INFORMATIONAL REPORT:

THE UNMET INFRASTRUCTURE NEEDS OF TRIBAL COMMUNITIES AND ALASKA NATIVE VILLAGES IN PROCESS OF RELOCATING TO HIGHER GROUND AS A RESULT OF CLIMATE CHANGE

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DEPARTMENT OF INTERIOR

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INFORMATIONAL REPORT

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This informational report outlines the unmet infrastructure needs of tribal communities and Alaska Native Villages in the process of relocating to higher ground as a direct result of the impacts of climate change. The information from this report was compiled in 2020. The BIA acknowledges that while the information herein has not changed greatly since 2020 as it relates to climate change-related infrastructure issues facing many Alaska Native Villages and some lower 48 Tribes, the context of federal leadership and priorities has changed.

Preparation and submission of this report was completed by the BIA Tribal Climate Resilience Program (TCRP). This report presents a data-supported, community-based sample of the urgent unmet infrastructure needs directly related to climate change that Indian Country and Alaska Native Villages currently face. The complexities Tribes are facing are many but throughout this sampling Tribes have demonstrated enterprising grit and dedication to constructing resilient communities. There is vast economic promise which Tribes can unlock when properly resourced and properly equipped with the right instruments for self-determined, effective action.

Acknowledgments

The Report on Unmet Infrastructure Need of Tribal Communities- Fiscal Year 2020
Partners on this document include:

Federal Partners: BIA, USGS, USFS, Denali Commission

Tribal Organizations: Alaska Native Tribal Health Consortium, Affiliated Tribes of Northwest Indians, Aleutian Pribilof Islands Association

Other Organizations: State of Alaska Department of Commerce, Community, and Economic Development, CRW Engineering LLC, Neimeyer Consulting, Alaska Center for Climate Assessment & Policy

Note: Due to the COVID-19 Pandemic, outreach efforts and response times were complicated in the tribal communities. This report used the best available information.

BIA Tribal Climate Resilience Program

The BIA Tribal Climate Resilience Program (TCRP) provides federal-wide resources to Federally-recognized Tribes and authorized Tribal organizations to build capacity and resilience through leadership engagement, delivery of data and tools, training and tribal capacity building. Both technical and financial support is available to build resilience through competitive awards for tribally-designed resilience training, adaptation planning, vulnerability and risk assessments, supplemental monitoring, capacity building, and tribal youth engagement. The TCRP ocean and coastal management effort supports planning, science and tools, and capacity for coastal tribal decision makers, including the Great Lakes tribes. Program awards for relocation, managed retreat, and protect-in-place planning efforts support tribes facing relocation due to threats from intensifying coastal or riverine erosion, permafrost degradation impacts, sea level rise, flooding as a result of storm surge or extreme precipitation events, and similar impacts. Between 2011 and 2020, the Program awarded over $60 million to Tribal nations and organizations that serve federally-recognized tribes to build climate resilience and also improve tribal ocean and coastal management and planning.

Infrastructure / Tribal Climate Resilience Linkage

Indian Country's infrastructure is critical to supporting tribal economies, sovereignty, security, and ways of life. Tribal infrastructure networks that consist of human-built structures and facilities - from power grids to communication platforms - as well as cultural and subsistence-related infrastructure, are vital to the day-to-day lives across Indian Country and Alaska Native Villages. The project team recognizes that securing and enhancing the resilience of infrastructure plays a critical role in keeping Tribal communities safe, alleviating risks, and minimizing costly disruptions to daily lives. When infrastructure is threatened, both physical and economic security come under duress as the systems that provide essentials like food, clean water, electricity, healthcare, education and communication are placed in jeopardy.[1] This report highlights infrastructure challenges that tribes face, and some of the disconnect in being able to fully address these unmet needs. The specific focus of analyses that went into this report includes those identified Alaska Native villages and tribal communities in the lower 48 states that are in the process of moving infrastructure to higher ground. There are many shapes and forms to this complex process, detailed in the report.

Summary

Tribes are contending with multiple increasingly persistent climate impacts to infrastructure: flooding, erosion and permafrost subsidence -- at both coastal and riverine locations --, sea level rise, extreme precipitation events, storm surge, extreme weather events, and drought-induced wildfire including resultant post-fire flood damage, among others. These environmental threats to infrastructure are costly to repair or replace, but with proper planning, protecting infrastructure can be a cost effective option. Types of at-risk tribal infrastructure for the purpose of this report include: public safety and health, transportation, education, and basic community infrastructure such as roads and utilities.

Because of the extent of these threats, Alaska Native villages and tribal communities are contending with existential threats to their economies, livelihoods, and health. Climate-related threats to tribal infrastructure are expected to increase in frequency and severity under future climate scenarios, thus being highly vulnerable to impacts associated with climate change. As a result, these communities are facing the enormously complex undertaking to relocate to higher ground as climate change and other environmental hazards are encroaching on their land and infrastructure. Tribal infrastructure typically is considered to be physical infrastructure; however, tribes also rely on cultural and subsistence-based infrastructure that is critical to their livelihoods, such as proximity to subsistence resources.

On-the-ground conditions include hazardous or inoperable transportation routes – potentially rendering communities stranded, unable to access essential supplies and services. Shoreline residences and business infrastructure is at risk of collapsing into the ocean, and flooding of homes creates unhealthy living conditions. In rural Alaska, there are schools and homes that have fallen into and/or are within feet of the community's river or coastline, roads that have

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[1] Presidential proclamation on critical infrastructure security and resilience month 2019 – issued Oct 31- 2019

disappeared as permafrost is thawing, cemeteries that are having to be dug by hand and relocated so that they are not washed away, and bulk fuel tanks threatened by erosion are needing to be moved out of communities. As a result, over the past few decades tribes have mobilized on their own, and are beginning the process to develop climate change action plans, implement climate adaptation solutions, initiate community-based monitoring to collect relevant data and document environmental observations, make decisions independently, and navigate the complexities of various funding programs to apply for financial resources that will address their needs.

Despite the serious growing need, response has been limited, and local decision-making is key. Many tribal communities have determined not to let their communities fall into the sea or river, and to have implemented climate adaptation solutions- yet still do not have the access to enough resources to be successful in securing what is necessary for their communities. Other communities have endured repeated climate change-related impacts, but have not yet determined the appropriate response due to the lack of data and/or the lack of the experience to translate complex technical data into making informed and actionable decisions.

Four main problems were identified in this report:

1. <u>There is a significant unmet need for financial resources:</u>
   Forecasting infrastructure investment needs for tribal communities is a massive undertaking. These initial analyses of cost for unmet relocation infrastructure needs suggests:
   - $3.45 billion over the next 50 years for Alaska[2] which would equate to approximately $90 - $110 million in the first 10 years to address tribal infrastructure threats, which includes $32 million to complete all site-specific assessments;

   - $1.365 billion for the Contiguous 48 States Tribes (see unmet infrastructure needs for calculations- this takes into account available resources). Total Needs for two values: Planning ($463 *million*) and implementation ($1.446 *billion*) (see Appendix B for calculations- this does **not** take into account already available resources).

   In 2019 Alaska Native villages were awarded approximately $12.8 million in funding to address infrastructure for relocation (Appendix A). This estimate (of previous funding) was not possible to quantify for the tribal communities in the Contiguous 48 States with currently accessible information. However, available information suggests it is at a similar level. (Appendix B) This disparity between the need and resource availability is likely the biggest barrier to federal program effectiveness in supporting tribes with relocation, managed retreat, and protect-in-place construction.

2. <u>Need for technical support to navigate the scope of required financial and technical resources and institutional barriers to accessing resources:</u>

   Direct technical assistance is needed to assist tribes in navigating funding programs and

[2] This is based on idealized allocation and spending models, and includes funding for the vulnerability assessments noted below. It also assumes that projects can be implemented as pre-disaster mitigation projects prior to disaster events requiring emergency response.

the expertise needed for relocation. Current funding sources do not address complex, multi-layered, comprehensive problems due to narrowly focused funding objectives.

Many tribal communities have been proactively identifying and addressing climate impacts on infrastructure through navigating an array of federal programs, administered by distinct agencies. In general, each program is designed to address specified infrastructure needs, e.g. a particular infrastructure type; a particular step in the climate change response process (planning, implementation); or a particular aspect of agency capacity (technical resources, workforce). For tribes that are forced to relocate, or contend with climate impacts on multiple infrastructure types, the complexity can be daunting: tribal governments must allocate staff hours to identifying relevant programs, utilizing an assemblage of resources, and synchronizing resource availability with operational considerations.

Federal agencies generally prioritize assistance to relocating villages collaboratively with state agencies and villages on the basis of the applicable criteria for the programs they administer. Some examples of these criteria are included below:

- Village Needs: NRCS prioritizes Emergency Watershed Protection program funding on the basis of a damage survey to determine the village need for assistance;
- Cost Share: Several agencies use cost-sharing to prioritize assistance to relocating villages. The Corps' Continuing Authorities Program generally requires villages to fund between 25 percent and 50 percent of project costs. Similarly, FEMA's Hazard Mitigation Grant Program and Pre-Disaster Mitigation Program require a cost share of 10 percent to 25 percent. The NRCS Emergency Watershed Protection program also typically requires a 25 percent cost share for the cost of emergency measures, with certain exceptions.

Although some have been able to obtain federal assistance for projects in relocating villages to higher ground under these criteria, these criteria do not necessarily ensure that the villages in greatest peril get the highest priority. No relocation-specific programs exist, therefore funding is pieced together from agencies such as HUD on housing, BIA on planning and transportation, FEMA on emergency measures, USACE for engineering solutions to erosion issues, IHS for health infrastructure, and the BIE for schools/education infrastructure, etc. This patchwork approach leaves gaps in actions due to the criteria of each program and requirements of each (i.e. cost share, technical aptitude needed). Providing the direction for a coordinated, multi-organizational framework would help to address gaps among agency programs.

3. <u>There is an unmet need to address the lack of information and data:</u> A lack of baseline data and a limited ability to gather new data creates gaps in information, planning documents, and information technology. These data gaps make it impossible for tribes to create informed solutions. With some exceptions, very little necessary scientific information exists for tribal communities to make decisions on adaptation solutions such as relocation, protection-in-place or managed retreat efforts.

An additional challenge is that for community members to obtain the needed information and data, they must possess a certain level of community planning, engineering, economic and legal knowledge to coordinate and communicate effectively on a state and federal level. This is a great professional leap from the traditional roles that community members typically have such as fishers, hunters, paraprofessionals, and small-scale business owners. Inexperience also makes communities more vulnerable to inequitable contracts with consultants and contractors needed for their expertise on projects.

4. Relocation is complex: The process of relocation is time-consuming, culturally damaging, expensive, politically complex and divisive to community cohesiveness. This situation is complicated further by identifying a site that is both culturally acceptable and structurally sound. The myriad of political, cultural and economic factors complicate obtaining the funding needed for relocation. Climate impacts to tribal infrastructure are currently defined in three different strategies:
    - Protection-in-Place- The use of shoreline protection measures and structure rehabilitation, re-stabilization, or other adaptation measures to prevent or minimize impacts, allowing the community to remain in its current location;
    - Managed Retreat- Moving portions of the community in a phased approach from hazard prone areas to other locations in the community or adjacent to the current site; and
    - Relocation- Moving the entire community to a new location at higher ground that is not connected to the current site.

Unmet Infrastructure Needs

The values for unmet infrastructure needs across Alaska Native villages and the Contiguous 48 States tribal communities were approached using different methodologies, and are therefore not necessarily comparable to one another. Alaska methodology included costs of vulnerability assessments and planning for infrastructure scaled by community, per capita, and one of the three types of action responses: relocation, managed retreat or protect-in-place differences in costs. The Contiguous 48 States methodology for unmet needs included analysis by infrastructure type across communities.

Alaska Native Villages

It is difficult to understate the enormous complexities Alaska Native villages face to relocate their tribal communities. Tribes have to identify and acquire funds, quantify risks, develop plans for the community, implement construction activities coordinating at a statewide level, all the while under the pressure to keep the community's economy and resolve afloat while floods, erosion, and permafrost subsidence quickly sluff away land that has been stable for centuries.

> *"Our greatest fear is a storm will hit Shaktoolik in the middle of the night and, when we pick up the phone in the morning the line is dead, and the whole community is wiped out." - Chief of Civil Works, U.S. Army Corps of Engineers Alaska District, December 2019*

As mentioned, threats to infrastructure are expected to increase in frequency and severity under future climate change scenarios – and these can have far greater consequences in rural Alaska than in the contiguous United States, where communities are connected with roads and interstate electric distribution systems. Alaska is also warming twice as fast as the global average (Markon et al. 2018).

1. Approximately $3.45 billion in 2020 dollars will be required over the next 50 years in order to protect infrastructure in Alaska Native villages from damage due to flooding, erosion, or permafrost degradation. This is based on an analysis done on 144 Alaska Native villages that were determined to be the most likely to relocate to higher ground. Additionally, $833 million in costs that was estimated to likely be required for hub communities of Bethel, Dillingham, Kotzebue, Nome, Unalaska, and Utqiagvik.
2. This estimate suggests that $90 - $110 million per year will be required over the next 10 years to address tribal infrastructure threats, which includes $32 million to complete all site-specific vulnerability assessments[3]. This is based on idealized allocation and spending models, and includes funding for the vulnerability assessments noted in Appendix A. It also assumes that projects can be implemented as pre-disaster mitigation projects prior to disaster events requiring emergency response.

(See Appendix A: Alaska Native Villages Summary Report for further detail on this section)

Contiguous 48 States Tribal Communities

Many coastal tribes are developing climate change vulnerability assessments and adaptation plans to address impacts such as flooding, erosion, and sea level rise. Inland Tribes also are contending with periodic flooding by rivers and extreme storms, especially in post-wildfire hydrophobic environments which can increase runoff and thus the likelihood of flood events.

Wildfires leave the watershed charred, barren, and can physically alter the ground's ability to absorb water, creating conditions ripe for flash flooding and mudflow. Flood risk remains significantly higher until vegetation is restored—up to five years after a wildfire. Flooding after a wildfire is often significantly more severe, as debris and ash left from the fire can combine with eroded soil and sediment to form mudflows (Wise Oak Consulting, L. L. C. S, 2018).

These environmental impacts have severely challenged tribes across the continental U.S. For instance, the Hoh tribe, Quileute Tribe, and the Quinault Indian Nation, located in the Northwest, have sought to move to higher ground for nearly a decade (Walker, 2012; Quileute Tribe, 2017; Quinault Indian Nation, 2019). In coastal Louisiana, the Isle de Jean Charles (the Island), home to the Isle de Jean Charles Biloxi-Chitimacha-Choctaw Tribe, has lost 98% of its landmass since 1955. The Tribe has inhabited the Island since the era of forced removals in the late 1700s and early 1800s; the Tribal community living on the Island has experienced a population decline from 400 to 85 residents (Lowlander Center, 2015). This situation has resulted in separation of families, loss of livelihood, and the loss of culture, due to the destruction of traditional foods and medicines, burial grounds, and other sacred sites. These examples illustrate the threats to resilience that tribal communities are dealing with around the Nation.

In New Orleans, the land is lowering (also referred to as subsiding) making sea level rise feel larger than in other Gulf communities whose land is not subsiding. In the United States, the fastest rates of sea level rise are occurring in the Gulf of Mexico from the mouth of the Mississippi westward, followed by the mid-Atlantic (Lindsey, 2019). In Washington State, the Pacific coastline is uplifting rapidly, while the nearby Puget Sound is subsiding (Miller *et al.*,

[3] To date, only 14 communities have completed necessary assessments and another 11 have partially completed assessments. One or more threat-specific assessments are needed for *each* of the remaining 119 communities.

2018). Scientists found that localized sea level rise predictions are critical to assess flooding vulnerability and for accurate hazard response planning (Miller *et al.*, 2018).

1. Approximately $1.908 Billion is required for planning and implementation costs for infrastructure unmet needs across the Contiguous 48 States Tribal Communities. This value consists of two essential costs:
    a. Planning Costs- Approximately $463 Million in planning costs is required to address infrastructure. Team review identified 3,083 projects:
        i. transportation (339, $50.9 million);
        ii. healthcare (348, $52.2 million);
        iii. residences (327, $49.1 million);
        iv. education, businesses, and services (343, $51.5 million);
        v. water and sanitation (345, $51.8 million);
        vi. energy and communication (341, $51.2 million);
        vii. cultural (351, $52.7 million);
        viii. protective structures (349, $52.4 million);
        ix. unspecified infrastructure (340, $51 million).
    b. Implementation Costs- Approximately $1.446 Billion in implementation costs is required to address infrastructure implementation in the context of relocation needs. Team review identified 115 projects:
        i. transportation (16, $116.6 million);
        ii. healthcare (5, $45.1 million);
        iii. residences (28, $368.4 million);
        iv. education, businesses and services (13, $359.9 million);
        v. water and sanitation (11, $65.1 million);
        vi. energy and communication (14, $23.8 million);
        vii. cultural (5, $13.6 million);
        viii. protective structures (7, $33.3 million);
        ix. unspecified infrastructure (16, $419.9 million).
2. Approximately $543 million in annual funding programs was identified as already available resources for all Tribes in the U.S. (including Alaska).
3. The difference between $1.908 B (1) Total Need- $543M (2) Existing Support= $1.365 Billion in potential Unmet Need in the Contiguous 48 States tribal communities. (Note: this value is an underestimation because (2) includes funding available for Alaska).

However, the value of the implementation estimate should be understood as a broad generalization and may be a significant underestimation for this estimate. This is because infrastructure planning has not been conducted for most tribes, or is at a negligible level of completion. Thus, the documented implementation costs are significantly less than the needed infrastructure investments. On the other hand, the value of available multi-program Existing Support is an overestimation, because these values were analyzed on a programmatic level rather than specific to these communities (program funding is also available to other entities). In addition, the documented cost estimates that were included in the calculation of estimated Total Need only included the documented impacts that were identified, during a limited research time period. The identified planning needs and direct work with tribes would make for better progress in identifying the actual Total Need investment in tribal infrastructure.

(See Appendix B: Contiguous 48 States Tribal Communities Summary for further detail on this section)

	Infrastructure Type									
	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Implementation Projects	16	5	28	13	11	14	5	7	16	115
Total Estimated Cost for Implementation Projects ($, Millions)	$116.6	$45.1	$368.4	$359.9	$65.1	$23.8	$13.6	$33.3	$419.9	$1,445.5

Table Appendix B- B.1 - Estimated implementation costs. As applicable, the estimate is based on specific infrastructure projects that were identified and reported detailed cost estimates.

	Infrastructure Type									
	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Planning Projects	339	348	327	343	345	341	351	349	340	3,083
Total Estimated Unmet Planning Costs ($, Millions)	$50.9	$52.2	$49.1	$51.5	$51.8	$51.2	$52.7	$52.4	$51.0	$462.5

Table Appendix B-B.2 - Estimated planning costs. Costs pertain to each infrastructure type assessed in this report. Cost estimate pertains only to infrastructure types for which detailed cost estimates were not identified. Planning needs were evaluated for every federally-recognized Tribe in the contiguous U.S. Non-federally-recognized Tribes were outside the scope of cost estimation.

Existing Support

In order to estimate the unmet infrastructure needs due to climate change impacts for tribes and Alaska Native villages that need to relocate to higher ground, it is necessary to assess existing and accessible financial resources. The project team compiled federal resources using an analysis of available data and outreach to agencies and tribes using a survey approach. Due to time constraints, the team identified only federal programs in the Contiguous 48 States, meanwhile multiple federal, state, and Tribal organizations were considered in Alaska.

One additional difference previously mentioned is that in the analysis and outreach, the Alaska team tailored its request to survey participants to identify relevant funding programs only for relocation, protection-in-place, and/or managed retreat activities for a subset of Alaska Native villages identified to be the most vulnerable in FY 2019 (please see Appendix A for more details about this methodology). In the Contiguous 48 States, the team requested from agencies and also researched all funding that was available, which resulted in funding identified that ranged from FY06 - FY19. The team was not able to obtain responses from federal agencies that could easily delineate its programs for the purposes of relocation-related projects. This is due to the fact that these funding purposes are just beginning to emerge in the Contiguous 48 and are not clearly specified in program funding requirements as they are in Alaska.

Thus, the team found that an estimated $543 million was potentially available to Tribes in the Contiguous 48 States, while approximately $13 million of federal funding was awarded to Alaska Native villages for the purpose of addressing climate impacts to infrastructure for the purpose of relocation in the fiscal year 2019. Table 1 below summarizes the agencies and organizations in both regions that both teams conducted outreach or surveys to.

Federal Agencies Contacted	**State Agencies Contacted**	**Tribal Organizations Contacted**	**Tribes Contacted**
Bureau of Indian Affairs Tribal Climate Resilience Program	Department of Homeland Security and Emergency Management	Maniilaq Association	Native Village of Shishmaref
Bureau of Indian Affairs Tribal Transportation Program	Department of Community, Commerce and Economic Development- Division of Community & Regional Affairs	American Indian Higher Education Consortium	Native Village of Napakiak
Bureau of Indian Affairs Housing Improvement Program	Alaska Center for Climate Assessment and Policy	Tanana Chiefs Conference	Village of Kotlik
Denali Commission Village Infrastructure Program	Alaska Department of Natural Resources	Yukon Intertribal Watershed Council	Native Village of Shaktoolik
FEMA Pre-Disaster Mitigation Tribes		Alaska Native Tribal Health Consortium	Village of Alakanuk
FEMA Hazard Mitigation Grant Program		Affiliated Tribes of Northwest Indians	Native Village of Deering
FEMA Public Assistance		Kawerak, Inc.	Chinik Eskimo Community
FEMA Pre-Disaster Mitigation State		United South and Eastern Tribes, Inc.	Other tribes indirectly contacted through Tribal Liaison partners
NSF Navigating the New Arctic		Great Plains Tribal Water Alliance	
HUD Community Development Block Grant		Yukon Kuskokwim Health Corporation	
USDA NRCS Emergency Watershed Protection		Association of Village Council Presidents	

NOAA National Coastal Resilience Fund		Aleutian Pribilof Islands Association, Inc	
US Army Corps of Engineers		Bristol Bay Area Health Corporation	
		North Slope Borough	

Table 1- Agencies and organizations contacted with outreach or surveys. This includes agencies and organizations contacted by both the Alaska author team and the lower 48 author team.

Climate Change Impacts to Infrastructure

Alaska Native Villages

Permanent, physical infrastructure in most Alaska Native villages is constructed on low-lying barrier islands, sand and gravel spits, and adjacent to rivers and coastlines. These locations are essential for food security, livelihoods, and cultures. Unfortunately, the proximity to rivers and coastlines often increases vulnerability to climate-related threats.

Alaska is currently warming twice as fast as the global average (Markon et al. 2018). Over the past half-century, annual precipitation has increased in all regions of the state and, in western Alaska, it has increased by 17% between 1969 and 2018 (Thomas, 2019). Projected environmental changes in Alaska are enormous, equal to or greater than the magnitude of change from the ice ages to the present. Air temperature is expected to increase by 7°F to 13°F by 2100. In northern and western Alaska, the expected result from future change is a transition from an environment with an average temperature of 10°F below freezing, without trees, in which humans and wildlife rely on predictable sea ice, to one where the average annual temperature is above freezing, trees can grow, and spring and fall sea ice is rare, if it exists at all (Aleutian Pribilof Islands Association et al., 2017).

The expected environmental changes will likely result in:

- Loss of barrier sea ice, which buffers the coastline from severe storms
- Increased wind speeds
- Relative sea-level rise
- Thawing permafrost
- Increased precipitation

Erosion impacts to Alaskan communities range from minor landscape changes to catastrophic threats to the sustainability of a community. When an eroding shoreline reaches community infrastructure, it undermines the foundation of the infrastructure and leads to structural failure. The greatest current needs to address erosion threats are to implement immediate actions to prevent disasters and to secure baseline data and risk assessments that support communities in developing informed long-term solutions.

Flooding is currently Alaska's most common disaster, often costing in excess of one million dollars annually and causing loss of life and major disruptions to society (Department of Homeland Security & Emergency Management 2018b). Climate change can lead to increased flooding through diminishing shore fast sea ice, increasing wind speeds, increasing severity of storm surge, relative sea-level rise, and extreme precipitation events (Markon et al. 2018; Meredith et al. 2019; Department of Homeland Security & Emergency Management 2018a). To manage flooding threats to community infrastructure, Alaska Native villages can implement immediate actions that prevent disasters (e.g. elevating structures) and secure baseline data and risk assessments that support communities in developing informed long-term solutions.

Permafrost is found beneath nearly 85% of Alaska's land (State of Alaska Department of Natural Resources n.d.). Similar to the importance of river and sea ice, subsurface ice is structurally important to the health and function of communities (Department of Homeland Security & Emergency Management 2018b). Permafrost thaw causes the land to sink (subsidence), resulting in landslides and erosion. Subsidence due to permafrost thaw threatens all community infrastructure that is not mobile or rapidly adaptable, and can lead to the complete destruction of infrastructure such as power plants, fuel tank farms, water treatment plants, and homes (Melvin et al. 2016).

Contiguous 48 States Tribal Communities

This issue is significant for several reasons. Tribes are particularly vulnerable to climatic impacts. These impacts function as a threat multiplier to societal challenges that have been imposed upon them for generations—in turn, posing a threat to tribal community resilience. Tribal infrastructure is also highly vulnerable to impacts associated with climate change, which is particularly troublesome because communities have come to depend upon having reliable systems that are foundational to quality of life in the twenty-first century. These environmental threats to infrastructure are very costly to repair or replace, and with proper planning, protecting infrastructure can be a cost-effective option.

The expected climate changes will likely result in:

- Increased extreme events
- Drought
- Flooding
- Wildfire

Flooding and erosion are primarily impacting Tribes located along ocean coastlines, rivers and desert drainage washes, and along lake shorelines. The primary climatic factors that amplify flooding and erosion are: sea level rise, changes in the timing, form, and amount of winter precipitation, increases in storm frequency and intensity, and wildfire.

Tribes along oceanic coastlines face a trifecta of compounding influences on their community infrastructure near the ocean. The combination of sea level rise, high tides, and storm surges accentuate flooding along coastlines. Flooding is often accompanied by erosion which adds to the destruction felt by coastal communities. Increased river flows can combine with seawater levels to flood coastal areas (Coastal Hazards, 2019).

A study of tribes' participation in the federally run and subsidized National Flood Insurance Program (NFIP) finds that, as of 2012, only 7% of tribal communities were participating in the program due to lack of information, limited local government capacity, and limited land jurisdiction. (NCA4 Chapter 15 Tribes and Indigenous, Adaptive Capacity)

The NFIP draws its roots form FEMA flood maps, one data limitation that faces many tribes is having access to accurate and up-to-date FEMA flood maps. These data products identify terrain that is at risk of flooding at different time intervals. Having these maps more readily would allow Tribes to identify infrastructure at-risk of flooding impacts. These data products have not been developed for many tribal reservations, and there currently is not a method set up to specifically request this. Current process is that the reservation must lie within an existing watershed project. This opportunity could be considered as low hanging fruit for policy makers as there is an existing process in place for developing these maps and the U.S. government has the expertise available to do so.

Opportunities for Policy-makers to Support the Needs

Program compatibility with tribal needs

There are opportunities to develop program structures that align with the insights gained from work with Tribes (Marino, Maldonado, and Jollerman, pers. comm., 4/21/20). Insights that would be worth considering include:

- Remove the cost sharing or match requirements for funding, particularly in rural and impoverished communities.
- Budget and account for the full costs of implementing integrated tribal relocation efforts; if the assessment of costs stops at the point of physical relocation and only considers the built infrastructural needs, the community will unjustly bear the externalized costs and experience increased impoverishment.
- Floodplain location, or other sites that have been exposed to repetitive flooding, characterize the homelands of many tribes. Infrastructure needs often are currently unmet due to multiple challenges with building and maintaining habitable infrastructure in such high-risk locations. Therefore, rebuilding funds should allow for land in a low-risk location, as well as the structure.

Overcoming constraints on tribal capacity

For many tribal governments, a significant barrier is insufficient workforce capacity and expertise. In many cases, there are limits to the number of tribal staff with the expertise or technical background to assess tribal infrastructure that is at risk of short or long-term climate impacts. Furthermore, the specialized skill sets that are necessary for developing cost estimates and implementation plans are needed. There are many approaches to addressing this constraint:

- Funding resources could be directed towards tribal capacity building projects.
- Support professional training of the tribal government workforce.
- Support for training of future tribal workforce through investments in youth engagement and training efforts.
- Direct support for positions that conduct climate change response planning and implementation.
- Development of standards and guidelines by the BIA or other relevant agency for tribes to consider adopting within hazard mitigation plans, risk management plans, climate adaptation plans, climate vulnerability assessments, etc. Identifying specific suggestions for the types of information that would be useful for tribes to document so that they will be best prepared to take advantage of federal programs to move forward with their tribal preferred infrastructural responses (e.g., specific rough cost estimates for preferred activities so that they can quantify their infrastructure needs).

In response to Report outreach, one Bureau of Indian Affairs resource manager observed,

"Several Tribes lack the capacity to do the kind of planning needed (e.g., structural

engineering, geological, hydrological risk assessments, contract negotiation, and community design planning identified). Anecdotal evidence from those working directly with Tribes suggests that some smaller tribes struggle to differentiate between infrastructure in jeopardy and infrastructure in need of routine maintenance. The BIA Tribal Resilience Program has a grant category dedicated to these tribes (facing relocation-related decisions). Because of the lack of professional training in various disciplines requiring advanced degrees, some Tribes may assume that they've done an adequate job of planning. This would open the door to occurrences of a Tribe developing plans that may fail to cover critical planning areas (in absence of technical assistance, guidance, or helpful planning standards). I think technical support is needed to empower Tribes that lack these advanced professional capacities and potentially inadequate plans. I have contended (for several years now) that BIA would be of good service to develop recommended standards for tribal emergency management plans, climate adaptation plans, and vulnerability assessments. This would ensure BIA meets its trust in terms of providing for public safety in a proactive way by ensuring a minimal standard of quality is provided" (Anderson, pers. communication, 4/16/20).

Deploy resources strategically

Strategic Alignment is a process that links key operational systems and processes to the organization's mission and mission objectives. In this case the mission is to uphold the tribal sovereignty, culture, health and safety while providing resources to fulfill the planning and implementation phases of this process. Approaches to addressing this constraint are:

- Expand and refocus federal funding
- Allow for federal guidance to prioritize assistance on the basis of level of threat
- Data collection must be accompanied by outreach to vulnerable communities to assist them in using data for advocacy and designing solutions
- Establishment of a coordination structure for federal programs and resources
- Review the current deferred maintenance for existing tribal infrastructure and develop a plan to remedy the backlog

Conclusion

This BIA Tribal Climate Resilience Program (TCRP) report presents a data-supported, community-based sample of the urgent unmet infrastructure nmneeds directly related to climate change in Indian Country and Alaska Native Villages. Tribes are contending with multiple climate impacts to infrastructure: flooding, erosion and permafrost subsidence, sea level rise and extreme precipitation events; storm surges; extreme weather events; and drought-induced wildfire including resultant post-fire flood damage; among others. Inland Tribes also are contending with periodic flooding by rivers and extreme storms, especially in post-wildfire hydrophobic environments which can increase runoff and thus the likelihood of flood events. Despite the serious growing need, response has been limited.

Because of the extent of these threats, it is difficult to understate the enormous complexities tribes are facing to relocate including: identifying and acquiring funds, quantifying risks, community planning, implementing construction activities while coordinating at a statewide level all while under the pressure to keep the community's economy and resolve afloat while floods, erosion, or permafrost subsidence quickly sluff away land that has been stable for centuries. In order to accomplish this tribes must possess a certain level of community planning, engineering, economic and legal knowledge to coordinate and communicate effectively on a state and federal level. This is a great professional leap for many of the smaller tribes, particularly in small Alaska Native villages where community members typically are fishers, hunters, para-professionals and small-scale business owners. Through evaluation of the current available data, there are measures that the federal government can make to ease obstacles and assist Tribes in their efforts to protect their communities.

Forecasting infrastructure investment needs for Tribal nations is a massive undertaking. The values across tribes in Alaska and the Contiguous 48 States were approached using different methodology and are not necessarily comparable to one another. However, the value of the implementation estimate should be understood as a broad generalization and may be a significant underestimation because infrastructure planning has not been conducted for most tribes, or is at a negligible level of completion.

These initial analyses, conducted for this report, to estimate the costs for unmet infrastructure needs due to relocation suggest:

- $3.45 billion over the next 50 years for Alaska which would equate to approximately $90 - $110 million in the first 10 years to address tribal infrastructure threats, which includes $32 million to complete all site-specific assessments
- $1.365 billion for the Contiguous 48 States Tribes (see unmet infrastructure needs for calculations- this takes into account available resources). Total Needs for two values: Planning ($462 *million*) and implementation ($1.446 *billion*) (see Appendix B for calculations- this does **not** take into account already available resources).

This report outlines the unmet infrastructure needs, whereas the main issues discovered in terms of unmet needs are summarized in four broad points: 1) there is a significant unmet need for financial resources, 2) there is a need for technical support to navigate the scope of required financial and technical resources and institutional barriers to accessing resources, 3) there is an unmet need to address the lack of information and data, and 4) relocation is complex. This report also identifies numerous opportunities for policy makers to make progress toward meeting the infrastructural needs of Indian Country and Alaska Native Villages. These are: improving program compatibility with tribal needs, overcoming constraints on tribal capacity, and deploying resources strategically.

References

See Appendices A & B for citations, as this summary was pulled from these original reports. Please see Appendix C for Case Studies for further review.

Appendix A

Unmet Infrastructure Needs of Alaska Native Villages in the Process of Relocating to Higher Ground as a Direct Result of Climate Change

Figure 1. The Yup'ik village of Newtok is the first community in Alaska forced to relocate due to climate change. Approximately one-third of Newtok residents relocated to Mertarvik in November 2019. Navigating numerous federal programs and securing funding has been and continues to be one of the community's largest challenge. Significant uncertainty exists regarding the ability to secure the $85 million needed to construct the remainder of the Mertarvik site. Credit: Orlinksy, Katie; 2019.

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Introduction

This report appendix outlines the unmet infrastructure needs of Alaska Native villages in the process of relocating to higher ground as a direct result of climate change.

Threats to infrastructure are expected to increase in frequency and severity under future climate change scenarios – and can have far greater consequences in rural Alaska than in the contiguous United States, where communities are connected with roads and interstate electric distribution systems.

It is difficult to understate the enormous complexities Alaska Native villages face to relocate their tribal communities. Tribes have to work towards acquiring funds, assessing real risk, developing plans for the community, implementing construction, coordinating at a statewide level all while under the pressure to keep the community's economy and resolve afloat while floods, erosion, and permafrost subsidence quickly sluff away land that has been stable for centuries. To synthesize complex information regarding the infrastructure needs of so many varied Alaska Native Villages with the information required and the urgency of the situation is a challenge.

This analysis was completed using new cost data sources from the relocation of Newtok, professional opinion on future risks and predicted solutions and an analysis of funding received by Alaska Native villages, and survey results from agencies and organizations. However, in order to fully respond to this request, the writing team faced the following challenges, contributing to some gaps in the findings:

- Timeline: The short time frame under which this report was compiled (April to May 2020) limited our ability to properly consult with tribes and obtain their input in a timely manner. For this reason, we are not including a list of the communities that we identified to be threatened by climate change impacts, nor a list of the specific unmet infrastructure needs by community. The estimated costs of unmet infrastructure needs that Alaska Native villages are facing due to climate impacts in this report should be considered a starting point for a more detailed study with direct tribal input and consultation of the unmet infrastructure needs.
- Pandemic: The COVID-19 pandemic further limited our ability to properly consult tribes for data and input, as tribal nations have had to declare a state of emergency due to the COVID-19 virus.
- Infrastructure assessment: Due to the limited time, the cost of mitigating climate impacts to cultural and subsistence infrastructure was not included in this analysis.

The following next steps are recommended to obtain a full picture:

- Further inquiry with tribal input
- Tribal consultation with each tribe facing relocation
- Village specific Engineering/geological investigation
- Completion of vulnerability assessments for the Alaska Native villages that have not yet completed them

Background

Figure 2. The son of a hunter after they return from unsuccessfully hunting bearded seals in the Arctic Ocean near Utqiagvik, Alaska in June 2015. Hunting affects all aspects of life and is the main food source for the community. As permafrost continues to thaw at an ever-quickening pace, the traditional ice cellars where hundreds of pounds of staple hunted foods need to be stored all year long are threatened.

Permanent, physical infrastructure in most Alaska Native villages is constructed on low-lying barrier islands, sand and gravel spits, and adjacent to rivers and coastlines. These locations are essential for food security, livelihoods, and cultures. Unfortunately, their proximity to rivers and coastlines are also often increases vulnerability to climate related threats.

Physical infrastructure systems in rural Alaska lack redundancy. Most Alaska Native Villages and Alaska tribal communities often have only one power plant, one school, one water treatment plant, and one cellular phone tower. When one of these is damaged or lost due from climate-related threats such as permafrost degradation, erosion or flooding events, the entire community loses service for days or, in some cases, years due to the high cost and complexity of both repairing the system and accessing funding to do so. In addition to physical infrastructure, which typically includes engineering facilities or systems, cultural and subsistence related infrastructure are also critical to Alaska Native village livelihoods and are vulnerable to climate-related impacts.

The establishment of schools was the primary driver of the siting and development of permanent settlements in rural Alaska. (Berardi 1999). Oftentimes, the location of schools was determined more on the ease of logistics than on traditional, local knowledge and science regarding the long-term habitability of the sites. For example, Newtok's current site was selected because it was the farthest point up the Ninglick River that the Bureau of Indian Affairs (BIA) barge could navigate to offload school building materials. (ASCG Inc. 2004) Once BIA built a school on the barrier island where Kivalina exists today, the intermittent inhabitants of the seasonal camp were ordered to settle permanently on the island and enroll their children in school, or else face imprisonment. (Shearer 2011) Similarly, the decision by the federal government to build a school on Sarichef island, where Shishmaref is now located, along with the mandate that children must attend the school, led to consolidation of the nearby population to a permanent settlement on the island (Marino 2015). The introduction of schools led to the development of homes, clinics, power, water, and sewer infrastructure.

Many of the key aspects of traditional culture that contributed to adaptability are still woven into the social and cultural fabric of most communities, including kinship ties, language, rituals and spiritual connections. (Ayunerak et al. 2014; Schweitzer & Marino 2005)

Today there are 229 federally recognized tribes and tribal organizations in Alaska. Although the current locations of many Alaska Native villages provide outstanding access to subsistence food resources on which their economies depend, these locations also leave them exposed to environmental and climate-related threats to infrastructure from floods, permafrost thaw and rapid erosion. While communities once migrated seasonally for food by foot, they now travel to and from villages to their subsistence hunting and gathering sites via boat, snowmachine, and all-terrain vehicles. Close proximity to reliable subsistence harvest resources is one of the primary considerations in making a decision regarding relocation of a village in order to continue a durable subsistence and cash economy.

Climate Change Impacts in Rural Alaska

Alaska is warming twice as fast as the global average (Markon et al. 2018). Moreover, rural Alaskan communities are more vulnerable to climate-related impacts, as they are rapidly affecting all aspects of life, from nutrition, infrastructure, economics, and health, and the existence of communities themselves (Markon et al. 2018). In order to address such climate-related impacts and mitigate the consequences as much as possible, communities must plan and implement climate adaptation strategies.

The expected environmental changes will likely result in the loss of barrier sea ice, increased wave action, storm surges, thawing permafrost, sea-level rise, and increase precipitation. The impact of these changes is shown in Figure 3 below.

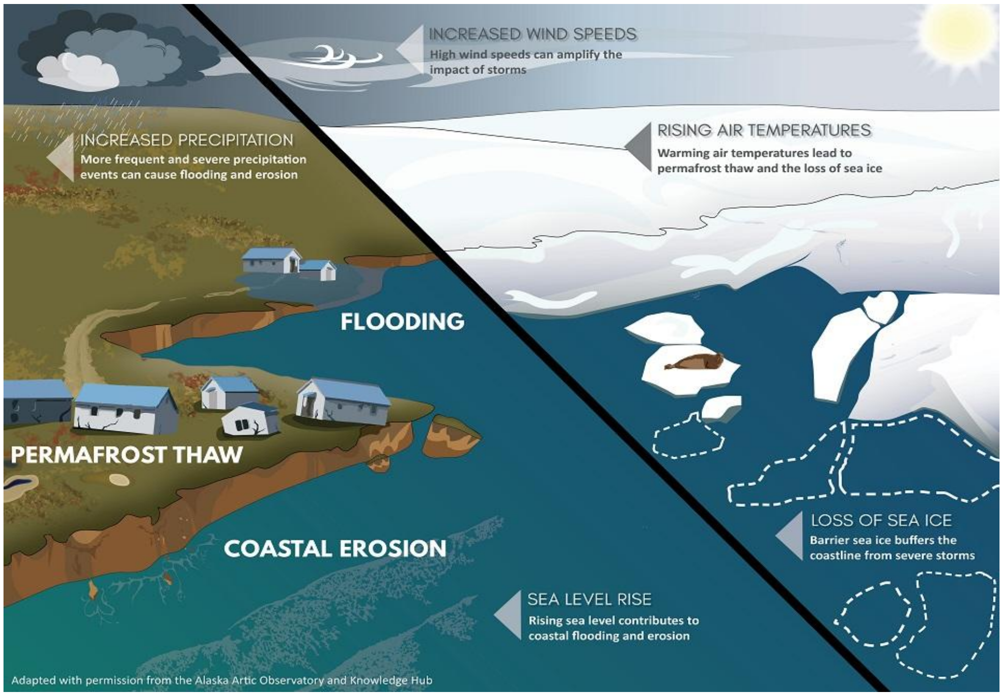

Figure 2. Common climate impacts to infrastructure in Alaska Native villages are shown in this graphic. Graphic credit: Alaska Climate Adaptation Science Center; 2020.

These changes increase the severity of impacts to infrastructure through erosion, flooding, and permafrost thaw, and the combination of those hazards (UAF Institute of Northern Engineering et al. 2019). In the past two decades, there has been a 53% increase (from 7 disaster declarations between 1986-1996 to 15 disaster declarations in 2008-2019) in the number of presidentially-declared disasters for flooding and severe storms in Alaska (Alaska Division of Community and Regional Affairs 2019). Consequently, increasing erosion, flooding and permafrost thaw are causing many communities to desperately search for solutions to determine if they can continue to live in their current locations. In 2019, the Alaska Federation of Natives declared a climate change state of emergency. The following is an excerpt from that declaration.

> *Our indigenous lands and waters are warming at twice the rate as the rest of the world. Many communities across the state face hardships directly correlated with Climate Change, such as the extreme warming temperatures which melt the permafrost, causing mass erosion, resulting in the relocation of entire communities along with devastating the natural habitats of our animal and plant relatives. These impacts have disrupted indigenous seasonal hunting and gathering traditions; and In recent years we have lost community members due to unpredictable and unsafe ice conditions, have seen the die-off and disease of seals, salmon, migratory birds, shellfish, whales, polar bears, and recognize that these are also our relatives; and we, the Alaska Native youth, are asking our tribal leaders to consider, as is traditional, the future of their grandchildren and the generations to come* (Alaska Federation of Natives 2019).

Rural Alaska is More Vulnerable to Climate Change than the Lower 48

Alaska Native villages are more vulnerable to climate change related impacts for some of the following reasons related to rural Alaska's remoteness and technical capacity of the communities:

- Enormity of the cost to adapt infrastructure to the impacts of climate change: Planning and implementing can be more difficult and more expensive than in the contiguous United States. There are no roads to and massive distances between supply hubs to Alaska Native villages. Therefore, materials, equipment, and supplies needed for infrastructure projects must be shipped via seasonal barge during the ice-free season, which substantially increases the cost and timing logistics. Many communities do not have local access to the supplies they need to address climate impacts to infrastructure. For example, Point Lay cannot harvest enough gravel locally to address imminent permafrost impacts to critical infrastructure. Harvesting and shipping gravel hundreds of miles via barge can dramatically increase the cost of a project.
- Technical capacity: For community members to plan and implement climate adaptation strategies, they must possess a certain level of community planning, engineering, economic and legal knowledge to coordinate and communicate effectively on a state and federal level. This is a great professional leap from the traditional roles that community members typically have such as fishers, hunters, and small-scale business owners. Inexperience also makes communities more vulnerable to inequitable contracts with consultants and contractors needed for their expertise.
- Transport: Most Alaska Native villages are not connected by roads due to the sheer size and scale of Alaska. They instead depend on waterways, seasonal ice and small aircraft for connection to nearby villages as well as "hub" communities, which serve surrounding villages as transportation, health, distribution and economic centers. Additionally, rural communities rely on air transportation for the delivery of essential goods and services and for transportation to medical care.
- Physical infrastructure systems: Physical infrastructure systems in rural Alaska lack redundancy as most Alaska Native villages and Alaska tribal communities often have only one power plant, one school, one water treatment plant, and one cellular phone tower. Increasing climate related threats to infrastructure thus make communities very vulnerable. When one of these is damaged or lost, the entire community loses service for days or, in some cases, years due to the high cost and complexity of both repairing the system and accessing funding to do so.
- Limited internet capabilities: Most villages have limited internet delivered via a system of repeaters beaming broadband to villages. Some of the smaller villages only have internet connection available at the public library.
- High cost of fuel: Gasoline in many villages is over $10 per gallon, and fuel storage is also expensive.

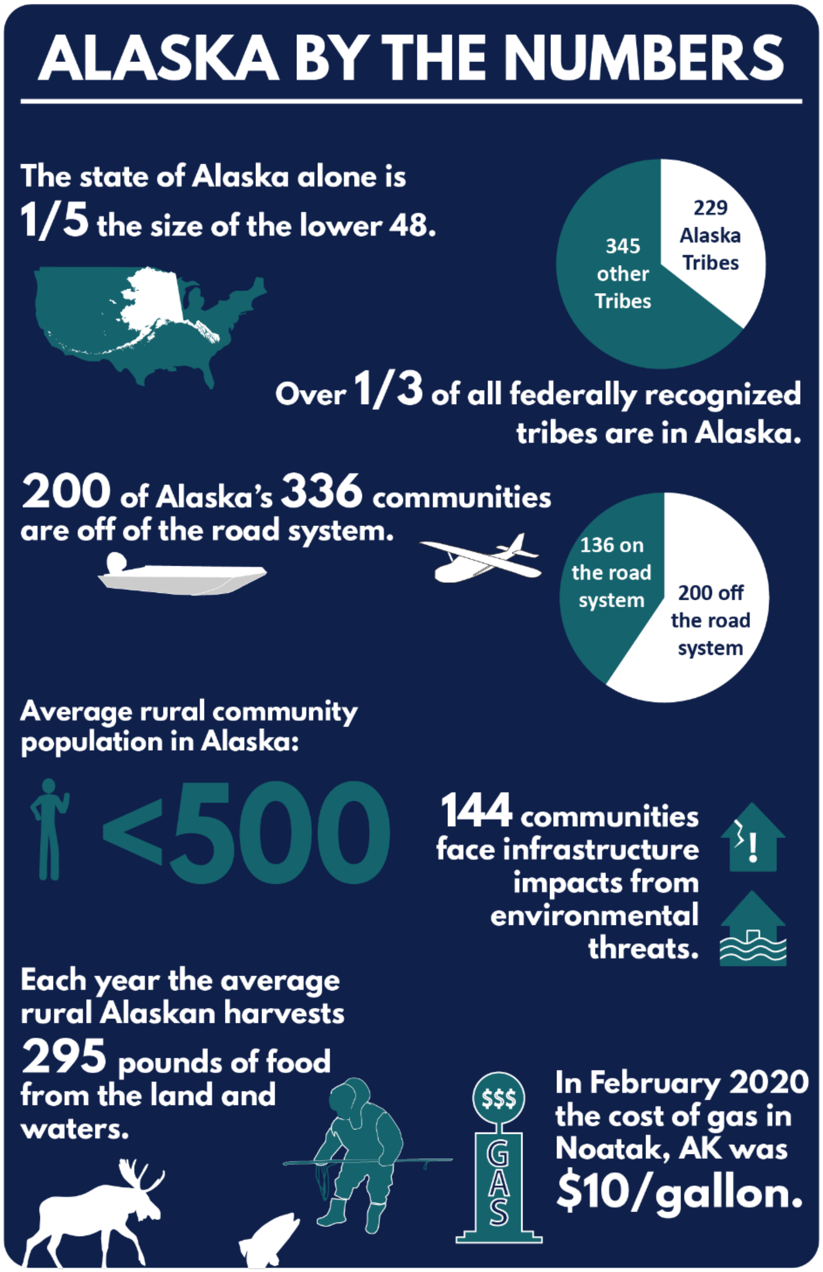

Figure 4. Credit: DeLue, Mike; Alaska Climate Adaptation Science Center; 2020.

Climate Impacts to Infrastructure Exacerbate Existing Stressors

Climate impacts to infrastructure can exacerbate existing stressors faced by Alaska Native villages; such as overcrowded housing, access to clean water, health issues and food insecurity that are further described in this section.

Overcrowding and Lack of Housing

Homes in Alaska Native villages can be extremely overcrowded, with rates reaching approximately 12 times the national average in some areas (Alaska Housing Finance Corporation 2018). Due to the high cost of construction and poverty, many local residents aren't able to build new houses themselves, which means communities rely on regional housing authorities to build homes. This combination of factors results in families, relatives, and close friends sharing a home. Existing overcrowding can be exacerbated when a community faces erosion. For example, in Kotlik, Alaska, 21 homes are threatened by erosion in the near-term. Nineteen people live in one of those threatened homes (796 square feet). According to community members, if a new subdivision cannot be constructed in time, "people will have nowhere to live" (project team personal comms).

Access to Clean Water

Damage to water and sanitation infrastructure is regularly occurring through Alaska Native villages due to erosion, thawing permafrost, and flooding. These damages adversely impact human health by way of facilitating waterborne diseases and decreasing the availability and quality of drinking water. For example, residents in Kotlik and St. Michael lost running water and flush toilets for several years when flooding and permafrost thaw, respectively, damaged piped infrastructure. Currently, extremely aggressive erosion in Napakiak is degrading water quality and a new $14 million well may not be able to be constructed before the community loses the current water source.

Accidents and Injuries

Accidents and injuries due to extreme weather events, such as droughts, floods, storms, and ice loss are already occurring, and are predicted to increase with climate change. In 2019, Alaska's hottest year on record, at least eight Alaskans died when snowmobiles or four-wheelers broke through unusually thin ice (Lydon 2019). Increased severity and frequency of flooding is a concern because floods are the second deadliest of all weather hazards in the United States (Bell et al. 2016).

Mental health

"What are we supposed to do? Send our kids to school with life jackets on?"
-Napakiak Advisory School Board member Jacqueline Andrew in 2018. (Napakiak's school is imminently threatened by erosion and is the most urgent need in the community.)

Alaska Native villages facing climate change may experience mental health impacts that can cause anxiety, depression, and post-traumatic stress disorder (Yoder 2018). Acute events, such as floods and storm surges, and slower-moving impacts, such as permafrost thaw and erosion, may contribute to these mental health impacts. Decreased food security, damaged infrastructure, water quality concerns, and associated economic impacts could exacerbate mental illness. Additionally, climate change can affect mental health by causing solastalgia, the distressing sense of loss as a result of unwanted environmental changes that occur close to one's home. In Kotlik, community members are "100% confident" that they will lose their land due to increased flooding and erosion.

This sense of impending doom results in feelings of distress or helplessness. Case Study C.9 in Appendix C of this report tells the full story in Kotlik.

"Thinking of all these environmental changes worries me. Sometimes I feel helpless when I want to do so much to help our community which is experiencing dramatic impacts from climate change"
-Philomena Keyes, Resilience Coordinator for the Village of Kotlik.

Food Security/ Access to subsistence foods
Practicing a traditional lifestyle is critical for the health, wellbeing, and economic durability of Alaska Native peoples. Alaska native communities harvest salmon, moose, caribou, medicinal plants, berries, and more. In the north of Alaska, community members venture out onto sea ice to hunt for seal, walrus, and whale. The harvest in many communities is to such a degree that it accounts for nearly all their protein per year. The majority of Alaska Native villages operate mixed cash-subsistence economies, in which income from part-time, full-time and seasonal work in tourism, commercial fishing, construction or other activities supports or supplements subsistence activities. Subsistence harvesting offsets the high cost of living in rural communities that have few long-term jobs (Holen 2014; Callaway et al. 1999).

As climate change is increasingly threatening rural infrastructure in Alaska, it is subsequently threatening the food security and livelihoods of Alaska Native peoples and cultures. For example, community members are increasingly forced to spend a significant amount of time addressing climate impacts to infrastructure, such as jacking up homes due to subsidence caused by permafrost degradation. Such activities take away from the time communities need for their subsistence harvest, which require a great amount of time and hard work, complex skill, and knowledge. Diminished food quality (e.g. smaller salmon) and quantity (e.g. less halibut), as well as changing distribution and abundance of subsistence resources, are predicted to continue to increase due to climate change. Many communities have already reported adverse impacts to subsistence harvests, such as salmon die-offs, shifting caribou migration, the decline in sea mammals, and increased variability in berry harvest (Yoder 2018). Thinning ice makes hunting more dangerous. Further, warming temperatures have negatively impacted traditional underground food storage methods, such as ice cellars collapsing and flooding.

It is important that communities receive ample support in developing and implementing adaptation solutions in order to protect their infrastructure, which in turn preserves their food security and a traditional way of life.

Erosion, Permafrost Degradation, and Flooding Impacts to Infrastructure

Erosion

Erosion impacts to Alaskan communities range from minor landscape changes to catastrophic threats to the sustainability of a community. When an eroding shoreline reaches community infrastructure, it undermines the foundation of the infrastructure and leads to structural failure. The greatest current needs to address erosion threats are to implement immediate actions to prevent disasters (e.g. constructing a new subdivision and relocating threatened structures to that site) and to secure baseline data and risk assessments that support communities in developing informed long-term solutions.

In Alaska erosion is increasing in frequency and severity. For example, in Akiak during a single springtime high water event claimed 50 to 75 feet of riverbank along 1200 feet of riverfront over the course of two days (May 18-19, 2020). See case studies that follow in Appendix C that illustrate a few of the current impacts to Alaskans as a result of erosion. In other communities, erosion immediately threatens the existence of the entire community.

Figure 5. On August 2, 2019, an unusual summer storm washed 350,000 cubic feet of Shaktoolik's storm surge berm into the Bering Sea, leaving all of the community's infrastructure highly vulnerable to fall storms (shown above). Shaktoolik must apply to a myriad grant programs across many different state and federal agencies to secure funding to respond to their threat. Credit: Sophia Katchatag, Native Village of Shaktoolik.

Flooding

Flooding is currently Alaska's most common disaster, often costing in excess of one million dollars annually and causing loss of life and major disruptions to society (Department of Homeland Security & Emergency Management 2018b). Climate change can lead to increased flooding through diminishing shorefast sea ice, increasing wind speeds, increasing severity of storm surge, relative sea-level rise, and extreme precipitation events (Markon et al. 2018; Meredith et al. 2019; Department of Homeland Security & Emergency Management 2018a). To manage flooding threats to community infrastructure, Alaska Native villages can implement immediate actions that prevent disasters (e.g. elevating structures) and secure baseline data and risk assessments that support communities in developing informed long-term solutions.

Figure 6. In September 2005, a severe fall storm caused flooding of the entire spit in Golovin, where the school, power plant, fuel tank farm, clinic, and other critical infrastructure are located. Golovin is planning to migrate all community infrastructure from the spit to an area of higher ground adjacent to the community, an immensely complex process. Credit: Chinik Eskimo Community.

Permafrost

Permafrost is found beneath nearly 85% of Alaska's land (State of Alaska Department of Natural Resources n.d.). Similar to the importance of river and sea ice, subsurface ice is structurally important to the health and function of communities (Department of Homeland Security & Emergency Management 2018b). Permafrost thaw causes the land to sink (subsidence), resulting in landslides, erosion, the disappearance and development of new lakes, and saltwater intrusion of freshwater aquifers and surface waters. Subsidence due to permafrost thaw threatens all community infrastructure that is not mobile or rapidly adaptable, and can lead to the complete destruction of infrastructure such as power plants, fuel tank farms, water treatment plants, and homes (Melvin et al. 2016). Alaska communities are just beginning to experience the persistent and devastating impacts of thawing permafrost. As average temperatures increase, impacts are expected to first become widespread in the Yukon-Kuskokwim Delta and spread north over time. To manage permafrost thaw, immediate actions to stabilize structures and replace foundations, in tandem with the development of data and risk assessments, will inform long-term solutions. As permafrost thaw impacts accelerate statewide, it is expected that most homes and smaller structures will require adjustments and adaptations to their foundations, while many larger structures and critical community infrastructure will need to be repaired and replaced (Berman and Schmidt 2019).

Usteq

Figure 7. Blocks of ice-rich permafrost crumble into the Beaufort Sea. Credit: Meixell, Brandt; United States Geological Survey.

Usteq, from the Yup'ik word meaning "surface caves in," is a catastrophic form of permafrost thaw collapse that occurs when frozen ground disintegrates under the compounding influences of thawing permafrost, flooding, and erosion. Normally, permafrost degradation can be a slow or moderately rapid process. However, in combination with flooding (including storm surge) and erosion, permafrost thaw causes the ground to collapse at rapid rates--up to 100 feet per year--resulting in damage that occurs much faster than through individual processes alone (Department of Homeland Security & Emergency Management 2018b). When the threat of permafrost thaw is high in a community that is also impacted by erosion and flooding, the risk of usteq may be high. Usteq is expected to increase as a result of climate change and may cause communities with ice-rich permafrost to pursue managed retreat and relocation. Due to lack of site assessments for villages and the uncertainties associated with the individual erosion, flooding, and permafrost processes, it is difficult to predict usteq. Comprehensive data collection and risk assessments that integrate erosion, flooding, and permafrost processes are needed to develop proactive solutions.

Figure 8. The three common climate adaptation solutions or strategies that Alaska Native villages are increasingly facing as their lands and infrastructure are being threatened by climate change. Relocation is always the strategy of last resort when all other options have been exhausted.

Relocation process

Alaska Native villages are responding to climate impacts to infrastructure and their livelihoods in ways that can be grouped into three primary categories of protection-in-place, managed retreat, and relocation. These are what are referred to as climate adaptation solutions, or strategies. These are shown in Figure 8.

Protect-in-place solutions include rock revetments to slow erosion, elevating homes and building berms to mitigate flooding, and modifying water and sewer systems with flexible service connections to combat sinking ground. Examples of managed retreat solutions include moving fuel tank farms back from eroding shorelines; planning, designing, and constructing new subdivisions with new roads, new utilities, and relocating homes to the new site.

For communities facing complete relocation, an entirely new village must be constructed at a new location, with existing infrastructure either abandoned at the previous site or relocated to the new location.

It is common for communities to combine these approaches. For example, reinforcing a riverbank (protection-in-place) while gradually moving infrastructure from hazard-prone areas to another place in the community (managed retreat). Similarly, some communities that may be forced to relocate are currently protecting-in-place and retreating until they develop plans and secure the necessary resources for long-term relocation.

The process of assessing risks posed by erosion, flooding and permafrost thaw and developing infrastructure solutions to prevent or mitigate the effects generally follows these three phases:

1. Assessing Risk:
    a. Collect site-specific baseline data such as LIDAR, bathymetry, tidal determinations, river currents, sediment transport, flood history, and geotechnical investigations;
    b. Make a determination about the suitability of available climate projections and downscale models if appropriate;
    c. Conduct hazard-specific forecasts such as shoreline mapping, inundation and storm surge modeling, hydrodynamic modeling, permafrost degradation modeling, etc.
2. Planning and Decision-Making:
    a. This includes assessing the technical feasibility, benefits, and costs of solutions and the process for a community to reach a decision regarding solutions that support their specific economy. Planning occurs for the community as a whole as well as for individual elements of infrastructure (e.g. power plant, barge landing, school), each requiring their own feasibility study, land ownership record, assessment, design, and permitting process.
3. Implementation:
    a. This occurs by locally managed construction or outside project management contractors and includes permitting, contracting, administrative reporting, and reimbursement processes.

Each of phases listed above consists developing a scope of work, schedule, and budget for each project. Each project includes multiple facets, including its own unique financing (most commonly a grant), diverse state and federal program requirements, permitting requirements, professional services contracts (e.g., flood modeling, architecture, engineering, survey, cultural resources, etc.), construction contracts, project accounting, grant management, and a myriad of administrative, legal, and coordination tasks associated with each project.

The state and federal agencies that award funding for these projects all work within their own programs' mission and purpose the results for the villages is implementing projects on an ad-hoc basis. Tribal community members must apply for and manage the disparate funding sources, which can be immensely complex and time consuming for small tribal offices with one or two staff members. For example, it has taken the Village of Newtok more than a decade to relocate to Mertarvik and the relocation effort is currently between 29% and 55% complete.

Determining an Estimated cost of the Unmet Infrastructure Needs of Alaska Native Villages

Relocating to higher ground as a direct result of climate change is defined as tribes assessing risk, planning, and implementing solutions to erosion, flooding, and permafrost degradation on infrastructure over the next fifty years (though many villages' infrastructure is threatened in the next one year to three years). Infrastructure in Alaska refers to physical infrastructure that consists of human-built structures and facilities that support the community and economy as well as cultural and subsistence related infrastructure. In this report specifically, references to infrastructure in Alaska includes:

- Airport and airport roads
- Schools
- Wastewater lagoon
- Residential homes
- Barge landings
- Power plants and power distribution
- Piped water and wastewater facilities
- Solid waste disposal facilities
- Bulk fuel storage facilities
- Clinics
- Telecommunications
- Other community facilities such as government offices

Introduction to Determining a Cost Estimate

This section outlines the methods used to quantitatively determine the cost needs for infrastructure needs in Alaska Native villages for relocation, protect in place and managed retreat. Since the timeframe of this report did not allow for direct consultation with Alaska Native villages; to calculate this cost estimate a list of communities most likely facing relocation, protect in place or managed retreat were delineated by a subject matter advisory team. These methods are described further on in this report. The following simple calculation was used to determine unmet need:

Total Need – Existing Support = Unmet Need

$90-100M/year - $13M/year = $77-97M/year

This analysis suggests that an additional $77-97M per year of funding is needed to meet the unmet infrastructure needs of the Alaska Native villages that are in the process of relocating to higher ground due to climate related impacts. The following section explains how that number was calculated.

1. **Approximately $90 - $110 million per year will be required over the next 10 years to address tribal infrastructure threats, which includes $32 million to complete all site-**

specific vulnerability assessments.[1] This is based on idealized allocation and spending models and includes funding for the vulnerability assessments noted below. It also assumes that projects can be implemented as pre-disaster mitigation projects prior to disaster events requiring emergency response.

1. **Approximately $3.45 billion in 2020 dollars will be required over the next 50 years in order to protect infrastructure in Alaska Native villages from damage due to flooding, erosion, or permafrost degradation.** This amount is divided by geographical region in Table 1 below. The total amount excludes approximately $833 million in costs likely to be required for the hub communities of Bethel, Dillingham, Kotzebue, Nome, Unalaska, and Utqiagvik.

Table 1. Estimated Costs Required Over the Next 50 Years in Order to Protect Infrastructure from Climate-Related Impacts in Alaska Native Villages by Alaska Region

Region	Mitigation
Aleutian Pribilof	$68,805,000
Arctic Slope	$281,600,000
Bristol Bay	$72,290,000
Interior	$158,480,000
Northwest	$1,172,710,000
Southeast, South Central, Kodiak	$26,430,000
Yukon Kuskokwim	$1,673,535,000
Total	**$3,453,850,000**

Existing Support

In total, approximately $12.8 million of federal funding was awarded to Alaska Native villages for the purpose of addressing climate change impacts to infrastructure for the purpose of relocation in the fiscal year 2019. Figure 9 below summarizes the amounts awarded by relevant federal programs for relocation, managed retreat, or protection-in-place efforts in the 144 communities identified in this report as being vulnerable to climate impacts. The graph shows amounts disbursed in 2019, although the funding may have been appropriated in FY2017 or FY2018.

Methodology

To obtain the total amount of existing funding of approximately $13 million, the project team sent a survey to federal agencies, state, tribal organizations as well as private sector consultants

[1] To date, only 14 communities have completed necessary assessments and another 11 have partially completed assessments. One or more threat-specific assessments are needed for *each* of the remaining 119 communities.

with relevant programs related to relocation, protection-in-place, and/or managed retreat for the 144 identified Alaska Native villages. Survey participants were asked to:

1. Identify relevant programs related to relocation, protection-in-place, and/or managed retreat activities for the 144 identified Alaska Native villages; and
2. Calculate the total amount of funding awarded to the identified communities in FY 2019

In addition to assessing financial support from federal agencies, the project team also sought to understand the level and type of support provided by state agencies and Tribal organizations. A full list of all agencies and organizations that were contacted and surveyed are included below.

Federal Agencies Contacted	State Agencies Contacted	Tribal Organizations Contacted
Bureau of Indian Affairs (BIA) Tribal Resilience Program	Department of Homeland Security & Emergency Management	Maniilaq Association
BIA Tribal Transportation Program	Department of Community, Commerce and Economic Development – Division of Community & Regional Affairs	Kawerak, Inc.
BIA Housing Improvement Program		Tanana Chiefs Conference
Denali Commission Village Infrastructure Program		Yukon Intertribal Watershed Council
FEMA PDM Tribes		
FEMA HGMP		
FEMA PA		
FEMA PDM State		
NSF NNA		
HUD CDBG		
USDA NRCS EWP		
NOAA NCRF		

Table 2. Federal, State and Tribal Organizations and Nonprofits

General Comments and Assumptions in Estimating the Amount of Existing Resources

There are several assumptions made in order to complete the estimation of the existing resources exercise.

- Due to time constraints, individual tribes were not consulted for their feedback in this survey. Only tribal organizations were contacted.
- Most programs did not have funding specifically meant for relocation-related purposes, with the exceptions of a few such as the BIA Tribal Resilience Program and the Denali Commission's Village Infrastructure Program. The other agencies provided numbers based on their personal opinions or interpretations of how communities adapted their applications to use the programs to benefit relocation-related activities.

- There is an inherent amount of bias as the staff member surveyed may have a different interpretation from another colleague of how the communities used their programs for relocation-related activities.
- Also due to time constraints, the list of agencies is incomplete; there are additional federal funders and/or programs that did not respond to our request or were unknowingly overlooked by the project team.
- State and non-governmental funders were not included in the total due to time restraints, which are critical in determining the whole picture of existing resources. For example, state block grants have contributed a major amount to communities needing to relocate.
- Only one fiscal year's worth of funding was calculated, so this does not represent a true picture of the existing financial resources available to Alaska Native villages that need to relocate due to climate change.

Figure 9. FY2019 Funding Awarded to Alaska Native Villages for Relocation Related Purposes

This figure shows approximately $12.8 million was awarded to Alaska Native villages from different federal programs, that villages used for purpose of addressing climate change impacts to infrastructure in 2019. This figure illustrates that funding is available through competitive award to communities from multiple agencies with different purposes and missions. Many of the federal programs are not designed to address relocation directly, but the villages find projects that meet the mission of the programs and their relocation needs.

Unmet Need

If funding levels and rate of awards remained the same as in 2019, this would assume that tribes were equally successful in being awarded competitive grants and program funding and priorities had remained the same, then an additional $77-97M per year of funding would be needed to meet the unmet infrastructure needs of the Alaska Native villages that are in the process of relocating.

$90-100M/year - $13M/year = $77-97M/year

According to the calculation described previously approximately $90-110 million per year over the next 10 years to address infrastructure threats in the 144 identified Alaska Native villages. If tribes were successful in upcoming years in being awarded $13 million similar to what was awarded in FY19 than this would suggests approximately $77 - $97 million dollars in additional funding per year is needed.[2] This of course is an unreliable amount of assumptions. However, the difference between what this analysis suggests is needed versus what has be awarded to the villages is great enough that is demonstrates that more funding is needed. This also suggests that this annual unmet need estimate should be revised after site-specific risk assessments have been funded and completed statewide.

Methodology for Estimating the Cost

Identification of 144 Alaska Native villages facing relocation:

The short list of 144 tribal communities was selected from the 2019 *Statewide Threat Assessment: Identification of Threats from Erosion, Flooding, and Thawing Permafrost in Remote Alaska Communities.* Published by the Denali Commission the Statewide Threat Assessment evaluated environmental threat risks for 187 rural communities throughout Alaska. The Assessment evaluated impacts to infrastructure from three primary environmental threat risks: erosion, flooding, and permafrost thaw and developed relative community risk rankings for each of these three threats. The assessment determined that a "short-list" of 144 tribal communities out of the 187 total communities in the State are considered to be at risk to some degree of infrastructure damage from environmental threats.

Subject Matter Advisory Team

For many of the communities, protection-in-place, managed retreat, and relocation strategies have yet to be determined at the individual community level thus a Subject Matter Advisor (SMA) team was assembled. The SMA team made professional recommendations based on their personal opinions, experience and knowledge with each community to determine the strategy most likely to be deployed in each community to protect threatened infrastructure. The SMA team consisted of engineers, planners, state and federal agencies, and representatives from regional tribal organizations, each with direct experience working with 144 communities. The SMA affiliations are listed in the Acknowledgments Section and/or Table 1 in the Summary for Policymakers part of this report.

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[2] It should be kept in mind that this number reflects an assumption that the exact funding levels would stay the same every year.

Cost Spreadsheet Model Method
An estimate of the total cost of infrastructure impacts for the communities was developed using a spreadsheet model[3]. The model generated costs at the individual community level for the identified 144 Alaska Native villages. While the total cost is believed to be representative of the investments needed to protect and/or relocate threatened tribal infrastructure over the next 50 years, it must be noted that assumptions made regarding individual community adaptation strategies do not represent the critical formal decision making and site assessments on the part of tribal communities if time allowed for this. For more reliable cost estimate tribal engagement and site assessments specific to each community would be necessary.

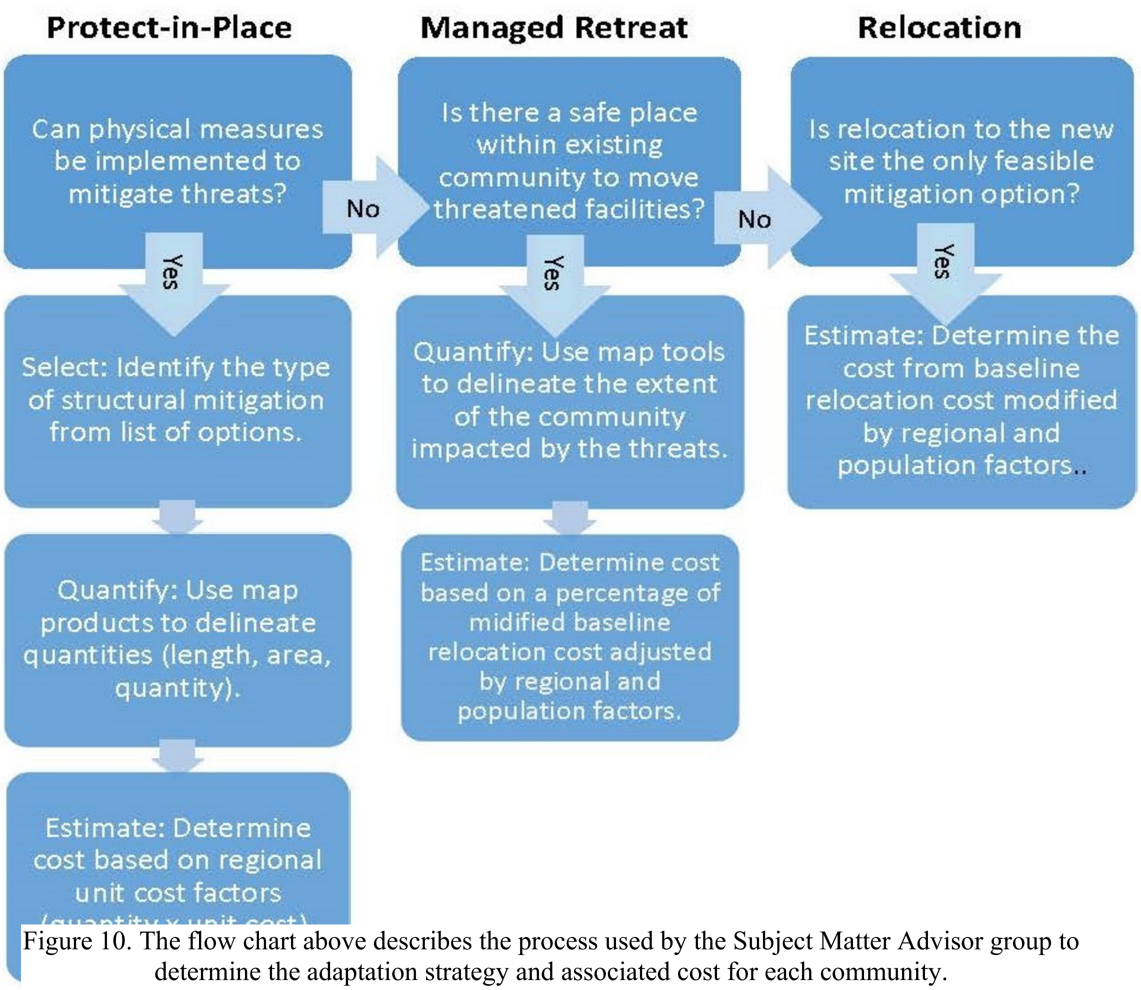

Figure 10. The flow chart above describes the process used by the Subject Matter Advisor group to determine the adaptation strategy and associated cost for each community.

Estimates included the assumed adaptation strategy (protect-in-place, managed retreat, or relocation) and the map annotations created during the discussion. The selection of the mitigation strategy determined the algorithm to be used to estimate the cost. A general

[3] The spreadsheet model is not included in this report due to the sensitivity of the methodology and the village names since there was insufficient time to conduct tribal consultation. It is available upon request.

description of the cost model for each adaptation strategy follows. A flow chart of the subject matter advisory team's evaluation and estimating process is provided in Figure 10.

After the SMA identified the most likely adaptation strategy, CRW Engineering, a contracted consultant firm, then estimated the total need in 144 "environmentally threatened communities" between the years 2020 and 2070 and then subtracted an annual estimate of the resources that are currently accessible to Alaska Native villages.

General Comments and Assumptions for Estimates and Allocations
Before describing the algorithms used for each of the adaptation strategies, this section lists the many assumptions made in order to complete the cost estimation exercise. This section is intended to capture all the assumptions that have been incorporated in the estimation process.

- The planning horizon for these impact estimates is 50 years.
- Cost estimates were developed as a desktop exercise based on readily available public information and the experience of the members of the Subject Matter Advisory team.
- This evaluation considered 144 tribal communities throughout Alaska that were included based on results of the Denali Commission's 2019 Statewide Threat Assessment.
- Individual rural Alaska Tribal consultations and community visits were not conducted as part of this exercise.
- Rural Alaska Tribes will continue to exist as unique individual place-based communities.
- Cost estimates assume that projects can be implemented as pre-climate adaptation in advance of disaster and as such do not include any emergency response costs.
- For the purpose of this study, regional hub communities with substantial commercial and industrial operations and/or that may have majority non-native populations have been excluded from the summary costs. While hub communities are acknowledged to be critical for both the safety and the economic viability of tribal communities, there is no readily available strategy for separating tribal and non-tribal impacts. This results in an exclusion of more than $800M in costs for environmental threat mitigation that is likely to be required for Bethel, Dillingham, Kotzebue, Nome, Unalaska, and Utqiagvik.
- Professional judgements regarding mitigation options that were made as part of the estimating process do not represent formal decisions that have been made by Alaska Tribes. Ultimate tribal decision-making regarding mitigation strategies may vary from assumption made to generate this cost estimate.
- In general, no cost-benefit analysis of the selected mitigation options has been conducted. In a few specific community cases where two mitigation options might be feasible, both were estimated, and the lesser cost was included.
- All costs are presented in 2020 dollars.
- Cost estimates for both relocation and managed retreat assume that structures will have to be replaced and cannot be physically relocated. In some instances, this may overestimate mitigation costs.
- Estimated costs for school facilities do not include stand-alone water and wastewater facilities.

- Flood and Permafrost mitigation costs for Protect-in-Place communities are focused on the protection of structures via foundation modifications, and do not consider the potential additional costs to elevate or modify existing roads, water reservoirs, and lagoons.

Relocation Cost Algorithm

Whole community relocation costs were developed using the existing and projected costs for the relocation of Newtok, which is roughly 40% complete in terms of constructed development. The remaining projects are well defined and easily estimated. Therefore, Newtok costs were used to establish a baseline from which other community relocation costs could be projected. This baseline relocation cost was modified based on population and regional cost factors to arrive at specific community estimates.

Not all costs related to community relocation cost can be directly scaled based on population. For example, rural gravel airstrip construction requirements generally do not change much based on population. Therefore, several major construction costs, including the airport, school, and wastewater treatment lagoon were removed from the baseline cost prior to applying regional and population factors. After scaling for regional and population differences, costs for these facilities were added to establish the total relocation cost estimate. The general formula for relocation cost estimates is as follows:

(Scalable Baseline Cost x Population Factor x Location Factor) + Airport + School + Lagoon Costs

When calculated as noted, the subsequent relocation cost estimates include costs for the following infrastructure: residential homes, schools, airports, roads, barge landings, power plants and power distribution, piped water and wastewater facilities, solid waste disposal facilities, bulk fuel storage facilities, rural clinics, telecommunications, and other community facilities such as government offices.

Managed Retreat Cost Algorithm

The scalable portion of the relocation cost algorithm described above was also used as the basis for generating a managed retreat cost algorithm. However, because there are elements embedded in the relocation estimate that are only relevant to a relocation exercise and not to a managed retreat scenario, additional modification was required. The modification was made by simply subtracting line items that pertain only to the relocation of an entire community. Examples of such line items needed to facilitate a full-scale relocation but not expected to be required in a managed retreat exercise include full-service construction camp facilities, new quarry development, and multi-purpose facilities that can serve as temporary schools, clinics and offices. Subsequent to these modifications, managed retreat costs were then estimated by multiplication of the “modified” scalable baseline costs by applicable regional and population factors; and then multiplied by an estimate of the percent of community impact as established by SMA evaluations. In the case of managed retreat scenarios, costs for the airport, school, and/or wastewater lagoons are only added into the managed retreat costs if they have been specifically identified as needing to be moved. The general formula for managed retreat cost estimates is as follows:

((Modified Scalable Baseline Cost x Population Factor x Location Factor x % Impact) + Airport + School + Lagoon Costs if applicable)

When calculated as described above, managed retreat costs include allocations for the expansion of roads, public utilities, and telecommunication systems in addition to the costs associated directly with the movement of structures. This is deemed reasonable because existing utility ready subdivisions to which threatened infrastructure can be moved simply do not typically exist in rural Alaska. Managed retreat costs do not include cost allocations for airports, schools, or wastewater treatment lagoons unless these facilities are specifically identified as threatened and needing to be relocated.

Protect-in-Place Cost Estimates

When the SMA team determined that protect-in-place solutions were the most likely response for a given community, the group was also tasked to identify the structural measure likely to be implemented and to delineate the area where the measure would be applied. The bulleted list below identifies the range of structural measures delineated by the SMA team. One of these measures was identified as the primary response for each protect-in-place community. The delineation of quantities was recorded on map products.

- Erosion Protection: Structural barrier to stop erosion.
- Flood Protection: Foundation renovations to raise structures above the flood threat.
- Permafrost Thaw Protection: Foundation renovations to prevent damage from thawing permafrost.
- Surface Drainage: Repairs and upgrades to surface drainage systems to accommodate increased annual precipitation.

Subsequent to the work of the SMA team, an engineering consultant was hired to develop unit costs for more specific structural options. Regionally adjusted unit costs for each structural measure was established using the same regional factors as described in the relocation and protect-in- place sections. The list of detailed unit costs used in cost estimates follow below.

- Coastal Rock Revetment for Erosion Control (per lineal foot)
- Riverine Rock Revetment for Erosion Control (per lineal foot)
- Sheet Pile Wall (per lineal foot)
- Residential Structure Foundation Renovation for Flood Protection (per each)
- Community Building Renovation for Flood Protection (lump sum for typical set of public structures)
- Residential Structure Foundation Renovation for Permafrost Protection (per each)
- Community Building Renovation for Permafrost Protection (lump sum for typical set of public structures)
- Surface Drainage for Increasing Annual Precipitation (lump sum per community)

It should be noted that while the list of structural options delineated above is representative of typical options expected to be implemented, it is not a comprehensive list of all available mitigation options. As site specific vulnerability assessments are completed, then additional options are likely to be developed to fit community specific requirements

For estimating purposes, only one of the above options was selected as the primary structural response for each community. The generalized formula for subsequent protect in place cost estimates is as illustrated below.

(Structural Measure Unit Cost x Quantity Required)

Cost Allocation Methodology
Estimates of annual investments required to address infrastructure impacts were made by allocating total estimated costs over time, based on a projected project start date and an idealized project implementation and investment schedule.

Projected project start dates were determined based on a time-to-damage estimate extracted from the *Threat Assessment*. The threat assessment document estimated time to damage for each community as Short Term (1-10 years), Medium Term (10–20 years) or Long Term (> 20 years). Project start dates were extrapolated accordingly.

Implementation schedules were established for Relocation, Managed Retreat, and Protect-in-Place projects. Relocation projects are assumed to last for 15 years from the start date; managed retreat projects 10 years from the start date; and protect-in-place projects 10 -years from the start date. Costs are allocated over the noted time spans based on an idealized investment schedule.

Vulnerability Assessments
As noted previously, this cost estimate was developed without defined adaptation planning at the village level. This challenge highlighted the critical need to complete community-specific vulnerability assessments over the next 3 – 5 years to guide the selection and implementation of reasoned mitigation strategies. As part of this exercise, a separate estimate of the cost to complete these mitigation studies was generated. This estimate was also based on data pulled from the 2019 *Statewide Threat Assessment: Identification of Threats from Erosion, Flooding, and Thawing Permafrost in Remote Alaska Communities.* This analysis estimates that $32 million will be needed for tribes to complete cost effective adaptation projects, community-specific risk assessments.

Barriers That Alaska Native Villages Face When Trying to Meet Their Infrastructure Needs in the Process of Relocating to Higher Ground

There are three identified overarching barriers in addressing infrastructure needs during this process:

1. Insufficient funding and technical support for tribal communities with all stages of relocation (capacity building, risk assessments, planning, implementation);
2. Different objectives and limitations of various program funds are not necessarily specific to relocation, managed retreat, or protect-in-place efforts;
3. State and Federal political transitions can de-stabilize effective long-term resources.

1. Funding and technical support is needed for all stages of relocation efforts.
It is difficult to understate the enormous complexities tribes face to relocate, and the lengthy processes and timelines involved. Acquiring funds, assessing real risk, developing an official plan for the community, implementing coordination at a statewide or regional level, all while under the pressure to keep the community's economy and resolve afloat while floods, erosion, and permafrost subsidence quickly sluff away land that has been stable for centuries. The rate of progress does not oftentimes keep up with the rate of change. To synthesize the complex information required with the urgency of the situation is a challenge. As shown above, many of the Alaska Native villages have achieved success despite these obstacles but at a price.

"Our small community's staff are overloaded and don't have the training and knowledge base to move through the process of government assistance to address climate change impacts."
- Twyla Thurmond, Native Village of Shishmaref

a. <u>Securing funding is expensive.</u> Developing projects and grant applications can be very expensive. Developing a project suitable for a funding proposal (e.g. a scope of work, schedule, and budget) takes dozens of hours and consultation with skilled professionals which may cost $10,000, including travel to coordinate with engineering and construction contractors. After the project is developed, a competitive grant application can take anywhere from 40 to 300 hours and usually requires revising the project scope, schedule, and budget multiple times to meet the needs of the funder. In some cases, such as with FEMA Hazard Mitigation Assistance (HMA) funding programs, it can cost more than a hundred thousand dollars to satisfy the requirements for an eligible grant application. A recent example of this is in Kotlik where the community sought $143,000 from one FEMA program to develop a grant application to a separate FEMA program to pay for the relocation of 21 homes threatened by erosion. In total, meeting the requirements to be eligible to apply for the FEMA program (e.g. an active Tribal or Multi-Jurisdictional Hazard Mitigation Plan), securing funding to meet the grant applications requirements, and developing a competitive funding application for the homes relocation is estimated to cost nearly $200,000. simplifying funding through a lead federal agency would result in cost savings and great benefits to communities.

b. Securing funding is slow. For example, if a managed retreat required five funding sources with an average delay of six months between application and award and a 50% success rate of being awarded, it would then take five years to secure funding. Furthermore, if momentum stops in year three and a community does not have grants to claim indirect costs on, technical assistance to secure funding goes unpaid for.

2. Support for the navigation of available program funding opportunities, not necessarily specific to relocation, managed retreat, or protect-in-place efforts.

Federal agencies are oftentimes obligated to only be able to provide annual, thus temporary or ad-hoc technical assistance as a part of their funding programs or specific projects. To accommodate for the demands of funding sources, progress toward relocation efforts are oftentimes expensive and slow. Many of the Alaska Native villages have hampered and stalled by the myriad objectives and limitations different programs and processes necessary to develop and implement solutions to climate change impacts. A sample of the complexity in funding sources in The Denali Commission's 2018 guide Community Resilience in Alaskan Communities: Catalog of Federal Programs are funding programs that can be used for relocation, although most funding sources used by villages for relocation are not designed specifically to address this problem. Of the 60 programs listed in that publication, only seven in the past two years have awarded funding to communities facing relocation. Some of the requirements for the grants create obstacles that make the grant unattainable for the village relocating. For example, federally funded arctic and climate change *research* have had little practical benefit to communities facing relocating infrastructure. Thus, the area that involves navigation of resource opportunities themselves needs more support.

a. A specific barrier is that some funding programs can exclude Alaska Native villages due to their prohibitively high non-federal cost-sharing and other requirements. Small tribes often are unable to meet cost-sharing requirements greater than zero percent. When a funding program requires cash or in-kind match, most Alaska Native villages do not have the resources to meet the requirement (e.g., staff time, equipment, materials, cash, etc.) and therefore are ineligible to receive support from the program. Alaska Native villages do not have property taxes and, therefore, do not have the basis for the cost-share match. Similarly, communities are not eligible or cannot afford to participate in FEMA's National Flood Insurance Program.

b. Additionally, most funding agencies do not support planning. Most agencies focus on one area, such as housing. Their funding is not available for comprehensive community planning required to coordinate all the disparate pieces of protection-in-place, managed retreat, and relocation. This leads to poor planning, inefficiencies, re-doing portions of projects, and higher long-term operation and maintenance costs for the community.

3. State and federal political transitions can de-stabilize effective long-term financial and capacity-building resources.

A change in elected leadership and the varieties of economic prioritization can continuously shift priorities away from making progress on relocation, managed retreat, and protect-in-place efforts. These fluctuations in national priorities have the potential to impact the entirety of the country long-term, but even more so the vulnerable villages as such, struggling with quickly compounding effects of climate change- but also as the social disparities are larger, as in many tribal communities. This is a long-term stability issue in governance, of many currently available programs that could potentially give increased consideration of enabling support to these types of efforts for remote villages.

a. More long-term multidisciplinary technical assistance teams are needed to support communities to navigate current programs and processes would enable communities to get the infrastructure to support their communities : Supporting communities with long-term multidisciplinary technical assistance team to co-develop an overall strategy, secure funding, and move through the risk assessment, planning, and implementation stages described above. The magnitude of the technical assistance needed depends upon the severity and timing of the climate impacts. For example, some communities with a high capacity, relatively low level of threat, or long-term threats may seek little to no assistance.

Opportunities

To meet the unmet need of $77-97 million needed annually over the next 10 years to Alaska Native villages needing to relocate due to climate change, we offer the following three considerations:

1. Increase funding to federal programs with a demonstrated track record of success in supporting Alaska Native villages to address environmental impacts to infrastructure;
2. Provide the direction for a coordinated, multi-organizational framework, similar to the National Disaster Recovery Framework, charged with addressing the needs of Alaska Native villages; and
3. Provide the direction to waive federal cost-share requirements for Alaska Native villages across federal funding programs.

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Appendix B

Tribal Communities in the Contiguous United States: Unmet Infrastructure Needs and the Recommended Pathway to Address a Fundamental Threat to Lives, Livelihoods, and Cultures

Left side: The Quileute Tribe has endeavored to relocate over the past decade in response to the impacts of storm surges amplified by sea level rise. Climate impacts have severely damaged the Tribe's infrastructure, including transportation, residences, and centers for education and business. Washington State. Image credit: Quileute Tribe Hazard Mitigation Plan, 2015. Right side: Severe flooding has repeatedly impacted the Moapa Band of Paiute Indians reservation, including the adjacent I-15. The Tribe still had not received its federal funding 13 months after the flood. Image credits: Moapa Band of Paiutes Hazard Mitigation Plan, 2015.

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Preface

The Bureau of Indian Affairs developed Appendix B (Report), which outlines the unmet infrastructure needs of tribal communities in the contiguous 48 states who are in the process of relocating to higher ground as a direct result of the impacts of climate change on their existing lands. This Report assesses the impacts of climate change-related factors on the infrastructure of tribal communities across the lower 48 states. This is intended to be an initial step toward understanding a critical need for Tribal Nations and the U.S.

Key Findings

Tribal Nations and their communities ("identified tribes") are recognized as being particularly vulnerable to climate change impacts (Bennett et al., 2014; Jantarasami et al., 2018; USGCRP, 2018), as these impacts function as a threat multiplier to societal challenges that have been imposed upon them for generations. Note that the "identified tribes" in this Report are based off a subset of tribal communities that have been identified to be experiencing infrastructure impacts directly related to climate change. Tribal infrastructure is highly vulnerable to impacts associated with climate, which is particularly troublesome because communities have come to rely upon having resilient systems that are foundational to quality of life in the twenty-first century. Types of at-risk tribal infrastructure for the purpose of this Report include: public safety and health, transportation, education, and culturally important infrastructure. Tribes are contending with multiple climate impacts: flooding and erosion at both coastal and riverine locations, due to sea level rise and extreme precipitation events; storm surges; extreme weather events; and drought-induced wildfire including resultant post-fire flood damage; among others. These environmental threats to infrastructure are very costly to repair or replace, and with proper planning, protecting infrastructure can be a cost-effective option.

The unmet infrastructure needs in this Report are outlined for tribes which are impacted, or are projected to be impacted, by climate change. Final estimates for the unmet infrastructure need were determined by using the difference between Total Need and currently available Existing Support. The estimated, likely underestimated, Total Need for tribes of the continental U.S. is $1.908 billion. In addition, approximately $543 million in annual funding was identified as available for all Tribes in the U.S. (including Alaska). Note that this Existing Support includes agency funding that is additionally available to other entities, rather than only available to the tribes which have been identified as experiencing impacts from climate change. Thus, Existing Support is likely overestimated, since not all Existing Support goes directly to these identified tribes for infrastructure need due to climate change. Here, the difference between the Total Need and the Existing Support is the approximate Unmet Need, which equates to $1.365 billion. This Report also identifies several opportunities that could enable the Federal government and other key players to advance progress toward meeting this Trust responsibility, as well as inform NGOs, and other entities who work with Tribal Nations of the great need related to Tribal infrastructure being impacted by climate change.

1. Introduction

1.1. Climate impacts on tribal communities and infrastructure

Tribal communities have been identified as being highly susceptible to climatic impacts (Bennett et al., 2014). There are many reasons for these vulnerabilities, but the impacts of climate change amplify the threats posed by other social disparities. However, the threat of climate change to tribal infrastructure poses tangible risks to tribal communities. Tribal infrastructure is foundational to the quality of life for tribes and tribal communities, and provides the basis for public safety and health, transportation and livelihoods, education, and maintenance of cultural resources. Many tribes are threatened by various climate change impacts: coastal flooding and erosion due to storm surge, often amplified by sea level rise; and riverine flooding and erosion due to extreme precipitation events; the latter often is amplified by hydrophobic soils, due drought-induced wildfire (USGCRP, 2018). These climate impacts threaten tribal infrastructure, which may require extremely high costs for repair or replacement. A study by the Multihazard Mitigation Council and the National Institute of Biological Sciences estimated that the Nation saves $6 for every $1 invested in disaster mitigation grants by select federal agencies (MMC, 2017). Proactive planning is often more cost-effective, more efficient (thus freeing up valuable time for tribes to pursue their daily activities) and have fewer community impacts. Response and prevention strategies include relocation, managed retreat, or protection-in-place of at-risk infrastructure.

Many coastal tribes are developing climate change vulnerability assessments and adaptation plans to address impacts such as flooding, erosion, due to sea level rise. Inland Tribes are also contending with periodic flooding near rivers during extreme storms, especially in post-wildfire hydrophobic environments. Because hydrophobic soils mean more stormwater runoff, the likelihood of flood events increases. These environmental impacts have severely challenged tribes across the continental U.S. For instance, the Hoh tribe, Quileute Tribe, and the Quinault Indian Nation, located in the Northwest, have sought to move to higher ground for nearly a decade (Walker, 2012; Quileute Tribe, 2017; Quinault Indian Nation, 2019). In coastal Louisiana, the Isle de Jean Charles (the Island), home to the Isle de Jean Charles Biloxi-Chitimacha-Choctaw Tribe, has lost 98% of its landmass since 1955. The Tribe has inhabited the Island since the era of forced removals in the late 1700s and early 1800s; the Tribal community living on the Island has experienced a population decline from 400 to 85 residents (Lowlander Center, 2015). This situation has resulted in separation of families, loss of livelihood, and the loss of culture, due to the destruction of traditional foods and medicines, burial grounds, and other sacred sites. These examples illustrate the threats to resilience that tribal communities are dealing with across Indian Country and Alaska.[1]

Promoting the resilience of tribal communities is an attainable goal that is consistent with the Federal Government's treaty and trust obligations. **Appendix B** outlines the unmet infrastructure needs of tribal communities of the contiguous 48 states and the role that the Federal Government can take to resolve this problem, consistent with its trust obligations. This Appendix is comprised of eight sections. **Section 1: Introduction, Section 2: Background,** outlines the impacts of climate change on the infrastructure of Tribal Nations of the contiguous U.S., and presents an overview of climate factors. **Section 3: Unmet infrastructure needs**, and **Section 4: Root causes of limited progress**, reports the scope of the problem, specifically a cost estimate and causal factors. **Section 5: Opportunities for policy makers**, presents options to address this critical issue. Additional sections are **Section 6: Methods**; **Section 7: Conclusions**; and **Section**

[1] **Resilience**: the capability of a social or natural system to maintain function through periods of change, or alternatively, to reorganize and adapt to meet new challenges (Resilience Alliance 2002).

8: Literature Cited. **Chapter B1** to **Chapter B7** reports infrastructure needs at the level of the BIA Region, or as appropriate, BIA Region group.

The goals of this report are: (1) outline the unmet infrastructure needs of Tribal Nations in the contiguous 48 states of the U.S. in the process of relocating to higher ground as a result of climate change impacts to their existing lands, (2) identifying the existing federal funding that is available for responding to climate impacts on tribal infrastructure, and (3) estimating the funds required to fulfill infrastructure needs, including both planning and implementation of response strategies.

2. Background

2.1. Climate change impacts on the infrastructure of Contiguous 48 States Tribal Nations

Tribal communities across the contiguous 48 states are contending with the impacts of climate change on their infrastructure. Consistent with the federal government's tribal trust and treaty obligations, this critical issue demands action. In this Report, infrastructure refers to the basic physical and cultural structures and facilities needed for the operation of a society or enterprise (Lexico.com, 2020). Here, physical infrastructure consists of (i) transportation (e.g., roads, bridges, marinas); (ii) healthcare; (iii) residences and buildings; (iv) education, businesses, & service infrastructure; (v) water and sanitation; (vi) energy and communication; and (vii) protective structures. This Report also includes cultural infrastructure: the gathering points and accessways to ecological features that are essential to the maintenance of a particular tribal community's traditions and heritage, as well as social cohesion and networks, spiritual practices, and intergenerational knowledge exchange (DLGSC, 2018). Cultural infrastructure examples include salmon fishery sites and huckleberry harvesting grounds for many tribes of the Pacific Northwest, wild rice beds for many tribes of the Great Lakes region, and oyster harvesting grounds for many tribes of the Atlantic coast (Lake et al., 2018; Flanigan et al., 2018; Steen-Adams et al., 2019; Chang et al., 2020; BIA-Midwest Region, 2020). In the aggregate, maintaining functional, sustainable infrastructure is critical to supporting resilient communities, due to the foundational role that infrastructure plays in public health, livelihoods and economies, subsistence lifestyles, community well-being, and culture and heritage. The Federal Government has a fiduciary obligation to Tribal Nations, based on the history of treaties established with specific Nations (Goschke, 2016). The tribal trust relationship confers obligation on the part of the Federal government to protect tribal treaty rights, lands, and resources of Federally-recognized tribes (BIA, n.d., https://www.bia.gov/frequently-asked-questions; ACF, 2014).

Overall, climate change increasingly threatens the infrastructure of tribal communities – as well as non-tribal communities across the Nation – due to heavy precipitation events, coastal flooding, wildfire, and changes to precipitation and temperature (USGCRP, 2018). For tribal communities however, these impacts are pronounced for several reasons. Tribes are vulnerable to enduring disruptions due to underlying issues of poverty, access to human services, and historical contests over sovereignty (Lynn et al., 2011; Norgaard and Karuk Tribe, 2019). In addition, the federal government's maintenance of tribal infrastructure is often deficient; in combination with climate stressors, this situation can render infrastructure inoperable, hazardous, or unhealthful (Jones et al. 2007). For instance, a widespread concern raised by tribal communities is mold in residences, a residual effect after flooding or extreme storms (e.g., Chippewa Cree, 2016). Moreover, public service infrastructure is often subject to severe maintenance deferment. A good illustration of this infrastructural precariousness is the state of the irrigation projects of tribes in the Rocky Mountain and Great Plains Regions: the maintenance deferment for irrigation infrastructure of six tribes was $176,000,000 (Fiscal Year 2014) (GAO, 2015, in Conant et al., 2018). Although irrigation projects are beyond the scope of this report, these data illustrate the broader point of deferred maintenance by the federal government that is prevalent across tribal communities. Finally, many tribal communities are located near coastlines or shorelines, where flooding and erosion, due to storm surges amplified by sea-level rise, has been occurring (USGCRP, 2018).

In response, many tribal communities are contending with the prospect of relocation to higher ground (Bronen, 2011; Albert et al., 2017). For instance, on the Louisiana coastal plain, several Tribal Nations are dealing with such severe flooding and erosive land loss that they must relocate. Likewise, in coastal areas in the Pacific Northwest, several Tribal Nations are considering or have adopted a relocation strategy.

Relocation can be conceptualized as a spectrum of community response strategies: protect-in-place; managed retreat; and relocation. Where feasible, many communities may elect to protect-in-place, such as by constructing shorebank hardening to curb erosion. Elsewhere, communities may opt for managed retreat, where they choose to relocate specified exposed structures, while otherwise maintaining structures that are viable to leave in-place.

On the whole, federal government response to the needs of impacted tribes has been protracted, disjointed, and incomplete in the continental U.S. and Alaska (GAO, 2009; Shearer, 2012; Maldonado et al., 2017). Policy makers have opportunities to improve the capacity of Tribal Nations to plan for, mitigate, and respond to climate hazards through effective policy and targeted appropriations.

2.2. Hazards exacerbated by climate change

Flooding and erosion are primarily impacting tribes located along ocean coastlines, rivers, desert drainage washes, lake shorelines, and near to sloped landscapes with post-wildfire conditions. The primary climatic factors that amplify flooding and erosion are: sea level rise; changes in the timing, form, and amount of winter precipitation; increases in storm frequency and intensity; and wildfire.

2.2.1. Coastal hazards

Tribes along oceanic coastlines face a trifecta of compounding influences on their community infrastructure near the ocean. The combination of sea level rise, high tides, and storm surges accentuate flooding along coastlines. This type of flooding is often accompanied by erosion, which adds to the destruction felt by coastal communities. In addition, increased river flows can combine with seawater levels to flood coastal areas (WCHRN, n.d.).

2.2.1.1. Sea level rise

Climate change is causing sea level to rise due to the melting of polar ice caps, mountain glaciers and the thermal expansion of seawater. Sea level rise does not necessarily happen uniformly along a given coastline. For example, communities geographically adjacent to each other may experience more or less change in sea level, because the very ground their community is built on is moving vertically relative to ocean levels (relative sea level). These vertical land movements affect sea level change on a national, regional, and even a state scale. In New Orleans, the land is lowering (also referred to as subsiding) making sea level rise feel larger than in other Gulf communities whose land is not subsiding. In the United States, the fastest rates of sea level rise are occurring in the Gulf of Mexico from the mouth of the Mississippi westward, followed by the mid-Atlantic (Lindsey, 2019). In Washington State, the Pacific coastline is uplifting rapidly, while the nearby Puget Sound is subsiding (Miller *et al.*, 2018). Scientists found that localized sea level rise predictions are critical to assess flooding vulnerability and for accurate hazard response planning (Miller *et al.*, 2018). At coastlines, topography influences flood magnitude. Topographic variation, particularly coastline steepness, results in variable coastal flooding intensity across regions.

2.2.1.2. Hurricanes, extreme weather events, and storm surges

Extreme weather events (e.g. hurricanes, tropical storms, monsoons, atmospheric rivers, tornados, lightning storms) can cause widespread flooding, wind damage, and start wildfires. Due to sea level rise, coastal storms and high tides have amplified coastal flooding and erosion impacts, and this trend will continue into the future (Fleming et al. 2018).

> *When severe storms such as hurricanes, cyclones, and nor'easters move toward land from the ocean, low pressure and strong winds can push abnormally high water levels onto the coast. Storms moving across the Great Lakes can also produce flood-causing surges. Along ocean coasts, storm surges can produce water levels much higher than normal high tide, resulting in extreme coastal and inland flooding. When a storm surge arrives at the same time as high tide, as it did when Hurricane Sandy came ashore on the East Coast in 2012, it can raise water levels 20 feet or more above mean sea level (Storm Surge | U.S. Climate Resilience Toolkit, no date).*

At the coastline, wind-driven waves can push water higher and further onto land, causing coastal flooding (WCHRN, n.d.). Large waves and storm surges, made more extreme by sea level rise, overtop protective man-made structures like levees and shoreline hardening structures and are a major cause of beach erosion (U.S. Climate Resilience Toolkit, 2020).

> *Recent economic analysis finds that under a higher scenario (RCP8.5), it is likely (a 66% probability, which corresponds to the Intermediate-Low to Intermediate sea level rise scenarios) that between $66 billion and $106 billion worth of real estate will be below sea level by 2050; and $238 billion to $507 billion, by 2100* (Fleming et al. 2018).

2.2.2. River hazards

> *Flooding damage in the United States can come from flash floods of smaller rivers and creeks, prolonged flooding along major rivers, urban flooding unassociated with proximity to a riverway . . . Flash flooding is associated with extreme precipitation somewhere along the river which may occur upstream of the regions at risk. Flooding of major rivers in the United States with substantial winter snow accumulations usually occurs in the late winter or spring and can result from an unusually heavy seasonal snowfall followed by a "rain on snow" event or from a rapid onset of higher temperatures that leads to rapid snow melting within the river basin. In the western coastal states, most flooding occurs in conjunction with extreme precipitation events referred to as "atmospheric rivers" with mountain snowpack being vulnerable to these typically warmer-than-normal storms and their potential for rain on existing snow cover.*

Hurricanes and tropical storms are an important driver of flooding events in the eastern United States (Wehner et al., 2017).

2.2.2.1. Wildfire influence on flooding and erosion

Wildfires are increasing in frequency and severity across the West (Hessburg et al., 2015; Gonzalez et al., 2018). This change in fire behavior can be both attributed to land management practices and climate change. Climate change is increasing wildfire frequency and severity for a number for reasons, including: warming air temperature, loss of soil moisture due to declining snowpack, changes in rainfall patterns, drought, and declining forest health associated with insects and disease. Forest fires also often contribute to an increase in soil erosion and water runoff, which can cause increased impact of flood events.

Wildfires leave the watershed charred, barren, and can physically alter the ground's ability to absorb water, creating conditions ripe for flash flooding and mudflow. Flood risk remains significantly higher until vegetation is restored — up to five years after a wildfire. Flooding after a wildfire is often significantly more severe, as debris and ash left from the fire can combine with eroded soil and sediment to form mudflows (Wise Oak Consulting, L. L. C. S, 2018).

2.2.3. Shoreline hazards

Shorelines along the Great Lakes are also experiencing issues related to erosion and changes in water level. Changing precipitation patterns are causing lake levels to fluctuate more than that which has occurred historically. When this alteration is combined with changes in wind and storm intensity, localized flooding and erosion has the potential to damage infrastructure.

3. Results

This section of the Report strove to develop an estimate of the unmet infrastructure need of Tribes in the continental U.S. The conceptual framework to estimate unmet need consists of three elements: (i) Total Need; (ii) Existing Support (i.e. available resources: financial); (iii) Unmet Need.

3.1. Total Need

The lower bound of the estimated Total Need is $1.908 *billion* (Figure B.1). This value consists of two essential costs: (1) planning costs ($462 *million*) – summarized for all Tribes, for all eight infrastructure types (see Tables B.1 and B.2 for infrastructure types); (2) implementation costs ($1.446 *billion*) – based on the preferred alternative of each Tribe and on documented data. This estimate encompasses the need of all Federally-recognized Tribes of the contiguous 48 states (345 Tribes; nine BIA Regions). However, the value of the implementation estimate should be understood as a *significant underestimate*. As a broad generalization, infrastructure planning has not been conducted for most Tribes, or is at a negligible level of completion. Thus, the documented implementation costs are *significantly less* than the actual need for infrastructure investments. In addition, the documented cost estimates that were included in the calculation of the Total Need only included the documented impacts that were identified during a limited discovery period. The identified planning needs, if resources were made available, would make progress in identifying the total needed investment in tribal infrastructure.

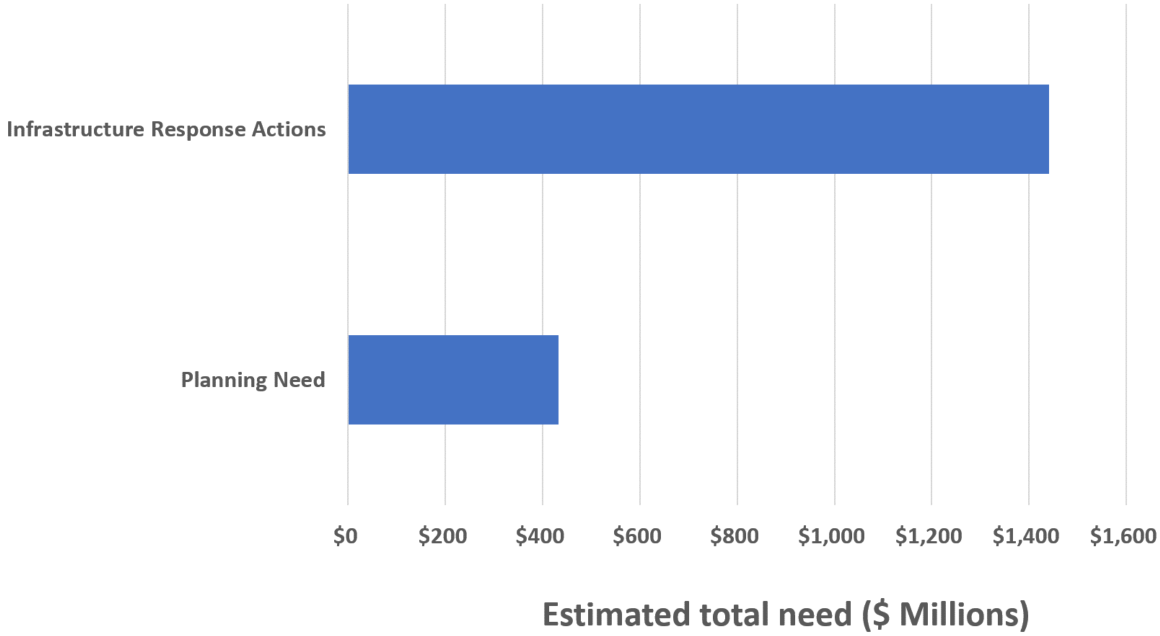

Figure B.1 – Estimated Total Need for infrastructure, as determined for identified Federally-recognized Tribes of the contiguous states of the U.S. (currently, 345 Tribes).

3.1.1. Infrastructure Need, specified by infrastructure type

The estimated need spans eight categories of critical physical infrastructure and cultural infrastructure for both planning and implementation, respectively (Table B.1, Table B.2). Need of these eight infrastructure categories is documented by empirical data, as available, of each Tribal Nation (Chapter B.1 - B.7).

The analysis of infrastructure planning identified 3,083 projects: transportation (339, $50.9 million); healthcare (348, $52.2 million); residences (327, $49.1 million); education, businesses, and services (343, $51.5 million); water and sanitation (345, $51.8 million); energy and communication (341, $51.2 million); cultural (351, $52.7 million); protective structures (349 $52.4 million); and unspecified infrastructure types (340, $51 million). Total planning project costs are approximately $462.5 million (Table B.1).

The analysis of infrastructure implementation identified 115 projects: transportation (16, $116.6 million); healthcare (5, $45.1 million); residences (28, $368.4 million); education, businesses & services (13, $359.9 million); water and sanitation (11, $65.1 million); energy and communication (14, $23.8 million); cultural (5, $13.6 million); protective structures (6, $33.3 million); unspecified infrastructure (16, $419.9 million). Total project costs are approximately $1.446 billion (Table B.2).

	Infrastructure Type									
	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Planning Projects	339	348	327	343	345	341	351	349	340	3,083
Total Estimated Unmet Planning Costs ($, Millions)	$50.9	$52.2	$49.1	$51.5	$51.8	$51.2	$52.7	$52.4	$51.0	$462.5

Table B.1 - Estimated planning costs. Costs pertain to each infrastructure type assessed in this report. Cost estimate pertains only to infrastructure types for which detailed cost estimates were not identified. Planning needs were evaluated for every federally-recognized Tribe in the contiguous U.S. Non-federally-recognized Tribes were outside the scope of cost estimation.

	Infrastructure Type									
	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Implementation Projects	16	5	28	13	11	14	5	7	16	115
Total Estimated Cost for Implementation Projects ($, Millions)	$116.6	$45.1	$368.4	$359.9	$65.1	$23.8	$13.6	$33.3	$419.9	$1,445.5

Table B.2 - Estimated implementation costs. As applicable, the estimate is based on specific infrastructure projects that were identified and reported detailed cost estimates.

Infrastructure type	Needs description examples
Transportation	Roadways ($25 million damage, Bad River Band of Ojibwe, 2016 flood (Fitzpatrick et al., 2017)) Bridges (Quileute Indian Nation)
Healthcare	Healthcare clinic (clinic destroyed by flood, Chippewa Cree Nation, 2010, (Chippewa Cree Climate Adaptation Plan, 2016))
Residences	Houses destroyed by storm surge (Quileute Indian Nation)
Education, businesses, & services	Day care center (destroyed by storm surge, Quileute Indian Nation, 2003 (Quileute Tribe Hazard Mitigation Plan, 2015))
Water and sanitation	Wastewater treatment facility (exposed shoreline site, Passamaquoddy Tribe at Pleasant Point (Wright-Pierce, 2018))[2]
Energy and Communication	Providing emergency backup generators Installation of broadband telecommunications network
Protective infrastructure	Installation of protective levees and dikes Flood Protection Charenton Floodgate (new and rehabilitate old), Chitimacha Tribe of Louisiana[3]; (Spear et al., 2019)
Cultural infrastructure	Restoration of wild rice (*manomin)* gathering grounds (BIA-Midwest Region, 2020) Restoration of oyster reef gathering grounds, Shinnecock Indian Nation

Table B.3 - Documented examples of infrastructure need, by infrastructure type.

3.2.Existing Support: Available federal resources

The total amount of identified federal resources that are available specifically for Tribes is ~$543 *million*; in addition, an estimated $12.225 *billion* is available from other programs that are not limited to Tribal Nations (Figure B.2). The compilation of federal programs (Table B.4) on which this estimate is based, is not exhaustive. Additional programs are available both to Tribal governments and non-tribal entities. Nevertheless, these results report the major relevant programs, based on examination of data resources and outreach response. It is also assumed that these funding programs are available to all Federally-recognized Tribes, including those in

[2] Cost estimate: $10-15 million (Wright-Pierce, 2018).

[3] Chitimacha Tribe of Louisiana, "Priority Concerns", 4 pp., 5/7/20. Tribal staff reported, *For 10 years, the Chitimacha Tribe of Louisiana has been working with the U.S. Army Corps of Engineers (USACE) to address the design and construction of a new floodgate, for both access and flood control. An allocation from Congress was needed in order for USACE to build what had been designed. The total cost is estimated to be $60 million. In February 2020, USACE notified the Tribe that they had received $17 million and could begin Phase I. Approximately $43million is still needed to complete the construction of the new flood control structure.*

Alaska. Thus, these values *overestimate* resources available specifically to identified Tribes of the contiguous U.S which *are* in need of infrastructural resources due to climate change impacts.

Figure B.2 reports the funding appropriation of relevant programs for the most recent fiscal year that could be identified. In many cases, the methodology included reports stating the total funding available in programs for the entire U.S., not necessarily specifically for identified tribes for infrastructure or relocation-related needs. As mentioned, data reported for the entire U.S. therefore inflates the resulting estimate of financial resources available specifically for tribes. In particular, the funding available from FEMA, HUD, SBA, IRS and USDA RD are all available to non-tribal entities as well as tribes.

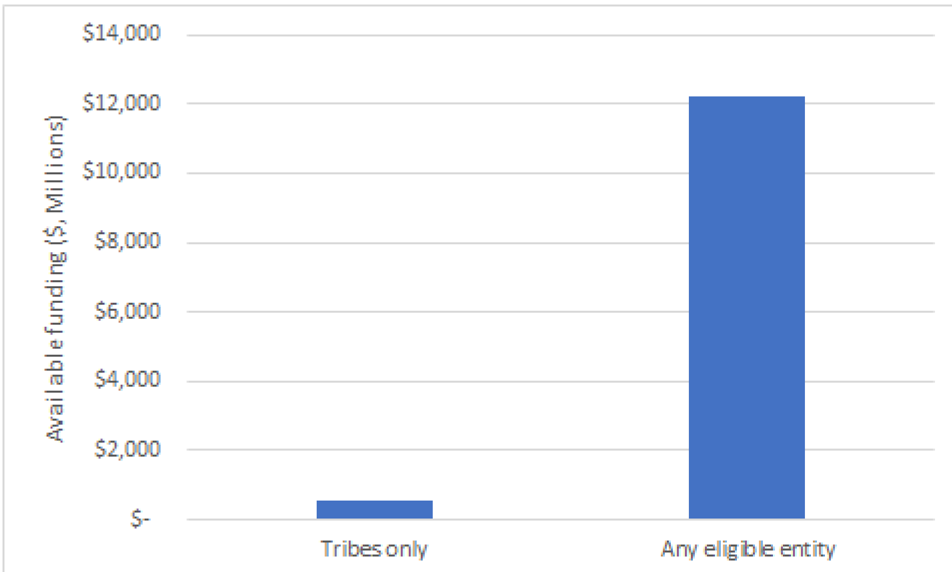

Figure B.2. Existing support: available federal resources. Appropriated funding of all programs identified in Table B.4 for project planning and implementation, as pertains to Tribes only and any eligible entity.

Tribes that are contending with climate-related impacts on infrastructure must navigate an array of federal programs, many of which are administered by distinct agencies (Table B.4). In general, each program is designed to address specified infrastructure needs, e.g. a particular infrastructure type (Table B.5); a particular step in the climate change response process (planning, implementation); or a particular aspect of agency capacity (technical resources, workforce). For tribes that are forced to relocate, or contend with climate impacts on multiple infrastructure types, the complexity can be daunting: tribal governments must allocate staff hours to identifying relevant programs, utilizing an assemblage of resources, and synchronizing resource availability with operational considerations. Resources from state, local, or private entities also may be available, but are not identified in Table B.4.

Federal agency	Program
Army Corps of Engineers (USACE)	● Tribal Partnership Program (Sec. 203) [FY06 $5M; more recent numbers are unknown]
Bureau of Indian Affairs (BIA)	● Tribal Resilience Program [FY19 $8.7M]
Bureau of Indian Education (BIE)	● Education Construction Program [FY19 $25M]
Environmental Protection Agency (EPA)	● Indian General Assistance Program [FY19 $63.3M]
Federal Highway Administration (FHWA)	● Tribal Transportation Fund [FY17 $440.8M]
Federal Emergency Management Administration (FEMA) [FY18 $7,234M]	● Assistance to Firefighters Grant Program ● Emergency Management Performance Grants ● Fire Prevention and Safety Grant Program ● Hazard Mitigation Grant Program ● Individual Assistance Program ● National Flood Insurance Program ● Nonprofit Security Grant Program ● Port Security Grant Program ● Public Assistance Program ● Staffing for Adequate Fire and Emergency Response Grant Program ● Tribal Homeland Security Grant Program

Housing and Urban Development (HUD)	● Indian Housing Block Competitive Grant [FY19 $198M] ● Indian Housing Block Grant ● Indian Community Development Block Grant [FY18 $63M] ● Healthy Homes Production Grant Program for Tribal Housing [FY19 $198M] ● Section 184 Home Loan Guarantee ● Title VI Leveraging ● Tribal Veterans Affairs Supportive Housing (HUD-VASH) [FY17 $7M]
Small Business Administration (SBA)	● Disaster Assistance Program [FY19 $2,200M]
Internal Revenue Service (IRS)	● Tribal Economic Development Bonds [unknown funding available]
USDA Rural Development (USDA RD) [FY17 $33,802M]	● Rural Business Enterprise Grant [FY17 $27.5M] ● Community Facilities Direct Loan & Grant Program [FY17 $2,893M] ● Water and Waste Disposal Loan and Grant program [FY17 $1,316M] ● Emergency Community Water Assistance Grants [FY17 $590M] ● Rural Electric Program and Telecommunication Infrastructure Loan Program [FY17 $4,732M]

Table B.4. Federal agencies and programs relevant to climate change-related infrastructure needs of Federally-recognized Tribes. Table content was modified from a compilation by the Quinault Indian Tribe (Quinault Indian Nation, no date). (Note: Federal agencies and programs that are potentially relevant, but were not feasible to document during the reporting period: (1) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, "Superfund"); (2) National Oceanic and Atmospheric Administration (NOAA) Climate Program Office; (3) NOAA Office for Coastal Management.)

3.2.1. Federal programs for project implementation, by infrastructure type

Federal programs generally are designed to address a specific type of infrastructure need. Consequently, Tribes that are contending with relocation or other climate change impacts must cobble together resources that span many programs (Table B.5).

Infrastructure type	Programs
Roads	● Federal Highway Administration: Tribal Transportation Program (formerly, BIA Indian Reservation Roads Program) ● USDA Rural Business Enterprise Grant ● HUD Indian Community Development Block Grants
Water, wastewater and stormwater	● USDA Rural Development: Water and Waste Disposal Loan and Grant program ● USDA Rural Development: Emergency Community Water Assistance Grants Program ● Economic Development Administration: Public Works Program ● USDA Emergency Community Water Assistance Grants ● Indian Health Service
Telecommunications	● USDA Rural Development: Rural Electric Program and Telecommunication Infrastructure Loan Program
Housing	● Dept. of Agriculture Rural Development: Multi-Family Housing Direct Loan Program
Community buildings	● USDA Rural Development: Community Facilities Direct Loan & Grant Program ● FEMA Pre-Disaster Mitigation Grant Program ● Indian Community Development Block Grants

Table B.5 - Federal programs for project implementation, by infrastructure type.

3.2.2.Funding for planning

- Federal Highway Administration Tribal Transportation Program funds planning improvements of roads, as well as pedestrian and bicycle facilities, parking areas, interpretive signage, and transit programs, all of which will be included in the new village. $9.5M was available for Tribes in 2018.

- BIA Tribal Climate Resilience Program: The BIA Tribal Climate Resilience Program (TCRP) provides federal resources to tribes and tribal organizations to build capacity and resilience through competitive awards for tribally designed resilience training, adaptation planning, vulnerability assessments, supplemental monitoring, capacity building, delivery of data and tools, training, and youth engagement. The TCRP funding does not currently support implementation projects (other than feasibility or desktop studies, onsite assessments, etc.), meaning that no development, construction, or other earth-moving activities may be funded. TCRP funding also does not focus specifically on infrastructure planning, however, infrastructure planning related to relocation, managed retreat, and protect-in-place activities are supported if impacts are directly related to climate change.

In Fiscal Year 2020, there have been 56 requests received from identified tribes. The program will award ~$6.4 million to identified tribes for relocation planning, managed retreat, protect-in-place, and other climate impacts-related infrastructure planning. Total program funding available is approximately $14.4 million. Most identified tribal requests will be funded (82%). However, TCRP funds are not sufficient to meet the needs of all identified tribes: 18% of requests went unfunded. Unmet funding requests, including identified tribes of both the Lower 48 and Alaska, are $1.4 million.

Title	**Requests**	**Funded**	**Unmet needs**
Identified Tribes	56	44	10
Amount	$7.8 million	$6.4 million	$1.4 million

Table B.6 - BIA Tribal Resilience Program (TRP), FY 2020. Analysis of Lower 48 and AK, combined.

TCRP funding requests from tribes of the Lower 48 totaled ~$3.5 million (FY 2020). These requests were made by 24 identified tribes, from six different BIA regions: Northwest (OR, WA), Pacific (CA), Western (NV, UT, AZ), Great Plains (ND, SD, NB), Eastern Oklahoma (OK), and Eastern (states from Maine to Florida over to Louisiana and up to Illinois).

3.3. Unmet infrastructure need

This section of the Report outlines the determined unmet infrastructure need. The conceptual framework to estimate the value of unmet infrastructure need, is the difference between Total Need and Existing Support (i.e. available resources). The estimated Unmet Need generated by this analysis is roughly $1.365 billion, based on the estimates of Total Need ($1.908 *billion* (Figure B.1) and Existing Support, or federal resources only available to Tribes (~$543 *million*, Figure B.2). This value is assumed to be much lower than the actual need, however, for the reasons identified in Section 3.1.

In addition, eligibility for federal program resources is contingent on Federally-recognition status; however, many Tribes lack federal-recognition (e.g., state-recognized Tribes; unrecognized Tribes). Many Tribes consequently are ineligible to access the reported resources, despite contending with unmet infrastructure need.

4. Key factors affecting limited progress on climate change response

For tribal communities, the planning and implementation of relocation, managed retreat, and protect-in-place strategies involve distinct challenges. Tribes across the U.S. have been contending with existing impacts on infrastructure, exacerbated by climate change impacts on infrastructure, yet limited progress has been made (Quileute Tribe, 2017). For instance, the Quileute sought to relocate for decades, after enduring repeated coastal and riverine flooding impacts. The root causes of this situation can be distilled down to several key factors:

- Insufficient financial resources and unrecognized costs
- Pre-existing vulnerability of infrastructure, due to deferred maintenance by the federal government and other factors

- Incompatibility between the structure of federal programs and the multi-sector nature of relocation planning and implementation
- Capacity shortfalls, exacerbated by inefficiencies
- Baseline data gaps

4.1. Insufficient financial resources and unrecognized costs

Tribal community relocation involves a number of costs that are essential to maintaining tribal community lifeways, livelihoods, and community well-being, yet are often overlooked. Relocation poses distinct challenges for tribal governments and communities. Social science knowledge about this topic has been developing over the past decade (e.g., Kingston and Marino, 2010; Marino et al., 2012; Maldonado, 2014). Communities and investigators have observed that government programs are often ill-suited to covering several types of costs (Marino, Maldonado, and Jerolleman, pers. comm., 4/21/20):

- Costs associated with retention of ownership and title to land from which communities relocate.
- Costs associated with the infrastructure necessary to support continued physical access to land and waterways that are often essential to a Tribe's traditions and subsistence livelihoods.
- Costs associated with community led planning for resettlement and relocation.
- Maintenance of current infrastructure, protection, and habitability at the current site, while relocation is in process (which can require extended periods).
- Financial mechanisms to support residents in the process of relocation. This would include assistance with existing financial obligations.

4.2. Pre-existing vulnerability of infrastructure, due to deferred maintenance

The infrastructure of tribal communities is vulnerable often to damage from climate related impacts, due to pre-existing conditions, exposed location, and/or deferred maintenance by the federal government (Conant et al., 2018). Tribal communities report that fundamental elements of housing or other types of infrastructure often are either absent or of a type of construction that is susceptible to catastrophic damage from extreme events. Another issue is the prevalence of exposed locations, such as a floodplain. For instance, members of the Fort Belknap Tribe voiced these concerns:

> *There are many preexisting challenges with housing in the Fort Belknap Indian Community that make residents particularly vulnerable to climate change impacts. First, there is a shortage of housing. The Lands Department works with 2.5-acre home site leases but lacks sufficient home sites to meet demand. As a result, the majority of houses are overcrowded. Second, most housing is old and in need of repair, making homes susceptible to damage from extreme weather events. For example, many HUD homes here are old and dilapidated. Third, many homes lack proper landscaping, such as proper drainage. Poor drainage increases moisture collection around the home and causes molding. A lot of older homes were even built without rain gutters. Finally, some houses are built in flood zones, primarily in scattered sites where people built on their own lands (Fort Belknap Indian Community, Climate Change Adaptation Plan, in-preparation).*

A related issue is the prevalence of deferred maintenance to infrastructure. For instance, the deferred maintenance of irrigation projects of six Tribal Nations in the Northern Great Plains is

$176,000,000 (Table B.7). Although irrigation projects are beyond the scope of this Report, these data illustrate the broader point of deferred maintenance that is prevalent across tribal communities.

Irrigation Project	Deferred Maintenance for FY 2014	Replacement Value
Blackfeet	$26,000,000	$50,000,000
Flathead	$82,000,000	$237,000,000
Fort Belknap	$8,000,000	$19,000,000
Fort Peck	$13,000,000	$33,000,000
Crow	$17,000,000	$59,000,000
Wind River	$30,000,000	$93,000,000
Total	**$176,000,000**	**$491,000,000**

Table B.7 - Deferred maintenance and replacement costs for U.S. Bureau of Indian Affairs irrigation projects on six Northern Great Plains reservations (2014 dollars). Source: U.S. Government Accountability Office, 2015, in Conant et al., 2018.

4.3. Incompatibility between the structure of federal programs and the complexity of relocation planning and implementation

Federal programs generally are ill-suited to the complex, multi-part operations that characterize tribal relocation.

- Current funding sources do not address complex, multi-layered, comprehensive problems due to narrowly focused funding objectives (e.g., unable to fund road construction, relocate utility infrastructure, and fund mixed use housing developments). For instance, a member of the Quileute Tribe observed,

  There is difficulty in financing some new developments, especially neighborhoods. Funding can be obtained from Housing and Urban Development (HUD), but only for affordable housing. We are trying to do a mixed-income development. We'll need to build road and sewer/water infrastructure simultaneously, but Department of Transportation (DOT) grants only cover roads. Indian Health Service (IHS) funding solely covers utilities. If there were some sort of integrated funding, that would be advantageous. Also, transportation grants that we'd use to construct roads are often based on criteria such as traffic alleviation, good repair, reducing crashes, and economic competitiveness. These are all admirable goals, but we simply need to provide people a place to live and save lives from tsunamis. (Quileute tribal member, personal communication, 2020).
- Residential infrastructure programs typically are open only to individuals, not communal owners (e.g., HUD programs). Such program rules are out of sync with the communal tenure concept as is held by many tribes; this incompatibility between federal program rules and tenure concepts of many indigenous groups has posed an access barrier, such as to the Isle de Jean Charles Biloxi-Chitimacha-Choctaw Tribe (Lascurain, pers. comm, 4/16/20).

- It has been reported that in some cases, federal partners and tribal governments have a difference in interpretation about acceptable allocations of available resources (Chippewa Cree Tribe, 2016). Thus, there may be opportunities for adding clarity about acceptable uses of funding, but this could also be met by removing excessive limitations of how tribes are able to spend funding on infrastructure projects.
- Tribes are required to have FEMA-approved hazard mitigation plans to be eligible for FEMA's National Flood Insurance Program so that they can access funds from the Disaster Recovery Program. Furthermore, those plans need to be approved by state and local governments. This is an example of an existing institutional barrier for Tribes.
- In addition, some Tribes are enrolled in relevant non-FEMA insurance programs, which makes them ineligible to receive FEMA Disaster Recovery funding. It would be beneficial to ensure that non-FEMA insurance programs are sufficient so that FEMA was able to allow Tribes to access Disaster Recovery Funds despite their insurance provider. This would protect non only infrastructure, but also the local economies of Tribal Nations.
- Hazard assessment based on FEMA flood insurance studies does not take into account hazard due to climate change effects, thereby potentially underestimating actual hazard: *"It is worth emphasizing that sea level rise projections are different from Federal Emergency Management Agency (FEMA) flood insurance studies, because (1) FEMA studies only consider past events, and (2) flood insurance studies only consider the 100-year event, whereas sea level rise affects coastal water elevations at all times" (Miller et al., 2018)*.

4.4.Capacity shortfalls, exacerbated by inefficiencies

- Tribal governments often lack the workforce or staff with the technical capacity to carry out hazard mitigation assessment, climate planning, grant acquisition, or grant management.
- The piecemeal nature of acquiring funding from disparate programs results in an inefficient use of workforce time (Table B.4, Table B.5).

4.5.Baseline data gaps

- The basic data for hazard mitigation and climate change response planning often are absent, despite location on exposed sites for many Tribes.

5.Opportunities for Improvement

Advancements in meeting the unmet infrastructural needs for identified tribes can be achieved through a variety of steps. The key factors identified in the previous section highlight several concepts that are worth considering for improving the situation for Tribes. As sovereign Nations, it is essential that Tribes have autonomy in planning and implementing their preferred climate change responses through a process that is self-led, self-determined, and government-assisted (Shearer, 2012; Maldonado et al., 2013). Two overarching, concrete actions to advance fulfillment of this need are these: (1), the Federal Government can provide funding to enable needed planning for and implementation of tribal strategies for relocation, managed retreat, or protection-in-place of tribal infrastructure; (2) the Federal Government agencies can address the institutional barriers to enhance coordination, efficiency, and effectiveness of existing programs.

These actions are detailed below. Several additional opportunities for moving these goals forward are also highlighted.

5.1. Opportunity to invest financial resources

An obvious step towards meeting the unmet infrastructure need of Tribes includes identifying or developing resources that are commensurate with the problem magnitude. A related step is timely appropriation, in response to the urgency. This disparity between the need and resource availability is likely the biggest barrier to federal program effectiveness in supporting Tribes with relocation, managed retreat, and protect-in-place planning. Related essential considerations include: the preferred mitigation activities of Tribes; pre-existing vulnerabilities; and deferred maintenance of infrastructure.

5.2. Opportunities for overcoming existing institutional barriers

5.2.1. Establishment of a federal government interagency structure that coordinates federal programs and resources

Establishment of an interagency structure that coordinates federal programs and resources would prospectively increase effectiveness and efficiency. This step could increase tribal access to resources (financial, information) and technical expertise by increasing navigability (Bronen, 2011). This development may reduce institutional barriers across and within federal agencies. It would be beneficial to enter into Tribal Consultation regarding this effort (Steen-Adams et al., in press), as tribes have extensive insight into the challenges that they face when attempting to work within the federal system.

5.2.2. Making programs more compatible with tribal needs

There are opportunities to develop program structures that align with the insights gained from work with Tribes (Marino, Maldinado, and Jollerman, pers. comm., 4/21/20). Insights that would be worth considering include:

- Remove the cost sharing or match requirements for funding, particularly in rural and impoverished communities.
- Budget and account for the full costs of implementing integrated tribal relocation, managed retreat, and protect-in-place infrastructure efforts; if the assessment of costs stops at the point of physical relocation and only considers the built infrastructural needs, the community will unjustly bear the externalized costs and experience increased impoverishment.
- Floodplain location, or other sites that have been exposed to repetitive flooding, characterize the homelands of many Tribes. Infrastructure needs often are currently unmet due to multiple challenges with building and maintaining habitable infrastructure in such hazardous locations. Therefore, rebuilding funds must allow for land in a non-hazardous location, as well as the structure.
- Establish an independent monitoring program to oversee the fulfillment of tribal needs; and promptly resolve procedural hurdles noted by Tribes. These steps can help to overcome the often-prevalent history of distrust between Tribes and federal agencies.

5.3. Opportunity for additional study

Development of **Appendix B** for identified tribes of the contiguous 48 states occurred over a compressed period, with an extensive research effort. However, additional research and outreach will be needed to develop more opportunities for improvement in addressing unmet infrastructure need.

5.4. Opportunities for overcoming constraints on tribal capacity

For many tribal governments, a significant barrier is insufficient workforce capacity and expertise. In many cases, there are limits to the number of tribal staff with the expertise or technical background to assess tribal infrastructure that is at risk of short or long-term climate impacts. Furthermore, the specialized skill sets that are necessary for developing cost estimates and implementation plans are needed. There are many approaches to addressing this constraint:

- Funding resources could be directed towards tribal capacity building projects. This is the case for some programs (e.g., BIA Tribal Climate Resilience Program (Categories 1 and 2); in general, however the need exceeds available resources (Table B.6).[4]
- Support professional training of the tribal government workforce.
- Support for training of future tribal workforce through investments in youth engagement and training efforts.
- Direct support for positions that conduct climate change response planning and implementation.
- Development of standards and guidelines by the BIA and other relevant agencies for tribes to consider adopting within hazard mitigation plans, risk management plans, climate adaptation plans, climate vulnerability assessments, etc. Identifying specific suggestions for the types of information that would be useful for tribes to document, so that they will be best prepared to take advantage of federal programs to move forward with their tribal preferred infrastructural responses (e.g., specific rough cost estimates for preferred activities so that they can quantify their infrastructure needs).

In response to Report outreach, one Bureau of Indian Affairs resource manager observed,

> *Several Tribes lack the capacity to do the kind of planning needed (e.g., structural engineering, geological, hydrological risk assessments, contract negotiation, and community design planning identified). Anecdotal evidence from those working directly with Tribes suggests that some smaller tribes struggle to differentiate between infrastructure in jeopardy and infrastructure in need of routine maintenance. The BIA Tribal Climate Resilience Program has a grant category dedicated to these tribes (facing relocation-related decisions). Because of the lack of professional training in various disciplines requiring advanced degrees, some Tribes may assume that they've done an adequate job of planning. This would open the door to occurrences of a Tribe developing plans that may fail to cover critical planning areas (in absence of technical assistance, guidance, or helpful planning standards). I think technical support is needed to empower Tribes that lack these advanced professional capacities and potentially inadequate plans. I have contended (for several years now) that BIA would be of good service to develop recommended standards for tribal emergency management plans, climate adaptation plans, and vulnerability assessments. This would ensure BIA meets its trust in terms of providing for public safety in a proactive way by ensuring a minimal standard of quality is provided"* (Anderson, pers. communication, 4/16/20).

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[4] Relevant categories of the BIA TRP include Category 1: Workshops and Trainings; Category 2: Adaptation Planning (https://www.bia.gov/sites/bia.gov/files/assets/bia/ots/tcrp/2019_TRPAwardSummary.pdf, accessed 5/7/20).

5.5. Opportunities for addressing technical and data resource constraints

One data limitation that many tribes encounter is access to accurate and up-to-date FEMA flood maps (Figure B.5). These data products are generally available for most communities in the contiguous states and identifies terrain that is at risk of flooding at different time intervals. Having these maps more readily available would allow tribes to identify infrastructure at-risk of flooding impacts. These data products have not been developed for many tribal reservations. This opportunity could be easily taken through an existing processes already in place for developing these maps, in addition to U.S. government access to available expertise. This said, federal agency experts note a practical constraint of hazard mapping efforts: potential sanctions of risk mapping on tribal lands.

> *Although knowing the risk is optimal, any ramifications from being mapped leading to potential sanctions is concerning for tribes; even to the point of not participating in the mapping efforts to protect themselves (Keys, 4/14/20).*

6. Methodology

Chapters B1 - B7 generated both regional- and national-scale summaries of the unmet needs of identified tribal infrastructure impacted by climate change. Analysis was organized by BIA Region (Figure B.3). In specified instances, analysis was organized by BIA Region group (Chapter B4, Rocky Mountain Region, Great Plains Region; Chapter B5, Southern Plains Region, Eastern Oklahoma Region). A multi-level geographical approach was adopted. First, analysis was conducted at the regional-scale, based on data resources of identified tribes within the respective region. Second, the regional analyses were summarized to the national-scale – that of the contiguous 48 states – generating an initial national assessment of infrastructure need. This differs from the methodology employed to develop Appendix A for the Alaska Region.

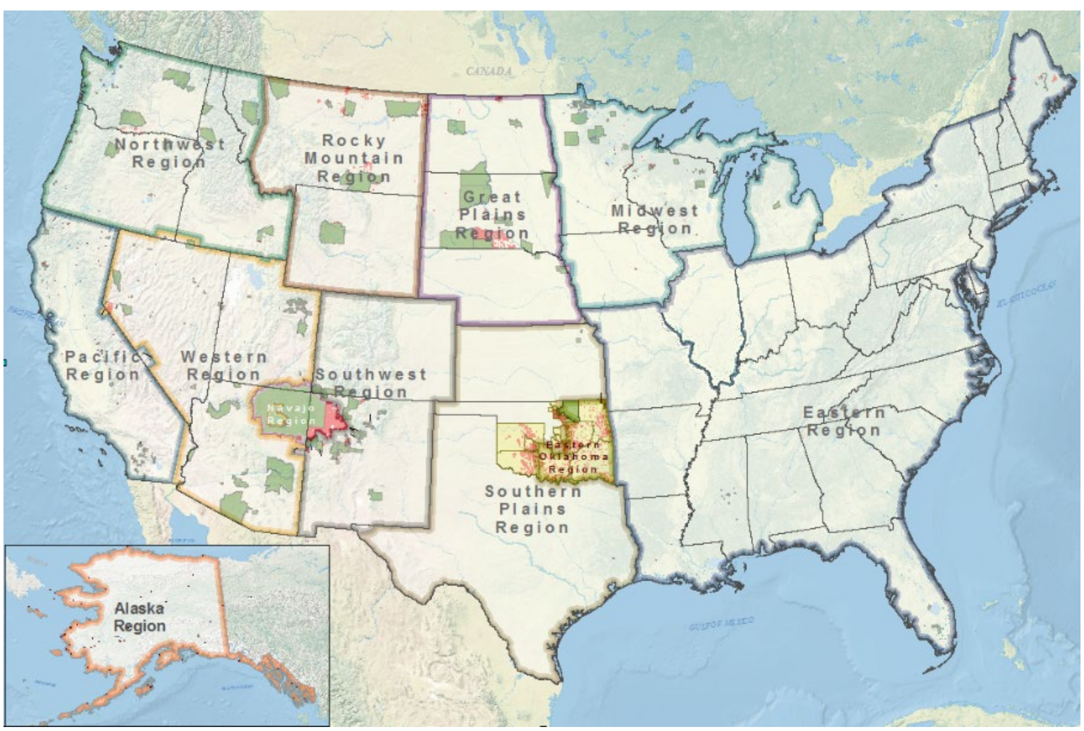

Figure B.3 - BIA administrative regions.

6.1. Data resources

Information and relevant documentation was gathered through outreach to professional staff from Federal agencies (BIA, USGS, IHS, EPA, NRCS, and FEMA), Tribal Nations, state agencies (Dept. of Transportation), intertribal organizations, and others. The resulting documentation included hazard mitigation plans (HMPs), climate change vulnerability assessments (CCVA), climate change adaptation plans (CCAP), project plans developed by environmental engineers, and grant applications. Additional documents were identified by mining document databases and targeted research.

6.2. Estimate of unmet need

The documents were reviewed to identify specific information (if available), including: impact response strategy,[5] types of at-risk infrastructure, cost information for implementing the preferred response actions for each type of infrastructure, and total estimated cost to implement the overall response strategy across all types of infrastructure. Where specific cost information was available, costs were aggregated regionally and nationally to quantify the estimated costs for overcoming the unmet tribal infrastructural needs. Where this information was not available, data was entered based on a 5-level cost category (for specific details, see table legend).

Second, an estimate of infrastructure planning cost was calculated --specifically that of hazard mitigation planning. This estimate was based on an assumption of $150,000 per infrastructure type, per identified tribe. This estimate includes only infrastructure types for which a detailed cost estimate does not currently exist, as determined for each identified tribe. These values were aggregated regionally and nationally to estimate the planning needs for the tribes in the contiguous 48 states.

Federal agency funding reports were reviewed to compile data about available resources. The data are based on the most recent data, as discovered during the report development period. This information was gathered for all the relevant programs that were identified during the discovery process. The available funding for each program was aggregated based upon whether the funding was available only for tribes, or whether it was available to other entities as well.

6.2.1. Constraints on Report findings

This report is an initial effort at a national scale to estimate the Unmet Need, due to climate change factors, of tribal infrastructure. The available data resources on which the estimate is based were incomplete, however. This constraint is due to conditions that limited the effectiveness of outreach – in particular, with tribal staff. Key conditions were: (i) the coincidence of the COVID-19 pandemic with the report-development period; and (ii) the short timeframe of the report outreach and writing (4 weeks), relative to the national scope and requirement for data spanning nine BIA Regions. For many tribes, the workforce priorities focused on COVID-19 considerations, and routines were disrupted. Federal agency staff often

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[5] Protect-in-place: Assumed to be the least expensive mitigation strategy and assumed to be the default approach for impacted tribal infrastructure unless specified.
Managed retreat: Gradual relocation of select tribal infrastructure over time.
Relocation: Moving all infrastructure from one location to another location that is less susceptible to climate impacts.

were similarly affected, resulting in a low response rate for that data collection as well. For these reasons, this report constitutes an initial step toward addressing an important need across tribal communities.

In addition, while Tribal reservations are frequently included in FEMA Hazard Mitigation Plans (HMPs) for states or counties, a layperson that is unfamiliar with the geography would often be unable to separate the "tribal" mitigation actions vs. nontribal. Some plans separate them, but most do not. For this project, tribal HMPs were usually most helpful. Yet, there are likely to be many planning documents from states or counties that cover tribal lands and could be used by someone familiar with the area to gather additional details that would benefit a similar assessment.

In addition, the use of FEMA HMPs for states or counties as a key data source imposed a limitation on data quality, in some cases. HMPs often serve as a valuable data resource, due to frequent inclusion of tribal reservations frequently within the plan's geographical scope. In some cases, however, the research team's lack of familiarity with the geography hampered capacity to distinguish the tribal vs. non-tribal mitigation actions. Some plans distinguish tribal lands, but many do not. Many of the available planning documents cover tribal lands yet are not feasible to interpret at the geographical scale appropriate to this assessment.

Lastly, when developing HMPs, tribes and decision makers may not be recommending solutions to solve the basic cause of a problem, but rather they could be identifying temporary solutions due to the overall high expected expense of solving the real problem (e.g. location). Most tribes and other governmental entities likely identify solutions that are considered to be achievable. Thus, a review of existing documents alone is not the ideal solution to addressing the key factors affecting unmet infrastructure need, as more communication and outreach would greatly benefit Report findings.

7.Conclusions

The impacts of climate to tribal infrastructure have also been indicated as a concern not only for the communities themselves that are being impacted, but also by the U.S. House of Representatives Committee of Appropriations. The Committee indicated a particular concern for coastal tribal communities, Alaska Native villages, and Alaska Native Corporations that face challenges to their long-term resilience due to the impacts of climate change.

Overall, it is apparent that the unmet infrastructure needs of tribal communities are very high and difficult to quantify comprehensively in a short period of time. Given the ubiquitous nature of climatic impacts, it is safe to assume that *most tribes* are likely to be threatened by extreme events or long-term environmental trends associated with climate. For example, the nature of inland flooding gives good reason to suspect that most inland tribes are susceptible to the impacts of flooding. Similarly, there is equally good reason to suspect that most coastal tribes are prone to the impacts of coastal erosion or flooding. Many tribes are experiencing increases in frequency of wildfire occurrence in certain regions due to climate-induced drought. Wildfire has the potential to burn infrastructure within a community, but it may also burn key infrastructure components that are found outside of the community. Further, wildfire also has the potential to amplify the infrastructure impacts of climate change-related flooding in post-wildfire hydrophobic environments.

In this Report on unmet Tribal infrastructure needs, an estimated Total Need of $1.908 *billion* was identified, but this estimate was also assumed to be *much lower* than the actual need, as discussed in the Results section. This value consists of two essential costs: planning ($462 *million*) and implementation ($1.446 *billion)*. An estimated $543 *million* in Existing Support through annual funding is currently available to Tribal Nations, but this should be considered to be *much higher* than the amount that goes directly toward specific tribes who may want to focus on infrastructure need due to climate-related impacts. There are many challenging issues that tribes are dealing with on a regular basis, and the unmet funding need for their physical and critical infrastructure would be difficult to underestimate.

This Report also identifies numerous opportunities to make progress toward meeting the infrastructural needs of Indian Country. In tribes' efforts to become more resilient to the impacts of climate change, tribes are reducing other climate change amplification of social disparities imposed upon their communities. Yet, there is tremendous need in Indian Country for assistance (financial and technical) to address the monumental challenges posed by climate change impacts on infrastructure. This Report is an attempt to assess infrastructure impact at a both a regional national scale, and should be understood as an initial step toward understanding an important need across tribal communities.

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Chapter B1. Northwest Region

1. Regional Overview

In the BIA Northwest Region, there are forty-four Federally-recognized Tribes (Figure B1.1) and 14 unrecognized tribes within Washington, Oregon and Idaho. Tribes live along the Pacific Ocean coast, the inland Puget Sound, along the mighty Columbia and Snake Rivers, and smaller navigable rivers. An ecologically diverse region, tribes face several climate change impacts to their physical and cultural resources.

Approximately 60% of Federally-recognized Tribes in the Northwest Region have developed climate change vulnerability assessments for their communities. Over 60% have hazard mitigation plans that address climate impacts. If not explicit in tribal or agency documents, the default response strategy was assumed to be protect-in-place, due to the lower cost burden. Cost estimate information was retrieved from available documents, although many tribes lack capacity and funding to develop infrastructure cost estimates. The known funding need is estimated to be $540M, representing the lower boundary of funding needs. Actual funding needs are anticipated to be higher than estimated, due to unforeseen contingencies.

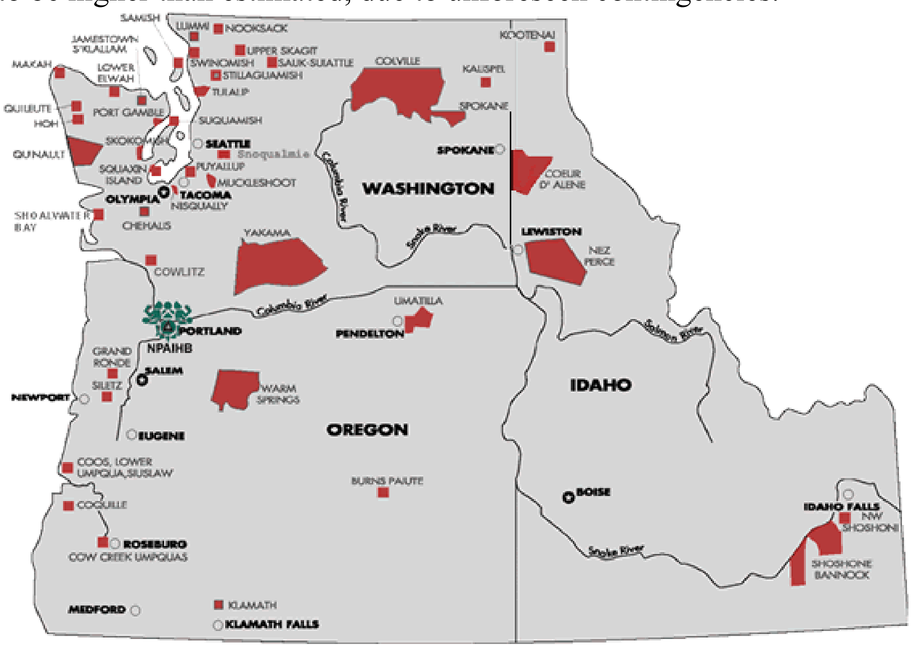

Figure B1.1 - Federally recognized tribes in the Northwest Region. Source: http://www.npaihb.org/clickable-map/

2. Tribes and climate impacts

The Northwest Region tribes are already experiencing climate impacts and are leading the Nation in assessing hazard vulnerability, and developing climate adaptation and resiliency plans. To determine Northwest tribal infrastructure needs, the Report team reviewed tribal documents, county/state HMPs, and corresponded with knowledgeable staff from a multitude of intertribal, federal, and state agencies. Due to the concurrent COVID-19 crisis, additional documentation and direct consultation with more Tribal Nations would improve unmet need estimates.

The estimated need is $462.5 million (362 projects) for planning; and $540.4 million (25 projects) for implementation (Table B4.1).

	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified Infrastructure	Total
# Implementation Projects	40	40	38	40	40	40	40	42	42	362
Total Estimated Unmet Planning Costs ($, Millions)	$50.9	$52.2	$49.1	$51.5	$51.8	$51.2	$52.7	$52.4	$51.0	$462.5
# Implementation Projects	3	3	5	3	3	3	3	1	1	25
Total Estimated Cost for Implementation Projects ($, Millions)	$80.0	$44.3	$33.1	$263.0	$40.0	$16.0	$13.0	$10.0	$41.0	$540.4

Table B1.1 - Infrastructure needs analysis of Northwest Tribes.

3. Climate change hazards that affect Northwest tribes

3.1. Synopsis of regional climate change projections

Warming and related changes in climate are already affecting aspects of the natural resource economy and cultural heritage of the Northwest Region. The region has warmed substantially—nearly 2°F since 1900. The Northwest is projected to continue to warm during all seasons under all future scenarios...The warming trend is projected to be accentuated in certain mountain areas in late winter and spring, further exacerbating snowpack loss and increasing the risk for insect infestations and wildfires. Average winter precipitation is expected to increase over the long term, but year-to-year variability in precipitation is also projected to increase. Years of abnormally low precipitation and extended drought conditions are expected to occur throughout the century, and extreme events, like heavy rainfall associated with atmospheric rivers, are also anticipated to occur more often. Along the coast, severe winter storms are also projected to occur more often, such as occurred in 2015 during one of the strongest El Niño events on record. El Niño winter storms contributed to storm surge, large waves, coastal erosion, and flooding in low-lying coastal areas. Changes in the ocean environment, such as warmer waters, altered chemistry, sea level rise, and shifts in the marine ecosystems are also expected. These projected changes affect the Northwest's natural resource economy, cultural heritage, built infrastructure, recreation, and the health and welfare of Northwest residents (May et al. 2018).

Figure B1.2 - "Windblown waves from Puget Sound batter houses in Seattle". Photo: Elaine Thompson/ AP. Source: (Le, 2018).

3.2. Sea level rise

In Washington, "absolute sea level rise will reach or exceed 4.1 feet for a low greenhouse gas scenario, 4.8 feet for a high greenhouse gas scenario by 2100, . . . An extreme high-end projection, which we consider to represent an approximate physical upper limit for sea level rise. . . We project an upper limit of 8.3 feet of absolute sea level rise by 2100" (Washington State Report, 2018 (p.7). Disparate, relative sea level changes will be felt by Tribal Nations in Washington State due to vertical land movement.

3.3. Flooding and erosion along rivers

This occurs when a river or stream overflows its natural banks and inundates normally dry land. Most common in late winter and early spring, river flooding can result from heavy rainfall, rapidly melting snow, and severe storms.

3.3.1. Land use impacts on flood risk

Both inland and coastal tribes experience flooding from rivers. Coastal tribes often experience impacts from both river flooding and coastal inundation impacts, while inland tribes experience flooding from both large rivers and smaller streams. Climate change drivers that cause river flooding is exacerbated by upstream land use changes that diminish stormwater absorption capacity into rivers. Tribal resilience efforts often emphasize restoration of natural ecosystem functions upstream of their communities to reduce river flooding hazards. Although reducing climate change impacts is a global effort, Tribes can increase natural buffering capacity and combat climate change on a local level.

3.3.2. Declining snowpack

In the Northwest, warming air temperatures are affecting the mountain snowpack in two important ways that contribute to flooding hazards:

> *The key climate concern relative to flooding is increasing temperatures and its effect on snowpack and the timing of spring runoff. By the 2050s average maximum winter temperatures are projected to be between +3º F and +8º F (RCP 8.5). These projected increases in winter temperatures will mean that more precipitation will fall as rain (versus snow), reduce the snowpack, and increase the potential for flooding* (Nasser, E., Petersen, S., Mills, P., 2015).

3.3.3. Changes in storm frequency and intensity

In general, the precipitation pattern in the Northwest has been characterized as strong, frequent rain and snowstorms throughout winter months, and dry summers with episodic rainstorms. Although the general pattern of wet winters and dry summers will likely remain the same, the precipitation amount and type falling during the winter is shifting. Warming air temperatures mean more rain falls instead of snow in the winter.

3.3.4. Sediment build-up in rivers increases flooding

When sediment builds up in riverbeds, the sediment reduces the capacity of a river to carry as much water as before the sediment was deposited. One cause is widespread glacier recession in combination with extreme storm events. Melting glaciers leave behind vast deposits of loosely packed sediment (unconsolidated sediment), which is vulnerable to erosion. Intense rainstorms can mobilize this loose sediment and also cause landslides, which rapidly deposit sediment into the river channel. Large rain events produce enough water to carry these sediments downstream in the flatter river valleys. This sediment frequently is deposited near communities that are typically located in the flatter, more hospitable valley bottoms. More frequent flooding ensues as reductions in water carrying capacity forces the river to overflow protective embankment structures.

3.3.5.Wildfires

Wildfires are increasing across the West in frequency, duration, and intensity. Climate change is increasing wildfires for a number for reasons including: warming air temperature, loss of soil moisture due to declining snowpack and changes in rainfall patterns, drought, and declining forest health from insects and disease.

Wildfires often have a catastrophic effect on flooding and erosion in nearby tribal communities. Communities are observing frequent wildfires that burn the landscape more severely and frequently. Because severely burned soil repels water, rain runs off the surface and quickly overwhelms drainage channels accustomed to accommodating much smaller water volumes. As more and more water overwhelms the small creeks, washes and rivers, the water begins to erode the land and a natural cycle of increased erosion occurs.

4.Cultural impacts

The Pacific Northwest is blessed with natural beauty, where enjoyment of the natural environment is part of the Indigenous and non-indegenous culture.

Rampant population growth in the region has resulted in a multitude of environmental assaults on the region's aquatic ecosystems. The harvest of salmon in the Pacific Northwest, the cultural lifeblood of numerous regional tribes, has declined as much as 90 percent over the past few decades. The plunge has resulted from a variety of human impacts, all of them aggravated by climate change (Wall, 2008).

Figure B1.3: Salmon by Haisla, Heiltsuk artist, Mervin Windsor (https://nativeartprints.com/collections/catalogue/products/salmon-by-mervin-windsor)

(Please see Appendix C: Case Studies C.15 & C.16 for the Northwest Region)

Chapter B2. Pacific Region

1. Tribes, environmentally-threatened tribal communities, and climate change hazards

There are 104 Federally-recognized Tribes in the BIA Pacific Region, which includes most of California. In addition, there are many state-recognized tribes, as well as unrecognized tribes (Figure B2.1). These communities are located in areas that span from arid deserts in Southern California, to urban environments, to temperate rainforests, to high elevation mountainous environments with abundant snowfall.

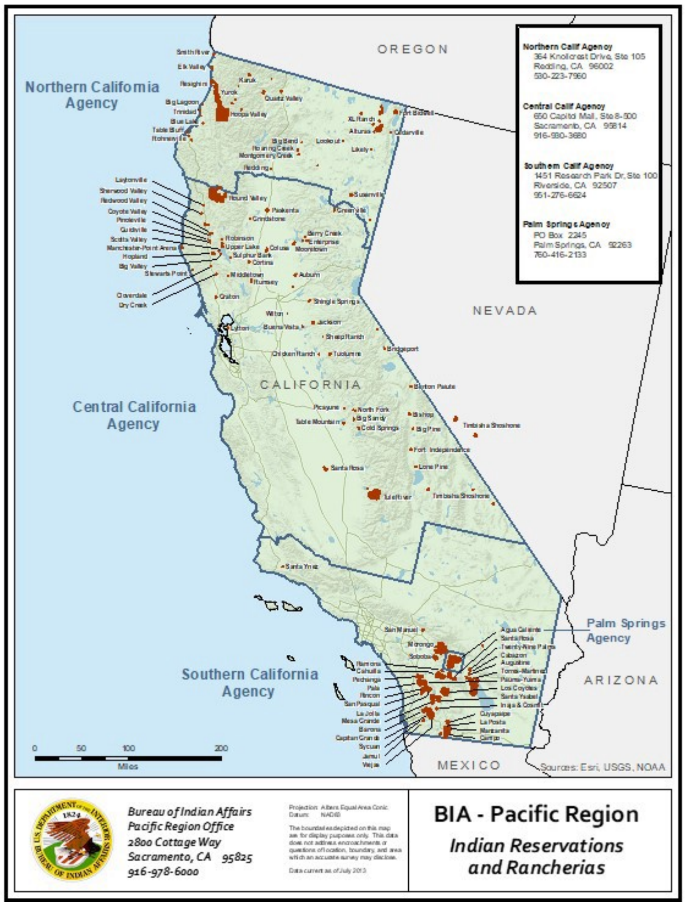

Figure B2.1 - Federally-recognized Tribes located in BIA's Pacific Region (Bureau of Indian Affairs; https://www.bia.gov/sites/bia.gov/files/assets/public/webteam/pdf/idc1-028635.pdf).

Tribal communities of the Pacific Region are contending with numerous impacts of climate change: coastal and riverine flooding and erosion associated with storm surges, sea level rise, and extreme precipitation events. Many tribes are located along the California coasts and/or rivers, where susceptibility to flooding and/or erosion is especially acute. In addition, there is a prevalence of steep areas that are susceptible to landslides and exacerbated by extreme precipitation events and/or wildfires. Region-wide, these types of impacts can affect all infrastructure types, as well as communities and individuals.

Wildfire exacerbates many other climate-related factors that impact community vulnerabilities (Gonzalez et al., 2018, Figure B2.2). In general, tribal reservations and communities in both rural and urban landscapes are frequently threatened not only by the direct infrastructural impacts of wildfire (burning of all types of infrastructure), but also the secondary impacts of loss of electricity. In some cases, power poles, power lines, and other energy infrastructure are impacted directly. In other cases, the electrical infrastructure has sparked major wildfires during drought conditions that are coupled with severe wind events. The 2019 Camp Fire is just one example of a recent utility-initiated wildfire. In response to the devastating effects of catastrophic wildfire, electric utilities have started shutting off power to large regions of the electric grid so that they are less vulnerable to starting wildfire. This hazard directly impacts tribal and non-tribal communities in both urban and rural landscapes.

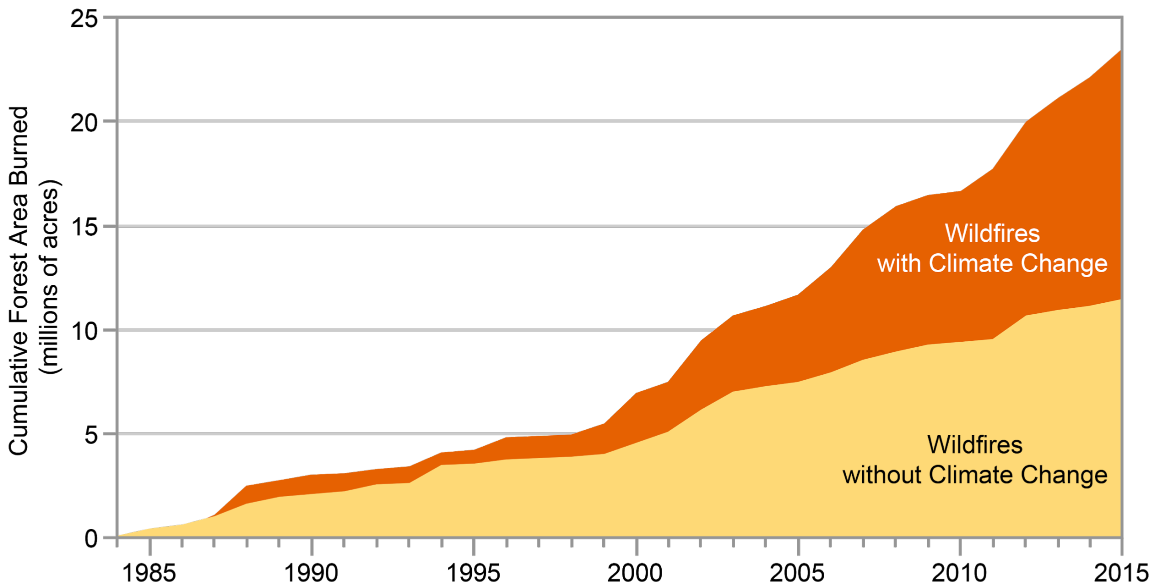

Figure B2.2 - Climate change effects on wildfire, as indicated by cumulative area burned. Source: adapted from Abatzoglou and Williams 2016, in Gonzalez et al., 2018.

2. Response strategies by infrastructure type: needs assessment

2.1. Infrastructure impacts

The main infrastructure types that are reportedly affected by climate change-related impacts are transportation, residences, and energy and communications infrastructure, specifically power lines (Table B2.1).

2.2. Response to climate change impacts and resource needs

The response of Pacific Region tribes to climate change is projected to span the range of response strategies, including protect-in-place, managed retreat, and relocation options (Kitto, pers. comm., 4/18/20). The projected costs to relocate a single tribe is estimated at multiple millions ($USD). Cost estimates for the protect-in-place and managed retreat strategies were not able to be generated for multiple reasons. One contact noted, "Specialized studies would be needed to put a price tag on any future response efforts. One issue is determining the severity of the threat, such as 100-year versus 500-year flood events, or local fires versus regional firestorms. Estimated costs would vary depending on the level of threat in the scenario" (Kitto, pers. comm., 4/18/20). The take-away is that the cost magnitude for climate change response for each tribe is potentially very large – as a reference point, the relocation of the Isle de Jean

Charles community was $48 million (Lowlander Center, 2015) – yet, there is substantial lack of precision in the current capacity to generate a cost estimate, due to the dearth of data resources. The estimated need is $138.8 million (925 projects) for planning; and $8.4 million (11 projects) for implementation (Table B2.1).

	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Planning Projects	101	104	102	104	104	101	103	103	103	925
Total Estimated Unmet Planning	$15.2	$15.6	$15.3	$15.6	$15.6	$15.2	$15.5	$15.5	$15.5	$138.8
# Implementation Projects	3	0	2	0	0	3	1	1	1	11
Total Estimated Cost for Implementation Projects ($, Millions)	$4.6	$0.0	$0.3	$0.0	$0.0	$2.5	$0.5	$0.5	$0.0	$8.4

Table B2.1. Analysis of unmet infrastructure needs, due to climate change impacts, of tribes in the Pacific Region.

Chapter B3. Western Region, Navajo Region, and Southwest Region

There are 41 Federally-recognized Tribes in the BIA Western Region; 1 tribe in the Navajo Region; and 25 tribes in the Southwest Region. There are also many state-recognized tribes, as well as unrecognized tribes.

> *Staff members repeatedly echoed the need for a long view when considering the complexity of natural resource management in a changing climate. As Mike Montoya explains, "it is yet unclear how climate change will affect our lives and the lives of our children," though one thing is certain to him, "destructive events – wildfires, floods, and extended drought – are no longer rare and stochastic as I once believed…they are dramatic evidence of climate change. It is clear that a shift has occurred and continues to occur in the Sacramento Mountains. Healthy rain events that once brought life-giving moisture are now catastrophic floods that carry deadly ash and silt." Montoya explains that we must first understand the impacts of climate change and use that knowledge to adapt. Says Montoya, "I am afraid that if we do not learn from our errors, and constantly strive to live as one, living in harmony with our environment, with the Earth Mother as our teacher and not our experiment, then we will become the victims of our own endeavors."* (Montoya and González-Maddux, 2013).

Tribes in these regions are among the most vulnerable of the areas' residents to climate change.

> *Native Americans are among the most at risk from climate change, often experiencing the worst effects because of higher exposure, higher sensitivity, and lower adaptive capacity for historical, socioeconomic, and ecological reasons. With one and a half million Native Americans, federally recognized tribes, and many state-recognized and other non-federally recognized tribes, the Southwest has the largest population of Indigenous peoples in the country* [note: California Tribes included]. *Over the last five centuries, many Indigenous peoples in the Southwest have either been forcibly restricted to lands with limited water and resources or struggled to get their federally reserved water rights recognized by other users. Climate change exacerbates this historical legacy because the sovereign lands on which many Indigenous peoples live are becoming increasingly dry. Further, climate change affects traditional plant and animal species, sacred places, traditional building materials, and other material cultural heritage. The physical, mental, emotional, and spiritual health and overall well-being of Indigenous peoples rely on these vulnerable species and materials for their livelihoods, subsistence, cultural practices, ceremonies, and traditions* (Gonzalez et al., 2018).

1. Climate change impacts on Tribal infrastructure

The estimated need is $80.6 million (537 projects) for planning; and $848.7 million (59 projects) for implementation (Table B3.1).

	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Implementation Projects	56	62	48	60	63	64	66	64	54	537
Total Estimated Unmet Planning Costs ($, Millions)	$8.4	$9.3	$7.2	$9.0	$9.5	$9.6	$9.9	$9.6	$8.1	$80.6
# Implementation Projects	10	2	18	7	4	2	1	2	13	59
Total Estimated Cost for Implementation Projects ($, Millions)	$32.0	$0.8	$326.9	$92.9	$8.7	$0.8	$0.1	$7.7	$378.9	$848.7

Table B3.1 - Analysis of unmet infrastructure needs, due to climate change impacts, of Tribes in the BIA Southwest Region, Western Region, and Navajo Region.

2.Climate change hazards: flooding and wildfire

2.1.Flood causes

Tribes in these arid regions contend with an array of climate change alterations to precipitation patterns. Drought is the primary climate change stressor affecting the region's tribes. The sovereign lands on which tribes live are becoming increasingly dry affecting food security. This is a major concern for many tribes, as exemplified by the Navajo Nation (Navajo Nation, 2018). Tribes are also experiencing the devastating interplay between drought, poor land management, and lack of vegetation that creates very hazardous flooding events during the monsoon season (A. Walker 2020, personal communication, April 17).

Figure B3.1. Flooding on the Navajo Nation. Photo credits: Left: KOAT 7, 11/22/3013; Right: Navajo Nation (2013).

Flooding is frequently caused by three different precipitation scenarios:

Tropical Storm Remnants: Some of the worst flooding tends to occur when the remnants of a hurricane that has been downgraded to a tropical storm or tropical depression enter the state. These events occur infrequently and mostly in the early autumn, and usually bring heavy and intense precipitation over large regions causing severe flooding.

Winter Rains: Winter brings the threat of low intensity; but long duration rains covering large areas can cause extensive flooding and erosion, particularly when combined with snowmelt.

Summer Monsoons: A third atmospheric condition that brings flooding to Arizona is the annual summer monsoon. In mid to late summer the monsoon winds bring humid subtropical air into the state. Solar heating triggers afternoon and evening thunderstorms that can produce extremely intense, short duration bursts of rainfall. The thunderstorm rains are mostly translated into runoff and, in some instances, the accumulation of runoff occurs very quickly resulting in a rapidly moving flood wave referred to as a flash flood (JE Fuller Hydrology & Geomorphology, INC., 2015).

2.2.Types of flooding

Due to the arid nature of these regions, flooding takes several forms and impacts communities differently. Flash floods are especially dangerous because often there is little warning and time to react. In their hazard plans, many Tribes identified installing emergency warning systems in their communities as key infrastructure improvements.

***Flash floods** tend to be very localized and cause significant flooding of local watercourses. Damaging floods in the county can be primarily categorized as either riverine, sheet flow, or local area flows. **Riverine flooding** occurs along established watercourses when the bank full capacity of a wash is exceeded by storm runoff and the overbank areas become inundated. There are also areas within the county where the watercourse is broad and generally shallow with ill-defined low flow paths and broad sheet flooding. **Local area flooding** is often the result of poorly designed or planned development wherein natural flow paths are altered, blocked, or obliterated, and localized ponding and conveyance problems result. Erosion is also often associated with damages due to flooding (JE Fuller Hydrology & Geomorphology, INC., 2015).*

*According to the Utah Division of Emergency Management (DEM), the main type of flooding in the Skull Valley Reservation is **alluvial fan flooding**. Alluvial fans develop at the base of steep mountains or hills, such as the Stansbury Mountain Range. Alluvial fans form where a stream leaves steep mountains and meets flatter ground, as shown in Figure 4. These streams carry soil and rock from the hillside or mountain to the valley floor below. Eroded material piles up and spreads out at the base of the mountain or hillside, forming what looks like a fan (Skull Valley Band of Goshute Floodplain Management Plan, 2018).*

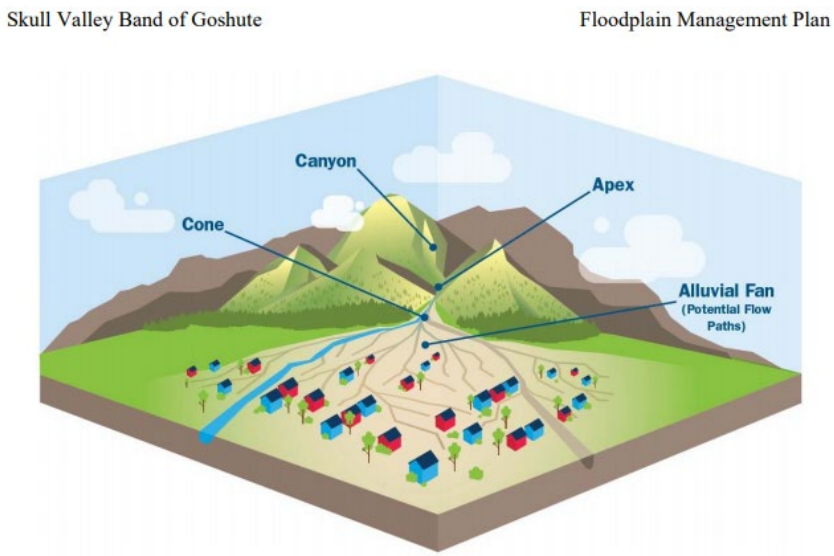

Figure B3.3: There are two types of alluvial fan flooding affecting the Reservation: streamflow and debris flow. Streamflow flooding occurs typically in arid mountainous regions that are dry most of the year. Streams only flow after brief and intense storms like thunderstorms or when the snow in the mountains melts each year. Snowmelt runoff water may only flow for a few weeks of the year. (Skull Valley Band of Goshute Floodplain Management Plan, 2018).

> *The path that water takes in a streamflow flood event changes often, and the flows can be dangerous. Heavy rain or snowmelt can cause flash floods over alluvial fans. When water is flowing on an alluvial fan, soil gets washed away by the rushing water and moved downstream, blocking the stream's path. When the stream's path gets blocked, it is forced to move in a different direction. It is challenging to know when an alluvial fan will flow, where the flow will go, and when the flow path will change (Skull Valley Band of Goshute Floodplain Management Plan, 2018).*

2.3.How will climate change influence flood risk?

Changes in the amount and intensity of rainfall, as well as warming air temperatures that influence whether precipitation falls as rain or snow, are shifting in these regions. The monsoon pattern has changed with rain falling in larger amounts and greater intensity (Wotkins, 2011).

> *Climate models project an increase in the frequency of heavy downpours, especially through atmospheric rivers, which are narrow bands of highly concentrated storms that move in from the Pacific Ocean. A series of strong atmospheric rivers caused extreme flooding in California in 2016 and 2017. Under the higher scenario (RCP8.5), models project increases in the frequency and intensity of atmospheric rivers. Climate models also project an increase in daily extreme summer precipitation in the Southwest region, based on projected increases in water vapor resulting from higher temperatures.*
> *In parts of the region, hotter temperatures have already contributed to reductions of seasonal maximum snowpack and its water content over the past 30–65 years, partially attributed to human-caused climate change. Increased temperatures most strongly affect snowpack water content, snowmelt timing, and the fraction of precipitation falling as snow* (Gonzalez et al., 2018).

2.4. Wildfires increase flood risk and severity

An exacerbating factor to flooding is wildfire. Santa Clara Pueblo has probably had the most catastrophic results related to wildfire and post-fire flooding, according to local experts (Cruz, personal communication, 2020).

> *Wildfires leave the watershed charred, barren, and can physically alter the ground's ability to absorb water, creating conditions ripe for flash flooding and mudflow. Flood risk remains significantly higher until vegetation is restored — up to five years after a wildfire. Flooding after a wildfire is often significantly more severe, as debris and ash left from the fire can combine with eroded soil and sediment to form mudflows (Wise Oak Consulting, L. L. C. S, 2018).*

Cochiti Pueblo and Santo Domingo (Kewa Pueblo) also faced significant flooding following the Cerro Grande and Las Conchas Fires in the Jemez National Forest. Southwest Tribal Climate Change Workshop participants noted "There's been an increase in fire intensity and frequency. Fire intensity is increasing, affecting the water quality, fisheries, traditional and exotic species, salamanders, mudslides, flooding, and endangering historical sites. Grazing permits were lost because of the Wallow Fire, causing an economic impact on the tribe. More acres are burning each year" (Wotkyns, 2011).

> *Wildfire is a natural part of many ecosystems in the Southwest, facilitating germination of new seedlings and killing pests. Although many ecosystems require fire, excessive wildfire can permanently alter ecosystem integrity. Climate change has led to an increase in the area burned by wildfire in the western United States. Analyses estimate that the area burned by wildfire from 1984 to 2015 was twice what would have burned had climate change not occurred (Figure 25.4). Furthermore, the area burned from 1916 to 2003 was more closely related to climate factors than to fire suppression, local fire management, or other non-climate factors* (Gonzalez et al., 2018).

(Please see Appendix C: Case Studies C.17 & C.18 for the Western, Navajo and Southwest Region)

Chapter B4. Rocky Mountain Region and Great Plains Region

1. Tribes and climate change hazards

There are nine Federally-recognized Tribes in the BIA Rocky Mountain Region and sixteen tribes in the BIA Great Plains Region (Figure B4.1). In addition, state-recognized tribes, as well as unrecognized tribes may be located in these two regions. Here, these two BIA administrative regions were grouped together, due to relative cohesion as a distinct biophysical unit - that of the Upper Missouri River Watershed --to assess climate change impacts, following (Conant et al., 2018). Variability within these two regions is noted --particularly associated with that of montane vs. plains social-ecological systems.

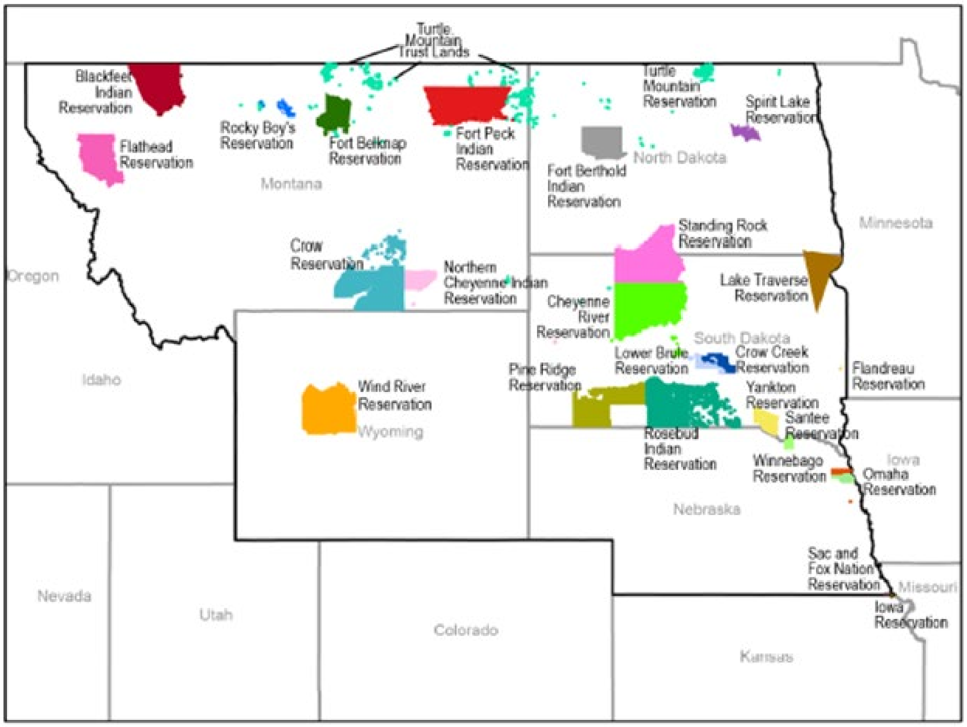

Figure B4.1 - This map illustrates the locations of the 27 federally recognized Tribes in the Northern Great Plains BIA Region Source: Conant et al., 2018.

Overall, climate models suggest that the number of extreme precipitation events (> 1 inch precipitation / day) is projected to increase across these two regions, with the exception of high mountain sites in the southwestern area (Conant et al., 2018). This change is projected because the Upper River Missouri Watershed – within which lie the BIA Rocky Mountain and Northern Great Plains Regions – is very sensitive to climate fluctuations, resulting in extreme precipitation or drought events roughly every decade over the past century (Conant et al., 2018). For instance, a flood occurred in 2011, followed by a drought in 2012.

1.1.Flooding

The main climate change impact relevant to infrastructure needs of the HR 116-100 request is flooding and erosion, due primarily to extreme storms and precipitation events (Conant et al., 2018). Several tribes have reported heavy precipitation events in recent years. For instance, authors of the Chippewa Cree adaptation plan observed,

> *Beginning on June 17, 2010 and lasting for four days, a massive storm cascaded rain on the Rocky Boy's Reservation [of the Chippewa Cree] in northern Montana. A Presidential Disaster Declaration was signed on July 10, 2010 nearly one month after a major rainstorm resulted in flooding on the Rocky Boy's Reservation. Three floods occurred within three years, all of which resulted in separate federal flood disaster declarations. The first flood occurred in 2010, and the second and third floods in 2011 and 2013. Approximately 150 stream miles were affected by the flooding* (Chippewa Cree, 2018).

Expanding upon the 2010, 2011, and 2013 events, the Chippewa Cree reported broader observations of climate change impacts on their homeland area:

> *Most of the precipitation falls during the warm period from April to September and is heaviest from May to August. Annual average precipitation is 10 to 13 inches, except up to 20 inches in the higher elevation of the Bears Paw Mountains. The heaviest most intense precipitation often occurs with localized downpours associated with thunderstorms in June through August. Significant flash flooding can result from these downpours with over four inches of precipitation reported in a few events. Widespread heavy precipitation events of one to two inches can occur every few years and are most common from April through June and September through early November. Severe thunderstorms are common from June into early September. Typically the greatest hazards associated with these thunderstorms are very high winds and large hail which cause damage to structures and crops every summer. Tornadoes have been reported, but are relatively rare.*
> *The highest wind gusts often occur with thunderstorms during the summer, with gusts over 60 mph occurring every year. The highest sustained winds tend to occur in the spring and fall, with sustained winds over 40 mph occurring every year. Strong winds lasting for several days at a time occur in the spring and fall* (Chippewa Cree, 2018).

An exacerbating factor is rain-on-snow events. When such events occur, it can increase the risk of flooding - a concern raised by the Confederated Tribes of Salish Kootenai (CTSK, 2016), as well as the Fort Belknap Tribe (Fort Belknap Tribe, plan-in-development).
Tribes of this region have also documented hydrological alterations, and consequent tribal community impacts (CTSK, 2016):

> *Hydrology – This area has already experienced many changes in hydrology patterns. The snow water equivalent (SWE) of winter snowpack has declined, stream flow has declined (especially late summer flow), and water temperatures have increased. The time of many events, such as average freeze and thaw dates, has also changed substantially over the last 50-100 years.*
> *Future expected trends include longer and lower summer stream flows, increasing flood risks and more precipitation falls as rain instead of snow, increasing summer stream temperatures, and declining groundwater recharge.*
> *The geographical impact on people is Reservation wide. It is expected that the more isolated communities will be affected the most by climate change. Some of the impacts will include increased flooding that washes out roads and bridges. This will make service delivery and emergency response more difficult. The timeframe of these impacts is near-term (0-10 years)* (CTSK, 2016, p. 46).

1.2. Wildfire

Tribal communities have also raised concern regarding potential increase in wildfire severity and frequency on their communities (Figure B4.2). For instance, the Chippewa Cree adaptation plan observed, “Fire severity can be expected to increase given warmer and drier conditions. An assessment of climate change and forest fires over North America Projected 10-50 percent increases in seasonal severity rating (SSR) over most of the U.S., implying increases in area burned and fire severity” (Chippewa Cree, 2018).

Figure B4.2 - Concern regarding the effects of potential changes in wildfire frequency and severity on the Blackfeet Nation (Blackfeet Nation, 2018 (photo by Sadie Harwood).

2.Response strategy by infrastructure type: needs assessment

The estimated need is $34.7 million (231 projects) for planning; and $0.3 million (3 projects) for implementation (Table B4.1).

	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Implementation Projects	26	26	26	25	26	24	26	26	26	231
Total Estimated Unmet Planning Costs ($, Millions)	$3.9	$3.9	$3.9	$3.8	$3.9	$3.6	$3.9	$3.9	$3.9	$34.7
# Implementation Projects	0	0	0	1	0	2	0	0	0	3
Total Estimated Cost for Implementation Projects ($, Millions)	$0.0	$0.0	$0.0	$0.1	$0.0	$0.2	$0.0	$0.0	$0.0	$0.3

Table B4.1. Infrastructure needs assessment, Rocky Mountain and Great Plains Regions.

The primary response strategy of these two regions is protect-in-place, as exemplified by the climate change adaptation plans of the Confederated Tribes of Salish and Kootenai, the Fort Belknap Tribe, and the Blackfeet Tribe. In addition, at least one tribe has adopted a hybrid of managed retreat and protect-in-place. The Chippewa Cree Tribe (of the Rocky Boy's Reservation) has relocated a specified structure - its healthcare facility, which was previously cited on a location vulnerable to flooding --while protecting other critical infrastructure (Chippewa Cree Tribe, 2018):

> *The flooding of June 2010 resulted in a Presidential Disaster Declaration for the damages sustained in Hill County and the Rocky Boy's Reservation. The Natoose Healing Center, otherwise known as the Rocky Boy health care facility, was demolished as a result. Long Term Community Recovery involved partnerships to move construction of the new healthcare facility and flood recovery forward. The Middle Dry Fork area along Upper Box Elder Road was selected by the Tribe as the ideal re-development site in line with tribal planning prior to the flood. The first disaster in 2010 represented a new frontier for FEMA in the intergovernmental working relationship between the federal government and a tribal government.*
>
> *FEMA (Federal Emergency Management Administration) presence became standard at Rocky Boy's and the Tribe demonstrated a strong, effective emergency response and administration in this second disaster only to be followed by a third flood and subsequent federal disaster declaration again in 2013.*

Review of the available documents indicated that climate change-response infrastructure needs raised by tribal communities primarily fell into these categories: (i) transportation; (ii) housing and buildings; (iii) water and sanitation; in addition, tribes voiced needs for healthcare infrastructure; and communications infrastructure (Table B4.1). Below, the infrastructure needs are detailed.

An expert panel on climate change impacts on the Northern Great Plains (including the Rocky Mountains) concluded that tribal communities in this region are highly vulnerable to climate change impacts in terms of human health, livelihood, and community wellbeing. A major reason for this high level of vulnerability is the already compromised state of the infrastructure of many tribal communities. The authors observed,

> *In the Northern Great Plains, just under 29,000 (76%) Indigenous house-holds are in need of new or improved sanitation facilities, and approximately 5,000 households lack safe water supply, sewage facilities, or both. The total cost to remediate sanitation facility deficiencies in the region was estimated at around $280 million according to a 2015 annual report from the Indian Health Service. Climate change has already begun to exacerbate the problem of disruptions to water supplies from decreased water availability, as happened in 2003 when Standing Rock Reservation ran completely out of water during drought* (Conant et al., 2018).

A good illustration of this infrastructural precariousness is the state of the irrigation projects of many of the region's tribal nations (Table B4.2). Although irrigation projects are beyond the scope of this Report, these data illustrate the broader point of deferred maintenance that is prevalent across tribal communities of these two BIA regions.

Reservation Irrigation Projects: Deferred Maintenance and Replacement Costs

Irrigation Project	Deferred Maintenance for FY 2014	Replacement Value
Blackfeet	$26,000,000	$50,000,000
Flathead	$82,000,000	$237,000,000
Fort Belknap	$8,000,000	$19,000,000
Fort Peck	$13,000,000	$33,000,000
Crow	$17,000,000	$59,000,000
Wind River	$30,000,000	$93,000,000
Total	**$176,000,000**	**$491,000,000**

Table B4.2. Deferred maintenance and replacement costs for U.S. Bureau of Indian Affairs irrigation projects on six Northern Great Plains reservations (2014 dollars). Source: U.S. Government Accountability Office, 2015, in Conant et al., 2018.

2.1.Transportation infrastructure

A main theme of the region's tribal communities is concern regarding the effects of extreme precipitation events on bridges and roadways (Figure B4.3). For instance, at least 6 bridges of the the Fort Belknap community required replacement due to recent floods (2006, 2009, 2011, 2013): ...Three other bridges on Highway 66 were replaced, because of damage from the 2011 and 2013 Floods to Peoples Creek: Crazy Bridge, Prince Brockie Bridge and the Thomas Bridge, all in the old Hays area where Peoples Creek crisscrosses the highway. In some instances the underlying infrastructure condition is hazardous: "over the years several fatalities have occurred on or near this bridge. There is absolutely no space on the sides of the bridge to walk, only drive, with one lane going each way with a guard rail."

Figure B4.3 - Impacts of severe precipitation events on transportation infrastructure, Chippewa Cree community (Chippewa Cree Climate Adaptation Plan, 2018.)

2.2. Housing and buildings

Another major concern raised by tribal communities are climate change-related impacts on housing. Consistent with the findings of the National Climate Assessment for this region (Conant et al., 2018), tribal communities highlight the role of precarious pre-existing infrastructural conditions on climate vulnerability (Fort Belknap, in development):

> *There are many pre-existing challenges with housing in the Fort Belknap Indian Community that make residents particularly vulnerable to climate change impacts. First, there is a shortage of housing. The Lands Department works with 2.5-acre home site leases but lacks sufficient home sites to meet demand. As a result, the majority of houses are overcrowded. Second, most housing is old and in need of repair, making homes susceptible to damage from extreme weather events. For example, many HUD homes here are old and dilapidated. Third, many homes lack proper landscaping, such as proper drainage. Poor drainage increases moisture collection around the home and causes molding. A lot of older homes were even built without rain gutters. Finally, some houses are built in flood zones, primarily in scattered sites where people built on their own lands.*
>
> *A major cause of the housing shortage is the fact that many people are unable to obtain home loans because they are living on tribal land, which they cannot use as collateral on a mortgage. Additionally, electricity is so expensive that people cannot afford to run electricity out to houses. Utility rates are high, estimated costs of getting a meter box installed on a new home is around two thousand dollars- a significant barrier to the development of new homes. Similarly, getting power poles to run electricity from a transmission line to the meter box cost can range up to $10,000.*

Flooding and heavy rainfall and snows have impacted infrastructure, sinking roads and jeopardizing people's access to homes. Due to flooding and heavy runoff water is getting into crawl spaces and basements. Even with proper drainage, heavy and sustained rain forces water into buildings. For example, the Environmental Department's office building frequently floods. Flooding in buildings and other places can increase the risk of mold, which has health consequences and is expensive and difficult to remove. This especially affects families living in older homes which are susceptible to mold.

Climate impacts are imposing additional costs on tribal communities pertaining to needed site improvements to control water seepage into living spaces: Risk of floods and damage from storm water runoff means grading needs to be done around homes. This is costly: between $6-7,000 per home ... The housing authority relies upon other departments (such as for sewer, stormwater management, and roads) in order for houses to be livable. When those systems are impacted by climate changes and events, housing is also impacted (Chippewa Cree Tribe, 2018).

2.3. Water and sanitation

Many people are concerned about increasing infrastructure damage, whether its lagoons overflowing, pipes freezing or breaking, grain silos eroding into the river, or power lines breaking with subsequent outages. Electrical outages put people at risk because many homes lack alternative heat sources (Fort Belknap Tribe, plan-in-development).

Chapter B5. Southern Plains Region and Eastern Oklahoma Region

1.Tribes and climate change hazards

There are 45 Federally-recognized Tribes (47, including the three state-recognized tribes) in the BIA Southern Plains Region (25 tribes) and the Eastern Oklahoma Region (20 tribes) (Kloesel et al., 2018). The two BIA regions span the states of Oklahoma, Kansas, and Texas (Figure B5.1). In general, Indian Tribes of these regions are located along the Arkansas River, as well as the Canadian River and Red River.

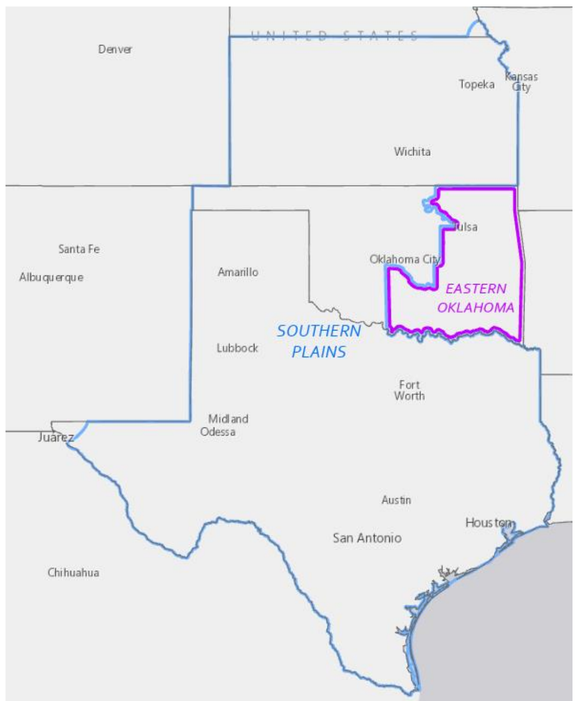

Figure B5.1 - Southern Plains Region and Eastern Oklahoma Region. Source: BIA Southern Plains Region GIS

Essentially all of the tribes of the Southern Plains and Eastern Oklahoma regions may be climate change affected. All tribes of the region contend with extreme weather events of storms, hail storms, tornadoes, and drought, regardless of climate change impacts. There is some likelihood that climate change will result in increased flooding (statistically, medium confidence (Kloesel et al., 2018)). Many tribal communities may be affected by flooding of one of the region's rivers, tornadoes, or drought.

Extreme events in the Southern Plains may become more severe under a warming climate, although the magnitude remains difficult to quantify (Kloesel et al., 2018). There is some suggestive evidence of increased severity in local storms, hailstorms, and tornadoes. Nevertheless, extreme events are inherent to the region and can cause significant damage to infrastructure and property. For instance, in 2019 (May 7, May 9), a state of emergency was ordered for all 77 Oklahoma counties, and most of Kansas. A presidential disaster declaration was issued for several of the region's FEMA districts, due to severe storms, flooding, straight-line winds and tornadoes (Table B5.1, Figure B5.2, B5.3, B5.4, BIA Southern Plains Region, 2019).

Tribe	Number of properties affected
Apache Tribe of Oklahoma	26
Kiowa Tribe	315
Comanche Nation	533
Wichita and Affiliated Tribes	113
Delaware Nation	3
Caddo Nation	175
Fort Sill Apache	1
Jointly owned KCA properties	12 (5,646 acres)
Jointly owned WCD properties	2 (2,330 acres)

Table B5.1. Anadarko Agency -hurricane impacts, April 2019. (Source: BIA Southern Plains Region, 2019).

Figure B5.2 - Comanche member home, vicinity of Geronimo, Oklahoma. (Source: BIA Southern Plains Region, 2019).

Figure B5.3 - Effects of a severe storm event, May 2019. Cherokee Nation, Fort Gibson Casino (left); Highway 62 near Fort Gibson. (Source: BIA Eastern Oklahoma Region, 2019).

Figure B5.4 - Effects of severe storm, May 2019. Effects of flood on Pawnee Agency Agriculture (Pawnee 599-601). (Source: BIA Southern Plains Region, 2019).

2.Mitigation activities by infrastructure type: needs assessment

Tribes of the Southern Plains Region and Eastern Oklahoma region are both highly vulnerable to the impacts of climate change on infrastructure and generally lack resources to implement an adaptation strategy, further eroding community resilience. An expert panel of climate change impacts on the region observed:

> *Lack of physical infrastructure, tied directly to limited economic resources and power, poses a substantial obstacle to climate change adaptation for the tribes of the region. While cities and other governmental jurisdictions make plans to build resilient physical infrastructure by using bonds, public–private partnerships, and taxes and tax instruments, only a handful of tribal nations have the ability to use these tools for climate adaptation. Most tribes and Indigenous peoples remain dependent on underfunded federal programs and grants for building and construction activities to improve the resilience of their infrastructure in the face of climate change threats* (Kloebel et al., 2018).

To the extent feasible, Eastern Oklahoma tribes are generally adopting a protect-in-place strategy in response to climate change impacts. Of the major infrastructure needs considered in this analysis, the available data resources suggest that the priority needs are (i) water and sanitation infrastructure (Table B5.2); (ii) residences; (iii) transportation.[6] Representative cost estimate data for the region was not available during the period of analysis (Ross, personal communication, 2020).

Project	Estimated Cost	Category
Tishomingo Alternative Water Supply - well and lines	$15,000,000	Water Scarcity
Ada Reuse	$13,000,000	Water Scarcity
City of Lone Grove Water Infrastructure- well and storage	$3,000,000	Water Scarcity
Sulphur Alternative Water Supply- well and line	$6,500,000	Water Scarcity
Goldsby Waste Water Project	$3,000,000	Water Scarcity
Stonewall Water Infrastructure- well and storage	$3,000,000	Water Scarcity
Ravia - well head and distribution system	$2,075,000	Flooding
Southern Oklahoma Water Corporation Alternative Water Supply- wells and	$12,500,000	Water Scarcity
Tishomingo Intake Structure	$1,000,000	Water Scarcity
Wapanuka and Bromide- well	$8,000,000	Water Scarcity
Buckhorn and Daugherty- plant	$5,000,000	Water Scarcity
Ardmore Alternative Water Supply-Wells	$4,500,000	Water Scarcity
Stratford Water System Improvements	$6,144,000	Water Scarcity
Ada Alternative Water Supply- Atoka connect and plant	$50,000,000	Water Scarcity
Total	**$132,719,000**	

Table B5.2 - Water infrastructure needs, Chickasaw Nation (Taylor, pers. communication, 2020).

Total estimated cost for the Southern Plains and Eastern Oklahoma Regions is $59.4 million (396 planning projects) and $28.1 million (9 implementation projects) (Table B5.3).

[6] Infrastructure types of this analysis: transportation; healthcare; residences and buildings; Education, businesses, & service infrastructure; Water and Sanitation; Energy and Communication; Cultural infrastructure; Protective structures.

	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Implementation Projects	45	45	43	44	43	43	45	43	45	396
Total Estimated Unmet Planning Costs ($, Millions)	$6.8	$6.8	$6.5	$6.6	$6.5	$6.5	$6.8	$6.5	$6.8	$59.4
# Implementation Projects	0	0	2	1	2	2	0	2	0	9
Total Estimated Cost for Implementation Projects ($, Millions)	$0.0	$0.0	$2.1	$0.0	$11.3	$3.6	$0.0	$11.1	$0.0	$28.1

Table B5.3. Infrastructure needs, Southern Plains and Eastern Oklahoma Regions.

Chapter B6. Midwest Region

1. Tribes and climate change hazards

Thirty-six Federally-recognized Tribes reside in the BIA Midwest Region (MN, IA, WI, MI) - locally often referred to as the Great Lakes Region (Figure B6.1). Nineteen of these tribes were identified as environmentally threatened communities. Most Midwest Region tribes are located along a river or near the shoreline of one of the Great Lakes. Climate change impacts of extreme riverine flood events, as well as shoreline erosion, are prevalent for many of these tribes, due to this geographical setting. For instance, the Midwest Region tribes suffered damage from river flooding caused by extreme weather: between 2014 and 2017 the Region experienced 3,500-year floods, impacting the Fond du Lac Band of Lake Superior Chippewa; the Bad River Band of Lake Superior Chippewa; and the Saginaw Chippewa Tribe (Anderson, personal communication, 2020). The latter flood was from a minor river that flooded into a broadly flat area with saturated soils.

Figure B6.1. Tribes of the Great Lakes Region. This region generally corresponds with the BIA Midwest Region, other than upstate New York. Source: BIA Midwest Region, 2020.

Increasingly severe precipitation events are projected to increase flooding and erosion rates in the Lake Superior region (Kling et al., 2003; Cruce and Yurkovich, 2011; Bad River Band of Lake Superior Chippewa Tribe, 2016). By 2100, most models project a 20% increase in precipitation in the Great Lakes region (Gregg et al., 2012). In Michigan, heavy rains have become more common throughout the year, leading to a greater incidence of flash flooding. Flash floods are anticipated to increase more than 25% over the next 20 years (Match-e-be-nash-she-wish Band of Potawatomi Indians of Michigan, 2015). The winter and spring seasons of Michigan, when flood risk is already high, would become more than 25% percent wetter. Erosion rates are projected to increase, as soil particles become dislodged with a higher level of surface flow (Gregg et al., 2012).

Several tribes are also located on the Great Lakes, where storm surge, and in some areas, lake level rise, has returned as a concern in recent years. Tribal facilities are mostly protected from this, although concerns exist in Grand Portage (MN), Bad River (WI), the L'Anse Reservation (MI), and the Bay Mills Indian Community (MI) (Anderson, BIA Regional Forester, pers. comm., 4/21/20). The latter is experiencing loss of its cultural heritage, specifically that of its old burial ground, due to shoreline erosion of Lake Superior, near Brimley, Michigan (Figure B6.2).

Figure B6. - The Bay Mills Indian Community old tribal burial ground near Brimley, Michigan. The graveyard contains burials dating to a 1662 battle between Iroquois and Chippewa bands. The U.S. Army Corps of Engineers is studying how to protect the shoreline-adjacent property from bluff erosion caused by high water levels on Lake Superior (right image). A U.S. Army Corps of Engineers photo of the Bay Mills Indian Community old tribal burial ground along Lake Superior near Brimley, Mich., which is threatened by coastal erosion (left image) Source: Ellison, G. Mar 31, 2020, Historic Michigan tribal burial ground threatened by coastal erosion, https://www.mlive.com/news/2020/03/historic-michigan-tribal-burial-ground-threatened-by-coastal-erosion.html, accessed 4/17/2020.

2. Climate change-related impacts on infrastructure

Climate change-related factors are impacting physical infrastructure and cultural infrastructure, as described below.

2.1. Transportation infrastructure - Roadways, bridges, marinas, and railways

Extreme precipitation events will increase flows in waterways. This hydrological alteration may increase wear and tear on bridges, culverts, and affected roadways (Red Cliff Band of Lake Superior Chippewa, 2018). In 2016 (July 11-12), 7.65” of water fell in the Bad River Reservation area, causing a reported $25 million in damage to roads, houses and related infrastructure of the Reservation and surrounding communities (Fitzpatrick et al., 2017, Figure B6.3). Storms on the region's lakes have damaged marinas and area parking lots.

Figure B6.3. Flood impacts on Bad River Reservation infrastructure, July, 2016. (Source: Kilger and Brock-Montgomery, 2018).

Maintaining functional roads is particularly important for the region's tribal communities due to the limited transportation infrastructure. For many tribes, only a few roads exist. For instance in Michigan, one tribe has two paved exits on their reservation, along with two dirt road exits. This situation can leave communities vulnerable, particularly for residents that have access to only two-wheel drive vehicles (Inter-Tribal Council of Michigan, Inc., 2016). Damage to railways has also been raised as a concern (Match-e-be-nash-she-wish Band of Potawatomi Indians of Michigan, 2015).

2.2. Housing and Buildings

Housing and other buildings may be damaged due to severe storm events, flooding, and potential rise in the water table. Threats to the degradation and failure of the foundation of buildings are of particular concern (Match-e-be-nash-she-wish Band of Potawatomi Indians of Michigan, 2015). Existing infrastructure is especially vulnerable because it was possibly constructed without the consideration of the changing climate (Bates et al. 2008). Damage to housing of tribal communities in Michigan has been observed: mold growth and severe erosion near home sites is occurring (Inter-Tribal Council of Michigan, Inc., 2016).

2.3.Water utility infrastructure

An increase in extreme daily rainfall events is projected to damage existing stormwater, drainage, and sewer infrastructures (Match-e-be-nash-she-wish Band of Potawatomi Indians of Michigan, 2015).

2.4.Energy Infrastructure

An increase in severe weather events may cause interruptions within the electric grid (Melilli et al. 2014).

2.5.Cultural infrastructure and culturally important resources

Climate impacts are disrupting traditions, culture, and livelihoods that depend on cultural infrastructure. Subsistence livelihood --the gathering, hunting, and planting of foods, medicines, and household goods to sustain familial economic needs --is particularly important for the region's tribes, many of which are remote from commercial economic centers. For instance, wild rice (*manomin*) is of central cultural importance to several Chippewa (Ojibwe) Tribes of the Great Lakes region (Bad River Band of Lake Superior Chippewa Tribe, 2016; BIA-Midwest Region, 2020). Wild rice is vulnerable to the impacts of climate change. Increased precipitation intensity can also adversely affect wild rice beds due to factors such as rapid changes in water levels over short time periods, or due to increased pollutant loading (e.g., phosphorus, sediments). Also, rising lake levels can promote sedimentation of shallow rice bed waterways, inhibiting productivity (BIA-Midwest Region, 2020). Heavy precipitation can cause abrupt changes in water levels that can uproot the plants (Bad River Band of Lake Superior Chippewa Tribe 2016). Restoration of wild rice habitat has been a major focus of the BIA Great Lakes Restoration Initiative (GLRI), with support from the Environmental Protection Agency (BIA-Midwest Region, 2020; Figure B6.4). Moose populations are another culturally important resource for tribes of the Midwest Region. They are an important traditionally hunted species. In the remote reservations of northern Michigan and other states, moose are a critical food source (Inter-Tribal Council of Michigan, Inc., 2016).

Figure B6.4 - Streambed restoration to restore water flow to a decimated wild rice lake bed. (Source: BIA-Midwest Region, 2020).

3.Infrastructure needs assessment

In general, the anticipated response to climate change impacts in this region is protect-in-place for most tribes. Interventions include stabilization of building foundations, such as is anticipated by the Forest County Potawatomi. Another intervention is protection of shoreline lands and maintenance of access, as is occurring on the Red Cliff Reservation, in Wisconsin (BIA-Midwest Region, 2020). Such actions to protect shoreline infrastructure are significant to maintaining traditions and livelihoods for these communities, such as maintaining walleye, a culturally significant fishery species.

	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Implementation Projects	36	36	36	36	36	35	36	36	36	323
Total Estimated Unmet Planning Costs ($, Millions)	$5.4	$5.4	$5.4	$5.4	$5.4	$5.3	$5.4	$5.4	$5.4	$48.5
# Implementation Projects	0	0	0	0	0	1	0	0	0	1
Total Estimated Cost for Implementation Projects ($, Millions)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.3	$0.0	$0.0	$0.0	$0.3

Table B6.1. Infrastructure needs assessment analysis of tribes in the BIA Midwest Region.

Resource needs for the BIA Midwest Region's Great Lakes Restoration Initiative (GLRI), which includes infrastructure needs, was $12,064,383 (in 2020), based on GLRI awards. Awards to Midwest Region tribes totaled $10,771,633 (i.e., excluding tribes located in New York). Significant funding was allocated to tribal capacity building.

Chapter B7. Eastern Region

1. Tribes and climate change hazards

Thirty-five Federally-recognized Tribes reside in the BIA Eastern Region (Maine to Florida, west to Louisiana, and north to Illinois). In addition, many state-recognized and unrecognized Tribes reside in this region.

Key climate change hazards of the Eastern Region are erosion, flooding, and sea level rise; wildfire is also a concern. Many tribal communities of the Eastern Region are contending with the impacts of coastal erosion (Figure B7.1). For the Shinnecock Indian Nation for instance, a primary concern is the loss of lands to erosion as sea level rises. Hurricane Sandy (October, 2012) washed away the bluffs along the Nation's shores in the Great Peconic Bay area. This beach is significant due to its historical use by tribal ancestors and continued use into the present. Flooding is another concern. During high precipitation events, storm water systems can become overburdened, causing water stagnation, and impairing surface and groundwater (T. Davis, IHS, pers. comm., 4/17/20, Figure B7.2).

Some tribal communities of the Eastern Region are contending with such severe erosion and sea level rise that they must relocate, as exemplified by the community of Isle de Jean Charles band of Biloxi-Chitimacha-Choctaw Indians of Louisiana (Figure B7.3). With the loss of more than 98 percent of the land, relocation is inevitable; only 320 acres remain of what was the 22,400-acre Island in 1955 (Lowlander Center, 2015). Twenty-five houses and a couple fishing camps flank the town's single street-down from 63 only five years ago (ITEP, 2008). Many Tribes of the Louisiana Gulf Coast are contending with issues of extreme erosion and sea level rise: the Pointe-au-Chien Indian Tribe and the Grand Caillou/Dulac Band of Biloxi-Chitimacha-Choctaw, and the Atakapa-Ishak Chawasha Tribe of Grand Bayou Village (Smith, 2020), and the Chitimacha Tribe of Louisiana (Thornbrough, pers. Comm., 5/8/20).[7] In sum, tribal communities across the Eastern Region are contending with the need to protect-in-place or relocate, in response to climate change factors.

[7] A compounding issue is the absence of federal recognition, which results in ineligibility to tap into federal assistance programs, such as those administered by FEMA (Smith, 2020). Grand Caillou/Dulac Band of Biloxi-Chitimacha-Choctaw, https://www.gcdbcc.org/; Pointe-au-Chien Indian Tribe, http://pactribe.tripod.com/, accessed 5/2/20.

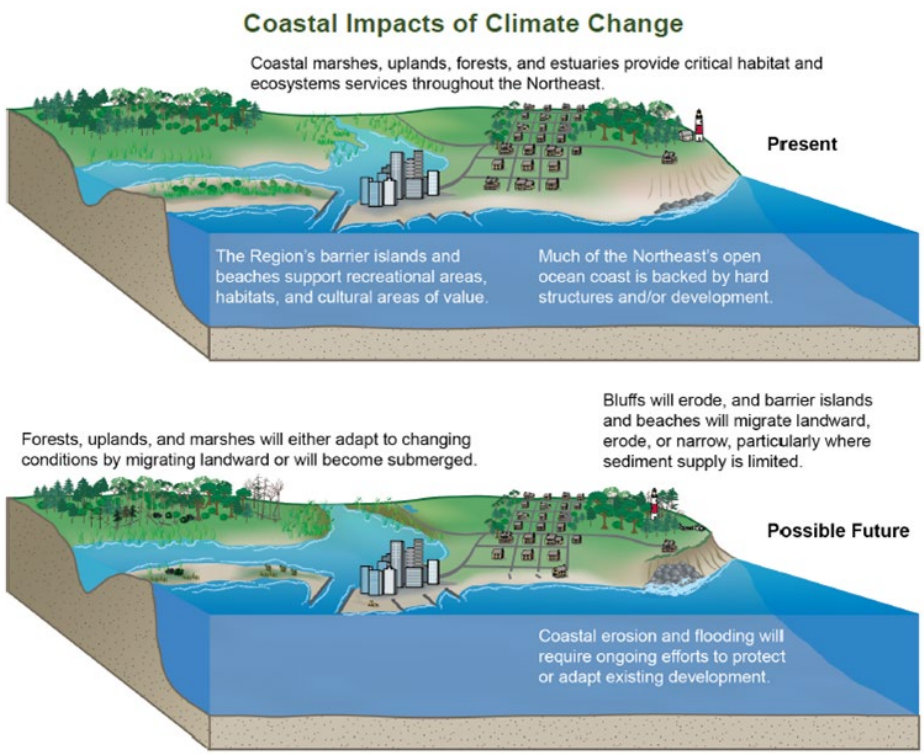

Figure B7.1 - Coastal impacts of climate change (Carter et al., 2018). Lower panel: erosion effects on coastlines, including bluffs.

Figure B7.2 - Water stagnation stagnation of storm-water runoffs during intense rain and storm Surges (undated), Shinnecock Indian Nation (B. Mhando, S. Smith, and T. Davis, pers. communication, 4/17/20).

Figure B7.3 - Isle de Jean Charles Band of Biloxi-Chitimacha-Choctaw Indians of Louisiana. Sources: Isle de Jean Charles Biloxi-Chitimacha-Choctaw Tribe, 2019 (left image); PRNFM (upper right image); Herman, 2018, Smithsonian Magazine (lower right image).

Flooding and erosion are occurring due to compounding factors: sea level rise and an increase in storm intensity and frequency. By 2100, the global average sea level rise is projected to rise 7.2 to 23.6 inches (IPCC, 2007). For some tribal communities who reside in vulnerable locations, the impacts may be much greater than this global average. For instance, Shinnecock Indian Nation lands are located on a low-lying, south-facing peninsula in Shinnecock Bay --as well as the Westwoods area of beach and bluffs bordering Peconic Bay (Figure B7.4). Sea level proximate to the Shinnecock Indian Nation lands is projected to rise 2.1 to 4.4 feet by 2100 (Shinnecock Indian Nation, 2013, Figure B7.5).[8] In addition, storms are becoming more intense, due to the warming of sea surface temperature and related factors (Hurricanes and Climate Change | Center for Climate and Energy Solutions, accessed 5/2/20). Sea level rise has amplified the impact of storm intensity and of storm surges (Dupigny-Giroux, 2018). Coastal flooding is resulting. The land area affected by coastal flooding during storm events is projected to increase in the coming years, as illustrated by projections of Shinnecock Indian Nation lands in 2050 and 2100 (Figure B7.6).

[8] To estimate sea level rise on the Shinnecock Indian Nation lands, investigators used data on local land movement, as measured by nearby tide gauges at Montauk and Port Jefferson, NY, and Sandy Hook, NJ, and global sea level rise projections from the two central National Climate Assessment scenarios, known as "Intermediate-Low" and "Intermediate-High" (Parris et al., 2012). The results of this adjustment, presented in Figure 4, suggest relative sea level rise on the Shinnecock Indian Nation lands of 2.1 to 4.4 feet by 2100.

Figure B7.4 - Shinnecock Indian Nation location. Image source: Shinnecock Indian Nation Climate Change Adaptation Plan, 2013.

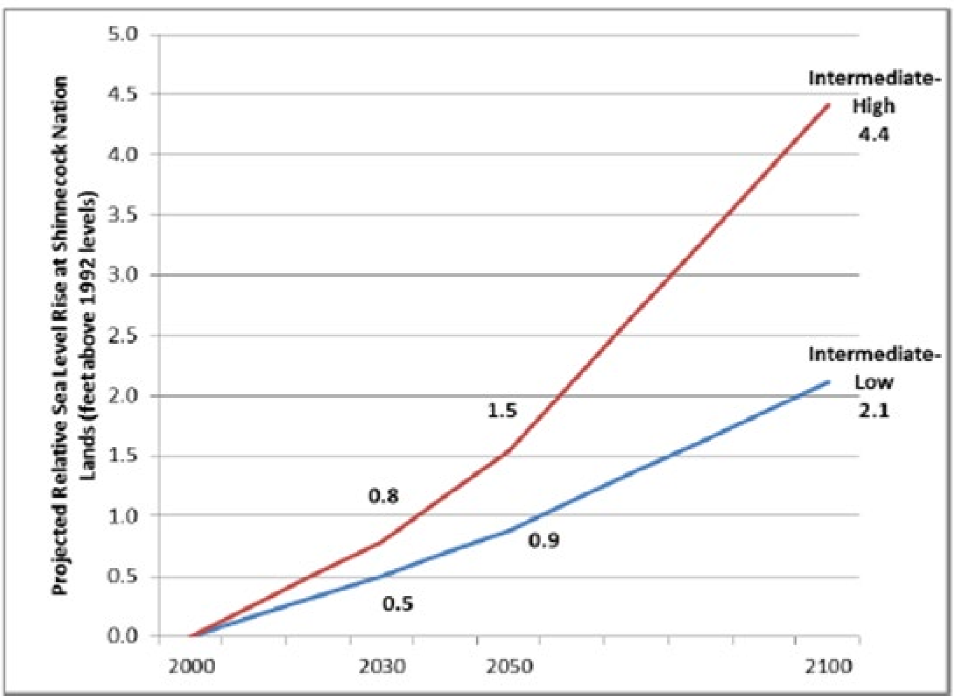

Figure B7.5 - Potential relative sea level rise, Shinnecock Indian Nation Lands, using intermediate national climate assessment scenarios. Scenario sources: Parris et al., 2012; NOAA Tides and Currents, Sea Level Trends. Image source: Shinnecock Indian Nation Climate Change Adaptation Plan, 2013.

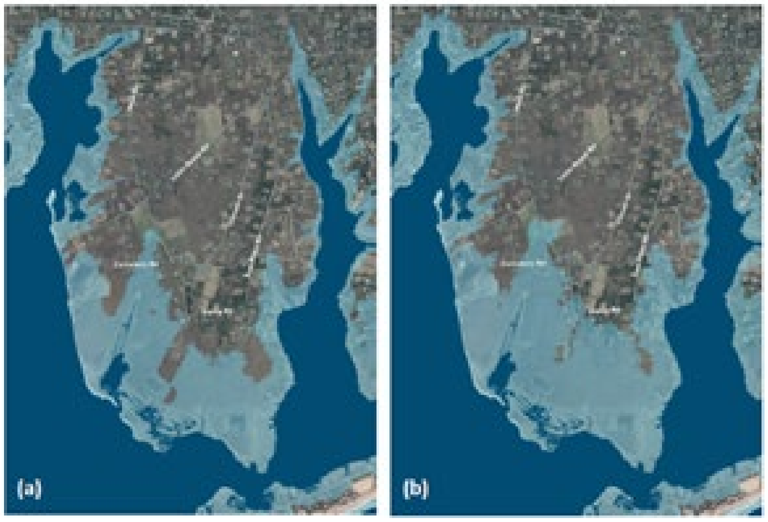

Figure B7.6 - Areas of predicted inundation during a 100-year storm presently (a); and in 2050, after a sea-level rise of 1.4 feet (b), consistent with the adjusted "intermediate-high" NCA global sea level rise scenario. Image source: Shinnecock Indian Nation Climate Change Adaptation Plan, 2013.

Tribal communities of the southeastern U.S. contend with somewhat distinct climate impacts from those of the northeast. In this sub-region, tropical storms, as well as prevalence of low-lying topography, contribute to climate change impacts (Carter et al., 2018). Storm surges of tropical storms, coupled with sea level rise, are resulting in floods that occur farther inland than in the past, particularly at low-lying sites. Another factor is extreme rainfall events. Heavy rains are contributing to flooding of inland sites, as well as coastal sites. For instance, in 2016 (August 11–15), nearly half of southern Louisiana--home to the United Houma Nation, the Chitimacha Tribe, and the Jean Charles Band of Biloxi-Chitimacha- Choctaw Tribe -- received at least 12–14 inches of rainfall, with 20 inches at coastal locations (Carter et al, 2018).

2.Mitigation activities by infrastructure type: needs assessment

Community response to climate change impacts varies with severity, as well as social-economic considerations, and resource availability (Peterson and Maldonado, 2016; Isle de Jean Charles Community, 2019; Smith, 2020). Most tribes identified in the research for this report are adopting a protect-in-place response. At the same time, one tribe is relocating (Isle de Jean Charles Band of Biloxi- Chitimacha-Choctaw Indians, https://www.lowlandercenter.org/isle-de-jean-charles-relocation, accessed 5/2/20), and three other three Tribes along the Louisiana coast appear to be assessing the spectrum of response strategies (protect-in-place, managed retreat, relocation).

Climate change factors in the Eastern Region are impacting an array of infrastructure types: (i) transportation; (ii) housing and buildings; (iii) water utilities; (iv) cultural infrastructure, and (v) protective infrastructure. These impacts have bearing on public health, livelihoods, family and community well-being, and maintenance of culture and traditions. Below, the impacts on the various infrastructure types are outlined.

Estimated cost for infrastructure planning is $46.2 million (308 projects); planning is $19.4 million (7 projects) (Table B7.1).

	Transportation	Healthcare	Residences	Education, businesses, & services	Water and Sanitation	Energy and Communication	Cultural	Protective structures	Unspecified infrastructure	Total
# Implementation Projects	35	35	34	34	33	34	35	34	34	308
Total Estimated Unmet Planning Costs ($, Millions)	$5.3	$5.3	$5.1	$5.1	$5.0	$5.1	$5.3	$5.1	$5.1	$46.2
# Implementation Projects	0	0	1	1	2	1	0	1	1	7
Total Estimated Cost for Implementation Projects ($, Millions)	$0.0	$0.0	$6.0	$3.9	$5.0	$0.5	$0.0	$4.0	$0.0	$19.4

Table B7.1 - Analysis of Tribes and infrastructure needs assessment status, BIA Eastern Region.

A constraint on the report findings of the Northeastern Region is the dearth of data resources that were able to be located during the report writing period, despite an outreach protocol that engaged networks of tribal liaisons of four distinct federal agencies (BIA, USGS, IHS, FEMA), as well as non-federal organizations. Data resources were located for six tribes. For these six Tribes however, the data quality was deemed to be high (>600 pp. of documentation, including engineering summaries, climate change vulnerability assessments, adaptation plans, flood protection assessment conducted by environmental engineers), indicating robust results for these communities.

2.1.Transportation infrastructure - Roadways and bridges

Need for mitigation actions to maintain roadways and bridges is a prevalent theme of tribal planning documents of this region. Bridges are a particularly critical link. For some communities, such as the Penobscot Indian Nation, tribal transportation depends on only a single bridge (Davis, IHS, pers. Communication, 2020). Project descriptions follow below.

(Please see Appendix C: Case Studies C.19, C.20 & C.21 for project descriptions of Transportation, Homes and Buildings)

2.1.1. Water utility infrastructure - water distribution systems and wastewater facilities

Many tribal communities in the Eastern Region are encountering climate change related impacts on water utility infrastructure. One type of affected infrastructure is wastewater facilities (Figure B7.7). Historically, such facilities were often sited proximate to shorelines, due to minimized interference with social considerations (aesthetic nuisances, odors) and operational considerations (sewer overflow) (Melosi, 2008). However, these past decisions have made wastewater facilities vulnerable to coastal climate change impacts.

(Please see Appendix C: Case Studies C.22, C.23 & C.24 for project descriptions of Water Utility Infrastructure, Cultural Infrastructure, and Protective Infrastructure)

Appendix C

Case Studies: Community Voices from the Front Lines of Climate Change

Table of Contents

Chapter 1: Alaska Native Villages

Throughout Alaska, rapid climate change threatens health, safety, culture, and the existence of Alaska Native villages. These stories illustrate the impacts to Alaskans.

C.1- In Napakiak, it is a Question of When, Not If Erosion will Impact their School Hazards

Figure C.1.1 - Walter Nelson is the Napakiak Managed Retreat Coordinator, funded by a grant from the BIA Tribal Resilience Program. Walter has significantly increased tribal capacity to address erosion threat. For example, Walter coordinated the emergency decommissioning of buildings and infrastructure in August 2019 in response to extremely aggressive erosion. Photo Credit: Neale, Max, Alaska Native Tribal Health Consortium; 2019.

Napakiak is a community of 354 people in western Alaska on the Kuskokwim River, and faces some of the most rapid erosion in the state. The erosion is so aggressive that 100 feet of land were lost in one year. The school in Napakiak is at the highest risk and sits less than 200 feet from the riverbank. Walter Nelson, the Napakiak Managed Retreat Coordinator, estimates that the first portion of the school will be impacted in 1-2 years. The school is often considered the heart of rural Alaska communities. It is a space to gather for basketball games, community meetings, and cultural activities. Often, there is no other space that can accommodate community events. It is very likely that the school will be impacted before a new school can be built. If so, Napakiak would be the first Alaska community to use portable units to educate their children.

C.2 - Storm Surge in Shaktoolik

"Shaktoolik is where my roots are. I feel a deep connection to the land and waters"
- Marlin Sookiayak

Twelve miles northeast of Shaktoolik is "Iyatayet," a site that is 6,000 to 8,000 years old. Alaska Native people have inhabited this area for thousands of years due to the outstanding abundance of wild foods. In recent years, however, increasingly severe storm surges threaten the safety of all residents and the long-term ability for the community to continue to live on the spit. To protect from storms, the community built a berm from local driftwood and gravel. It serves as a "sacrificial" protective structure to diminish wave energy and reduce wave run-up. On August 2, 2019, an unusual summer storm washed 350,000 cubic feet of the storm surge berm into the Bering Sea, leaving all of the community's infrastructure highly vulnerable to fall storms.

45% of Shaktoolik residents have reported flooding and/or storm damages in the last five years.
43% of residents do not feel safe in the community.

Figure C.1.2 - On August 2, 2019, an unusual summer storm washed 350,000 cubic feet of Shaktoolik's storm surge berm into the Bering Sea, leaving all of the community's infrastructure highly vulnerable to fall storms (shown above). More funding is needed to complete berm construction, which will likely serve as a temporary solution--until funding for a rock revetment can be secured or relocation to a safe site 14 miles away is determined to be the only long-term solution. Credit: Katchatag, Sophia; Native Village of Shaktoolik; 2019.

In December 2019, the Chief of Civil Works at the U.S. Army Corps of Engineers Alaska District said, *"Our greatest fear is a storm will hit Shaktoolik in the middle of the night, and when we pick up the phone in the morning the line is dead, and the whole community is wiped out."* In summer 2020, the community is scheduled to begin construction on a taller storm surge berm. More funding is needed to complete construction of the berm, which will likely serve as a temporary solution- requiring frequent repairs- until the community secures funding for a rock revetment or determines that relocation to a safe site 14 miles away is the only long-term solution.

"I envision a future here, where my four children can run free around our community, where they can walk next door to their grandparents and aunts and uncles, and where they can fish in both the rivers behind our home and in the ocean in front of our home. We would like to be protected so that we can feel safe here."

- Sophia Katchatag, Local Coordinator, Native Village of Shaktoolik

C.3 - Community Members in Akiak Relocate Gravesites due to Erosion

In 2010, erosion forced Akiak to undertake the emotionally grueling process of digging up and relocating their ancestors' remains to a safe location. Erosion of the banks of the Kuskokwim River exposed the community cemetery, which was used since the 1880s, resulting in "skulls, human remains, and coffins along the bank," said Sheila Carl, Tribal Administrator for Akiak Native Community. In order to prevent over 200 graves from being swept into the river, Akiak residents banded together with no external resources to dig up all the graves and relocate them to a new cemetery, where they held a service to honor the dead. Erosion in Akiak has accelerated in the past few years and the
community has decided to pursue a managed retreat to protect their community. It is estimated that the managed retreat will cost up to $27 million. However, given the uncertainty about the magnitude of the threat, the cost is still unknown.

Figure C.1.3 - In 2010, Akiak relocated 200 gravesites that were eroding into the river. Akiak had to undertake the emotional process without the support of outside resources. Credit: Akiak Native Community; 2010.

C.4 - Armoring the Eroding Riverbank in McGrath Protects Critical Community Infrastructure

Figure C.1.4 - In 2010, McGrath armored their riverbank to protect infrastructure from erosion with assistance from the Natural Resources Conservation Service Emergency Watershed Protection program, which has been effective in helping Alaska Native villages address climate impacts to infrastructure. Photo Credit: Natural Resources Conservation Service; 2015.

Erosion occurs along the entire Kuskokwim riverbank in McGrath and threatens emergency access roads, residences, the water plant, powerhouse, the fuel tank farm, the landfill, and other infrastructure. Accelerating erosion also exacerbates the risk of flooding for McGrath, which has a history of significant flooding. In 2015, the Natural Resources Conservation Service (NRCS) Emergency Watershed Protection (EWP) program assisted McGrath with the reconstruction of a protective levee and armored the eroding river bank with rock to protect the levee and community infrastructure from future damage. The next phase of the project will continue to mitigate riverine erosion by installing rock barbs, which slow and redirect the river current out into the main channel of the river away from the bank.

C.5 - Erosion Threatens to Cut off Water Service to 70 Homes in Huslia

Figure C.1.5 - In 2018, sections of the riverbank in Huslia were lost to rapid erosion, shown above. Erosion is expected to impact water and sanitation infrastructure in summer 2020, resulting in approximately $2 million in damage and loss of service to 70 homes. Traditional water and sanitation funding sources do not fund the modifications that Huslia needs to preserve water service to homes. The community is uncertain where funding will come from. Credit: Huslia Village; 2018.

The community of Huslia sits on the north bank of the Koyukuk River in interior Alaska and experiences rapid erosion. The bank lost 80 feet in 2018 due to erosion, and nearly 100 feet in 2019. The community has taken action to move threatened homes away from the river, but power lines, water service lines, and sewer service lines remain threatened and are expected to be impacted in 2020. If water and sanitation infrastructure is impacted, total damages would be approximately $2 million and service to 70 homes would be jeopardized. Modifications to the water distribution system- assuming sections of the current system are lost to erosion- are currently being designed and expected to cost $800,000 to construct. However, typical water and sanitation funding sources do not fund this type of work, which means Huslia will have to find and secure other funding to support this need. First Chief Burgett hopes funding will be secured and Huslia will continue to "grow and thrive."

C.6 - Shoreline Protection Costs Hundreds of Millions of Dollars in Utqiagvik, a Cost Other Communities Cannot Afford

"We brace ourselves every fall when we have a surge of waves eroding our beach line. Millions of dollars are spent every year on the gravel bar, but each time it would disappear due to the wave surge. We can't fight nature, but we can plan a better future by being proactive, instead of reactive." - Charlotte and Eugene Brower, Barrow Elders

Figure C.1.6 - A 5 mile gravel berm provides insufficient shoreline protection from coastal erosion in Utqiagvik and must be repaired after every storm, as shown above, which costs $8.3 million annually. A $328 million U.S. Army Corps of Engineers project will construct a fortified rock revetment to protect the shoreline and requires the North Slope Borough to contribute $110 million due to USACE non-federal cost share requirements. Virtually no other rural Alaska community has the resources to complete a similar project. Credit: North Slope Borough.

Utqiagvik is the political and economic hub of the North Slope Borough (NSB). The community experiences frequent and severe coastal storms, resulting in flooding and erosion that threaten public health and safety, over $1 billion of critical infrastructure, and access to subsistence areas. Currently, a gravel berm and sandbags help to prevent flooding and erosion, but do not offer any "real protection" according to Scott Evans, Assistant Risk Manager with the NSB. In order to mitigate the erosion threat, the NSB engaged with the U.S. Army Corps of Engineers (USACE) to complete a $3 million dollar feasibility study to analyze alternatives to protect the shoreline. The study, which required a 50% non-federal cost share, recommended the construction of a five-mile long revetment, which would armor the shoreline with rocks weighing nearly three tons. The next step for this study is to fully develop the design. The total construction cost of the project is estimated at $328.6 million, with NSB required to provide 35% or $110.5 million as non-federal cost share. The project will save NSB approximately $8.3 million in annual emergency response costs. If constructed, the structure will be the longest, largest, and most expensive erosion protection structure USACE has completed in Alaska. While the NSB has available resources to implement such a costly project, the majority of Alaska's rural communities would not be able to meet the 35% cost share requirement.

C.7 - Alaska's First Relocation: Newtok to Mertarvik

Figure C.1.7 - The eroding riverbank (shown above in 2018) forced Newtok to demolish the homes shown above in 2019 to prevent collapse into the river. For communities like Newtok, taking proactive action to respond to climate impacts would result in millions of dollars in savings as compared to responding to disasters. Credit: John, Andrew; Village of Newtok; 2018.

"The current site for Newtok will disappear forever and it will become just a memory"
- Bernice John, Tribal Member of the Village of Newtok

The eroding riverbank at Newtok, Alaska shows the devastating impacts of usteq, a catastrophic form of land collapse that occurs when frozen ground disintegrates under the compounding influences of thawing permafrost, flooding, and erosion. The soil along the riverbank adjacent to the community is composed of ice-rich permafrost, which, in the absence of other processes, would likely thaw relatively slowly. However, due to reduced sea ice, waves and storm surges batter against the bank during fall storms, causing the ice-rich frozen silts to thaw quickly. This process destabilizes the bank and results in a rapid loss of land in excess of 80 feet per year.[1] The community has already demolished seven homes to prevent their collapse into the Ninglick River. Usteq is projected to impact the community school as early as 2022 and the airport in 2023, rendering the site unlivable. Relocation of the entire community to a new site is the only viable adaptation strategy.

In the fall of 2019, the first wave of residents relocated from Newtok to Mertarvik, nine miles away. The 2019 construction season completed development of the essential infrastructure required to support a rural Alaskan community and as many housing units as possible. A diesel power plant, bulk fuel farm, water treatment plant, interim schoolhouse, interim clinic, and thirteen houses were constructed, bringing the total number of housing units to 21. All homes

[1] Dixon, Gavin; ANTHC.

are connected by gravel roads and contain a Portable Alternative Sanitation System with 100 gallons of treated water storage, handwashing sink, and a separating toilet and urinal. A small general store, 3G cell service, and wireless internet are available in the community. A rock quarry provides gravel materials, a barge landing provides seasonal marine access, and a 2,000’ x 35’ gravel landing strip provides year round access for small planes. The total cost of development in Mertarvik to date is between $60 and $70 million.

There are four critical projects remaining for the Newtok relocation to be complete: a DOT airport, a school, housing, and running water and sewer. Housing is the highest priority, with an additional 44 housing units (estimated at $17 million) required to relocate the entire population. The FAA has funded a Mertarvik runway, which is expected to be constructed by the State of Alaska by the fall of 2022. The Lower Kuskokwim School District anticipates new school funding by 2023 and school construction by 2026. Piped water and sewer would be the last major project to complete relocation. The total estimated remaining need for the relocation, excluding the airport, is $85 million. Although Mertarvik’s story is a success in that the people of Newtok have a new and safe home in their traditional lands, it is uncertain whether there will be sufficient funding to provide for the safe and successful relocation of the remainder of the people living in Newtok.

C.8 - Thawing Permafrost and Erosion Threaten Critical Community Infrastructure in Noatak

Figure C.1.8 - Thawing permafrost in Noatak is causing infrastructure to fail. Paul, the water and sewer operator, is constantly repairing leaking pipes due to the settling ground. For example, ice settling last summer – the hottest on record – broke a pipe and it took a month of digging and investigation to find the leak. The increasing damage from permafrost thaw is a sign that significant adaptation solutions must be implemented soon in order for the community to continue to have running water and flush toilets. Credit: Alaska Native Tribal Health Consortium.

“We are in a really bad predicament,” said Wilfred Ashby, President of the Native Village of Noatak, at an interagency meeting in Anchorage, Alaska in February 2020. The permafrost underlying Noatak is thawing, destabilizing the foundations beneath homes, the water treatment plant, and other critical infrastructure. Further, thawing permafrost along the riverbank accelerates erosion, which threatens the airport, the former landfill, the power plant, fuel tank farm, and more. Noatak is most concerned about the erosion impact to the airport --which is currently 100 feet from the river --because they rely upon it for food, fuel, emergency evacuation, and transportation to health care. The State of Alaska Department of Transportation will relocate the airport due to erosion—a $40 million effort that will take place in several years. If the airport is impacted before a new one can be built, it would cause serious impacts to community life, health, and safety.

C.9 - Flooding Can Cause Catastrophic Damage in Kotlik

"It was something scary to witness." - Victor Tonuchuk Jr., describing the devastating impact of a November 2013 flood in Kotlik.

Figure C.1.9 - In November 2013, an ice-jam flood inundated the entire community of Kotlik, resulting in a federal disaster declaration and causing $9.8 million in damages to the water and sanitation system alone. Although Kotlik received funding to rebuild after the disaster, the community has struggled to secure funding to take proactive action to protect community infrastructure before erosion causes a disaster in their community. Kotlik needs to develop a new subdivision site to relocate at least 21 homes threatened by erosion. Credit: Village of Kotlik; 2013.

Kotlik is vulnerable to major flooding that can impact all infrastructure in the community. In November 2013, an ice-jam flood inundated the entire community, resulting in a federal disaster declaration and $9.8 million in damages to the water and sanitation system alone. The community went without running water or toilets for months. The frequency and severity of flooding is increasing in Kotlik, creating rising concern among community members about potential disasters. Philomena Keyes said, "I am getting more concerned about our community and the risks we are facing. I'm sure you know that we recently had a large flood. The Tribe has been receiving more phone calls from individuals that are needing assistance raising their homes due to water entering them. A lot of talk is going around that this wasn't the big flood and that another one should be prepared for. It is scary just thinking about it." Pauline Okitkun, the Tribal Administrator for the Village of Kotlik, said in fall 2019, "I'm scared for this winter. I'm scared that we will get another winter storm that will flood homes and our community members will come to me for help."

Erosion threatens 21 homes in the near-term (five years or less) and all infrastructure along the riverbank in the long-term. In order to mitigate the threat, Kotlik is working to pursue a managed retreat by developing a subdivision site at their old airport site, which is safe from erosion and flooding impacts, for the relocation of threatened infrastructure.

C.10 - Melting Permafrost in Chefornak is Crippling Community Infrastructure

Figure C.1.10 - An aerial image shows the Kinia River and the dozens of vibrant blue tundra ponds that surround Chefornak.thawing permafrost has resulted in sinkholes throughout the community, leaning power poles, and impassable boardwalks. Credit: State of Alaska Coastal Hazards Program.

Thawing permafrost is putting the people, infrastructure, and culture of Chefornak at risk. Homes are being destroyed as the land underneath the community subsides and fluctuates, boardwalks are impassable and sunken, and spontaneous sinkholes are forming, which have injured people and increased fears about safety. In 2018, a young man was carrying a child on his shoulders and accidently stepped into a sinkhole and was submerged up to his chest. Erosion and flooding threatens homes, the Head Start building, the fuel tank farm, and electric power distribution systems. In order to protect community infrastructure and health, Chefornak is working to develop a new subdivision site for the relocation of threatened infrastructure. The community is pursuing funding to conduct a community- wide permafrost assessment and for the planning and design of a new subdivision site.

C.11 - In Order to Protect Future Generations, Golovin Has Decided to Migrate to Higher Ground

Figure C.1.11 - In September 2005, a severe fall storm caused flooding of the entire spit in Golovin, where the school, power plant, fuel tank farm, clinic, and other critical infrastructure are located. In order to protect from flooding, Golovin is planning to migrate all community infrastructure from the spit to an area of higher ground adjacent to the community, an immensely complex process. Small communities such as Golovin benefit from technical assistance to complete large-scale projects such as managed retreat. Credit: Chinik Eskimo Community; 2005.

Golovin is vulnerable to strong fall and winter storms, which have caused devastating flooding of the lower spit where a majority of critical community infrastructure is located. In September 2005, a severe fall storm inundated the entire spit, forcing community members to evacuate to higher ground, unsure if their homes would be there when they got back. “I never want to experience a flood like that again,” resident Jack Agerstron said. In order to protect from flooding, Golovin is in the planning stages to migrate all community infrastructure from the spit to an area of higher ground adjacent to the community, a process that will take years to implement. Jack looks forward to the day when his home is safe on the hill, “with a place for a garden, a well, and solar power.” Carol Oliver, an Environmental Coordinator with the Tribe, has a similar vision for “a safe and resilient Golovin with a thriving local economy, improved infrastructure, clean water, and protection from flooding and erosion.”

C.12 - Unprecedented February 2019 Rain Floods Permafrost-Impacted Home in Nunapitchuk

"Elders used to say, in 20 or more years, Nunapitchuk will just be water," said Bernice Sallison.

Figure C.1.12 - In February 2019, an unseasonal storm caused a permafrost impacted home to flood in Nunapitchuk, displacing the residents. Nunapitchuk is uncertain how severe future impacts to their land will be. Credit: Native Village of Nunapitchuk; 2019.

Nunapitchuk is located amongst wetlands in the Yukon-Kuskokwim region. Melting permafrost has caused homes and other critical infrastructure to sink into the ground. In February 2019, unprecedented winter rain in Nunapitchuk flooded the home of Zechariah Chaliak, Jr. The first floor filled with several feet of water, displacing the family for several weeks and permanently damaging the home. Community member Golga Frederick explains that with the combination of erosion and melting permafrost in Nunapitchuk, "we are losing the land very fast." Morris Alexie described how the permafrost is "very soft... very loose... Once you have trampled on the tundra, it will deteriorate. It will easily break and easily sink... Every building you see in the village is slanted or warped. We might level it up, but by the next spring, it is slanted again. There is no hard ground." Nunapitchuk residents are concerned that there is no more solid ground suitable for building, which threatens the long-term viability of the community in its current site.

C.13 - In Northern Alaska, Thawing Ice Means Losing Food for the Entire Year

Gordon Brower is a whaling captain in Utqiagvik and hunts for bowhead whales, which Alaska Native people have been hunting for thousands of years. Harvesting whale is essential for protecting food security and preserving a subsistence way of life. When a whale is harvested, meat is divided among the crew and shared with the entire community. Whale meat is stored in ice cellars, which are a natural form of refrigeration constructed within permafrost.[2] In Utqiagvik, ice cellars are failing due to flooding and collapse, caused by warming temperatures. According to Gordon, some ice cellars in Utqiagvik are caving in and most are suffering from temperature fluctuations that are causing meat to go bad. Gordon and others have resorted to pulling meat out of the cellars and putting it in walk-in freezers - "solely to save it." Ice cellars are a critical piece of infrastructure for communities such as Utqiagvik - their

Figure C.1.13 - Gordon Brower is a Whaling Captain in Utqiagvik and hunts for bowhead whales every spring and fall. He relies on ice cellars to store the harvested whale meat, which have been failing across Alaska. Failing ice cellars threatens the food security and livelihoods of Alaska Native people Credit: Gordon Brower.

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[2] Kelsey E. Nyland, Anna E. Klene, Jerry Brown, Nikolay I. Shiklomanov, Frederick E. Nelson, Dmitry A. Streletskiy & Kenji Yoshikawa (2017) Traditional Iñupiat Ice Cellars (SIĠḶUAQ) in Barrow, Alaska: Characteristics, Temperature Monitoring, and Distribution, Geographical Review, 107:1, 143-158, DOI: 10.1111/j.1931-0846.2016.12204.x

failure is a crisis and threatens traditional food supply and puts communities at risk for foodborne illness, food spoilage, and even injury from structural failure.[3]

C.14 - Quinhagak Has $11.5 Million in Immediate Needs to Protect Community Infrastructure

"Quinhagak, in response to climate change, will accept new teachings, listen more attentively, involve our kids, use our qannryyutit to adapt with a Yup'ik mindset for the future survival of our traditional ways, and respect our land and elders." – Quinhagak Vision Statement

"Quinhagak is at the tip of the iceberg," says Vivian Korthuis, the president of the Association of Village Council Presidents, a regional body for 56 tribes in the Yukon-Kuskokwim Delta. A report by ANTHC identified approximately $11.5 million in immediate needs to protect community infrastructure and health from permafrost degradation, coastal and riverine erosion, and flooding. Thawing permafrost is causing differential settlement for most of the structures that are not on driven pile foundations as well as the roads and airport. The community's highest priority is to address impacts to the multipurpose facility, which operates as the clinic and washeteria and experiences significant differential settlement likely due to permafrost degradation that will likely lead to foundation failure if not addressed. Quinhagak Elder Joshua Cleveland said, "We need to teach our young folks to take care of themselves and the land. They are our hope. We need to make it a priority to teach them."

Figure C.1.14 - Thawing permafrost in Quinhagak is likely causing the foundations beneath critical community infrastructure to sink, and will lead to foundation failure if not addressed. In order to protect imminently-threatened community infrastructure, the community requires $11.5 million. Securing and managing millions in funding requires small, rural communities to apply to many different programs across different state and federal agencies. Credit: Alaska Native Tribal Health Consortium; 2019.

[3] https://anthc.org/wp-content/uploads/2016/01/CCH-Bulletin-No-4-Climate-Change-Ice-Cellars-Barrow-Alaska.pdf

Chapter 2: Contiguous 48 States Tribal Communities

Northwest Region Infrastructure Impacts

Northwest tribes are considering whether utilizing a combined response strategy of protect-in-place, managed retreat or relocation is sufficient to adapt to climate change's growing pressures on community infrastructure. Due to cost and complexity, relocation is often viewed as the last resort. Several Washington tribes have begun relocation efforts, including the Quileute Tribe, Hoh Tribe, Makah Tribe, Shoalwater Bay Tribe and Quinault Indian Nation (May et al., 2018)

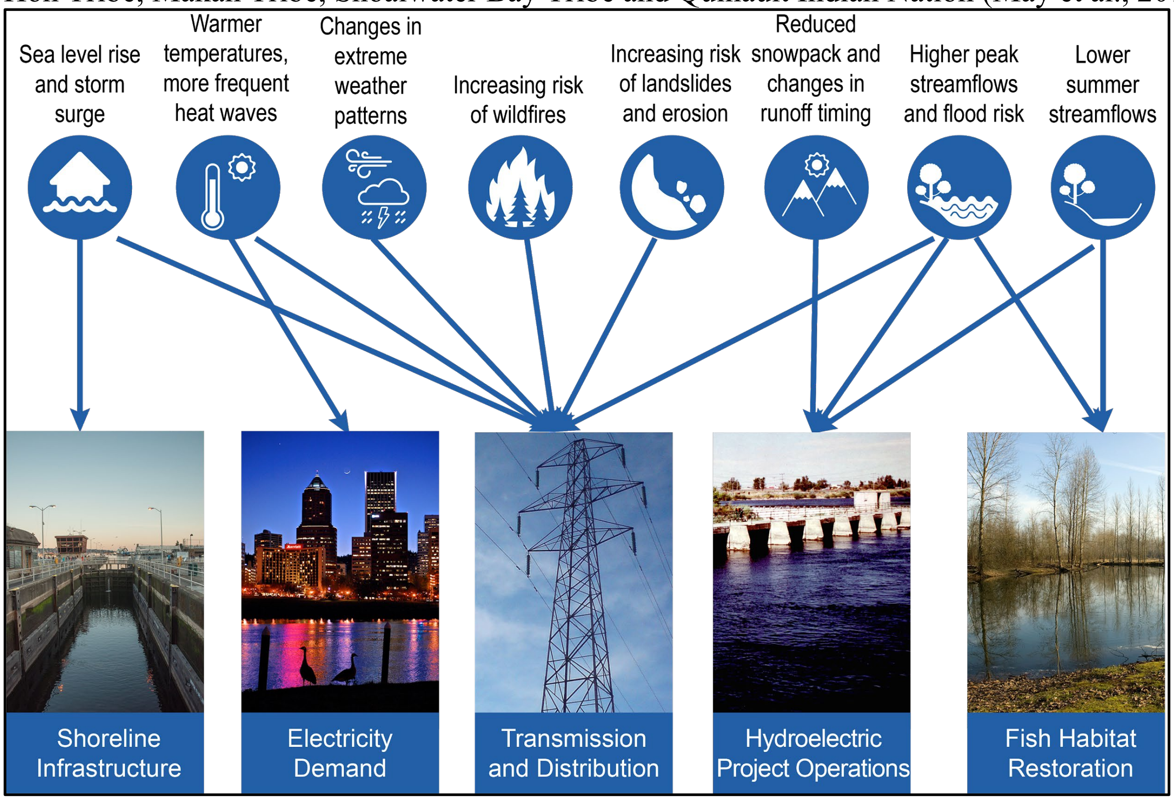


Figure C.2.1 - Multiple Climate Stressors Affect Vulnerable Infrastructure. Extreme events such as lower floods, heat waves, wildfires, landslides, and drought play an important role in the vulnerability of infrastructure. The figure, from Seattle City Light's Vulnerability Plan,133 illustrates how the utility's assets, operations, and management goals are affected by a broad range of climate impacts and extreme events. Adaptation strategies to increase the resilience of the energy system must focus on multiple potential risks as well as environmental considerations. Source: adapted from Raymond 2015.133 Photo credits (from left to right): Emmet Anderson (Flickr, CC BY-NC 2.0), Justin Miller (Flickr, CC BY-NC 2.0), photojojo3 (Flickr, CC BY 2.0), U.S. Department of Energy, Rick Swart, Oregon Department of Fish & Wildlife (NCA4, 2018, Ch. 24, Figure 24.11).

C.15 - Quinault Indian Nation Case Study: Coastal flooding and erosion increase pressure to relocate an entire village to higher ground

Overview

The Quinault Indian Nation, located on the Pacific Coast of the Olympic Peninsula, has chosen to enact a relocation plan to move Taholah Village. At the confluence of the Quinault River and Pacific Ocean, Taholah Village is particularly vulnerable to sea level rise, storm surges, and river flooding – all of which are expected to worsen with climate change (EPA: Environmental Protection Agency, no date). In addition, tribal members are at risk for tsunamis from offshore earthquakes. Approximately 20% of the population live in Taholah Village, and important cultural and physical infrastructure are threatened by both climate change threats and earthquake hazards (Quinault Indian Nation Community Development, 2017). The Village of Queets lies more inland that does Taholah and is less susceptible to physical damage from sea level rise; however, the lower areas of Queets are threatened by a tsunami tracking up the Queets River. The Lower Village will need to relocate to higher ground, also.

> *Even minor storm events can endanger the lower village. In March 2014, a storm surge breached the seawall that protects Taholah, causing the QIN to declare a state of emergency. While the seawall was reconstructed after that event, the seawall is not a permanent solution. In December 2015, waves nearly topped the seawall during a minor storm. In March 2016, residents could canoe between First Street and the police station because of localized floodin*g (Quinault Indian Nation Community Development, 2017).

Figure C.2.2 - "Quinault tribal member Sonny Curley canoes through Sea Breeze Field on the Quinault Reservation on March 10. The tribe is being forced to relocate part of the village of Taholah on the Washington coast due to ocean encroachment." Source: Larry Workman/Quinault Indian Nation (Sharp, 2016)

Figure C.2.3 - Lower Village Inundation Map showing tribal infrastructure locations in relation to flood hazards (Quinault Indian Nation Community Development, 2017)

Challenges to enacting relocation plan

School funding cannot be funded solely through federal government's trust responsibility

> *"Funding the school will be a challenge; the Taholah Education Center Master Plan (TECMP) estimates a total cost for school construction of $48 million. According to the TECMP, the School District is not eligible for Bureau of Indian Affairs (BIA) capital projects funding and no single federal agency has adequate capital investment program appropriations to undertake the new school project. The State of Washington requires that school districts raise the local share (up to 80%) of the funding for a new school through local bond issues, however, the School District encompasses Tribal Trust Land and therefore has virtually no bonding capacity. The TECMP concluded that the only viable option for funding a new school would be special federal financial assistance through Congress." (Quinault Indian Nation Community Development, 2017, p. 37)*

Funding sources cannot address complex, multi-layered problems due to narrow criteria

> *"There is difficulty in financing some of these new developments, especially neighborhoods. Funding can be obtained from Housing and Urban Development (HUD), but only for affordable housing and we are trying to do a mixed-income development.*

We'll need to build road and sewer/water infrastructure simultaneously, but Department of Transportation (DOT) grants only cover roads and Indian Health Service (IHS) funding solely covers utilities. So if there were some sort of integrated funding, that would be advantageous. Also, transportation grants that we'd use to construct roads are often based on criteria such as traffic alleviation, good repair, reducing crashes and economic competitiveness. These are all admirable goals, but we simply need to provide people a place to live and save lives from tsunamis. So in both cases lives would be saved, however transportation grantors are not as likely to look favorably on non-traffic related deaths when deciding who gets funded. Relocation projects are different from most projects seeking grant funding and do not necessarily fit with grant requirements. In order for such relocation projects to be successful, there should be funds set aside for this specific purpose." (Kelsey Moldenke, personal communication, April 29, 2020)

Incentivizing tribal residents out of the danger zone

> *"The biggest impediment, other than funding, is incentivizing people to move to higher ground if they have a mortgage or have paid off their mortgage. No one has been able to figure out a way to do this"* (Kelsey Moldenke, personal communication, April 29, 2020).

C.16 - Confederated Tribes of the Umatilla Indian Reservation Case Study: Inland - River Flooding

Inland river flooding is impacting the infrastructure of Tribes across the Northwest Region. Here, the impacts of inland flooding on the infrastructure of the Confederated Tribes of the Umatilla Indian Reservation illustrate the issues many Northwest Tribes are facing.

Major disaster declared amid COVID-19 crisis

On April 3, 2020 President Trump/ FEMA declared a major disaster on Confederated Tribes of the Umatilla Indian Reservation (CTUIR) lands due to the historic flooding event (U.S. Small Business Administration, 2020). This flooding event occured as the COVID-19 crisis was ramping up and local communities were enacting stay-at-home orders. Attempts to respond to this flooding event are unknown at reporting time.

As severe storms struck Oregon, causing flooding, landslides and mudslides, CTUIR experienced major flooding, forcing people to evacuate to higher ground. Heavy rain caused rapid snowmelt in the Blue Mountains, swelling the Umatilla River seven feet above flood stage (*KATU staff*, 2020). Floodwaters caused interstate and highways to close and sent residents scrambling to rooftops to await rescue.

> *When Umatilla County residents woke up last Thursday morning, they had no idea they were about to experience the area's worst flood in living memory...flood waters had overtopped district's gates all along the Umatilla River. Records show the river rose more than 7,000 cubic feet per second, past the mark of previous floods in 1996 and 1964 (Mcdowell and Pollard, 2020).*

Figure C.2.4 - "A man watches logs pile up at Threemile Dam on the Umatilla River", Source: McDowell J. (2020) (Mcdowell and Pollard, 2020)

Importance of emergency response planning

The 2016 Umatilla Indian Reservation Hazard Mitigation Plan foresaw this exact situation, thus demonstrating the necessity of tribal nations to conduct vulnerability assessments and hazard response planning. The report's authors predicted:

> *The most likely scenario for flood waters affecting the CTUIR is when a heavy snow pack exists in the Blue Mountains and a warm storm front occurs that carries an extensive amount of rain as was the case with the flood of February 1996. This "winter snow meets a pineapple express" scenario, although infrequent, is likely to occur again and become a major flood affecting the CTUIR (Perry and Hazard Mitigation Steering Committee, 2016).*

Wildfire - a key concern

Wildfires and forest health were also identified by CTUIR as a 'Key Item of Concern' because of the connection between water quality, stormwater run-off and flooding (Nasser, E., Petersen, S., Mills, P., 2015). Intense wildfires can quickly exacerbate flooding concerns and create debris flows and landslides. Studies have shown that after wildfires, more sediment is deposited into nearby streams, which negatively impacts fish spawning habitat.

> *"According to a landmark National Research Council Report conducted in 2011, for every 1.8-3.2 °F of warming, there was a 200-400% increase in area burned in the Western U.S. From 1970 to 2004 there were 4,592 fires reported in the Umatilla National Forest. Lightning was the cause of 66% of those fires and burned 149,034 acres. Human-caused fires accounted for 1,503 fires involving 45,843 acres"* (Nasser, E., Petersen, S., Mills, P., 2015).

History of flooding of the Umatilla River

The Umatilla River runs through the CTUIR Reservation. Thirty major floods have occurred between 1964 and 2014 on the Umatilla and Walla Walla Rivers. On average, a flood occurs every 1.89 years in the county. (Perry and Hazard Mitigation Steering Committee, 2016).

Flooding impacts on CTUIR infrastructure

Flooding within the CTUIR of areas closest to the Umatilla River has blocked transportation routes, compromised power and communication systems, created bridge and other road failures, isolated parts of the community, and challenged emergency response. Further, flooding causes damage to infrastructure such as roads, water and sewer lines, agricultural lands, and residential areas on reservation. According to the 2008 Hazard Mitigation plan for the area, flooding has impacted a number of specific areas on reservation (Nasser, E., Petersen, S., Mills, P., 2015).

Figure C.2.5 - Flooding on the Umatilla Indian Reservation in 2020. Photo credits: Lower left: Andrew Wildbill; lower right, upper right; and upper left: KATU staff, 2020.

There are approximately 49 addressed buildings located within the Umatilla River floodway and approximately 74 addressed buildings within the 100-year floodplain. These homes have an estimated average assessed valuation of $130,000. There are 49 homes located within the Umatilla River "floodway." If a major flood occurred, and these 49 homes were "substantially damaged," the estimated loss would be approximately $6,370,000. If the 74 homes, located within the Umatilla River floodplain but outside the Umatilla River floodway,were damaged but less than 50% of their value, the estimated losses could reach as high as $4,800,000 (Perry and Hazard Mitigation Steering Committee, 2016). Flooding is also negatively impacting culturally important infrastructure, like the first foods lamprey eel restoration facility see in Figure B1.9. Lamprey eels are a traditional food for tribal members.

Figure C.2.6 - "The lamprey restoration project on the Confederated Tribes of the Umatilla Reservation, near Mission, Oregon, was completely destroyed by recent flooding. Tanks full of some 1,500 eels washed away. The tribes are working to restore this valuable traditional food source by rearing juvenile lamprey" Source: King, A. Northwest News Network (Davis, 2020).

Western Region, Navajo Region, and Southwest Region Infrastructure Impacts

Tribal infrastructure in the Western, Southwest and Navajo regions have been primarily damaged due to flooding events from increases in monsoon rain events. Southwest Tribal Climate Change Workshop participants noted that "Rain has become fast and frequent, of shorter duration and higher intensity, and more localized. A week of rain flooded out First Mesa, AZ. impacting homes and sewer systems." (Wotkyns, 2011).

C.17 - The Havasupai Tribe of the Havasupai Reservation, Arizonan Case Study: Damage to tourism and reservation access infrastructure

Flash flooding endangers tourists and downstream villages

Visitors from all over the world come to experience the natural beauty of the Havasupai Tribe's home. Soaring red cliffs tower over aquamarine pools and waterfalls in Havasu and Supai Canyon. In 2008, severe flash flooding led to 426 people being airlifted to safety as floodwaters inundated Supai Village and downstream infrastructure (*Navajo-Hopi Observer*, 2008a, b, and c). This event caused at least $4 million dollars in damage to trails, campgrounds and other tourism infrastructure (Wagne, 2009). Tourism revenues are a major economic activity the Havasupai Tribe depends on. More recently, President Trump declared a major disaster as another severe 2018 flood event impacted tribal resources (FEMA, 2018). The tribe received $1 million in funding for its recovery efforts from the San Manuel Band of Mission Indians and federal and state agencies (Wotkyns, 2010).

Figure C.2.7 - Left side: Havasu Falls prior to the 2008 flood event[1] . Upper right: "Flash Flood: Trapped along the Trail to Havasupai" Source: (Pappagallo, 2013). Bottom left: Flash Flooding turns blue water brown at Havasu Falls[3]. Photo credits: [1] Havasupai Tribe (2017) https://www.havasupaireservations.com/; [2]Nicholas Pappagallo Jr.(2013) https://captureschool.com/articles/trapped-trail-havasupai-due-flash-flooding/; [3] Joel Masson (2008)[3]

Frequency of flooding on tribal lands

The 2008, 2010, and 2018 flood events are not anomalous. A 1996 study by the U.S. Geological Survey found that at least 14 other significant flooding events occurred in the 20th century with "nearly 80% of historical Havasu Creek floods occurring during or immediately following El Niño years" (Mellis *et al.*, 1996). These floods are typically caused by intense thuderstorms with several inches of rain falling in short time periods. In 1990, the largest flood measured by the USGS was over four times as large as the 2008 flood that resulted in significant property damage, livestock loss but fortunately averted the loss of life. Water flow was estimated at 4,731 cubic feet per second (2008) versus 1990 of over 20,306 cubic feet per second (Brown, no date; Mellis *et al.*, 1996). During the 2011 Southwest Tribal Climate Change Workshop, tribal members noted that "changes in weather patterns and the increased occurrence of extreme weather events, rain has become fast and frequent, of shorter duration and higher intensity, and more localized, and that the Southwest is experiencing drier winters and changing patterns in the monsoon" (Wotkyns, 2011).

C.18 - The Tohono O'odham Nation of Arizona Case Study: damage to homes, roads, utilities, earthen-dam infrastructure

Tropical storm threatens to collapse dam

In 2018, rainfall from Hurricane Rosa produced unprecedented levels of flooding on the Tohono O'odham Nation, raising water levels to the point where the integrity of Meneger Dam was a major concern. Over 162 people were evacuated overnight from the downstream communities of

Meneger's Dam, Ali Chuk, and Kohatk (Tohono O'odham Nation, Office of the Chairman and Vice Chairman, 2018c) and forced to seek emergency shelter. As the rain continued to fall, emergency measures to lower the lake level and construct sandbag levees to stabilize the dam were required. After water levels came within a foot of maximum capacity and caused concerns of imminent dam failure, residents waited in shelters for over two weeks for the water to recede (Radwany, 2018) . During the flooding event, roads to the communities were impassable further complicating evacuation and dam safety operations (Tohono O'odham Nation, Office of the Chairman and Vice Chairman, 2018a).

Figure C.2.8 - Impassable roads from flooding on Federal Route 42 on the Tohono O'odham Nation. Source: Tohono O'odham Nation (Tohono O'odham Nation, Office of the Chairman and Vice Chairman, 2018b)

Initial damage assessments of 50 homes within Districts impacted by Tropical Storm Rosa, including in: Gu Vo (11 homes), Pisinemo (17), Sif Oidak (20), and Hickiwan (2) (Tohono O'odham Nation, Office of the Chairman and Vice Chairman, 2018b). Assessments following the flooding showed "structural, roadways, infrastructure systems, environmental degradation, and other impacts", leading to President Trump's major disaster declaration (Federal Emergency Management Agency, 2018). Although total damage costs are not available for the Tohono O'odham Nation, damage from Hurricane Rosa flooding in the Southwestern United States totaled about $50 million (USD) (Impact Forecasting, 2019). Flooding is not limited to hurricanes, intense downpours also cause flooding. When it floods, the transportation system is severely impacted, so most tribal members have to shelter in place and lack access to essential resources like food and water (Walker, personal communication, 2020).

Figure C.2.9 - Upper left: "Meneger's Dam Lake. At the center of the image is the earthen embankment of the dam; just beyond the embankment the community of Meneger's Dam can be seen". Lower left: "The earthen Menagers Dam is in imminent danger of failing, potentially sending floodwaters rushing into the Tohono O'odham Village of Ali Chuk . . . after Hurricane Rosa's remnants drenched the western half of Arizona". Upper right: "Kohakt Village, the saturation in the ground indicating where water had flooded" Lower right: "Sandbagging operation to shore up the berm at Meneger's Dam". Photo credits: Richard Saunders, Tohono O'odham Nation Director of Public Safety. (Tohono O'odham Nation, Office of the Chairman and Vice Chairman, 2018c); Lower left: Mike Christy/Arizona Daily Star via AP (Anonymous] New Haven Register 2018 October 5 'Southern Arizona dam holding as water recedes').

Response to climate change impacts and resource needs

Long-term drought, which researchers have linked to climate change in both frequency and longevity, stresses water supplies and food sources (Wall, 2017)). Increasingly, tribes in these regions are finding that water is either in short supply or falling in significant rainfall events. These storms generate stormwater runoff that fills the ephemeral streambeds (i.e washes) and natural drainage channels (Hopi Hazard Mitigation Planning Team, 2015) and cause flooding throughout the community

> *The winter-time "Mother Rain," says the tribe's Water Resources Director, Selso Villegas, has diminished, and summer rainstorms are fewer but often more intense. Wood-and-stucco homes, which have slowly replaced traditional adobe homes on the Nation, sustain greater flood damage than adobes. "They should have been built on two-foot pedestals," Villegas says, "but they're not, so the flooding comes straight to their doorways. We've always had flooding problems here on the (Tohono O'odham) Nation. About 15 of our communities...have been affected by '50-year floods'. There are four places I stress about the most [Santa Rosa Valley, Menager's Dam, Chui Chu Village and Vamori Village]. If we get a '100-year flood' event, those communities may be devastate*d (Wall, 2017).

The primary response strategies to reduce damage to tribal infrastructure is to alleviate flooding from the monsoon rains. Several tribes have identified floodplain mapping, floodplain hazard evaluation, installing flood warning and monitoring systems, and creating protect-in-place structures as necessary steps to take (Tohono O'odham Nation, no date; Hopi Hazard Mitigation Planning Team, 2015). Protect in place structures range from dam control in upland areas (Havasupai) to levees to protect critical infrastructure and at-risk communities (Hopi, Tohono O'odham).

Eastern Region Infrastructure Impacts

C.19 -Penobscot Indian Nation Project: bridge construction

Need description: "There is only 1 bridge (from Old Town) to Indian Island. If a severe storm (hurricane) or severe flooding (increased or accelerated snow melt, ice damming of the Penobscot River (similar to those events back in the mid 80's), etc.) were to make the bridge impassable then the residents of Indian Island would not be able to get off (or back on to) Indian Island. Suggestions have been made to construct a bridge from Indian Island to Orson Island (NW of Indian Island) which is also Tribal Property. This would allow additional tribal housing to be constructed as Indian Island has little remaining land to put houses on. However, a third bridge would need to be constructed from Orson Island to a point in Old Town near to the local airport in order to utilize the area's road systems. Another possible location for a bridge would be from Indian Island on the east side near the school to a point in the community of Milford (non-tribal) and the road system there" (Davis, IHS, pers. communication, 4/17/20).

C.20 - Wampanoag Tribe of Gay Head (Aquinnah), Martha's Vineyard Project: Long-Term Viability Assessment of Lobsterville Road and West Basin Road, Aquinnah, MA

Key hazards: Flooding, Storms: Nor'easters, Blizzards, Hurricanes, tornadoes, etc., all of which are increasing in frequency and intensity due to climate change.
Project Description: Tribe has studied the potential impacts that climate change may impact Lobsterville Road, which provides access to 230 acres of tribal lands, and important marine ports. Improvements would include: Beach nourishment and the continuation of dune restoration projects in conjunction with the installation of natural barriers such as vegetated coir envelopes and potentially the relocation of the current roadway. The Tribe has had an engineering study of this project (Sourati Engineering Group, LLC., 2019).

Housing and Buildings

Unmet Need Estimate: $2,800,000 for infrastructure redevelopment and habitat restoration.
Priority Concern: Mold & flooding remediation in tribal homes
Key hazard: Flooding, caused by increased rainfall due to climate change impacts
Project Description: Flooding is impacting many of the 23 units of affordable rental housing on the Tribe's reservation. It is causing unsafe interior and exterior conditions for a number of dwellings. Stormwater runoff must be managed better. Engineering has been completed to address mitigation efforts, and EPA Section 319 funds have been budgeted.
Unmet Need Estimate: $120,000 for regrading area and redirecting stormwater towards new managed drainage areas.

Water Utility Infrastructure: Playground Drainage Mitigation Proposal

Goal: Mitigate Tribal Housing Authority Drainage Issues to Protect Black Brook Watershed

Due largely to road runoff and landscape grading issues, the Natural Resources Department has been working with an engineering contractor to find solutions for flooding in the playground area of Tribal Housing. During a heavy rain event, the runoff from this area affects the tributary to Black Brook, the playground area becomes flooded, and the basements of housing units do as well. In order to address this, they need to create an additional buffer within the bordering vegetative wetlands to protect Black Brook and stop road runoff from creating further erosion. For the housing units, this creates increased moisture and mold issues, resulting in direct health concerns. The Department has been developing a plan to work with the Housing Authority to regrade this area and redirect the runoff to existing catch basins, increase the capacity of existing catch basins, and install a roadside bioswale system with appropriate native plantings.

C.21 - Shinnecock Indian Nation

Sea level rise and storm flooding were identified as risks to the Nation's roadway infrastructure. Some roads are already susceptible to flooding during high tides and storms. Increased flooding will require transportation network upgrades (culverts, storm drains, raising roads).
Human health consideration: reduced emergency access during storms.

Housing and Buildings

Public health impact - Mold in housing structures
Resolve flooded basements issue. Mitigation needs to be put in place to prevent homes and the Nation's burial ground from flooding.
Equip 57 homes in the SLOSH (Sea, Lake, and Overland Surge from Hurricanes) zone with sump pumps for quick removal of flood water in basements.

Cultural infrastructure and culturally important resources

"The cemetery is also bordered on both the north and south by tidal marshes. Each marsh has a degraded drainage pipe that is intended to facilitate drainage of stormwater impoundment from the upland marsh area (following a storm or heavy rain event), and possibly to allow adequate tidal flushing to and from the marsh area. However, both pipes are damaged, partially buried, and clogged (Figure B7.8), resulting in poor drainage and limited tidal exchange capacity. Ultimately, this results in increased flooding potential and drainage times in the vicinity of the cemetery, and also results in substandard ecological habitat in the marsh systems. These two small tidal systems need to be evaluated, and likely the existing culverts need to be replaced with appropriate engineered and sized flow control, to improve drainage, reduce flooding potential, enhance tidal exchange, and restore water quality and marsh habitat" (Shinnecock Indian Nation Climate Vulnerability Assessment and Action Plan, 2019)

Figure C.2.10 - Culverts, pipes adjacent to Shinnecock Indian Cemetery. Pipes are clogged, and in need of repair.

Burial grounds

Hurricane Sandy impacts: The United South and Eastern Tribes (USET) set up a donation center to collect aid for the Shinnecock Indian Nation, after a storm surge eroded away the bluffs at the West Woods Tribal Reservation and caused flooding to Shinnecock tribal lands, including flooding of burial grounds, damage to homes and government buildings, debris, and wide-spread power outages (FDEM, 2012).

Following the storm, through a contract to provide support for climate change adaptation to the Saint Regis Mohawk Tribe and other tribes, Industrial Economics and Woods Hole Group, Inc. visited the site to assess potential coastal flooding vulnerabilities and coastal engineering adaptations that could be considered in planning for future sea level rise and storm events. Changing climate will likely lead to more, stronger nor'easters and hurricanes. Building oyster reefs and restoring submersed aquatic vegetation will lessen wave action and reduce shoreline erosion. New reef and submersed aquatic vegetation beds created today will also ensure that oysters along with other fish and shellfish, continue to thrive in the face of climate change (Figure B7.9).

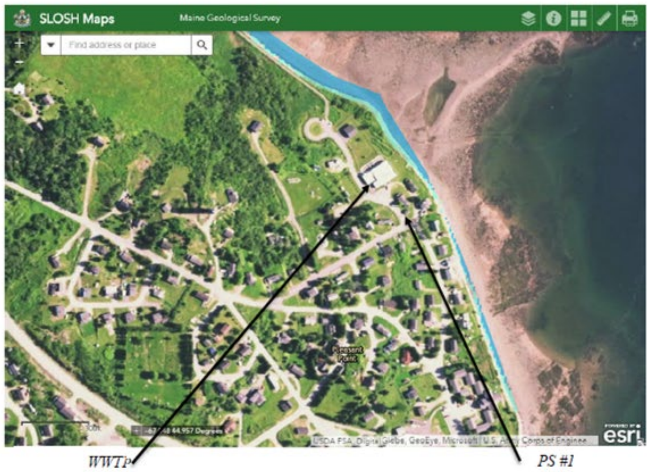
Figure C.2.11 - Building oyster reef at Peter Point, c. Mike Horak, TNC.

Protective infrastructure

Shoreline erosion mitigation. NFWF assisted the Tribe with $3.5 million to mitigate 320,000 sq. ft of shoreline, which represents 1/4 of the sandy shoreline in need of storm surge mitigation.

C.22 - Passamaquoddy Tribe at Pleasant Point

The Tribe is concerned with the potential for negative impacts to the wastewater treatment plant (WWTP), several pump stations and the collection system in the face of potential storm surges and sea level rise impacts to the WWTP located within Pleasant Point (Figure B7.7). An engineering study recommended, “In order to proactively address the potential for long-term relocation, it would be appropriate for the Tribe to consider potential sites for WWTP and pump station relocations in the near term.” The costs are substantial, however (estimate: $10-15 million).



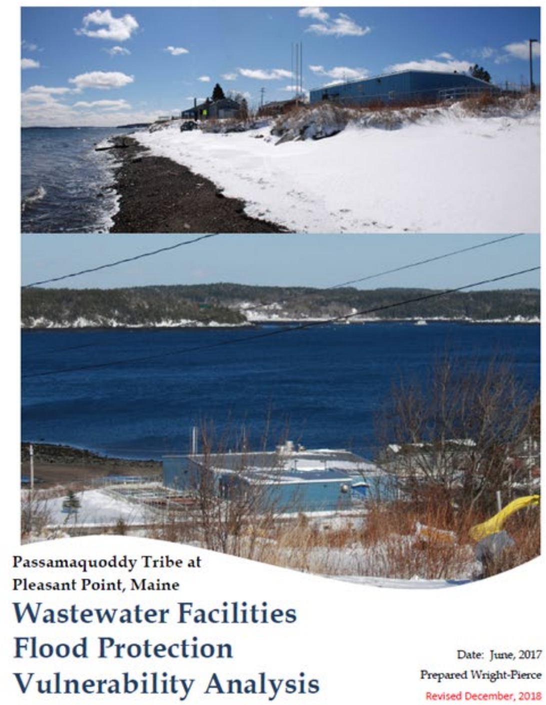


Figure C.2.12 - Wastewater facility vulnerability to coastline impacts (sea level rise, erosion), Passamaquoddy Tribe at Pleasant Point, Maine. Note proximity of facility to coastline. Source: Wright-Pierce, 2018.

C.23 - Passamaquoddy - Indian Township (PASI)

The water flowage surrounding the tribal communities, easily seen from a plan view (e.g. google maps) of The Strip & Peter Dana Point, are the headwaters of the St. Croix. Sea level rise combined with severe storm or severe flooding could possibly impact the Tribe's water and/or sewer infrastructure, clinic, or community center. Perhaps such a VA should be done for PASI. The cost of the VA done for PASP was about $75K.
Another type of affected infrastructure is water distribution systems.
Groundwater is the primary source of drinking water for the region's communities and of freshwater for the region's rivers, ponds, wetlands, and bays. Climate change has the potential to exacerbate these issues in several ways:
Changes in precipitation—especially the projected increases in total precipitation and extreme rainstorms—will likely lead to increased land-based and atmospheric inputs of nutrients (Sinha et al. 2017; USEPA 2019).
• SLR will likely result in the regular inundation of septic systems in coastal communities—either through higher tides or elevated groundwater levels—which could increase the amount of nitrogen and pathogens transmitted directly to estuarine waters (Suffolk County 2015).

C.24 - Chitimacha Tribe of Louisiana[4]: Report of unmet infrastructure needs

Receipt of this report occurred after analysis was nearly completed; as such, it was not possible to integrate this report into the regional analysis of this Chapter. This said, the tribal government invested significant time in report development (Thornbrough, pers. comm., 5/7/20). The report contains substantial content regarding infrastructure needs, due to climate change impacts, federal agency resources, and site-specific conditions.

[4] Chitimacha Tribe of Louisiana, "Priority Concerns", 4 pp., 5/7/20.

Priority Concerns: Flood Protection Charenton Floodgate (new and rehab. old)

The Charenton Floodgate is the oldest structure on the West Atchafalaya Basin Levee system and there is concern that it will not be able to protect the Chitimacha Tribe of Louisiana's reservation and surrounding communities from flooding. This structure is the lowest point within this entire levee system. It is located within approximately 1 mile of the Tribe's reservation. Currently the floodgate is chained closed, is inoperable for access, and additional sheet metal has been welded to the top of the gates in an attempt to keep floodwaters from topping the flood control structure. The floodgate is not on Bureau of Indian Affairs (BIA) Trust Lands for the Chitimacha Tribe of Louisiana, but it is still of major concern to the Tribal Nation. If the gate fails to hold, the Tribal Nation would be flooded with the contents of the Atchafalaya Basin at Grand Lake. Lives, homes, governmental buildings, Tribal school, museum, health clinic, Tribal courts, fire dept., police dept., etc. would be decimated, which would cost well over the project cost to mitigate.

For 10 years, the Chitimacha Tribe of Louisiana has been working with the U.S. Army Corps of Engineers (USACE) to address the design and construction of a new floodgate, for both access and flood control. An allocation from Congress was needed in order for USACE to build what had been designed. The total cost is estimated to be $60 million. In February 2020, USACE notified the Tribe that they had received $17 million and could begin Phase I. Approximately $43 million is still needed to complete the construction of the new flood control structure. Consultation under Section 106 of the National Historic Preservation Act (NHPA) has revealed that the Charenton Floodgate is listed on the National Register of Historic Places. This is good news for the Chitimacha Tribe of Louisiana because the Tribe's wishes are to keep the original floodgate. This would accomplish two things. It will provide a secondary protection barrier in case the new floodgate ever fails or needs repair. Having two operable gates would also allow safe access to Grand Lake (Lake Chitimacha) for fishing and recreation. The Charenton Floodgate, built in 1943, for both flood control and access to the lake, which was open before it was dissected by the levee system, constructed as a result of the 1927 flood. In 2010, the Tribe hosted a public meeting to demonstrate to USACE that Tribal citizens and others from surrounding communities wanted safe access through an operable floodgate. The meeting was "most well attended meeting in recent Corps history" and the public supports the Tribe's efforts. USACE has concerns that the original Charenton floodgate could pose a risk to lead in the drinking water due to the peeling and flaking lead paint on the old gate falling into the water. The two drinking water sources for the Tribe (a combined 2,300 homes and businesses) are located near the floodgate. Drinking water has been tested and lead levels have been shown to be below risk levels at this point, but this could change over time. The cost of rehabbing the original structure and replacing the gate is not in the current scope of work for USACE therefore it has not been planned or budgeted. Costs could be around $15,000,000, but that is an estimate. Lead paint abatement might be most cost efficient, but would be complicated. *The Tribe or any other local government is prohibited from contributing to any project at this structure because it is owned by the federal government.*

Sediment Build-up in Drinking Water Intake System-Water & Sewer Commission #4 of the (Parish of St. Mary)

The water intakes for Water & Sewer Commission #4, located on the Charenton Drainage Canal and within the Atchafalaya Basin at Grand Lake are being impacted by both erosion and sediment from heavy rain events. The intake on the Basin side is filling in from the sediment loads being brought in by feeder channels during heavy rainfall. This is filling in the intake pipes as well as the area where groundwater is obtained. In 2016, the Tribe received $10,000 from the Bureau of Indian Affairs (BIA) to address water quality at this site. The Tribe reimbursed the district for needed work to clean out the intakes by using divers and also for repair of a critical communications antenna at the Basin intake. This cleaning needs to be done periodically. The channels and lake that feed the intake are in need of dredging, but funding is an issue. This intake area is also off of BIA Trust lands, but this is the only water system that services the Tribe so it is critical that dredging be done to ensure that the intake area doesn't completely silt in. If there is no water on the Basin side then the second intake would have to be utilized which is not preferred.

The second intake is being impacted by sediment and it also draws in toxins from the agricultural fields, outside of the Tribal lands, that are fallow. Sediment washes off into the Charenton Drainage Canal intake system, feeder canal, and the Lake Fausse Point. As a result, the water quality here isn't as good as it is at the Basin intake and more chemicals are required to treat it. When the Charenton Floodgate was operational water of higher quality from the Basin could be mixed into this intake to improve the water quality. This has not been possible with the inoperability of the Charenton Floodgate.

Also, the pipe at the Charenton Drainage Canal intake is vulnerable. The district has placed a water buoy over the pipe in the canal in an effort to prevent boats from damaging it. The pipe crosses the drainage canal and the bank line where it was once buried has eroded away. Ideally, the water district would have the pipe placed under the water way. The second fix would be to reclaim the lost land by bulk heading and pumping sediment over the pipe. Third, but only temporary, would be to place heavy structures over the pipe to cap it and keep it in place. The district states that this option would cost $300,000. A long-term fix would be preferred.

Drinking Water System, well and water towers (on reservation)

Water availability and water quality for the Tribe could be resolved by the installation of a water well (into the Chicot aquifer), two 100,000-gallon tanks, and a filtration system. The Tribe could use help to obtain permission to tap into the state's aquifer. At this time, the Tribe has the distribution system in place due to our connection to the local Water District, so no additional water utility mains, hydrants, backflow preventers or valving would need to be installed. No budget has been established given this obstacle, but it is estimated that the drinking water well system project would cost between $750,000 and $1,000,000.

Watershed Dredging to prevent flooding and enhance fisheries

The Teche Watershed and the Atchafalaya Basin are rapidly filling in with sediment. The more infilling that occurs, the less water these systems can handle. Without dredging and with continued heavy rains we will experience rising water and backwater flooding. Some drainage canals have filled in and are preventing water from flowing out.

The Chitimacha Tribe is also working with United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) using the Environmental Quality Incentives Program (EQIP) funding to pay for agriculture producers and landowners to plant cover crops and buffer zones, which could mitigate the sediment deposition into this part of the Teche Watershed. As stated by Louisiana Wildlife and Fisheries this watershed is being used as a sump by agriculture producers. With the heavy rains that we have increased in recent years, the problem is getting worse, impacting fisheries, possibly irreparably.

The Chitimacha Tribe hosts and are members of the Lake Fausse Point, Grand Avoille Cove, Lake Dauterieve (State of Louisiana) Advisory Board, which has applied for $5 million to dredge Lake Fausse Point, rehabilitate fish habitat, create a recreational area and pave the access

road, which would aid in hurricane evacuation if the entire levee road were also paved. This funding was denied in FY'20.
The cost of comprehensive system-wide dredging is unknown.

Marsh Creation and Shoreline Protection Projects

Louisiana's shoreline south of the Chitimacha Tribe's reservation could benefit from some shoreline restoration and marsh creation projects which would give the Tribe some protection from hurricanes. Storm surge and other impacts to the tribe will continue to increase as the Gulf of Mexico gets closer and the marsh buffers disappear. Again, these lands are off reservation and not within the Tribe or BIA's authority. The Chitimacha have used partnership opportunities to make some projects happen.
The Tribe presented two restoration projects to the RESTORE Council. One was closer to the Tribe located in St. Mary Parish and presented by the USACE. The other was within the Tribe's aboriginal lands at Bayou DuLarge and presented by USDA NRCS. $5 million of funding was given to USDA NRCS to design this project. The construction is not funded. The Tribe had planned to resubmit the St. Mary Parish project with USACE, but now USACE is not participating in RESTORE due to the 3% administrative costs rule. The Tribe has begun discussions with USDA NRCS to ask if they are willing to partner on RESTORE projects that could help give the Tribe some hurricane protection by restoring Louisiana's coastline.
USDA NRCS has stepped up and will present a $2,650,000 planning, engineering and design project on behalf of the Tribe. The Cote Blanche Freshwater, Sediment introduction and Shoreline Protection Project will be presented to RESTORE Council for funding consideration during the next funding round. The cost to construct this shoreline project is unknown. The Louisiana Coastal Protection Restoration Authority may have estimates.

Cultural Resources and Lower Elevation Home Protection- Bulkhead Bayou Teche (on reservation)

Bayou Teche is the northern boundary of the BIA Trust Lands/reservation for the Chitimacha Tribe of Louisiana. This Bayou Teche portion of the reservation is part of the long-term Tribal homeland and archaeological survey has found that there are many contiguous cultural sites present. Some of this area is eroding, while other areas are building into the bayou. There are also 4 to 6 homes that could be protected as they sit at a lower elevation, closer to Bayou Teche. These homes are threatened by occasional flooding from hurricanes and back water from spring floods.
The Tribe had a baseline bank line survey done in order to establish limits of erosion or fill for areas on the reservation boundary due to the vulnerability of this area by water action created by movement of the Bayou Teche. Subsequently, the Tribe has an additional survey to compare the bank migration over time and to assess the areas that are most impacted. The data showed that there are several areas of loss as well as a few areas of sedimentation along the Tribe's boundary. The Chitimacha Tribe of Louisiana approached USACE about installing a bulkhead to stabilize the trust lands with cultural resources along Bayou Teche and to provide flood protection for homes on the eastern end of the reservation which are in danger. USACE applied their economic analysis formula and found that the bulkhead project wouldn't qualify because it did not meet the economic impact threshold. The cost of this project is to be $2,150,000 for the entire length and $658,000 for the most critical portions near the at-risk homes.
The Tribe does not desire a sea wall at this time because it would prohibit access by Tribal citizens to Bayou Teche to fish, hunt, and engage in other cultural activities along the waterway.

Sea Level Rise

As per a USGS mapping project (see map attached), data showed that the Chitimacha Tribe of Louisiana could remain intact at its present location with a 4-6 ft. sea level rise; however, there could be flooding of 4-6 homes and possibly impacts to one Tribal business, Raintree Market, the Tribe's grocery store. Mitigation costs are unknown at this time.

Storm Surge and probable Increased Flooding caused by installation of Parish Floodgate in Bayou Teche

The St. Mary Parish Levee District is building a new floodgate structure in the Bayou Teche at Baldwin to protect the City of Franklin. The Chitimacha Tribe of Louisiana and local residents outside of the city opposed it because the new structure will prohibit storm surge, entering the Charenton Drainage Canal, from going into to Bayou Teche (east) which would divert more water to the Chitimacha Tribe of Louisiana's reservation and community. With an operable Charenton Floodgate the risk of flooding from this water diversion could be mitigated, if water levels were lower in the Basin and water could be released there.
The BIA's hydrologist contacted USACE about the concern of flooding the Tribe, but the Bayou Teche Floodgate is nonetheless being constructed. At a meeting held by the Tribe, engineers maintained that the increase in water would be minimal. We will know more after the next hurricane. If this causes repeated flooding, there may be a need to elevate homes.

Storm Surge Protection- Charenton Drainage Canal Flood Control Structure

The Bayou Teche Floodgate was installed at its location because there wasn't enough funding to construct a floodgate on the Charenton Drainage Canal. This option would have protected the Tribe as well as the surrounding area, instead of just the Franklin area. The canal is wider and deeper than the Bayou Teche so the cost is much higher (an estimated cost of $50,000,000). The Tribe has been told that this structure could be tied into an existing (possibly federal) levee system, which would need some upgrades, however since the local levee district does not communicate with the Tribe, we do not know for sure if this is true.

Erosion and Drainage (on reservation)

As with sediment deposition, erosion and proper drainage is also a problem during heavy rain events. The Chitimacha Tribe of Louisiana would like to place culverts and perform drainage maintenance which would prevent flooding of roads and stop erosion in one of the large outfall areas. The cost of these combined is an estimated $220,000 for maintenance of 6 outfalls and culverts for 1.

Governmental Challenges

Overall, the Tribe's most critical infrastructure needs related to weather/environmental/climate issues are projects primarily located off reservation, on lands that surround the Tribe's reservation for which the Tribe and/or BIA have no authority or control. The Tribe does not have other avenues to address these funding needs, except appealing to Congress.

The Tribe has worked to submit some of these projects to RESTORE through a federal agency as a part of the work to restore the ecosystems and economy of the Gulf Coast region. The best partner for these projects is USACE. RESTORE has a 3% administrative cap, which prohibits the USACE from participating because staff hourly and not salaried employees. The Chitimacha Tribe has expressed their concerns to the RESTORE staff and they have stated that they have spoken with USACE and have no solution. The Chitimacha and others are concerned that this ruling will not only hamper partnerships between USACE and the Tribe on restoration projects, but will also impair the work of restoring the Gulf Coast in Louisiana because USACE is the agency that does the most work on coastal restoration, however, it is no longer a participant.

Estimated Costs: For Tribal (on reservation) Projects
Water Well System: $750,000 to $1,000,000
Bayou Teche Protection: $658,000 to $2,150,000
Sea Level Rise Impacts: unknown
Storm Surge Impacts: unknown
Erosion and Culvert Installation: $220,000
TOTAL ESTIMATED COST: $1,628,000 to $3,370,000 PLUS

Costs for Federal or Other-State or Local (off tribal lands) Projects
Charenton Floodgate Protection: $43,000,000 (+ $15,000,000 est. rehab.)
Sediment Removal Intake Improvements: $300,000 min. + $10,000 to clean intakes (ongoing)
Storm Surge Protection-Charenton Drainage Canal Floodgate: $50,000,000
Watershed and Basin Dredging: $5,000,000 (Lake Fausse Point only)
Marsh Creation and Shoreline Protection: unknown (contact CPRA)
TOTAL ESTIMATED COST: $113,310,000 PLUS