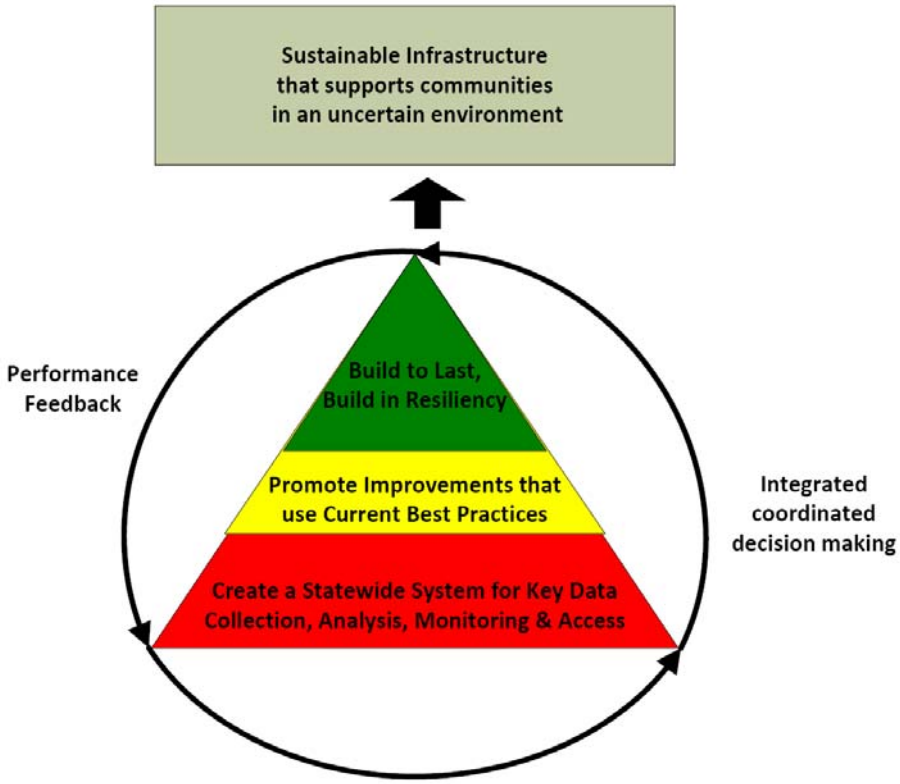
Appendix E. Public Infrastructure Technical Work Group Recommended Adaptation Options

Introduction

Vision: Sustainable Infrastructure that Supports Communities in an Uncertain Climate

The key design feature of the three recommended adaptation options for public infrastructure is that it is an integrated system. Three policies (in the triangle and described below) build upon and support one another. Continued, routine communication and feedback is essentially to adapt and refine actions taken over time.



Updated key data analysis, aligned research and modeling outcomes

Policy Option 1 - Create a Statewide System for Key Data Collection, Analysis, Monitoring and Access.

Baseline data on the condition of current infrastructure and on regional and local environmental conditions needs to be collected. We need to know where and what the problems are. We need to know what is working and what is not working. Based on the best science and collected empirical data we need to predict our future. The resulting information needs to be available to all interested parties.

Policy Option 2 - Promote Improvements that use Current Best Practices.

Managing the risks and/or reducing the uncertainties associated with climate change will take time. Promoting sustainability, reducing operating costs, and protecting/extending the service life of existing infrastructure is always worthwhile. As PI-1 is enacted and we learn from new data and updated analyzes and assessments, improvements to existing infrastructure that use current best practices are worth doing regardless of climate change effects.

Policy Option 3 - Build to Last; Build Resiliency into Alaska's Public Infrastructure.

As Policy Options 1 and 2 are enacted and we learn more as a result, new and upgraded infrastructure needs to be sited, planned, designed, and built to be resilient and sustainable in an uncertain environment. Funders of public infrastructure need to require systematic feedback that includes performance review and analysis as a stipulation for funding, development, construction, and operations of infrastructure. This will provide information that planners, engineers, and builders need about "what works" and facilitate assessing and improving codes and standards to address changing and predicted future conditions as we strive to achieve the best results.

Defining the Challenge

Infrastructure is the platform upon which society functions. Public Infrastructure is the essential facilities and utilities under public, cooperative or private ownership that deliver goods and services to communities. Common examples in Alaska include, but are not limited to:

- Highways and bridges, railways
- Airports, landing strips
- Harbors, docks and ports
- Public buildings (schools, fire stations, health clinics, post offices, etc.)
- Seawalls and river shoreline protection
- Water, sewer, stormwater and solid waste systems including sewage lagoons, dumps/landfills, and related pipes and utilidors
- Publicly owned or essential utilities, distribution systems and power grids
- National defense infrastructure, military installations

Climate change in Alaska is creating the following potential impacts to public infrastructure, with significant regional variation:

- Increased flooding and erosion
- Decreased duration (cold season) and extent (warm season) of shore fast sea ice
- Increasing freeze/thaw cycles
- Changing wind and precipitation
- Increased storm frequency and duration
- Warming and thawing permafrost
- Increased fire risk

Climate change is impacting infrastructure in a number of ways that are well documented and dramatic (See for example: ACIA 2004, ACIA 2005, Nelson et al. 2003, Robinson et al. (in prep), Stephani et al. 2008, IAWG 2008, Hamlen et al. 2004, Larsen et al. 2007, Romanovsky et al. 2007, Infrastructure Canada 2006, Kelly et al. 2008).

As frozen ground thaws existing public buildings, roads, pipelines, utilidors, and airports are likely to be destabilized, requiring substantial maintenance, rebuilding and investment. This is causing pipeline, road, bridge and building instabilities. The Alaska Department of Transportation and Public Facilities (ADOT&PF) Northern Region is currently spending approximately $10 million to combat warming permafrost on Alaska's highway system. ADOT&PF has already had to relocate entire airports due to flooding/erosion and there are several other airports that are being studied for relocation. Utilities have reported that telecommunication towers are settling due to warming permafrost (United Utilities, Yukon-Kuskokwim Delta).

Thawing permafrost can disrupt community drinking water supply. For instance the community drinking water source lake in Kwigillingok disappeared in June 2005 when the permafrost liner was lost and the lake drained overnight. The same risk of rupture exists for sewage lagoons. The added risk of contamination of surrounding areas is also a concern if the impermeable barrier for a sewage lagoon is lost. Increased failure rates and dramatically increasing operations and maintenance costs are due to freeze/thaw cycles that cause shifting soils in once permanently frozen ground. Transportation routes and pipelines are particularly susceptible and are already being disrupted and disturbed in some places by thawing ground and this problem is likely to expand. Future development will require new design elements to account for ongoing warming.

Changes such as declines in river flows and water levels, higher water temperatures, storm surges, and heavier short duration rainfalls may cause impacts such as a decline in hydroelectric power, declining water supplies, water quality problems, flash floods and overtaxing of drainage facilities. The U.S. Army Corps of Engineers reports that increasing erosion along the Bering Sea coast means the villages of Shishmaref, Kivalina, and Newtok in western Alaska will need to be moved in the next 10 to 15 years, at an estimated cost of up to $455 million.

The U.S. General Accountability Office (GAO) has reported that “flooding and erosion affect 184 out of 213, or 84 percent, of Alaska Native villages to some extent. While many of the problems are longstanding, various studies indicate that coastal villages are becoming more susceptible to flooding and erosion caused in part by rising temperatures. Reduced sea ice allows higher waves and storm surges to reach the shore. It will enhance ocean access to northern coastlines. Communities and infrastructure are already threatened; some are being forced to relocate, while others face increasing risks and costs.

Coastal storms threaten infrastructure critical for community viability (harbors, docks, schools, fuel tanks, runways, power plants, water/sewer provisions and more) by eroding sea walls and other shoreline protection and exposing infrastructure to erosion, flooding and storm surge. In December 2004 a storm surge contaminated the drinking water supply of Nunam Iqua with salt water, creating an emergency that required drinking water to be flown into that community.

Erosion, flooding, and fires are threatening many villages along the Yukon River. For example, the entire village of Koyukuk lies within the floodplain of the Yukon River. Erosion occurs anytime the river is open and specifically during high flow events on the Yukon River. These events happen throughout the year, including floods during spring breakup ice jam events and during spring/ summer/fall significant rainfall events. These floods are often severe, inundating a majority of the village and sometimes requiring evacuation of citizens to other villages. In May 2009 the eastern Interior Alaska saw record high temperatures that quickly melted snow, pushing water into the Yukon River. That, combined with a winter of heavy snowfall and thick river ice made perfect conditions for ice jams that can act as dams that flood riverside. In Eagle and Eagle Village for example, an old Native cemetery was flooded, power and phones turned off, the clinic and Village Public Safety Office (VPSO) were lost, and all buildings and houses along the riverfront in the old village were flooded. In Koyukuk these problems have been persistent and serious enough – often flood warnings provide only a 2 hour window to evacuate – that the community has begun planning efforts to relocate themselves to higher ground above the floodplain of the Yukon River upon nearby Koyukuk Mountain.

The Vulnerability of and Risk to Public Infrastructure is Growing.

Most of these impacts are not new to Alaska. What is new, is the increased magnitude, rapid development and progression, and increasing geographic extent of these impacts and affected communities. In some locations entire Alaskan villages are at immediate risk. In other locations critical roads and public buildings are at risk. The immediacy and level of risk varies by region, and locally within regions, adding to the challenge.

Reliable and sustainable infrastructure is the foundation that the future of Alaska will be built upon. To ensure that Alaska is prepared to optimize investment opportunities and demonstrate that the return on investment for Alaska’s current and future infrastructure provides good value for the state and the nation, an on-going, aligned statewide effort to monitor, analyze and proactively adapt to our changing environment is required.

Adaptive Capacity is Low.

The adaptive capacity of public infrastructure is generally quite low. Most public infrastructure is hard and fixed (for example, roads, airport runways, bridges, buildings) and cannot easily alter its alignment, elevation, or structural foundation to accommodate coastal erosion or increased flood risk.

Increased Communication, Coordination and Information Sharing is Critical.

Impacted and potentially impacted communities, agency funders, and researchers often do not know about each other’s planning efforts, infrastructure improvement projects, funding opportunities, or research, materials testing and demonstration project results. Information is not being systematically shared with all who need it and could benefit. The lack of routine coordination and information sharing raises costs, creates redundancies and adds inefficiencies to efforts to adapt Alaskan infrastructure.

In order to successfully implement the PI TWG's three-policy system and achieve both short and long term success in adapting public infrastructure **the three bulleted actions that follow are required to increase communication, coordination and systematic information sharing.**

- **There must be across the board improvement in the coordination and accessibility of information.** This includes information on the condition of existing infrastructure and the environment where it is located; information on updated forecasts and trend analysis (such as rate of erosion, permafrost thaw, flooding); and ready access to community plans and infrastructure design.

- **Collection, coordination and communication of pertinent information needs to start immediately. A program partner should be identified with the capability to organize and host an Information Center or Clearinghouse.** The Center would standardize, coordinate, and link data among the many differing sources to enable queries and integrated use. It would also track and index readily available and cost effective infrastructure development techniques that are working, that didn't work, materials development and testing results, developing designs, and contact information.

- **Create/designate an Immediate Action Work Group (IAWG)-like entity to assume a coordinating role now.** A permanent, action-oriented, entity is needed to align and coordinate (not regulate) decisions. An IAWG-like entity is needed to coordinate communication horizontally among partner agencies and vertically among levels of government and other stakeholders. It will streamline processes, eliminate duplicate efforts, minimize unnecessary effort, and minimize transaction costs of developing and carrying out a statewide system. A State of Alaska Executive Order is likely needed to establish this entity or structure. A senior-level executive should be manager. Implementation will be through existing agencies and authorities.

PI-1: Create a Statewide System for Key Data Collection, Analysis, Monitoring and Access

Option Description

Baseline data on the condition of current infrastructure and on regional and local environmental conditions needs to be collected. We need to know where and what the problems are. We need to know what is working and what is not working. Based on the best science and collected empirical data we need to predict our future. The resulting information needs to be available to all interested parties.

Across the board improvement in the coordination and accessibility of information is needed. This includes information on the condition of existing infrastructure and the environment where it is located; information on updated forecasts and trend analysis (such as rate of erosion, permafrost thaw, flooding); and ready access to community plans and infrastructure design.

Enacting Public Infrastructure Policy 1 (PI-1) will establish a coordinated and integrated system to:

1. Observe, collect, catalog, and disseminate data on the existing condition of public infrastructure and the environmental conditions where it is located.
2. Use this information to prepare forecasts and trend analysis yielding up-to-date rates of erosion, permafrost thaw, flooding etcetera by region.
3. Systematically assess the vulnerability of Alaska's public infrastructure in communities to establish the local level of risk.
4. Share information in a useable format with communities to enhance local understanding of climate change and the effect on the community, and, to facilitate and coordinate project planning and development.

There are many ongoing data collection, applied research, and technology projects accumulating information on local environmental conditions, looking to find ways to better predict climate conditions and locate infrastructure accordingly, and design infrastructure to better adapt to new conditions. The challenge, and why an entity that can increase communication and coordination is so strongly needed, is that impacted and potentially impacted parties do not routinely know about each other's efforts nor are the results being routinely shared with all who could benefit.

This lack of routine coordination and information sharing raises costs, creates redundancies and adds inefficiencies to efforts to adapt Alaskan infrastructure. To be successful in implementing PI-1, PI-2 and PI-3, two new "entities" as outlined below, are needed.

Create/designate an IAWG-like entity to assume a coordinating role now. We recommend that it be permanent and action-oriented, and focus on aligning and coordinating (not regulating) decisions. Impacted and potentially impacted communities, agency funders, and researchers frequently do not know about each other's planning efforts, infrastructure improvement projects, or funding opportunities. An entity such as this is needed to coordinate communication horizontally among partner agencies and vertically among levels of government, scientists, academia, those engaged in applied engineering, and other stakeholders. It will streamline processes, eliminate duplicate efforts, minimize unnecessary effort, and minimize transaction costs of developing and carrying out a statewide system to implement the three policies recommended by the public infrastructure TWG (and other climate change related decision-making and programming). A State of Alaska Executive Order is likely needed to establish this entity or structure. A senior-level executive should be manager. Implementation will be through existing agencies and authorities.

Immediately establish an Information Center or Clearinghouse that networks professionals across government and academia to collect, coordinate and link pertinent information. A program partner (such as University of Alaska) should be identified with the capability to organize and host. The Center would standardize, coordinate, and link data among the many differing sources to enable queries and integrated use. Focus on key or critical data needed to adapt to climate change. The Center would also track and index readily available and cost effective infrastructure development techniques that are working, that didn't work, materials development and testing results, developing designs, and contact information.

Option Design

Sub-Option 1: Standardize information to be gathered. Establish a baseline and benchmarks, so data comparison and analysis is possible over time and across agencies/parties. Identify key data needs, mechanisms to share and link databases, and fill data gaps.

Targets

1. Standardize information to be gathered. Establish a baseline and benchmarks so that data from differing sources can be compared and to enable analysis over time, regional geographic areas, and across agencies/parties. Do not replicate existing databases, instead set up a system to link data and enable queries and integrated use.

2. Gather two types of data; on the condition of existing infrastructure and on regional and local environmental conditions. Specific environmental data to gather routinely are:
   a. Soil temperature
   b. Air temperature
   c. Precipitation
   d. Surface runoff
   e. Shore fast sea ice duration (cold season) and extent (warm season)
   f. Coastal wind speed and duration

3. Organize data around designated climatic regions that are based on geopolitical boundaries. Identify and fill data gaps over time.

Timing

Begin immediately. These efforts are scalable; work can begin with existing resources and data. The effort can be enlarged over time as resources permit. Even initial efforts will contribute to significant improvement in project effectiveness. Data gathering priorities should be determined by region based on the most significant vulnerabilities and risk factors. As an example, for the Northwest Arctic Borough permafrost temperature should be monitored, data on permafrost ice content, and development of surface processes (as thermokarst, thermal erosion, ponding, slope processes) collected.

Evaluation

Conduct a baseline survey of existing and needed data. Future evaluation can be based on subsequent surveys to determine: (1) If all the data that are needed are being collected? (2) If these data are being collected at all needed locations to be able to reach regional conclusions and local applications? (3) If the data is broadly available, and if representation of data are good enough to be understood and easily used? (4) Is there a feedback loop to link scientists and academia to applied scientists, engineers and builders to guide data collection and use?

Research and Data Needs

Measurements Needed:
- Air temperature
- Soil temperature
- Wind velocity, duration (for gusts) and direction
- Precipitation (snow and rain)

- Arctic coastline wave frequency and height, storm surge, sea ice formation and seasonal extent
- Other as needed, tailored to specific regional weather changes

Evaluate use of remote sensing technologies to gather measurements. Recommend appropriate remote sensing applications to all parties that collect data and design, install or maintain infrastructure. Establishing the locations for installation of remote sensing technology can be optimized through modeling that interpolates between data collection points.

Engineers typically look back in time using climatic data to predict the future but this methodology is not as valid if the system is at a change point; there is significant uncertainty as to whether we are near or at change points (example: permafrost degradation). In the interim, use the best available data to project trends over time. Conduct modeling, based on measurements and data (above), to produce predicted regional trends over time.

Sub-Option 2: Systematically conduct local hazard analyzes for public infrastructure based on up-to-date climate data that takes regional variation into account. Produce vulnerability assessments to rank the risk level or vulnerability of existing infrastructure for each administrative region. Create easy to use products (such as isograms maps) to facilitate sharing and use by municipal and tribal governments, state and federal agencies, and non-governmental users.

Infrastructure vulnerabilities vary both across regions as well as for site specific conditions such as ice rich permafrost, erosion or flooding. Conditions must be evaluated for each specific location based on known regional vulnerabilities in order to determine the types and levels of risk each community will face. Information derived from this analysis should be used to focus initial efforts on those communities determined to be at greatest risk from climate change impacts.

Targets

1. Use data gathered through implementation of sub-option 1 (above) to run predictive models. Modeling is needed that yields up-to-date rates, trends and maps for:
   a. Soil temperatures
   b. Coastal and riverine erosion
   c. Event intensity
   d. 100 year floodplain

   Trend analyzes should address extreme events as well as averages.

2. Conduct systematic hazard analysis based on up-to-date regional climate data.
3. Produce local vulnerability assessments to rank the risk level or vulnerability of existing infrastructure in communities. Determine the status, capability and vulnerability of current infrastructure. Determine the useful life of current infrastructure.

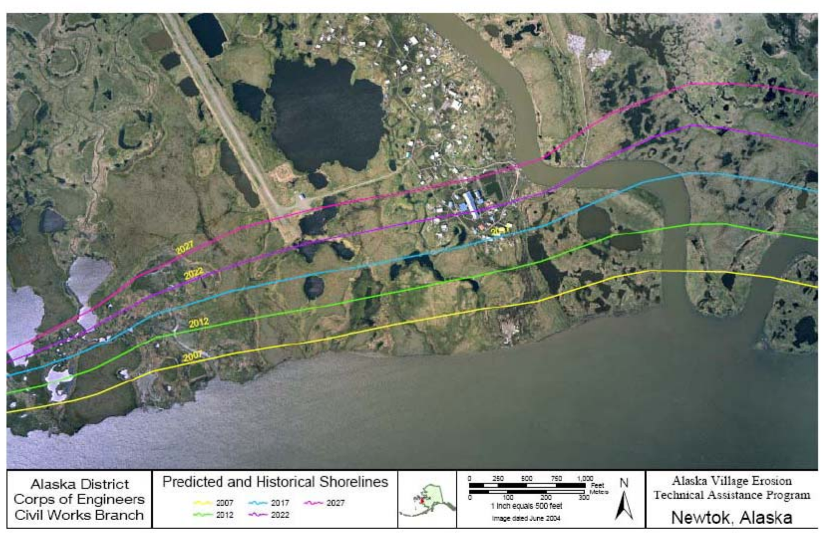


Image Source: Bruce Sexauer, U.S. Army Corps of Engineers, Alaska 2006

4. Share information in an easy-to-understand format to facilitate its use by municipal and tribal governments, state and federal agencies and Non-Governmental Organization (NGOs) users. Distribute results to: infrastructure designers, engineers and professional organizations, and to municipal/tribal governments, state/federal agencies and NGOs. The environmental data and modeling completed in this step is also needed to update engineering designs and codes (Policy Option PI-3) to reflect changing conditions.

   An example of an easy to use format is the isogram map to the right for Newtok that shows historic and predicted coastal erosion and shorelines .

Timing

Ideally, a baseline of current local environmental and infrastructure conditions is needed before hazard analyzes and vulnerability assessments are completed. However, because establishing this baseline will take several years to complete, and because public infrastructure in some areas is clearly threatened, the hazard analyzes should begin immediately with best available data in high risk areas. This would include thawing permafrost in areas of discontinuous or warm permafrost that are most vulnerable to change, erosion and flooding in the Arctic coastal areas, and areas in northern southeast Alaska with geotechnical instability caused by isostatic rebound.

Evaluation

Evaluation can be measured by determining the status of:

1. The state Division of Homeland Security and Emergency Management's (DHSEM) situational awareness and possession of trend analyzes so it can effectively prioritize use of resources to complete state emergency management plans.
2. Documenting the number of communities that received useable products (such as maps documenting result of a hazard/vulnerability analyzes, updated floodplain maps etc.) every 1-2 years
3. Documenting the number of community's each year that request assistance with adapting public infrastructure by asking for updated hazard/vulnerability assessments, updated hazard maps, requesting emergency planning assistance, or similar activities.

Research and Data Needs

Information necessary to perform a hazard analysis and conduct a vulnerability assessment is not readily available for most communities. Research and data needs include:

1. Orthographic suite of mapped physical and environmental conditions, current flood plain delineation based on up-to-date trend analysis on what risk changes are likely to occur.
2. Population demographics
3. Supply chain information: movement of goods and services (barge or shipping access, airfield access, weather conditions, etc.).
4. Establish a mechanism for regular information sharing so that a feedback loop can be established to continually adapt "No Regrets" Improvements (PI-2) and Build Infrastructure to Last (PI-3).

Sub-Option 3: Gather and review planning documents for proposed public infrastructure. Analyze and eliminate conflicts for renovation, retrofit, replacement, or relocation of existing infrastructure.

Many community plans address public infrastructure. Better communication and integration of these efforts will ensure up-to-date climate change information is being used, and that the timing and nature of public infrastructure investment is being coordinated. The suite of community plans that typically address public infrastructure planning in some way includes: community evacuation plans; community emergency operation plans; hazard mapping, analysis, and mitigation plans; preparedness activities such as outreach, training, and exercises; community wildfire protection plans for communities at significant risk of wildfire; community comprehensive plans; and strategies that address incorporated and unincorporated community eligibility for the National Flood Insurance Program.

Awareness of current efforts to fund and build public infrastructure is also important to implement Public Infrastructure Policy 3 – Build to Last, Build in Resiliency, and Public Infrastructure Policy 2 - Promote Improvements that use Current Best Practices.

Targets

Coordinated planning efforts between projects across agencies must become a best management practice.

Coordinate statewide and regional public infrastructure planning efforts, link to comprehensive community planning, and systematically address climate change.

Review agency infrastructure plans. Identify and resolve conflicts between agency plans. Determine future plan for use of current best practices to repair, renovate, retrofit, replace or relocate public infrastructure.

Timing

Begin immediately. Planning and coordination can occur independently within regions. Prioritize the regions where public infrastructure and populations are most at risk and vulnerable.

Evaluation

To evaluate effectiveness, assess whether:

1. A statewide infrastructure planning network is up and running that includes all involved parties (across agency, state/federal/NGO).
2. Electronic sharing of project planning information is occurring.
3. Integrated efforts are occurring to establish financial, managerial and other local community capacity needed to achieve sustainable infrastructure management and monitoring.

Research and Data Needs

As Public Infrastructure Policy 1 is implemented and regional insights are obtained from data collection and analysis of infrastructure vulnerabilities, reference documents will need to be updated to reflect this information and plan reviewers will need updated training.

Establish a tool for sharing state, regional and local conditions and projects.

Research efforts by other states to address planning for climate change impacts on infrastructure.

Sub-Option 4: Identify measures to adapt design criteria for public infrastructure using a performance feedback loop.

Use a performance feedback loop to adapt infrastructure design; improve policy coordination; to update analyzes based on new information on weather, economic assumptions, or demographic changes; and to integrate results of research, foundation and material testing. Use modeling to improve data alignment, scenarios, and assumptions for future infrastructure policies and plans.

A feedback loop that allows parties to learn from ongoing efforts and adapt accordingly is important. This will allow infrastructure to be designed to better withstand climate change throughout its design life without the need for costly over-design. This has the potential for a significant payback in reduced construction and life-cycle costs.

Targets

Prioritize and coordinate research /computer modeling so that environmental data, modeling and engineering needs are as up-to-date and as accurate as possible to meet each region's varying infrastructure development needs.

1. Regional data (PI-1 sub-option 1) and trend analysis (PI-1 sub-option 2) are critical components to adapt site specific criteria to improve infrastructure and provide resilience to climate change conditions (PI-3).
2. Uncertainties can be reduced by modeling/projecting environmental conditions (PI-1 sub-option 2).
3. It is important to critically evaluate performance of existing models on an ongoing basis, improve predictive capabilities, and develop mechanisms and procedures for how to best use modeling outcomes.
4. Establish a system to identify and track modeling efforts.

Timing

Ongoing

Evaluation

To effectively implement this policy:

1. Update to the Environmental Atlas of Alaska.
2. Forward recommendations to Uniform Building Code committees on needed criteria changes.
3. Conduct a retrospective evaluation of model's predictions to evaluate the model's performance.

Research and Data Needs

Improvement in model performance will be needed. This might be achieved by improving the models themselves, by improved parameterization used in these models, or by better assimilation of remote sensing and ground observation data.

As Public Infrastructure Policy 1 is implemented and regional insights are obtained from data collection and analysis of infrastructure vulnerabilities, reference documents will need updated to reflect this information and plan reviewers will need updated training.

Participants/Parties Involved

There are many ongoing data collection, applied research, and technology projects accumulating information on local environmental conditions, looking to find ways to better predict climate conditions and locate infrastructure accordingly, and design infrastructure to better adapt to new conditions. The challenge is that participating, impacted and potentially impacted parties do not routinely know about each other's efforts nor are the results being routinely shared with all who could benefit.

This lack of routine coordination and information sharing raises costs, creates redundancies and adds inefficiencies to efforts to adapt Alaskan infrastructure. To be successful in implementing PI-1 (and PI-2 and PI-3) two new "entities" are needed:

1. Create/designate an IAWG-like entity to assume a coordinating role now. We recommend that it be permanent and action-oriented, and focus on aligning and coordinating (not regulating) decisions. Impacted and potentially impacted communities, agency funders, and researchers frequently do not know about each other's planning efforts, infrastructure improvement projects, or funding opportunities. An entity such as this is needed to coordinate communication horizontally among partner agencies and vertically among levels of government, scientists, academia, those engaged in applied engineering, and other stakeholders. It will streamline processes, eliminate duplicate efforts, minimize unnecessary effort, and minimize transaction costs of developing and carrying out a statewide system to implement the three policies recommended by the PI TWG (and other climate change related decision-making and programming). A State of Alaska Executive Order is likely needed to establish this entity or structure. A senior-level executive should be manager. Implementation will be through existing agencies and authorities.

2. Immediately establish an Information Center or Clearinghouse that networks professionals across government and academia to collect, coordinate and link pertinent information. A program partner (such as University of Alaska) should be identified with the capability to organize and host. The Center would standardize, coordinate, and link data among the many differing sources to enable queries and integrated use. Focus on key or critical data needed to adapt to climate change. The Center would also track and index readily available and cost effective infrastructure development techniques that are working, that didn't work, materials development and testing results, developing designs, and contact information.

Specific to establishing the Information Clearinghouse/Center that sub-option 1 addresses, note that there are several government agencies and academic databases already in use but not integrated. Each has a database manager or monitor. Examples of climate databases: Alaska Climate Research Center (http://climate.gi.alaska.edu), Scenarios Network for Alaska Planning (SNAP), permafrost databases: University of Alaska Fairbanks (UAF) Geophysical Institute Permafrost Lab (www.permafrostwatch.org), CALM (www.udel.edu/Geography/calm/). An example of an existing infrastructure database is the Alaska Department of Commerce, Community, and Economic Development Alaska Capital Projects Database that hosts partial data for on-going projects. Sources for data on public and critical infrastructure include State agencies; Federal agencies; Denali Commission; local governmental entities, including tribal entities; NGOs; private sector and industry groups; and academia.

Specific to establishing the 'feedback loop' that sub-option 4 addresses, every municipal and tribal government, state and federal agency, and NGOs that invests in or builds infrastructure has a role. An example of what could be done is occurring at the Alaska Department of Environmental Conservation (ADEC), Village Safe Water Program (VSW), which now includes a sustainability review in its projects by asking how climate change conditions are to be addressed.

Implementation Mechanisms

This policy can be implemented by existing state and federal agencies, however greater efficiencies and cost savings will be achieved if the two entities, an IAWG-like coordination entity and an Information Center, as described in the previous section (Participants/Parties) are established to align implementation and communication horizontally among partner agencies and vertically between the various layers of government.

Four steps required to implement the Public Infrastructure Policy 1 are:

1. Conduct a hazard analysis and vulnerability assessment; the product will be a regional risk assessment map for the Alaska.
2. Starting with the most vulnerable sub-regions, develop an inventory of public infrastructure and the current technical condition of each component.
3. Establish an efficient interagency environmental monitoring system to include only those components that are essential to keep the risk assessment products updated. This system should also be capable to produce future projections of changes in regional and local risk assessments.
4. Establish an effective system of dissemination of gathered and processed information among all potential local and tribal government, state and federal agency, NGO and other users.

Related Policies/Programs and Resources

Climate Change Executive Roundtable hosted by federal Fish and Wildlife Service.

Memorandum of Understanding (MOU) group meetings hosted by the Denali Commission.

Resources and potential of the University of Alaska.

National Science Foundation's (NSF) Interagency Arctic Research Policy Committee (IARPC) led by NSF and NOAA

U.S. Arctic Research Commission has initiated coordinated efforts to establish an Arctic Observing Network and to report on existing plans of stakeholders across federal, state, industry and academic consortia on topic areas of "Arctic Infrastructure."

Benefits and Costs

Implementing the programs described and establishing a communication and decision-making network will significantly improve coordination on public infrastructure projects that involve State, Federal, municipal and tribal agencies. There is a potential for significant savings as multiple agencies that fund, design, build and operate infrastructure in Alaska develop common planning assumptions and coordinate on the timing and sequence of otherwise disparate projects. The costs will vary with the scale of implementation from low (network of existing planners and database managers) to moderate (small professional cadre for analysis and a standing resource for policy makers).

Feasibility Issues

Implementing this approach and these programs is feasible. The coordinated, networked approach described here is similar to that used over the last two years by the IAWG. It is also similar to that used by the State of Iowa to rebuild or repair 8,000 elements of public infrastructure damaged or destroyed by the 2008 floods. The Rebuild Iowa Office, with a small group of professionals working under the Lieutenant Governor and a coordinated network of public and private sector agencies has coordinated, prioritized, and monitored the rebuilding effort of dozens of state and federal agencies with many funding sources. On the state side, it is also similar to the Alaska State Division of Policy Development and Planning (DPDP) instituted by Governor Hammond and subsequent policy that utilized a resource sub-cabinet for coordinated state decision-making.

Status of Group Approval

Approved unanimously, with no objections.

PI-2: Promote Improvements that Use Current Best Practices

Option Description

Managing the risks and/or reducing the uncertainties associated with climate change will take time. Meanwhile, as data is being collected and analyzed, the focus should be on implementing public infrastructure improvements that are worth doing regardless of climate change effects. This is the goal of PI-2: Promote Improvements using the Current Best Practices. Promoting sustainability, reducing operating costs, and protecting/extending the service life of existing infrastructure is always worthwhile.

How we deal with these uncertainties about the impacts of climate change on the public infrastructure will ultimately determine how we adapt to a changing climate. For sure, as predictions on future climate change become more accurate with the execution of PI-1 the uncertainties will be reduced. By accurately forecasting future climate change and its effects, we can better protect our existing infrastructure and better plan and design new infrastructure. This approach is cost-effective and provides cost-saving benefits regardless of future climate changes. It creates balanced awareness by promoting agility and resiliency that does not overly depend on the potential consequences of future climatic events on infrastructure in Alaska.

The state (and others) can systematically improve existing infrastructure by using current best practices while PI-1 is being enacted and we are obtaining new data and updating analyzes and assessments. Use of current best practices that are continually being improved as we get better information from a performance feedback loop creates a transition to use of new and updated designs and procedures called for in PI-3: Build to Last; Build in Resiliency. PI-2 thus serves as a “bridge” between PI-1 and PI-3.

Option Design

PI-1 will establish a data baseline, continue data collection over time, and improve trend analysis and forecasting tools to achieve the best value in our future infrastructure development. The ability to accurately forecast the effects of climate change are critical to success. However, our understanding today of climate change processes and the associated impacts in Alaska are incomplete, which makes it difficult to adapt existing and new infrastructure to future changes in the environment. Due to these uncertainties, the overall infrastructure strategy and the purpose of Public Infrastructure TWG Policy PI-2 is to balance the short term need for agility with the long term need for resiliency of facilities.

Current best practices are actions to adapt infrastructure so that it can better withstand impacts due to the changing climate and the use of measures that are designed to address the vulnerabilities of existing infrastructure. Utilizing the most current information and technology, public infrastructure projects need to protect Alaska’s infrastructure investment regardless of climate change impacts by:

1. Protecting and extending the design service life of infrastructure,
2. Reducing infrastructure operating costs and complexity, and
3. Promoting sustainability in the development, design and construction of new infrastructure.

Implementing sustainable infrastructure improvement projects will provide cost-effective benefits to communities even if the underlying climate change assumptions are incorrect.

Implementation of a policy to repair and improve existing infrastructure will continue to build resilience that starts with Policy PI-1 and ends with Policy PI-3, which requires regular reporting of environmental data and infrastructure performance to create a systematic feedback loop and thereby continually better measures and options.

An example of using current best practices are the efforts of the IAWG, part of the Governors Climate Change initiative.

Over the past year the IAWG methodically labored to prevent loss of life and infrastructure and protect what is already in place in six imminently threatened rural Alaska communities. The IAWG functions as a central coordination entity. Membership is comprised of an array of senior agency staffers that coordinate the various agency authorities and ensure that each agency acts in alignment with the others. These experienced members know who to coordinate with and how to make things happen within state and federal governments.

Each of the six immediately imperiled communities had an overall vulnerability assessment completed and recommended infrastructure improvements have been integrated into a series of near term plans to protect an/or extend the service life of each town site. Individual analysis of each location has enabled them to tailor current best practice recommendations to each site. The examples below show applicant of current best practices. PI-2 recommends routinely using adaptation actions like this.

- An emergency evacuation road has been proposed for Shaktoolik potentially enabling the current town site to be occupied for many more years. The availability of a safe evacuation route during winter storms will greatly reduce the risk of injury or death for residents and enable the continued utilization of town infrastructure for many years to come.
- Strengthening the existing revetment in Unalakleet was judged to be the appropriate approach to protect and extend the operating life of existing core town site infrastructure while a migration plan to the hillside is being developed.
- The concept of incremental relocation has been introduced at Newtok. The design and incremental construction of new community infrastructure has started at a new townsite in close proximity, but away from hazard zones.. This will enable the State to maximize the remaining service life of existing infrastructure and then incrementally build replacement stock in the new location. New homes are being designed to be relocateable, relying on the concept of resilience rather than strengthening foundations and armoring current locations.
- Kivalina and Shishmaref are relying on extensive new revetments to slow erosion and extend the service life of existing infrastructure.
- No infrastructure improvements have been approved for Koyukuk yet. A feasibility study and community planning grant will help the community create a plan supported by residents to help protect the community from seasonal flooding.

Each community has been assessed and an individual plan that utilizes current best practices has been put in place or is under development that will enable residents to better cope with their changing environment. The current best practice approach enables the state to incrementally respond to communities across Alaska with available resources. The efforts and successes of the IAWG provide an excellent model of how to effectively and efficiently protect our current infrastructure investment, while data is being collected and a longer term climate change strategy is being developed.

Targets

The goal of Public Infrastructure Policy 2 is to use current best practices to make infrastructure improvements that are worth doing regardless of climate change’s effects. This is both critical and practical because we can’t stand still while we gather and analyze data and reduce the uncertainties associated with climate change. In the interim PI-2 focuses efforts on accomplishing actions that promote sustainability, reduce operating costs, and protect/extend the service life of existing infrastructure.

Utilize a communication and coordination network, and implement techniques such as changing funding formulas, in order to routinely enact actions that adapt public infrastructure by using current best practices, such as:

- Use of existing technology such as adjustable and/or mobile building foundation systems.
- Building foundations that use thermosiphons or thermopiling.
- Protecting facilities from flood or erosion damage.
- Providing energy conservation upgrades.

- Long-term planning and preparedness.
- Building local capacity for operations and maintenance.
- Promoting energy–efficient technologies.
- Using alternative energy sources.
- Building with better materials.

Timing

Implementation of PI-2 can begin immediately. During an initial phase (years 1-5) implementation of Policy PI-2 will proceed concurrently with Policy PI-1. As both efforts progress, Policy PI-3 (Build to Last, Build in Resiliency) will be introduced. PI-3 will eventually overtake and replace PI-2 once the ability to accurately forecast the effects of climate change is firmly in place and adaptation strategies for future infrastructure are created.

Participants/Parties Involved

Use of current best practices can be readily integrated into investment prioritization formulas now in use by funding agencies. This will enable federal and state agencies that already fund infrastructure development, construction and/or operation to transition to use of new and updated designs and procedures as called for in PI-3: Build to Last; Build in Resiliency.

Infrastructure development, construction and operation are key responsibilities throughout all levels of government. Participation by federal and state agencies, municipal and tribal governments, design professionals and others will be necessary for the successful deployment of this policy.

Implementation of PI-2 will be much more efficient if routine coordination and information sharing is occurring through an IAWG-like entity. (See the "Participants/Parties" section in PI-1 or PI-3 for a full description.)

Evaluation

Evaluation of the effectiveness of this policy will depend on establishing a regular schedule and process for sharing the results of already built improvements. Opportunities for sharing current best practices and information on the performance of new techniques through a feedback loops needs to be integrated into infrastructure funding awards, reporting and follow-up processes. The Information Center/Clearinghouse (recommended in PI-1) should receive and index infrastructure retrofit, repair, replacement techniques that are working, that didn't work, materials development and testing results, developing designs, contact information, and more.

Research and Data Needs

While research and data are critical to the PI-1 and PI-3 and thus to the overall implementation of the Public Infrastructure three-policy system to adapt infrastructure, PI-2 has no independent research and data needs.

Implementation Mechanisms

PI-2 can be best implemented through close coordination among federal, state and local government agencies, academia and design professionals that fund and build infrastructure. This will allow alignment of process and purpose. This will be achieved most efficiently if an IAWG-like coordination entity is established to align implementation and communication horizontally among partner agencies and vertically between the various layers of government and other stakeholders.

Implementation can begin immediately by:

1. Routinely gather and make available information on measures and practices that are, and are not, working to adapt infrastructure. A program partner should be identified with the capability to organize and host an Information Center or Clearinghouse for tracking sustainable and resilient best practices. This Center/Clearinghouse could index readily available and cost effective infrastructure development and protection techniques that are working, that didn't work, materials development and testing results, developing designs, contact information, and more.
2. Integrate factors into agency funding and prioritization formulas (such as Alaska DOT&PF Statewide Transportation Improvement Program evaluation or VSW Capital Improvement Project) to reward consideration of climate change and use of current best practices. For example, funding agencies could give higher scores to projects that:
   - Include an engineering peer review process that incorporates current best practices (as catalogued by the to-be-established Information Clearinghouse/Center),
   - Include a value engineering review process that demonstrates improved performance, reliability, quality and life cycle costs.
   - Present a project site or community vulnerability assessment to document its location compared to expected hazards.
   - Commit to a schedule of reporting environmental data and infrastructure performance (to the to-be-established Information Clearinghouse/Center) following project construction.

By systematically rewarding behavior that promotes more resilient and sustainable infrastructure, the state will be better prepared to meet the future. More efficient information exchange will reduce the time typically needed to accomplish cycles of learning and performance improvement, further enhancing the effect.

As more climate change data becomes available it can readily be introduced into the information feedback loops established by this process and allow for a smooth transition to PI-3.

Related Policies/Programs and Resources

Policies PI-1 and PI-3 of the Public Infrastructure system are integrally related to the long term success of policy PI-2. All three policies must be initiated as a system to achieve the vision and to ensure the maximum return on investment.

Benefits and Costs

The public relies on infrastructure to provide a safe and healthy environment. Maintaining transportation and sanitation infrastructure are key to ensuring public health, safety and welfare are protected. Existing public infrastructure that is required to protect public health, safety and welfare must be repaired and upgraded so it is safe and operable. Implementing modifications and repairs using current best practices will maintain the functionality of existing infrastructure, extend its service life, potentially reduce or contain operating costs and sustain capital investment. The benefits to protecting public health, safety and welfare will outweigh the costs associated with the implementation of this methodology.

Feasibility and Constraints

The United States has the required technology and needed capacity to be successful in this endeavor. Public Infrastructure Policy PI-2 can be initiated with minimal additional resources. To optimize its effectiveness an IAWG-like central coordinating entity should be established to ensure existing infrastructure funding, development, construction and operations agencies are better aligned.

Existing resources of the agencies that currently fund the development, construction and operation of infrastructure can be used to implement this policy. Adequate funding is not available to repair, retrofit or relocate all vulnerable infrastructure; however, this policy will help align funding opportunities and priorities.

Sufficient Alaska specific scientific research capacity does not yet exist to assure the long-term success of the overall three-policy public infrastructure sustainable infrastructure system.

A coordinated statewide database with key information displayed and readily available to decision-makers in an understandable and actionable format does not currently exist.

The ability does not yet exist for state and federal agencies, and municipal and tribal governments to regularly communicate and share data or establish connected and aligned policies, procedures, and information to empower decision-makers.

Status of Group Approval

Approved unanimously, with no objections.

PI-3: Build to Last; Build Resiliency into Alaska's Public Infrastructure

Option Description

To adapt Alaska's existing and future public infrastructure to the effects of climate change we must build in resiliency so that it lasts. This can be accomplished by building it in locations outside of hazard zones (that have been updated and defined using climate change modeling), or by designing and locating public infrastructure to meet acceptable risk limits or expected forces at the location over the life of the infrastructure.

Accomplishing this presumes that climate change modeling has occurred that has produced updated hazard zone locations and revised data on expected forces and conditions for which infrastructure must be designed (all per Policy PI-1). This will also require modification of some engineering design standards, building codes, and operation and maintenance practices.

Building resiliency into Alaska's public infrastructure will require:

1. Meet or exceed infrastructure design life.
2. Optimize life cycle costs/asset management practices.
3. Design infrastructure using the best science combined with appropriate building codes and engineering standards in order to withstand expected weather events and a changing environment.

Institutionalizing a feedback loop to report on how infrastructure is performing (and to transmit updated climatic data) is critical to success as this enables adaptation over time.

Option Design

Sub-Option 1: Meet or exceed infrastructure design life.

Current building codes address safety and performance of infrastructure by both manmade and natural forces. The concept of service life focuses on the ability of structures to fulfill their intended function over the design life. The design life is often set by either the infrastructure owner or by public policy rather than an engineer. For example, buildings for 'box stores' have a design life of 20 years; whereas dams for mining sediments have an infinite design life.

Some infrastructure design also considers natural forces. For example, highway, railroad and airport design considers not only structural design criteria but also erosion, flooding and thermal impacts. Erosion control features are commonly incorporated into the design. Building design on the other hand primarily focuses on the function, safety and on sites which provide an adequate foundation for the function with little consideration to natural forces. Schools are sited close to housing, post offices are sited close to business areas, and power generation plants are located safely away from populated areas.

Consideration of natural forces is the focus of the impacts of climate change on infrastructure. Coastal erosion, increased flooding, and thermal degradation potentially threaten to shorten the life of infrastructure if not properly managed. Practices of predicting the future environmental parameters based on past conditions are proving inadequate. Scientific evidence leads us to believe this practice must be altered to address a changing environment.

Unfortunately a lack of both supportive public policy and information makes it difficult for engineers to incorporate climate change in infrastructure design.

To improve we must use the collective experience of both infrastructure owners and design professionals; compile best practices for planning, design, and maintenance of infrastructure; and provide a continuous feedback during the project development cycle.

Targets

Two changes are required to ensure public infrastructure achieves its design life.

1. Develop a policy to ensure public buildings are sited in locations which preclude damage by natural forces such as flooding, erosion or thermal degradation. If that is impractical then appropriate measures must be part of the design.

2. Require sufficient climatic data is included in design codes. At present, engineers use historical data to predict the future. Unfortunately, climatic models indicate this procedure may not adequately predict future environmental parameters. Without improved prediction models of adequate resolution and reliability, designs will be a speculative patch work.

Timing

All aspects of Public Infrastructure Policy 1 must be enacted before PI-3 can begin in earnest because the information generated by PI-1 is needed to enact PI-3. This demonstrates the systems approach to the Public Infrastructure TWG's suite of three interrelated policies and why continuous monitoring and feedback are needed.

PI-1 requires collection of usable climatic data; to implement PI-3 policy makers and engineers must use this data to make and refine criteria for locating, designing, constructing and maintaining infrastructure. It may take years to fully develop a widely accessible information platform however, as information becomes available over time policies and best practices can be updated and implemented. This is why implementation of PI-2 takes place in the interim.

PI-1 recommends conduct of a vulnerability assessment of existing public structures to identify potential impacts and determine courses of action. In some cases simple action may be sufficient; in others the loss of the structure may have to be accepted. In all cases, it is important to avoid a crisis. Implementation of PI-1 also requires a vulnerability assessment for all proposed, publicly funded, new infrastructure leading to policy and design requirements which limit or eliminate these threats.

Participants/Parties Involved

Infrastructure development, construction and operation are key responsibilities for all levels of government. Participation by federal, state, municipal and tribal governments will be necessary for the successful implementation of this policy.

A lead entity needs to be designated to integrate the overall efforts, whether it is an existing or new state agency. Given the unique characteristics of Alaska compared to the rest of the Nation, it is suggested that the state assume a lead role in assembling and coordinating this partnership of agencies, owners and users.
Engineers must assess codes and engineering practices to ensure public safety is adequately addressed. The engineering community must unite on these issues to provide feedback to the building and infrastructure owners and policy makers about the consequences of decisions. In the end, as long as codes, regulations and public safety concerns are met, it is the governmental agencies that make the final decisions.

Evaluation

There are numerous examples of ongoing evaluation to see if design life is being achieved. Bridges are evaluated every two years for structural and functional deterioration. Roadways are evaluated every two years to find deficiencies. Unfortunately, not all infrastructure undergoes routine evaluation to assess how it is performing and to encourage timely corrective action.

Establishing a regular schedule and process for sharing the information on infrastructure design life will enhance effectiveness. Opportunities for sharing best practices and setting up regular feedback loops for planning, design and construction of public infrastructure will lead to longer lasting, more cost effective programs. This approach, often termed Asset Management, provides tools to assess the condition and performance of the infrastructure and to suggest appropriate and timely corrective action. Unfortunately, many agencies have little information concerning the infrastructure or its condition that is under its jurisdiction.

Research and Data Needs

Research and data are critical to successful implementation of PI-1 and PI-3. The two major data needs to implement PI-3 and meet or exceed infrastructure design life are:

1. Climatic data must be available at a resolution and accuracy to be useful to decision makers and design professionals. Statements like ‘increasing precipitation expected’ provide little information to assist the design process for snow loading on a roof structure. More useable information would be, for example, “the snow load has increased to 100 pounds per square foot.”

2. Regular sharing via a feedback loop of the condition inventory and infrastructure vulnerability assessment developed under policy PI-1 is needed to provide information to update best practices.

<u>Sub-Option 2: Optimize life cycle costs/asset management practices.</u>

Life-cycle costing uses all costs including first costs, repair, and maintenance and operating costs to select the best alternative. For example, if decisions are based solely on first cost, it is likely that the structure built will minimally meet the need even though this option may have high heating or maintenance costs. In some cases, these structures become obsolete before achieving their design lives.

Asset Management provides a tool to evaluate all an agency’s assets and develop a program that either maximizes the performance with a given budget or minimizes the budget for a set performance criteria. This process helps decision-makers put limited funds to best use. Asset management also allows decision-makers to plan for upgrades and replacement over a 10 to 20 year time span. However, it is important to understand that political and social needs are also a part of the decision process. Asset management techniques allow an understanding of the impact of these decisions.

Targets

Implementing life cycle costing and asset management is a management decision of both the funding agency and the improvement owner. Both of these tools have been available for many years and when used have either improved the overall condition and performance of infrastructure, reduced the budget, or both. The complexity of these procedures is predicated on the desired outcomes and the size of the inventory.

Timing

For work to begin, all levels of government must first support the concept of life cycle costing. At the present time, many agencies award infrastructure projects based solely on the capital costs. As a first step, development of a consensus may require changes in program authorities and priorities.

Participants/Parties Involved

Development of life-cycle costing and asset management requires buy-in from all decision-makers including the agencies affected, the legislature and to a limited extent the engineering community. If it is to be accepted, the public must see the benefits. The major barriers are the feeling by both decision-makers and the public that they lose control. While these procedures provide input about the impact of a decision, they do not dictate the decision. They do tend to force a more thorough discussion and rationalization of decisions which go counter to life-cycle costing and asset management.

Evaluation

Both life-cycle costing and asset management require collection and input of cost data, condition inventories and performance data. Further, performance-life curves will be required as feedback into the process to ensure we learn from experience. A major benefit is that we can begin to document and understand the impacts of climate change on the performance of infrastructure and to implement appropriate design changes.

Research and Data Needs

These techniques are well established. If the State of Alaska chooses to implement them, data collection and inventories will be required. These data may include energy costs, structural deficiencies, and vulnerabilities.

Partnerships among federal and state agencies, municipal and tribal governments will be required to ensure data sharing and consistent procedures.

Sub-Option 3: Design infrastructure using the best science combined with appropriate building codes and engineering standards in order to withstand expected weather events and a changing environment.

The easiest and often the most cost effective means of coping with natural disasters is to locate the infrastructure outside the hazard zone. For example, locate power plants beyond the anticipated 50 or 100 year coastal erosion zone. This requires developing models that are able to predict erosion over this time frame, per Policy PI-1. Where it is impractical to locate the structure outside the hazard zone, the structure must be designed to withstand the hazard or provide protection against it. For example, a power plant designer could include erosion control measures in the plant design. In the case of an existing structure, engineers and the owners must assess the structure and determine whether to move or protect it. Each case is different, but the process is the same. Through the use of benefit/cost analysis, each alternative can be evaluated to determine the most attractive solution to provide resilience to withstand expected weather events and a changing environment.

At present, outside of the boundaries of major cities, these decisions are typically left to the project manager without guidelines or policy. In most states, when there are no local government regulations, state requirements become the default standard.

Targets

If infrastructure across Alaska is to withstand impacts of climate change throughout its life, uniformly deployed policy, guidelines, standards and codes are needed. This requires active adaptation to the changing environment. Planning, designing and maintaining infrastructure against thermal changes, coastal erosion, flooding and other climate related impacts must be conscientiously included in the decision process.

Timing

First, establish a policy recognizing the impact of climate change on public infrastructure. Agencies must recognize they have the opportunity and responsibility to locate public facilities in a safe location and that the design of the structure can include resiliency against climate change. Further, agencies must recognize that they are responsible to establish consistent performance criteria for the infrastructure.

Engineering codes should be modified to adopt these new requirements. The time frame is a function of the sense of urgency of funding and operating agencies. Many of the changes can occur almost immediately.

Participants/Parties Involved

Federal, state and local agencies that own and operate the facilities are responsible for establishing the performance standards for their facilities. Engineers are responsible for ensuring these performance standards are met within the framework of engineering codes. As has been repeatedly stated, climate data required to carry out implementation of these decisions must be developed in a usable form. This is called for in Policy PI-1.

Evaluation

Routine inventory and inspection of infrastructure provides data on how well resilience is being designed and built into Alaska's public infrastructure. For example, if we regularly see displacement of pile foundations in thawing permafrost, we need to alter design procedures. Without collecting that information engineers can only assume the designs are adequate.

Evaluation of the effectiveness of this policy will depend on establishing a regular schedule and process for sharing the results of infrastructure inspections. Opportunities for best practices information sharing and project administration/ outcome feedback loops should be integrated into infrastructure funding awards and follow-up processes.

Research and Data Needs

Again, obtaining up-to-date climatic data is critical, as called for in Policy PI-1. It is also important to evaluate existing infrastructure to identify common failure modes and routinely transmit this information into the engineering design and code creation process. A Canadian study has shown that some foundation types perform better in permafrost areas than others, and that some are more resilient to climate change. Research and testing like this to identify which designs are successful and which are not is needed.

Implementation Mechanisms

Four steps required to implement PI-3:

1. Establish performance standards and policies, and modify engineering codes, to incorporate hazard analysis and vulnerability assessment in a changing environment.
2. Revise engineering standards based upon updated information and new policies.

3. Obtain climatic and performance data to be incorporated into 1 & 2 above; this feedback process will ensure improvements with time.
4. Establish processes to align communication among partners and government agencies.

No new group need be established to implement this policy although some agencies and other organizations may need to refocus efforts. Greater efficiencies could be achieved however if a central coordinating entity with membership from partnering agencies existed.

Related Policies/Programs and Resources

There are many ongoing applied research and technology projects looking to find ways to design infrastructure to better adapt to new conditions. The challenge, and why an entity that can increase communication and coordination is so strongly needed, is that impacted and potentially impacted parties do not routinely know about these and other efforts, nor are the results being routinely shared with all who could benefit. The lack of routine coordination and information sharing raises costs, creates redundancies and adds inefficiencies to efforts to adapt Alaskan infrastructure. A few relevant efforts are:

- UAF Permafrost Research Project (partners: US Federal Highway Administration, Yukon Highways & Public Works, Alaska University Transportation Center, Transport Canada, Université Laval, Public Works and Government Services Canada) A 10-year project is testing 10 adaptive techniques including: Full air convection embankment (ACE), Full heat drain embankment, Covered ACE shoulder treatment, Uncovered ACE shoulder treatment, Heat drain should treatment, Longitudinal convection culverts, Heat drain shoulder treatment with insulation, Snow-free side slopes, Grass covered side slopes, and Light colored BST treatment.

- Cold Climate Housing Research Center –Sustainable Northern Shelters Project was developed to address the needs of sustainable rural housing for northern climates.

All three Public Infrastructure policies must be initiated to enact a comprehensive program of sustainable infrastructure in Alaska and help ensure that the state achieves the maximum return on its investments. PI-1 and 2 are integrally related to the long term success of PI-3.

Existing resources of agencies that fund the planning, design, construction and operation of the state's infrastructure can be utilized to implement this policy.

The professional engineering design community has well established mechanisms to maintain standards, codes and best management practices. Oversight agencies have the responsibility to see that social and environmental requirements are met.

Benefits and Costs

Adapting public infrastructure to a changing climate will be expensive. However, the cost of not adapting infrastructure will be greater.

Feasibility and Constraints

Technology exists to allow us to address the changing climate. However, we do not have adequate resolution or accuracy of climate data to include in engineering design processes. Further, as we gain this information, professionals must change how we predict the environment in which the infrastructure must perform.

The ability does not yet exist for municipal and tribal governments, state and federal agencies, and non governmental organizations to regularly communicate and share data, or establish aligned and connected policies, procedures, and information to empower informed and coordinated actions.

Status of Group Approval

Approved unanimously, with no objections.