:
  - https://www.surveymonkey.com/r/arctic_council_water_sanitation

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Charting a new direction for wastewater treatment in the Canadian north

Ken Johnson
Planner, Engineer, and Historian

Cryofront
Cool Ideas

With support from
Arctic Council
National Research Council of Canada
Stantec Consulting Ltd.

Charting a new direction for wastewater treatment in the Canadian North

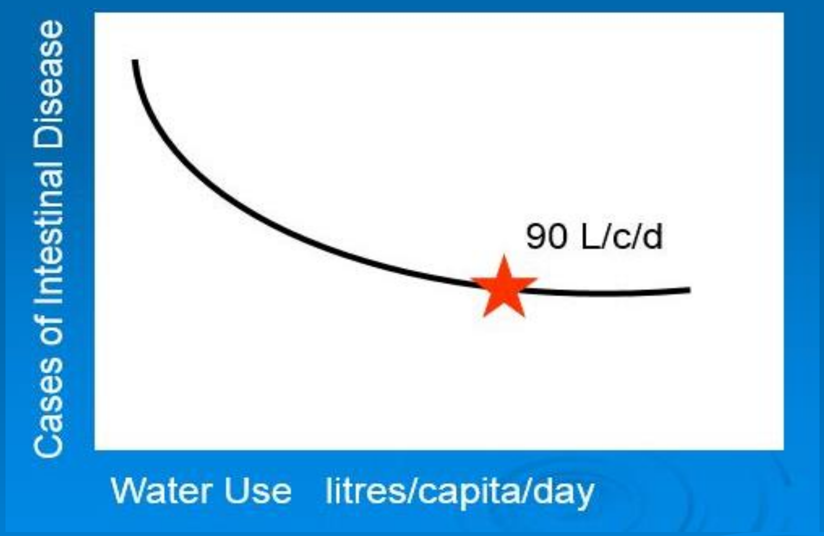
The Canadian north is big… really BIG

Alaska 1.72 million km2 Northern Canada 3.92 million km2

Charting a new direction for wastewater treatment in the Canadian North

Standards and Criteria

Based upon 1980's research, a water and sewer policy was developed and implemented based upon public health of a minimum water use of 90 litres/capita/day. This became the design standard for trucked water supply and all of the associated infrastructure.



A water and sewer subsidy began with the baseline being the cost of water in Yellowknife which was 0.2 cents per litre – subsidies were provided for residential use in all communities for all operation and maintenance costs above the Yellowknife benchmark.

Charting a new direction for wastewater treatment in the Canadian North

Cost of Water and Sewer in Canadian North

Grise Fiord, Nunavut - Operation and Maintenance

Year	Water $	Sewer$	Total$
2001	234,391	100,200	334,591
2002	255,959	109,696	365,655

$2240 per capita per year in 2002 or 6.4 cents per litre

Water use - 5,678,500 litres per year or 95 litres per capita per day

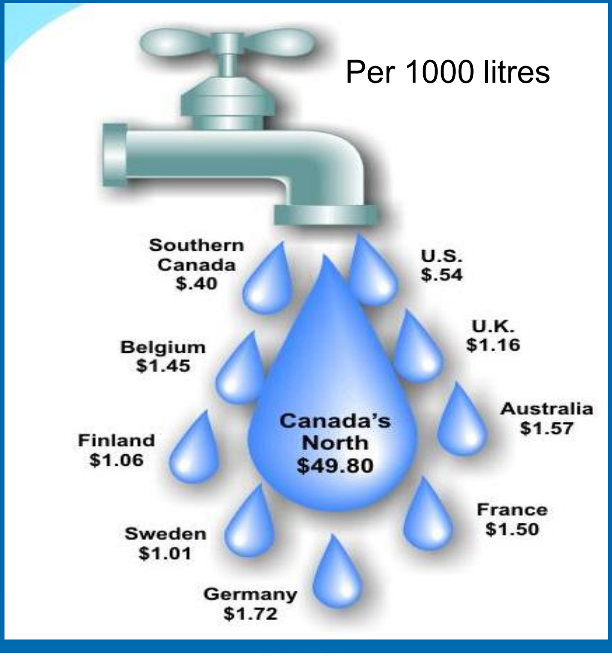
Whati, NT - Operation and Maintenance

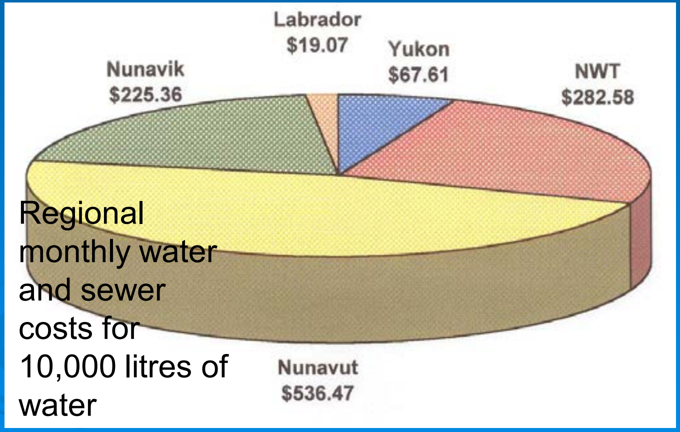
Year	Water$	Sewer$	Total$
2001	167,800	71,900	239,700
2002	184600	79,100	263,700

$580 per capita per year in 2002 or 2.3 cents per litre

Water use: 11.5 million litres per year or 70 litres per capita per day

0.12 cents per litre in Edmonton, Alberta



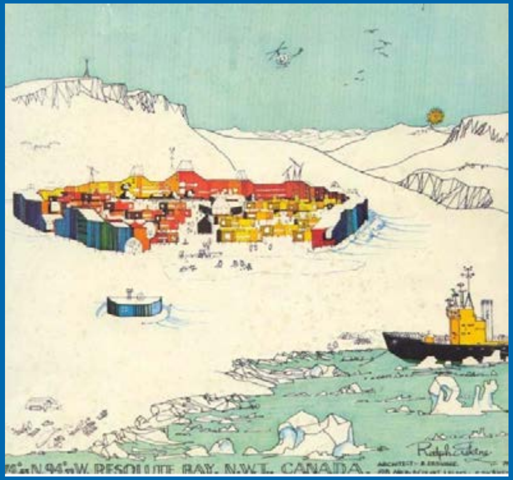


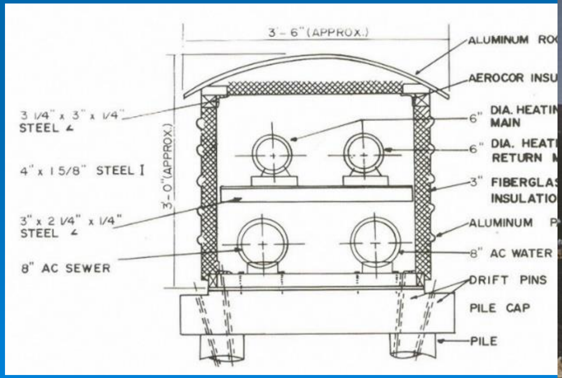
Charting a new direction for wastewater treatment in the Canadian North

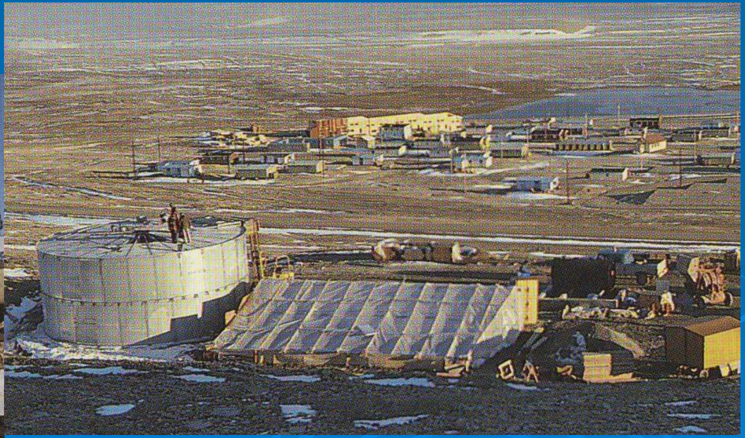
Innovation History

1960 Inuvik utilidor

1975 Resolute buried water and sewer







Charting a new direction for wastewater treatment in the Canadian North

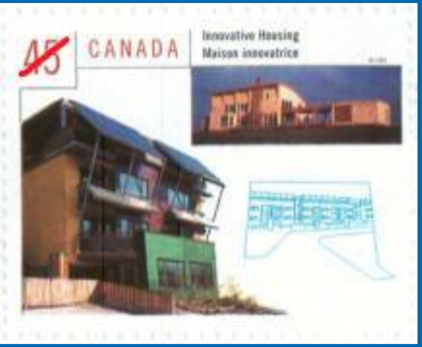
Innovation History

1985 Iqaluit buried water and sewer system

1995 Wetland wastewater treatment systems

Buried water and sewer system in Iqaluit

Charting a new direction for wastewater treatment in the Canadian North



Innovation History

1998 On site water reuse in the north
1998 Iqaluit wastewater treatment facility
2006 Bundled water treatment project
2010 Dawson WWTP or WTF

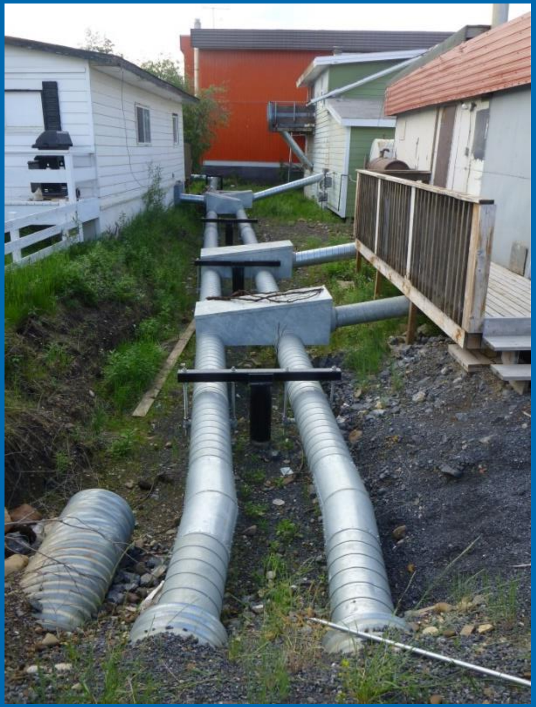
Bioreactors to be retrofitted from original MBR bioreactor construction

Dawson wwtp

Charting a new direction for wastewater treatment in the Canadian North

Inuvik utilidor replacement

The "utilidor" infrastructure in Inuvik is slowly being replaced with modern materials that include metal clad, insulated pipe, and steel pile systems – the cost is $8,000 per metre.



Charting a new direction for wastewater treatment in the Canadian North

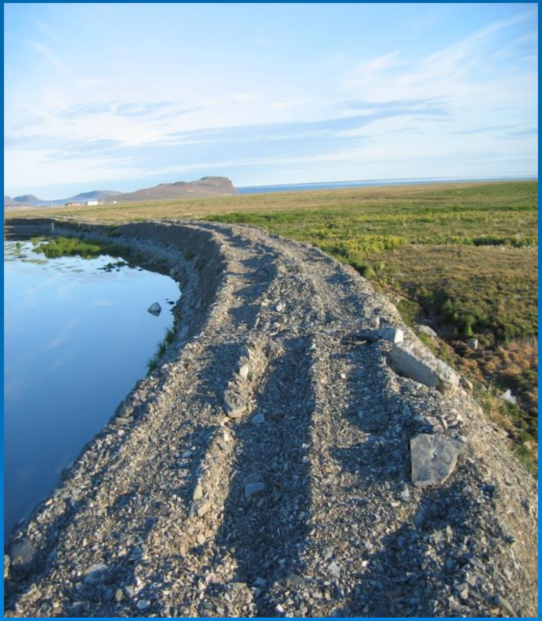
Resolute water and sewer

A piped water and sewer system envisioned to service a community of 2500 people was built in 1975, and has ultimately served a population of only 250 – replacement of the entire piped system is costing $40 million

Charting a new direction for wastewater treatment in the Canadian North

The lagoon and wetland processes

Lagoon systems remain the most common form of sewage treatment, in spite of demands for more sophisticated technologies. Improving upon the performance of lagoons is occurring with the application of wetlands for tertiary treatment.



Ulukhaktok, Northwest Territories

Charting a new direction for wastewater treatment in the Canadian North

Iqaluit wastewater treatment plant

Process – membrane bioreactor (MBR)
History – abandoned by contractor in 2000, never finished
Construction – design / build

New design completed in 2004 for conventional treatment with only phase 1 completed – new design initiated in 2015 and construction completion anticipated in 2018

Charting a new direction for wastewater treatment in the Canadian North

Bundled water treatment project

The NT government has completed the phase 2 of a unique project delivery approach where water treatment facilities for communities were "bundled" into groups of 5 projects and tendered as design build – the program has delivered 10 water treatment facilities costing on average $2.5 million each.

Water treatment facility in Edzo, NT

Water treatment facility for Ulukhaktok, NT – on route and in place

Charting a new direction for wastewater treatment in the Canadian North

Performance of northern lagoon systems

Livingston Trail Environmental Control Facility

	Water License	2003 Tests
Constituent	Max. limit for discharge of treated effluent	Effluent Quality data from LTS
BOD	45 mg/L	<4
Suspended Solids	60 mg/L	<1
Oils and Grease **	5 mg/L	<1
PH	6-9	7.8
Ammonia	N/A	<0.05
Faecal Coliforms	2000 MPN/100mL	
E.Coli	2000 MPN/100mL	<1
Giardia	N/A	0
Total Phosphorus	N/A	3.32
Dissolved Oxygen	N/A	2.1
96-hour static LC_{50}	100%	100

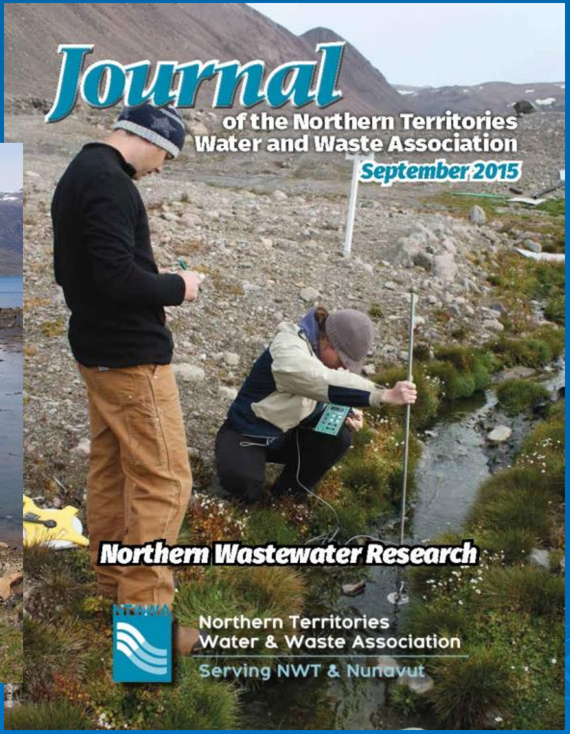
(< symbol) less than detection limit

Capital Cost
$20 million (1996 $)
$36 million (2016 $)
O + M (per year)
$200,000 (2015 $)

Whitehorse sewage lagoon system is the largest facility of its kind in northern Canada serving a population of 24,000 and producing a very high quality effluent, which is well below the Wastewater Systems Effluent Regulations.

Charting a new direction for wastewater treatment in the Canadian North

Current challenges with lagoon systems and responses



The lagoon systems in a number of communities in the Nunavut Territory have issues associated with stability and seepage – these issues and other research is demanding a rethinking of the performance of lagoons in the high arctic given the influent quality (pure sewage) and environmental impact (minimal impact).

Charting a new direction for wastewater treatment in the Canadian North

Back to 1st Principles

CCME MWWE Principles and apparent practices that are "rolling" out

• Be fiscally responsible and sustainable by identifying costs and taking into account other environmental issues

The capital budget for the Dawson City wastewater facility is $25 million – this is in addition to approximately $8 million previously spent on "work" that was never implemented. The operation and maintenance budget was estimated to be $300,000 per year, and reality is over $1 million per year.

Natural sewage lagoon in Tuktoyaktuk, NT

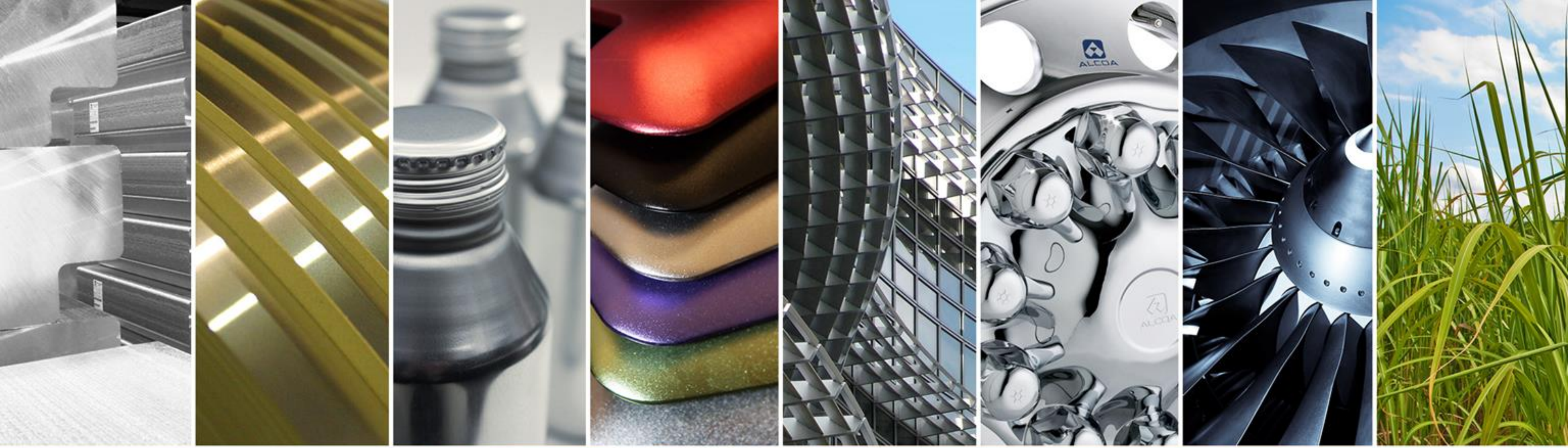
Charting a new direction for wastewater treatment in the Canadian North

… and in conclusion…

There is a significant gap associated with wastewater management between regulatory principles, and reasonable practices for the communities of the far north.

We are in a position to either implement solutions which are appropriate to the administrative, financial, technical, and human resource capacities of northern communities OR create legacies which will unreasonably burden the communities for a generation.

Trucked sewage collection in Repulse Bay, NU



Advancing each generation. ALCOA

Natural Engineered Wastewater Treatment:

NEWT Nature at Work.

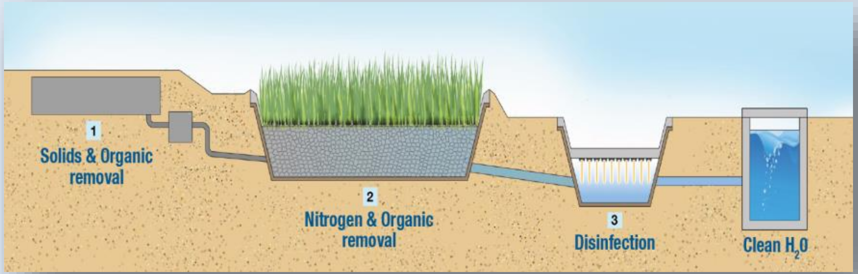
Prepared by Alcoa for Technology Introduction

September 2016

While Alcoa is traditionally considered an Aluminum company, our technical expertise has developed broad innovative solutions

Alcoa has set the goal of **reducing freshwater consumption 25%** by 2025

When Alcoa couldn't find a commercial technology that achieved a **step change in our water sustainability goals**, we created our own…



*…the NEWT™ technology was perfected as an **innovative hybrid wastewater treatment technology** that maintains high effluent quality*

This innovative technology helps Alcoa **exceed** its water consumption goals and maintain our standing as one of the world's most sustainable companies

Today, Alcoa has three permitted installations operating, with over 10 NEWT-years of total domestic & international operating experience

With positive technical and financial performance and three additional installations *in the build stage*, ***Alcoa is commercializing the NEWT™ technology***

Natural Engineered Wastewater Treatment: NEWT^{TM}

NEWT TECHNOLOGY OVERVIEW

Advancing each generation. ALCOA

NEWT Nature at Work. is a green solution with real economic benefits

Natural, green design produces high quality effluent

Simplified maintenance

Condensed Footprint

Sustainable operations

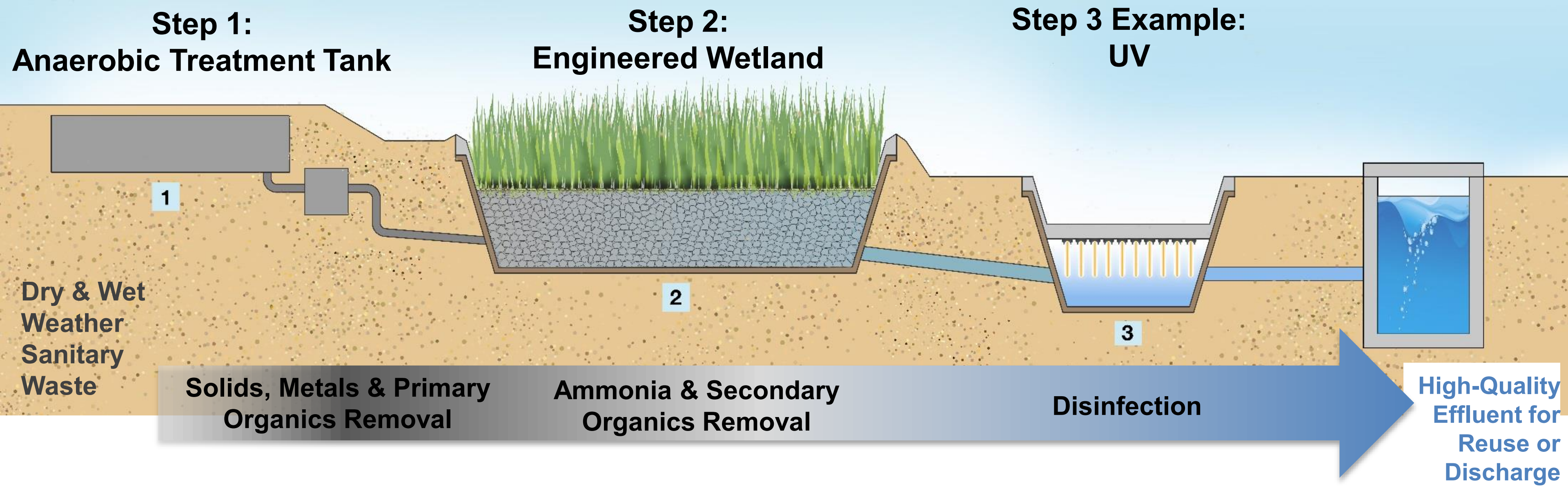
Nearly Odorless

Minimal sludge disposal

Source: Alcoa Technical Center, Ma'aden

NEWT Nature at Work. removes a wide range of contaminants in three simple steps.

Resulting from continuous innovation in wastewater treatment for Alcoa production facilities, the **NEWT™ system effectively removes a wide range of contaminants** from industrial and sanitary wastewaters and **generates high quality treated effluent suitable for reuse** – ***while significantly lowering energy and operating costs.***



The NEWT system can be design to remove contaminants like Nitrate and Phosphate

Source: Alcoa Technical Center

NEWT[TM] is active in all stages of deployment: bid & proposal, construction, and operation

Alcoa has accumulated over 10 NEWT-years of operational know-how & experience

Alcoa Technical Center
Pittsburgh, Pennsylvania
U.S.A.

*Since replacing an ageing conventional system in **2009 the first commercial-scale system has experienced first sludge removal after 6 years.***

System Facts:

Installed: 2009
Wastewater Type: Sanitary
Design Flow: **50,000 gpd**
Footprint: 1.5 acres

Ma'aden Aluminium
Ras Al Khair
Kingdom of Saudi Arabia

*In one of the most arid regions on the planet, **reducing water demand through reuse of 1.3 million gallons per day will save the industrial facility over $8 million annually**.*

System Facts:

Installed: 2013
Wastewater Type: Sanitary & Industrial
Design Flow: **1.3 MGD**
Footprint: 17 acres

1.0 MGD reference plant has further reduced footprint to 2.5 acres

Alcoa Power and Propulsion
Wichita Falls, Texas
U.S.A.

*In 2014, North Central Texas's Stage 5 drought conditions required industrial users to cut water consumption **- installing a NEWT system allows the facility to reduce its water consumption by 68%** - far above the 10-35% required*

System Facts:

Installed: 2015
Wastewater Type: Sanitary
Design Flow: **35,000 gpd**
Footprint: 2 acres

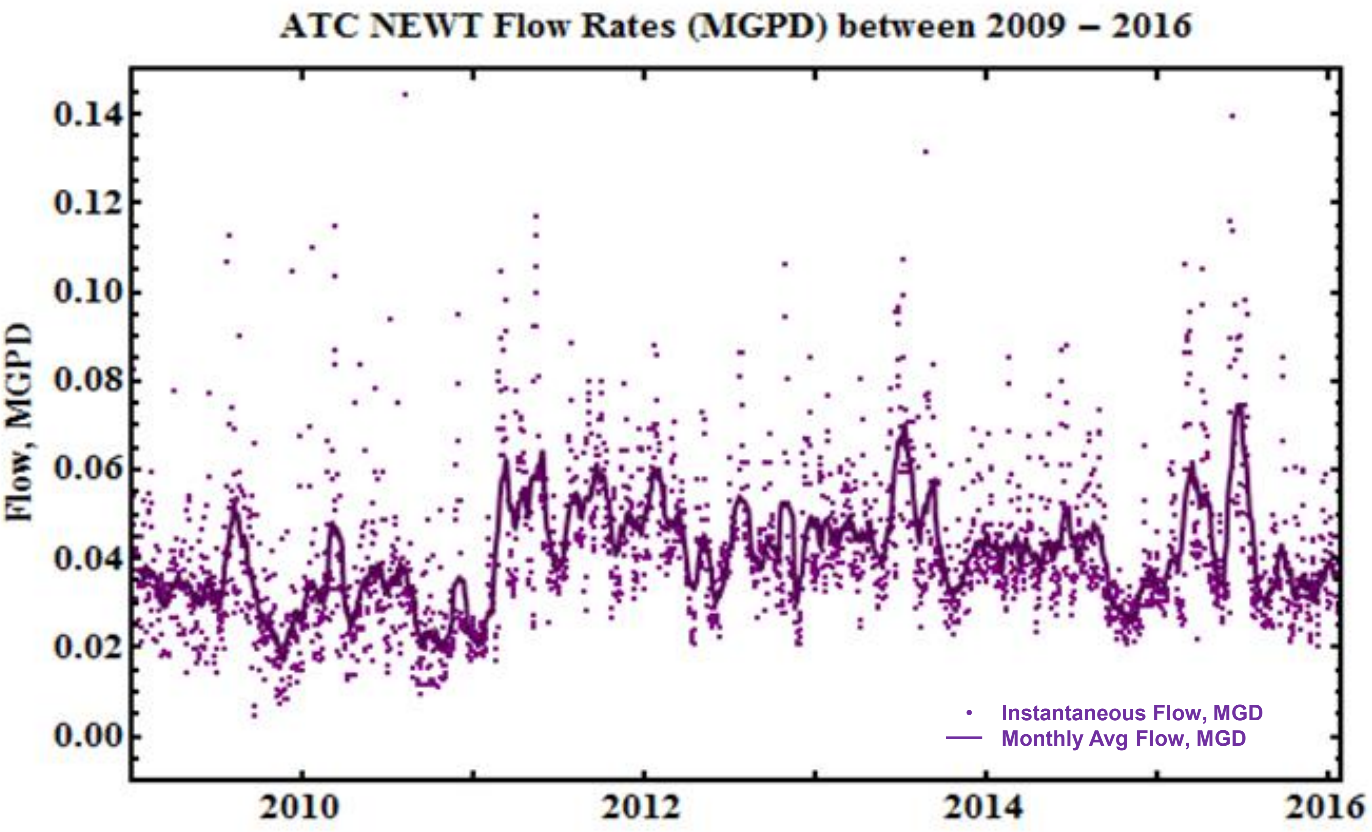
NEWT™ System Performance Data for Alcoa Technical Center's (ATC) Sanitary Natural Engineered Wastewater Treatment

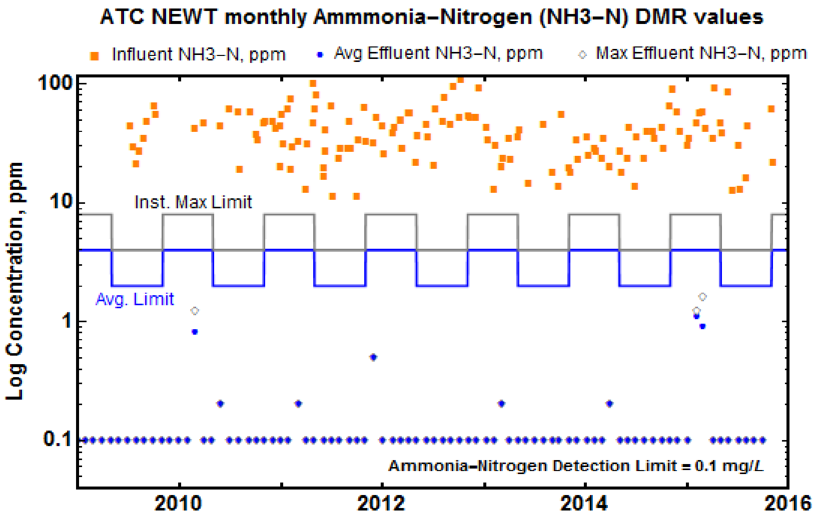
Given proper final design, and installation, the system is capable of providing the minimum effluent quality listed for the influent quality cited

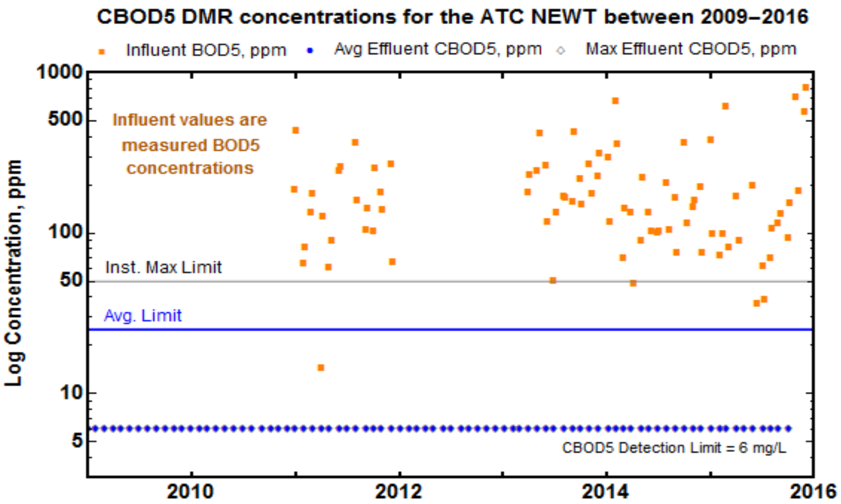
	Influent Upper Limit	Effluent Upper Limit Monthly average	Effluent Upper Limit Instantaneous Max.
Water Temperature	> 45 F	Matches inlet	Matches inlet
Oil & Grease	50 mg/L	Matches inlet	Matches inlet
pH	6 to 9	6 to 9	6 to 9
Flow Rate	Design flow	Matches inlet	Matches inlet
Fecal Coliform	~ 10^6 CFU/100 ml	200 cfu/100 ml summer 2000 CFU/100 ml winter (monthly geometric mean)	1000 cfu/100 ml summer
Ammonia	50 mg/L	5 mg/L	
Total Suspended Solids	389 mg/L	30 mg/L	60 mg/L
BOD-5	400 mg/L	25 mg/L	50 mg/L

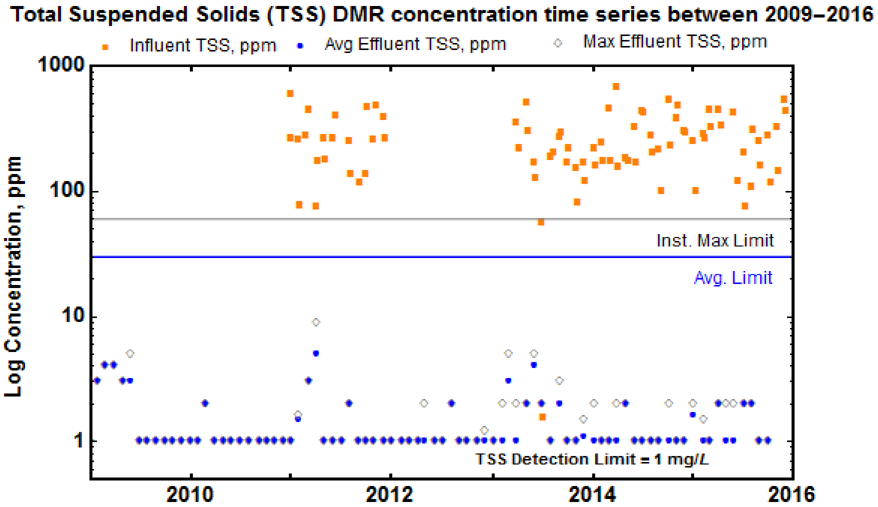
The system can be designed to remove Phosphorus and Nitrate. Data can be supplied upon request.

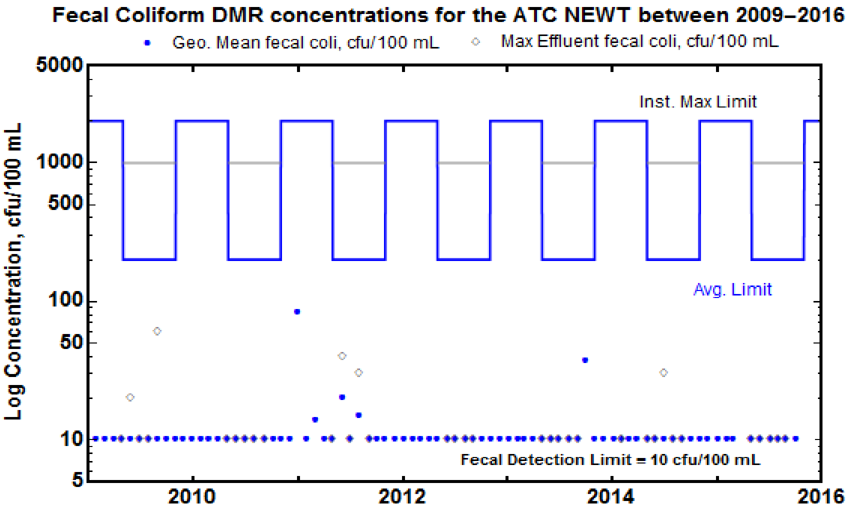
Range of Flow Rates @ ATC NEWT

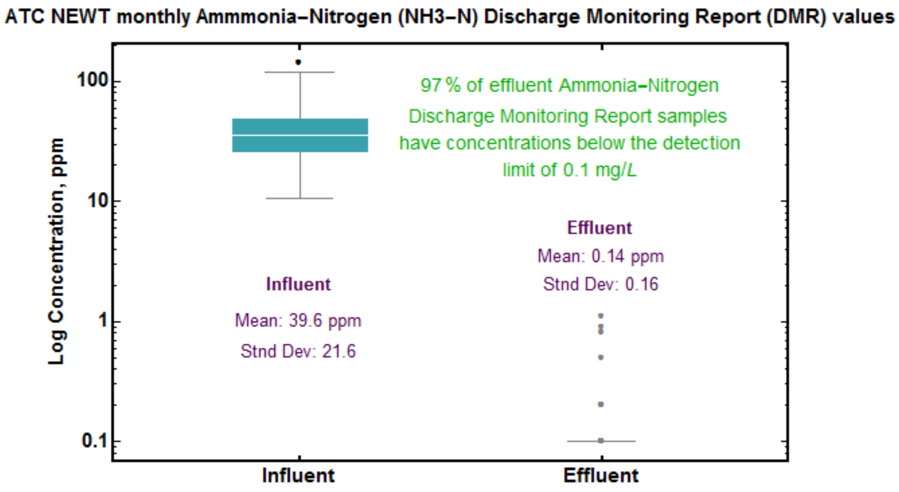


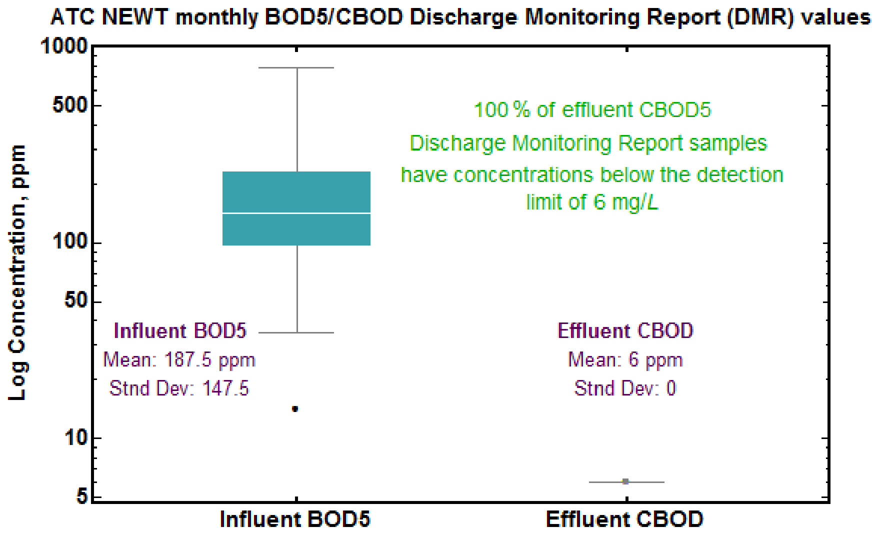

ATC NEWT monthly Ammmonia–Nitrogen (NH3–N) DMR values
Influent NH3–N, ppm
Avg Effluent NH3–N, ppm
Max Effluent NH3–N, ppm
Log Concentration, ppm
Inst. Max Limit
Avg. Limit
Ammonia–Nitrogen Detection Limit = 0.1 mg/L
100
10
1
0.1
2010
2012
2014
2016

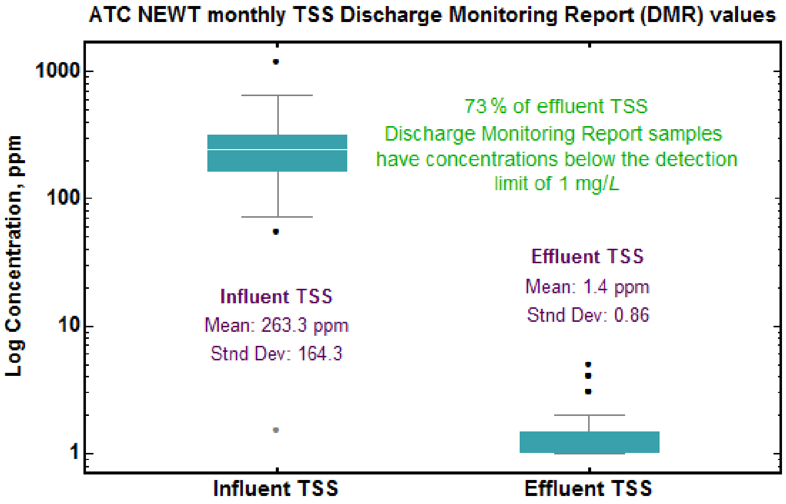

CBOD5 DMR concentrations for the ATC NEWT between 2009–2016
Influent BOD5, ppm
Avg Effluent CBOD5, ppm
Max Effluent CBOD5, ppm
Influent values are measured BOD5 concentrations
Log Concentration, ppm
Inst. Max Limit
Avg. Limit
CBOD5 Detection Limit = 6 mg/L
1000
500
100
50
10
5
2010
2012
2014
2016


Total Suspended Solids (TSS) DMR concentration time series between 2009–2016
Influent TSS, ppm
Avg Effluent TSS, ppm
Max Effluent TSS, ppm
Log Concentration, ppm
Inst. Max Limit
Avg. Limit
TSS Detection Limit = 1 mg/L
1000
100
10
1
2010
2012
2014
2016

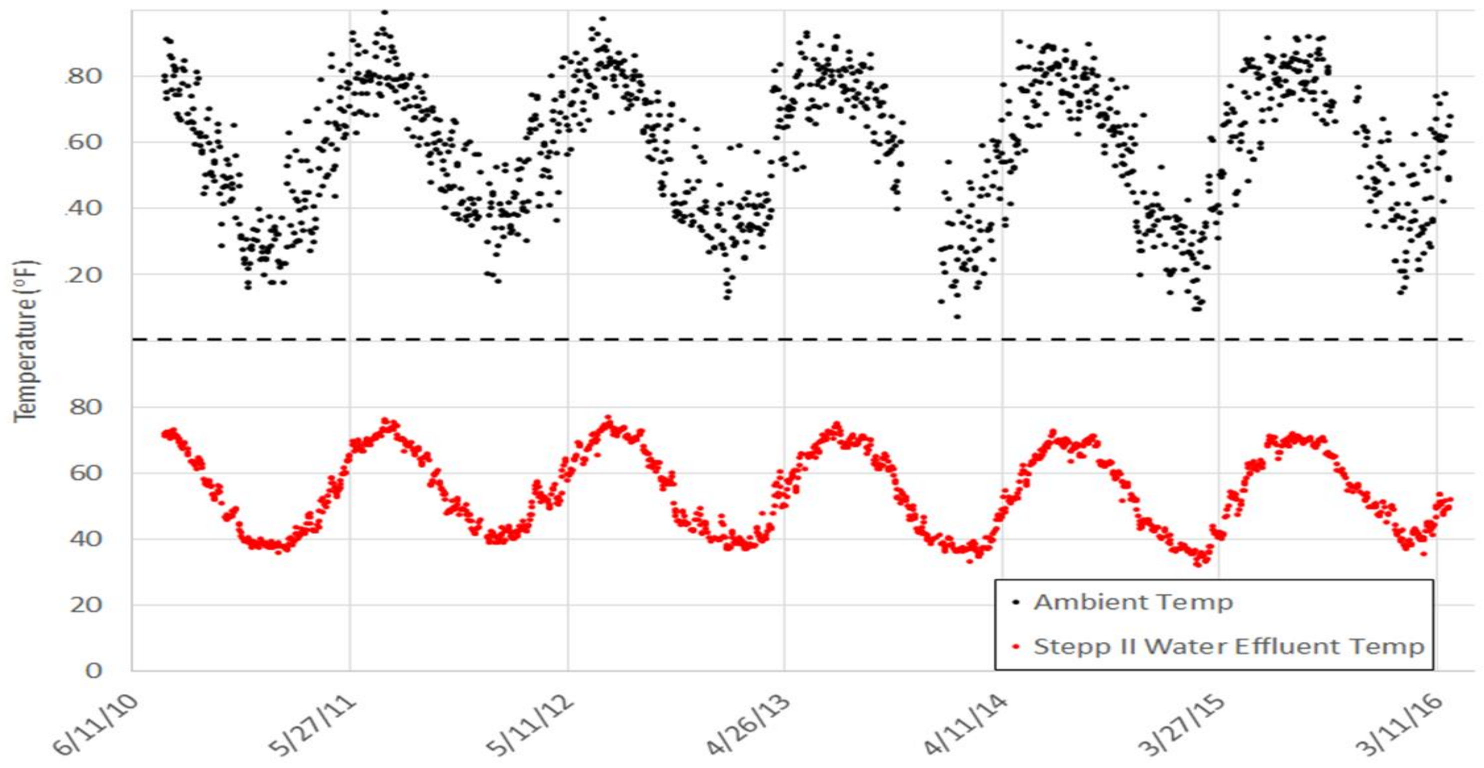

Fecal Coliform DMR concentrations for the ATC NEWT between 2009–2016
Geo. Mean fecal coli, cfu/100 mL
Max Effluent fecal coli, cfu/100 mL
Log Concentration, cfu/100 mL
Inst. Max Limit
Avg. Limit
Fecal Detection Limit = 10 cfu/100 mL
5000
1000
500
100
50
10
5
2010
2012
2014
2016


ATC NEWT monthly Ammmonia–Nitrogen (NH3–N) Discharge Monitoring Report (DMR) values
97 % of effluent Ammonia–Nitrogen
Discharge Monitoring Report samples
have concentrations below the detection
limit of 0.1 mg/L
Influent
Mean: 39.6 ppm
Stnd Dev: 21.6
Effluent
Mean: 0.14 ppm
Stnd Dev: 0.16
Log Concentration, ppm
100
10
1
0.1
Influent
Effluent


ATC NEWT monthly BOD5/CBOD Discharge Monitoring Report (DMR) values
100 % of effluent CBOD5
Discharge Monitoring Report samples
have concentrations below the detection
limit of 6 mg/L
Influent BOD5
Mean: 187.5 ppm
Stnd Dev: 147.5
Effluent CBOD
Mean: 6 ppm
Stnd Dev: 0
Log Concentration, ppm
1000
500
100
50
10
5
Influent BOD5
Effluent CBOD


ATC NEWT monthly TSS Discharge Monitoring Report (DMR) values
73 % of effluent TSS
Discharge Monitoring Report samples
have concentrations below the detection
limit of 1 mg/L
Influent TSS
Mean: 263.3 ppm
Stnd Dev: 164.3
Effluent TSS
Mean: 1.4 ppm
Stnd Dev: 0.86
Log Concentration, ppm
1000
100
10
1
Influent TSS
Effluent TSS

Range of Temperatures @ ATC NEWT



Ambient Temperature taken daily at 12 noon

NEWT™ Design for Alaska

Can NEWT work in sub-freezing temperatures?

- Keeping a trickle of flow through the system helps prevent freezing
- Step 2 flow is always 6” below media level, latest design is 6’ deep
- ATC insulates STEP2 with bails of hay in winter
- Store in the lagoons in the winter and discharge through NEWT in summer

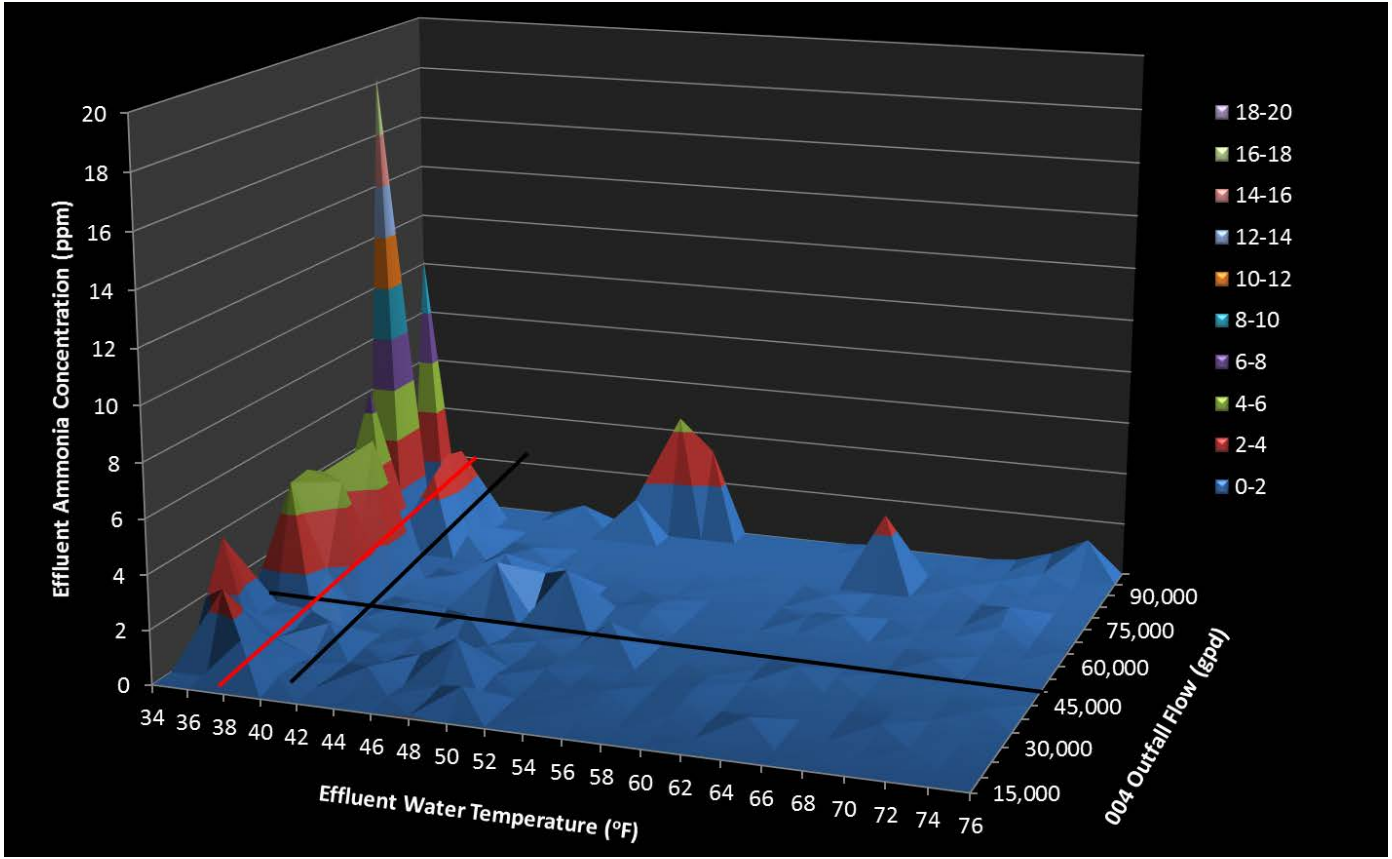
Can NEWT work if there is no power?

- NEWT™ requires limited power for pumps, aeration blower, and UV
- Evaluate low cost alternate power

Can NEWT pair with an existing lagoon?

- A lagoon with low TSS could feed the NEWT™ system
- Regular lagoon dredging/maintenance would be essential

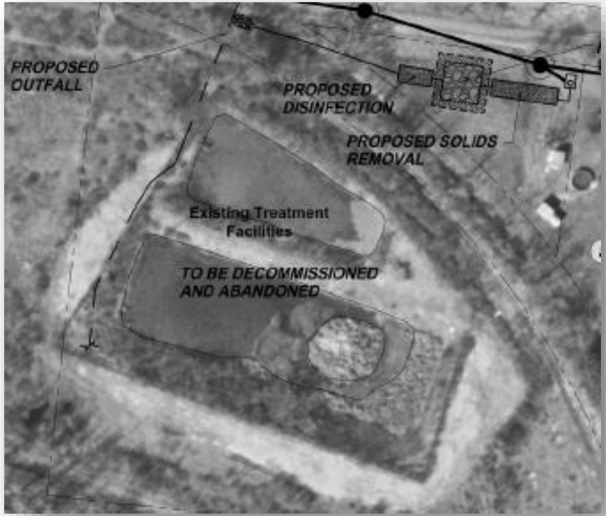
Ongoing Analysis on ATC NEWT™ system performance



Limits

Winter	4.8 ppm
Summer	2.4 ppm

Two Projects are Active to Replace Lagoon Systems with NEWT™ System



Location	Western PA
Flow Rate	35,000 gpd
Justification	Lower Life Cycle Cost More customers served
Status	EPA Act 537 plan awaiting approval

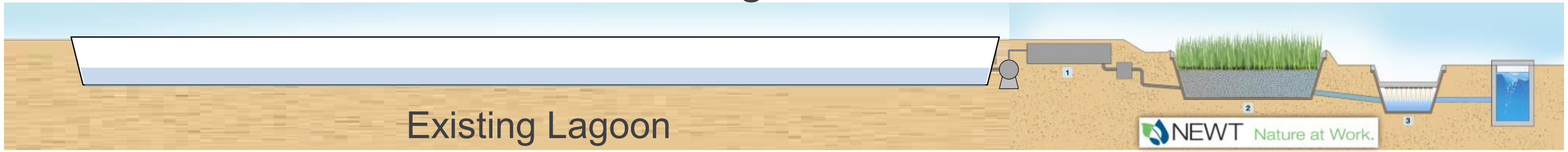
Location	Colorado
Flow Rate	350,000 gpd
Justification	Lower Life Cycle Cost More customers served
Status	Seeking CDPHE approval

Lagoon/NEWT™ Concept for Alaska

Summer Operation

Discharge or Reuse?

Draw Down Lagoon Before Winter



Refill Lagoon & Store During Winter

Spring NEWT Restart

A green solution
that produces higher quality water

Solids	Organics	Ammonia	Fecal Coliform
0.14* mg/L	<6* mg/L	1.4* mg/L	< 10** cfu/100 ml

At a lower total cost

- Minimal sludge disposal
- Little to no chemical use
- Condensed Footprint
- Simplified maintenance and operation
- Nearly Odorless

*Based on ATC averages
** Based on UV capability


ALCOA
NEWT ™
Natural Engineered Wastewater Treatment
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Development Manager
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National Research Council of Canada

Ottawa, ON & Montreal, QC
(Canada's premier science and technology research organization)

LIFEWATER ENGINEERING COMPANY

Fairbanks, AK
(Researchers and developers of sewage treatment equipment for the Arctic)

Preliminary Test Results from an Electrically-Assisted, Anaerobic Sewage Treatment System

Subtitle:

Bio-Electrochemical Anaerobic Sewage Treatment (BEAST) technology for energy-efficient wastewater treatment in northern communities

Authors: Bob Tsigonis[1] (presenter)
Yehuda Kleiner[2]
Boris Tartakovsky[2]

1 – Lifewater Engineering Company
2 – National Research Council of Canada

Topics covered

BEAST technology by NRCC

Pilot test by Lifewater

Brief History

Background

- NRCC developing anaerobic treatment technology
- Lifewater Engineering Company building aerobic STP's for cold climates since 1999

Events

- Late 2015 NRCC personnel visited Lifewater
- Established collaborative research agreement
- Lifewater built full-size residential anaerobic STP
- WIHAH

Objective: Sustainable wastewater treatment

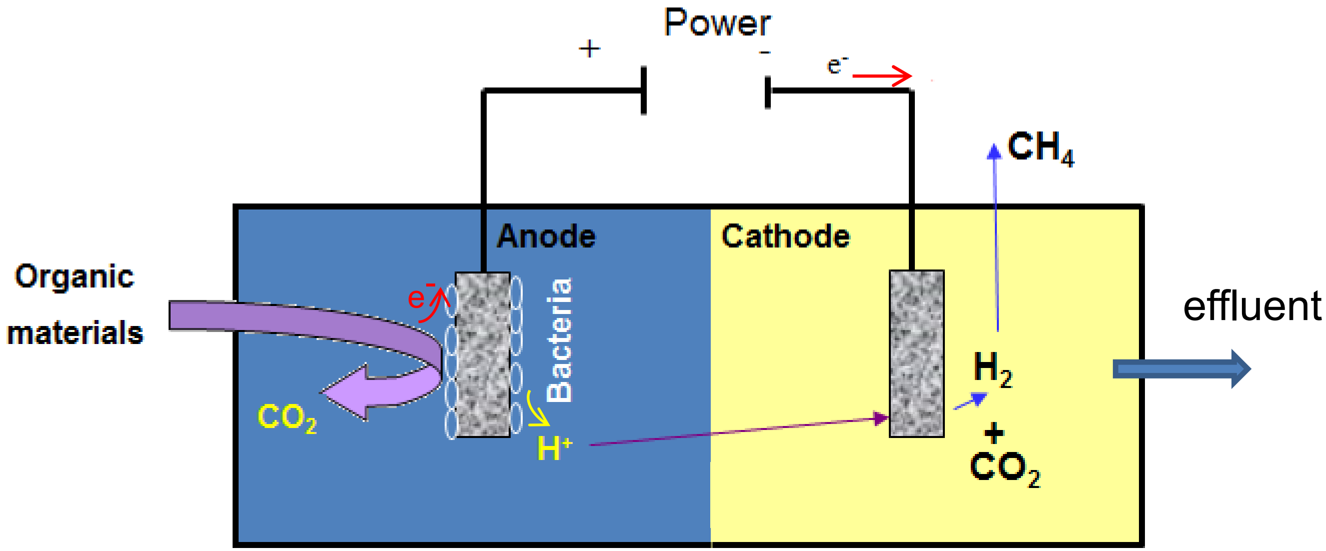
- Simple and robust (extreme conditions), relying solely on local staff for operation and management
- Meet or exceed effluent quality standards ($BOD_5 \leq 25$ mg/L; SS ≤ 25 mg/L)
- Energy-efficient
- Low upfront investment and low operating costs

Microbial Electrochemical Technology

Concept: a low voltage (0.5 - 1.5 V) is applied to enable electron transfer (enhance biodegradation)

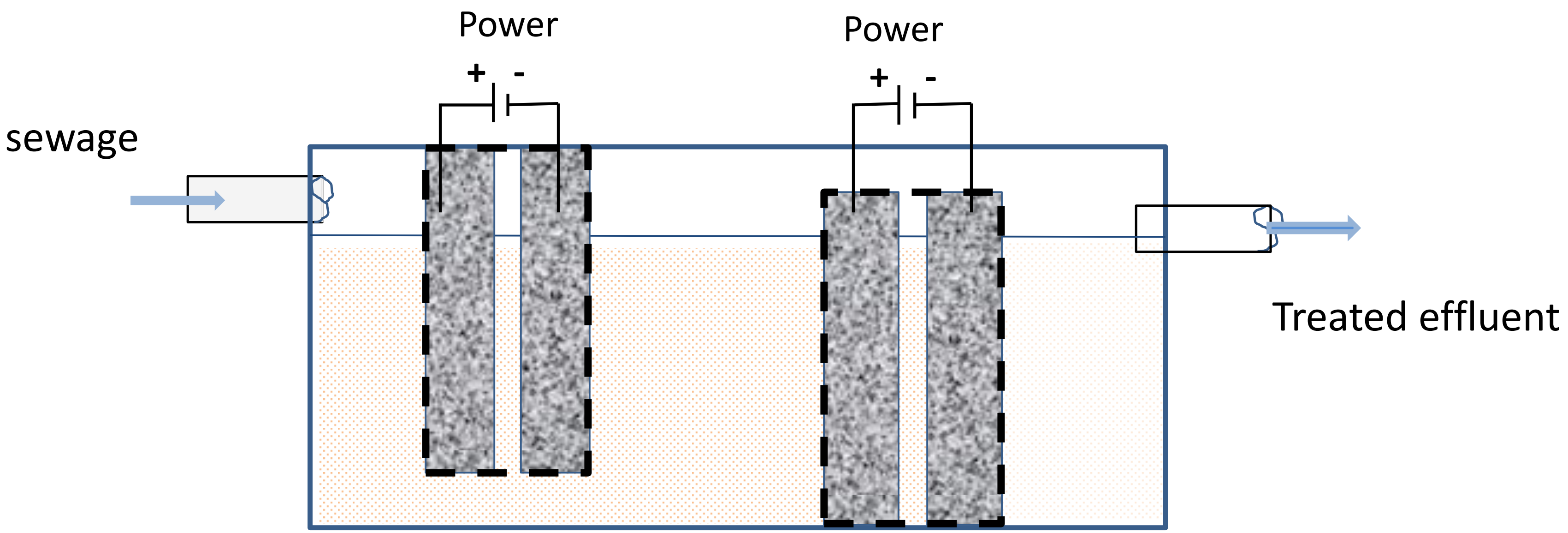
Anode reaction (bacteria): Organic materials + water → $CO_2 + n\ e^- + n\ H^+$

Cathode reactions: $8H^+ + 8e^- \rightarrow 4H_2$; $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$



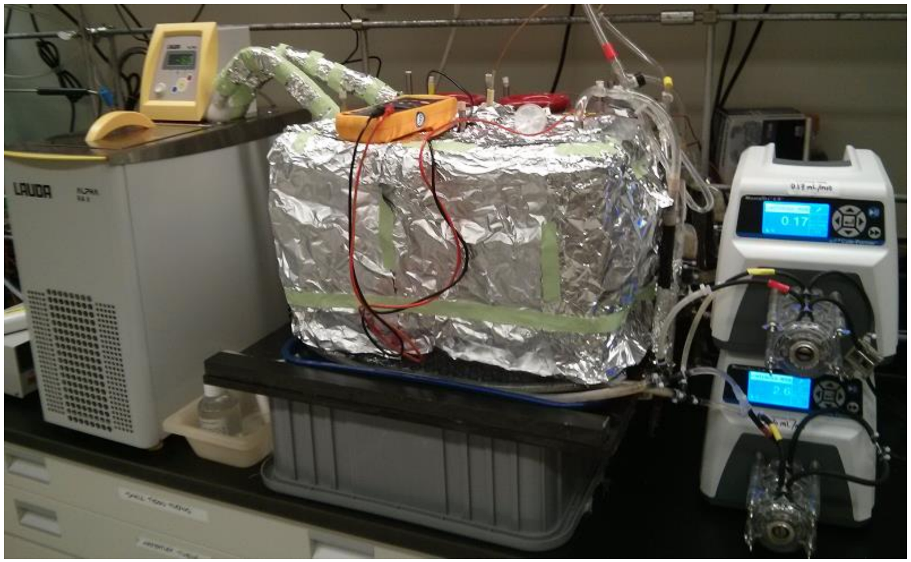
- H_2 is readily transformed to methane by methanogens

Bioelectrochemical Anaerobic Sewage Treatment (BEAST) technology



- Reactor design similar to septic tank (simple)
- Porous conductive electrodes
- Low voltage power supply used to enhance anaerobic degradation of sewage

Laboratory setup in Montreal, QC

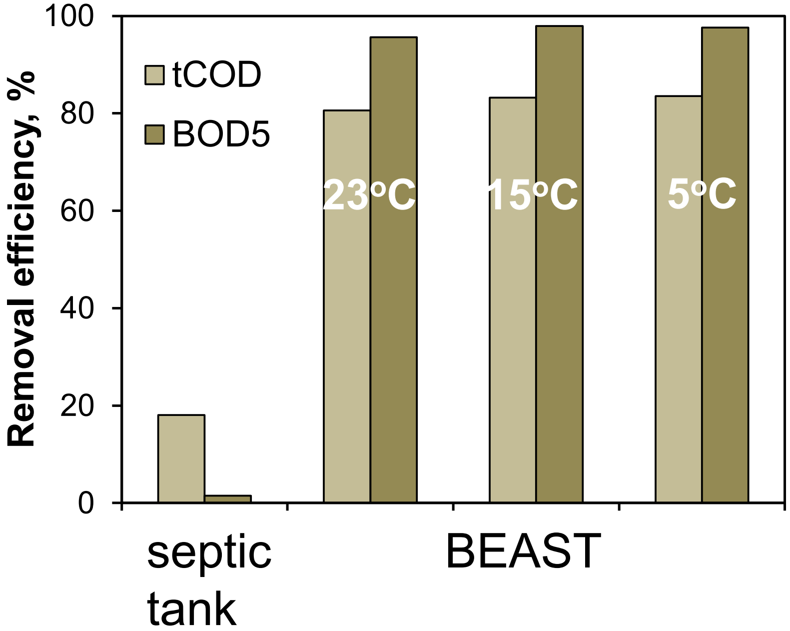


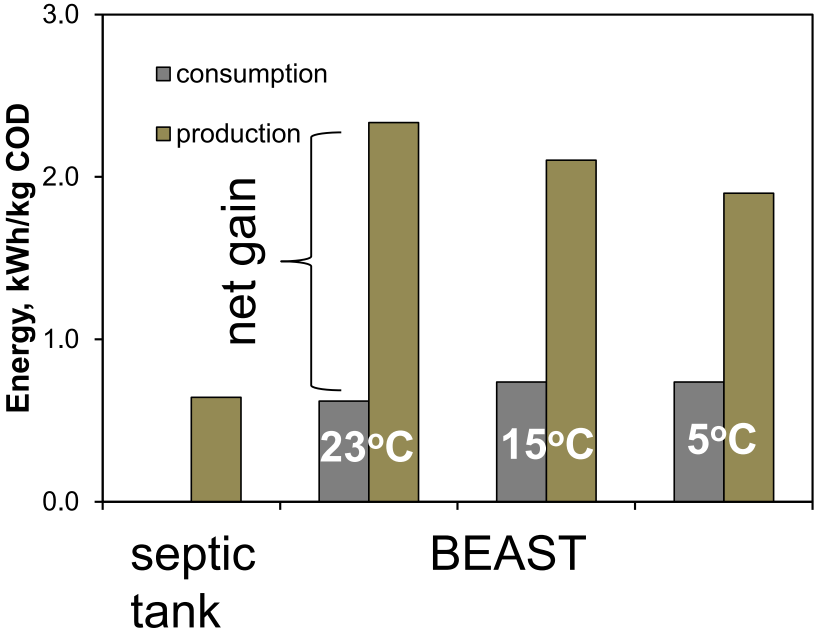
Operating conditions

- Hydraulic retention time 3.3 days
- Continuous flow
- Tests at 22°C, 15°C, and 5°C
- Applied voltage: 1.4 V

- 20 L reactor
- Synthetic and municipal sewage
- Tests at different temperatures

COD/BOD_5 removal and energy balance





BEAST performance:

- Influent BOD_5 : 350 mg/L
- Effluent BOD_5 : 7-15 mg/L (96-97% removal)
- Suspended solids: 20-40 mg/L
- Colony forming units (CFU): two log reduction

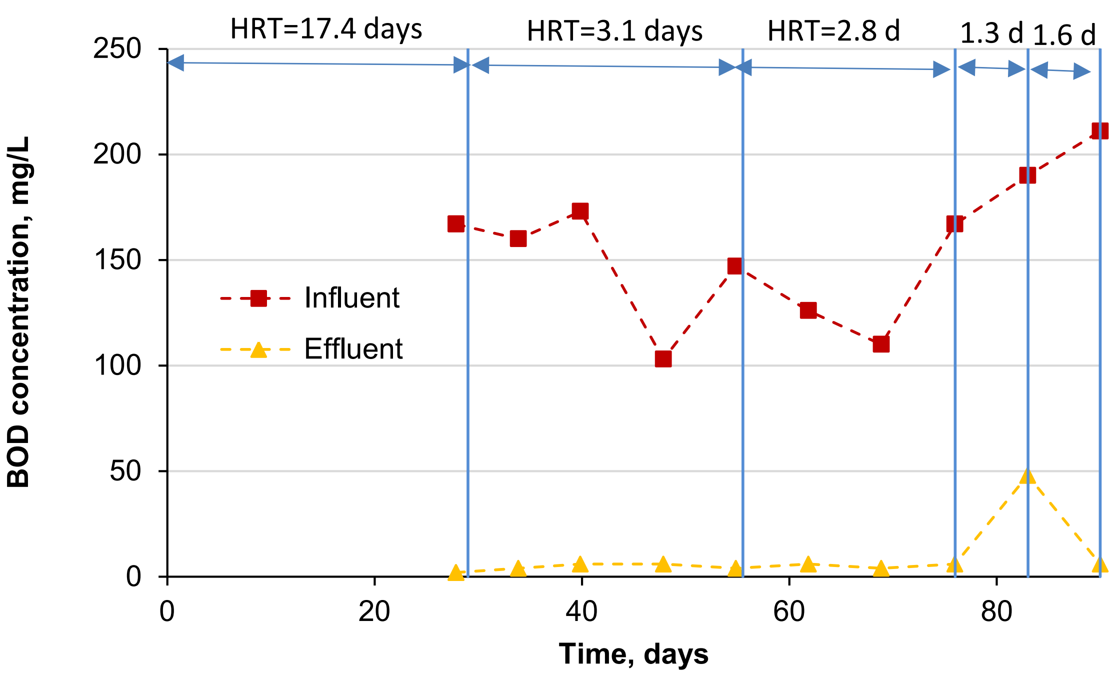
Pilot test at MWWTP (Ste Catherine, QC)

- Test period: April to August, 2016
- 50 L reactor (40 L fluid volume)
- Raw sewage characterization (after primary grit removal):

  Total COD: 500 - 530 mg/L
  BOD_5 : 230-250 mg/L
  Suspended solids: 300-330 mg/L

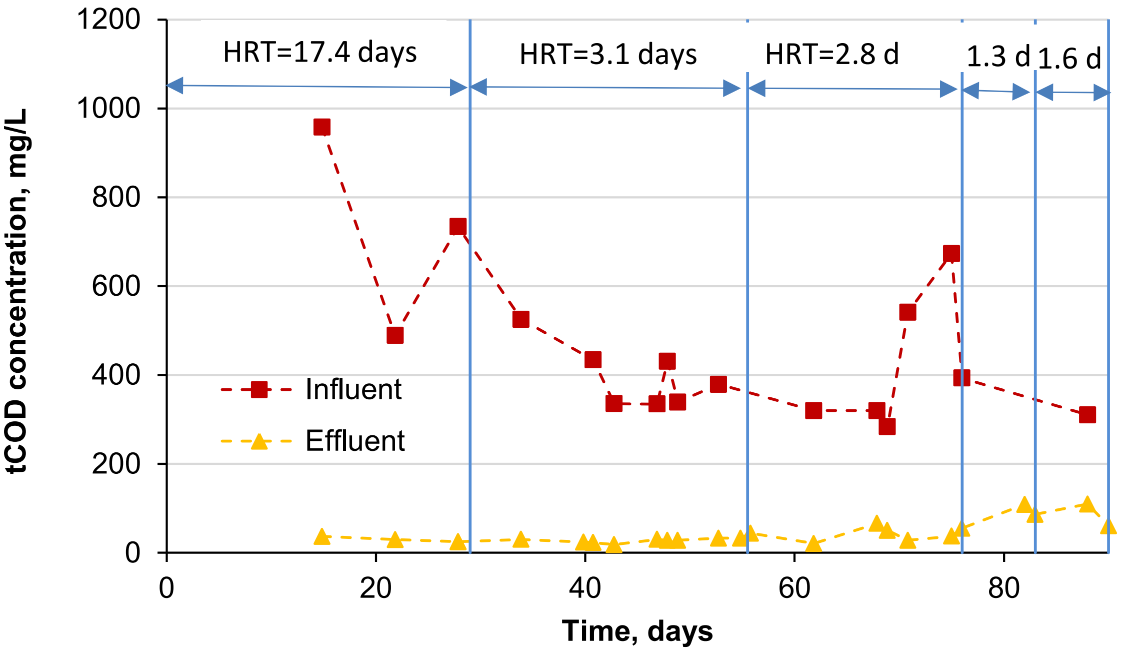
- Single pair of electrodes (anode & cathode)
- Inflow rate varied to examine performance at different HRTs (17, 3.1, 2.8, 1.3 and 1.6 days)
- tCOD, sCOD, BOD_5, TSS and fecal coliforms monitored

Pilot test - BOD_5 removal



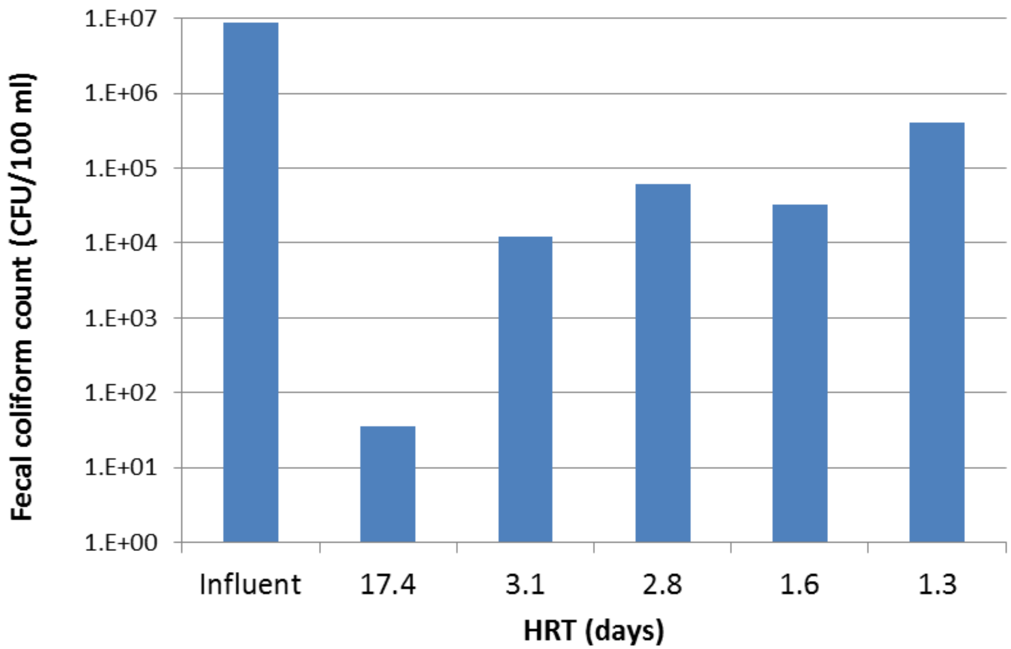
HRT (days)	Mean Influent	Mean Effluent	% removal
17.4	167	2.0	98.8%
3.1	145	5.3	96.3%
2.8	137	5.0	96.4%
1.3	190	48.0	74.7%
1.6	211	6.0	97.2%

Pilot test – total COD removal



HRT (days)	Mean Influent	Mean Effluent	% removal
17.4	729	29.1	96.0%
3.1	397	26.9	93.2%
2.8	428	40.6	90.5%
1.3	428	97.8	77.1%
1.6	463	85.3	81.6%

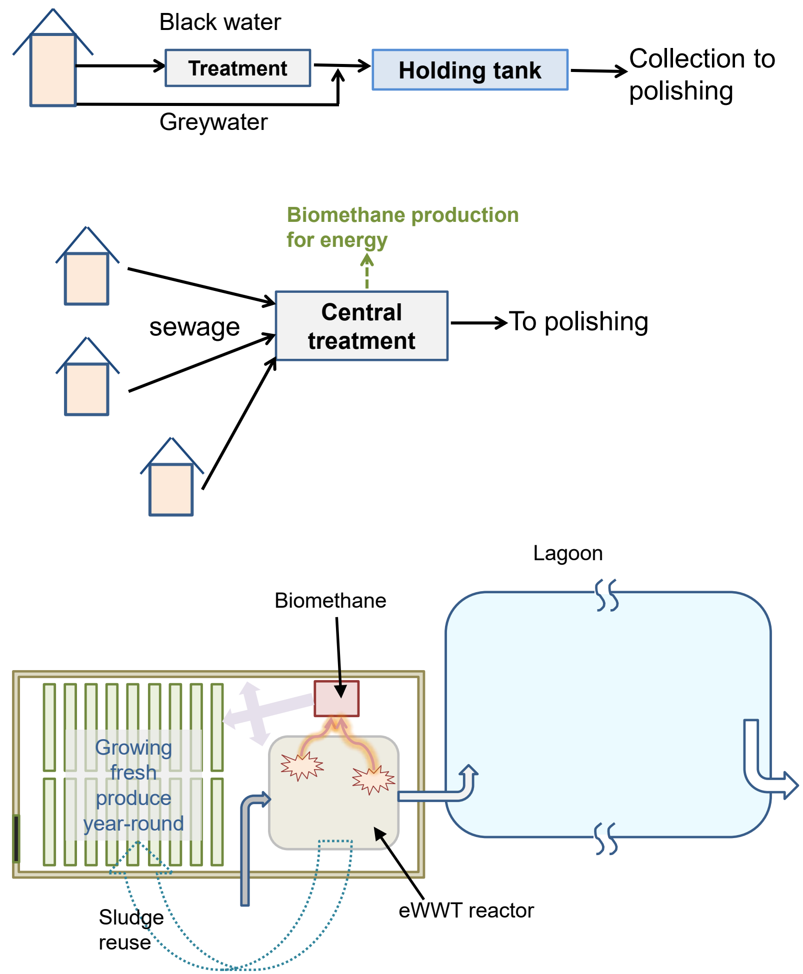
Pilot test - fecal coliform removal



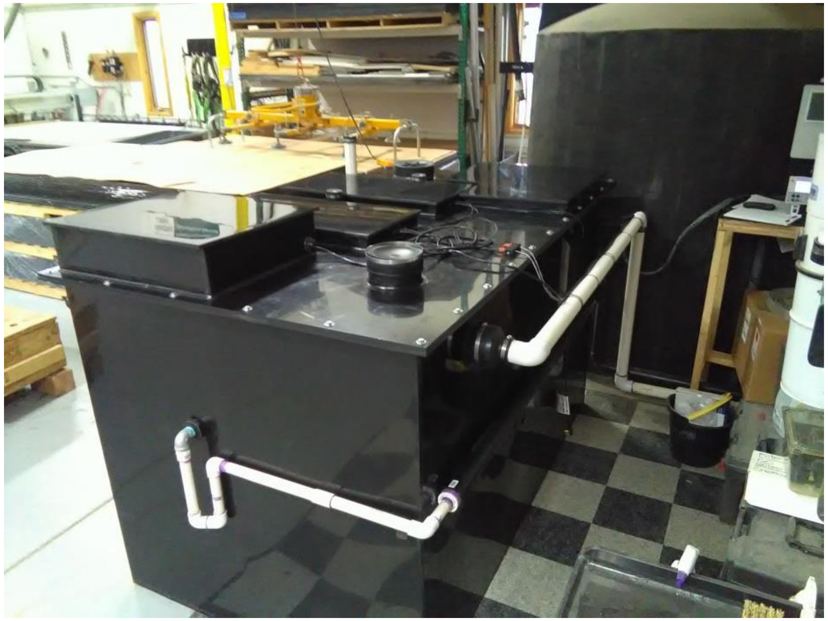
- Two log reduction in fecal coliforms (before disinfection)

NRCC Conclusions

- Electrically assisted anaerobic wastewater treatment demonstrated high effluent quality (likely to exceed standards)
- Proven net energy gain (if bio-methane can be used)
- Simple design (could be used in conjunction with lagoon treatment)
- Fully scalable (from single-dwelling unit to community level)



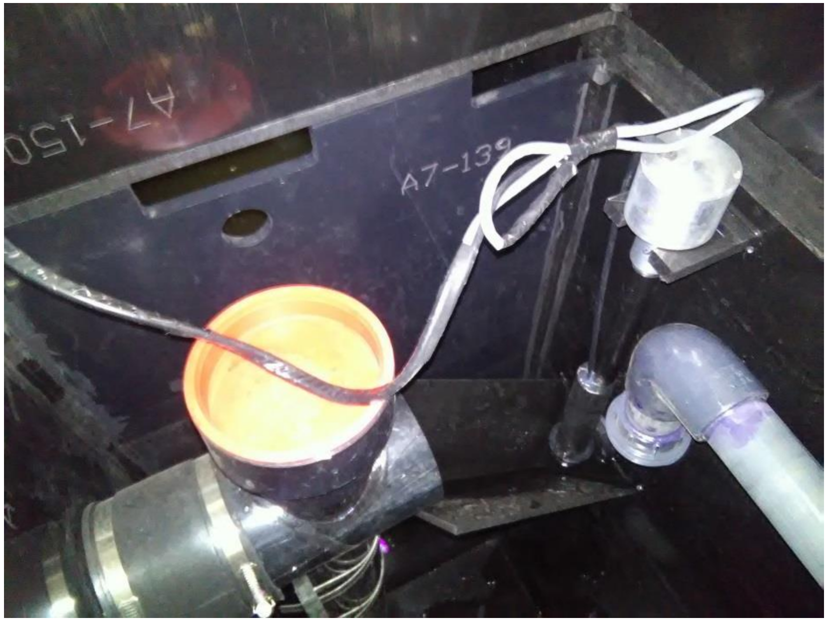
Residential full-scale system at Lifewater (Fairbanks)



~2800L

~7 days retention time

Programmable power supply & COD fluorimeter



LIFEWATER ENGINEERING COMPANY
NRC·CNRC

Sources of domestic sewage

- 3-bedroom upstairs apartment
- Office with 2 to 3 people
- Shop with 3 to 6 people
- Occasional visitors

Timeline

- Began filling system with sewage – Sept. 2nd
- System mostly full; turned on power – Sept. 9th
- Got COD fluorimeter operating – Sept. 13th
- First influent and effluent COD samples to the laboratory – Sept. 14th
- Now Sept. 19th – just 10 days after power was turned on

Effluent results five days after startup

- Influent COD: 357 mg/L (after primary treatment)
- Effluent COD: 147 mg/L (59% removal)

(expect 4 to 6 weeks of operation to achieve a steady state)

Power comparison five days after startup

Aerobic STP

	kWh/day
• Air blower	1.10
• UV	0.96
• Effluent pump	0.08
• Heat trace (50F inside)	4.51

BEAST

	kWh/day
• Electrodes	0.05
• UV (add float control?)	0.96
• Effluent pump	0.08
• Heat trace (35F inside)	less

(add insulation, use methane)

Assuming all goes well with effluent quality, what happens next?

- Simplify treatment system as much as possible
- Reduce power use
- Optimize design for fabrication
- Apply arctic engineering
- Fabricate welded plastic tank (insulated, double-walled)

Welded plastic tanks

- Lightweight
- Never corrodes
- UV resistant
- Extremely durable!

Test in rural Alaska

- Test at one or more homes in rural Alaska

Challenges ahead (on a residential scale)

- How best to capture and contain the methane
- A simple, safe method to use the methane to:
  - Keep the system warm
  - Generate power for the electrodes
  - Some other purpose

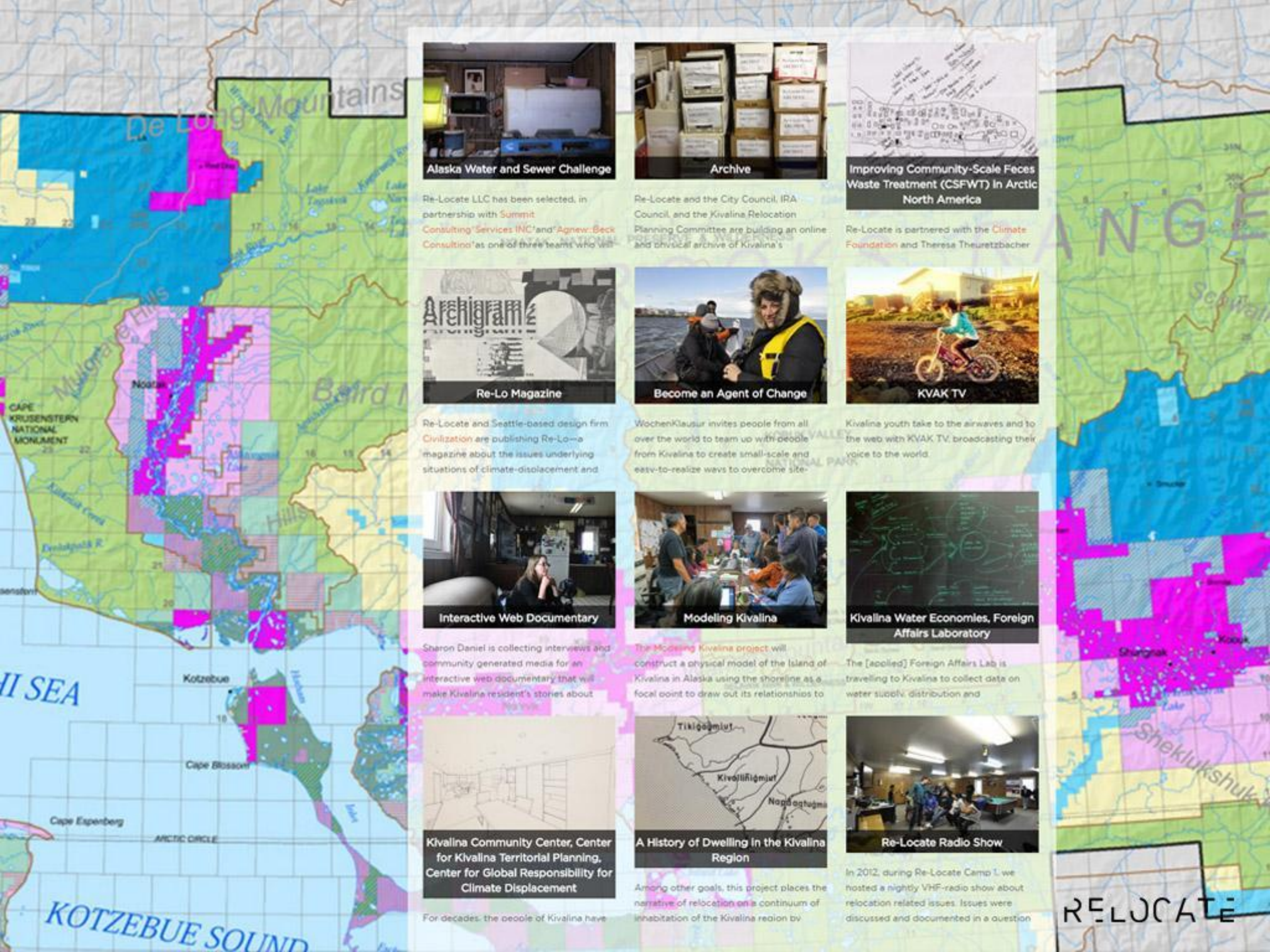
Please share your ideas, experiences, and needs with us

God bless you in your endeavors to advance healthy Arctic living around the world!

RELOCATE

KIVALINA BIOCHAR REACTOR


KIVALINA
BIOCHAR
2.6m
8'6"
RE-LOCATE LLC
RELOCATE


Alaska Water and Sewer Challenge
Re-Locate LLC has been selected, in partnership with Summit Consulting Services INC and Agnew::Beck Consulting as one of three teams who will
Archive
Re-Locate and the City Council, IRA Council, and the Kivalina Relocation Planning Committee are building an online and physical archive of Kivalina's
Improving Community-Scale Feces Waste Treatment (CSFWT) in Arctic North America
Re-Locate is partnered with the Climate Foundation and Theresa Theuretzbacher
Re-Lo Magazine
Re-Locate and Seattle-based design firm Civilization are publishing Re-Lo—a magazine about the issues underlying situations of climate-displacement and
Become an Agent of Change
WochenKlausur invites people from all over the world to team up with people from Kivalina to create small-scale and easy-to-realize ways to overcome site-
KVAK TV
Kivalina youth take to the airwaves and to the web with KVAK TV, broadcasting their voice to the world.
Interactive Web Documentary
Sharon Daniel is collecting interviews and community generated media for an interactive web documentary that will make Kivalina resident's stories about
Modeling Kivalina
The Modeling Kivalina project will construct a physical model of the Island of Kivalina in Alaska using the shoreline as a focal point to draw out its relationships to
Kivalina Water Economies, Foreign Affairs Laboratory
The [applied] Foreign Affairs Lab is travelling to Kivalina to collect data on water supply, distribution and
Kivalina Community Center, Center for Kivalina Territorial Planning, Center for Global Responsibility for Climate Displacement
For decades, the people of Kivalina have
A History of Dwelling in the Kivalina Region
Among other goals, this project places the narrative of relocation on a continuum of inhabitation of the Kivalina region by
Re-Locate Radio Show
In 2012, during Re-Locate Camp I, we hosted a nightly VHF-radio show about relocation related issues. Issues were discussed and documented in a question
De Long Mountains
Baird M
CAPE KRUSENSTERN NATIONAL MONUMENT
Noatak
Kotzebue
Cape Blossom
Cape Espenberg
ARCTIC CIRCLE
HI SEA
KOTZEBUE SOUND
Shungnak
RANGE
RELOCATE


AML
2.6m
8' 6"
KIVALINA
BIOCHAR
RELOCATE

How many people live in the houses where you empty honey buckets?
s: 9
: 0/1
and : 6

How are you related to the people living in your house?
Mom

Grandma and Grandpa

How are you related to the people living in the houses where you empty honey buckets?
s Auntie.
F l and : Dad's parents
l and

How many honey buckets are there in your house?
1

How many honey buckets are there in the houses where you empty honey buckets?
s: 1
F l and s: 1
's: 1

How often do you empty the honey bucket(s) in your house?
Once a day.

Where do you put the honey bucket waste that is waiting to be taken to the dump?
In a box.

How often do you empty the honey buckets in house 1, 2, 3, ...?
s: Not often/Sometimes. Just bring to dump.
d and : When visits.
s: When she's living here. Once every two days.

Do you always empty honey bucket(s) at the same time each day?
His house: Around the same time each day / when it's full. Morning.
s: 6 or 7 PM
d and V : 5 PM
s:

Who uses or can use the honey bucket(s) in your house?
s: Kids
F l and : only visitor from out of town use the honey bucket.
: Don't know

Do you use the honey bucket at other people's houses?
No.

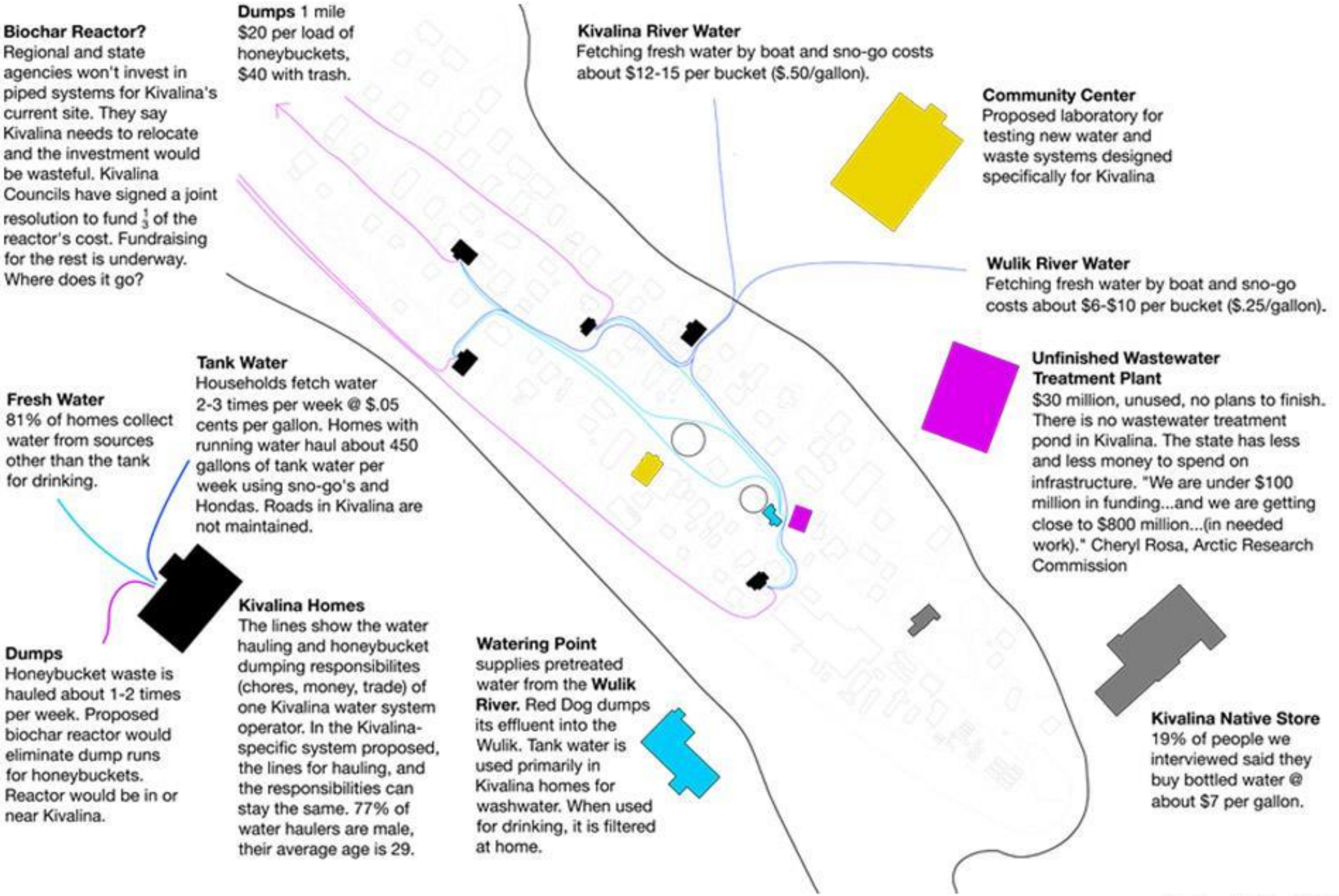
Do you wear protective clothing (masks, and gloves) when you're handling honey bucket waste?
No. Rubber gloves. Not all the time.

Why do you empty the honey bucket(s) in house 1, 2, 3, ...?
F l and l: Because it's my job. Because I'm living there. He or his uncle : typically empties it. To get pop. And just to be helpful.
s: Because she's my mom.
: Because i help him out.

Do you do other chores for the household(s) where you empty honey bucket waste?
l and : Get dirty water out. Get Water. Stove. Dumps. Trash
: Mom. Anything she asks me to do or when she calls me.
s: When he asks me.

RELOCATE

ANY CHORES
ONCE EVERY TWO
1 MOM KIDS
AUNT & UNCLE
1 BUCKET
JUST BRING TO DUMP
SOMETIMES
7 OR 6 AT NIGHT
ONCE A WEEK
TO DUMP
DUMPS
WATER
9
8
ONCE A WEEK
WATER
DUMPS 1 BUCKET
STOVE ONCE DAY
VISITORS
MOMS PARENTS
WHEN (MORNING)
6 1 BUCKET
DAD'S PARENTS
EMPTY WHEN VISIT
5 PM
SODA
BUCKET
DIRTY WATER
TRASH
NAME:
SANITATION SURVEYS
RELOCATE


Biochar Reactor?
Regional and state agencies won't invest in piped systems for Kivalina's current site. They say Kivalina needs to relocate and the investment would be wasteful. Kivalina Councils have signed a joint resolution to fund $\frac{1}{3}$ of the reactor's cost. Fundraising for the rest is underway. Where does it go?
Dumps 1 mile
$20 per load of honeybuckets, $40 with trash.
Kivalina River Water
Fetching fresh water by boat and sno-go costs about $12-15 per bucket ($.50/gallon).
Community Center
Proposed laboratory for testing new water and waste systems designed specifically for Kivalina
Wulik River Water
Fetching fresh water by boat and sno-go costs about $6-$10 per bucket ($.25/gallon).
Tank Water
Households fetch water 2-3 times per week @ $.05 cents per gallon. Homes with running water haul about 450 gallons of tank water per week using sno-go's and Hondas. Roads in Kivalina are not maintained.
Fresh Water
81% of homes collect water from sources other than the tank for drinking.
Unfinished Wastewater Treatment Plant
$30 million, unused, no plans to finish. There is no wastewater treatment pond in Kivalina. The state has less and less money to spend on infrastructure. "We are under $100 million in funding...and we are getting close to $800 million...(in needed work)." Cheryl Rosa, Arctic Research Commission
Kivalina Homes
The lines show the water hauling and honeybucket dumping responsibilites (chores, money, trade) of one Kivalina water system operator. In the Kivalina-specific system proposed, the lines for hauling, and the responsibilities can stay the same. 77% of water haulers are male, their average age is 29.
Watering Point
supplies pretreated water from the **Wulik River.** Red Dog dumps its effluent into the Wulik. Tank water is used primarily in Kivalina homes for washwater. When used for drinking, it is filtered at home.
Dumps
Honeybucket waste is hauled about 1-2 times per week. Proposed biochar reactor would eliminate dump runs for honeybuckets. Reactor would be in or near Kivalina.
Kivalina Native Store
19% of people we interviewed said they buy bottled water @ about $7 per gallon.

RELOCATE

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KIVALINA CITY COUNCIL
RE-LOCATE LLC
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NANA VILLAGE ECONOMIC DEVELOPMENT
NAPECA
CLIMATE FOUNDATION
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CXT/LB FOSTER
CIVILIZATION
THREE DEGREES WARMER
ARTPLACE AMERICA

CONTRIBUTORS:
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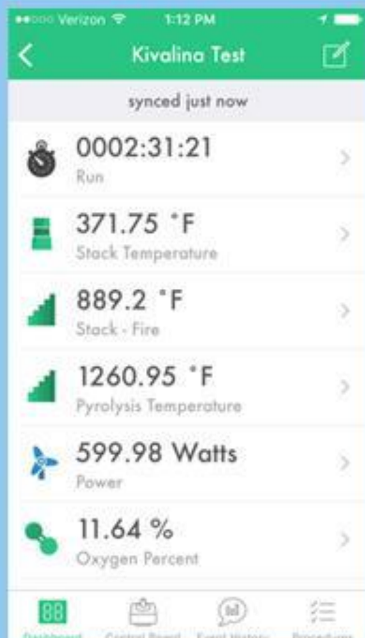
GRIND DRY PYROLIZE

RELOCATE


Verizon 1:12 PM
Kivalina Test
synced just now
0002:31:21
Run
371.75 °F
Stack Temperature
889.2 °F
Stack - Fire
1260.95 °F
Pyrolysis Temperature
599.98 Watts
Power
11.64 %
Oxygen Percent
Dashboard
Control Board
Event History
Procedures


Verizon 1:12 PM
Control Board
Kivalina Test
Kivalina Unit
Ran 4 Days, 3 Hours
Putnam, CT
99 Canal St
Alert Me For
Export Data
Followers
Wireless Configuration
Sensor Selection
Adjust Setpoints
Dashboard
Control Board
Event History
Procedures


kelvin


SANITARY ALUMINUM
ZERO REVEALS
VENTILATION:
ODOR, EXHAUST, AMBIENT
EMERGENCY SHUT OFF
BUILT-IN TIE DOWNS
SOLAR PANEL MOUNTING
FULLY INSULATED
TOUCH CONTROLS PANEL
COLD RATED COMPONENTS
CUSTOM O.S.
MAN DOOR ACCESS
LED LIGHTING
PLUG-IN MULTIPLE POWER SOURCES
WATER TIGHT/REINFORCED
OCEAN READY
RELOCATE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RELOCATE

Net-Zero Water: Energy-Positive Municipal Water Management

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Sathvika Ramaji (Student resident)
Katelynne Storey (Incoming student resident)
Alyssa Walker (Incoming student resident)
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MS and undergraduate students: (65)

High school interns (5)

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Univ. of Miami Dept. of Civil, Arch., & Environ. Engrg.

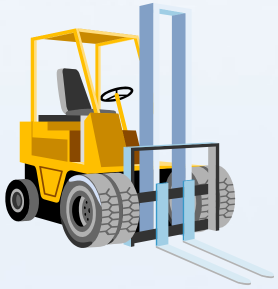
REGULATORY AGENCIES
Miami-Dade County Dept. Envir. Resources Mgmt.
Miami-Dade County Dept. Health
Florida Dept. Environmental Protection
Coral Gables Building & Zoning

Motivations since 2003: Water, Energy, Chemicals

- Water
  - California, Texas, Alaska
  - Miami (60 in/y) → Landscape ≤ 2 days/week
- Energy
  - Sea level rise

Third Challenge: Chemical Accumulation

- TRI releases: 6.2 billion lbs. (2001)
- US pesticide usage: 5 billion lbs. (2002)
- US surface + ground runoff: 1.8 trillion gpd
- Average 2000 µg/L toxics → US waters

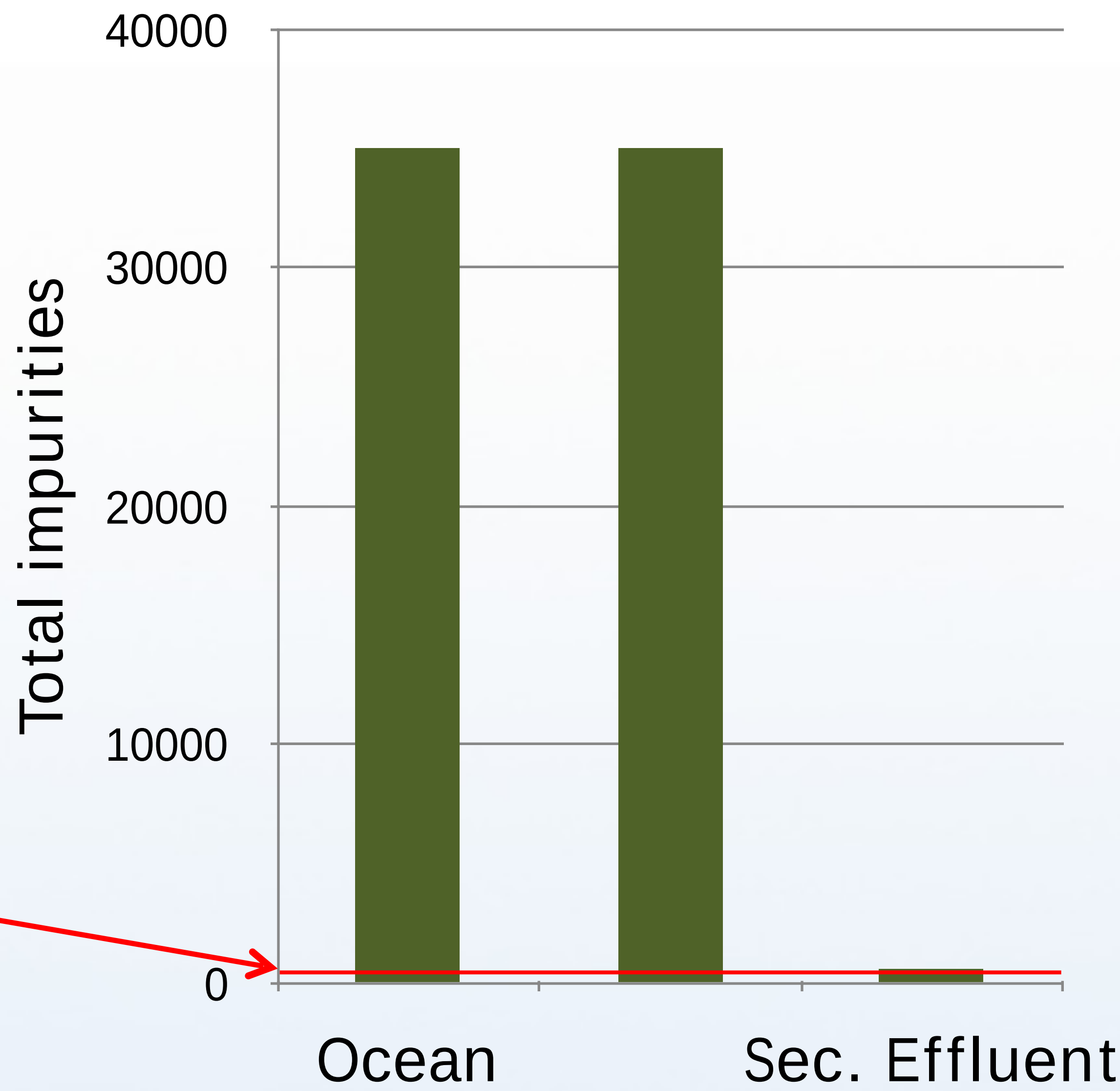


Health and Environmental Effects

- US blood samples → toxics universal
  - (Thornton et al. 2002; CDC 2003)
- Wildlife/humans → endocrine disruption
  - 5% alligator fertility Lake Apopka

Water Impurity Levels (TDS)

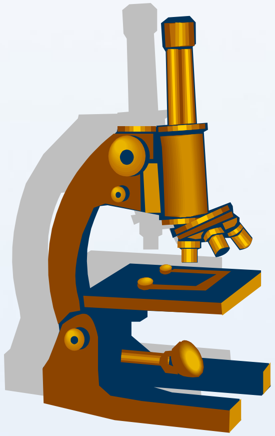
Secondary drinking water standard



Treated Wastewater Quality (Average S. Florida)

Meets drinking water standards except:

- Antimony
- Total coliforms
- Secondary:
  - – Color
  - – Odor
  - – TDS (551 mg/L)
  - – foaming agents



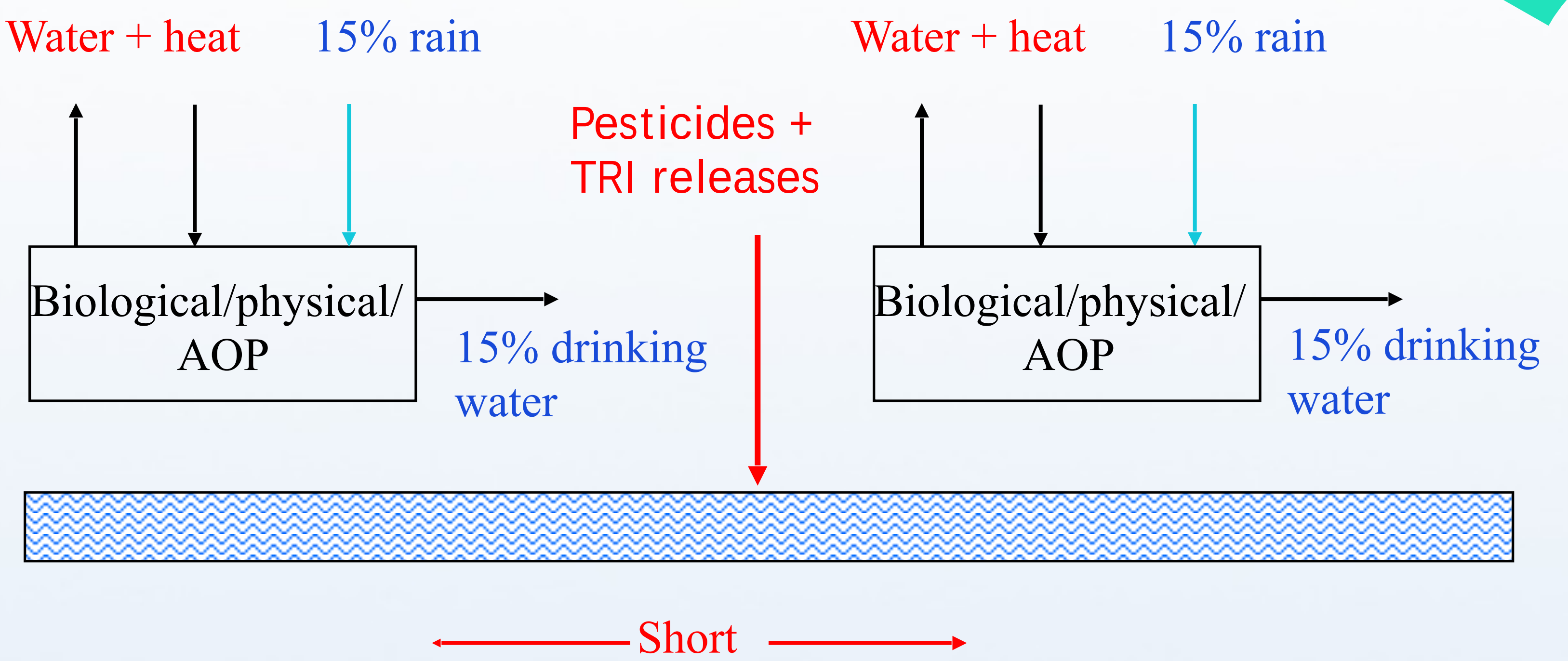
Current Water Recycling

- Wastewater segregation
  - Multiple conveyance and treatment systems
  - No water independence
  - Dry (composting) toilets
- Direct potable reuse: reverse osmosis
  - Continual concentrate disposal
  - Chemical constituents
  - Microbes

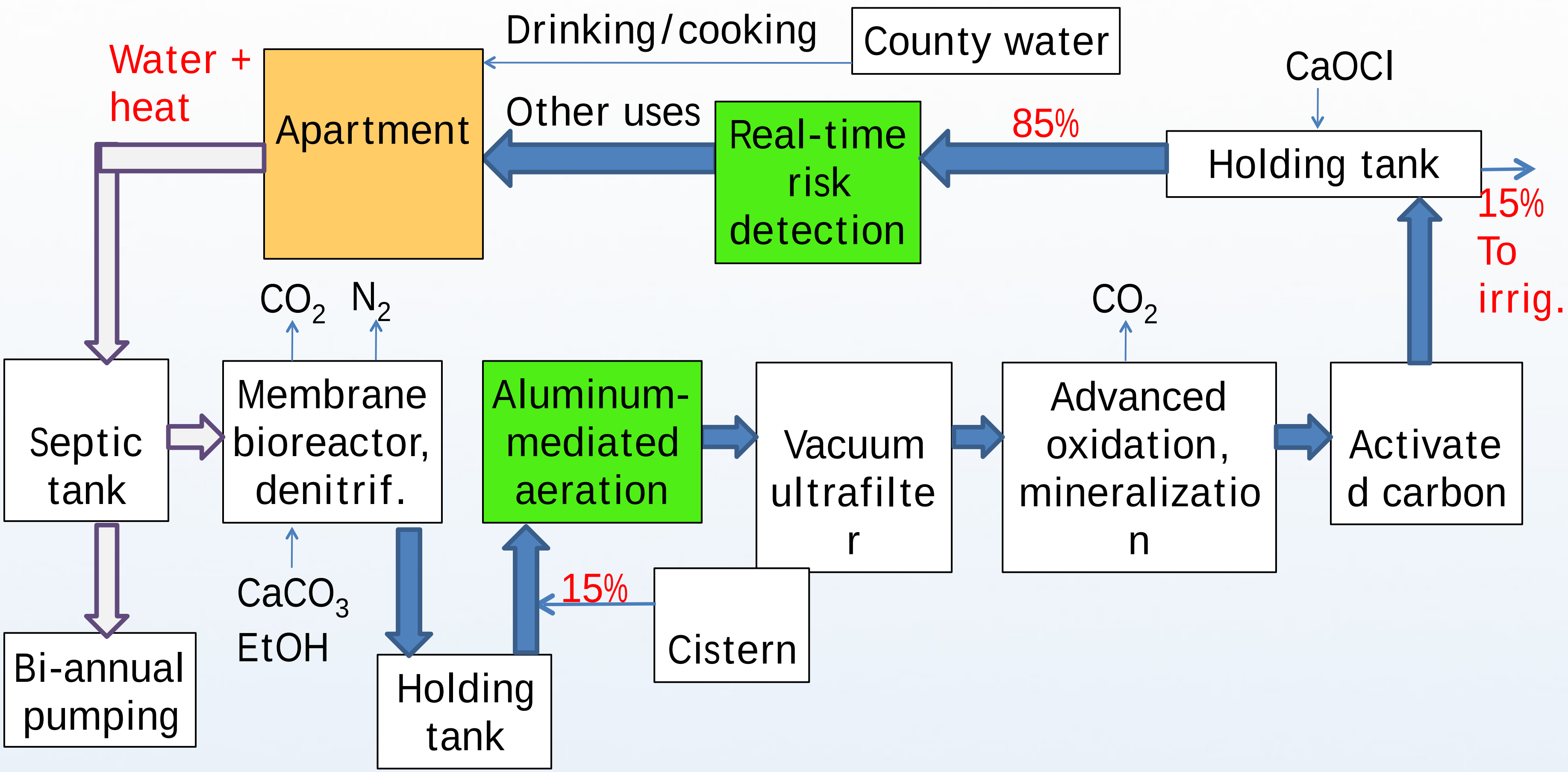
DPR Water & Energy Recovery

- Windhoek, Namibia: 20% recycle
- Big Spring, TX: 20%
- International Space Station: ~75% urine
- U of Miami Net-Zero Water system: 85%

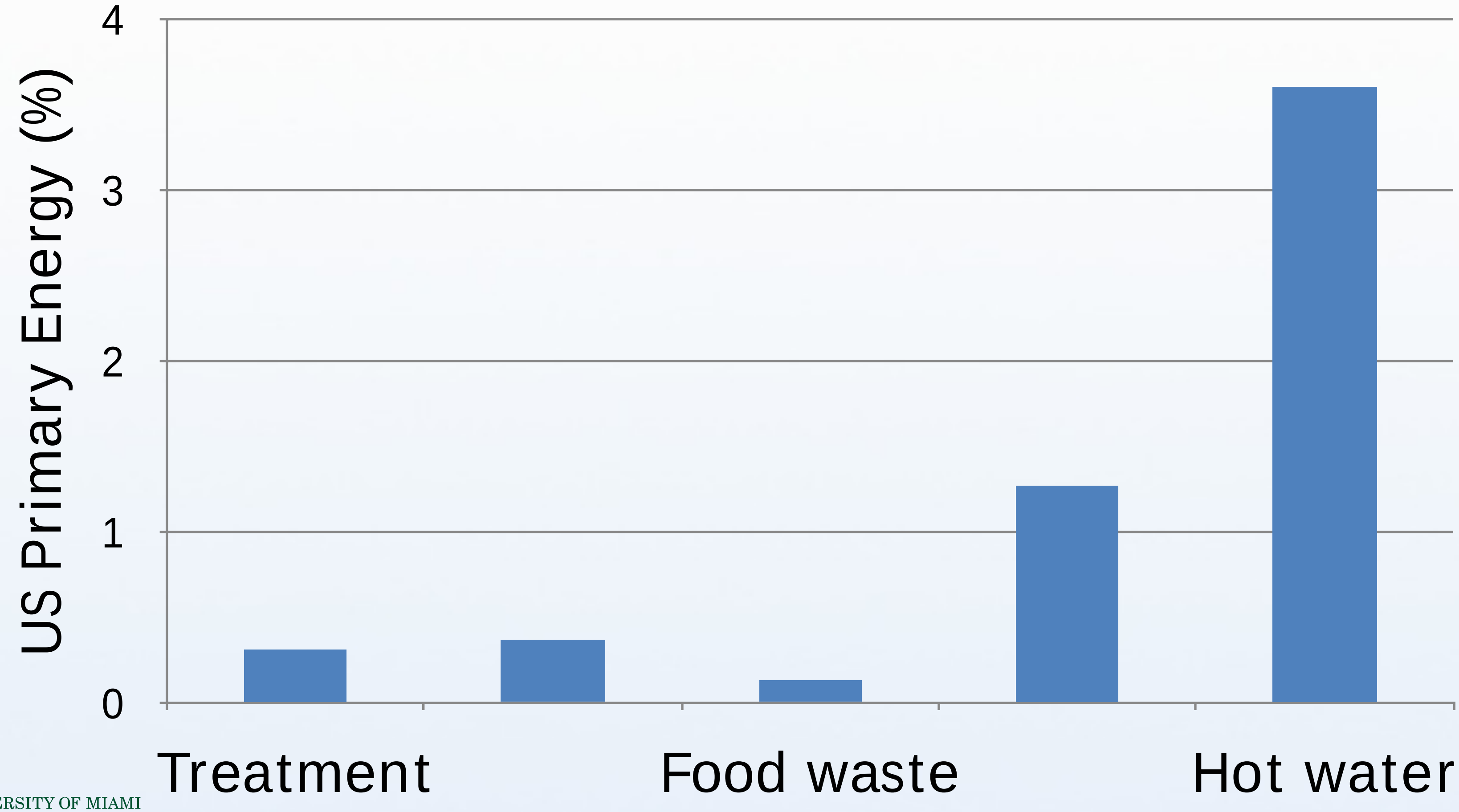
Net Zero Water Management (85% Recycle)



Net-Zero Water:
Nearly Closed-Loop Water/Energy Recycling



Municipal Water Energy



UM Urban Net-Zero Water System

- Save 56% of hot water energy
  - Equal to that used for treatment
- Water recycle: 85%
- No concentrate disposal
- Pump sludge every 1-2 years
- Meet potable reuse guidelines

Residence Hall Site

Auton. net zero water unit

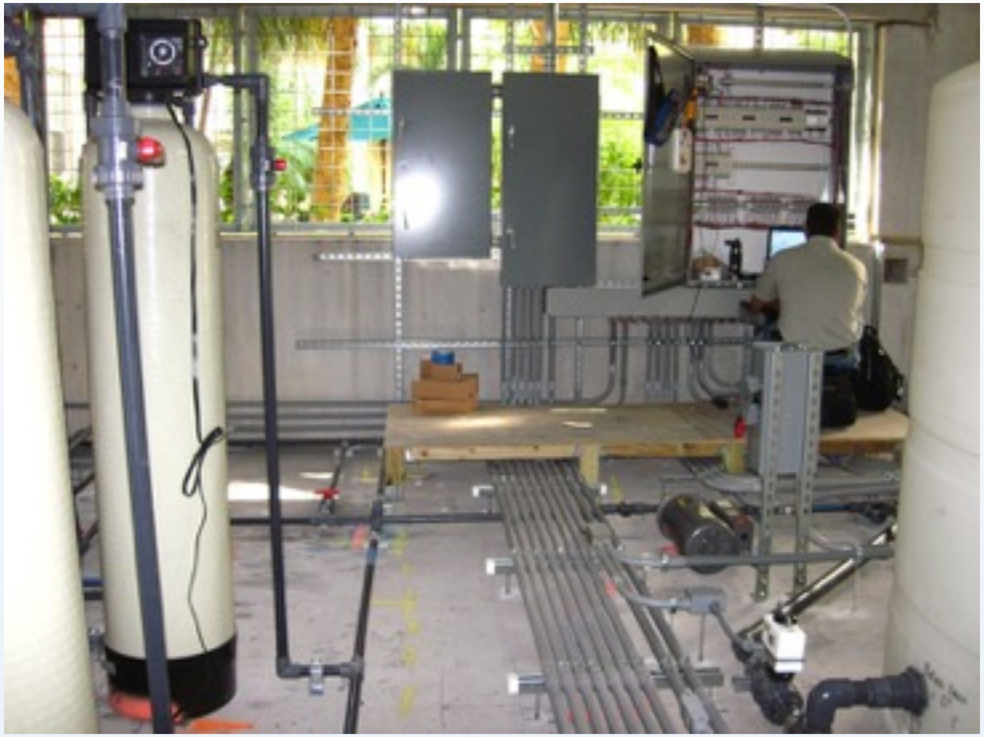
Treatment System

Above-ground

Aerobic/cistern

Control Systems

Master controls

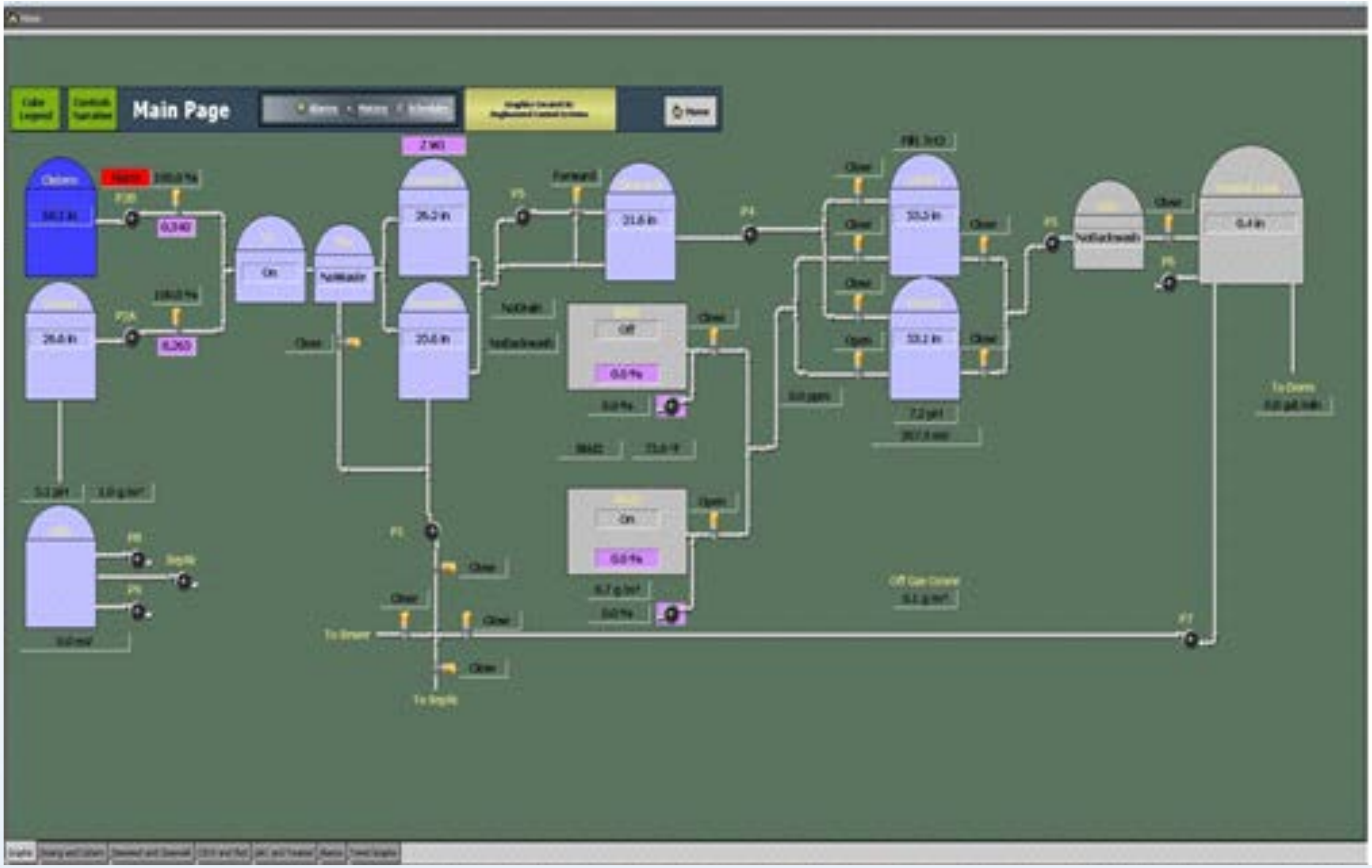


Peroxone & UV-peroxide

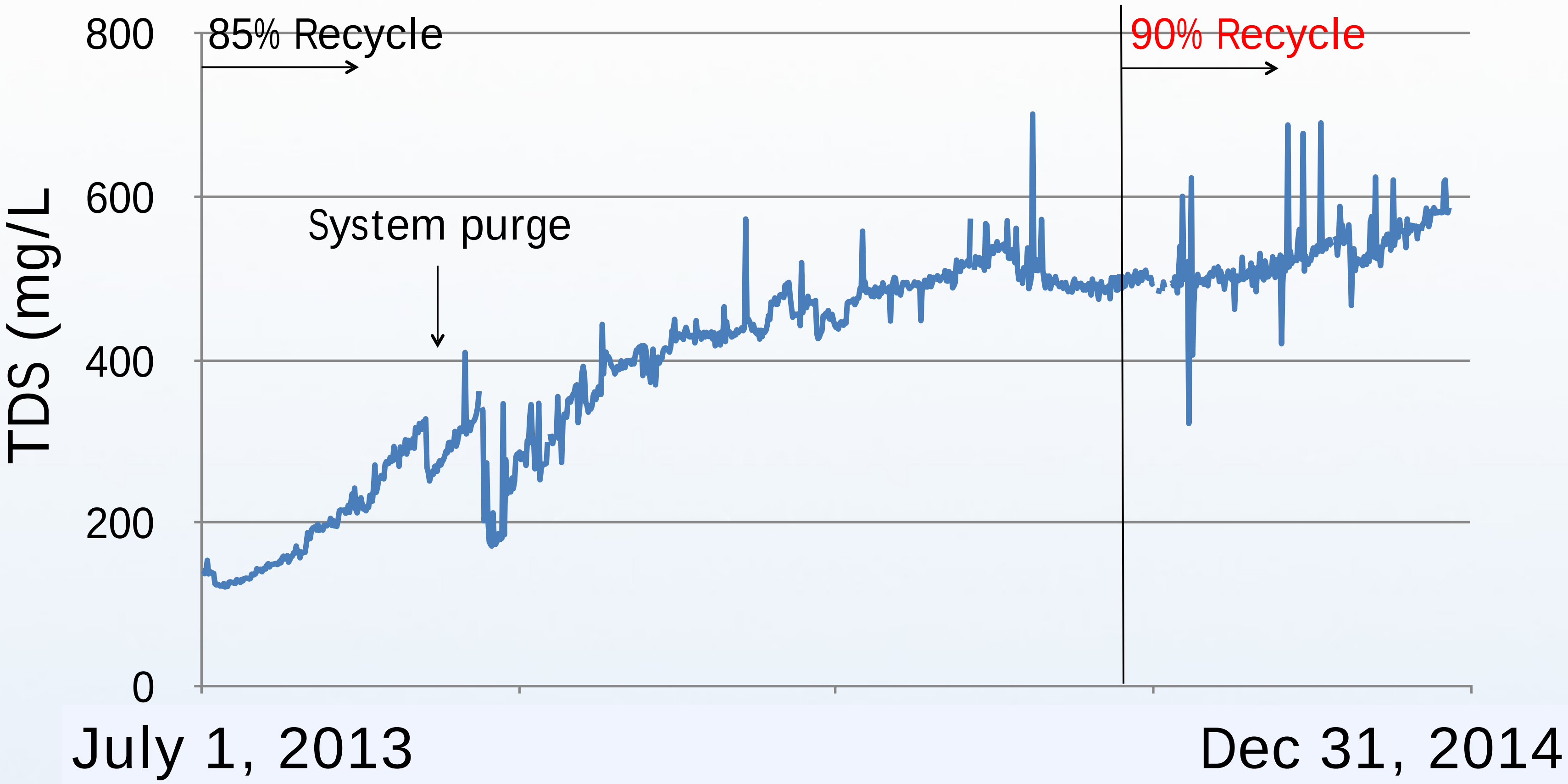
National Science Foundation (NSF)
April 26

University of Miami students are taking part in a water recycling research project just by living in the Autonomous NetZero Water Dorm - catch the story in our featured podcast line-up @Science360 Radio!
http://go.usa.gov/kVXz

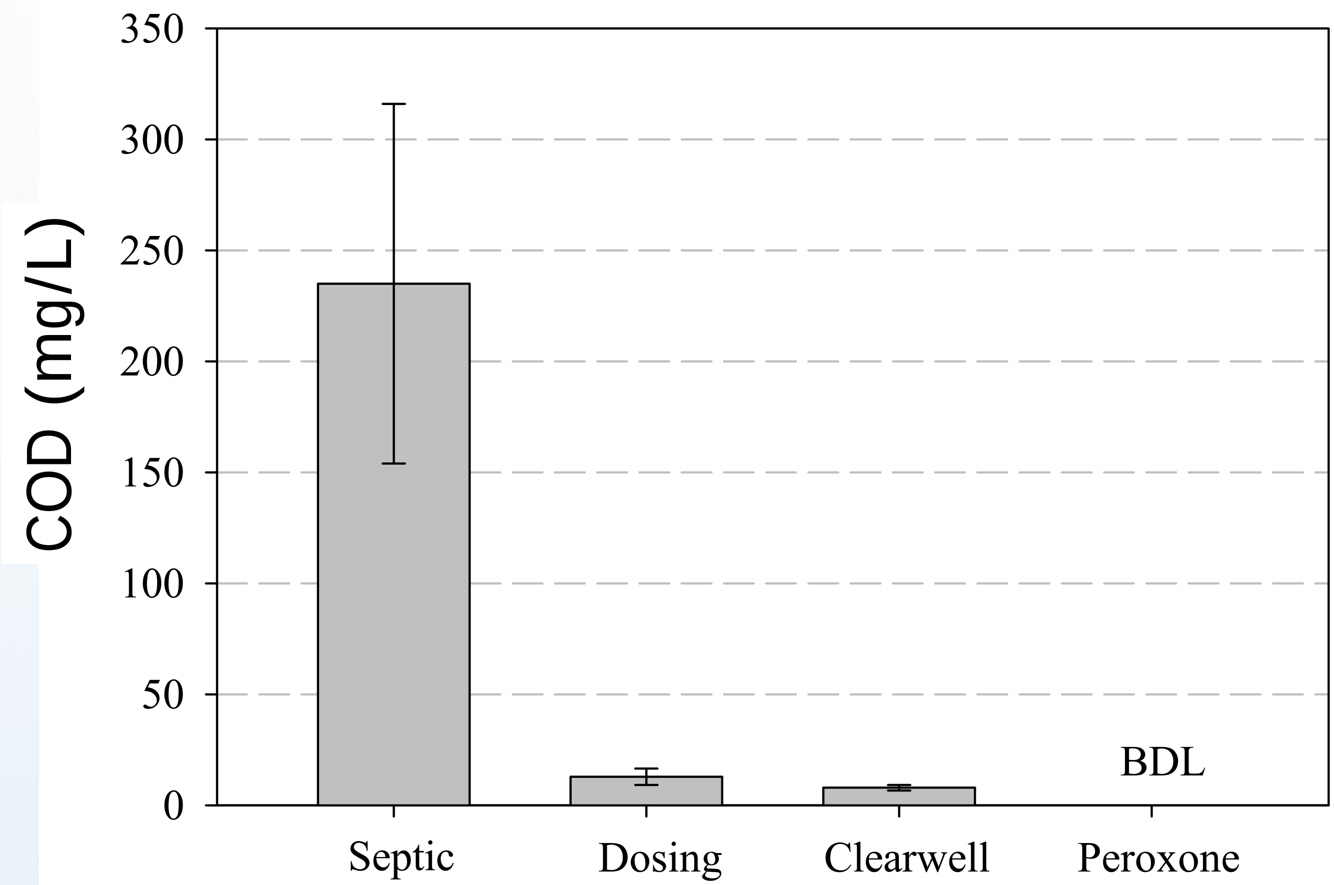
Remote Process Control



Minerals (mg/L TDS)

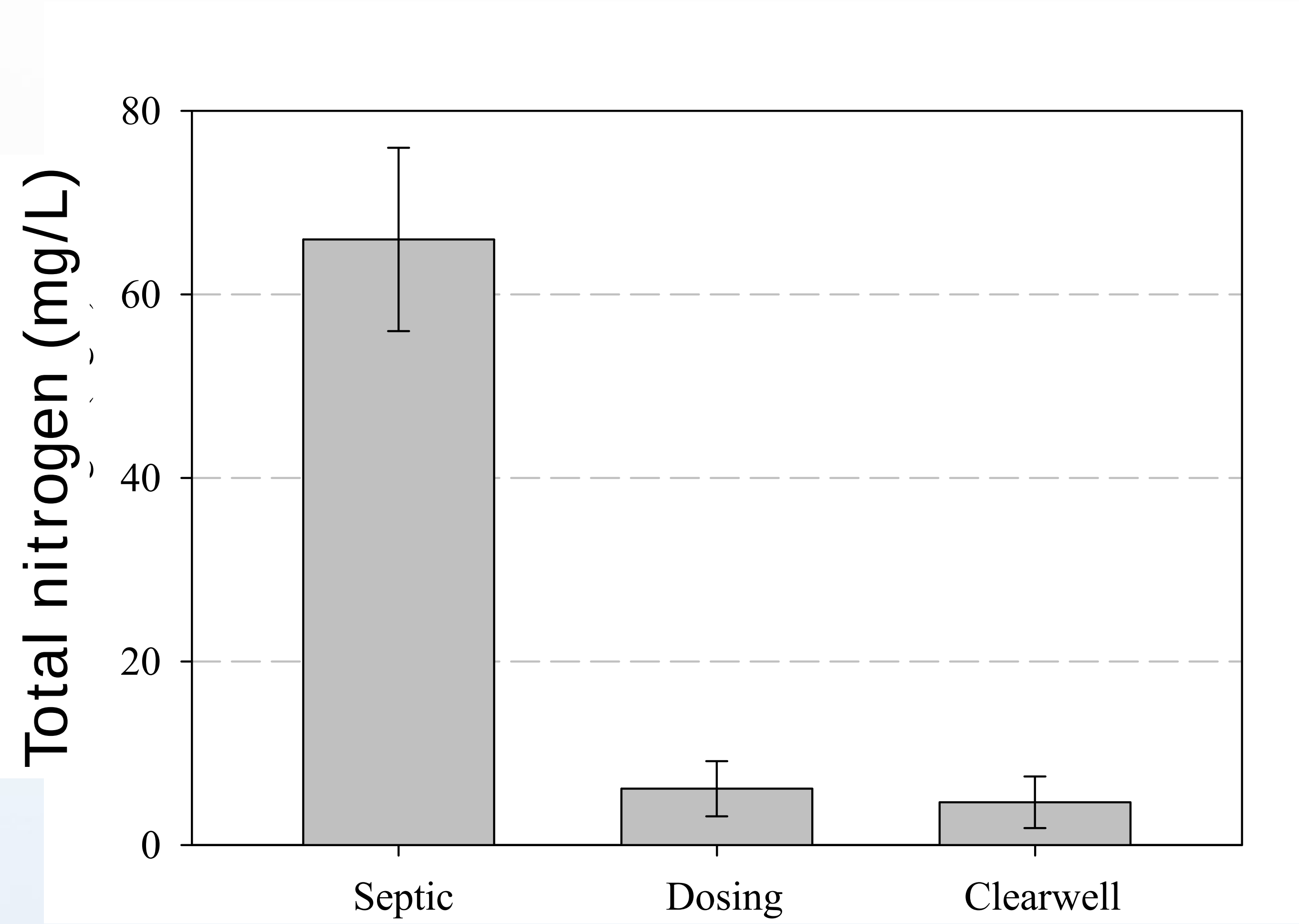


Organics Reduction through System

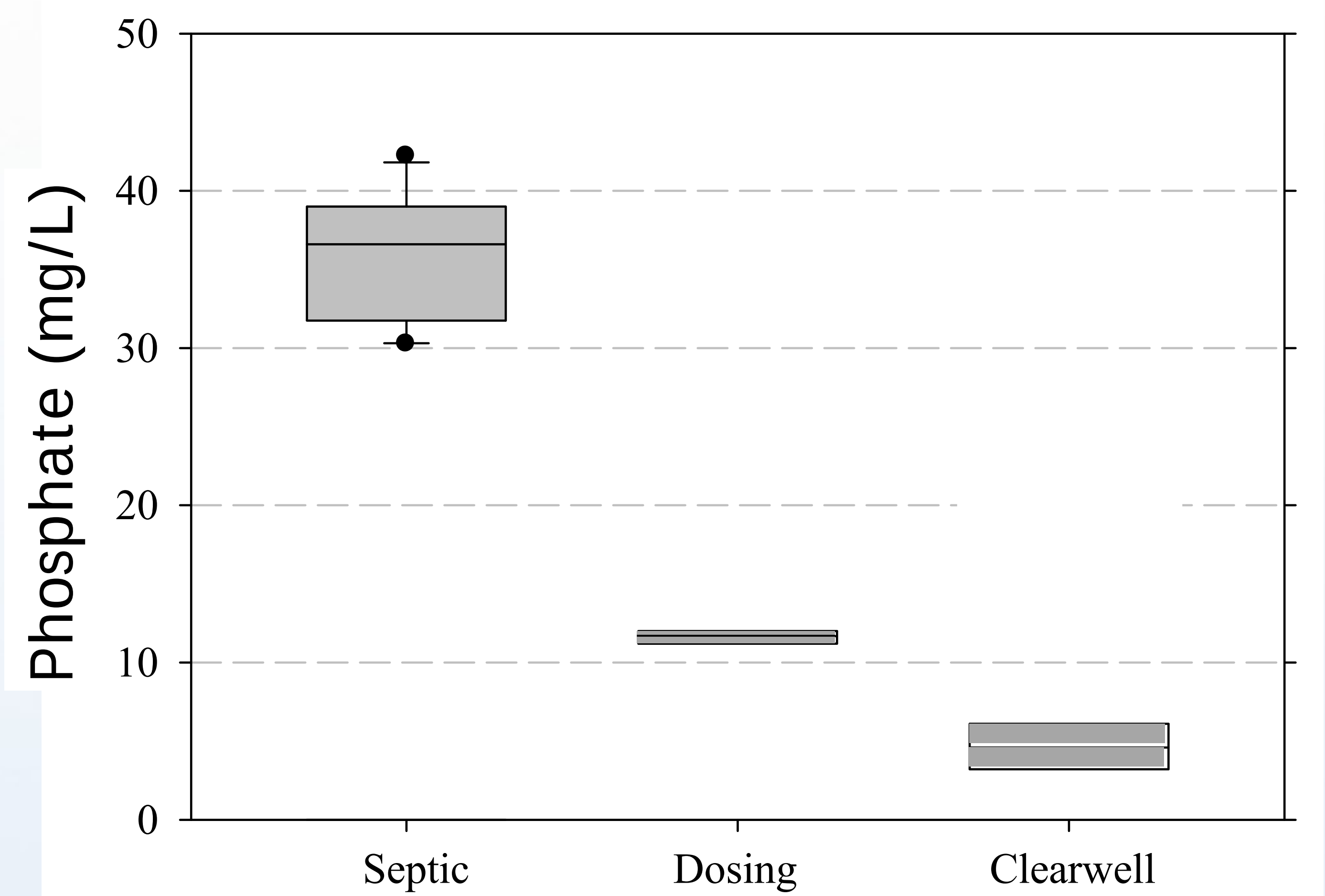


Reduction of Nitrogen Species

(Jul., 2013 - Dec. 2013)



Phosphate Reduction through System



Chemicals

- 1006 emerging constituents tested
- Influent: 56
- Effluent: 50 removed >90%
  - 50 removed >90%
  - 3 increased including DEET
  - 97 of 97 pharms, hormones, personal care products undetected

Microbes

- MS coliphage: none
- Somatic coliphage: none
- Adenovirus: one qPCR signal
- Cryptosporidium: none
- Giardia: none
- Fecal coliform: 8 positive of 136 daily plates

Log Reductions – if we could extrapolate treatment response linearly

Organism	Virus	Giardia	Crypto
NZW: Peroxone	44	89	40
NZW: UV/H_2O_2	164	32	30

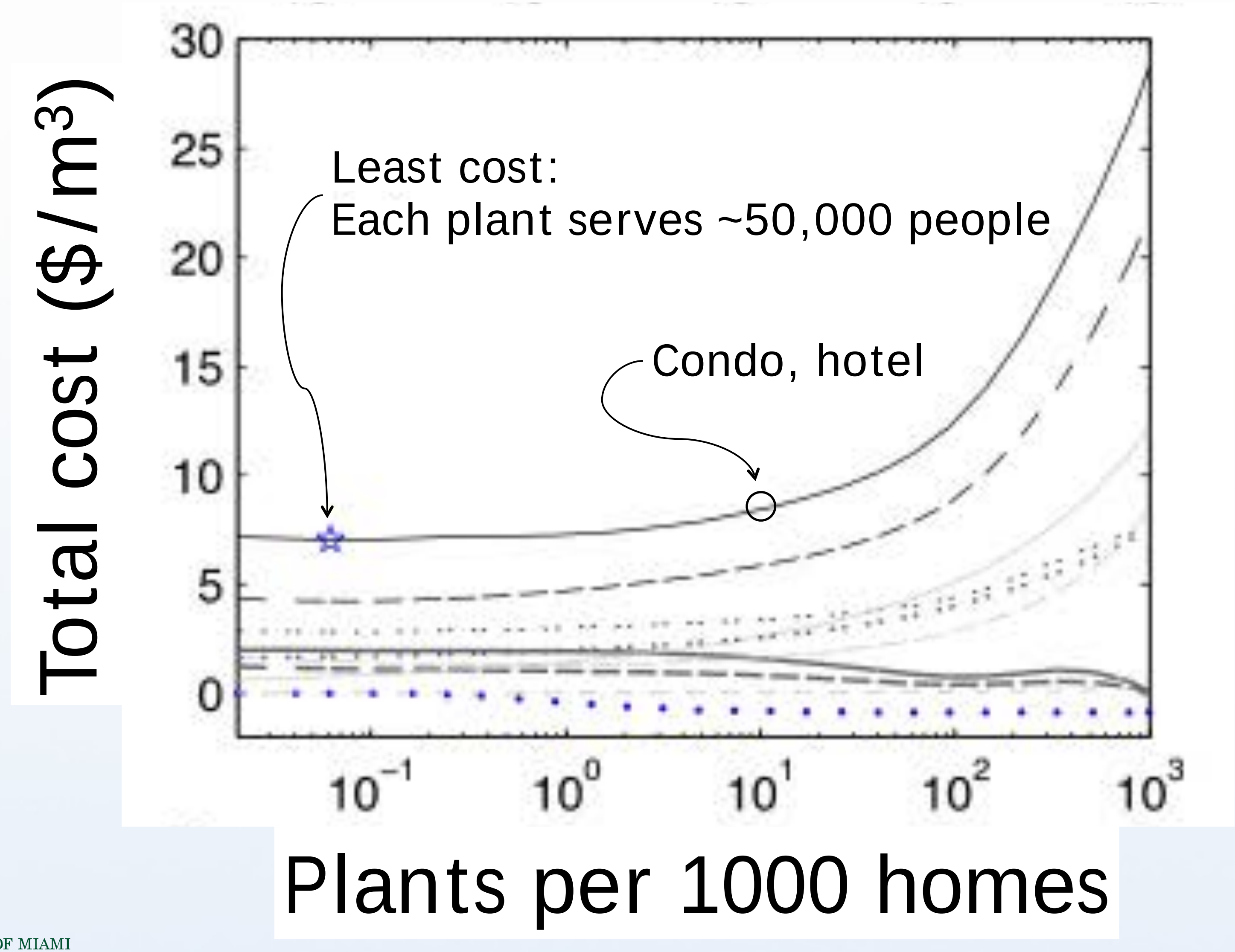
Compliance

- 115 of 115 drinking water stds met:
  - 10/15/2013 – 7/3/14
- 114 of 115 drinking water stds met:
  - 7/3/14 – 12/3/2014
  - Bromate: 20 µg/L

Process Control

- Bromate → Backwash water disposal
- FC → catalytic GAC
  - Remove hydrogen peroxide residual
  - Maintain chlorine residual

Cost versus Plant Scale



Energy Demand: 1 MGD Plant
(kWh/m^3 primary energy; EPRI 2002)

Treatment total:		-9.12
• Wastewater:	-2.39	
• Water:	-2.10	
• Peroxone mineralization:	-6.52	
Hot water savings:		13.25
• Hot water:	23.81	
• Losses:	10.56	
Energy Saved:		4.13
Conveyance Energy:		-0.99

Conclusions: NZW

- Mineralization energy: $8/1000 gal
  - Total cost 45% lower than San Francisco
- Water independence
- Energy retained in closed loop
- No concentrate disposal
- 15% drinking water disposed
- 1-2 year sludge pumping

Recommendations: NZW

- Remote automated process control
- Local monitoring, maintenance
- Skilled technician on call

- Information:
  - Google: net-zero water miami
  - jenglehardt@miami.edu

Goundbreaking in Miami

Working …

… for the next generation, in Alaska

Thank you

Potentials and challenges of biogas from fish industry waste in the Arctic

Pernille Erland Jensen
Arctic Technology Center
Department of Civil Engineering
Technical University of Denmark.

Content

- Introduction
- Why make biogas in the Arctic?
- Why is it not done already?
- Biogas potential of fish residues and organic waste
- Perspective

Present challenges

Fish industry residuals

- Major part disposed off at sea
- Oxygen depletion at seafloor
- Methane emission

g

General waste

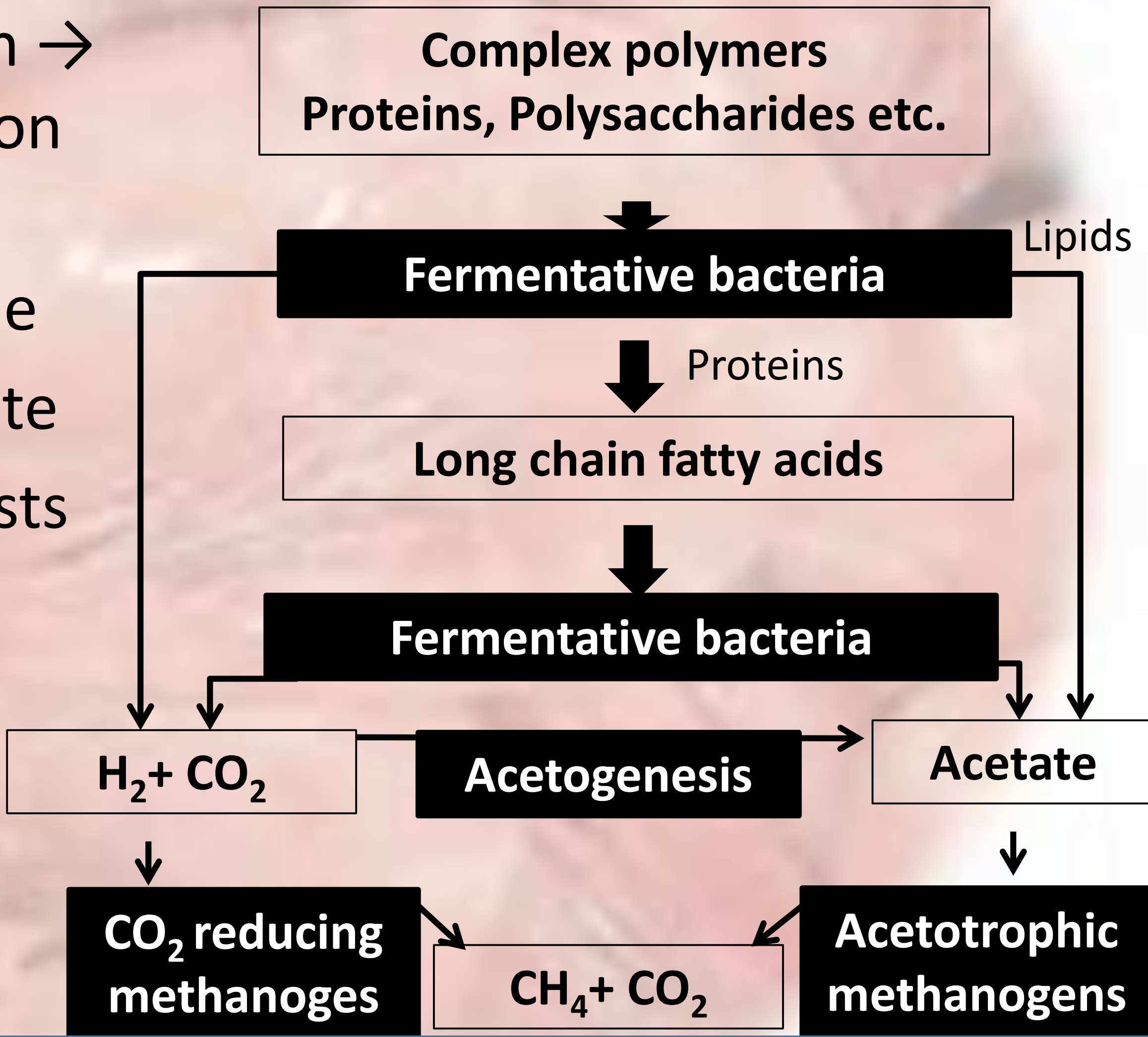
- Organic household waste
- Sludge from wastewater treatment
- Bag toilet and septic tank content

Can we make the anaerobic digestion happen under controlled conditions, collect biogas and utilize the energy?

Envisioned challenges

- Shrimp, crab: Protein → Ammonia → Inhibition
- Halibut: Lipids → Inhibition of methane
- Cold, changing climate
- Lack of local specialists
- Seasonal shift in loading material and rate

Simplified overview of anaerobic digestion process



Biogas plants

Can be very simple installation or highly industrialized optimized plant.

Biogas use

- Electricity – requires large scale plant + energy conversion
- Vehicles – biogas from vegetable products, requires upgrading of gas
- Heat or cooking – can be used directly

  - Simple technology for use of gas to e.g. heat water for boiling of shrimps or heating of buildings

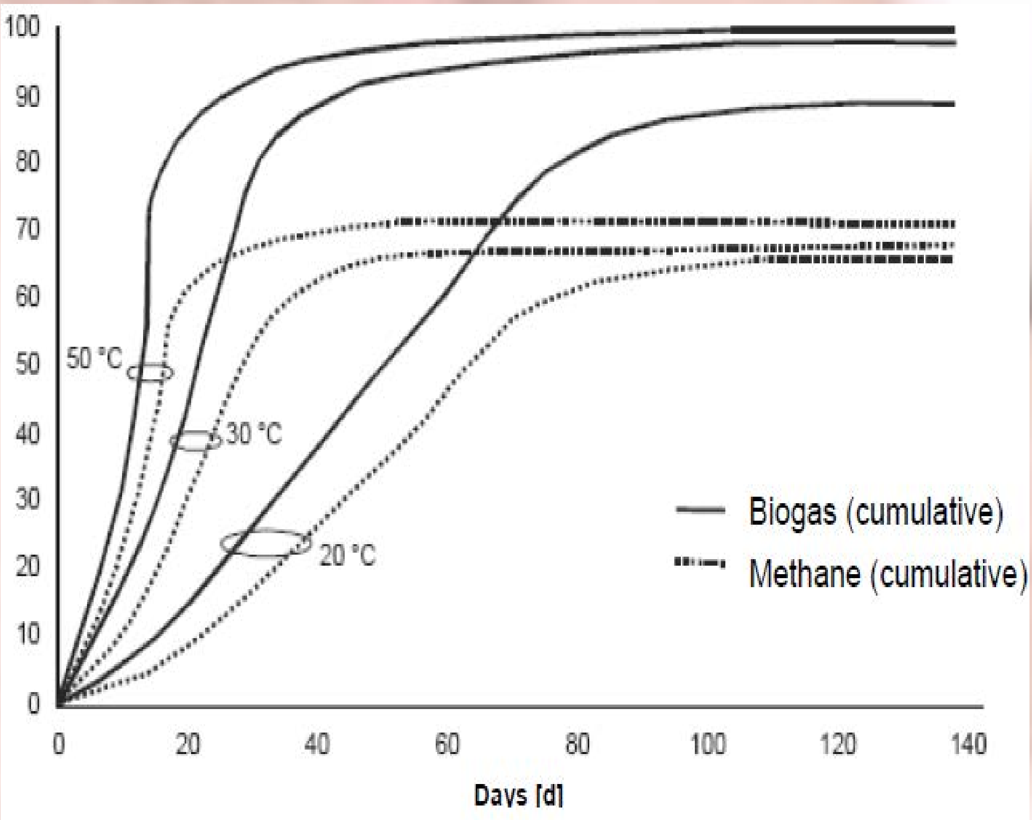
WIHAH
ANCHORAGE, ALASKA 2016 SEPTEMBER 18 - 21
WATER INNOVATIONS FOR HEALTHY ARCTIC HOMES

ARCTIC TECHNOLOGY CENTRE DTU

Temperature

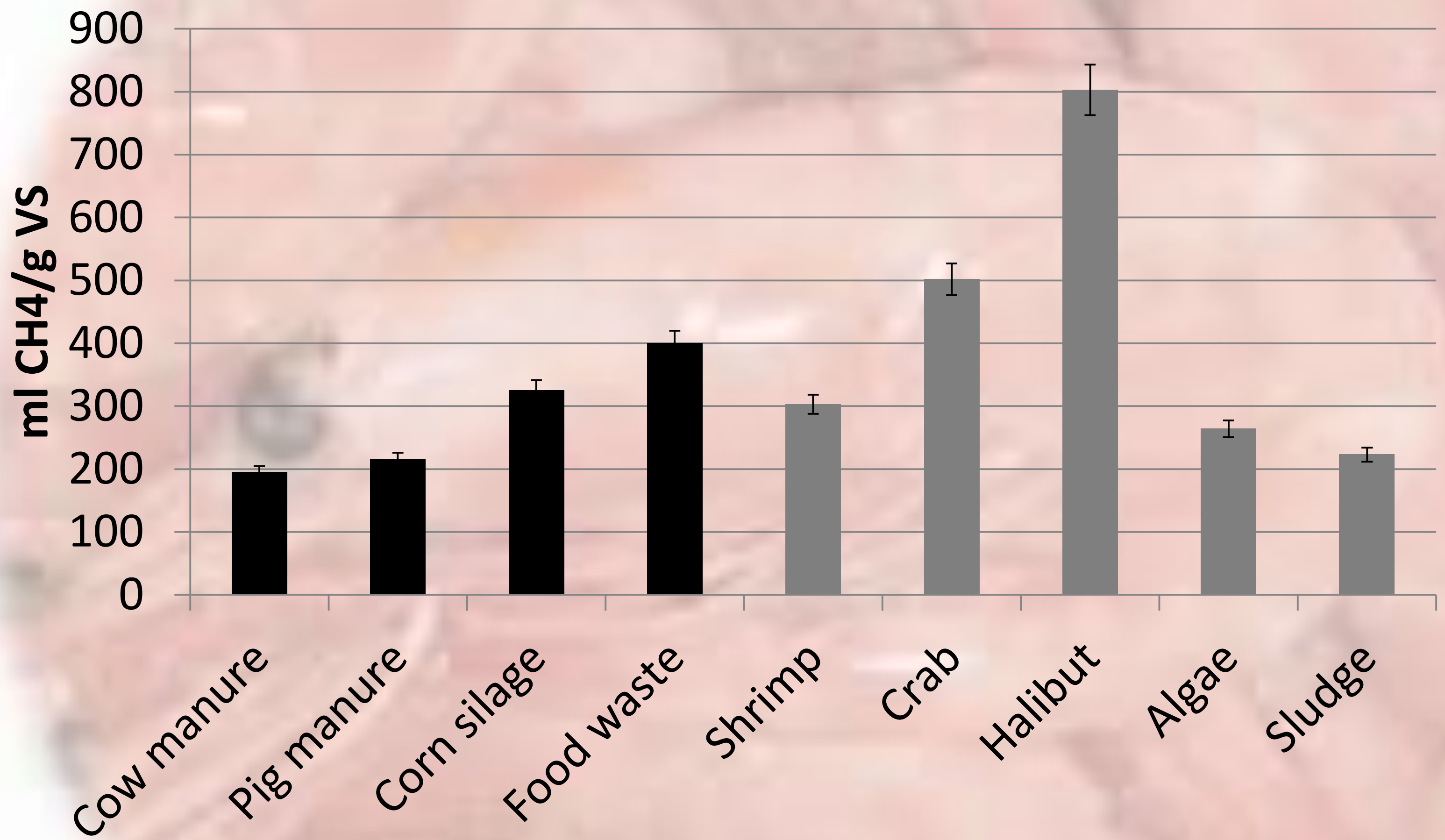
Low temperatures
Slower – higher retention time – larger tank

Lower risk of inhibition and instability at mesophilic conditions



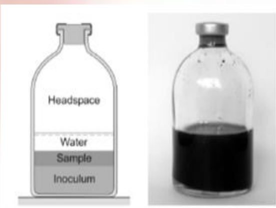
Thermal stage	Process temperatures	Retention time
Psychrophilic	< 20ºC	70 – 80 days
Mesophilic	30 – 42 ºC	30 – 40 days
Thermophilic	43 – 55 ºC	15 – 20 days

Methane potential

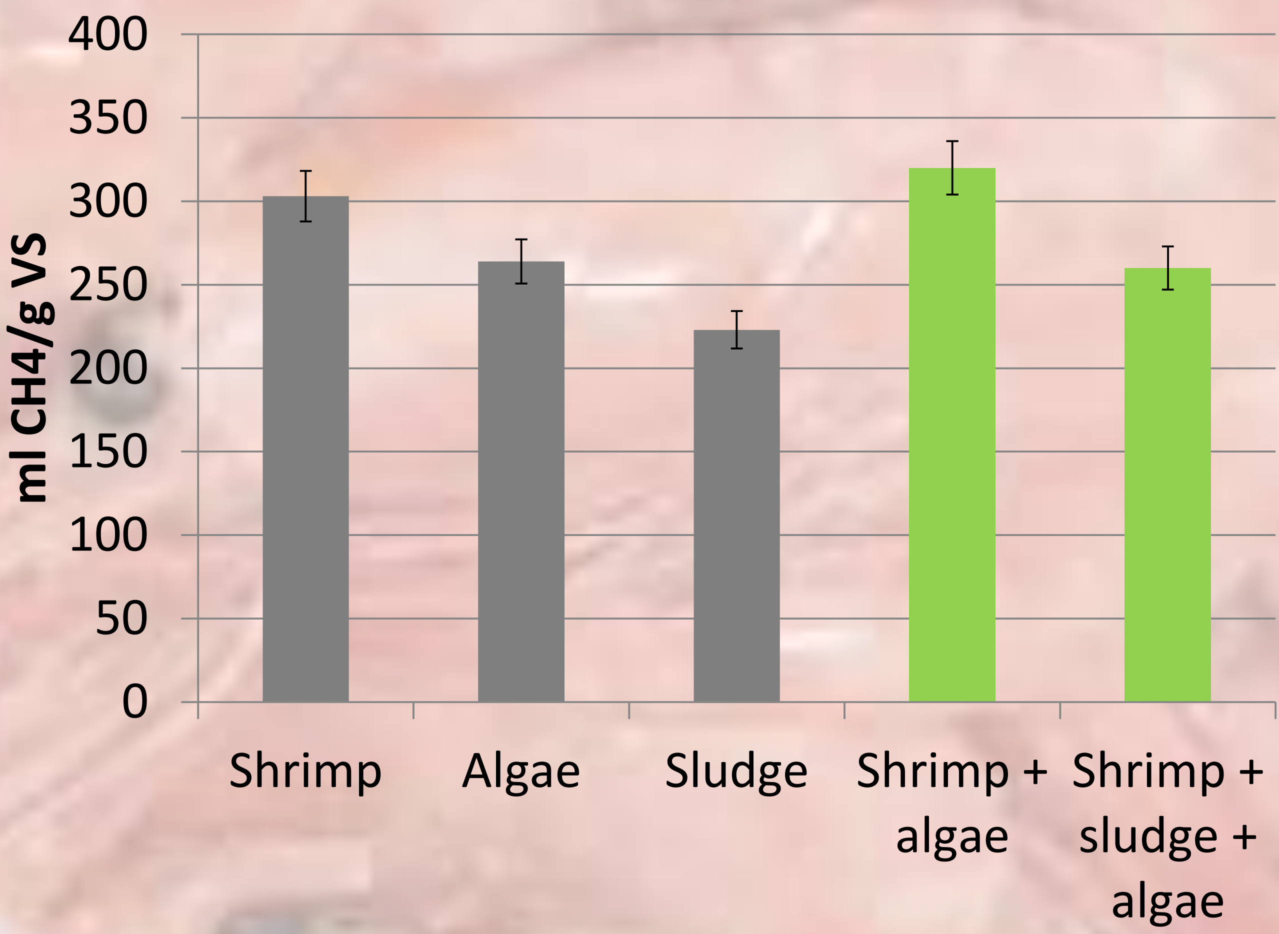


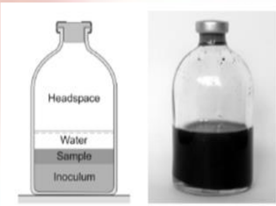
Literature values, thermophilic

Our measurements, mesophilic



Methane potential





Potential

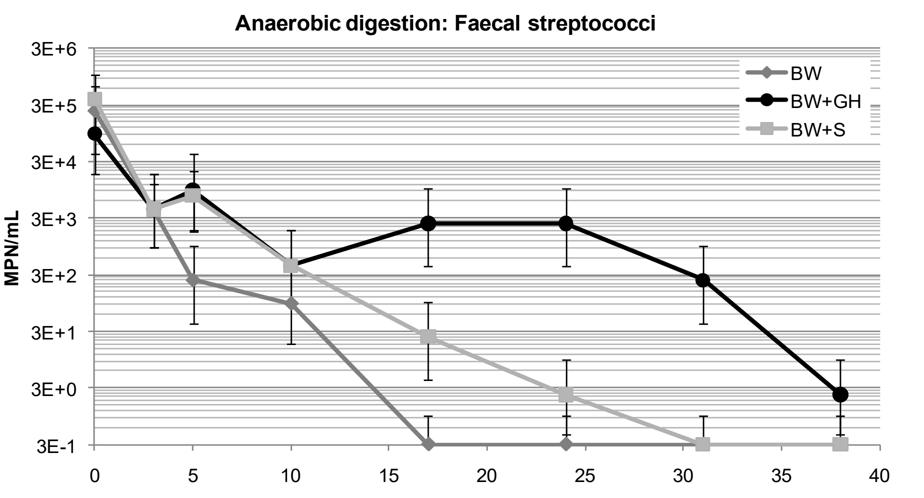
In Sisimiut

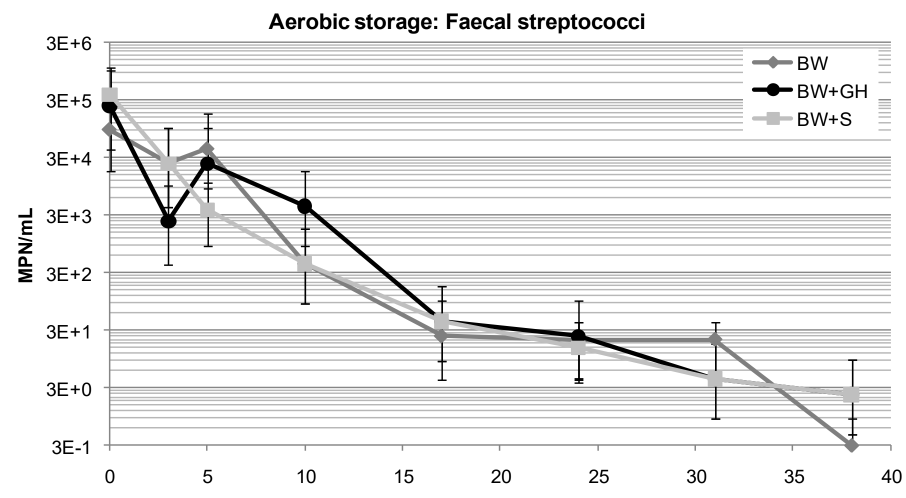
> 80% of energy used for heating at shrimp processing plant

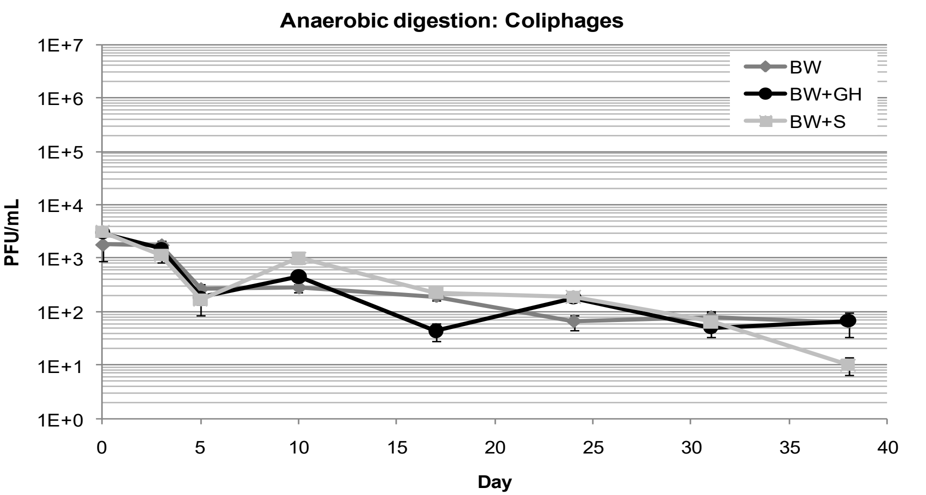
↑

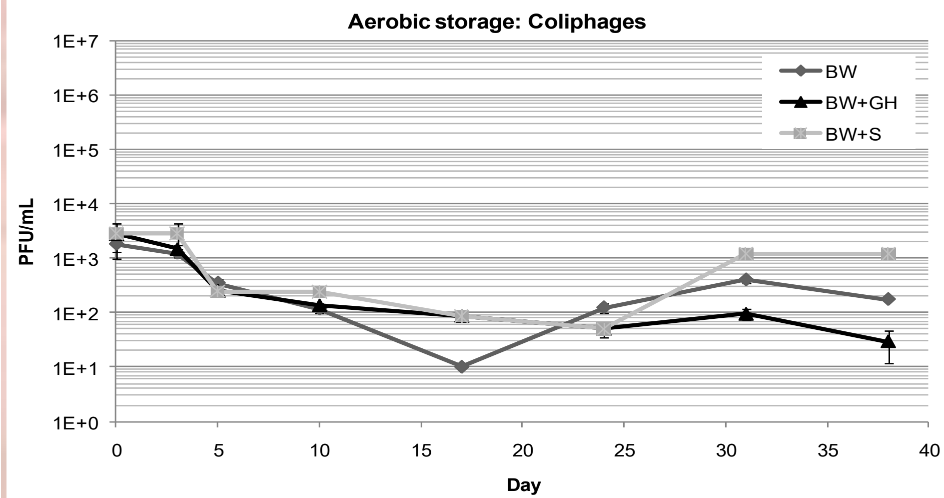
Hygienization of blackwater

Anaerobic Mesophilic incubation Aerobic









Gunnarsdóttir, R.; Heiske, S.; Jensen, P.E.; Schmidt, J.E.; Villumsen, A; Jenssen, P.D. Effect of anaerobiosis on indigenous microorganisms in blackwater with fish offal as co-substrate, *Water Research*, 63, 1-9, 2014.

Other options

- Shrimp flour
  - Local experience
  - Low price
  - Only shrimp residuals
- Bio oil
  - Only halibut
- Chitin
  - Advanced processing
- Food for fish farming?
- Food for dogs?

Conclusions and outlook

- Fish and seafood by-product do have significant biogas potential.
- Risk of instability of process due to high lipid and protein content, change in temperature, seasonal variations in loading, lacking of local experts.
- Mesophilic conditions may help stabilize process + reduce need of heating/insulation.
- Mixing with organic food waste, sludge and/or algae may help stabilize process + solve mutual waste challenges – needs to be investigated.
- Knowledge exists for operation, but innovation is needed prior to successful implementation.

Questions

EPA REGULATIONS, POLICIES, AND GUIDELINES FOR WATER REUSE – IMPLICATIONS FOR DECENTRALIZED GREYWATER REUSE

Robert K. Bastian, Senior Environmental Scientist

Office of Wastewater Management

U.S. Environmental Protection Agency

Washington, D.C. 20460

Two basic questions …

How do current EPA regulations, policies and guidance address decentralized greywater reuse?

Do other standards and sources of guidance address decentralized greywater reuse?

EPA has established drinking water standards and water quality standards and criteria focused on various designated uses of surface water, but there are no formal EPA regulations or criteria focused on water reuse in general or specific to decentralized greywater (or is it graywater or gray water or grey water) reuse ...

- Drinking water standards and health advisories ... https://www.epa.gov/dwstandardsregulations/drinking-water-contaminant-human-health-effects-information

- EPA water quality standards and criteria ... https://www.epa.gov/wqs-tech

Recreational Water Quality Criteria

Quality Criteria for Water [The Red Book] – 1976

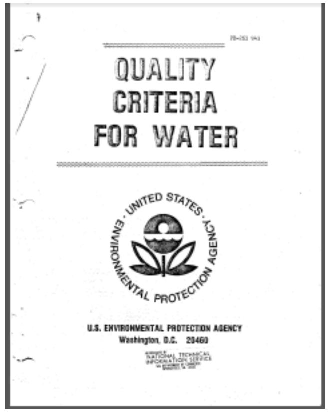
Fecal coliforms … geometric mean of 200 organisms per 100 mL

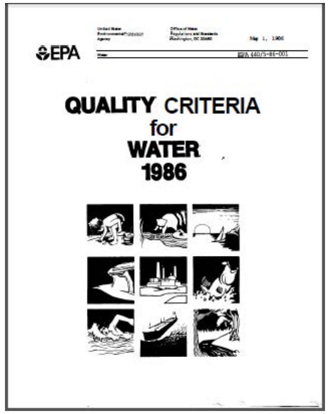
U.S. PHS had previously recommended fecal coliform criteria of 200 cfu per 100 mL

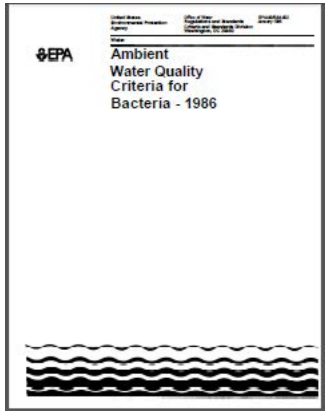
Quality Criteria for Water [The Gold Book] – 1986

Ambient Water Quality Criteria for Bacteria – 1986

Freshwater	…	E. coli	126 per 100 mL, or
		enterococci	33 per 100mL
Marine Water	…	enterococci	35 per 100mL

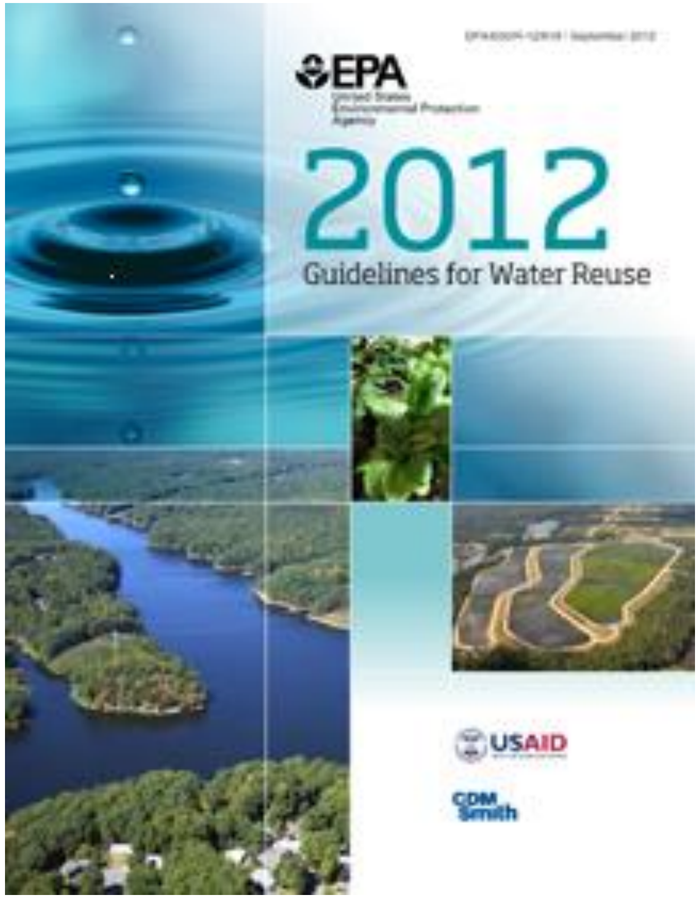






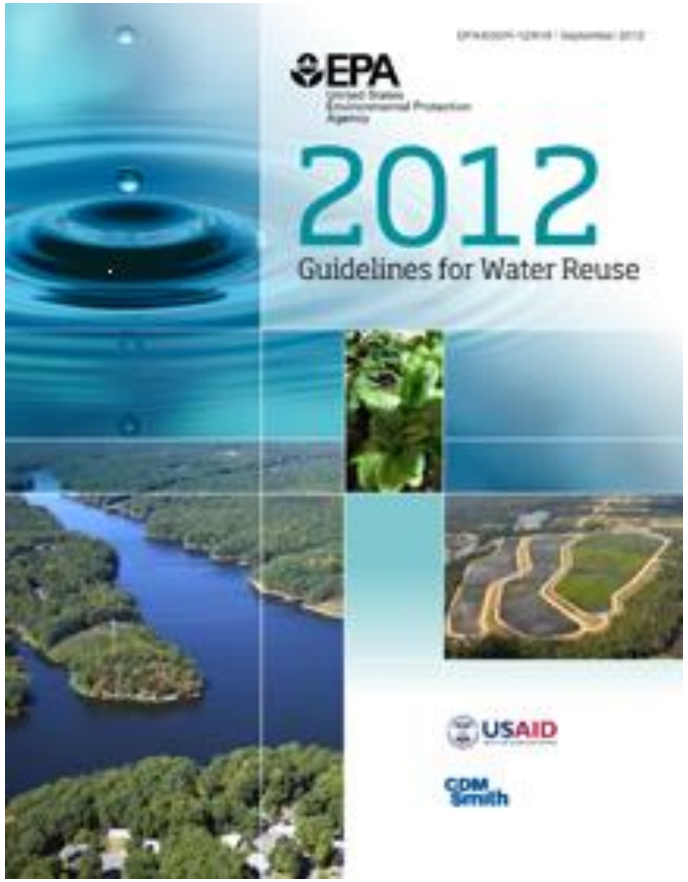
2012 Recreational Water Quality Criteria

CRITERIA ELEMENTS	Recommendation 1 Estimated Illness Rate 36/1,000		Recommendation 2 Estimated Illness Rate 32/1,000	
Indicator	GM (cfu/100 mL)	STV (cfu/100 mL)	GM (cfu/100 mL)	STV (cfu/100 mL)
Enterococci (marine & fresh)	35	130	30	110
E. coli (fresh)	126	410	100	320



"https://nepis.epa.gov/Adobe/PDF/P100FS7K.pdf"

However, the **2012 EPA *Guidelines for Water Reuse*** document does provide recommended minimum requirements for a series of water reuse practices and refers quite a lot to "Graywater" and "Greywater" reuse, especially in **Chapter 2: Planning and Management Considerations** and most intensively under **2.3.2.1 Individual On-site Reuse Systems and Graywater Reuse** (p.2-32 – 2-35) and throughout **Chapter 5: Regional Variations in Water Reuse**.



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Includes recommended minimum requirements for …

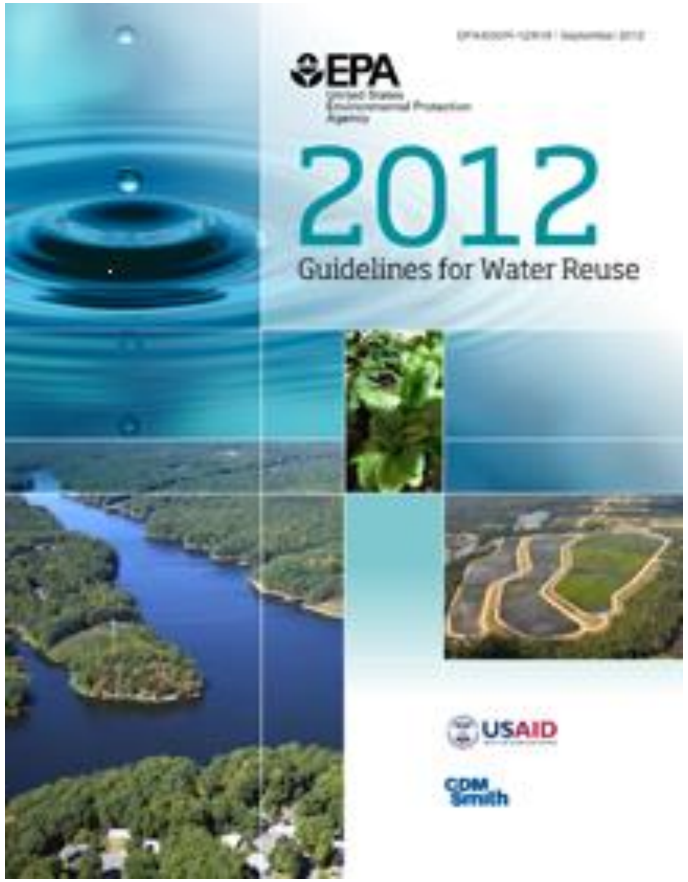
- Urban Reuse – Unrestricted … and Restricted
- Agricultural Reuse – Food Crops … and Processed Food Crops and Non-food Crops
- Impoundments – Unrestricted … and Restricted
- Environmental Reuse
- Industrial Reuse
- Groundwater Recharge – Nonpotable Reuse
- Indirect Potable Reuse (IPR)

Have been applied by some states to graywater and harvested stormwater.

Table 4-4 Suggested guidelines for water reuse

Reuse Category and Description	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring	Setback Distances [3]
Urban Reuse				
Unrestricted The use of reclaimed water in nonpotable applications in municipal settings where public access is not restricted.	▪ Secondary[4] ▪ Filtration[5] ▪ Disinfection[6]	▪ pH = 6.0-9.0 ▪ ≤ 10 mg/l BOD [7] ▪ ≤ 2 NTU [8] ▪ No detectable fecal coliform /100 ml [9,10] ▪ 1 mg/l Cl_2 residual (min.) [11]	▪ pH – weekly ▪ BOD - weekly ▪ Turbidity - continuous ▪ Fecal coliform - daily ▪ Cl_2 residual – continuous	▪ 50 ft (15 m) to potable water supply wells; increased to 100 ft (30 m) when located in porous media [18]

- pH = 6.0-9.0
- ≤ 10 mg/l BOD [7]
- ≤ 2 NTU [8]
- No detectable fecal coliform /100 ml [9,10]
- 1 mg/l Cl_2 residual (min.) [11]



"https://nepis.epa.gov/Adobe/PDF/P100FS7K.pdf"

References the **2011 NSF/ANSI Standard 350** ***Onsite Residential and Commercial Water Reuse Systems*** [assures water is treated to safe level for specific reuse, non-potable applications – e.g., surface or subsurface irrigation, toilet/urinal flushing, decorative fountains, etc.] and the **2011 NSF/ANSI Standard 350-1** ***Onsite Residential and Commercial Graywater Treatment Systems for Subsurface Discharge*** https://www.nsf.org/newsroom_pdf/ww_nsf_ansi350_qa_insert.pdf

SCOPE OF STANDARDS

STANDARD 350: ON-SITE RESIDENTIAL AND COMMERCIAL WATER REUSE TREATMENT SYSTEMS	
Building Types	Residential, up to 1,500 gallons per day Commercial, more than 1,500 gallons per day and all capacities of commercial laundry water
Types of wastewater treated (influent)	Combined black and graywater Graywater Bathing water only Laundry water only
Uses of treated water (effluent)	Nonpotable applications, such as surface and subsurface irrigation and toilet and urinal flushing
Ratings	Two classifications that vary slightly in treated water quality: Class R: single-family residential Class C: multifamily and commercial Systems are further described by the type of wastewater treated (combined, graywater, bathing only or laundry only).

TABLE 6 SUMMARY OF DRAFT NSF STANDARD 350 EFFLUENT CRITERIA FOR INDIVIDUAL CLASSIFICATIONS

Parameter	Class R		Class C	
	Overall test average	Single sample maximum	Overall test average	Single sample maximum
$CBOD_5$ (mg/L)	10	25	10	25
TSS (mg/L)	10	30	10	30
Turbidity (NTU)	5	10	2	5
E. coli[2] (MPN/100 mL)	14	240	2.2	200
pH (SU)	6–9	NA[1]	6–9	NA
Storage vessel disinfection (mg/L)[3]	≥0.5–≤2.5	NA	≥0.5–≤2.5	NA
Color	MR[4]	NA	MR	NA
Odor	Non-offensive	NA	Non-offensive	NA
Oily film and foam	Non-detectable	Non-detectable	Non-detectable	Non-detectable
Energy consumption	MR	NA	MR	NA

[1] NA = Not applicable
[2] Calculated as geometric mean
[3] As chlorine. Other disinfectants can be used.
[4] MR = Measured and reported only

https://www.nsf.org/newsroom_pdf/ww_nsf_ansi350_qa_insert.pdf

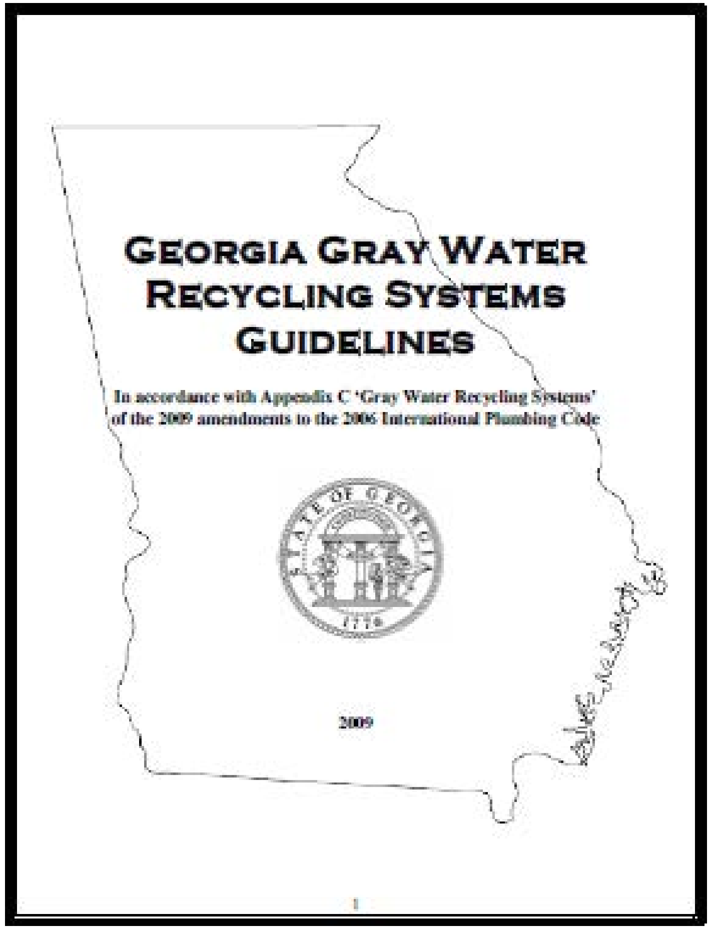
SCOPE OF STANDARDS

NSF/ANSI STANDARD 350-1: ON-SITE RESIDENTIAL AND COMMERCIAL GRAYWATER TREATMENT SYSTEMS FOR SUBSURFACE DISCHARGE	
Building Types	Residential, capacities up to 1,500 gallons per day Commercial, capacities more than 1,500 gallons per day and all capacities of commercial laundry water
Types of wastewater treated (influent)	Combined black and graywater Graywater Bathing water only Laundry water only
Uses of treated water (effluent)	Subsurface irrigation only
Ratings	Single effluent quality with no classifications Systems are further described based on the type of influent (graywater, bathing only, laundry only).

TABLE 7 SUMMARY OF DRAFT NSF STANDARD 350-1 EFFLUENT CRITERIA FOR INDIVIDUAL CLASSIFICATIONS

Parameter	Test Average
$CBOD_5$ (mg/L)	25 mg/L
TSS (mg/L)	30 mg/L
pH (SU)	6–9
Color	MR[1]
Odor	Non-offensive
Oily film and foam	Non-detectable
Energy consumption	MR

[1]MR = Measured and reported only



GEORGIA GRAY WATER RECYCLING SYSTEMS GUIDELINES

In accordance with Appendix C 'Gray Water Recycling Systems' of the 2009 amendments to the 2006 International Plumbing Code

2009

There are states with specific requirements for graywater reuse, such as the **2009 Georgia Gray Water Recycling Systems Guidelines – In accordance with Appendix C 'Gray Water Recycling Systems' of the 2009 amendments to the 2006 International Plumbing Code** that covers graywater recycling systems for the use of flushing water closets and urinals or subsurface irrigation, if treated according to their Code Standards.

http://www.dca.state.ga.us/development/constructioncodes/programs/downloads/GeorgiaGrayWaterRecyclingSystemsGuidelines_2009.pdf

Where gray water is used for flushing toilets and/or urinals, effluent quality must be improved. High amounts of suspended solids will interfere with the operation of the plumbing fixtures and make disinfection difficult. Because of the potential exposure to gray water by people and pets, any disinfection treatment should reduce the number of illness causing pathogens. After disinfection, total coliform bacteria should be reduced to 500 cfu/100 ml. or less. Fecal coliforms levels should be less than 100 cfu/100 ml. Treated gray water effluent which will be used for subsurface irrigation must meet the requirements found in the Division of Public Health's *Manual for On-site Sewage Management Systems.*

Recommended Minimum Water Quality Guidelines For Design of Recycling Gray Water Systems	
Turbidity (NTU)	**10 NTU (nephelometric turbidity unit)**
Total Coliform Bacteria	**500 cfu/100ml (colony forming units per 100 milliliter)**
Fecal Coliform Bacteria	**100 cfu/100ml (colony forming units per 100 milliliter)**

Some Other States with **Greywater (Graywater) Reuse** Req's

Arizona DEQ, **Water Quality Division: Permits: Reclaimed Water**

http://legacy.azdeq.gov/environ/water/permits/reclaimed.html

Using Gray Water At Home - http://legacy.azdeq.gov/environ/water/permits/download/graybro.pdf

California Dept. of Housing and Community Development (HCD)

http://www.hcd.ca.gov/codes/state-housing-law/preface_et_emergency_graywater.pdf

New Mexico, Environment Department, Liquid Waste (Septic Tank) Program

https://www.env.nm.gov/fod/LiquidWaste/graywater.html

Oregon DEQ Water Quality, Water Reuse Program -

http://www.deq.state.or.us/wq/reuse/graywater.htm

http://www.deq.state.or.us/wq/pubs/factsheets/reuse/11WQ029GraywaterRules.pdf- Fact Sheet

Arizona DEQ, **Water Quality Division: Permits: Reclaimed Water**

http://legacy.azdeq.gov/environ/water/permits/reclaimed.html

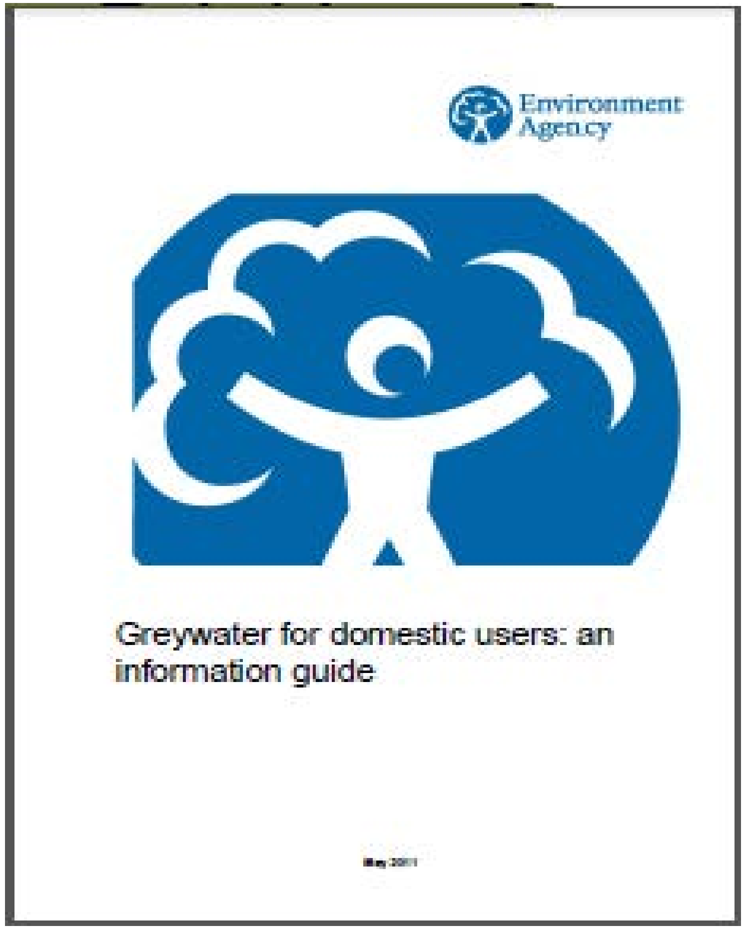
Using Gray Water At Home - http://legacy.azdeq.gov/environ/water/permits/download/graybro.pdf

Utah Administrative Code … Environmental Quality/Water Quality … Rule R317-401. Graywater Systems

http://www.rules.utah.gov/publicat/code/r317/r317-401.htm

Washington State Dept. of Health - Wastewater Management - **Greywater Reuse**

http://www.doh.wa.gov/CommunityandEnvironment/WastewaterManagement/GreywaterReuse



UK Environment Agency

Greywater for domestic users: an information guide

May'2011

How clean does the water need to be?

While stringent standards guard drinking water quality in the UK, **there are no regulatory standards for the quality of non-potable water**. Many groups have called for appropriate standards for non-potable water to overcome concerns about potential health hazards and to bolster public confidence in using non-potable water. However, the enforcement of such standards would be difficult as most systems are independently owned and maintained.

http://www.sswm.info/sites/default/files/reference_attachments/ENVIRONMENT%20AGENCY%202011%20Greywater%20for%20Domestic%20Users.pdf

The tables provide an indication of the water quality that a well designed and maintained system is expected to achieve for the majority of operating conditions.

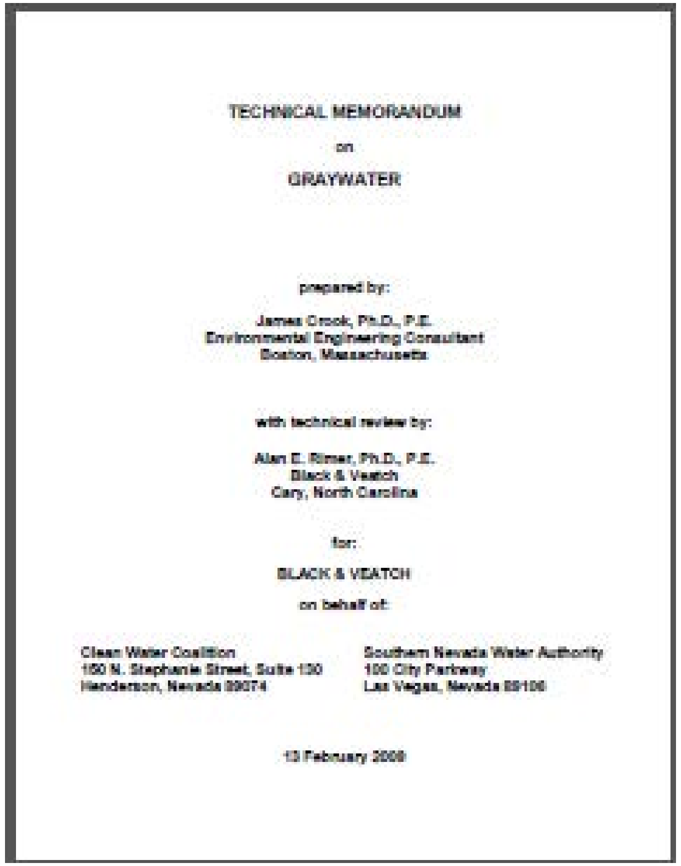
Table 1 – Guideline values (G) for bacteriological monitoring

Parameter	Spray application	Non-spray application			System type
	Pressure washing, garden sprinkler use and car washing	WC flushing	Garden watering	Washing machine use	
Escherichia coli (number/100mL)	Not detected	250	250	Not detected	Single site and communal domestic systems
Intestinal (enterococci number/100mL)	Not detected	100	100	Not detected	Single site and communal domestic systems
Legionella pneumophila (number/100mL)	10	N/A	N/A	N/A	Where analysis is necessary
Total coliforms (number/100mL)	10	1000	1000	10	Single site and communal domestic systems

Table 3 – Guideline values (G) for general system monitoring

Parameter[)]	Spray application	Non-spray application			System type
	Pressure washing, garden sprinkler use and car washing	**WC flushing**	**Garden watering**	**Washing machine use**	
Turbidity NTU	<10	<10	N/A	<10	All systems
pH (pH units)	5 - 9.5	5 - 9.5	5 - 9.5	5 - 9.5	Single site and communal domestic systems
Residual chlorine (mg/L)	<2.0	<2.0	<0.5	<2.0	All systems where used
Residual bromine (mg/L)	0.0	N/A	0.0	N/A	All systems where used

[A)] In addition to these parameters, all systems should be checked for suspended solids and colour. The treated greywater should be visually clear, free from floating debris and not objectionable in colour for all uses. Colour is particularly relevant for washing machine use.



TECHNICAL MEMORANDUM

on

GRAYWATER

prepared by:

James Crook, Ph.D., P.E.
Environmental Engineering Consultant
Boston, Massachusetts

with technical review by:

Alan E. Rimer, Ph.D., P.E.
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for:

BLACK & VEATCH

on behalf of:

Clean Water Coalition
150 N. Stephanie Street, Suite 130
Henderson, Nevada 89074

Southern Nevada Water Authority
100 City Parkway
Las Vegas, Nevada 89106

13 February 2009

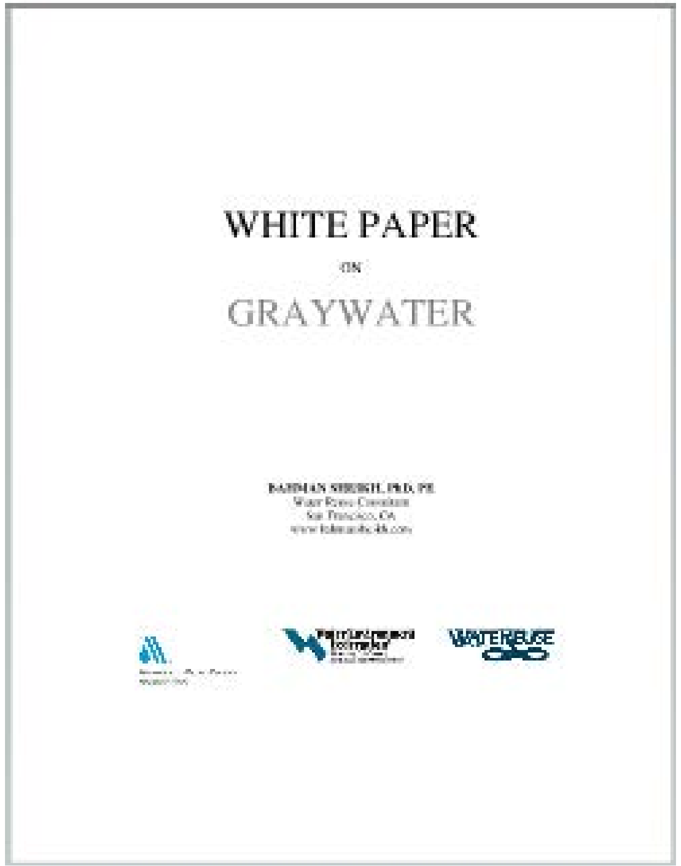
A forty page TECHNICAL MEMORANDUM ON GRAYWATER dated 13Feb2009 by Dr. James Crook and Black & Veach for the Clean Water Coalition and the Southern Nevada Water Authority (Las Vegas) …

- Graywater use is increasing in the U.S., where as many as 7% of households report some use of graywater, many, particularly in rural areas, without obtaining regulatory permits or approval.

http://www.nwri-usa.org/pdfs/CrookTechnicalMemorandumonGraywater.pdf

TECHNICAL MEMORANDUM ON GRAYWATER …

Untreated graywater is used for outside irrigation of turf, plants, or crops. Untreated graywater systems may be as simple as collecting and dispersing the water on single-family residential premises by buckets or may include much more sophisticated collection, piping, and dispersal systems with surge or storage tanks and coarse screening or filtering to remove particulate matter. The amount of graywater produced in a home varies from place to place, ranging from about 20 to 60 gallons/capita/day (50 to 150 gallons/household/day). Most homeowners do not use all of the available graywater produced in their homes, and actual quantities of graywater used are generally considerably less than the amount of graywater produced.



http://www.readbag.com/bahmansheikh-pdf-files-graywater-wra-wef-awwa-final

A fifty page **WHITE PAPER ON GRAYWATER** prepared by Dr. Bahman Sheikh for AWWA, WEF and the WateReuse Assoc. published in 2010 is focused on …

1) Characterize the most important issues associated with graywater reuse and identify the policy implications of each;
2) Assess the potential impacts of rising trends in graywater use on the water recyling industry; and
3) Develop a regulatory and policy framework that will allow the industry to take the appropriate actions to protect the integrity of the recycled water product and brand.

Provides a rather thorough review of graywater reuse practices and requirements. The section on **Indoor Reuse of Graywater (Toilet Flushing)** suggests that …

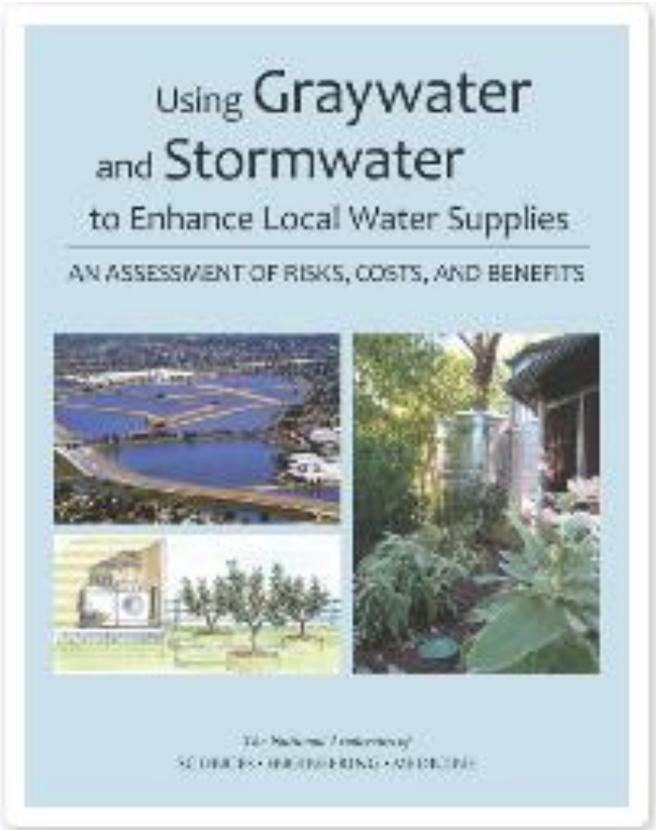
> Graywater used for toilet flushing indoors must be treated to standards similar to those of reclaimed water: filtration and disinfection of secondary effluent. By the time such treatment is provided, graywater is already of the same quality as tertiary (or Class A) reclaimed water and is indistinguishable from it. Conveying tertiary treated graywater in purple pipes should not cause conflicts or confusion or pose a public health problem—as long as the treatment system and their operations are in compliance with regulations governing similar uses of recycled or reclaimed water.

which raises the point that indoor uses of graywater will likely need to comply with standards similar to those imposed on indoor use of reclaimed water.

The **Treated Graywater Systems** section indicates that …

Graywater from nontoilet, nonkitchen sources at a high-rise building, a sports stadium, or an apartment house is sometimes collected separately and treated in an onsite wastewater treatment plant separate from the blackwater. Effluent from the onsite treatment system is then utilized as nonpotable recycled water in a manner similar to that for recycled water. The rationale for such systems is the (a) graywater sources within the building provides enough water for the nonpotable water demand in the building and its vicinity and (b) the lower solids loading, BOD loading, and microbial content of graywater make treatment less costly and less energy-intensive. Such systems are common in Japan, especially in cities where developers of new buildings containing over 3,000 m^2 or over 5,000 m^2 (depending on local regulations) of usable space are required to provide onsite treatment and reuse—mainly for toilet flushing. These graywater systems utilize highly sophisticated treatment systems, including membrane biological reactors, and are closely monitored.

Treated graywater systems are not in common use in the United States at the present time; however, the advent of Leadership in Energy and Environment Design (LEED) certification and of other sustainability incentives is expected to increase their utilization in the future. Treated graywater that meets standards and regulations for water reuse is essentially reclaimed water and is not the subject of this paper. However, lesser levels of treatment, especially those provided by homeowners, are common and do not necessarily provide adequate safeguards for those exposed to the water. These simple graywater systems rely on the aerobic topsoil's capability to provide additional treatment by decomposing organic matter and deactivating the microorganisms in graywater.



In 2016, the National Academy Press published the final Water Science and Technology Board report on ***Using Graywater and Stormwater to Enhance Local Water Supplies: An Assessment of Risks, Costs, and Benefits*** that addresses stormwater and graywater serving a range of nonpotable uses, including irrigation, toilet flushing, washing, and cooling, noting that treatment may be needed, resulting in savings of available potable water supplies.

https://www.nap.edu/catalog/21866/using-graywater-and-stormwater-to-enhance-local-water-supplies-an

Graywater Use…

For graywater, substantial water savings are possible when used for toilet flushing and/or in areas with near-year-round irrigation needs (as in the arid southwest) when irrigation demand is well-matched to graywater availability. Based on the committee's scenario analyses, graywater reuse in Los Angeles provides larger potential potable water savings (up to 13 percent) than household-scale stormwater capture (up to 5 percent), because graywater provides a steady water source during summer months with little or no rainfall.

There is substantial variation in on-site graywater [and stormwater] regulations at the state level with respect to design and water quality for household-scale projects, which leads to varying exposures and risk. The lack of authoritative, risk-based guidelines for the design and potential applications of graywater [and stormwater] in the United States is a major impediment to their expanded use.

Graywater [and stormwater] reuse is being incorporated into law in a variety of respects at the federal, state, and local levels, but not quickly enough to keep up with advances in the technology and its use. Several legal and regulatory constraints remain, hindering the capacity for graywater [and stormwater] to significantly expand the nation's water supplies.

Developing rigorous, risk-based guidelines for graywater [and stormwater] across a range of possible uses and exposures could improve safety, build public confidence in the practices, reduce expenditures on unnecessary treatment, and assist communities that lack an existing regulatory framework for on-site water supplies. Such guidelines could be developed by the Environmental Protection Agency, a collaboration of states, or a collaboration of U.S. water organizations working with the Environmental Protection Agency. This guidance could then serve as a basis for developing standards of practice for on-site non-potable water use. Oversight and enforcement of water quality standards for applications with significant exposures is also important but challenging, and local enforcement agencies would benefit from additional guidance on appropriate, cost-effective maintenance, monitoring, and reporting strategies.

http://oasisdesign.net/greywater/law/

Gray Water Policy Center

A compilation of grey water laws, suggested improvements to gray water regulations, legality & greywater policy considerations, sample permits, public health considerations, studies, etc.

For regulators, inspectors, elected officials, building departments, health departments, builders, and homeowners.

Policy resources

- Guidance for regulators
- Code Writing and Consultation Service
- Model Greywater Ordinance
- Best Practices Informational Handouts, Code Compliance Packages, Workshops etc
- Treatment effectiveness references
- Soil Percolation and Loading Rates, Percolation Tests, and Long Term Acceptance Rate (LTAR)
- General references, studies

Policy examples

- Uniform Plumbing Code
- Connecticut
- Montana
- New Jersey
- New York
- Oregon
- Utah
- Wyoming
- Australia
- International Plumbing Code
- Colorado
- Nevada
- New Mexico
- Massachusetts
- Texas
- Washington
- Vermont
- Jordan

http://www.nwri-usa.org/graywater.htm

Graywater

Historically, "graywater" is defined as water generated from domestic activities, including showering, bathing, and washing laundry (but not from toilets or kitchen sinks, due to the risk of contamination). The use of untreated graywater is limited to subsurface irrigation of outdoor plants.

However, in regions where water supplies are unreliable because of drought, water right conflicts, or other issues, interest exists in making greater use of graywater – considered a reliable local resource – for household and commercial purposes.

To expand the indoor and outdoor uses of graywater in the United States, research is needed on the regulatory, operational, and public health aspects of both treated and untreated graywater.

Graywater – A Potential Source of Water - http://www.ioe.ucla.edu/reportcard/article4870.html
This 2009 Southern California Environmental Report Card was prepared by the UCLA Institute of the Environment.

Graywater is typically wastewater low in turbidity, clear in color, and found from the drainage of bathtubs, showers, bathroom washbasins, clothes washing machines, and laundry tubs. Graywater quality is highly variable because it is source dependent given the variability in household water use. For example, water from clothes washers is high in phosphate content, whereas water from the shower has high turbidity and suspended solids. Residential graywater can be categorized as light graywater or heavy graywater.

Light graywater is wastewater from the shower, bath, bathroom washbasin, and clothes washing machine. Heavy graywater is wastewater from the kitchen sink and dishwasher. According to the revised 2007 California Plumbing Code, heavy graywater is not considered graywater in California. Commercial technologies already exist for processing both light and heavy graywater on-site for non-potable usage. However, the recycling and reuse of graywater requires careful considerations of potential health and environmental risks that can arise due to improper use

At present, given the revised 2007 California Plumbing Code definition of graywater, both heavy graywater and blackwater must be conveyed to and treated by centralized wastewater treatment plants. Only light graywater can be treated on-site for non-potable usage.

Graywater that can be used directly or with a reasonable level of local treatment (i.e., at the point of use) includes clothes washer, shower/bath and faucet (non-kitchen) water constituting about 60% of the total indoor water use in single-family homes (Figure 6).

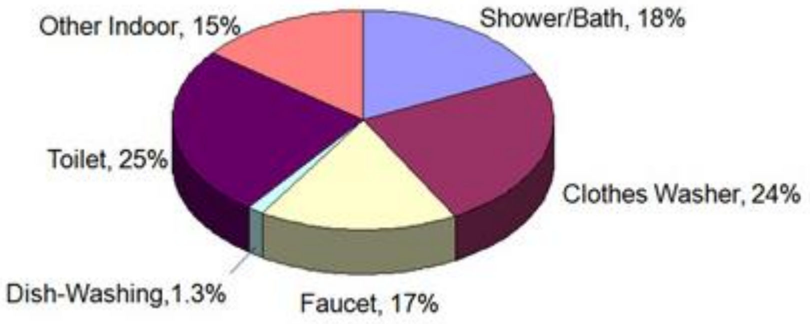


Figure 6. Indoor distribution of water use in a single-family home, based on average per capita indoor consumption data for four cities in Southern California.

Under the revised 2007 California Plumbing Code, Tiers 1 and 2 untreated graywater recycling can be used for subsurface or covered irrigation provided it is not for root crops or food crops with edible parts that contact the soil. According to the Draft 2010 California Plumbing Code, indoor use of Tiers 1-3 for toilet flushing would require water treatment to meet disinfected tertiary recycled water criteria as regulated by the California Department of Public Health. This proposed code implies treated graywater (from small and large volume generators) could be used for unrestricted non-potable use (outdoor and indoor) with the requirement of online water quality monitoring and regulatory oversight that seems to be approaching the level of large-scale centralized water treatment plants.

Three levels of graywater treatment steps are required in order to meet the level of recycled graywater quality for the above stated unrestricted non-potable use: a primary treatment for removal of suspended matter (e.g., sedimentation or filtration), a secondary step for stabilizing organic matter (e.g., biological treatment), and a third step that includes finishing filtration (using membranes or media filters) and disinfection (e.g., UV irradiation). Upgrading the quality of graywater to unrestricted non-potable use may require a significant investment and technical know-how to ensure an effective treatment that will provide adequate public health protection.

http://www.adn.com/alaska-news/rural-alaska/2016/08/08/can-rural-homes-use-the-same-water-over-and-over-a-uaa-project-aims-to-see/

Alaska Dispatch News Thursday, August 11, 2016 Anchorage

Rural Alaska

Can rural homes use the same water over and over? A UAA project aims to see

Author: Tegan Hanlon

Grad students Greg Michaelson and Cara Lucas and Aaron Dotson, a UAA civil engineering associate professor, stand in front of the home and conex in-home water reuse system at UAA on Friday, Aug. 5, 2016, in Anchorage. (Bob Hallinen / Alaska Dispatch News)

Greenland
Far from reaching The United Nations Millennium Development Goals
Why ?

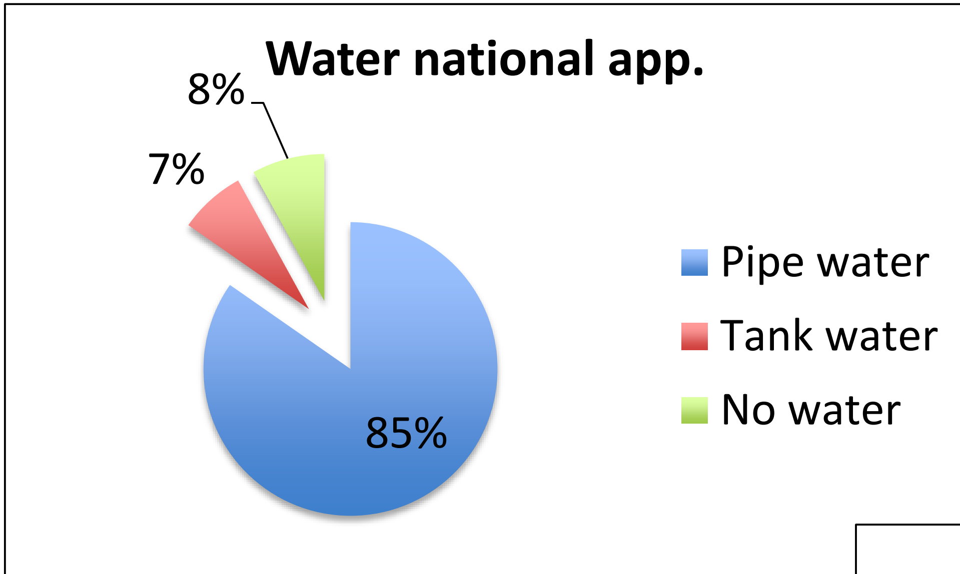
Kåre Hendriksen, Arctic Technology Centre
Technical University of Denmark

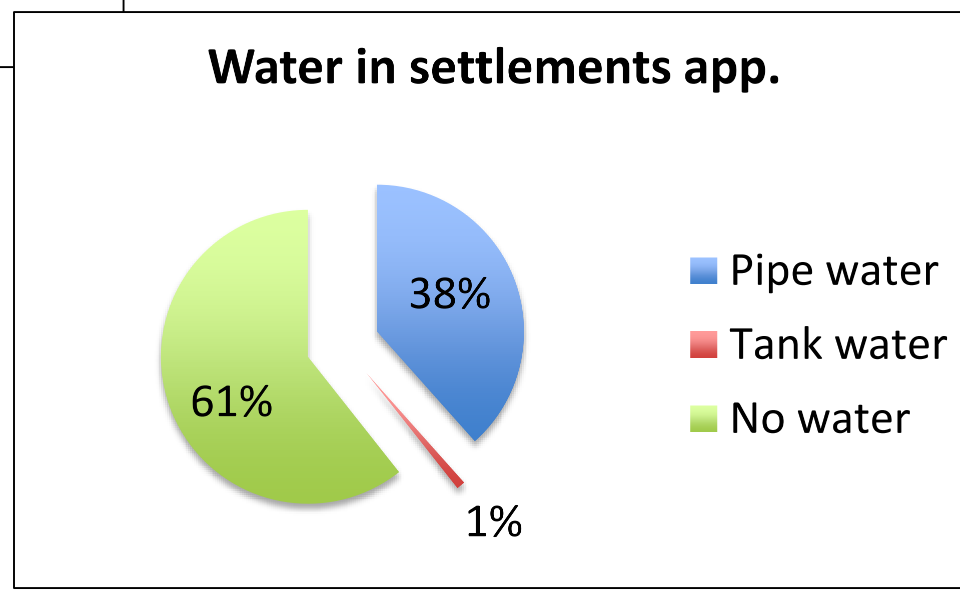
Center for ARKTISK TEKNOLOGI

DTU

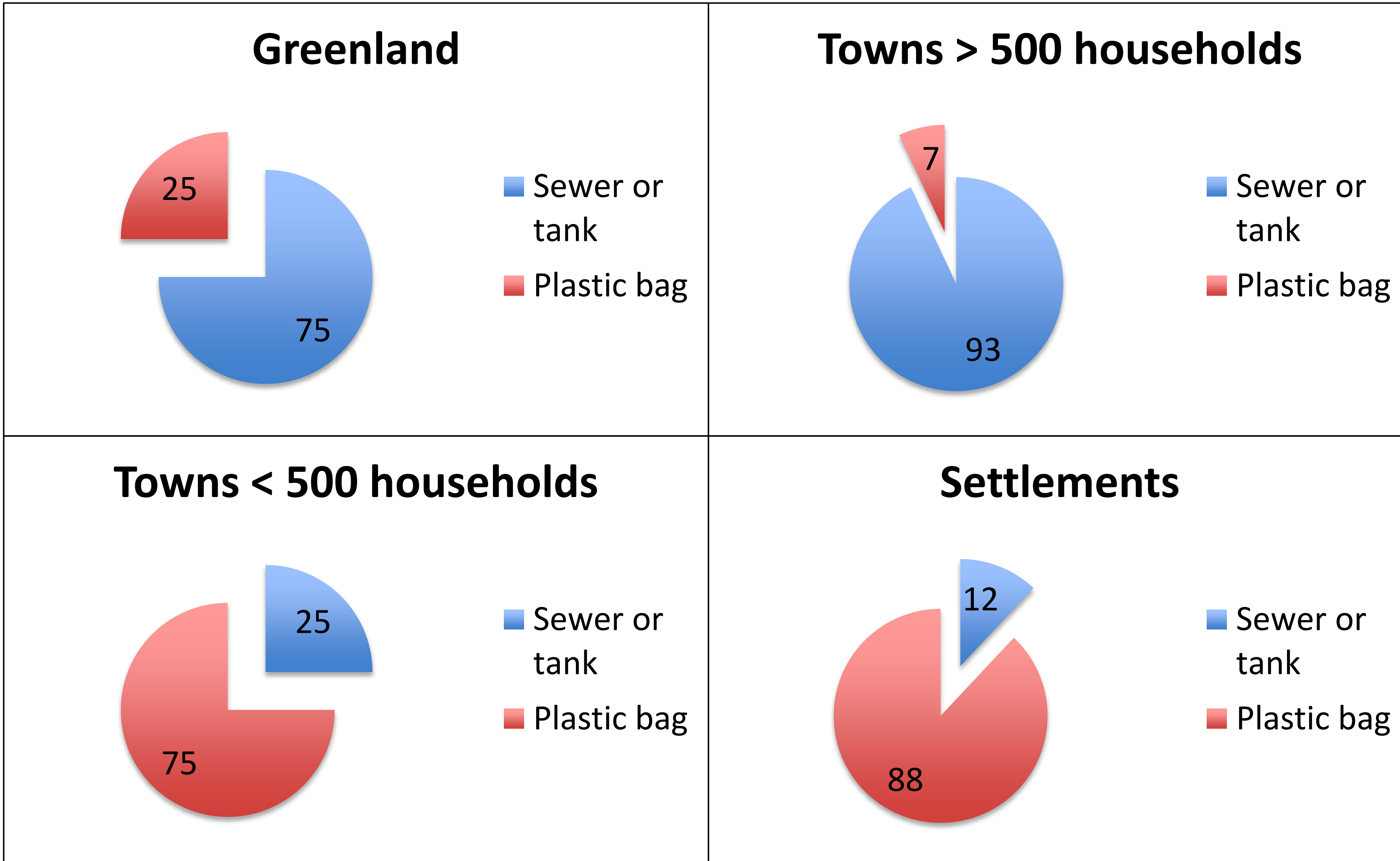
Sum up from yesterday’s presentation

Water supply





Black waste water

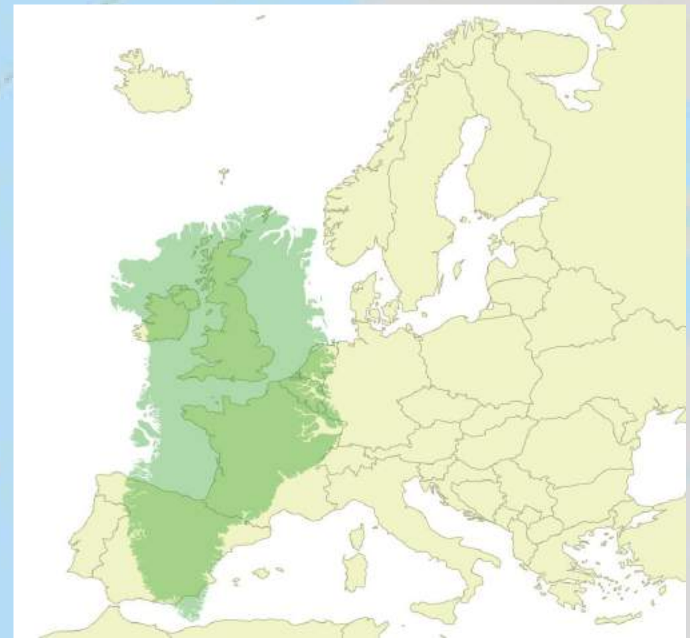


Why do we see these big differences?

It is necessary to understand the local and Greenlandic context

Greenland is a micro-state – however, the largest in the world

The 56.000 inhabitants are dispersed across 17 "towns" and 56 "settlements"



Greenland is part of the Danish Realm (Kingdom) with considerably Self Government

Denmark contributes with 50 % of the public budget

The main livelihood is the living resources of the sea

Shrimps and fish contribute with 90 % of the export income

Not one, but 73 island economies

A crucial characteristic of Greenland is that all settlements are isolated with their own infrastructures

- Island-operation of power, water, waste and sanitation
- No possibilities for commuting on a daily basis
- Limited and expensive transport infrastructure

The challenges of island-operation, extreme weather conditions, and the large distance to the international markets will inevitably result in additional costs

But a scattered settlement patterns is a prerequisites for sustainable use of the resource base

A look back …

During the 1950s and 1960s the Danish government attempted to gather the populations in the "open water cities"

They had to fish for cod or work in fish factories

The investments was done in this cities

The number of settlements was halved

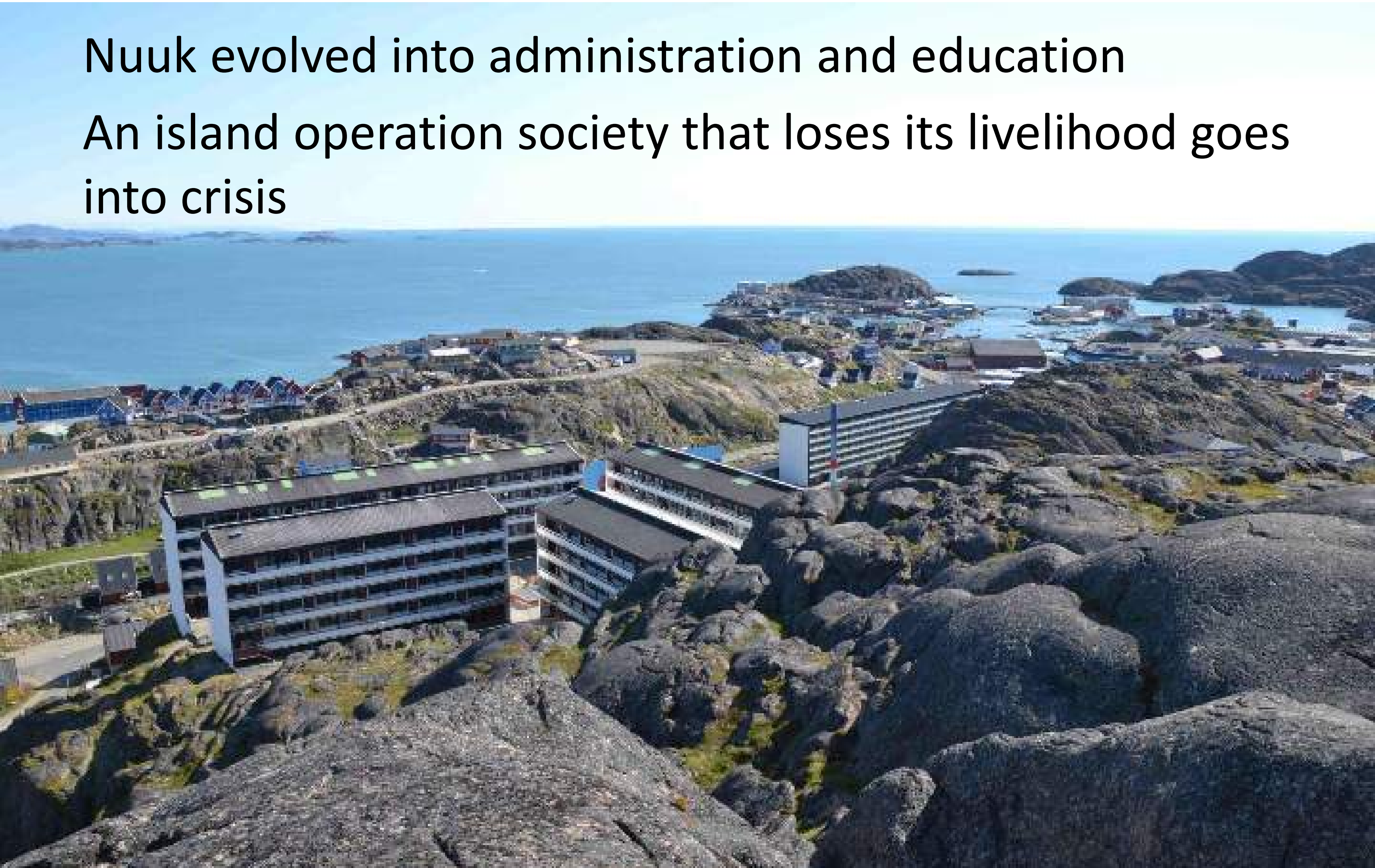
It was the intention to depopulate Upernavik and Uummannaq districts

But then the cod disappeared

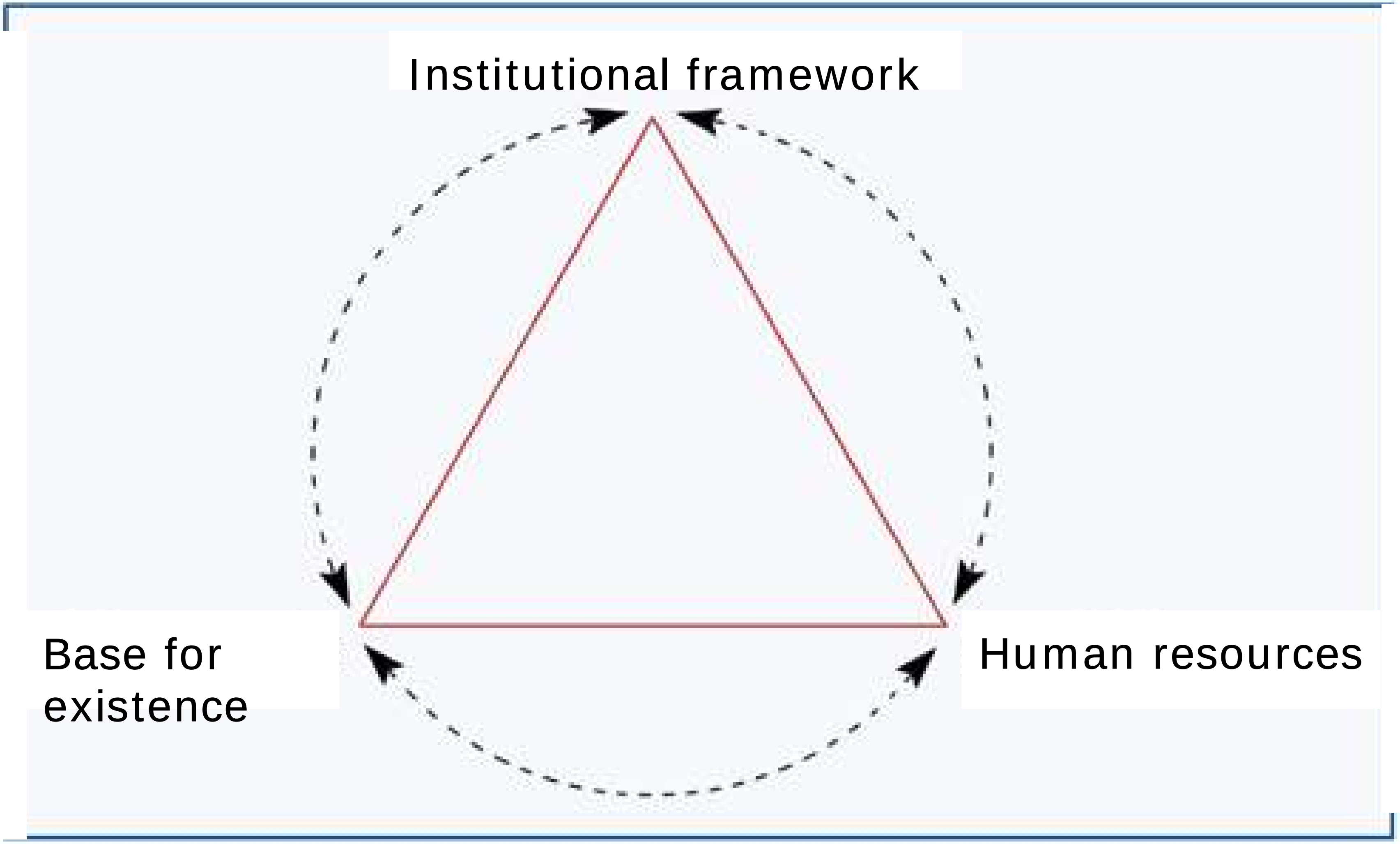
Most of these cities lost their livelihoods

Nuuk evolved into administration and education

An island operation society that loses its livelihood goes into crisis



Model for settlements' development dynamics



Hendriksen 2012

Paradoks

Some of the settlements that have resources and business potential are not supported at the institutional level

Upernavik district is an example

Upernavik district that Denmark wanted depopulated

From the late 1980s they began to catch halibut

Only 5% of Greenland's population lives in the district

60 % live in the small settlements

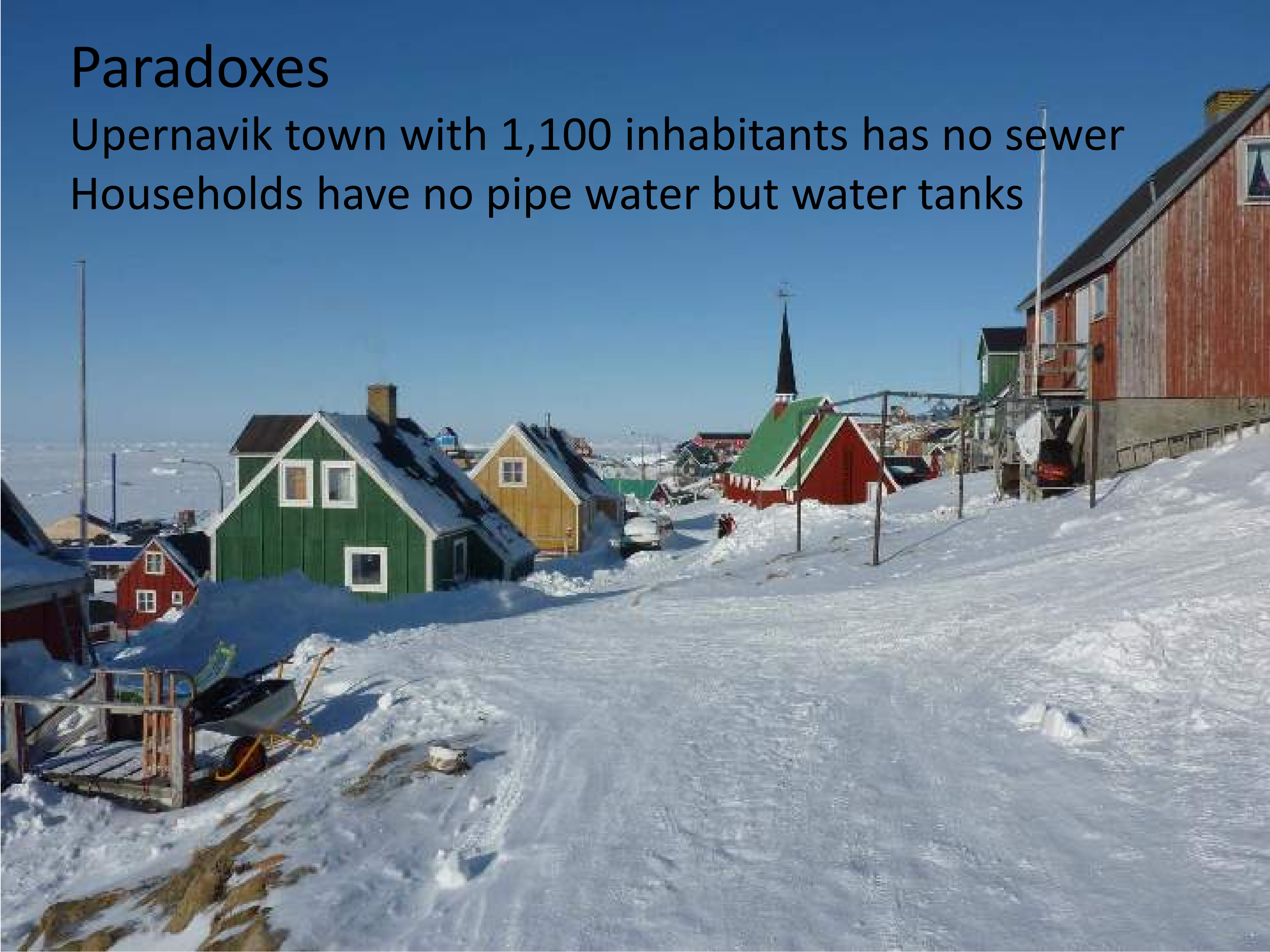
The district contribute 9% of the total export income

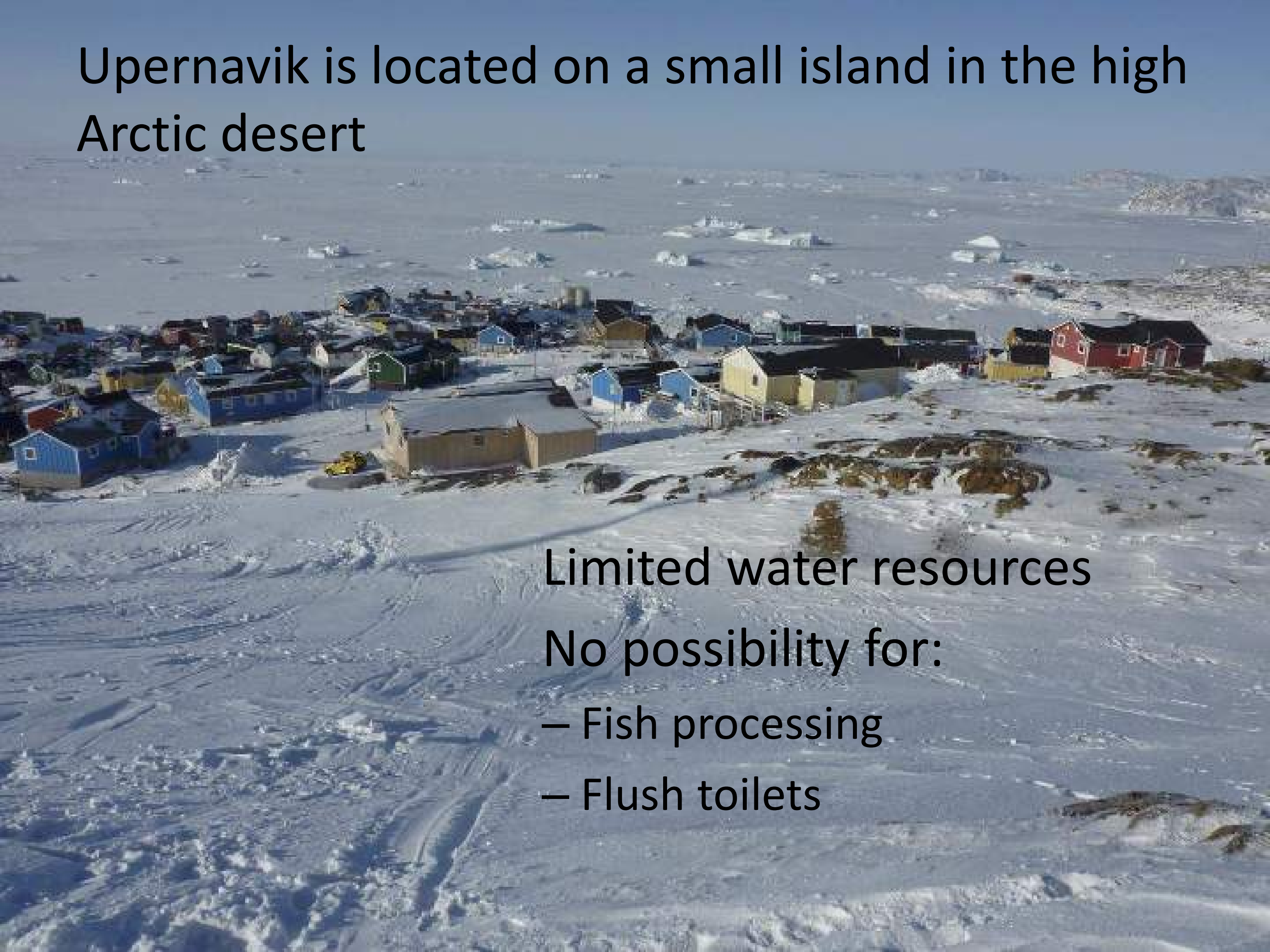
Paradoxes

Innaarsuit has the largest catch of halibut per capita

Thus, the largest contribution to export income

No sewer or in house pipe water


Paradoxes
Upernavik town with 1,100 inhabitants has no sewer
Households have no pipe water but water tanks



Upernavik is located on a small island in the high Arctic desert

Limited water resources

No possibility for:

- Fish processing
- Flush toilets

- Neighbouring island has plenty of water
- 1 km wide and 400 meters deep sound
- Drifting icebergs and sea ice

An engineering challenge

Investments continue to take place in major cities

What is most important - sewer and water supply in Upernavik or cultural center and swimming pool in Nuuk ?

No simple answers

Sectorialisation as a challenge

The former national technical organization has been divided into a number of Government owned companies

Sectorialisation

- Royal Arctic Line
- Airports
- Air Greenland
- Electricity and water
- Tele Greenland
- Royal Greenland
- Retail
- Housing
- Qaasuitsup Municipality

Selv-Government businesses sub optimize in order to create profits and economic balance.

- An international trend to optimize and liberalize the public sector

Does not account for the Greenland island operation challenges

Lack of cooperation

Lack of cooperation

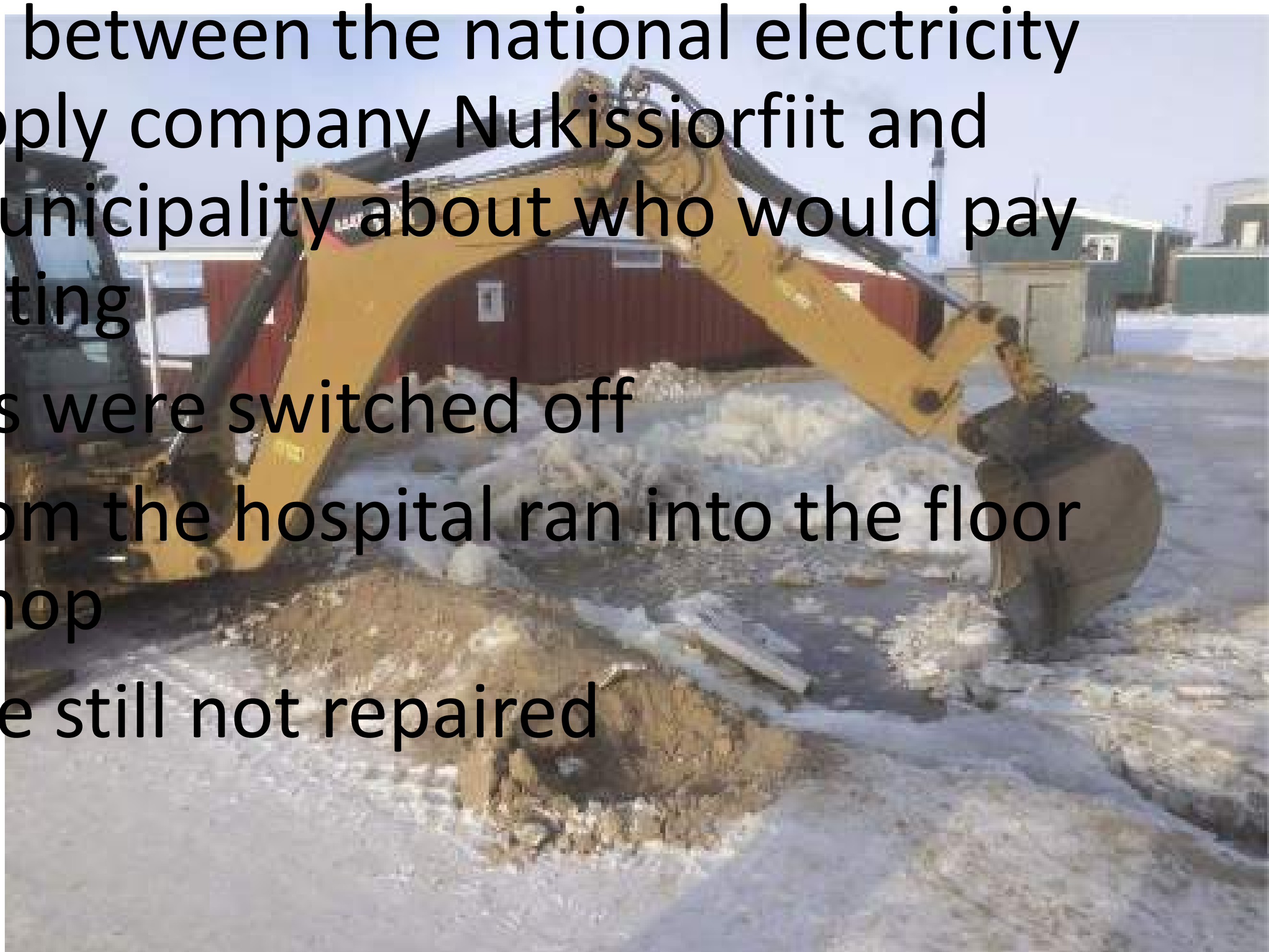
In the winter 2015 grey water sewers in Qaanaaq base froze and collapsed

Disagreement between the national electricity and water supply company Nukissiorfiit and Qaasuitsup municipality about who would pay power for heating

Heating cables were switched off

Grey water from the hospital ran into the floor of the retail shop

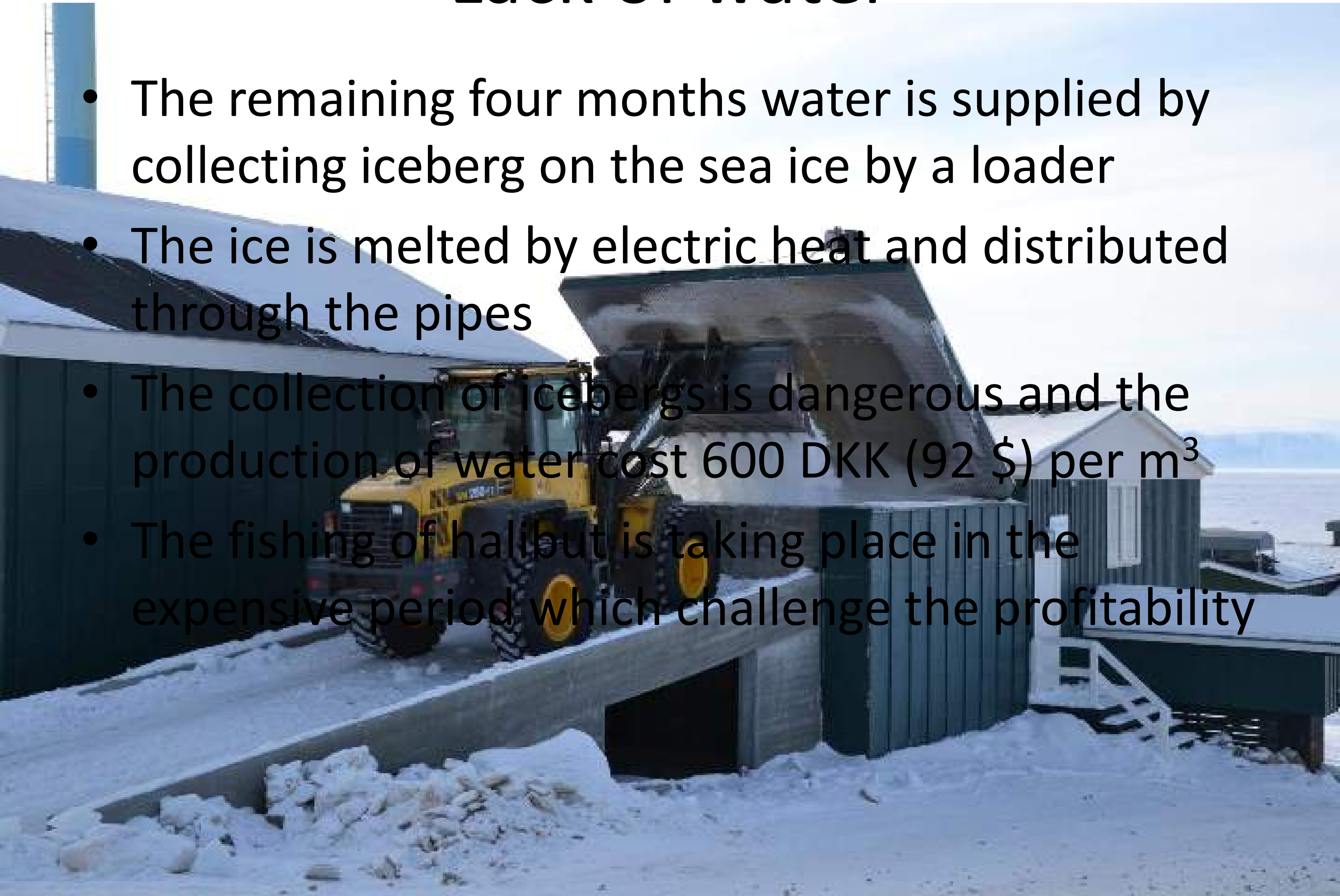
The sewers are still not repaired



Qaanaaq - lack of water

- The river is running four months and supply the town with fresh water
- The two large tanks are filled and can supply the town the coming four months

Lack of water



- The remaining four months water is supplied by collecting iceberg on the sea ice by a loader
- The ice is melted by electric heat and distributed through the pipes
- The collection of icebergs is dangerous and the production of water cost 600 DKK (92 $) per m^3
- The fishing of halibut is taking place in the expensive period which challenge the profitability

Social consequences

Average household income for:

– Settlements in southernmost Greenland 30,000 $

– Sisimiut 63,000 $

– Nuuk 77,000 $

Water per m^3 in:

– Settlements 5 $

– Sisimiut 3 $

– Nuuk 3.80 $

Social consequences

- Sewers financed by municipal taxes and free for users
- Households with bag or tank solution pays for emptying - the municipality contributes to the cost of bags
- Contributes to social inequality

Demografic consequences

- The lack of infrastructure and rising prices contributes to the increasing urbanization in Greenland

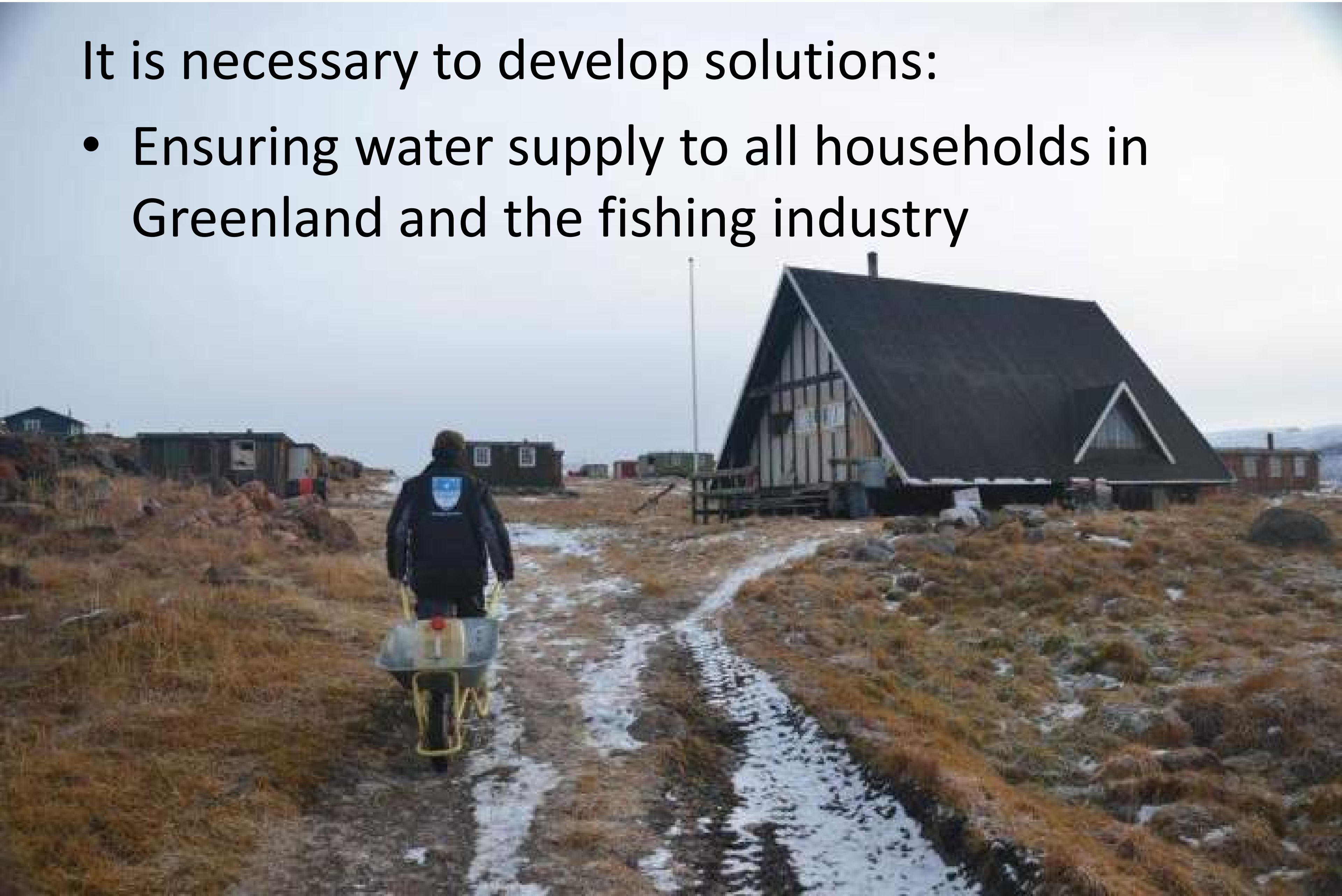
Demografic consequences

- The lack of infrastructure and rising prices contributes to the increasing urbanization in Greenland
- A development that challenge the sustainable use of the country's resources and thus economic development

Conclusion

It is necessary to develop solutions:

- Ensuring water supply to all households in Greenland and the fishing industry



Conclusion

It is necessary to develop solutions:

- Ensuring water supply to all households in Greenland and the fishing industry
- Cheap, simple and healthy sound management of waste water

An important part of our research

Qujanaq

Thank you

krhe@byg.dtu.dk

Center for ARKTISK TEKNOLOGI

DTU

Beyond education:

Using Social Change Marketing to drive behavior change

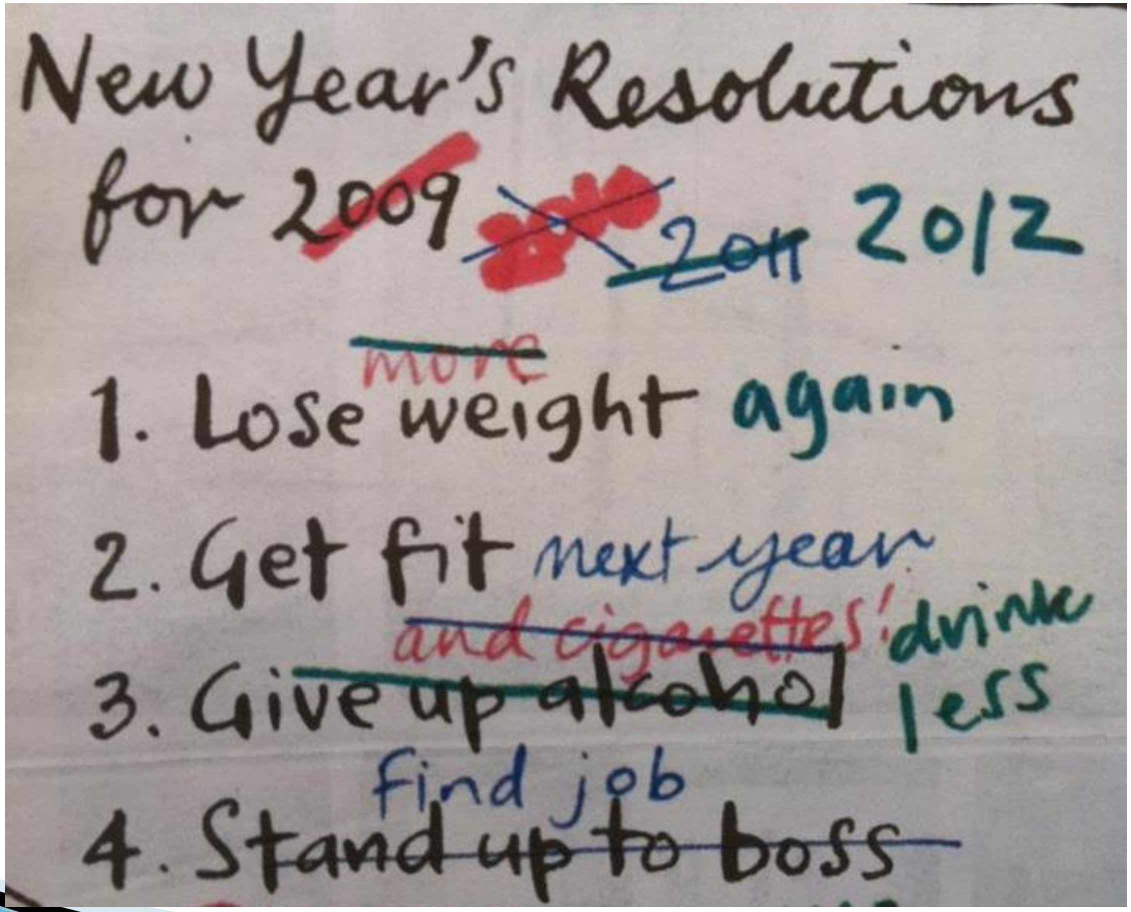
Kathy Anderson, MPH, PhD
kathyjanderson@outlook.com

Overheard this week
(from both public health folks and engineers!)

"people just won't do what you tell them to!"

Some of my behavior change attempts …

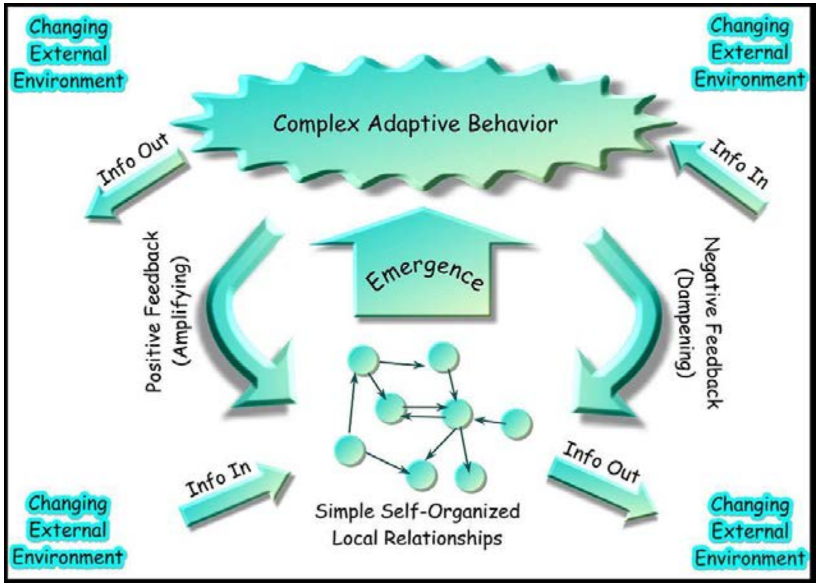
How about yours?!



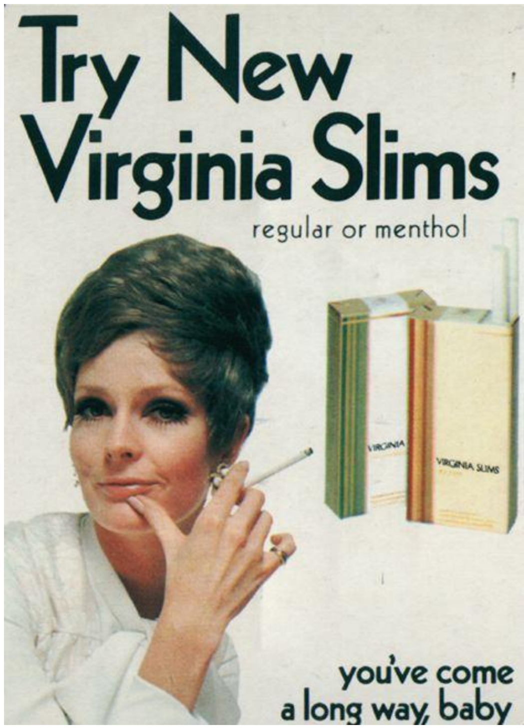
Changing behavior isn’t easy

- NOT simply a matter of *Education, Willpower, or Technology*

- We are complex beings, with
  - Free will
  - Changing external environment
  - Competing interests
  - Social context
  - Psychological makeups



Yet commercial marketers change our behavior all the time!



Why not borrow tactics from the “Evil Empire” of commercial marketing? ☺

Social Change Marketing

INFORMALLY:

"Influencing Behaviors for Good."

"Social [Change] Marketing is a process that uses marketing principles and techniques to influence target audience behaviors that will benefit society as well as the individual."

Nancy R. Lee, Mike Rothschild, Bill Smith (2011)

Hallmarks of Social Marketing

A. Behavior-change centric
B. Theory-informed
C. Careful segmentation of target audiences
D. Intensive target audience research
E. Understanding the "exchange" from the audience perspective
F. Using all of the above to creating an integrated, tailored set of interventions
  - Uses all the techniques of traditional marketing, not just advertising or communications

(adapted from French, et al. (2011)

TYPICAL APPLICATIONS

- Public health
- Environment
- Personal finance

Fun example: switch to fall lawn fertilizing in Chesapeake Bay area

Which campaign might work better?

(Courtesy of Chesapeake Bay Program)

Hallmarks of Social Marketing

A. Behavior-change centric

B. Careful segmentation of target audiences

C. Intensive target audience research

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E. Theory-informed

F. Using all of the above to creating an integrated, tailored set of interventions

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(adapted from French, et al. (2011))

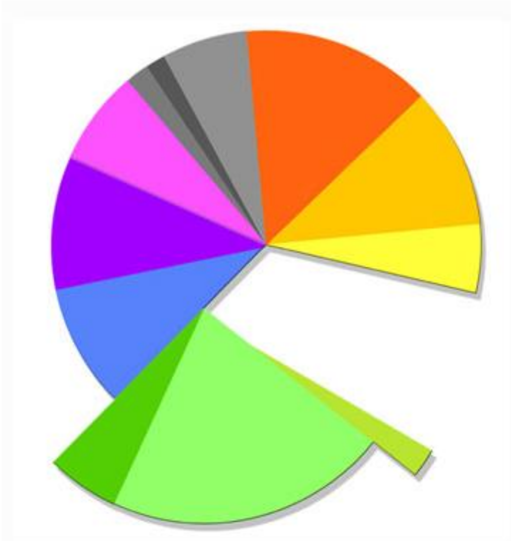
A: IT'S ALL ABOUT BEHAVIORS

- **Reject:** don't use drugs
- **Modify:** use a condom every single time
- **Accept:** contribute monthly to your retirement savings
- **Abandon:** stop smoking
- **Continue:** regular cancer screenings

A: Some sanitation-related behaviors?

- Reject: don't skip paying your bill
- Modify: reuse grey water only X times
- Accept: install a new system in your home
- Abandon: stop washing diapers in the greywater sink
- Continue: maintaining your in-house system

B. Audience Segmentation and Targeting



- Who are the people at highest risk?
- Who are the people most open to change?
- Who are the groups that are critical for success?

C. Intensive audience research

"You want to understand what the reality is for people who experience a particular problem…

…find out what they demand rather than only what can be supplied, and discover things that work."

Craig Lefebvre blog,
http://socialmarketing.blogs.com/r_craiig_lefebvres_social/2015/02/asking-the-first-question-for-change.html

D. Understanding the exchange:
Costs vs benefits: will the behavior change?

WIIFM ??

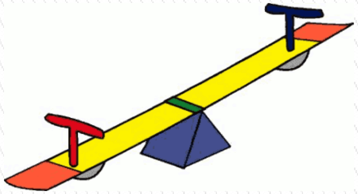
D. Understanding the exchange:
Costs vs benefits

WIIFM ??

Value = Benefits – Costs
Are Benefits > Costs?????

'Typical' costs of behavior change (not just money!)	Typical benefits

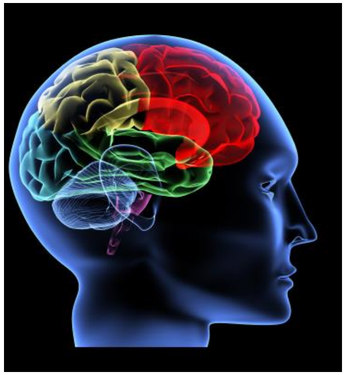
- Be uncomfortable
- Spend more time
- Break a habit
- Resist peer pressure
- Risk relationships
- Give up leisure time
- Learn new skills
- Pay more money
- …



- Traditional benefits
  - Better health
  - Better social life
  - Save the planet ☺
  - ...
- More nuanced benefits
  - Better role model for all children in their life
  - Being "cool"
  - Bonding with baby
  - .....

C, D: The Two Keys to Social Marketing Formative Research

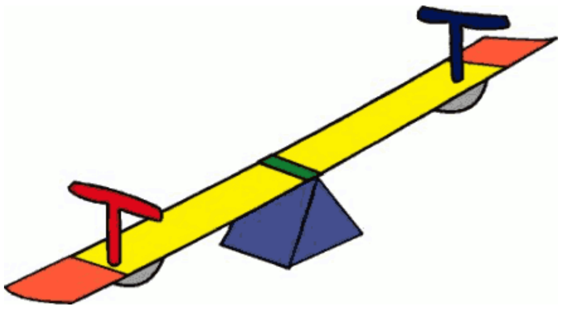
- Get "in their head," see things their way



- *Largely qualitative methods: interviews, focus groups, ethnography…*

- Seek their barrier:benefit equation

Are Benefits > Costs?????



- They know best what will motivate them!

E. Theory-informed

Common themes of behavior change theories (e.g. stages-of-change, ecological, planned behavior :

Self-image

Environmental constraints

F: Marketing's 4-pronged strategy

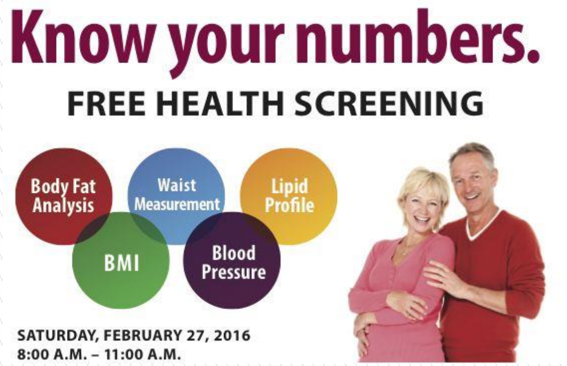
I. Develop **products and services** that serve the consumer *from their perspective*
II. Design the program to **maximize benefits and minimize "costs"** *from their perspective*
III. Make the behavior change **easy and pleasant** *from their perspective*
IV. **Promote** the program in cost-effective ways that fit *how they get their information*

I: SM Products and Services

- Some Goods



- Some services



II: Maximize benefits and decrease costs

- Increase the benefits of the new, desirable behavior
- Decrease the “costs” of this desired behavior

- Increase the costs of the current behavior

Example: Recycling

- Increase the benefits of the new, desirable behavior

Recognition in neighborhood newsletter

- Decrease the costs of the desired behavior

Discounts on garbage pickup if recyclables are sorted

- Increase the costs of the current behavior (putting recyclables in the trash)
- *Neon signs flagging violators*
- *$$ Fines*

III: Making the behavior change easy and pleasant

#1. **Make the Location Closer** (e.g. recycling)

#2. **Extend Hours** (e.g. screening

#3. **Be there at the point of decision-making**
(e.g. condom wallets)

#4. **Make the location more appealing**
(e.g. childhood exercise)

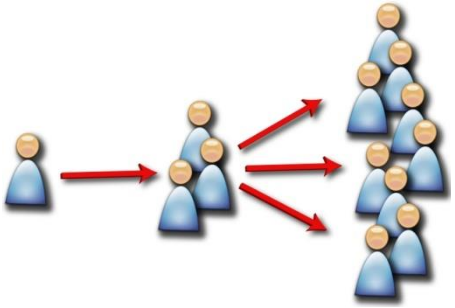
IV: Promoting the behavior change

- Advertising

- Events

- Public relations and publicity

- Word-of-mouth marketing



Social Change Marketing in Sanitation Settings

- **"Workbook" for creating a Social-Change-Marketing sanitation intervention**
  - Devine, J., & Kullmann, C. (2011). Introductory guide to sanitation marketing. Retrieved from https://openknowledge.worldbank.org/handle/10986/17352

- **Why SCM is relevant to sanitation projects**
  - Cairncross, S. (2004). The case for marketing sanitation. *WSP-AF (Water and Sanitation Program for Africa) Field Notes, Nairobi, Kenya.* Retrieved from http://www.wsp.org/sites/wsp.org/files/publications/af_marketing.pdf
  -

- **Experiences from under-developed areas**
  - Devine, J. (2010). Sanitation marketing as an emergent application of social marketing: experiences from East Java. *Cases in Public Health Communication & Marketing*, *4*, 38-54. Retreived from http://publichealth.gwu.edu/departments/pch/phcm/casesjournal/volume4/peer-reviewed/cases_4_04.pdf
  - Dickey, M. K., John, R., Carabin, H., & Zhou, X. N. (2015). Program Evaluation of a Sanitation Marketing Campaign Among the Bai in China A Strategy for Cysticercosis Reduction. *Social Marketing Quarterly*, *21*(1), 37-50.
  - Jenkins, M. W., & Curtis, V. (2005). Achieving the 'good life': Why some people want latrines in rural Benin. *Social science & medicine*, *61*(11), 2446-2459. Retrieved from http://hygienecentral.org.uk/pdf/SSM%20Jenkins&Curtis2005.pdf

Two recent student projects

- Adopting in-home grey water treatment systems for wash water (Cara Lucas, Jennifer Dobson)

- Sustainability of community systems through payment of bills (Korie Hickel, Bailey Gamble)

Summary

- Social change marketing is an effective, often-used framework for changing behaviors for the good
- It is complementary to technology solutions
- Major differentiators
  - Based on in-depth knowledge of target audience
    - Including cost vs. benefit analysis
  - Benefits of the behavior change are put in terms of “their” views, not “ours”
  - Full complement of marketing techniques
- Thanks!

Some general resources

- Books*
  - Lee, N. R., & Kotler, P. (2016). *Social marketing: Influencing behaviors for good* (5th ed.). Thousand Oaks, CA: SAGE.
  - McKenzie-Mohr, D. Fostering Sustainable Behavior. Available online www.cbsm.com
- Papers*
  - Grier, S., & Bryant, C. A. (2005). Social marketing in public health. *Annual Review of Public Health, 26*, 319-339.
- Periodicals
  - Social Marketing Quarterly
  - Journal of Social Marketing
- Online resources*
  - http://socialmarketing.blogs.com/r_craiig_lefebvres_social/
  - http://www.cdc.gov/healthcommunication/cdcynergy/index.html
  - www.cbsm.com (also a listserv) Doug McKenzie-Mohr, "environmental psychologist"
- Intermittent Summer Elective, UAA MPH Program ☺ *
  - bring a project

*see me for details

Sanitation-specific resources

- Devine, J., & Kullmann, C. (2011). Introductory guide to sanitation marketing. Retrieved from https://openknowledge.worldbank.org/handle/10986/17352 .
- Cairncross, S. (2004). The case for marketing sanitation. *WSP-AF (Water and Sanitation Program for Africa) Field Notes, Nairobi, Kenya.* Retrieved from http://www.wsp.org/sites/wsp.org/files/publications/af_marketing.pdf .
- Devine, J. (2010). Sanitation marketing as an emergent application of social marketing: experiences from East Java. *Cases in Public Health Communication & Marketing*, *4*, 38-54.
- Dickey, M. K., John, R., Carabin, H., & Zhou, X. N. (2015). Program Evaluation of a Sanitation Marketing Campaign Among the Bai in China A Strategy for Cysticercosis Reduction. *Social Marketing Quarterly*, *21*(1), 37-50.
- Jenkins, M. W., & Curtis, V. (2005). Achieving the 'good life': Why some people want latrines in rural Benin. *Social science & medicine*, *61*(11), 2446-2459.

Chinese SM sanitation campaign
(p.1) (Dickey et al., 2015)

- Background: Cysticercosis prevention
- Behavior change: Build, use, and maintain toilet
- Theory: possibly Social Norms or Social Cognitive
- Segmentation: rural Bai villages
  - Raise pigs, eat raw pork
- Understanding of "exchange"
  - Distrust of outside experts
  - Squat-style preferred over sit-style
  - Some wanted simple, others wanted elaborate
  - Main motivations: convenience, privacy, cleanliness, progress
    - note: not disease-prevention!

Chinese SM sanitation campaign (p.2)

- Elements of the program:
  - Demo toilets
  - Half-day kickoff "fair" with games & prizes
  - Brochures and logo'd hats
  - Personal followup
  - Local building coordinator
    - Help find and train local builders
    - Construction quality-control
  - Government price subsidies (dependent on Quality)
- Outcomes
  - Same # of toilets in intervention vs control villages
  - Superior user satisfaction and increased use of toilet in intervention villages

Sewer and Water Regulatory Reform in Alaska

- Multiple federal programs
- Complex Regulatory Structure for each program
- Two (or three) main allocation systems
- Villages administered either by ANTHC or the State of Alaska
- Reform principles

Alaskook.org

Cumulative need in Alaska: $2,279,960,585

- $80 million annually
- First time service: $1,397,079,862

  (30 communities)
- Regulatory upgrades to current systems : $349,461,870
- Upgrades to benefit system operation: $533,418,853

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STARS

Public SDS One-Line Report - Fiscal Year 2016
(Snapshot 19586 on 01/06/2016)

Area	State	Project No.	Project Name	Area Priority	Eligible Project Cost	Cumulative Eligible Project Cost
AN	ALASKA(2)	AK17552-5001	LOW. KALSKAG - In-home Plumbing Phase III	1	1,650,000	1,650,000
AN	ALASKA(2)	AK15430-2001	Iliamna- sludge disposal lagoon	2	630,000	2,280,000
AN	ALASKA	AK22749-5001	KOTZEBUE- Water and Sewer Service Lines	3	1,417,500	3,697,500
AN	ALASKA(2)	AK18606-5001	GALENA - First Time Water and Sewer Facilities for Seven Homes	4	798,000	4,495,500
AN	ALASKA	AK20707-5002	Fort Yukon - New Home Services	5	411,000	4,906,500
AN	ALASKA(1)	AK01003-3001	KLAWOCK - WST Replacement	6	575,000	5,481,500
AN	ALASKA(2)	AK23786-5101	Golovin - In-Home Plumbing - Upper Community CIP	7	817,000	6,298,500
AN	ALASKA(2)	AK19673-2001	TETLIN - Sewage Lagoon Upgrades	8	805,000	7,103,500
AN	ALASKA(2)	AK23790-2001	KOYUK - Lagoon Improvements	9	958,395	8,061,895
AN	ALASKA(2)	AK03485-3002	BETHEL - Water Trucks	10	511,000	8,572,895
AN	ALASKA(2)	AK03510-4002	TUNTUTULIAK - HB Collection Stations and Equipment	11	300,000	8,872,895
AN	ALASKA(2)	AK03496-2103	Kwigillingok FTH Sewage Lagoon	12	2,146,665	11,019,560
AN	ALASKA(2)	AK24846-3002	EMMONAK-Service & Plumbing for Four Homes	13	280,000	11,299,560
AN	ALASKA(2)	AK03496-5002	Kwigillingok - FTH Systems	14	325,800	11,625,360
AN	ALASKA(2)	AK24852-3101	Mt Village - 3c -Water Main Replacement (phase 3C, 2014 PER)	15	1,700,182	13,325,542
AN	ALASKA(2)	AK20705-5001	Circle Onsite Water and Sewer Systems	16	1,122,368	14,447,910
AN	ALASKA(2)	AK14365-1001	Chignik Bay - Water Treatment Plant Upgrade	17	1,550,000	15,997,910
AN	ALASKA(1)	AK06104-5001	Klukwan Water Storage Tank	18	620,000	16,617,910

State/Federal funding

Duel Allocation

- Roughly $82.3 m in funding annually
- State of Alaska Village Safe Water: $11.34 M
- United States Department of Agriculture: $23.82 M
- Environmental Protection Agency: $10.21 M
- Indian Health Service Regular: $9.24 M
- EPA Safe Drinking Water – Tribal: $3.61 M
- EPA Clean Water Act – Indian: $8.28 M
- IHS Housing: $4.90 M
- ANTHC/Private/Other federal: $13.92 M

Capital Improvement Projects

Sanitation Deficiency System

IHS Regular (SDS)

Sanitation facilities
Interior plumbing for native owned homes (no non-native homes)

IHS Housing

Like-new Native owned homes
No interior plumbing

EPA Safe Drinking Water Act – Tribal Set Aside

Community water facilities and water service lines – no individually owned homes – no solid waste facilities

EPA Clean Water Act – Indian Set Aside

Community sewer facilities & sewer service lines
50% washeteria cost
Individually owned septic tanks
No interior plumbing
No water or solid waste facilities

USDA Rural Development

Community and individual water, sewer, and waste facilities including interior plumbing
-must be defined a distressed community

State of Alaska Village Safe Water

Sanitation facilities, interior plumbing, planning projects

Source: ANTHC

Teller, AK

Tribal Housing Authorities responsible for housing development (NAHASDA $)

Regional tribal Non-profits responsible for road construction (Highway $)

Regional health organizations responsible for clinic construction (some water and sewer)

State of Alaska: school construction; water and sewer

Reform Principles

- Align regulatory structure
  - Allow tribes to use private sector financing and technology to leverage federal and state funds
- Tribal organizations must begin coordinating the infrastructure planning and investment both locally and regionally
- We must ensure that the accuracy and consistency of data across regions and communities within the Indian Health Service Sanitation Deficiency System
- Protect the federal investment in rural Alaska
  - Establish multi-tribal operations and maintenance organizations to extend the lifespan of existing utility systems.

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

WIHAH Conference

Adaptation of the Built Environment

To Climate Changes in Alaska

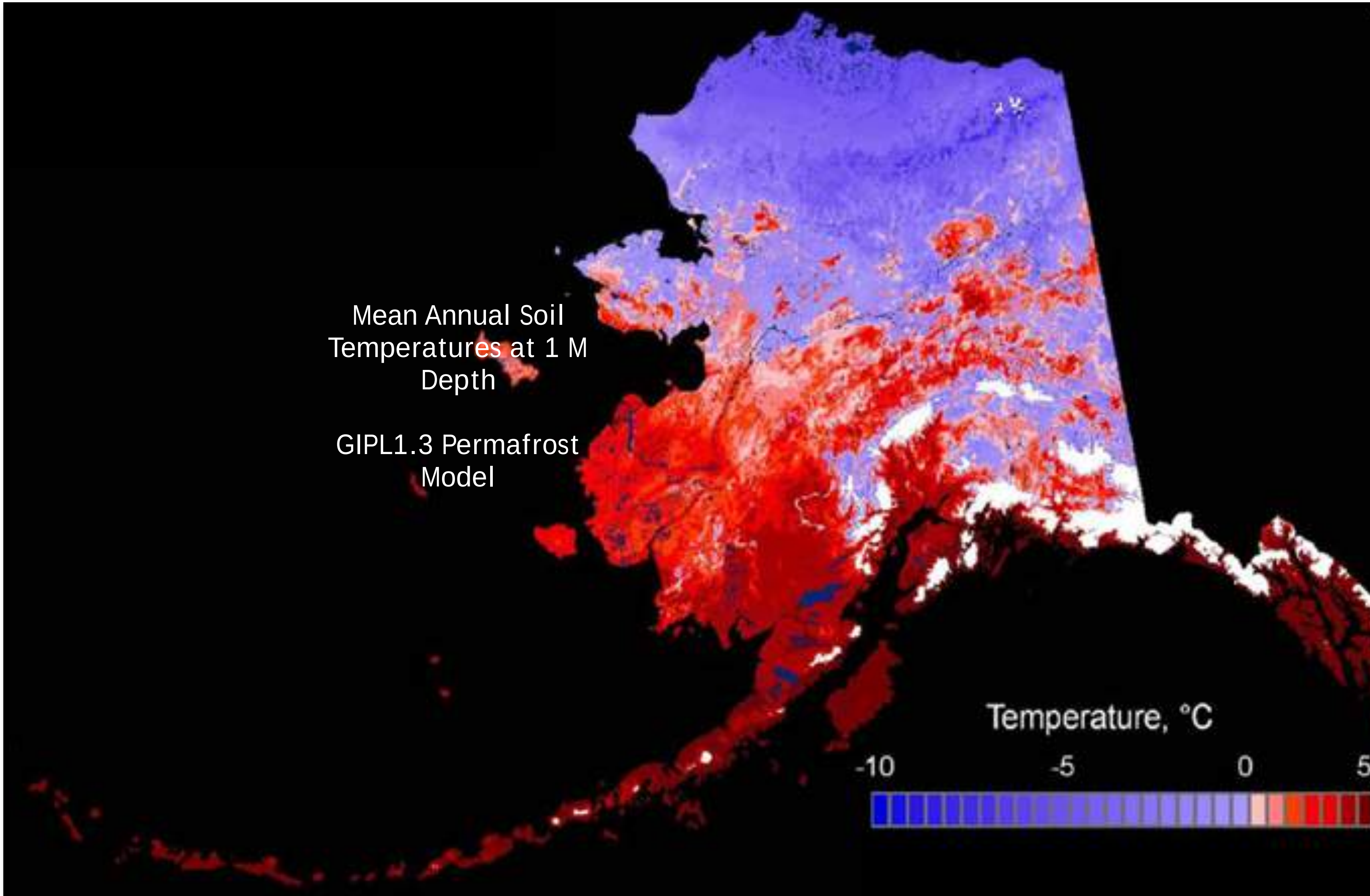
ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Utilities in the Changing Arctic: Water and Sewer

Michael Black, Director of Rural Utilities Management Services, ANTHC



ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

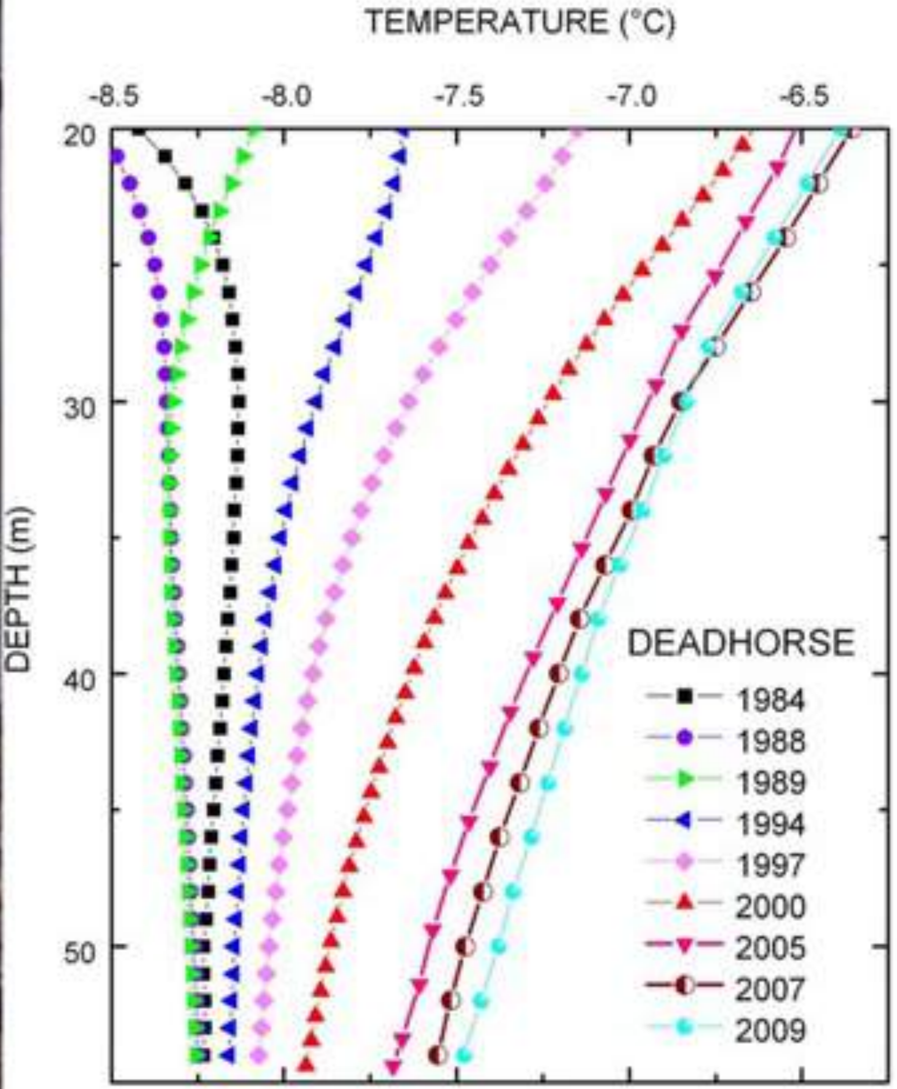

Mean Annual Soil Temperatures at 1 M Depth
GIPL1.3 Permafrost Model
Temperature, °C
-10
-5
0
5

Our current sanitation infrastructure is designed for the conditions of the past, not for the present or the future.

Average January air temperature in Point Hope, Alaska:

- 1961-1990, -3°F
- 2001-2010, 3°F
- 2031-2040, 6°F

Projected change of +9°F over 89 years.



ALASKA NATIVE
TRIBAL HEALTH
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What is the cost of climate change to water and sewer infrastructure?

- Water and Sewer along with Transportation Infrastructure is estimated to be most vulnerable to climate change.
- Cost of not adapting infrastructure has been estimated in a 2007 study by University of Alaska (ISER) to shorten the useful life of water and sewer infrastructure by 3.5 years (20 year normal design life assumed).
- Compounding this shortened life over decades adds billions of dollars to preserving the sanitation utility. Estimated to add $3-6 B (rebuilding) by 2030 for Alaskan villages.

(Larsen, Goldsmith, Smith, et al. (2007) Estimating Future Costs for Alaska Public Infrastructure At Risk from Climate Change.

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

How does climate change affect transportation in villages?

Damage and the inability to use trails, roads, rivers and boardwalks is caused by:

- Erosion
- Flood damage
- Storm damage
- Melting permafrost
- Sedimentation

How does changing Arctic affect solid waste?

Collection systems:

- Destruction or loss of access

Disposal systems:

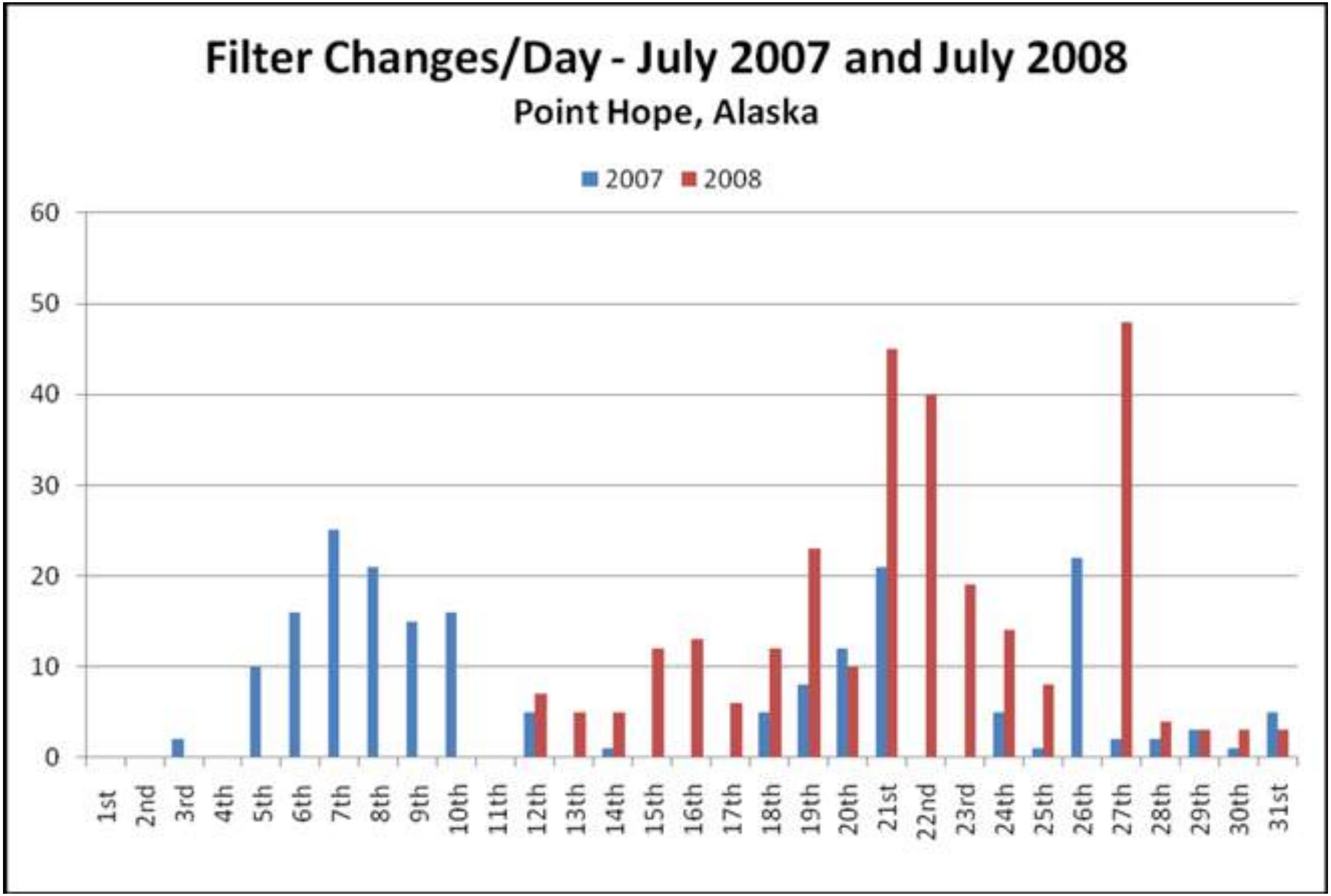
- Erosion intercepting the facility which spreads waste
- Flood water entering the facility which spreads waste
- Permafrost or waste melting and releasing contaminants

How does changing Arctic affect water and sewer ?

- Foundations-Pipes/Buildings
- Contamination
  - Rising sea levels
  - Storm surge (seawater contamination)
  - Northward migration of animals with disease or parasites (Giardia)
  - Saline intrusion into coastal groundwater
  - Increased algae
- Reduced supply
  - Drought or drying tundra ponds
  - Damage to intakes or impoundments from sediments, ice, and erosion

How does warming permafrost affect water chemistry and quality?

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM



Filter Changes/Day - July 2007 and July 2008
Point Hope, Alaska
2007
2008
60
50
40
30
20
10
0
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th
11th
12th
13th
14th
15th
16th
17th
18th
19th
20th
21st
22nd
23rd
24th
25th
26th
27th
28th
29th
30th
31st

In Unalakleet, erosion has exposed a water line.

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

In Kotlik, coastal flooding has damaged community infrastructure.

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

In Noatak, failing foundations from permafrost warming

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

Point Lay Permafrost Sustainability Workshop

1. May 2016 - Anchorage, Alaska to discuss permafrost and water-wastewater system
2. Goal: identify options, best practices, and impacts in regard to permafrost
3. Participants: NSB, UAF, CRREL, Engineers and Murkowski representative
4. Expertise: geotechnical, environmental, construction, operations, and planning engineering

The Problem: Snow and Ground Water

The Long Term Implications: Reduced Sustainability of Point Lay

Recommendations: Use Snow Management Strategies

Short term: Make sure to plow and shovel all snow away from each house, each structure and the entire village THOROUGHLY
Mid term: Use fine silt to fill-in cavernous water ponds and holes. Do not use gravel as water can penetrate it and melt the permafrost
Long term: Develop housing, structures, vehicle parking and utilities that allow the snow to blow through, rather than create drifts

UAF Participants: Doug Reynolds, Billy Connor, Tony Nakazawa, Yuri Shur, Dave Barnes, Bill Schnable, Srijan Aggarwal, Misha Kanevskiy and Jon Skinner Special thanks to the Native Village of Point Lay, the North Slope Borough, CREL, UAF's School of Management, Natural Resources and Extension, the Geophysical Institute and the Center for Environmentally Sustainable Transportation in Cold Climates, ANTHC, Golder, and Umiaq

UNIVERSITY OF ALASKA FAIRBANKS

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

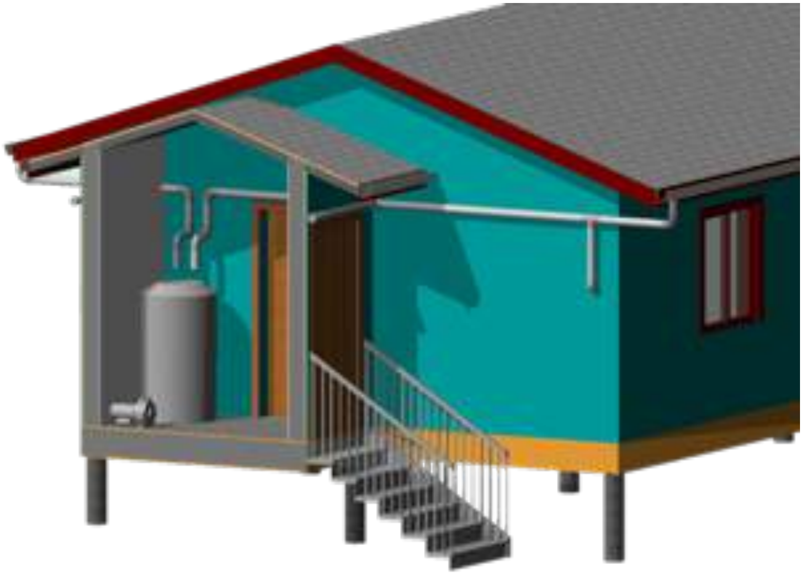
What can be done to save the infrastructure that villages depend upon? Conversion of passive to active cooling of foundations on warming permafrost. This is soon to be built in western Alaska

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

Adaptation: Portable Alternative Sanitation System (PASS) in Kivalina

This system is entirely homeowner-based and is designed to address the most basic sanitation needs and is portable so it can be moved with the community to a new location.

Typical system layout

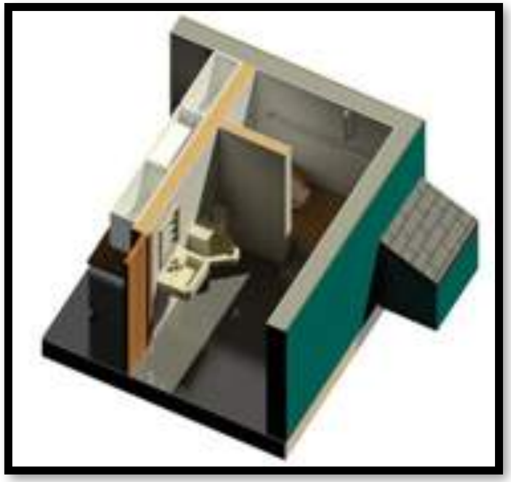


Rain catchment system

Nine homes received demonstration in home PASS units to improve availability of water and lower risk of wastewater disposal. Can be moved with home or abandoned.

Rain Catchment Systems

- Water tank equipped to accept hauled water and rainwater
- Point-of-use water treatment device to treat water from non-potable sources



Grey Water Disposal Systems

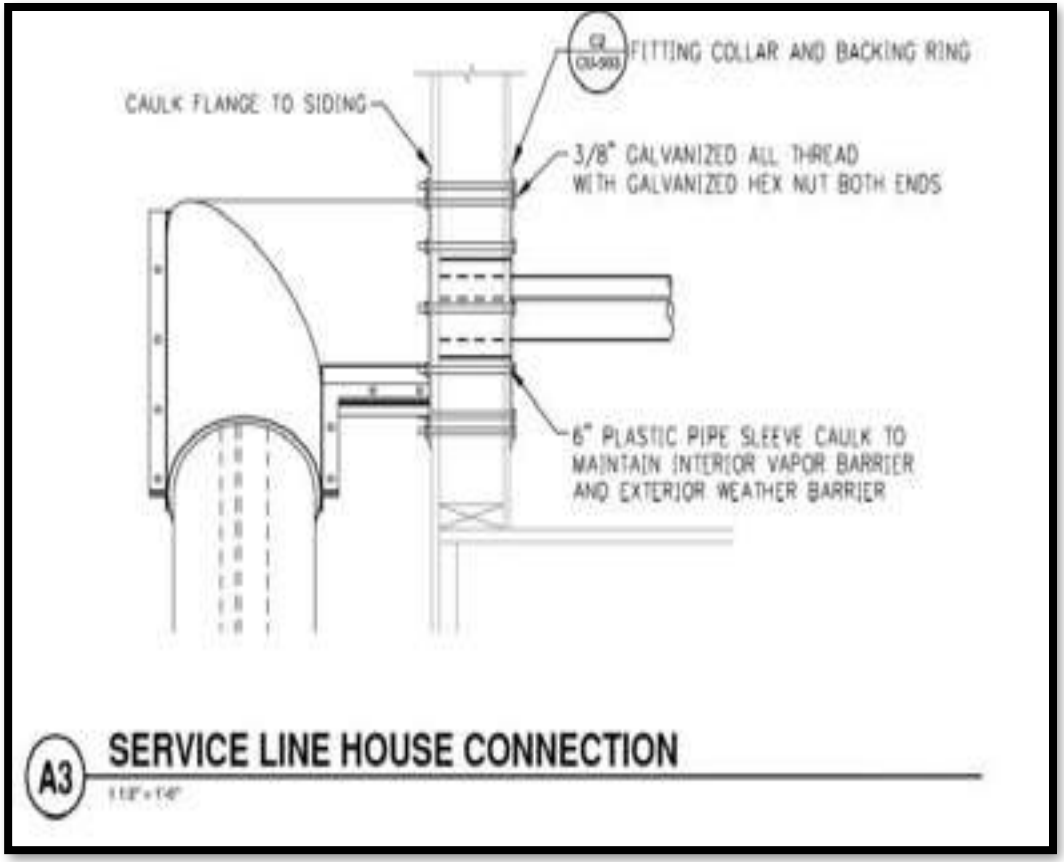
- Tank equipped to accept liquids that are discharged from the kitchen and bathroom sinks, urinal, and separating toilet
- Shallow brackish ground water and gravely soils are freeze-proof and environmentally sound for disposing grey water

Adaptation to shifting foundations: Arctic Boxes replaced by Flexible Connection to homes

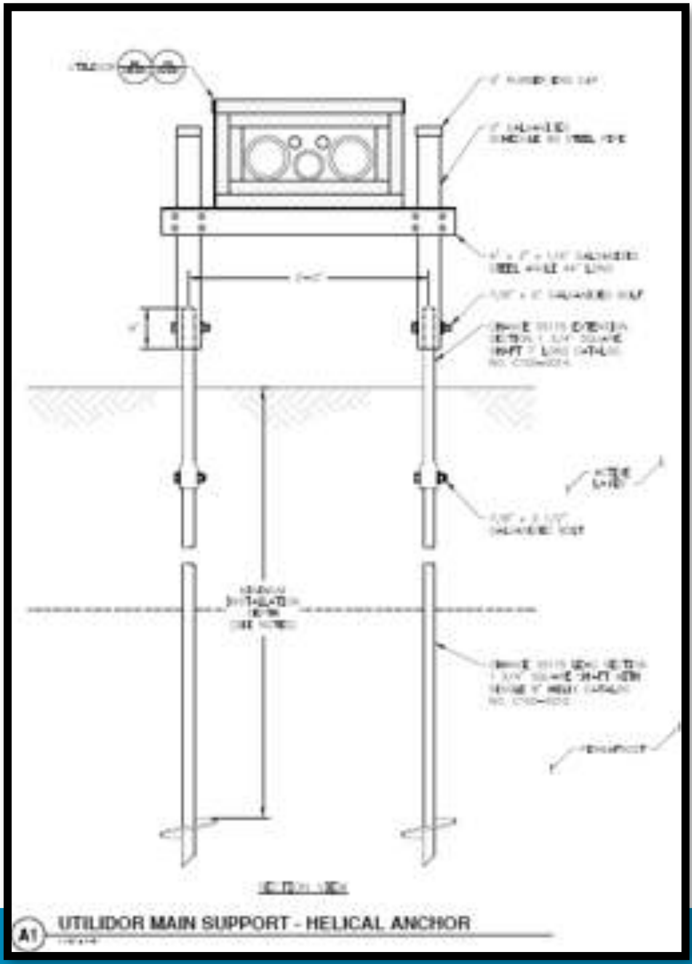
ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Flexible Service

<u>SOLID</u> connection to the house.

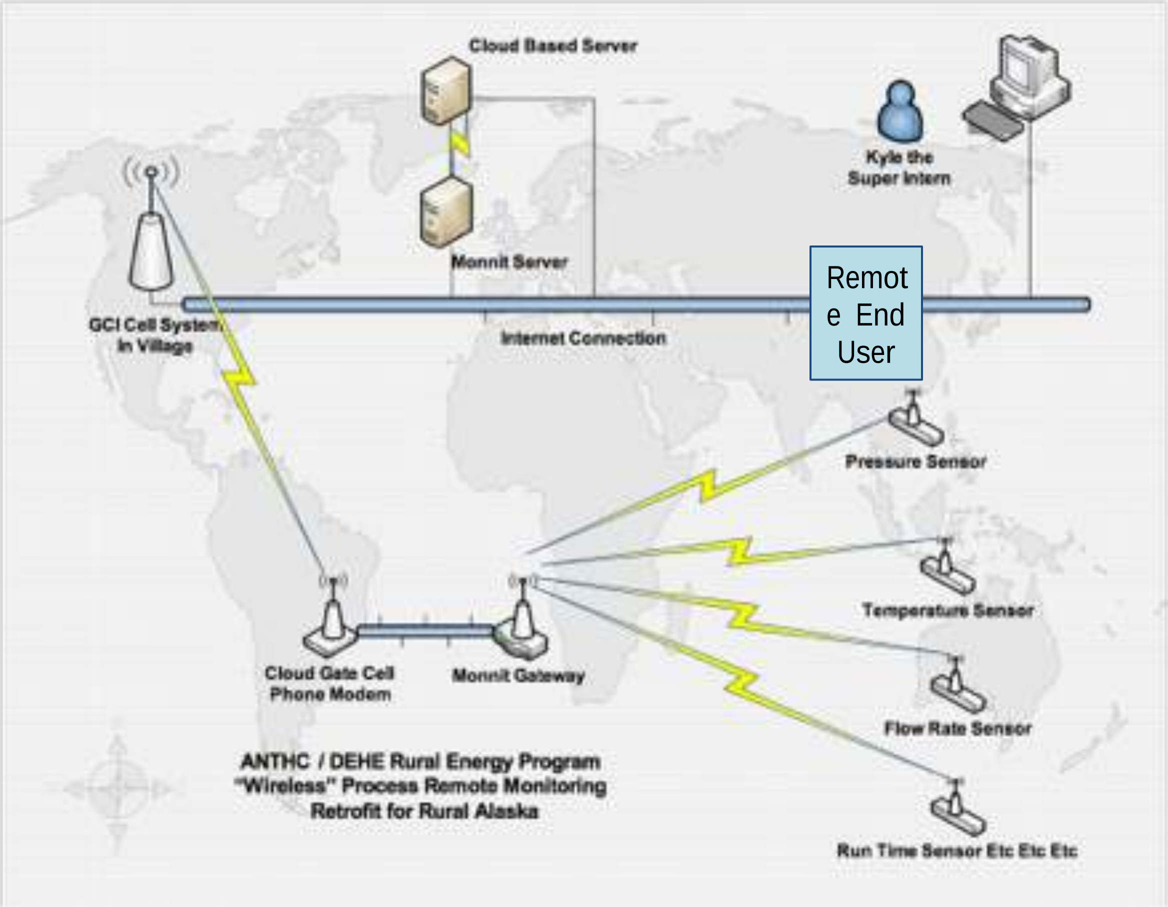


Adaptation: Kotlik carrier pipes placed on Helical Piers instead of sleepers



ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Remote Monitoring: System Concept



ANTHC Remote Monitoring

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

What can be done to save the infrastructure that villages depend upon?
Environmental Atlas to ensure Climate Data is updated for Design Engineers

Name of Village	Current Population (DEC)	Location (DEC Web)		Historic Temperature (°F) (Average 1961-1990)			Projected (2031-2040) Temperature (°F) (SNAP)			Historic Precipitation (in) (SNAP: 1961-1990)	Projected (2031-2040) Precipitation (in) (SNAP)	Historic Freezing Index	Adjusted (2031-2040) Freezing Index	Historic Thawing Index	Adjusted (2031-2040) Thawing Index
		Lat (N)	Lon (W)	Min (ICCP)	Max (SNAP)	Ave (ICCP)	Min	Max	Ave						
Ambler	259	67.086110°	-157.851390°	-52.0	82.0	23.0	-48.6	83.9	24.1	22.3	25.2	5657	5463	2933	3113
Buckland	458	65.979720°	-161.123060°	-49.0	86.0	22.0	-45.8	88.0	23.1	13.2	16.1	6456	6229	2668	2842
Deering	133	66.074970°	-162.712740°	-45.0	75.0	23.0	-42.1	76.7	24.1	10.2	12.8	6826	6371	1901	1950
Kiana	383	66.975000°	-160.422780°	-52.0	77.0	23.0	-48.5	78.8	24.1	14.7	17.5	6051	5836	2753	2937
Kivalina	406	67.726940°	-164.533330°	-51.0	80.0	22.0	-47.5	81.7	23.1	8.6	10.5	6962	6516	1827	1870
Kobuk	109	66.908570°	-156.881020°	-54.0	82.0	25.0	-50.5	83.9	26.2	16.8	19.8	5657	5452	2933	3113
Kotzebue	3126	66.898280°	-162.596850°	-44.0	84.0	21.0	-41.1	85.8	22.0	9.1	11.7	6659	6198	2465	2517
Noatak	512	67.571110°	-162.965280°	-49.0	91.0	26.0	-45.6	92.8	27.3	12.4	14.9	6489	5953	3745	3917
Noorvik	642	66.838330°	-161.032780°	-52.0	77.0	23.0	-48.5	78.8	24.1	12.2	14.9	6297	6129	2753	2929
Selawik	846	66.603890°	-160.006940°	-47.0	77.0	22.5	-43.9	78.8	23.6	15.8	18.7	6487	6244	2753	2937
Shungnak	272	66.888060°	-157.136390°	-54.0	82.0	25.0	-50.5	83.9	26.2	17.1	20.0	5657	5457	2933	3113
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

The take home

1. Communities across Alaska are increasingly fragile and vulnerable.
2. Permafrost thaw and erosion are leading threats to infrastructure.
3. Guidelines on design parameters and best practices is lacking.
4. Some infrastructure is operating outside of it's design parameters.
5. Monitoring is needed to address problems before catastrophic failures.
6. Rapid change is compounding existing problems in community systems.
7. Capacity to ensure compatibility between systems is needed.
8. Climate change is effecting the ability to provide basic health services.

Future Possible Guiding Principles of Infrastructure Design

- Flexible instead of rigid
- Moveable instead of permanent
- Smaller
- Adaptable to changing conditions
- Efficiency and simplicity over complexity
- Innovative
- Increased monitoring
- Modular
- Light Footprint

OUR VISION:

Alaska Native people are the healthiest people in the world.

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

DALHOUSIE UNIVERSITY

WIHAH Conference

Graham Gagnon, Kaycie Lane & Amina Stoddart

Civil and Resource Engineering
Dalhousie University

October 7, 2016

Water Safety Plans (WSPs)

- Objective: Ensure water is safe for consumption *from the source water through the distribution system*
- Promoted by the W.H.O. in the water guidelines of 2001
  - Designed as a risk assessment tool
  - Not strictly regulatory
- Ubiquitous*:* tailored to local water conditions
  - Community buy-in


Task 1 - Engage the community and assemble a water safety plan team
Task 2 - Describe the community water supply
Task 3 - Identify and assess hazards, hazardous events, risks and existing control measures
Task 4 - Develop and implement an incremental improvement plan
Task 5 - Monitor control measures and verify the effectiveness of the water safety plan
Task 6 - Document, review and improve all aspects of water safety plan implementation
Water safety plan continuous improvement cycle

WSP Review

- Iceland
  - Well established, all GW
  - Have different plans based on size of system

1.11.2 Risk assessment - checklist

Risk assessment is made for five components of the water supply system. That involves the catchments area, well-zone, storage reservoirs, pump stations and main pipe, distribution system and connections and finally fire hydrants. Only present those factors that scored 4 or higher in the valuation on probability and severity, others are left out. Following is a checklist for features that may be considered as risk factors:

I Water catchments area

Nr.	*Risk factor*	*Likelihood*	*Severity*	*Value*	*Control and control measures*
1	Roads, traffic such as oil trucks				
2	Transport of chemicals				
3	The use of fertilizer e.g. in forestry				
4	Industrial activity				
5	Agriculture e.g. sheep and horses				
6	Storage of chemicals				
7	Road fill				
8	Septic tanks				
9	Ablation				
10	Flood				
11	Approaching flights				
12	Vandalism				

Iceland Risk Scoring System

- Likelihood – how likely an event is to occur within your water system

1 – Less than 1/100 years
2 – 1/100 years
3 – 1/1year – 1/10 year
4 – 1/1 week -1/1 year
5 – More than 1/1 week

- Severity – the severity of an event if it did occur within your water system

1 – Very Little
2 – Little
3 – Average
4 – High
5 – Very High

M. J. Gunnarsdóttir, S. M. Gardarsson and J. Bartram. (2012) Icelandic experience with water safety plans. *Water Science and Technology Vol. 62.5* doi: 10.2166/wst.2012.801

WSP Review

- Alberta
  - Excel File: four sections
  - Same GCDWQ and national regulations

REFORMAT ALL / INS	Risk Description	Risk I.D.	Hazard	Cause of Potential Failure	Comment	Current Monitoring
Disinfection Risks	Failure of disinfection as a result of failure or lack of automatic shutdown following disinfection process failure	DWSP-T-071	Microbiological contamination	Due to WTW failing to shut down when disinfection fails.		
Disinfection Risks	Inadequate treatment as a result of reduced UV efficiency	DWSP-T-072	Microbiological contamination	Due to reduction transmittance of light due to fouling of lamp sheath or to increase in colour or turbidity	If light transmission is reduced UV becomes less effective.	
Disinfection Risks	Inadequate treatment as a result of inability to meet disinfection requirements due to high chlorine	DWSP-T-073	Microbiological contamination	Due to inability to add sufficient chlorine due to high flow or high		

... Source Detail | Source Schematic | Source Risks | Treatment Detail | Treatment Schematic | **Treatment Risks** | Netw ...

Alberta's Risk Scoring System

- Likelihood – how likely an event is to occur within your water system

0 – Not Applicable
1 – Highly Unlikely
2 – Unlikely
4 – Medium
8 – Probable
16 – Almost Certain

- Consequence – the severity of an event if it did occur within your water system

0 – Not Applicable
1 – Insignificant
2 – Minor
4 – Moderate
8 – Severe
16 - Catastrophic

Environment Alberta (2011). Alberta Training Manual. http://environment.alberta.ca/apps/RegulatedDWQ/DWSP.aspx

Risk Scoring

- Alberta Risk Score = Likelihood x Consequence
- Iceland Risk Score = Likelihood + Severity
- Each Risk Score prioritizes an issue
- Gives a matrix of possible risk scores
  - High
  - Moderate
  - Low

Risk Matrix (Alberta)

		Consequence Descriptor					
		Not Applicable	Insignificant	Minor	Moderate	Severe	Catastrophic
Likelihood Descriptor	Not Applicable	0	1	2	4	8	16
	Most Unlikely	1	1	2	4	8	16
	Unlikely	2	2	4	8	16	32
	Medium	4	4	8	16	32	64
	Probable	8	8	16	32	64	128
	Almost Certain	16	16	32	64	128	256

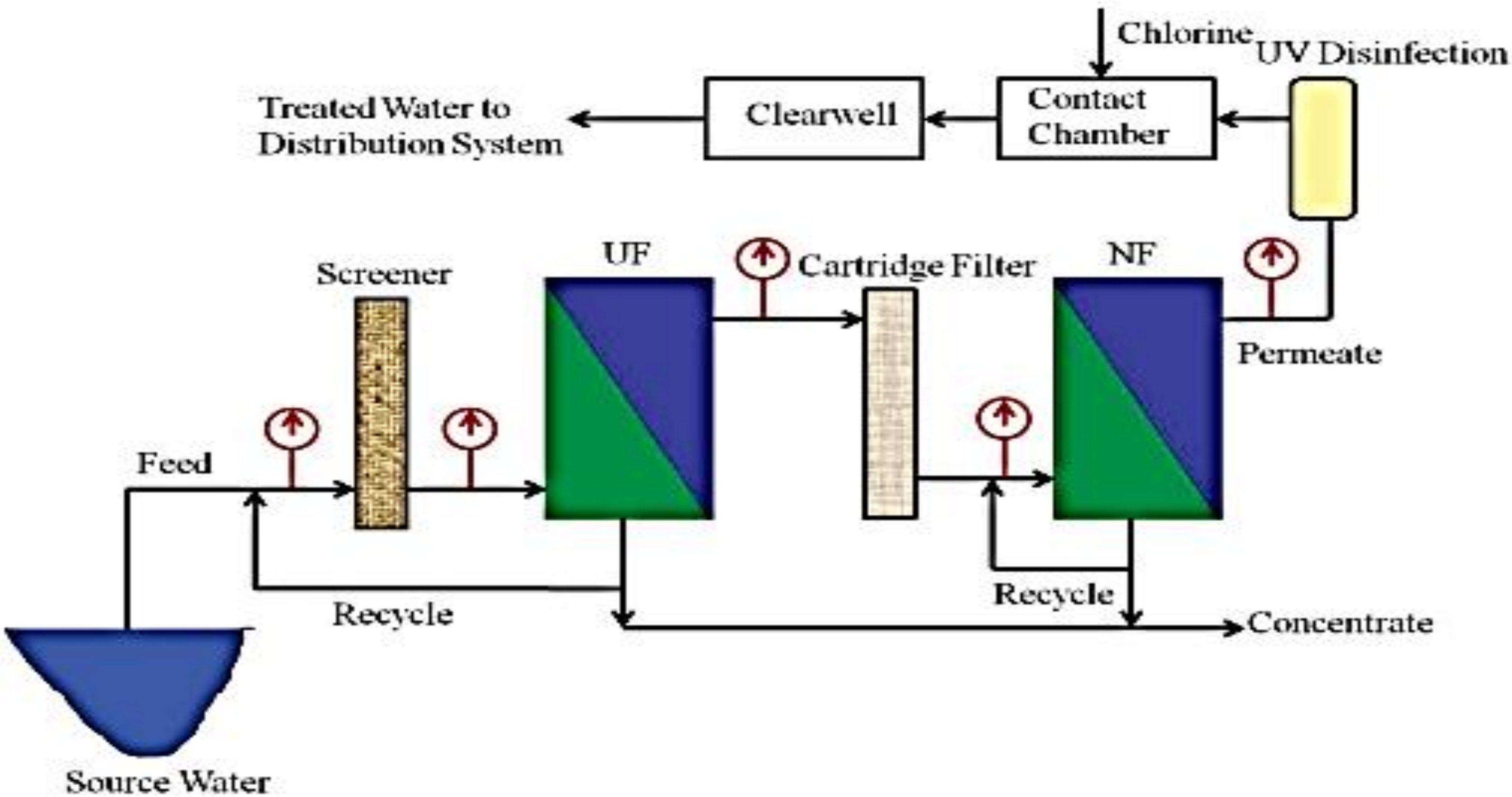
Case Study
Collins Park Water Treatment Plant

Source
Fletchers Lake

Treatment
Ultrafiltration, Nanofiltration, chlorination, UV disinfection

Serves
313 people

Collin's Park Treatment Schematic



Lamsal, Rupa. Advanced Oxidation Processes: Assessment of Natural Organic Matter Removal and Integration with Membrane Processes. 2012. Dalhousie University Department of Civil and Resource Engineering.
https://dalspace.library.dal.ca/bitstream/handle/10222/15135/Lamsal,Rupa,PhD,CIVL,July2012.pdf?sequence=1

Goals of a WSP at Collin's Park

- Find out whether different scoring systems make a difference in identifying risks
  - *Are the same risks identified?*
- Assess whether new r framework highlights the actual risks that are present within the system
- Re-evaluate our questions – are we asking the right things
  - *Use operator feedback and input to optimize the way we assess risks*

Example of Question Framework

Likelihood

Do you experience issues with low raw water quantity?

a) Yes 16
b) No 1

Consequence

How often do you have leaks in your intake pipes?

a) Frequently 16
b) Occasionally 8
c) Rarely 2
d) Never 0

Example of Question Framework

Likelihood

Do you experience issues with low raw water quantity?

a) Yes 16
b) No 1

Consequence

How often do you have leaks in your intake pipes?

a) Frequently 16
b) Occasionally 8
c) Rarely 2
d) Never 0

Issue being identified: Low raw water quantity due to leaks in intake pipes

Likelihood =16
Consequence = 2
Risk Score = 32
Risk Level= Moderate

Method Under Development

Source Water Quantity

Step 1 of 2: Submit

Has your source water ever provide insufficient water quantity? *

Select an option: ▾

Do you ever exceed water withdrawal permits? *

Select an option: ▾

Do storms or heavy rainfall influence water quantity? *

Select an option: ▾

Have you experienced issues with low influent water pressure? *

Select an option: ▾

Have you ever experienced pump failures? *

Select an option: ▾

Are there ever issues with leaks in raw water mains? *

Select an option: ▾

Online Survey Tool

Easy to use

Users don’t see the scores associated with questions

http://formsmarts.com/form/1qlf?mode=h5

Survey Answers

Raw Data from the Survey can be exported to Excel

- Raw data is easier to manipulate
- Changed easily every time you fill out your WSP

Source Water Quantity

SWQ L1	SWQ L1.C1	SWQ L1.C2	SWQ L2	SWQ L2.C3	SWQ L2.C4	SWQ L2.C5
No	No - Neve	No - Neve	No	Yes - Rare	No - Neve	No - Never

Source Water Quality

SW L1	SW L1.C1	SW L1.C2	SW L1.C3	SW L1.C4	SW L1.C5	SW L1.C6	SW L1.C7	SW L1.C8	SW L1.C9
Yes	Yes	Yes	Medium	Yes - Freq	Yes	No	No	Yes	No

Source Water Quantity

Step 1 of 2: Submit

Has your source water ever provide insufficient water quantity? *

Select an option: ▾

Do you ever exceed water withdrawal permits? *

Select an option: ▾

Do storms or heavy rainfall influence water quantity? *

Select an option: ▾

Have you experienced issues with low influent water pressure? *

Select an option: ▾

Have you ever experienced pump failures? *

Select an option: ▾

Are there ever issues with leaks in raw water mains? *

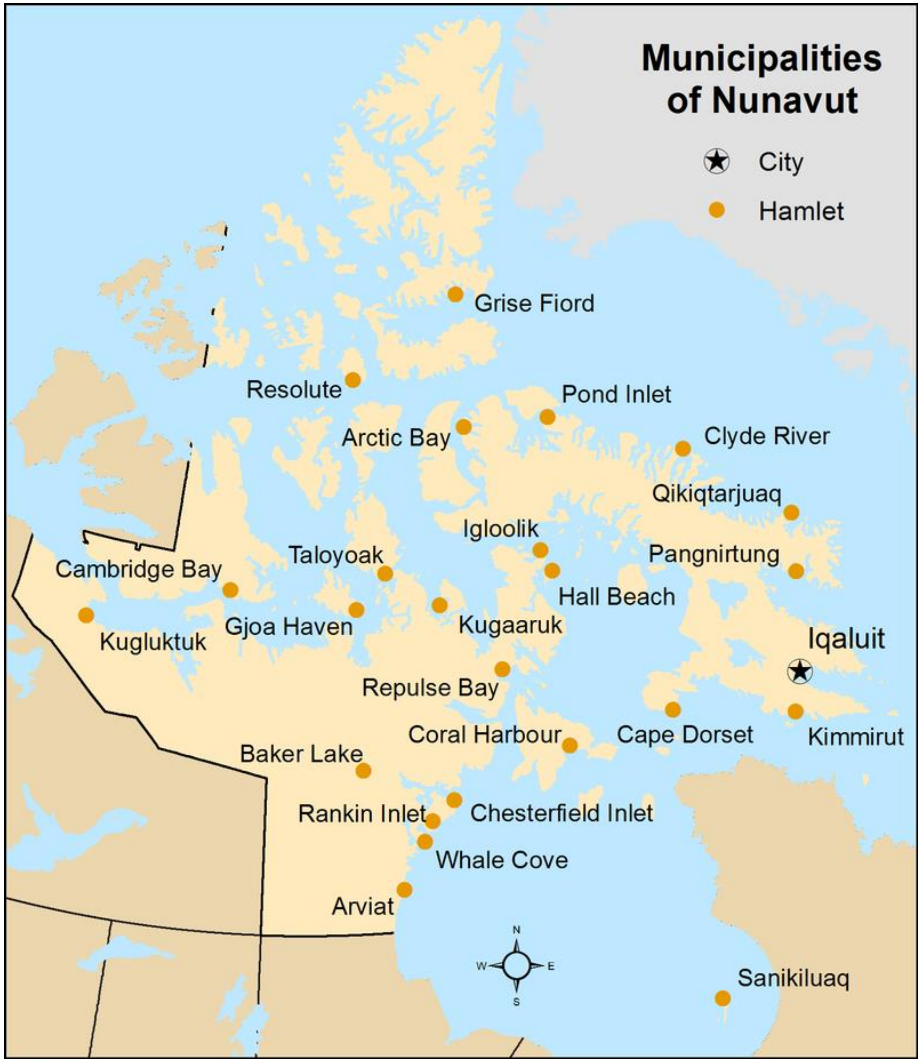
Select an option: ▾

30										
31	**Source Water Quantity**									
32	SWQ L1	SWQ L1.C1	SWQ L1.C2	SWQ L2	SWQ L2.C3	SWQ L2.C4	SWQ L2.C5			
33	No	No - Neve	No - Neve	No	Yes - Rare	No - Neve	No - Never			
34										
35	**Source Water Quality**									
36	SW L1	SW L1.C1	SW L1.C2	SW L1.C3	SW L1.C4	SW L1.C5	SW L1.C6	SW L1.C7	SW L1.C8	SW L1.C9
37	Yes	Yes	Yes	Medium	Yes - Freq	Ye				
38										

						Alberta Scoring System			
						Likelihood	Consequence	Risk Score	Risk Rating
Surface Water Quantity	SWQ L1	Has your source water ever run dry?		No		1			
	SWQ L1.C1		Do you experience high water demand?		No - Never		1	1	Low
	SWQ L1.C2		Do changes in weather influence water quantity?		No - Never		1	1	Low
	SWQ L2	Have you experienced issues with low influent water pressure?		No		1			
	SWQ L2.C3		Have you ever experienced pump failures?		Yes - Rarely		2	0	Low
	SWQ L2.C4		Are there ever issues with leaks in raw water mains?		No - Never		1	0	Low
	SWQ L2.C5		Are there ever damages with intake structures?		No - Never		1	0	Low
	SW L1			Yes					
	SW L1.C1		Are there major highways nearby?		Yes		16	16	Moderate
	SW L1.C2		Are there any septic systems nearby?		Yes		16	16	Moderate
	SW L1.C3		Please rate the security (i.e. from vandalism) of		Medium		8	8	Moderate

Applying a WSP to Nunavut

On-Going Work for WSPs in Nunavut



Very remote communities

Trucked water

Mix of ground and surface water

Challenges Unique to Nunavut

- Remoteness
- Highly varied water treatment methods
- Monitoring plans not well defined
- Operator training
- Trucked distribution system

Applying the Alberta DWSP Framework to Nunavut

- Four Sections: Source, Treatment, Network, Customer
- Risks applicable to Nunavut:

Risk Section	Applicable Questions	Total Questions	Percentage Applicable
Source	27	38	71%
Treatment	31	84	37%
Network	20	48	42%
Customer	10	20	50%

Questions Specific to Nunavut

SW L2.1) Is there wastewater infrastructure nearby (i.e. within 30m of a sewer or sewer pipe, within 46m from a septic tank or sewage disposal point, etc.)?

Yes 16

No 0

SW C2.1.1) Have you ever sampled for bacteria?

Yes 1

No 16

SW C2.1.2) Has E.coli ever been found?

Yes 16

No 1

SW C2.1.3) Have you sampled at least once per month for the past five years?

Yes 1

No 16

WSP questions are specific to Nunavut guidelines

Trucked Water Delivery System

- Different from conventional piped distribution system

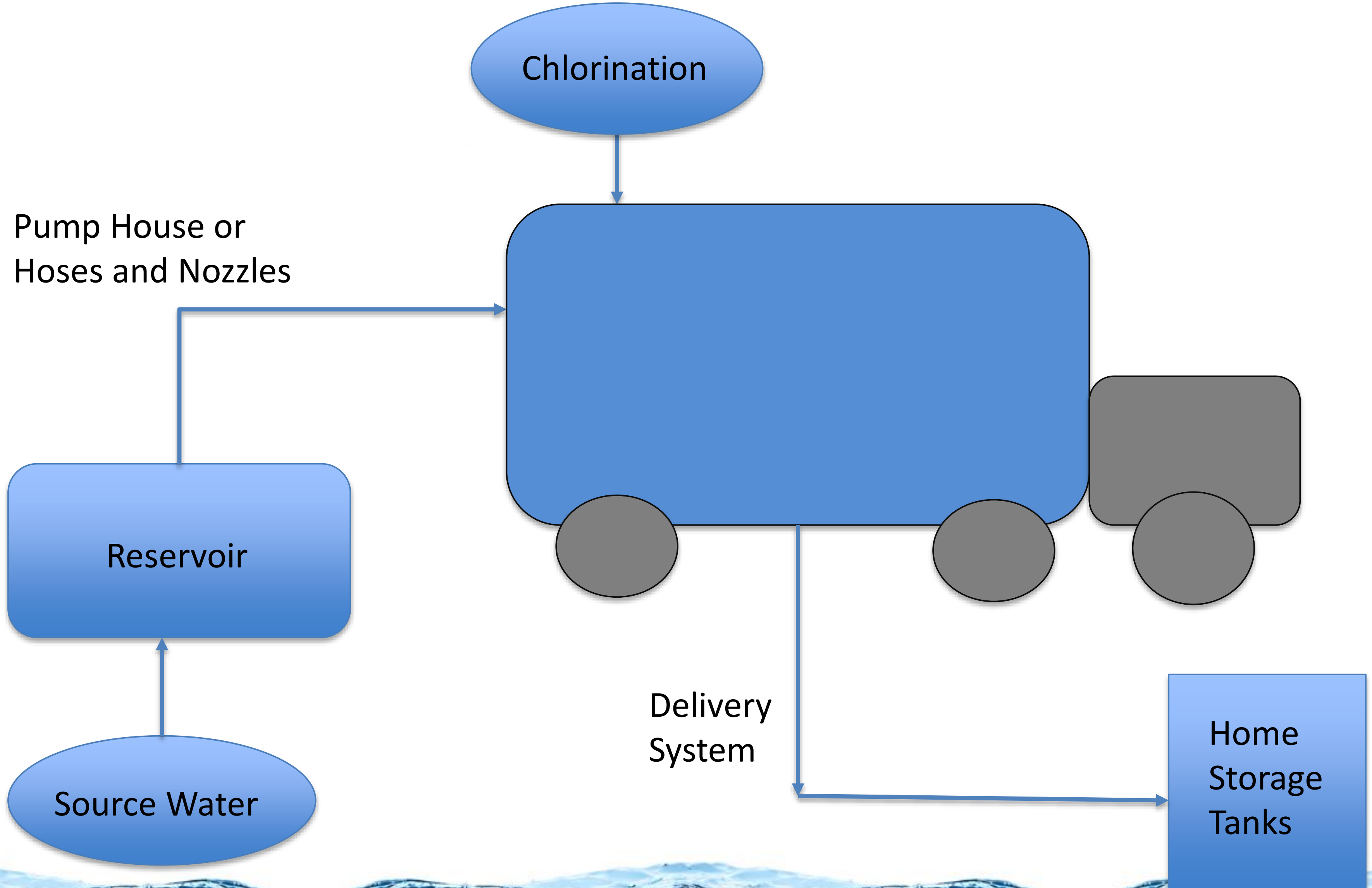
Manitoba
Health
Health Protection Unit

BULK WATER HAULING GUIDELINES

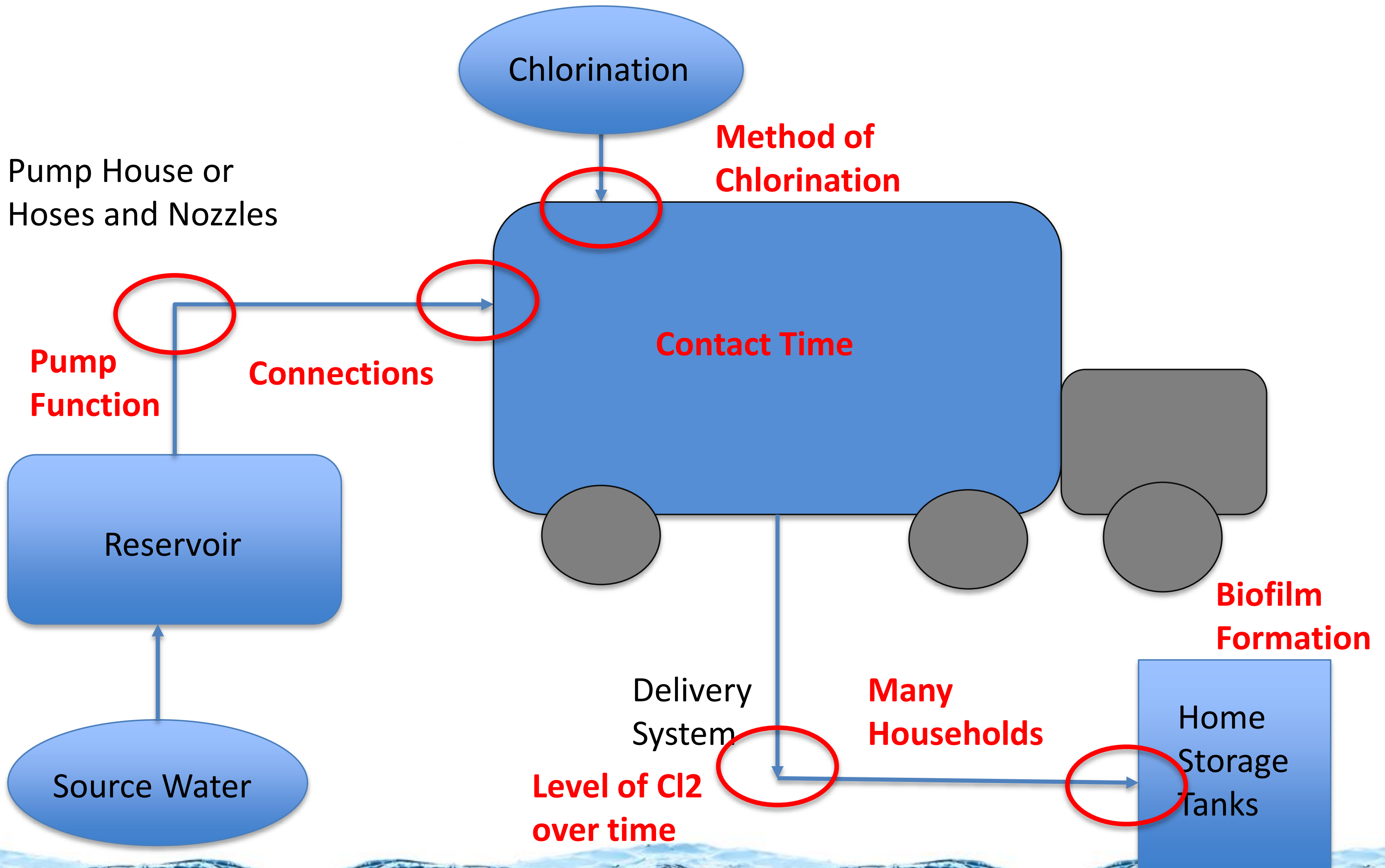
For the purposes of this guideline, **"Bulk Water"** is defined as potable water intended for human consumption that is conveyed and dispensed from an approved transport vehicle (*Water Hauling Truck*).

The water hauling vehicle and associated equipment ***must be designed, operated and maintained*** in a sanitary manner to ensure that water does not become contaminated and pose a risk to Public Health.

Trucked Water Delivery System



Trucked Water Delivery System



Trucked Water Survey

- Sections:
  - Connections to truck (pump house and household)
  - Maintenance and Sanitation
  - Chlorination

TWL) Are water delivery trucks used exclusively for treated drinking water?

Yes	1
No	16

→

TWC) Do water trucks ever carry wastewater (e.g. domestic, industrial, food)?

Yes	16
No	1

Trucked Water Delivery System

Question Code	Likelihood Question	Consequence Question	Likelihood Answer	Consequence Answer	Likelihood Score	Consequence Score	Risk Score	Risk Rating
TW L1	Are water delivery trucks used exclusively for treated (e.g., chlorinated) drinking water?		Yes		1			
TW L1.C1		Is written confirmation from a health officer given prior to using the water delivery truck for substances other than treated drinking water?		No		16	16	Moderate
TW L1.C2		Do water trucks ever carry wastewater (e.g., domestic, industrial, food)?		Yes		16	16	Moderate
TW L1. C3		Do water trucks ever carry untreated freshwater?		No		1	1	Low
TW L2	Are water delivery trucks visually inspected regularly?		No		16			
TW L2.C4		How often are visual inspections of water hauling trucks carried out?		Monthly		4	64	High
TW L2.C5		How often do you find issues (e.g., rust in the tank, leaks) with water hauling trucks?		Rarely		4	64	High

Next Steps

- The developed WSP is in its infancy
  - A first step in preventative drinking water regulations from a **risk management** perspective
- Several additional steps are required to understand how the approach could be best implemented:
  - E.g., pilot-scale application

Acknowledgments

- GN Department of Health
  - Michele LeBlanc-Havard
  - Dr. Maureen Baikie
- CWRS Team
  - Dr. Wendy Krkosek
  - Lindsay Anderson

NSERC
CRSNG

Halifax
Water

LUMINULTRA
SEE THE LIGHT

MANTECH
OPTIMIZE YOUR RESULTS. PROTECT OUR ENVIRONMENT.

CBCL
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Water
Utility
Committed To Quality

A New Affordability Indicator for Rural Alaskan Water Utilities

Barbara AL Johnson

Ms Resource and Applied Economics candidate
School of Management
University of Alaska Fairbanks

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DEPARTMENT OF ENVIRONMENTAL CONSERVATION
STATE OF ALASKA

SOM
UAF SCHOOL OF MANAGEMENT

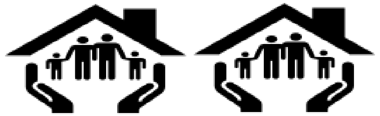
Outline

- Background
  - The Economics of water utility
  - Defining Affordability
  - Evaluating the Current Affordability Indicator
- The New Affordability Indicator
- Results
  - Akiachak
  - Shageluk
  - Overview of unserved communities
- Further research

Economies of scale

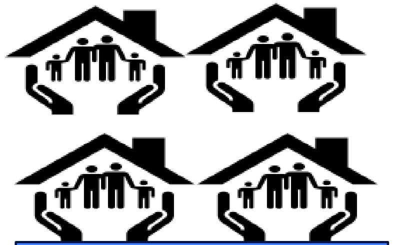
The Economics of Water Utilities: Economies of scale

Two household community



Cost per household: $50

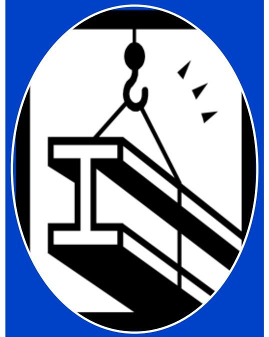
The water utility has annual costs of $100 per year



Four household community

Cost per household: $25

The Economics of Water Utilities: Funding and pricing



Capital costs (construction costs) are funded by state and federal agencies

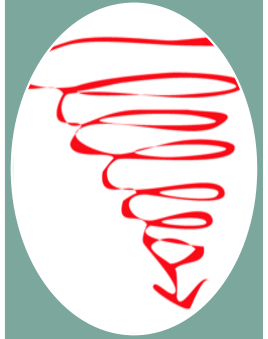
Once the utility is built the community is expected to cover the annual costs of running the utility.

Rates are set by dividing the annual costs by the number of customers.

If rates are too high, some customers will be unable to pay their bills.

Utilities cut off non paying customers and re-calculate rates.

Rates increase.



Even less customers can afford the water bills and so more drop off.

Rates increase again.

The Economics of Water Utilities

▸ **ARUC - Alaska Rural Utility Collaborative**

May 19, 2015 · Saint Michael, AK, United States ·

I wanna know how many villages have households paying $250 a month for water service, only reason i wanna know is because I think residents of St. Michael, Alaska are over paying on their water service. My water bill is current to this month, but thats because I work year round and can afford it. But so many families in this village hardly have a chance at keeping up with this rate. Its for those families I am concerned. There's no question that sanitation is a lot easier with running water and flush toilets, and every household or community that desires such a system deserves one. But at what cost?

The Economics of Water Utilities

ARUC - Alaska Rural Utility Collaborative Hello Scott, thank you for your question. The water and sewer rates for your community are based on expenses which must be paid in order to keep the water plant operating. As with all Alaska Rural Utility Collaborative (ARUC) communities, revenues must be equal to expenses.

Unfortunately, the collections are not generating enough revenue to pay water and sewer expenses. The annual operating expenses for providing water and sewer services for
St. Michael is $272,936. If all customers in St. Michael paid their water and sewer bills, the rate could decrease to $196 a month.

We do understand that the rates for some communities are high. In 2014, the City agreed to a subsidy to decrease residential rates to $175 per month. The agreed upon subsidy, however, was not sent to ARUC. Based on current service and collection rates and projected expenses, revenues will not be sufficient to cover current operating expenses, or reduce deficit or build critical equipment reserves.

Based on last year's finances, the ARUC Advisory Committee recommended that rates increase for residential users. However, the City is still working to get a subsidy for the residents. There are also some energy efficiency projects that will likely save in energy and fuel costs.

If you have additional questions or concerns please contact Rick Lind, the regional manager at 1-866-205-7581.

Defining Affordability

Affordability:

- **Individual (household level):** Whether a **low income household** is able to pay a water bill without giving up other essential goods and services

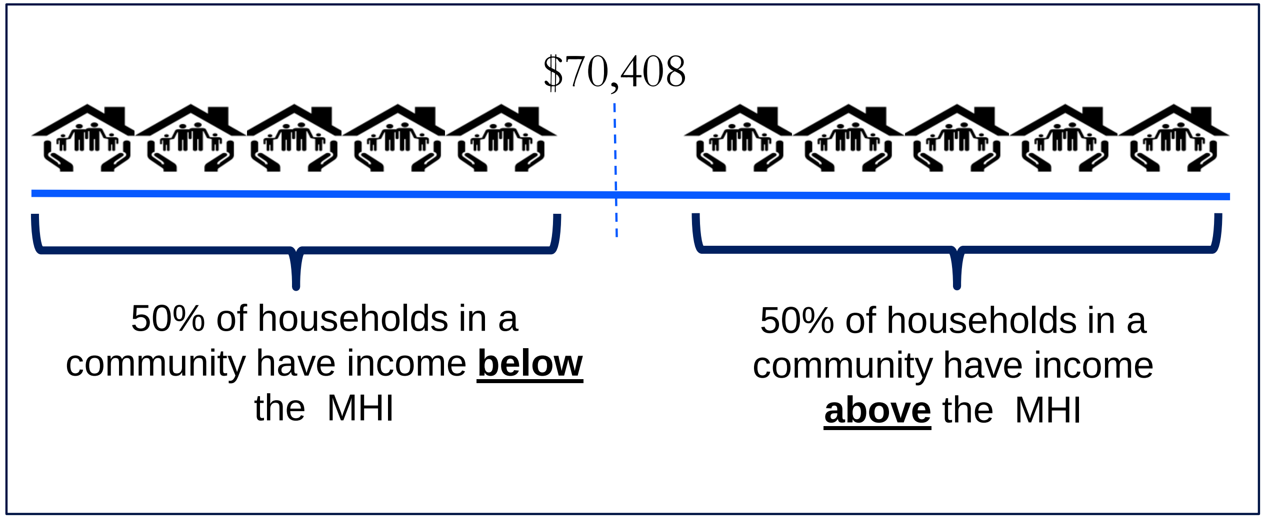
&

- **Community level:** The community is able to cover the utilities annual costs.

Defining Affordability

The DEC – VSW currently defines a system to be affordable if utility bills represent less than 5% of the community's Median Household Income (MHI)

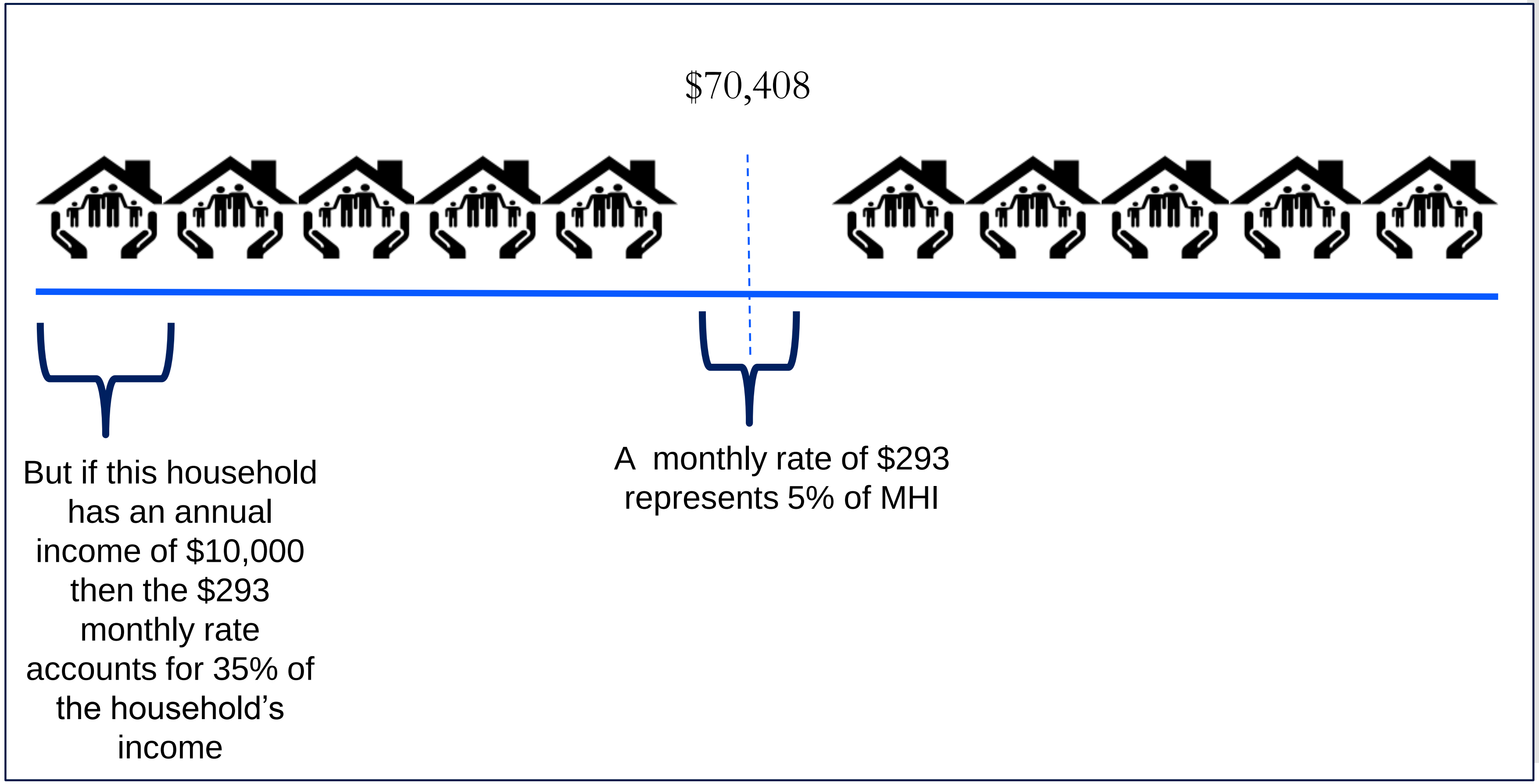
Median Household Income (MHI) in Fairbanks



According to the DEC definition, water utility rates of $293 per month or less are affordable in Fairbanks.

Evaluating the Current Affordability Indicator

1. The MHI fails to reflect the cost burden experienced by below median income households:



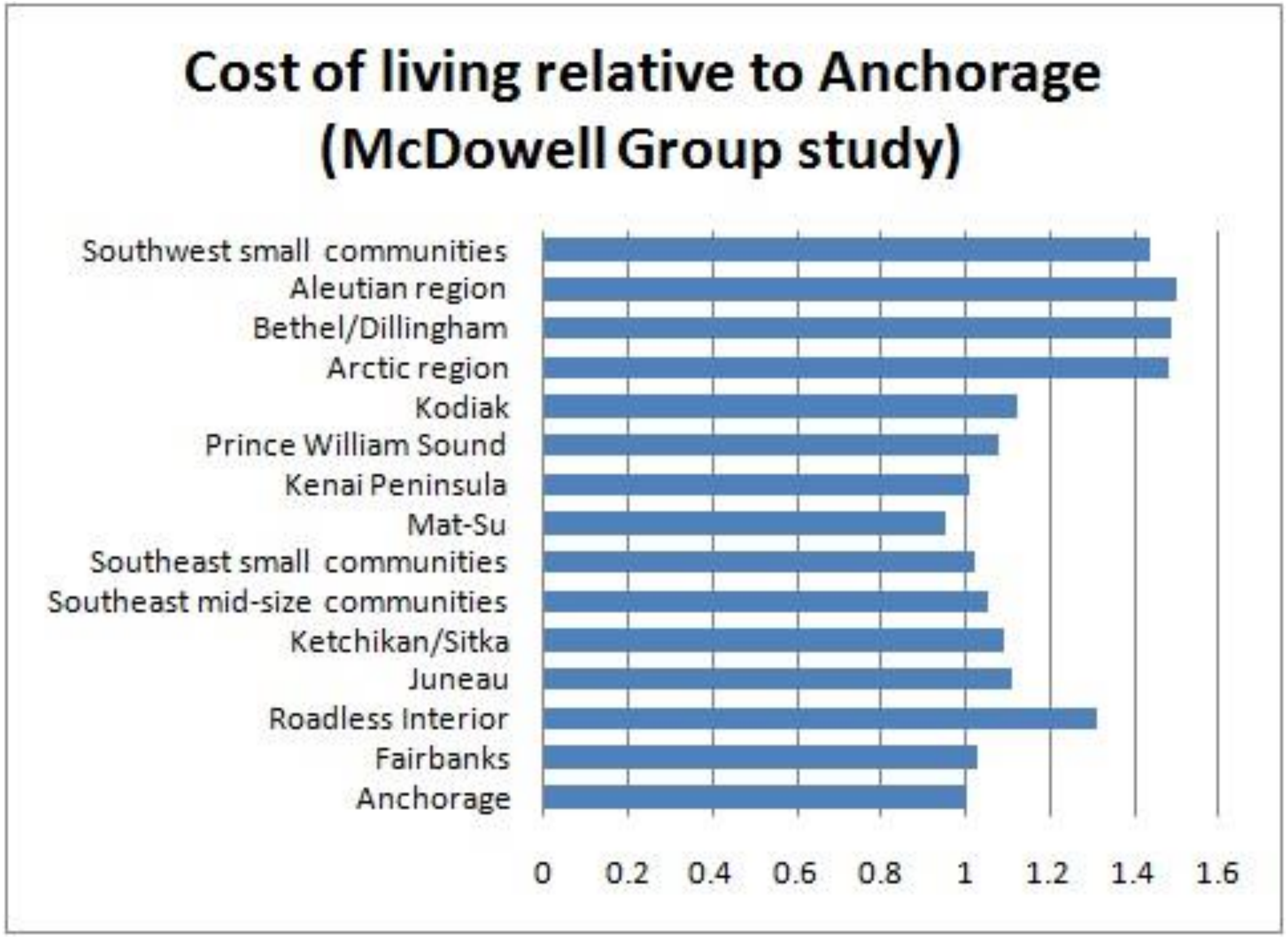
Evaluating the Current Affordability Indicator

2. The MHI is a static snapshot of income:

- Rural Alaskan MHI values are collected every 5 years.
- Evidence suggests that income in this region can vary significantly from year to year.
- Thus if the data was collected in a year with a higher than usual number of cash paying jobs the MHI figure would overestimate the community’s income. Conversely if the data was captured in a bad year, the MHI could be underestimated.

Evaluating the Current Affordability Indicator

3. It does not account for high costs of living:



Evaluating the Current Affordability Indicator

4. It does not account for the demographic composition of a community:

Average household size: 4.40

Age dependency ratio*:

87.3%

Average household size: 3.18

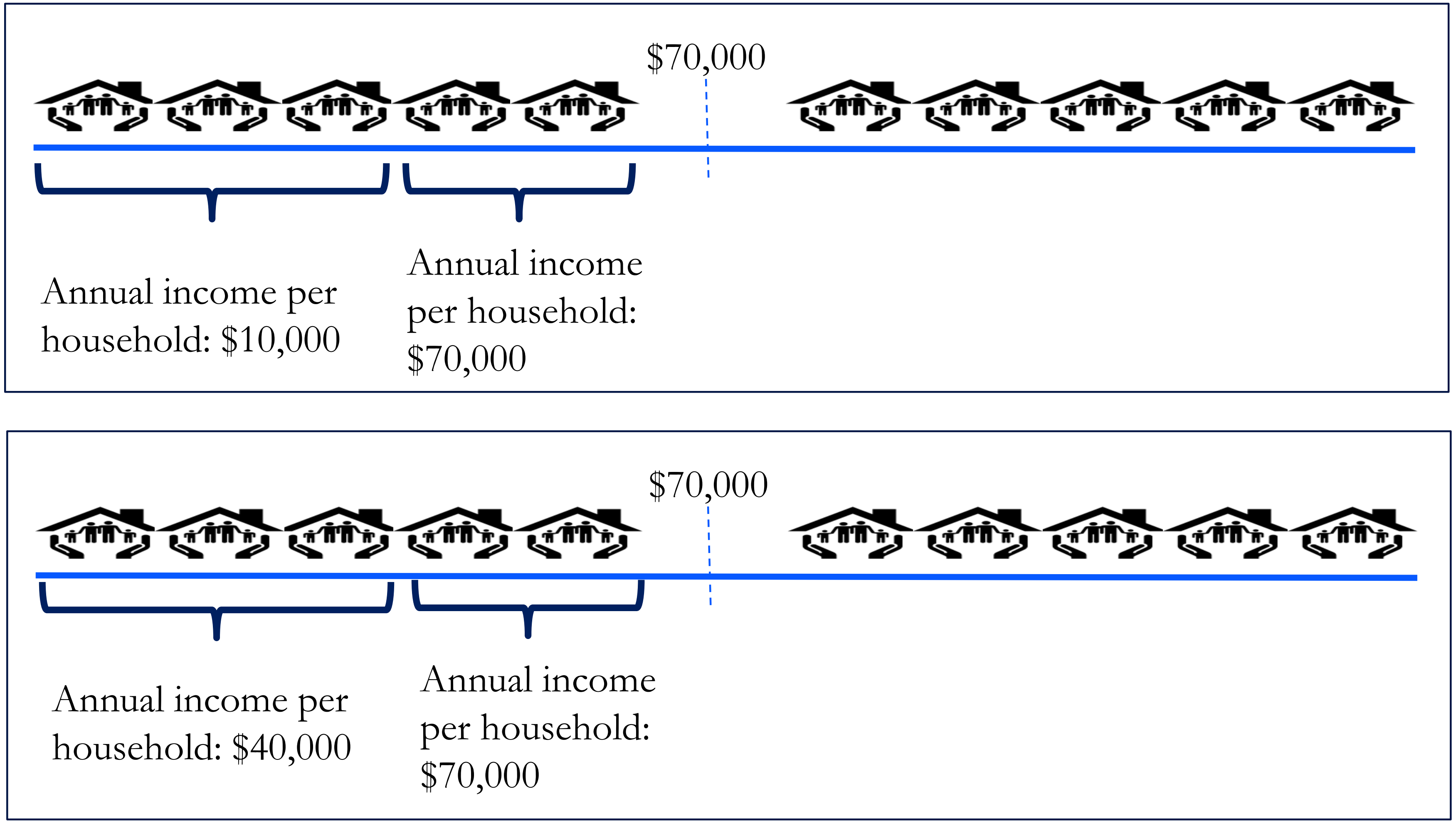
Age dependency ratio*:

65.8%

*Age dependency ratio: $\frac{\text{number of people under the age of 18 + people over the age of 65}}{\text{number of people between the ages of 18 - 65}}$

Evaluating the Current Affordability Indicator

5. MHI does not take into account income distribution:



The New Affordability Indicator

Financial Capability Indicator (FCI)	**Residential Index (RI)**		
	Low ≤ 2%	Mid-Range 2 % < RI ≤ 5%	High > 5%
Strong > 2.5	Low Burden	Low Burden	Medium Burden
Mid-Range 1.5 < x ≤ 2.5	Low Burden	Medium Burden	High Burden
Weak ≤ 1.5	Medium Burden	High Burden	High Burden

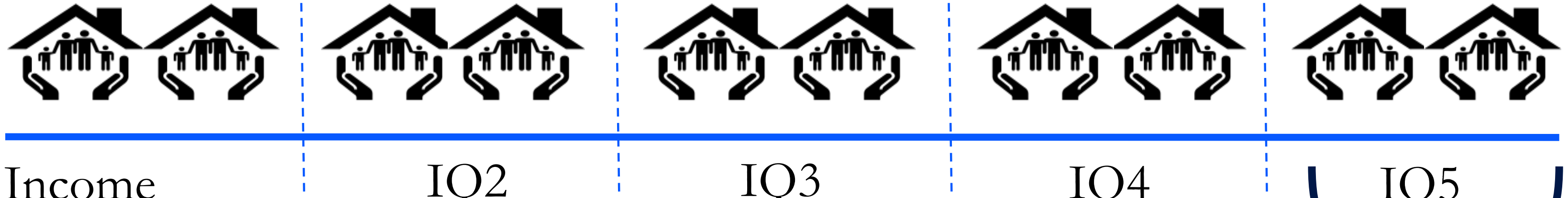
Affordability

Affordability

The New Affordability Indicator

- Residential Index (RI) calculated for every income quintile, in particular for those below the median values.
  - Low Impact- is an RI of less than 2%
  - Medium Impact- is an RI between 2% and 5%
  - High Impact-is an RI of over 5%

$21,852 $41,904 $67,215 $107,967



Income Quintile 1 (IQ1) | IQ2 | IQ3 | IQ4 | IQ5

20% of the population in Fairbanks has an income between $0-and $21,852.

The US Census calculates the lowest limit of the top 5% of IQ5. In Fairbanks this is $200,460.

Residential Index

Residential Index Calculations for Adak

IQ1	IQ2	IQ3	IQ4	IQ5
$ 67,583	$ 75,700	$ 93,833	$ 114,500	$ 127,167
Divide each Income Quintile (IQ) by the annual user fees: $720				
Residential Index for each quintile:				
720/67,583 = 1.07%	0.95%	0.77%	0.63%	0.57%
Average RI(IQ1-IQ3): 0.93%				

Income Quintile: American Community Survey 2014
User Fees: Dec 2015

The Financial Capability Indicator

- A Financial Capability Indicator (FCI) that is calculated by assigning values from 1 (weak) to 3 (strong) to the following:
    - Percentage of households which are Supplemental Nutrition Assistance Program (SNAP) recipients in the community,
    - Percentage of households which receive public assistance,
    - Percentage of households living under the poverty level,
    - Percentage of people over the age of 16 with full time jobs,
    - Percentage of MHI spent on an average electric bill and
    - Cross-price elasticity of demand of water with respect to electricity prices.

The Financial Capability Indicator

Energy Impact

Energy cost account between 40%-70% of utility expenditures. Furthermore, anecdotal evidence suggest that energy and water are *complementary goods.*

This means that they go together - let's imagine that right and left shoes were sold separately. In general, consumers would buy a right shoe with every left shoe.

Thresholds

% cost to quintile	≤ 2%	2% < x ≤ 5%	> 5%
Affordability value	Low Burden	Medium Burden	High Burden
% over the age of 16 employed full time	**≤ 30%**	**30% < x ≤ 50%**	**> 50%**
Affordability value	1	2	3
% households under the poverty level	> 20%	10% < x ≤ 20%	< 10%
Affordability value	1	2	3
% of households which are SNAP recipients	>20%	10% < x ≤ 20%	<11%
Affordability value	1	2	3
% of households receiving public assistance	>30%	10% < x ≤ 20%	<11%
Affordability value	1	2	3
Electric bill % of MHI	> 5%	2% < x ≤ 5%	<2%
Affordability value	1	2	3
Cross Price Elasticity of Water	<-0.66	-0.66% < x ≤ -0.33	> -0.33
Affordability value	1	2	3

Results-Akiachak

Annual Fee	RI(MHI)	RI(IQ1)	RI(IQ2)	RI(IQ3)	RI(IQ4)	RI(IQ5)	RI(IQ1-IQ3)
$1,416	4.0%	8.0%	5.0%	4.0%	3.0%	1.0%	6%

FCI indicator	Value	FCI Value	FCI Score
% of adults with full time employment	16%	1	1.33
% household below poverty level	17%	1	
% households on SNAP	32%	2	

Financial Capability Index (FCI)	Residential Index (RI)		
	Low ≤ 2%	Mid-Range 2 % < RI ≤ 5%	High > 5%
Strong > 2.5			
Mid-Range 1.5 < x ≤ 2.5			IQ1
Weak ≤ 1.5	IQ5	IQ2, IQ3, IQ4	

Shageluk

Annual Fee	RI(MHI)	RI(IQ1)	RI(IQ2)	RI(IQ3)	RI(IQ4)	RI(IQ5)
1200 (A)	7.38%	10.85%	8.89%	4.66%	2.32%	1.36%

FCI indicator	Value	FCI Value:	FCI Score:
% of adults with full time employment	32%	2	1.5
% household below poverty level	59.26%	1	
% households on SNAP	40.70%	1	
% households on public assistance	81%	1	
% MHI Electric Bill	17.5%	2	
Estimated impact of E prices on H20	-0.36	2	

Financial Capability Index (FCI)	**Residential Index (RI)**		
	Low ≤ 2%	Mid-Range 2 % < RI ≤ 5%	High > 5%
Strong > 2.5			
Mid-Range 1.5 < x ≤ 2.5			
Weak ≤ 1.5	IQ5(A)	IQ3-IQ4(A)	IQ1-IQ2 (A)

Shageluk

Annual Fee	RI(MHI)	RI(IQ1)	RI(IQ2)	RI(IQ3)	RI(IQ4)	RI(IQ5)
1512 (B)	9.30%	13.67%	11.20%	5.87%	2.93%	1.71%

FCI indicator	Value	FCI Value:	FCI Score:
% of adults with full time employment	32%	2	1.5
% household below poverty level	59.26%	1	
% households on SNAP	40.70%	1	
% households on public assistance	81%	1	
% MHI Electric Bill	17.5%	2	
Estimated impact of E prices on H20	-0.36	2	

Financial Capability Index (FCI)	Residential Index (RI)		
	Low ≤ 2%	Mid-Range 2 % < RI ≤ 5%	High > 5%
Strong > 2.5			
Mid-Range 1.5 < x ≤ 2.5			
Weak ≤ 1.5	IQ5(B)	IQ4(A,B)	IQ1-IQ3 (B)

Unserved Communities

Geography	Matrix Score	% MHI
Allakaket	High	12%
Arctic Village	High	15%
Atmautluak	High	6%
Beaver	High	20%
Birch Creek	High	77%
Chalkyitsik	High	7%
Chefornak	High	7%
Circle	High	35%
Crooked Creek	High	10%
Diomede	High	14%
Eagle	High	6%
Kipnuk	High	8%
Kongiganak	High	8%
Koyukuk	High	12%
Kwigillingok	High	10%
Lime Village	High	30%
Napakiak	High	16%
Napaskiak	High	13%
Nightmute	Medium	3%
Shageluk	High	9%
Stebbins	High	20%
Stevens Village	High	20%
Stony River	High	18%
Takotna	High	6.9%
Teller	High	7.1%
Tetlin	High	6%
Tuluksak	High	10%
Tuntutuliak	High	8%
Venetie	High	8%
Wales	High	7%

Unserved Communities

Geography	Matrix Score	% MHI
Alatna	High	-
Mekoryuk	High	4.2%
Nunapitchuk	High	3.0%
Platinum	High	2.9%
Tununak	High	3.9%

Acknowledgements & Disclaimer

This research project was made possible thanks to funding from the Alaska Department of Environmental Conservation (DEC) and the guidance of Mr. Bill Griffith, Ms. Camilla Kennedy and Mr. Dennis Wagner (EPA) as well as my committee members (Dr Joe Little, Dr Jungho Baek, Dr Christopher Wright and Ms Kennedy).

The analysis and conclusions contained in this study are those of the author alone and do not necessarily represent the point of view of the DEC or the EPA.

This document contains statements and models that are based on current estimates and assumptions that may be changed.

Questions?

Further Research

- Thresholds
  - Using pre-established thresholds used in the Lower 48
  - Investigate affordability thresholds in rural Alaskan communities
  - Is a medium burden affordable?
- Price elasticity of water
  - Determine price elasticity of water in rural Alaskan areas
- Affordability of other utilities
  - Burden on households by other utilities
  - Determine if other utilities are affordable

Financial Capability Index

Proportionally calibrated almost ideal demand system (PCAIDS) model

We need:

1. The industry elasticity
2. The elasticity of demand of the products
3. The market shares

What we did:

- *Industry elasticity :* assumed it is equal to 1 (backed by literature)
- *Product Elasticity of Demand*
  - *Electricity elasticity:* A previous Ms Econ student calculated the elasticity of demand of PCE communities
  - *Water elasticity* – used the average of elasticity of demand figures found in the literature for flat rate systems
- *Market shares:* Assumed communities only have two utilities (water and electricity).

Financial Capability Index

Economic theory suggest that as the price of a good goes up, the quantity of the complementary good consumed decreases. In other words, as the price of energy increases, we would expect people to consume less water - even with flat rates in effect.

We used the concept of *cross price elasticity of water.*

$$\varepsilon_{WaterElectric} = \frac{\%\Delta Q_{water}}{\%\Delta P_{Electric}}$$

Financial Capability Index

Proportionally Calibrated Almost Ideal Demand System (PCAIDS)

- $dS_{water} = -0.23\left(\frac{dP_{water}}{P_{water}}\right) + 0.23\left(\frac{dP_{electric}}{P_{electric}}\right)$
- $dS_{Electric} = -0.03\left(\frac{dP_{Electric}}{P_{Electric}}\right) + 0.03\left(\frac{dP_{Water}}{P_{Water}}\right)$
- $\varepsilon_{WaterElectric} = \frac{\varepsilon_E}{s_w} + s_w(\varepsilon_{market} + 1)$

Summary of Results

Served Communities

- Average MHI: $43,876
- Average Fee: $105
- Most projects are in the medium burden level

Unserved Communities

- Average MHI: $31,749
- Average Fee: $254
- Most projects are in the high burden level

Summary of Results

MHI vs. New Indicator

- The two indicators often differ
- The MHI indicator **tends to underestimate** the fee burden
- Chignik Lake is the only community where the MHI overestimates the fee burden with respect to the new indicator

Served and unserved communities

- Most projects in unserved communities are found to be unaffordable by both indicators
- Unserved communities have an average MHI of $31,749 (vs $43,876 for served communities)

Maximizing Sustainability in Arctic Water and Sewer: Energy Efficiency

Gavin Dixon

Senior Project Manager

ANTHC Rural Energy Initiative

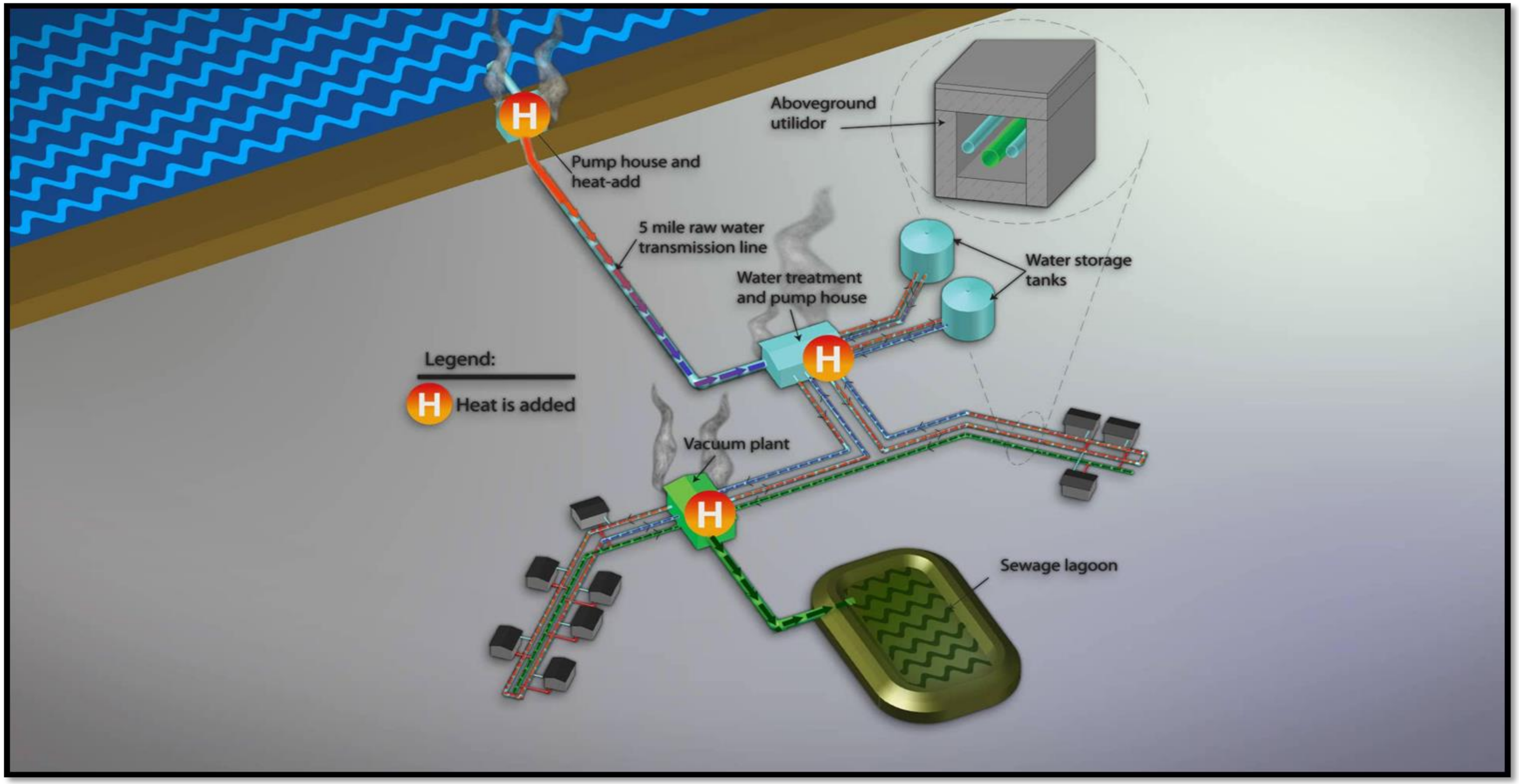
ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

ANTHC Rural Energy Initiative

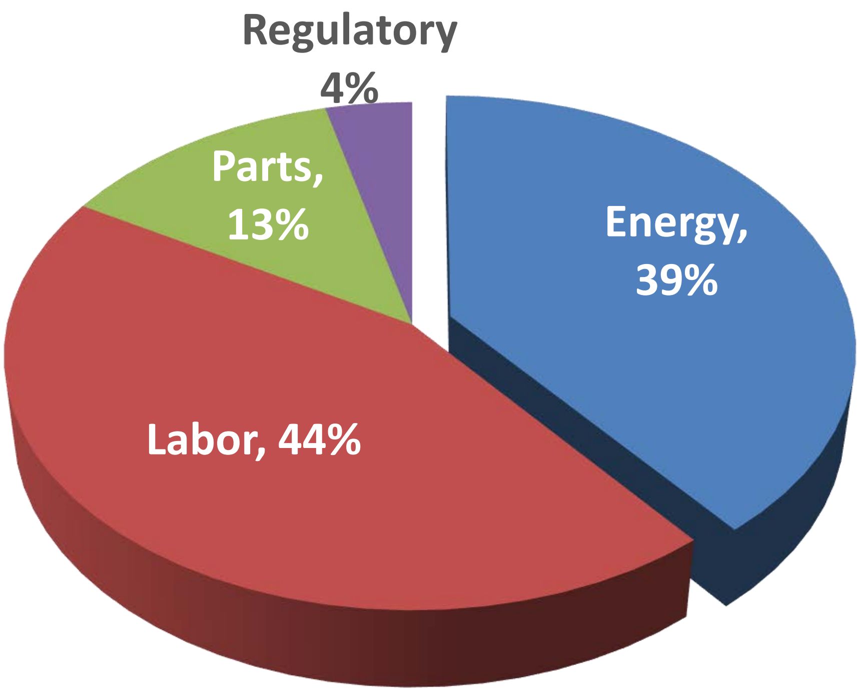
Our Purpose

The Alaska Native Tribal Health Consortium's (ANTHC) Rural Energy Initiative works with communities to implement innovative energy efficiency and renewable energy solutions to make public sanitation affordable for the people we serve across Alaska.

The Energy Intensive Arctic Sanitation System



Understanding the Arctic Water-Energy Nexus



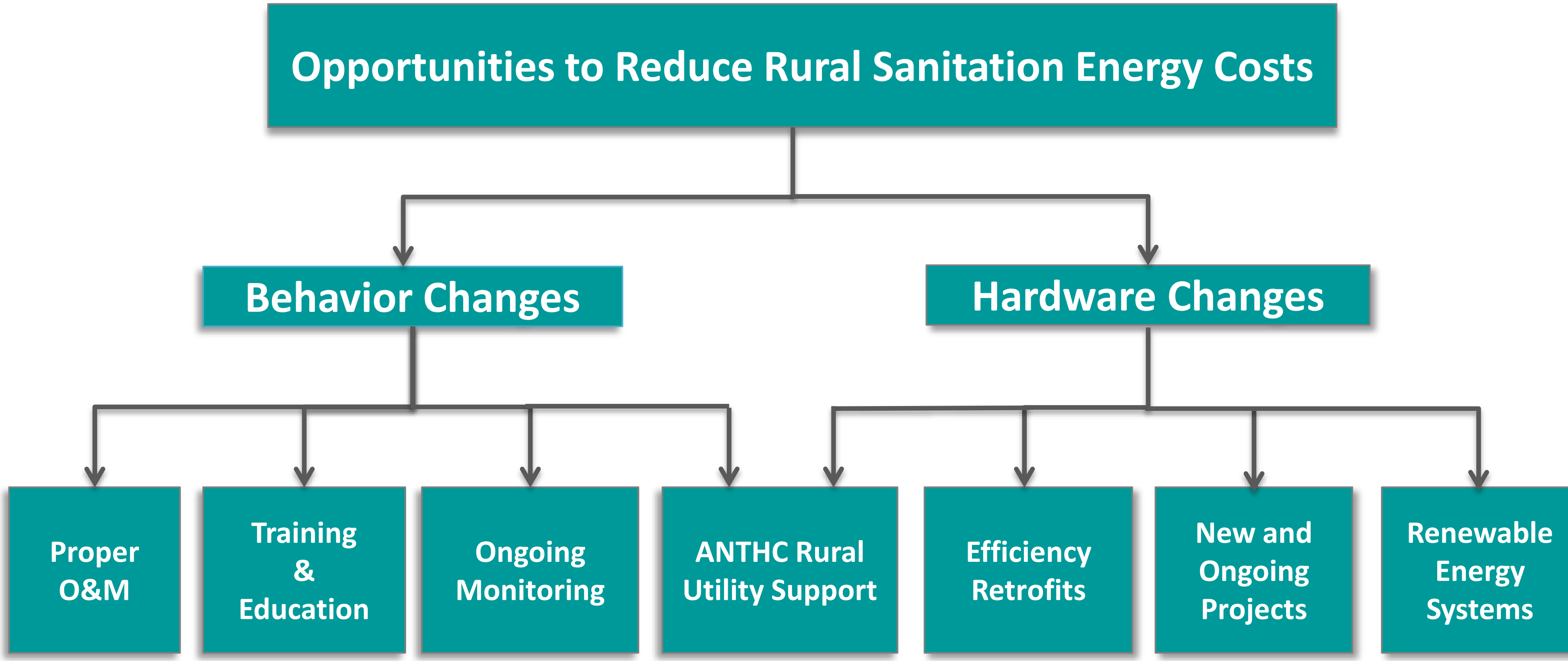
Breakdown of average operating costs for a water/sewer system in rural Alaska

Our Path: A Comprehensive and Collaborative Approach

Energy Audit → **Analysis** → **Implement Recommendations** → **Savings**

Energy Audit	Analysis	Implement Recommendations	Savings
Onsite Assessment	**Develop Energy Model**	Develop Training Plan	**Monitor Energy Usage**
Collect Data	Identify Potential Improvements	Purchase Materials	Evaluate Retrofit Effectiveness
Evaluate Operating Practices	Identify Cost to Implement	Implement Efficiency Retrofits	
Assess Facility Energy Use		Provide Operator Training	
		Construct Renewable Energy Systems	

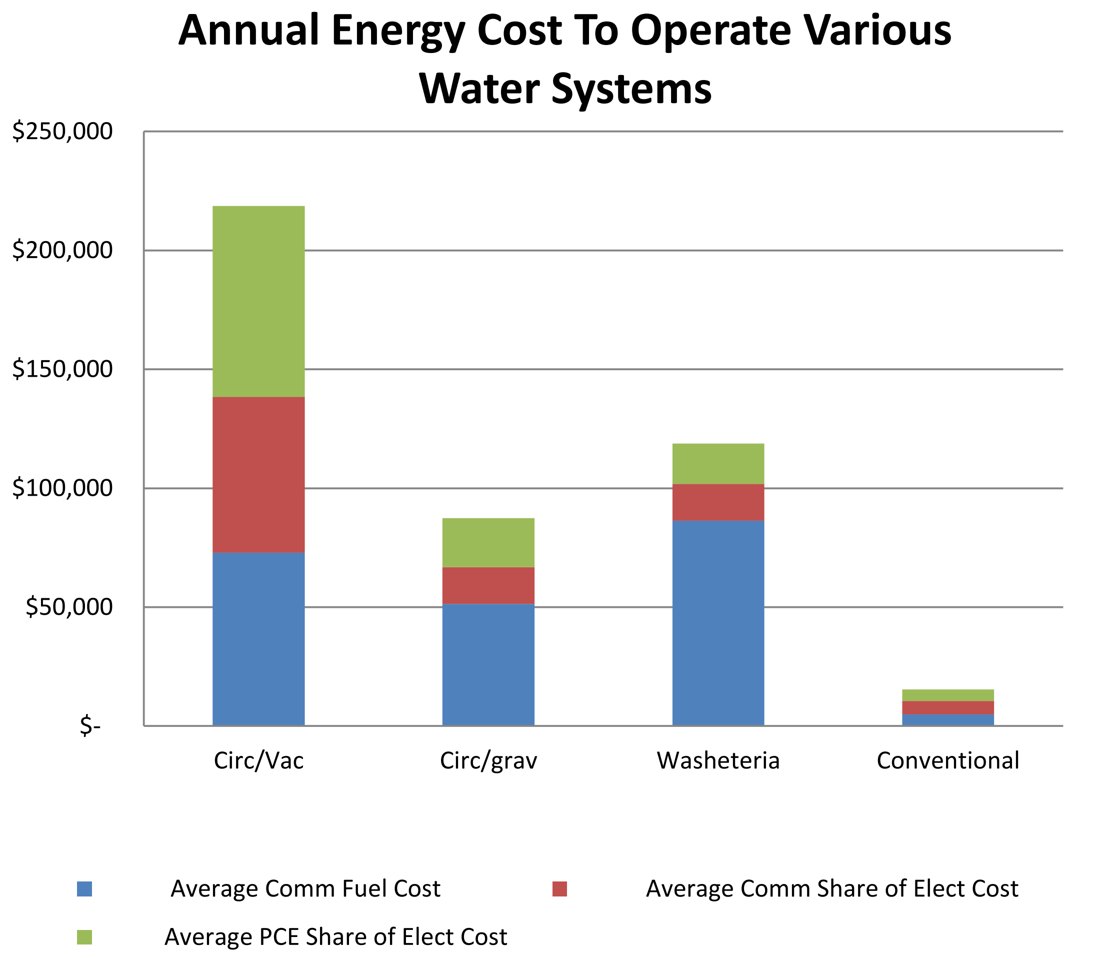
Our Path: A Comprehensive and Collaborative Approach



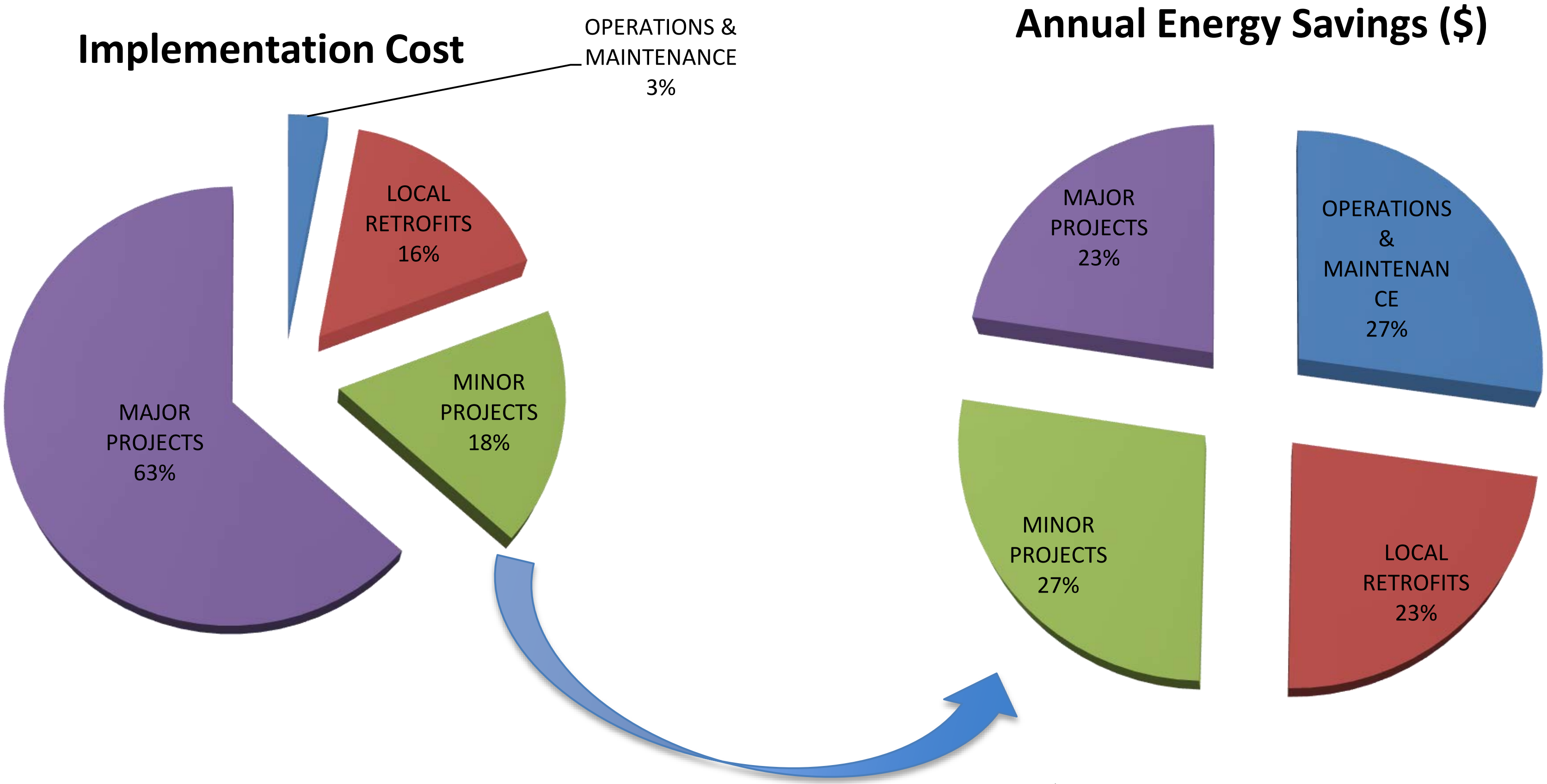
Energy Costs Vary by Type of Water System

- Northern & Interior Alaska communities have circulating water, and many have vacuum sewer, unlike Anchorage and Southeast Alaska conventional systems.

- The result is very high fuel and electricity costs.



Small Efficiency Investments Yield Big Savings



Small Efforts = **Big Results**

Typical Operational Issues and Minor Fixes Identified

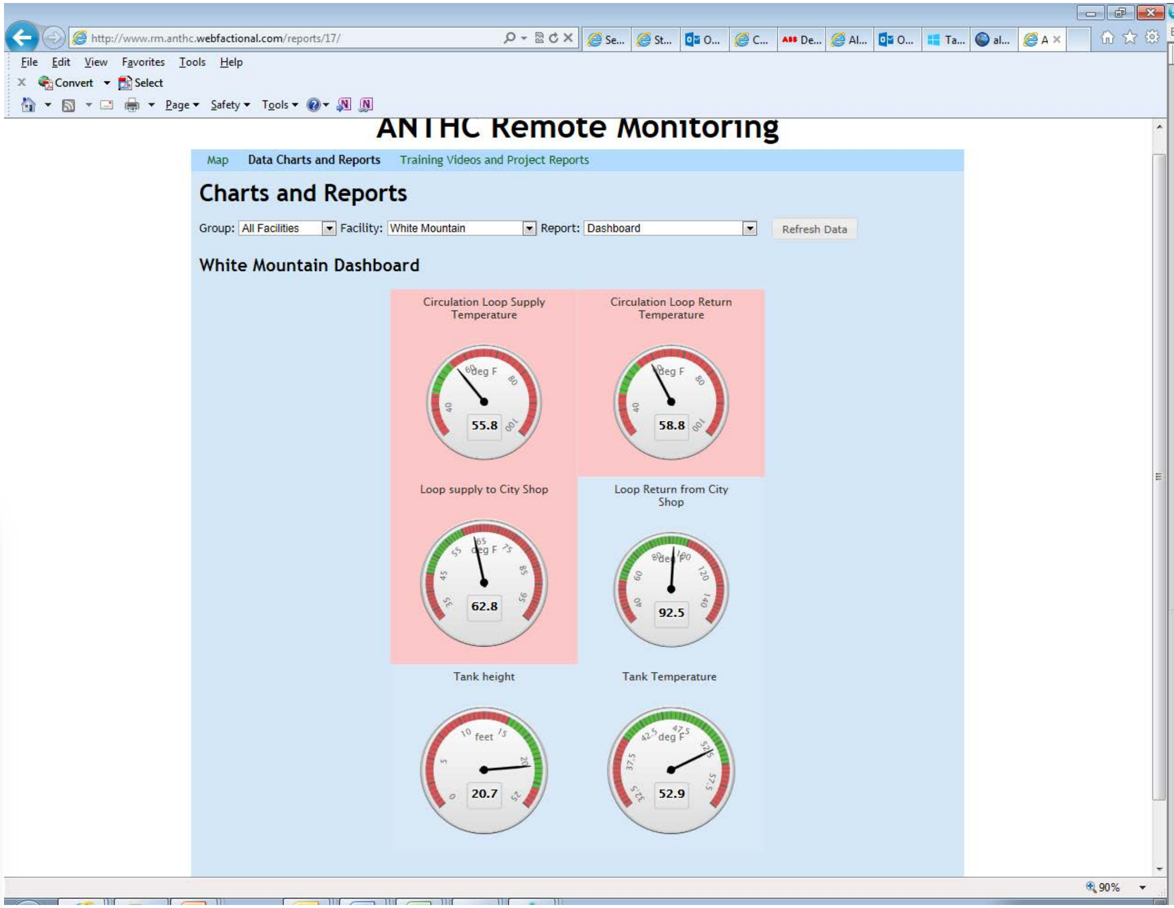
- Boilers need to be cleaned and tuned
- Boilers settings are too high and not properly staged
- Boilers are operated all summer when they are not needed
- Circulation pumps can be shut-off in summer
- Building temperature is not set back during unoccupied hours
- Water storage tank and circulating loop temperature set higher than needed
- Lift Station pumps short cycling due to fouled floats
- Electric heat trace used all winter (or all year) when designed for emergency thaw only
- Leaks in Distribution/Collection causing increased well pump/lift station run time

Longer Term Energy Upgrades Identified

- Improve the building shell by adding insulation and replacing windows/doors
- Replace old and tired boilers with new appropriately sized high efficiency cold start boilers
- Replace pumps with new high efficiency pumps and variable speed drives
- Repair and or replace process pipe and hydronic system insulation
- Add remote monitoring to optimize energy performance

Remote Monitoring

- http://rm.anthc.webfactional.com/reports/
- Records Results
- Allow for check ins and low cost technical assistance
- Greater access to information for regional partners



ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Non-Energy Benefits: Capacity

- Expanded Local Capacity
  - Expanded Knowledge
  - Improved Job Satisfaction
  - Local Ownership
- Access to Regional Support

Safety and Comfort

- Better Lighting
- Reduced Fire Danger
- Greater Confidence Interval on Freeze-Ups
- Improved Space Heat Balancing
- More Regular Hot Water

Health and Performance Improvements

- Reduced Moisture/Mold
- Faster/More Effective Drying
- Reduced Water Waste

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Expanded Lifespan

- Critical Component Replacement
- Improved Maintenance
- Improved Financial Sustainability
- Spare Parts Provision

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Appropriate Technology

- Visual feedback to inform operator behavior
- Ultra Efficiency / High–Tech versus Low–Tech
  - Low tech but locally operable encourages engagement, long term sustainability
  - SCADA versus local control / simple remote monitoring
- Low O /M Technologies
  - Heat Recovery, Programmable Thermostats
- Appropriate Technology/Scaled Renewables
  - Biomass Heating, Solar PV

Case Study: Energy Efficiency Retrofits – Pilot Station, Alaska

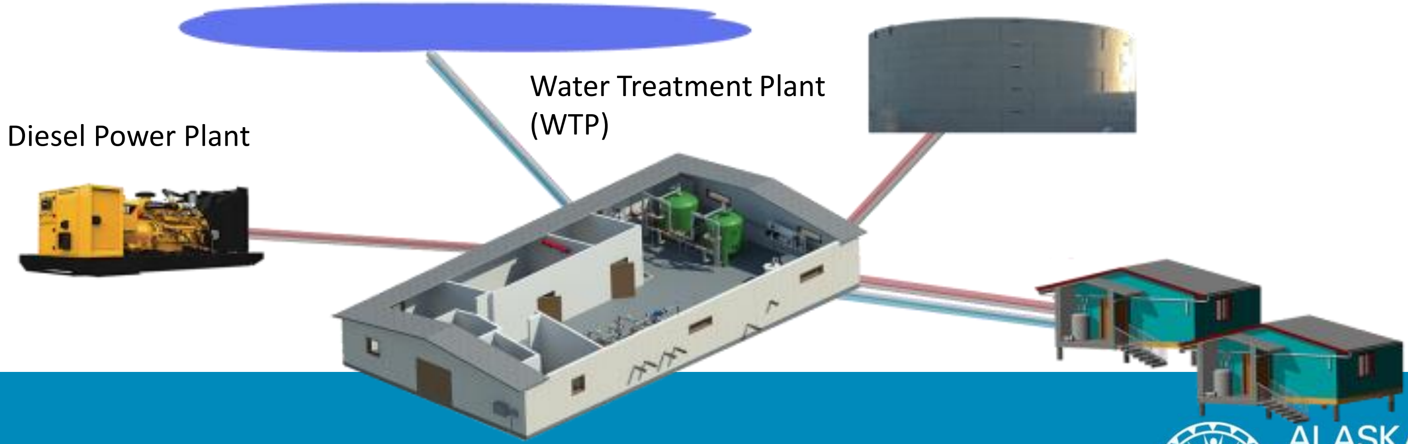
Training and small scale improvements.

- Saves sanitation system over **1,000** gallons of fuel oil and **25,000** kWh annually
- Equates to **66%** reduction in Fuel and **33%** drop in electricity
- Combined annual savings of **$11,090**

BEFORE:
Brushing & cleaning soot from boiler

AFTER:
Clean flue passage

Alternative Energy Options



ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

ANTHC Rural Energy Initiative

Current and Identified Projects Through 2018

Current Energy Efficiency Projects

44 communities

Identified Energy Efficiency Projects

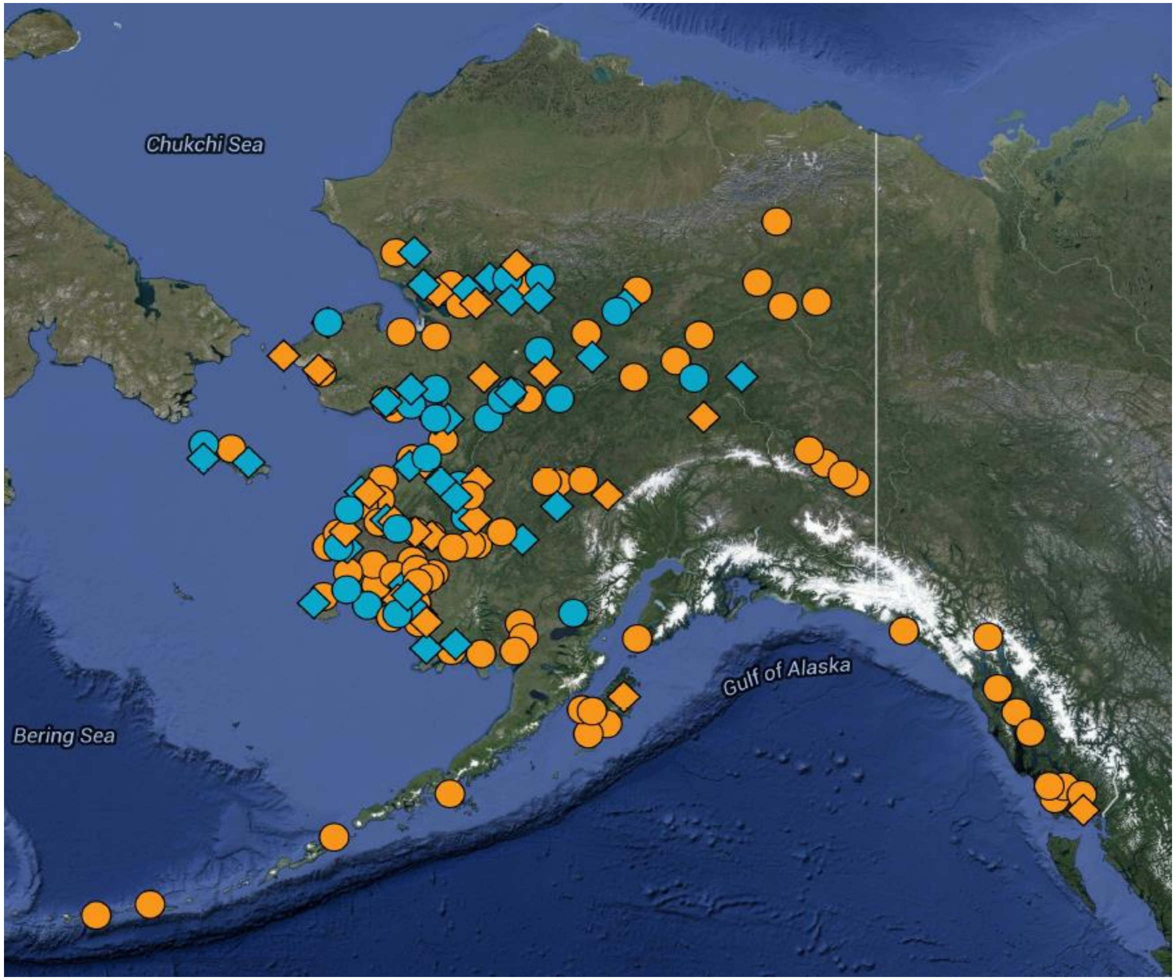
82 communities

Current Renewable Energy Projects

25 Heat Recovery Projects | 5 Biomass Projects | 4 Wind-to-Heat Projects

Identified Renewable Energy Projects

16 heat recovery projects | 5 Biomass Projects | 1 Ground Source Heat Pump Project | 1 Hydroelectric Project



Thank You

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For more information, please visit:
http://anthc.org/what-we-do/rural-energy/

WATER IS LIFE PROJECT

Alaska Native Tribal Health Consortium, National Tribal Water Center & Alaska Rural Utility Collaborative

WATER is Life is a collaborative health promotion campaign that uses art, culture, and media to create teachable moments that translate into positive community wide behavior change towards our most sacred resource – **WATER**.

Objective

1. Increase knowledge of water and its effects on health.
2. Increase community pride in and ownership of the local water and sanitation system.
3. Increase sustainability of the local water and sanitation infrastructure and traditional water culture.

Target Audience

The Water is Life project helps to create a pride and ownership in the water system to the three critical groups – Water Consumers, Water Treatment Plant Operators, and Utility Managers/Governments.

Partnering with Communities

Water is Life includes a community water visioning meeting, community water week activities and community water celebration.

Community Approach

Effective outreach and education starts with community participation.

Our team of experts are working together with the community:

- Youth education through teaching the importance of clean water through their traditional culture and lifestyle. (Lead by local elder)
- Youth water art activities. (Showcasing local artists)
- Community outreach on the Tribal radio station. (Interviewed by community members)
- Social media. (Facilitated and shared by local community members)
- Community newsletter articles. (Community members serve as contributing editors)
- Community Flyers. (Designed by local community members)
- Local News Coverage (Highlighting the community in a positive way)

WATER MURAL VISIONING

RUSSIAN MISSION

What: Community Vision Meeting (Dinner and Door Prizes!)

When: Tuesday, March 9th from 5:30-7:00 pm

Where: Russian Mission School – Cafeteria

Who's invited: Youth, Elders, Storytellers, Artists - Open to the Public

Please call James Temte at the National Tribal Water Center (907) 729-3600 or Francine Moreno at ARUC (907) 729-4502 with any questions

Please bring stories, photos, and memories to help describe Russian Mission traditional culture and water values

The National Tribal Water Center invites you to a community vision meeting to discuss and learn more about Russian Mission's traditional values and beliefs surrounding water. There will be a nationally recognized native artist in attendance to partner with local talent to design a mural for the school that will represent and celebrate the water culture of the village.

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

ARUC Alaska Rural Utility Collaborative

NTWC National Tribal Water Center

For project updates, follow us on Facebook: National Tribal Water Center and Alaska Rural Utility Collaborative

Community Water Culture Visioning Meetings

At community meetings the discussion is often about their traditional culture and what is most important to the community. This helps to inspires the design for the mural.

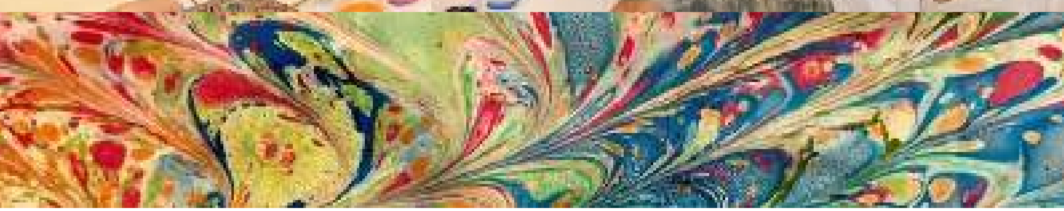
Visioning Meeting - Russian Mission AK – Water is Life

Visioning Meeting - Deering AK

Community Activities – Water Week

Activities to promote healthy water and sanitation behaviors include:

- Water bingo night
- Community movie night featuring films on traditional uses of water
- School Water Art Activities
- Water Ceremonies
- Children's Water Mural
- Water Celebrations



Youth Art Projects

Bringing water education into schools paired with exciting water art experiences provide lasting for our future city council members, tribal leaders as well as future utility operators, managers and consumers. Art activities with children reflecting water create teachable moments, opportunities to inspire youth, and promote healthy vibrant communities spaces.

Mural Creation

A public art mural reflecting the community's water culture. The mural is a continual reminder of our great heritage and is a source of community pride. When it is connected to the water and sanitation utility the positive community connection is formed between the community and the utility.



Celebrate Water!

A community dedication and celebration recognizes the importance of community water infrastructure, utility operators, and the role of the community.

Water is Life - Russian Mission

Through the efforts of the Water is Life project and the City of Russian Mission, the Russian Mission's water and sewer finances are no longer operating at a deficit, and now have a spare parts reserves account balance for the first time since being in the ARUC program. In September 2015, the City of Russian Mission had a negative balance of -$44,084. As of April 30, 2016, their water and sewer net income (revenue minus expenses) had a positive balance of $12,480.45. Additionally, the City of Russian Mission voted to have $50,000 of sales tax revenue applied as a water and sewer subsidy for residential water and sewer rates to be decreased to $60 a month. This is the lowest rate out of all of the ARUC communities.

Russian Mission water and sewer finances

Water is Life – Deering AK

Through the efforts of the Water is Life project and the City of Deering, the Deering sewer finances are decreasing debt. In a pre and post assessment the level of satisfaction the community has with their sewage service has rose from 8% to 46%.

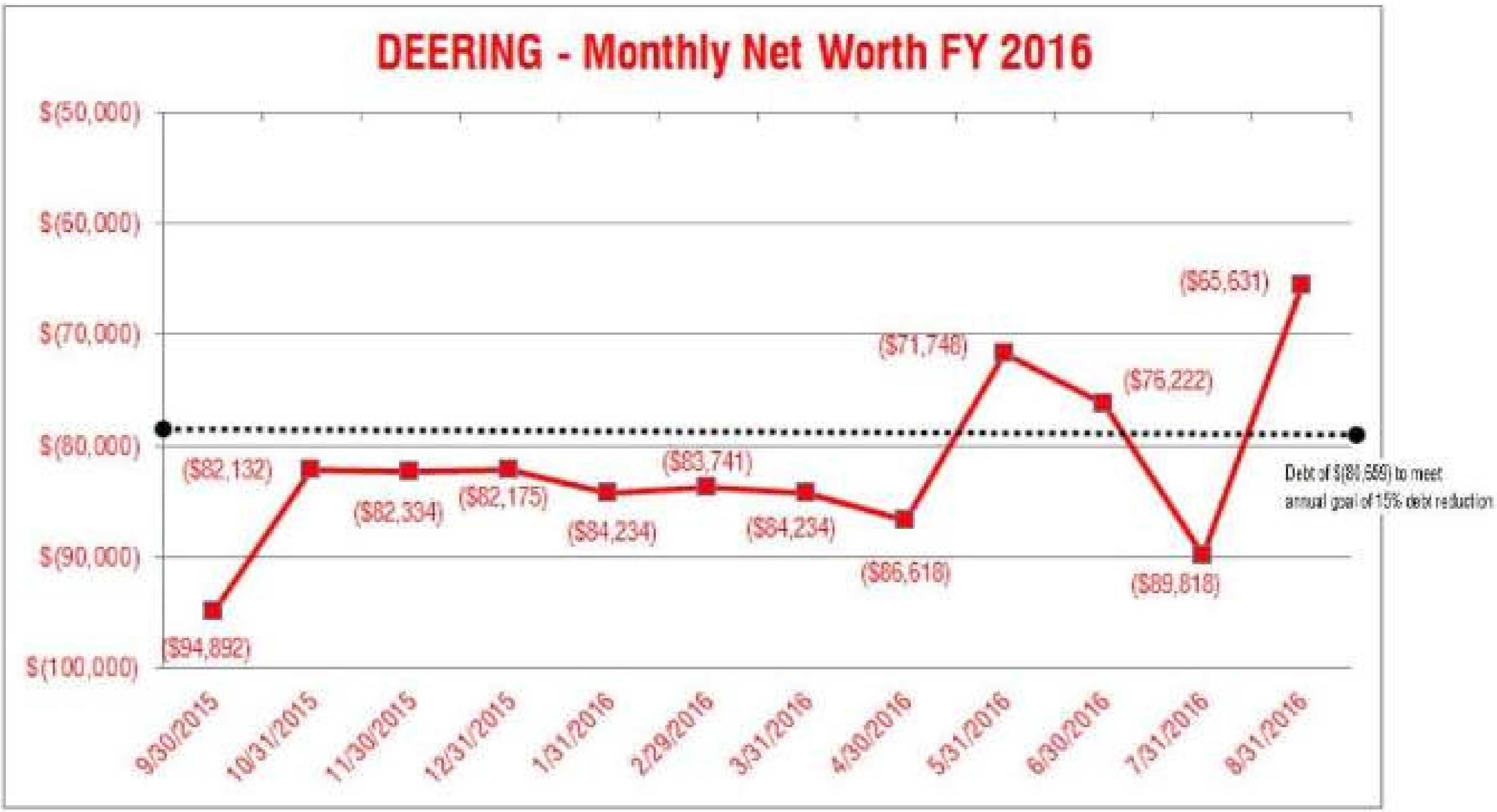
"Feeling very proud. This mural that was painted on the water tank in Deering is from a photo of my gramma that my cousin took. They did a beautiful job on the mural! Its great to see art on big spaces."

- Carmen Aqimayuk Sears, Deering community member

"A lot of my people are fishermen. We also hunt belugas, walrus, seals, ducks and other animals that also depend on water. What we eat is grown with water. It's important to show our kids how much we depend on water to feed our families every day and I think this (mural) helps."

- Ron Moto, mayor of Deering

Deering sewer finances



THANKYOU!

Behind the scenes there were many meetings with the Tribal and City Councils, Utility Management, Regional Health Corporations, ANTHC, ARUC and the NTWC. Without everyone's help this would not have been possible. Thank you, James Temte, Director of the NTWC and Marleah LaBelle, Community Relations Manager of ARUC.

COUNTRY COMPARISONS

WIHAH 2016

Tuesday Session: 8am-9:30am

™

Water and Sanitation Service Statistics

- Number and % of population without in-home water and sewer service
- Number and % rural without service
  - (could be per population or community)
- Number and % urban without

™

Water Service

- Water treatment methods are used?
- How is water distributed to homes?

™

- Sewage Service, household waste
- Costs
- Operations and Maintenance
- Regulation Authority
- Challenges

™

Water and Sanitation Summary for Greenland

Kåre Hendriksen
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Arctic Technology Centre, Technical University of Denmark
Sisimiut, Greenland
krhe@byg.dtu.dk

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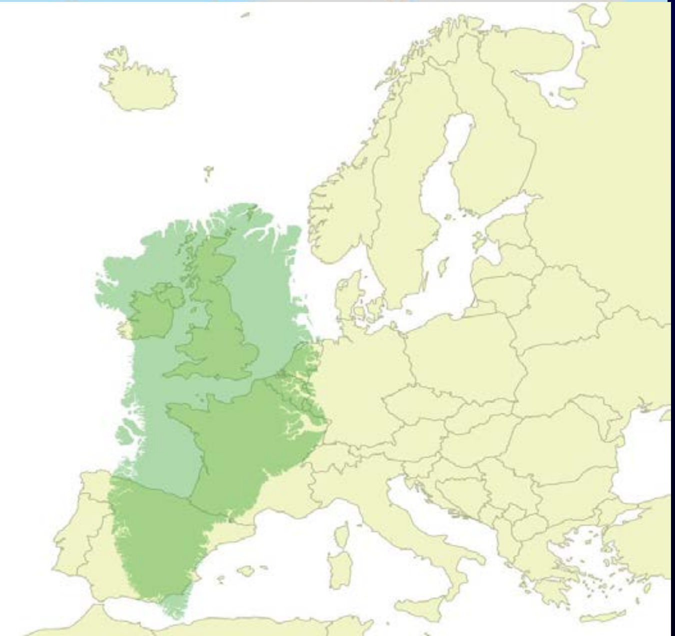
Geography and Demographics

- Greenland
  - 2,146,000 km^2
  - Population: 56,000
  - Urban: 17 “towns” with 430 to 17,000 inhabitants
    - Largest city Nuuk 17,000 inhabitants
  - Rural
    - 56 “settlements” with 20 to 460 inhabitants
    - App. 40 isolated sheep farms
- Ethnic groups
  - App. 86% Greenlanders (inuit)

All infrastructure in all towns and settlements in Greenland is based on island operation



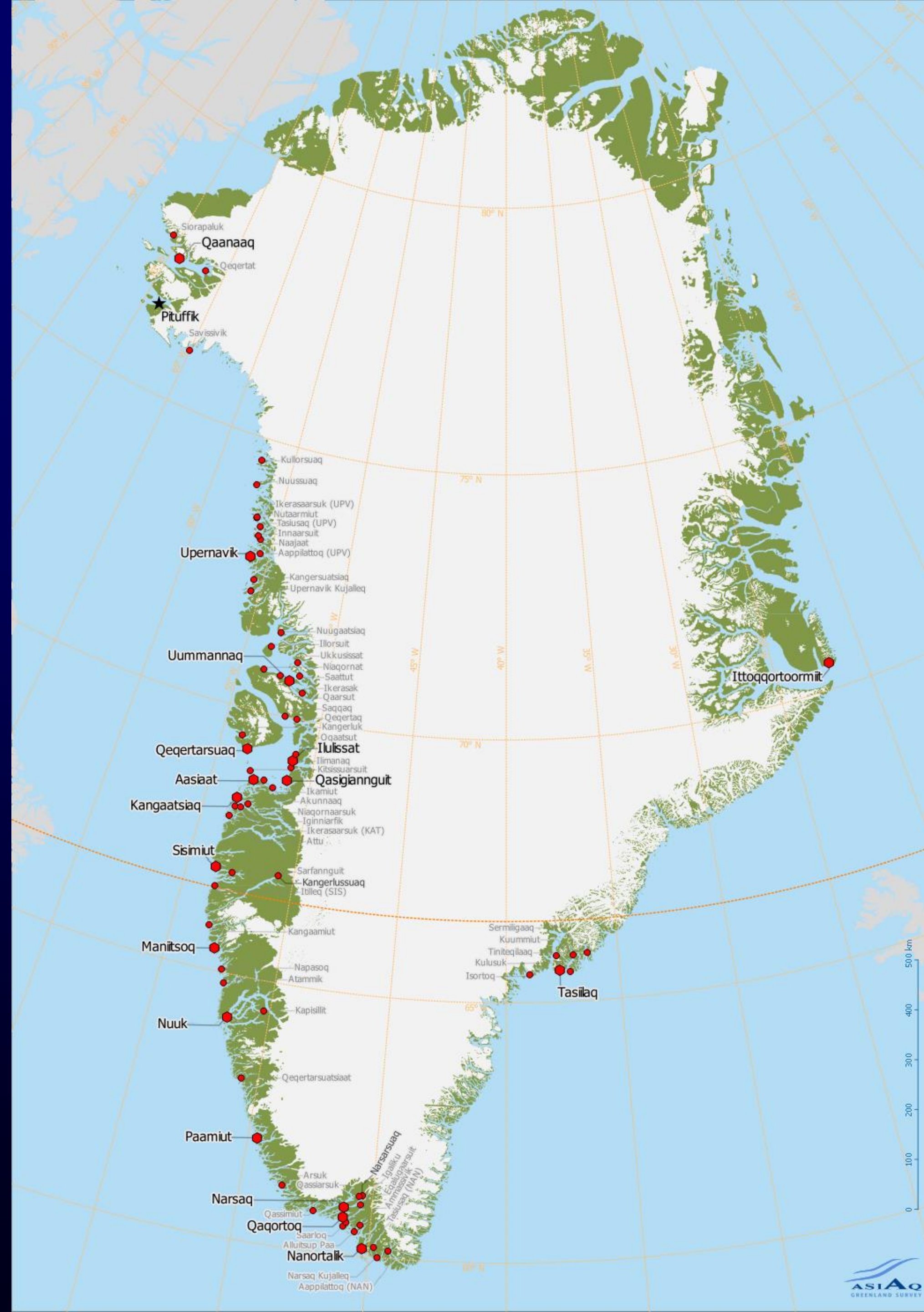
Water and Sanitation Services

Total number of households: 22,000

- Households without:
  - Water app. 1,800 = 8 %
  - Sewer app. 5,900 = 27 %
- Households in "settlements" without:
  - Water app. 1,600 = 60 %
  - Sewer app. 2,350 – 88 %
- Household in "towns" without:
  - Water more than 200 = 2 %
  - Sewer app. 20 – 25 %

TM

Unserved Communities



TM

Water Service

All water production based on surface water (except one smaller settlement that has groundwater)

- Generally using larger and deep lakes – alternatively rivers
- 1 settlement have no water supply
- 7 settlements are using reverse osmosis (RO)
- 1 town and 3 settlements with RO backup
- 1 town melt icebergs a third of the year

™

Water Service

Water treatment

- Towns
  - Sand filter, chloride and UV light
  - In case of organic material aluminum-salt
- Settlements
  - Bag filter and UV light (5 settlements without UV)
  - Chloride is only used in 6 settlements

™

Water Service

Water distribution to homes

- Towns
  - Mainly pipes
  - Truck transport
  - Individual collection at tap-houses
- Settlements
  - Few pipes
  - Individual collection at tap-houses
  - "Alternative solutions"

Intake of raw water in Ilulissat

Fotos: Hans Ole Hansen

Råvandsledning

Raw water pipe, waterworks and water tank of Ilulissat

Intake of raw water in Kuummiut

Intake of raw water in Sermiligaaq

Sewage Service, black water waste

Sewage and black waste water treatment

- Larger towns (+ 500 households)
  - Mainly sewages with pumps
  - Truck pick up from tanks
  - Plastic backs (honey buckets) 7 %
- Smaller towns
  - Manly plastic backs (honey buckets) 75 %
- Settlements
  - Manly plastic backs (honey buckets) 88 %

™

Grey water are let out to the ground

TM

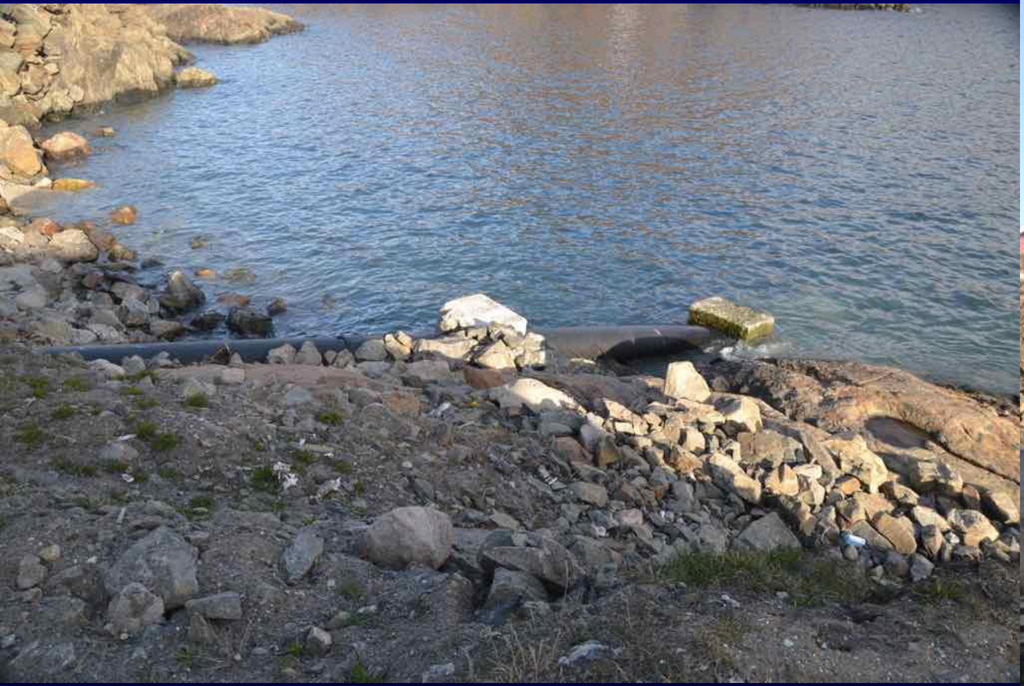
Sewage Service, household waste

Sewage and black waste water treatment methods

- Sewage is lead into the sea
- The tanks and plastic backs (honey buckets) are emptied into the sea

™

Sisimiut – the second largest town in Greenland



Sewage is lead into the sea

House for emptying the honey buckets

Emptying of honey buckets in settlement

Photo: Hans Holt Poulsen

Honey buckets in Qaanaaq

The bags are left on the dump

Loose dogs and birds tearing holes in the bags


Kommunia

™

Costs

Water supply is treaded by the national electricity and water supply company Nukissiorfiit

- Owned by the Self Government

- **Establishing** all older water supply systems was paid by the public
  - during the last decade new systems have been paid by Nukissiorfiit – unless it is in the Self Government budget

™

Costs

- Water is paid by the users
  - Until 2005 there were fixed prices for electricity and water – changed to ‘cost based prices’
  - Public subsidies to stay under a maximum price
  - Price differentiation up to app. 100 %

™

Costs

Sewers are established and run by the municipality

- There is no fee for using the sewer
- But there is a fee for empting tanks and collecting plastic bags (honey buckets)

™

Regulation Authority

- The overall regulation and definition of level of service is defined by the Self Government
- Nukissiorfiit is responsible for water
- The municipalities are responsible for sewer and black waste water treatment
- Ministry of Nature, Environment and Energy is responsible for control

™

Challenges

Water

- Several towns and settlements are located on small islands in high Arctic desert with limited water resources
- This challenges the opportunities for business development
- Searching for sustainable solutions

TM

Challenges

Black waste water treatment

- It is costly and complicated to establish and maintain sewer – especially in smaller towns and settlements
- Have to develop new and alternative solutions

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Building Nunavut Together
Nunavuliuqatigiingniq
Bâtir le Nunavut ensemble

ᐋᓐᓂᐊᖃᕐᓇᙱᑦᑐᓕᕆᔨᒃᑯᑦ
Department of Health
Munaqhiliqiyitkut
Ministère de la Santé

Department of Health Nunavut

Michele LeBlanc-Havard EHS to the CMOH Territory of Nunavut

Demographics

- Population of 36,919
  - Spread over 3 time zones in Northern Canada
  - 25 remote communities ranging in size from 192 – 7,543

Nunavut

Territory of Nunavut

Unique

- Nunavut's land mass is 20% of Canada with only 0.1% of Canada's population
  - Mass watersheds
  - Many considerations for treatment and protection

Canada's Drinking Water Regulatory landscape

Decentralized Regulations

- Canadian Drinking Water Quality Guidelines (CDWQG)
- Jurisdiction's responsibility

GCDWQ

1. Microbial
2. Chemical and Physical
3. Radiological
    1. 77 MACs
    2. 18 AOs/OGs

Nunavut's Water Regulations

Nunavut Water Board and AANDC

- Municipal use of water
  - Withdrawal of water
  - Storage of water

Public Water Supply Regulations DH

- Turbidity 5 NTU
- Color 15 Units
- Odor 3
- Chlorination
- List of 22 chemical parameters
- Radiological

Nunavut Water Board

- Each municipality/Hamlet operates via a "withdrawal and discharge" permit - Nunavut Water Board
- Fresh water
  - The terms and conditions of the permit are based on volume withdrawn from a surface water source and effluent deposited to a receiving water body
  - Specific to each municipality
  - Enforced by the federal government INAC

Public Drinking Water and Sewage Community Reality

- Distribution is via trucked delivery except for above ground utilidor
  - 3 utilidor communities – they also have a mix of above ground service and trucked

Community Drinking Water - Treatment

Treatment	Communities
Chlorination	All
UV disinfection	4
Cartridge Filtration	5 Another 4 under construction
Pressure media filtration	3
Slow Sand	2

Canada Wastewater Regulations

Harmonized Approach

- Pre 2012 was decentralized
- CCME Canada-wide Strategy for Municipal Wastewater (2009)
- Wastewater Systems Effluent Regulations (WSER)

WSER

- Came into effect in 2012
- Does not apply north of 54^{th} parallel
- The northern jurisdictions and the federal government are engaged in development of performance standards for the Far North

NU Wastewater license requirements

Nunavut Water Board and INAC - WRTA, AWPPA

- Deposit of waste

Water Licence Requirements

- Site specific
  - TSS: 100 – 180 mg/L
  - BOD: 80 – 120 mg/L
- Becoming more stringent
  - Reflective of WSER

DH Sewage Regulations

- Less robust than the regs for drinking water
- Concerned primarily with situations posing a "health hazard"

Public Drinking Water

- Source water
  - Water quality is very good
    - Low turbidity
    - Low organics
    - Low metals
    - Low bacteria both TC and EC
      - May see between 3 -5 BWAs per year
      - No permanent BWAs in place

NU Wastewater Management

Predominant Treatment	Communities
Mechanical System	4
Lined Lagoon	6
Granular Lagoon	6
Natural Pond	4
Tundra Wetland	5

Impacts

	Southern Jurisdictions	Nunavut
TSS	25 mg/L	100 – 180 mg/L
BOD	25 mg/L	80 – 120 mg/L
Special Impact of effluent	kilometers	meters
Temporal impact	Annual millions liters per day	Weeks thousands liters per day

Water and Sewage Costs

- Water and sewage services
  - Responsibility of the resident/homeowner
    - Water rates are based on the sewage pump out service
      - You pay for pump out and then water use is calculated
      - Fees are set by the municipality/Hamlet
      - Typical water rates are $150.00 dollars every 3 months for a family of 4 (heavily subsidized)

Infrastructure and Governance

- GN CGS provides financial and technical support to the municipalities (for the most part)
  - Operations and community infrastructure and development
- DH ensures the Public Health Act and Public Drinking Water Regulations are adhered to

Challenges

- Technically advanced system
  - Harsh climate
  - Remote locations
  - Cost
- Regulations
  - Application in the north
  - Public perception

Opportunities

- Appropriate Systems
  - Small communities
  - No industrial inputs
  - Unique climate
- Research
  - Science-based decision making
  - Inform policy development

Drinking Water Plan for Nunavut

- In preparation for new public drinking water regulations
  - A review of the water regulatory approaches in circumpolar regions, northern jurisdictions in Canada and the WHO with particular attention to guidelines and standards fro safe drinking water and use of water safety plans

Study on Drinking Water

- Joint venture through CGS and DH with Centre for Water Resources at Dalhousie University, Halifax Nova Scotia
  - The study has recommended the DH adopt WSP into their regulatory framework
    - Making reference to the GCDWQ
    - A risk assessment tool has been provided that could be used to classify and guide each municipal operator in determining and providing specific water safety plan for their source water

Sewage

- The proposed approach for water is similar to what is currently done with sewage
- The NWB sets the criteria to be met for deposition of sewage
  - INAC enforces the water license
    - Ensures that the effluent deposition criteria is met

Community Based Service with Territorial Program Development

Water truck fill station

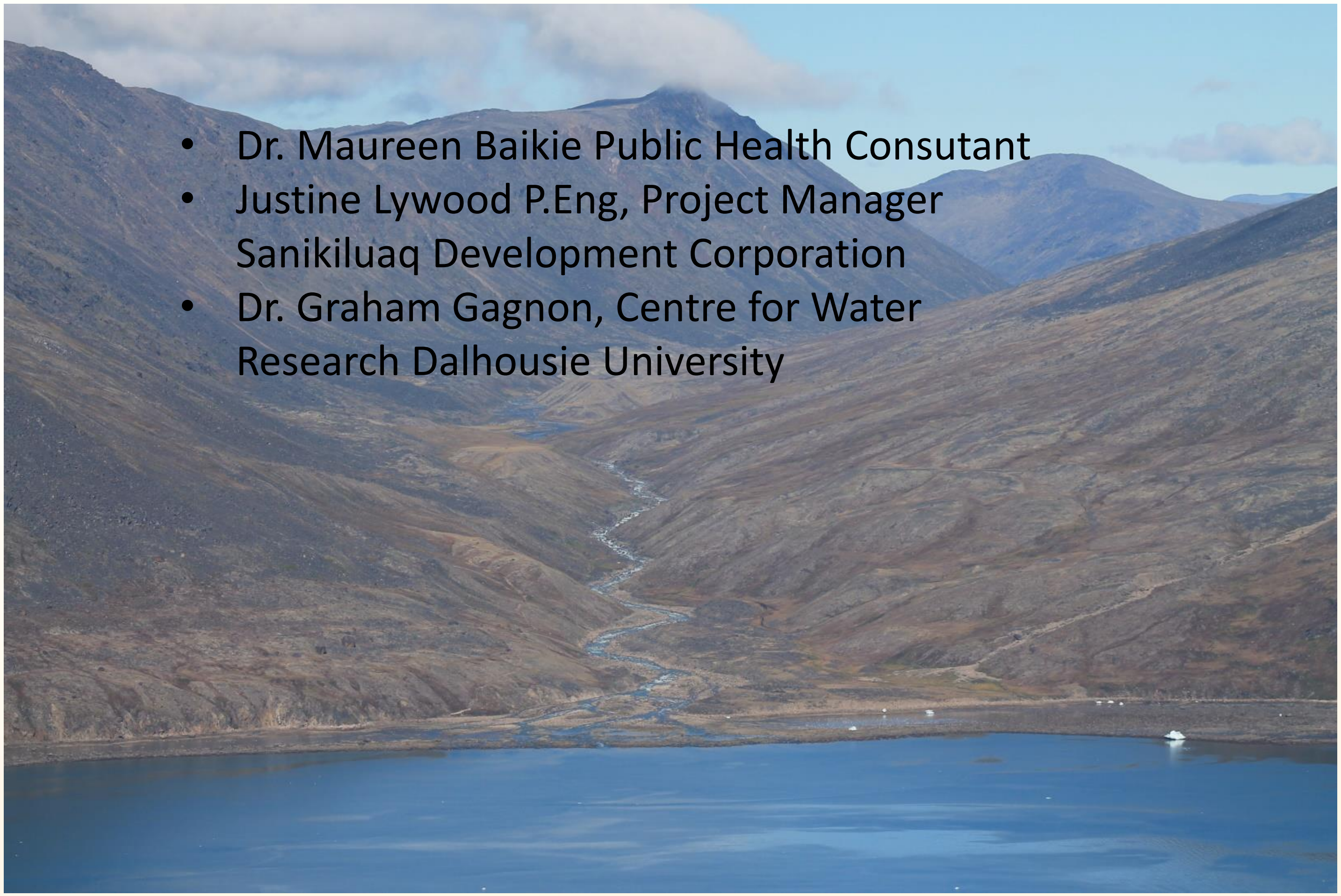
Sewage

Nunavut

Glimpse of Community Life

Pangnirtung Harbour

Thank You!



- Dr. Maureen Baikie Public Health Consutant
- Justine Lywood P.Eng, Project Manager Sanikiluaq Development Corporation
- Dr. Graham Gagnon, Centre for Water Research Dalhousie University

Questions??

Water and Sanitation Summary for Northwest Territories-Canada

Peter Workman BA Sc. CIPHI (C)
Chief Environmental Health Officer
Department of Health and Social Services, Government of Northwest Territories
Yellowknife, Northwest Territories, Canada
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™

Geography and Demographics

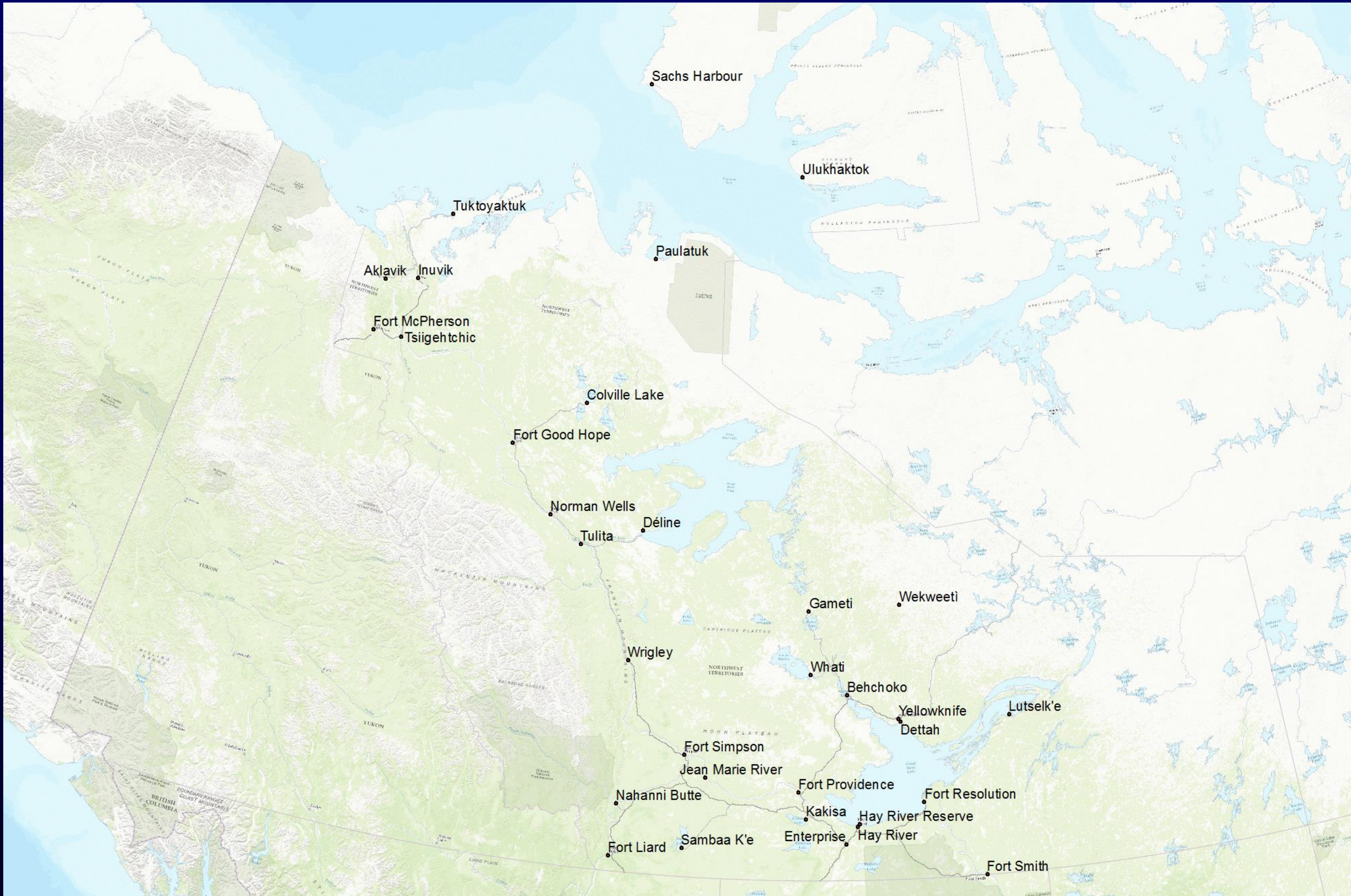
- Country/Region size
  - 1.35 million square kilometers
- Population: 43,000
  - Urban:
    - 19,000 in Yellowknife,
    - 23% in regional centres   Fort Smith, Hay River and Inuvik
  - Rural
    - 32% in 28 other communities (70 to 1900 people)

Demographics

- Racial or ethnic groups
  - about one half of NWT is aboriginal
  - 86% of population in smaller communities are Aboriginal
  - 23% in Yellowknife
  - 52% in Fort Smith, Hay River and Inuvik
- Aboriginal population includes:
  - First Nations (29%)
  - Inuvialuit- in the 6 northern most communities (11%)
  - Metis- mainly in Yellowknife, Hay River and Fort Smith.

Northwest Territories, Canada

TM


Sachs Harbour
Ulukhaktok
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Fort McPherson
Tsiigehtchic
Colville Lake
Fort Good Hope
Norman Wells
Déline
Tulita
Gameti
Wekweeti
Wrigley
Whati
Behchoko
Yellowknife
Dettah
Lutselk'e
Fort Simpson
Jean Marie River
Fort Providence
Nahanni Butte
Fort Resolution
Kakisa
Hay River Reserve
Enterprise
Hay River
Sambaa K'e
Fort Liard
Fort Smith

TM

Water and Sanitation Services

- Majority of homes in NWT have in-home water and sewer service (approx. 95% or more)
- Many NWT communities are on trucked services. Water is a community resource and is trucked to homes and sewage is pumped out disposed of in community sewage systems.

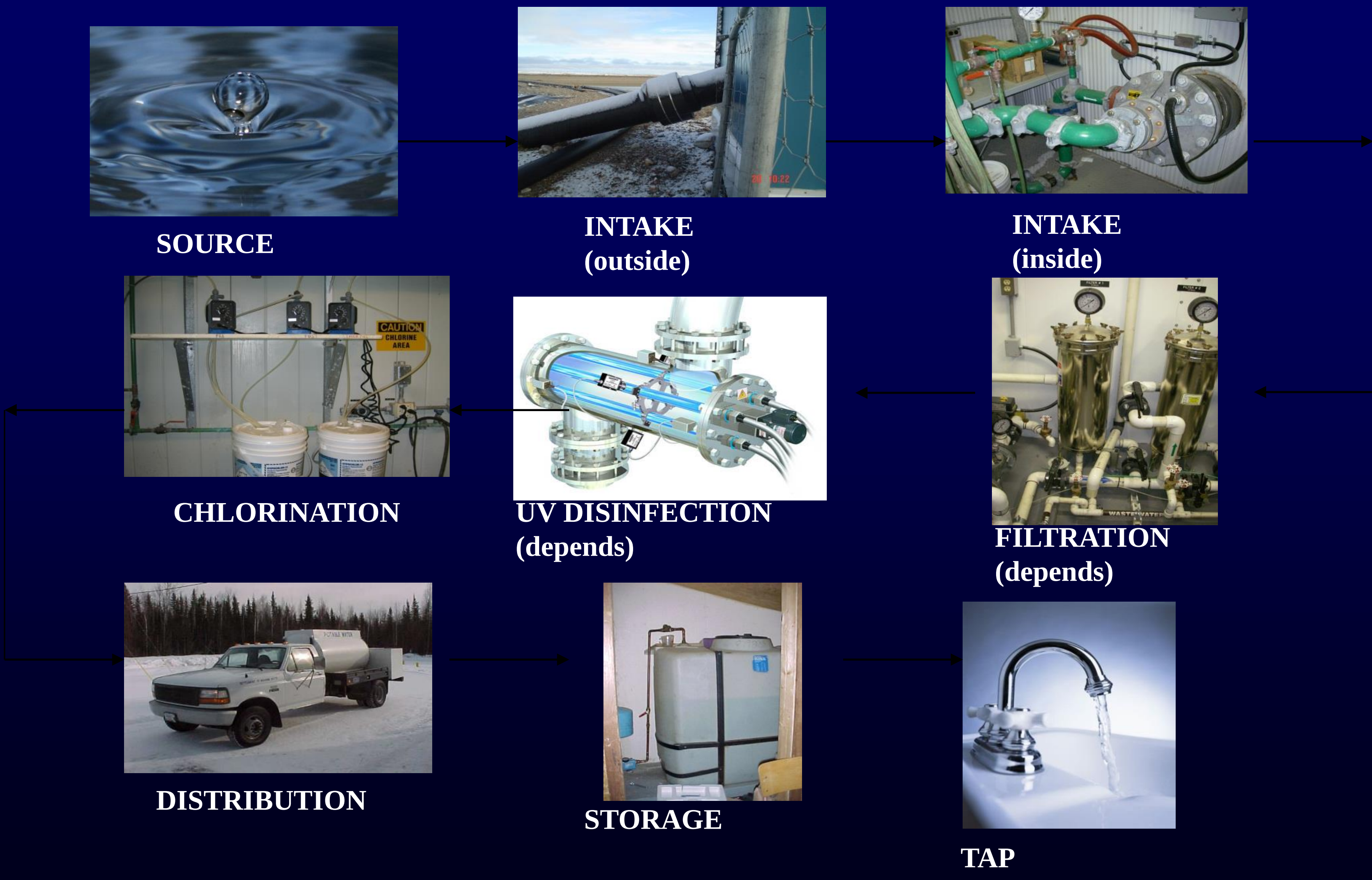
™

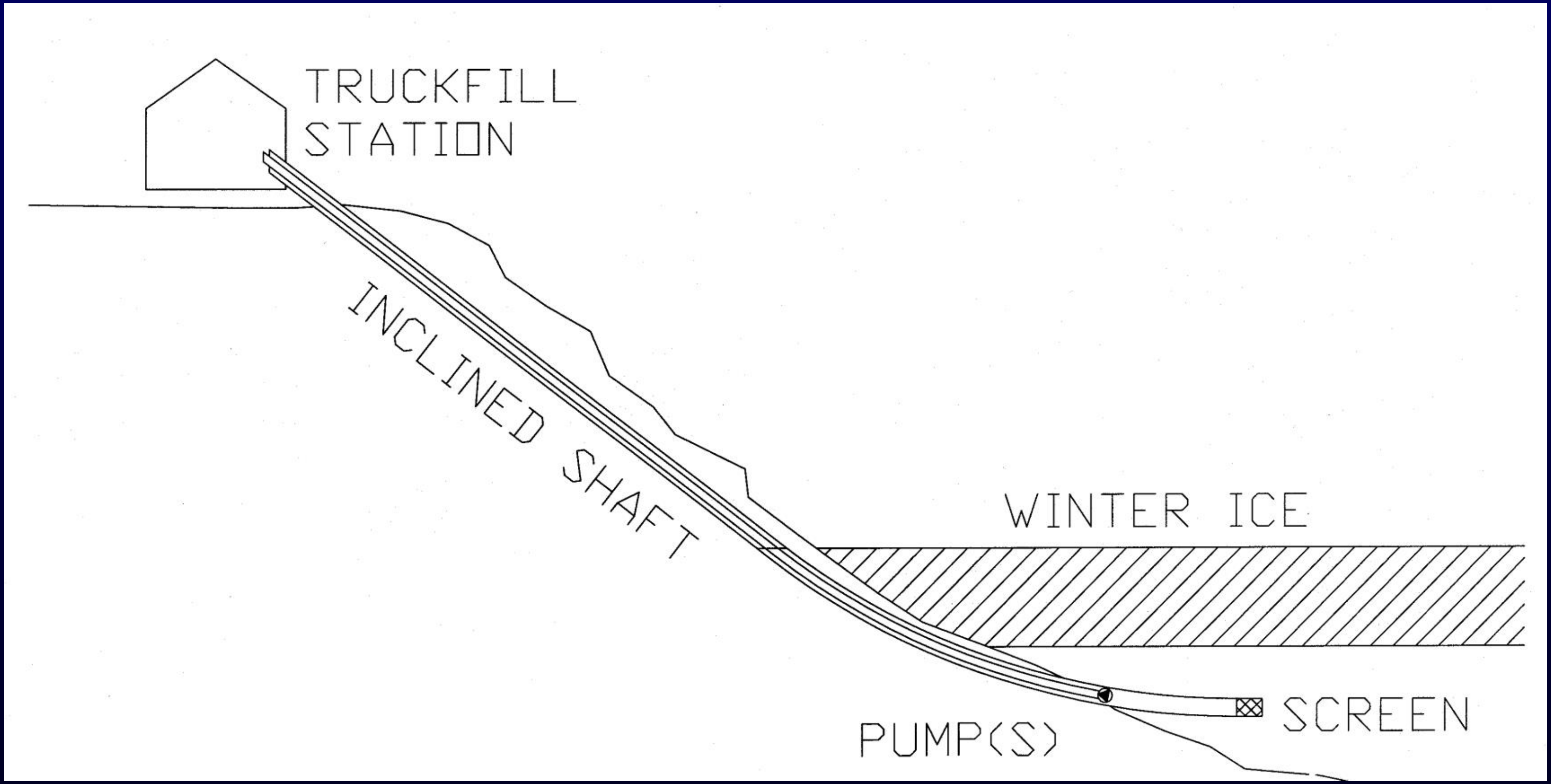
Water Service

- Water treatment methods are used?
  - Filtration, flocculation, chlorine, ozone, fluoride adjustment
- How is water distributed to homes?
  - pipes to home (large communities have mostly piped)
  - truck transport (some parts of each community and all services in smaller communities)

™

WATER SYSTEMS OVERVIEW




TRUCKFILL
STATION
INCLINED SHAFT
WINTER ICE
SCREEN
PUMP(S)

™

Sewage Service, household waste

- Sewage collection
  - pipes (gravity, into flowing/moving system large communities
  - truck pick up (some of each community and all of small communities)
- Sewage treatment methods
  - Primary, some secondary treatment, few tertiary

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Sewage Lagoon, Paulatuk NT

TM

Costs

- Who pays for?
  - Construction, engineering
    - Community governments (funded by Territorial or Federal Government initiatives)
  - Operations and maintenance
    - Local users, in larger communities with subsidy from territorial government

Operations and Maintenance

- How is this organized?
  - Local responsibility at community level Support ($ and training) from territorial government
- If local user fees are paid, who collects them?
  - Community governments/town

™

Regulation Authority

Who sets and enforces the rules for water and sanitation services?

- Local community responsibilities
  - Fees, call outs, delivery rules, operations
- Territorial government
  - HSS for drinking water,
  - ENR and MACA sewage
- Regional Water boards and land use planning groups.
- National government responsibilities
  - Guidelines, effluent criteria guidance

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Challenges

- Climate or environmental change
  - Some NWT communities are coastal/next to large rivers and risk flooding
- Regulations (laws, rules)
  - Regulations are meant to streamline and provide clarity to communities. Water boards and Government have dual jurisdiction
- Organization or Government
  - Approvals can be complex and multilevel and stages

™

Challenges

- Financial- costs far exceed recovery of cost models
- Engineering, design or age of systems
  - Systems are costly to install- permafrost and other issues
  - Replacement requires shipping by sea, barge or air.

“Thank You”

- Justin Hazenberg
  Department of Municipal and Community Affairs
  Government of Northwest Territories
- Dr. Andre Corriveau
  Chief Public Health Officer
  Department of Health and Social Services
  Government of Northwest Territories

™

Water and Sanitation Summary for Yukon, Canada

Tyler Heal, EIT
Civil Engineering Lead, Yukon
Stantec Consulting Ltd.
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™

Geography and Demographics

- Country/Region size
  - 482,443 km^2 *(28% Alaska)*
- Population: 37,642 *(5% Alaska)*
  - Urban: 32,671
    - Largest city – Whitehorse area (29,092 – 77%)
  - Rural: 4,971
    - 18 communities, 12 - 913 people in size
- Racial or ethnic groups (self-reported)
  - 7,796 Indigenous (21%) – 13 First Nations
  - 29,846 non-Indigenous (79%)

- Only 1 Arctic community (Old Crow)
  - Freezing Index: 4,400 degree-days-C
- Rest are road accessible year-round
  - Freezing Index: 1,800 to 3,300 degree-days-C

Water and Sanitation Services

- 600 (1.7%) of population without in-home water and sewer service
  - ~450 (1.2%) rural without service
  - ~150 (0.5%) urban without service
  - Coordination difficulties in First Nation vs. non-First Nation communities
    - Overall community responsibility (Territorial) vs. FN subdivisions
  - Many rural residential without adequate on-site services

™

Water Treatment / Source

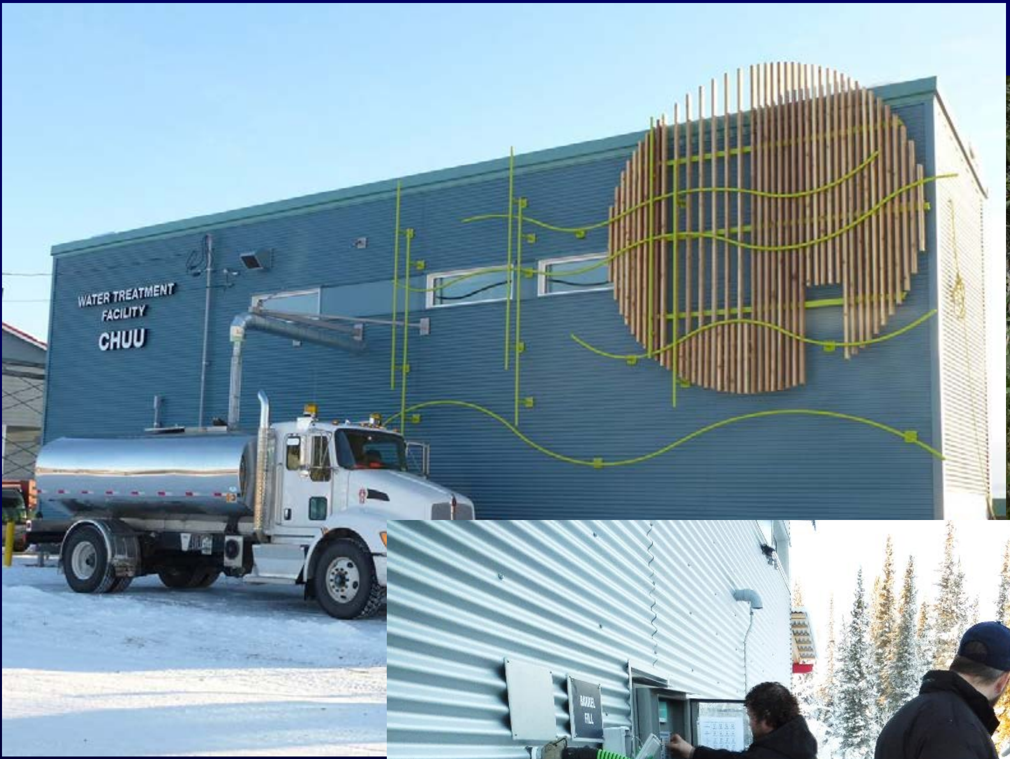
- New Guidelines on Canadian Drinking Water Quality require enhancement of treatment in many communities
  - GUDI groundwater sources generally require UV, chlorination
  - Hardness, iron, manganese common in ground water
- All but one community use groundwater sources ("local preference" to not use surface water)

™

Water Service

- 60% are Large Public Drinking Water Systems
  - Piped systems (7): ~29,000 (77%)
    - Whitehorse dominates this (75%)
  - Trucked haul: ~2,000 (5%)
- 40% are Small Water Systems or private wells
  - Private wells: ~5,000 (13%)
  - Self-haul: ~1,500 (4%)

Water Service - Hauled



Water Service - Piped

Water Service - Piped

- **Freeze protection!**
  - Community choice drastically influences water use – Dawson City (2,000) uses 1,600 Lpcd (420 gal/cap/day), approx 65% of which is bleeders

™

Sewage Service

- Sewage collection
  - Piped service: 29,000 (77%)
    - Again, dominated by Whitehorse (~75%)
  - Trucked pump-out: ~2,000 (5%)
  - Septic systems (on-site): ~6,500 (17%)
    - Large impact on water safety planning
  - Self-haul: negligible
  - Outhouses: unknown (by choice)

™

Sewage Service, Household Solid Waste

- Sewage treatment methods
  - Lagoons: ~29,000 (77%)
  - Mechanical (2 systems): 2,600 (7%)
  - On-site (septic field): ~6,500 (17%)
- Solid waste: 19 sites managed by Yukon Government, 7 managed by municipalities

Sewer Service

TM

Mechanical Sewage Treatment

- Poor experience in Yukon

Lagoons

Costs

- Jurisdiction influences funding:
  - First Nations communities - Federal
    - 9 self-governing, 4 Indian Act
  - Unincorporated communities – Territorial
  - Municipalities – Self-funding / Territorial

™

Costs

- Construction, engineering
  - Gas Tax funding
    - $163M, 2014-2024
  - New Build Canada Fund (75% Federal, 25% Territorial) – administered by Yukon Gov't, can be accessed by municipalities
    - $342M, 2014-2024
  - Yukon Government capital funding
  - Municipality water/waste funds (user fees)
  - First Nations: INAC contribution agreements

Costs

- Operations and maintenance
  - Local users (user fees)
  - Yukon Government / INAC subsidies in many communities (or directly operate some systems)

™

Operations and Maintenance

- How is this organized?
  - Municipalities
  - First Nations
  - Yukon Government directly operates some (water - 7 community supplies, 4 trucked)
- Local user fees (if exist): collected by municipality / First Nation
  - Larger communities are able to self-fund

Regulation Authority

- Federal: Canada
  - Guidelines for Canadian Drinking Water Quality (GCDWQ) – Health Canada
  - Wastewater Systems Effluent Regulations (WSER)
- Territorial: Yukon
  - Environmental Health Services
  - Yukon Water Board
  - Acts & Regulations
- Municipal / Community
  - Construction standards
  - Bylaws

Challenges

- Climate change
  - Impact on operation of lagoon systems
  - Melting permafrost – piped systems
- New federal regulations
  - Have prompted need for upgrade of nearly every water system (and sewage systems in future)
  - Large capital, O&M cost implication ($$$)
- Federal/Territorial/FN overlap
  - Ex: leads to one half of a community having good water & sanitation service; other half on boil water advisories

Challenges

- Sludge – how to handle this resource?
- Solid waste – lack of coordinated approach
- Lots of new funding available: How to determine appropriate levels of investments
  - Levels of service
  - Lifecycle cost
  - Prioritization
- Water use volumes & wastage
  - Bleeders (freeze protection), user education

Opportunities

- New Yukon Operator Training Program
  - EOCP (Environmental Operators Certification Program) at Yukon College in Whitehorse (2011)
- INAC Circuit Rider Program
- Self-governing First Nations and financing of infrastructure
- Sharing water and sanitation infrastructure between municipalities & nearby First Nation
- Use of SCADA & remote monitoring

™

Thank You

- Yukon Government
  - Community Services
  - Environmental Health Services
- Stantec colleagues
- Rick Savage, Tech-Con Engineering Services

™

Water and Sanitation Summary for Alaska

Bill Griffith, Facility Programs Manager
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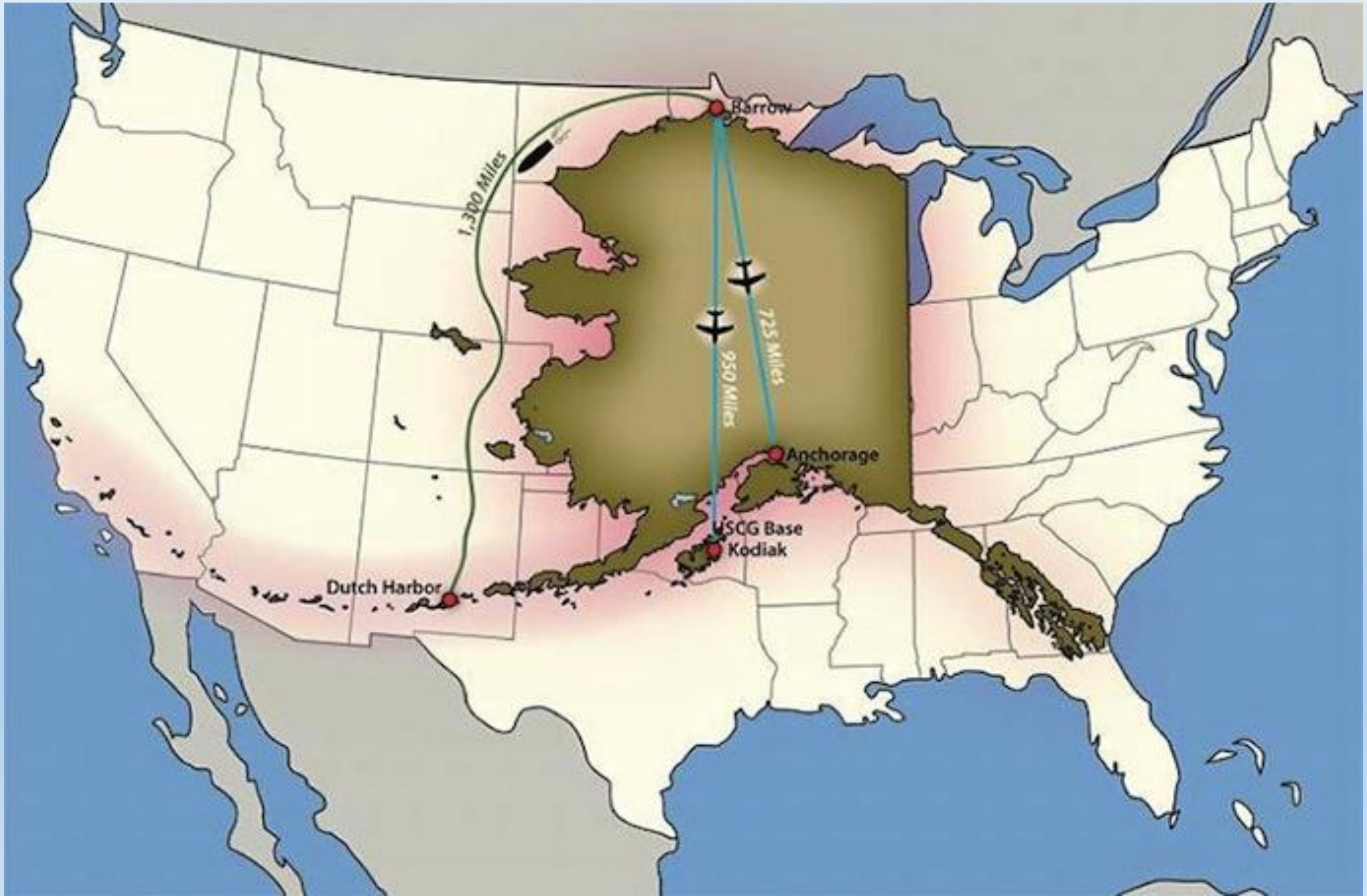
Alaska is 1.5 Million Sq. Km. (580,000 Sq. Miles)

2016 Population = 740,000 people

About 0.5 People Per Sq Km



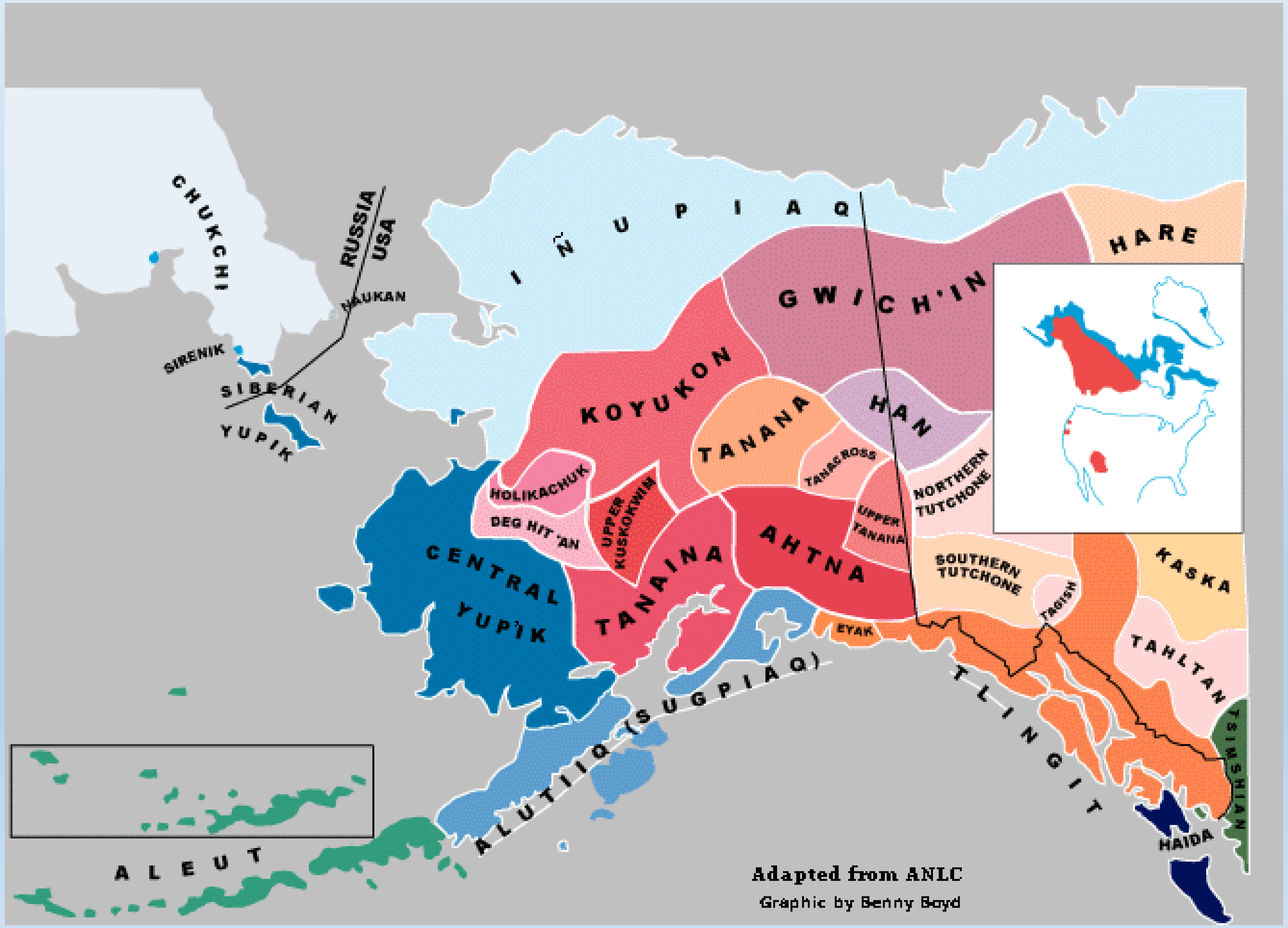
Population Distribution of Alaska *(Total population = 740,000)*

- About 54% of population (400,000 people) lives within one hour drive of downtown Anchorage.
- Roughly 10% of population lives in 185 remote communities, with populations less than 1,100 people.

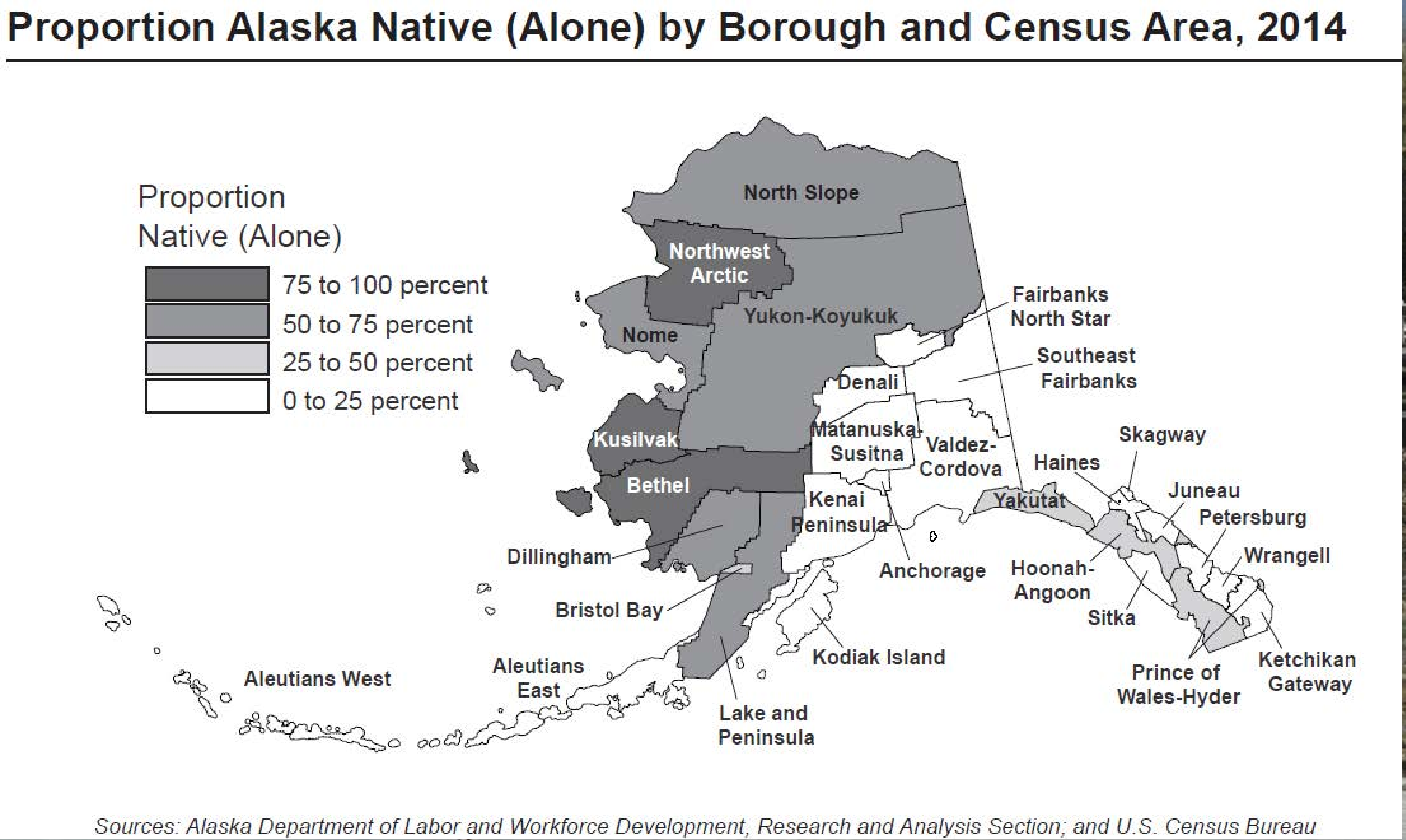
("Rural Alaska" in this presentation)

Alaska Population by Ethnic Group (2000)

White	Alaska Native	Asian	Black	Pacific Islands
70%	18%	5%	4%	1%



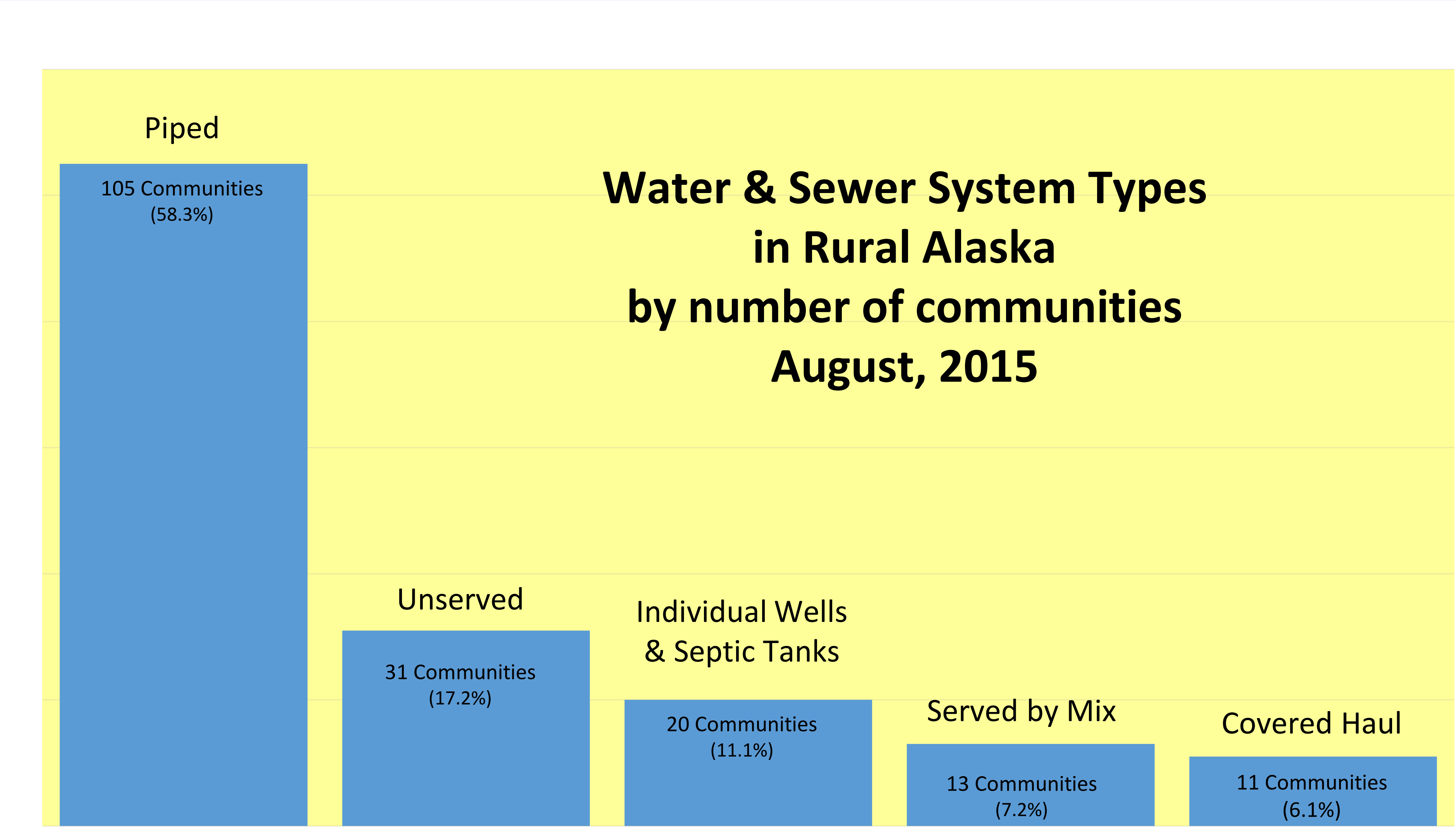
Geographic Dispersion of Alaska Native Population



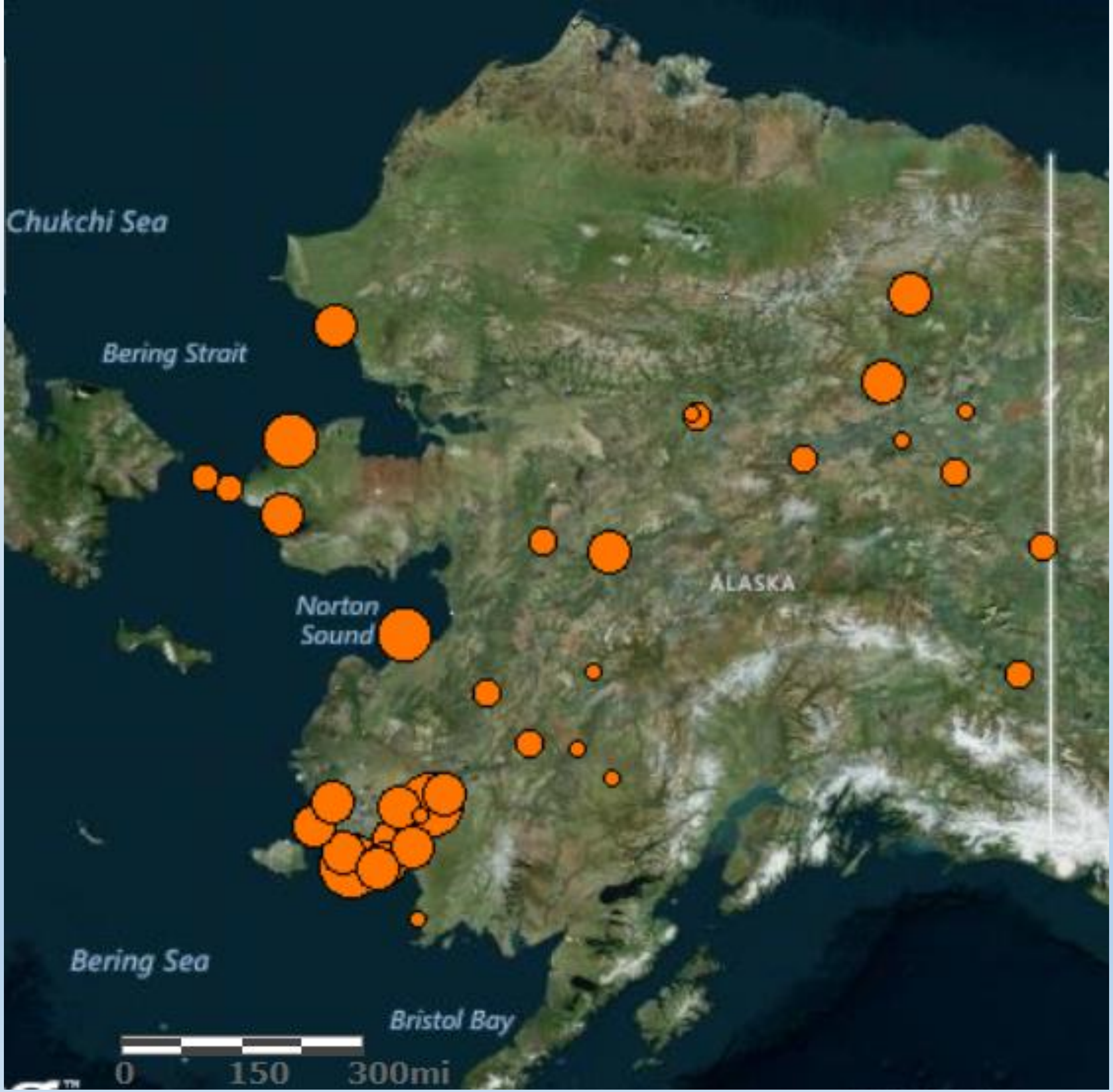
Three Levels of Water and Sewer Service in Rural Alaska Communities

- “Served” communities with a small percentage of unserved homes
- “Unserved” communities where the only service in the community is a washeteria and a community watering point
- “Under-served” communities with a closed haul water and sewer system

Rural Alaska Sanitation



Location of Unserved Alaska Communities



Communities by Population Size

- < 25 Residents
- 25 - 49
- 50 - 99
- 100 - 149
- 150 +

Alaska Housing Characteristics: Water and Sewer Service

- Total number of homes in Alaska: 264,270
- Number of homes in Alaska villages (rural Alaska): 34,300
- Number of <u>unserved</u> homes: 3,285
  - Total unserved homes in unserved communities: 2,135
  - Total unserved homes in served communities: 1,150
- Total number of <u>under-served</u> homes (water and sewer haul system): 789

Sources for Capital and Operational Expenses

- Capital – 100% Federal and State Grants
  - Grants do not require local contribution
  - Loans are available, but communities have limited capacity to borrow

- Operation and Maintenance Costs
  - 100% local user fees + local subsidies (gaming revenue, for example)
  - No Federal or State subsidy funding is available

Regulatory Authority in Alaska

- Public water systems: All water is treated to standards established nationally by the U.S. Safe Drinking Water Act, regardless of ultimate use (drinking, washing, flushing, household landscaping, etc.)

- Waste water systems: All wastewater discharges must meet treatment standards established nationally by the U.S. Clean Water Act. Specifically, the National Pollutant Discharge Elimination Program (NPDES) identifies treatment and discharge requirements for domestic wastewater treatment and disposal systems.

Alaska Challenges

- High cost of needed capital construction in remote Alaska villages (over $2 billion)
- Inability of most Alaska villages to borrow money, even for small capital improvements
- High cost of operation and maintenance, due largely to the high cost of energy
- Lack of state or federal subsidy to support and encourage good operation and maintenance practices
- Impact of climate change on traditional sources of water
- Environmentally threatened communities and infrastructure

Alaska Water Sewer Challenge – Phase 3

Team University of Alaska Anchorage

<u>Presenter</u>

Aaron Dotson, Ph.D., P.E. (AZ)

Associate Professor

Water Innovations for Health Arctic Homes

September 18-22, 2016

http://beta.adn.com/resizer/54BVJcIdWVnpnAXc2a1CwQGCIq0=/600x0...
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…/uploads/2016/08/05143226/UAAWaterSewage160805-003.jpg?token=bar

Our Team

UAA Civil Engineering Program
UNIVERSITY *of* ALASKA ANCHORAGE

UAA Master of Public Health Program
UNIVERSITY *of* ALASKA ANCHORAGE

College of Engineering & Applied Science
UNIVERSITY OF COLORADO **BOULDER**

UNC
GILLINGS SCHOOL OF GLOBAL PUBLIC HEALTH

USC Viterbi
School of Engineering

UBC
THE UNIVERSITY OF BRITISH COLUMBIA

DALHOUSIE UNIVERSITY

POLYTECHNIQUE MONTRÉAL

First Nations Health Authority
Health through wellness

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Cold Climate Housing Research Center
CCHRC

streamlineAM

GV Jones & Associates, Inc.
WATER AND WASTEWATER PROCESS ENGINEERS

MWH®

SOUTHERN NEVADA WATER AUTHORITY®

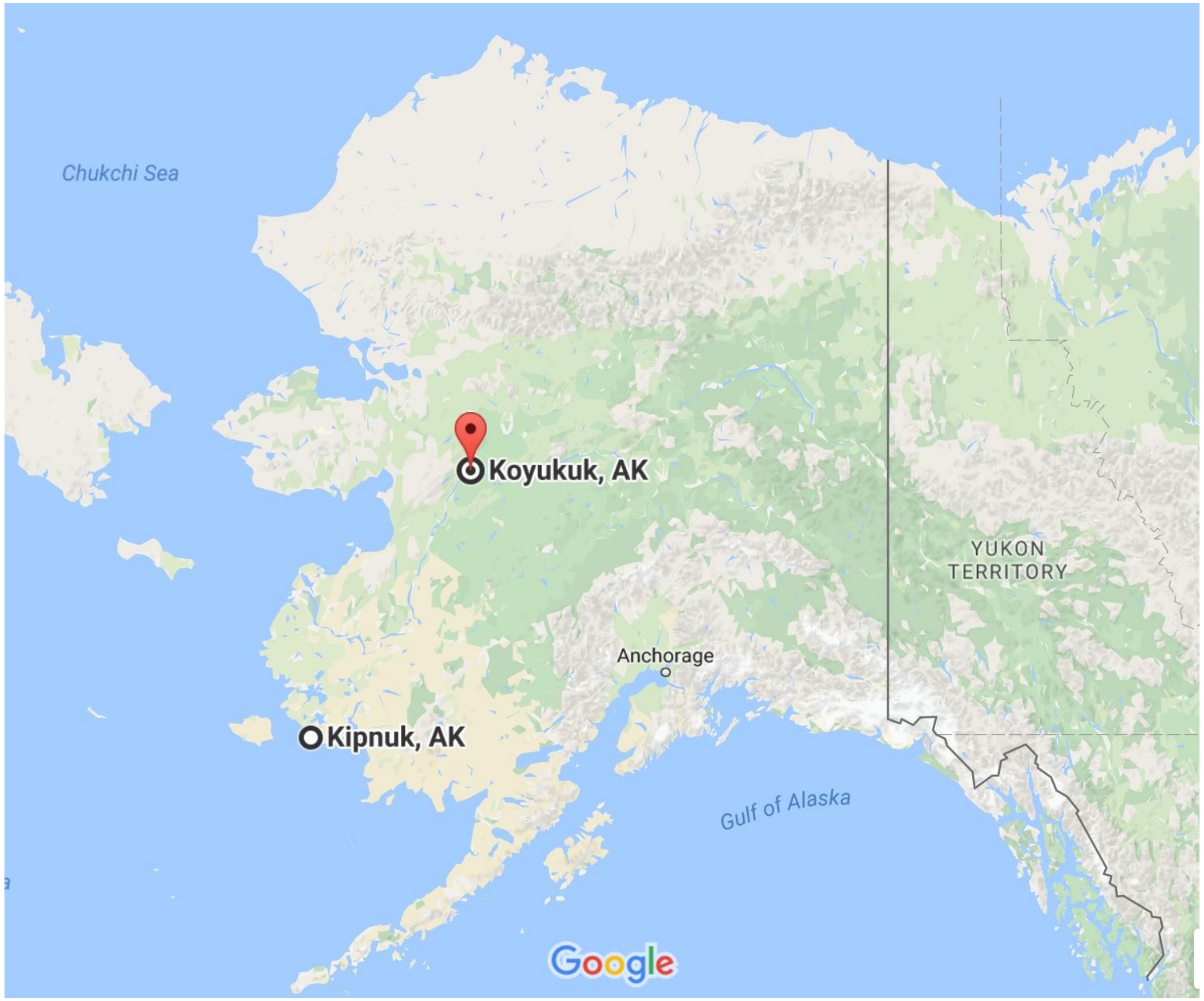
Our Communities

Kipnuk, AK

Population: 639 (2010)

Koyukuk, AK

Population: 95 (2014)



Team and Community Design Features

Community Features

- Real (durable) toilet
- Minimal home modification
- Assured quality/safety
- Choice in fixtures

Team

- Physical / Chemical Treatment Processes ONLY
- Minimize chemical usage
- A treatment goal of 85% water recovery

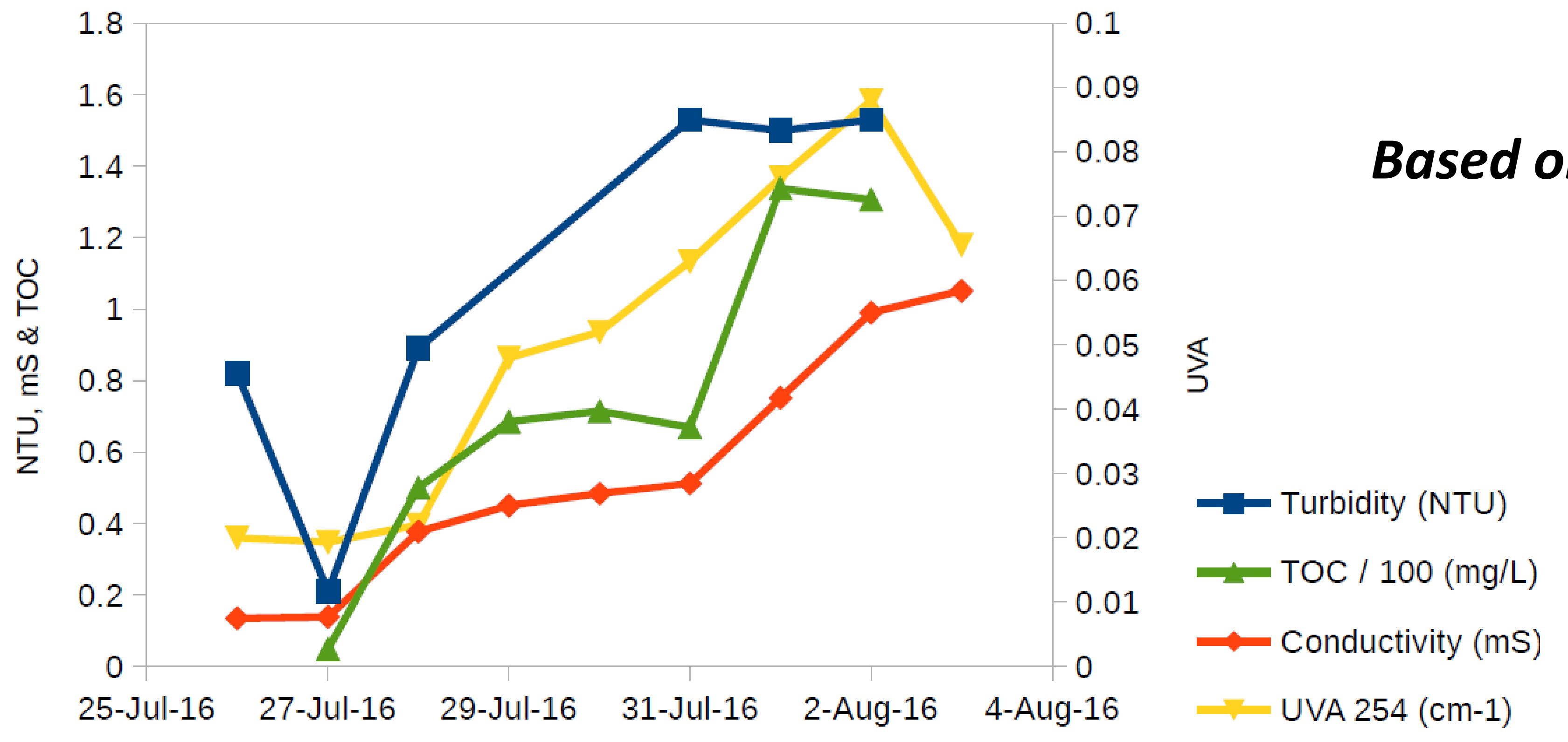
Design Evolution during this Phase

<u>Our focus on effectiveness has required design changes</u>

1. Acceptable water quality (human contact & premise plumbing)
2. Acceptable cost and effort of operation
3. Passes challenge tests of the State and our Team

Design Evolution during this Phase

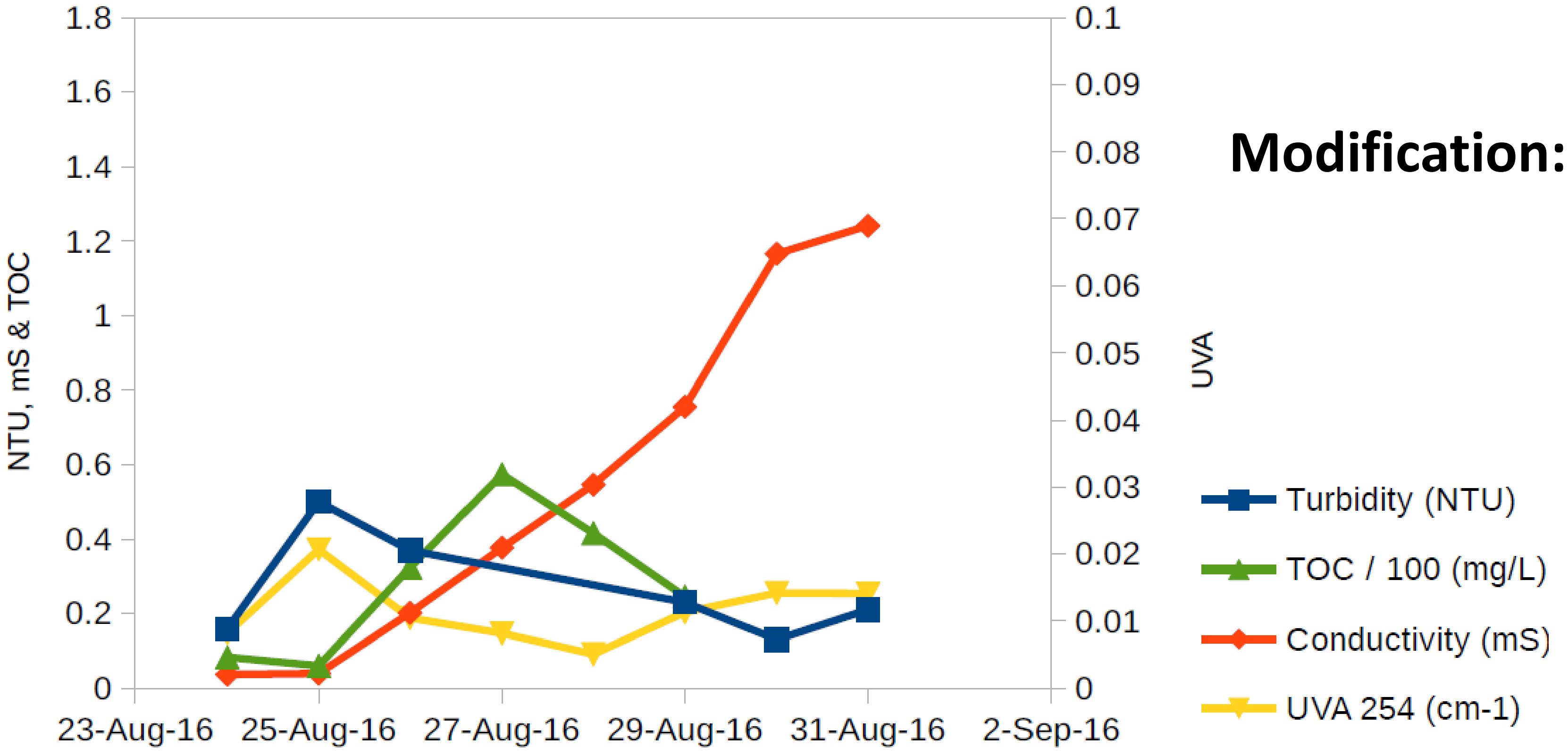
To date – based on improving water quality



Based on design after Phase II

Design Evolution during this Phase

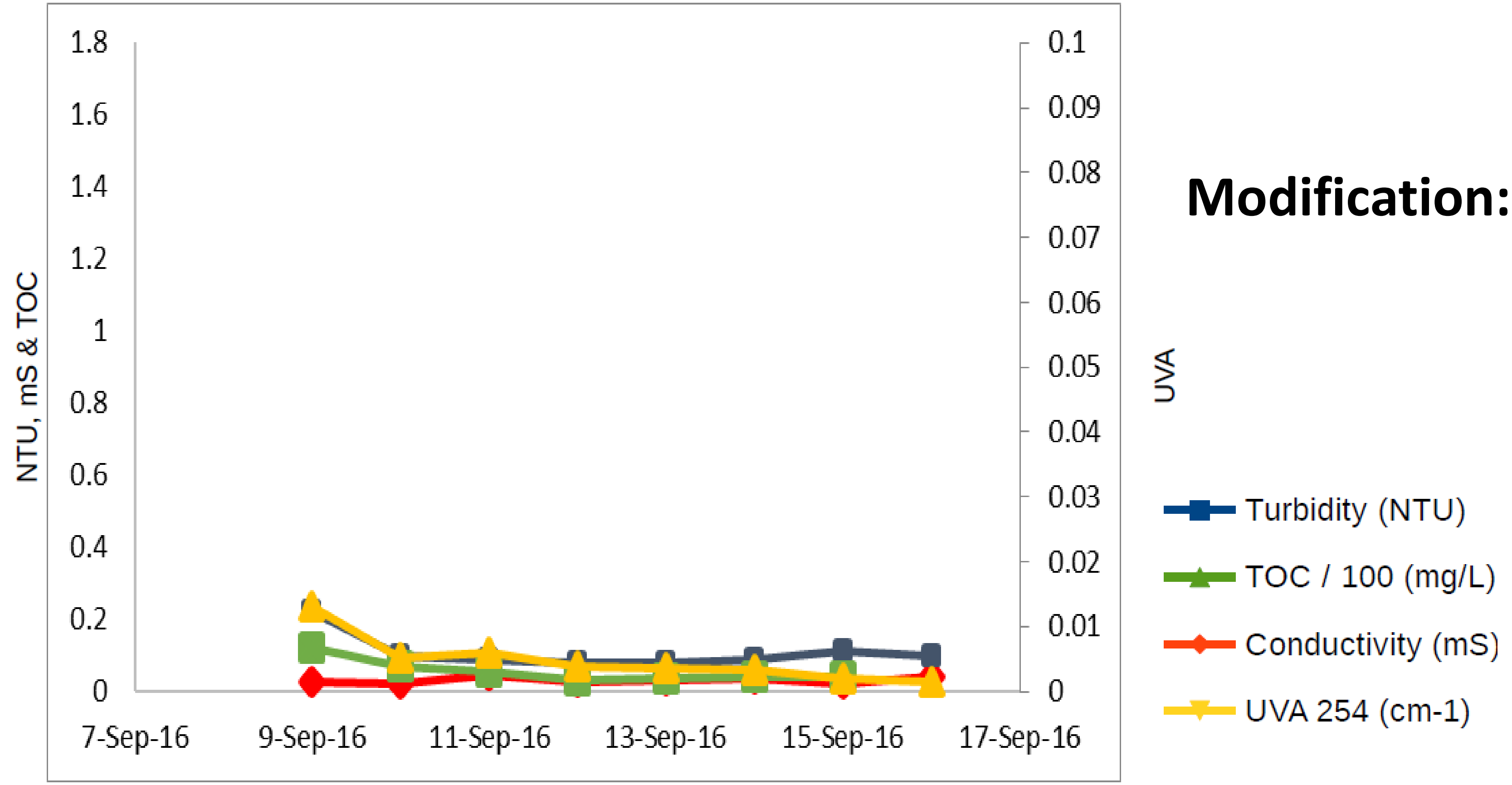
To date – based on improving water quality



Modification: Physical removal of soap

Design Evolution during this Phase

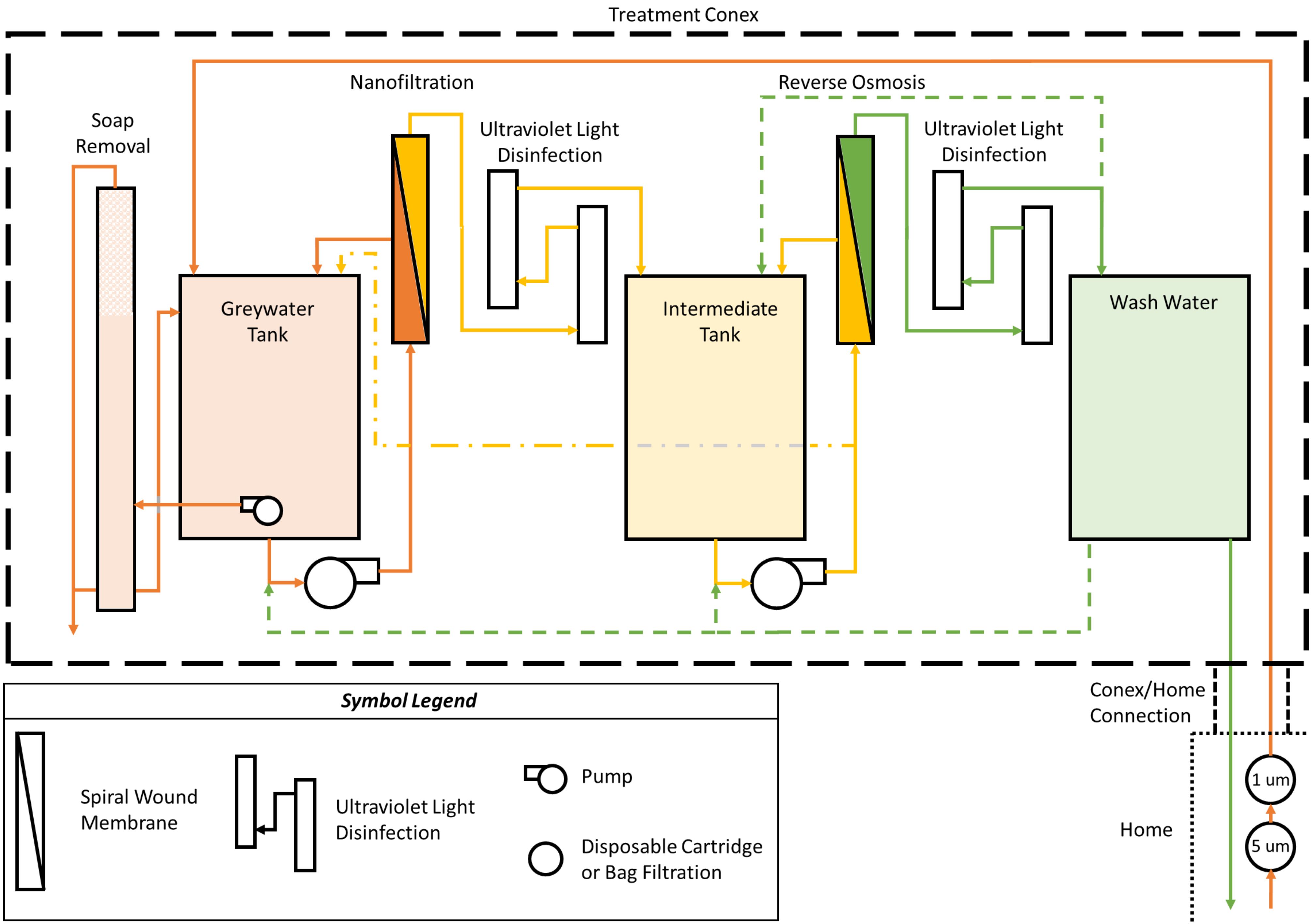
To date – based on improving water quality

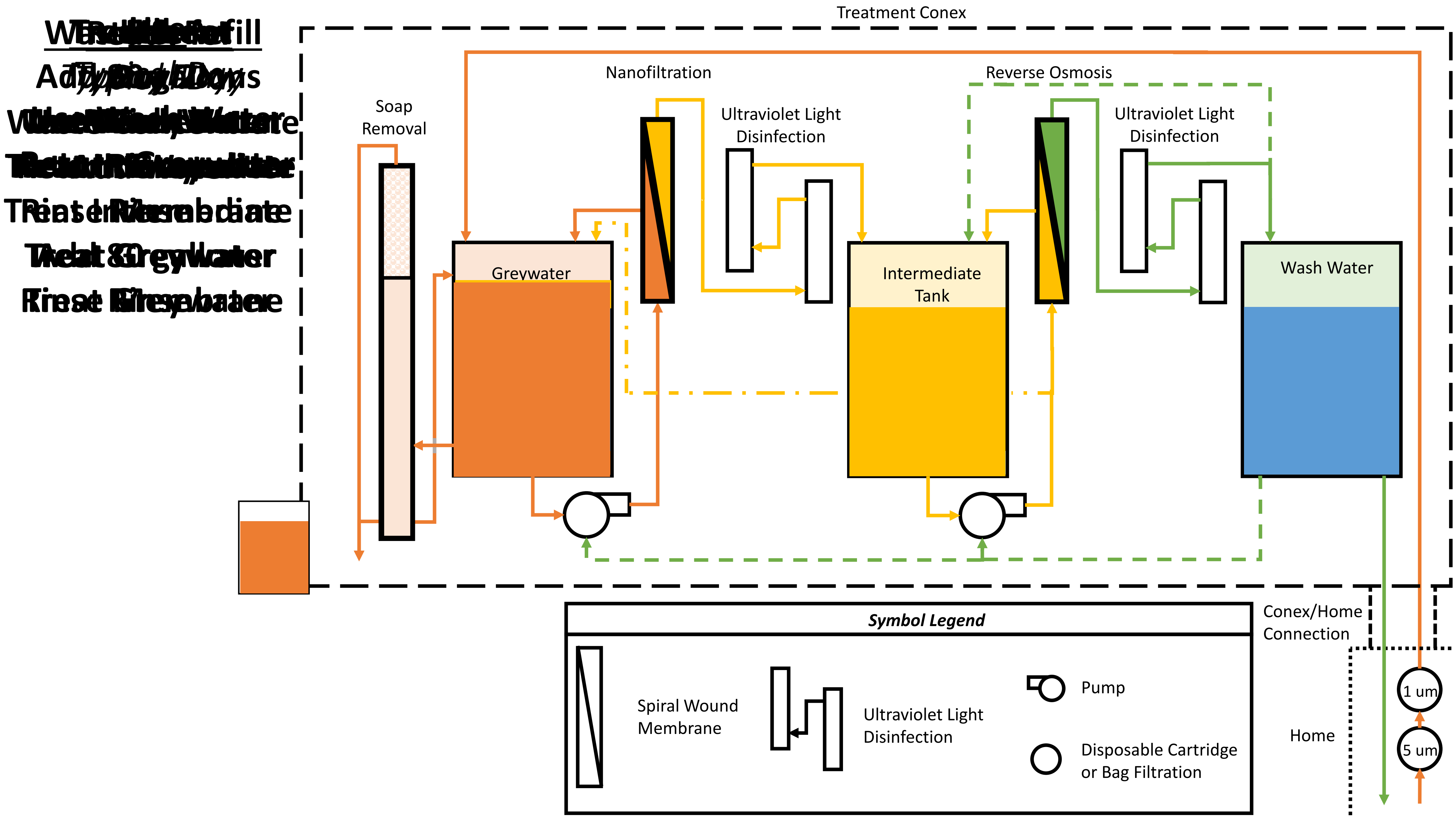


Modification: Stopped urine recycle
2 step treatment for all reuse

How do we achieve the quality?

Through treatment in our treatment conex


Treatment Conex
Nanofiltration
Reverse Osmosis
Soap Removal
Ultraviolet Light Disinfection
Ultraviolet Light Disinfection
Greywater Tank
Intermediate Tank
Wash Water
Conex/Home Connection
Home
1 um
5 um
Symbol Legend
Spiral Wound Membrane
Ultraviolet Light Disinfection
Pump
Disposable Cartridge or Bag Filtration



Treatment Conex
Nanofiltration
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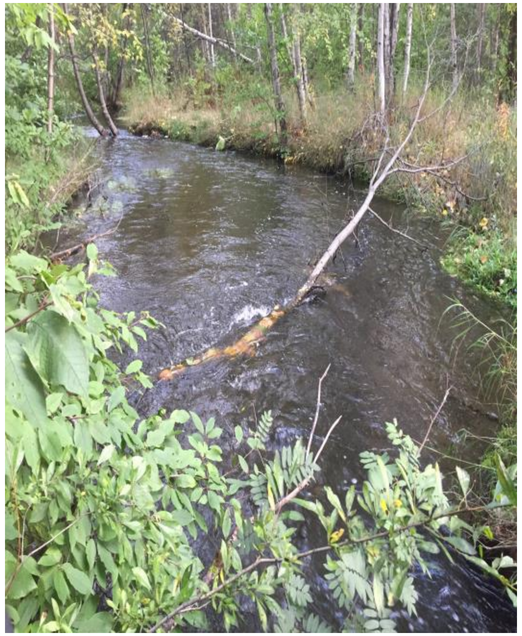
Symbol Legend
Spiral Wound Membrane
Ultraviolet Light Disinfection
Pump
Disposable Cartridge or Bag Filtration
Conex/Home Connection
Home
1 um
5 um

Treatment System Water Balance

- Goal is to achieve at least 85% recovery from our membranes
  - 20 gallons removed weekly
    - 19 gallons membrane concentrate
    - 1 gallon bubble concentrate
  - 20 gallons of source water added to replace weekly
- Reuse Factors
  - 20x reuse with dry toilet (8 weeks to replace entire water volume)!
  - 8x reuse with flush separating toilet (3 weeks to replace entire water volume)!

Where does the water come from?

Rain Water



Surface Water

Treated Water

Treatment Cost and Effort

Assumptions: 6 month cleaning cycle maintenance interventions

3 year membrane and UV lamp replacements

Water Source	Paid Haul	Weekly Water In	Weekly Waste Out	Monthly Usage Cost
Washeteria	Yes	20	20	$ 59.70
Washeteria	No	20	20	$ 21.50
Rain/Surface	Yes	20	20	$ 33.50
Rain/Surface	No	20	20	$ 13.50

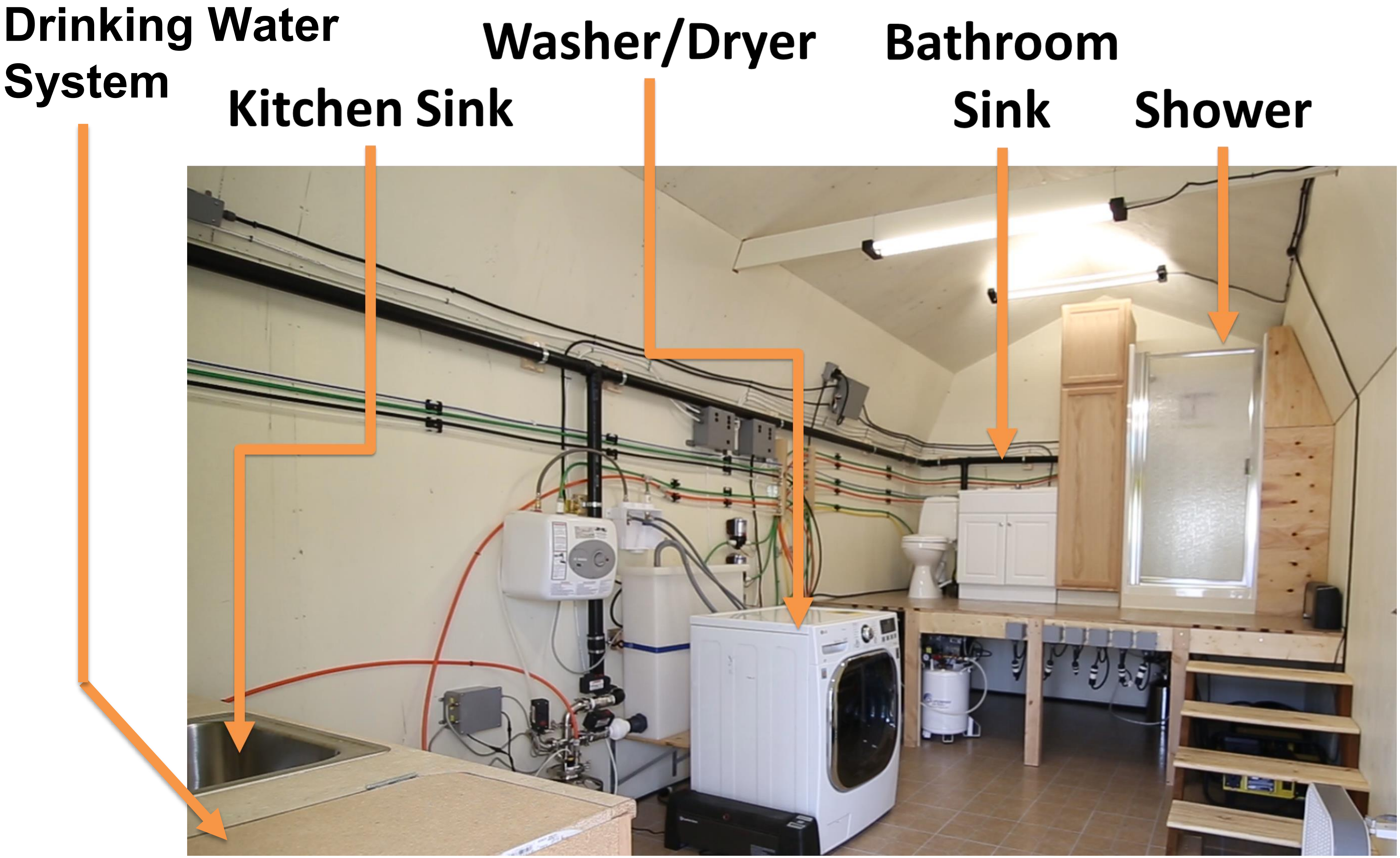
Upcoming Modifications

- Enhance Bubble Removal
  - Add recirculating filter
  - Upgrade to industrial components

- Purpose of Modification
  - Increase time between membrane cleanings (i.e. maintenance effort)
  - Reduce rate of membrane pressure rise (i.e. reduce operating cost)

How is this system connected to my home?

What about the drinking water and my toilet?


Drinking Water System
Kitchen Sink
Washer/Dryer
Bathroom Sink
Shower

Fixture Associated Air-Driven Sewer

Vent

15 psi Air

Actuated Ball Valve (3)

Drain

Tank Level Sensor

Discharge to Conex

Fixture Sewer Tank

5 um bag filter

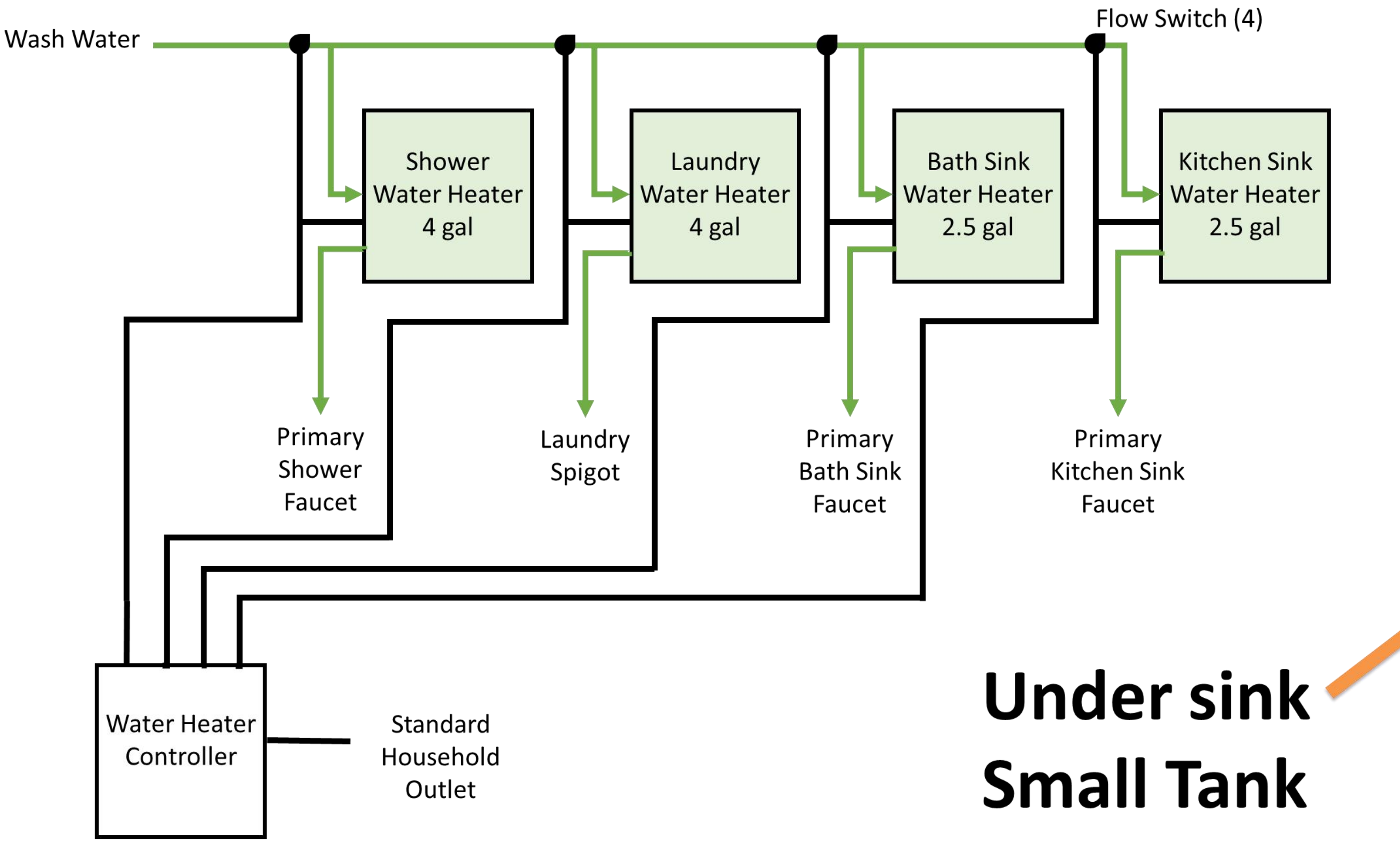
1 um cartridge filter

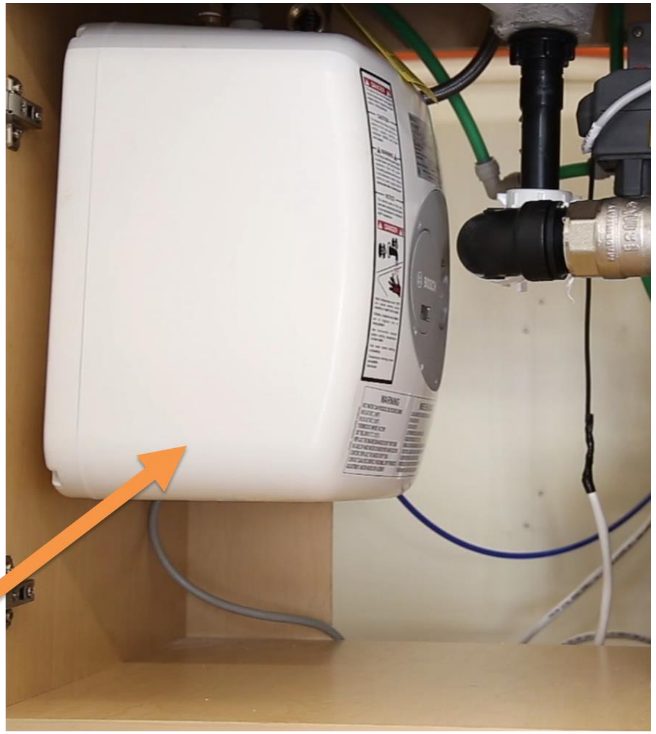
Fixture Associated Small Pump Water

1 pump per fixture

12 V DC
1.1 gal per min

Fixture Associated Small Tank Water Heating





Under sink Small Tank Water Heater

Drinking Water System

Drinking Water Faucets

Drinking Water Tank

UV Disinfection

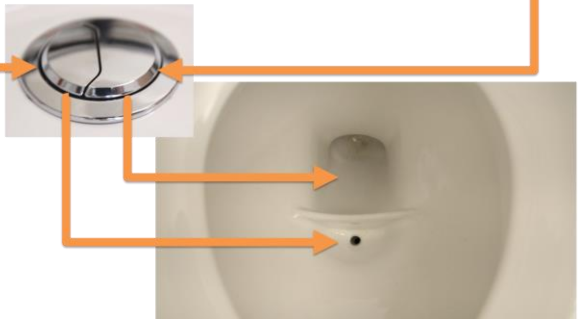
1um Filter

Porcelain Separating Toilet – Small Tank Haul

Dual Flush System

0.7 gallons/full flush

0.1 gallons/urine flush



Urine Drain
to Full Flush Tank

Toilet Selection
Is largest cost driver!

Gravity Full
Flush Tank

Capital Costs – Not paid by Homeowner

Category	Low	High
Materials & Construction Labor	$80,000	$100,000
Shipping & Location at Home	$5,000	$10,000
State Oversight Fee	$40,000	$50,000
Total Estimate	$125,000	$160,000

Capital Costs – Paid by Homeowner

- washer & dryer

Monthly Water/Sewer Operating Costs Paid by Homeowner

Water Source	Paid Haul	Monthly Cost
Washeteria	Yes	$ 170.40
Washeteria	No	$ 97.90
Rain/Surface Water	Yes	$ 141.50
Rain/Surface Water	No	$ 60.50

All costs include $40/month Co-op fee.
UV lamps and membrane replacement included
General maintenance covered by Co-op fee.

Other Monthly Operating Costs based on Usage Paid by Homeowner

Component	kWh/day	Cost
Condensing Washer/Dryer Combo	1	$ 6.90
Small Volume Electric Point-of-Use Water Heaters	1	$ 15.20

Appliance choice may have significant effect on water usage also and must be considered.

We appreciate your interest in our progress!

Code and Design Plans
http://www.github.com/dotsonlab

Blog
http://www.reusewaterak.com

Facebook
http://www.facebook.com/reusewaterak

Human Contact

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Team Lead – University of Alaska Anchorage
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** Sign up for Tuesday's System Tour **