Public Infrastructure Technical Working Group

Draft Adaptation Options for AAG Consideration – April 3, 2009

Public Infrastructure are the essential facilities and utilities under public, cooperative or private ownership that deliver goods and services to communities.

Climate change in Alaska creates the following potential impacts for **public infrastructure** (there is 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 frequencies and duration;
- Warming and thawing permafrost; and
- Increased fire risk.

The Public Infrastructure Technical Work Group (PI TWG) is taking a systems approach to the climate change challenge. We have established an overarching vision that Alaska must strive to meet. This vision can be achieved by enacting a comprehensive program with three policy components.

This system is adaptive in its nature; a continuous feedback and communication loop must occur among its program areas so information gained is continually used to update and inform the system.

Vision: Sustainable Infrastructure that Supports Communities in an Uncertain Environment

Infrastructure is the platform upon which our society functions. 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.

The infrastructure of Alaska is particularly vulnerable to the effects of climate change. It is predicted that climate change will bring warming temperatures that will cause sea level to rise and increase precipitation and storm intensity. With some 6,640 miles of coastline, and an estimated 47,300 miles of tidally affected shoreline, Alaska will be at the forefront of such change. Warming temperatures will likely also destabilize significant amounts of the permafrost across the state adding a uniquely Alaskan challenge to the climate change issue in America.

It is expected that as climate change unfolds and our understanding increases, predictions will change and interventions become more effective, therefore an integrated statewide plan that incorporates cycles of improvement and is well coordinated regionally, nationally and internationally is essential to build the resiliency necessary to meet the challenges ahead.

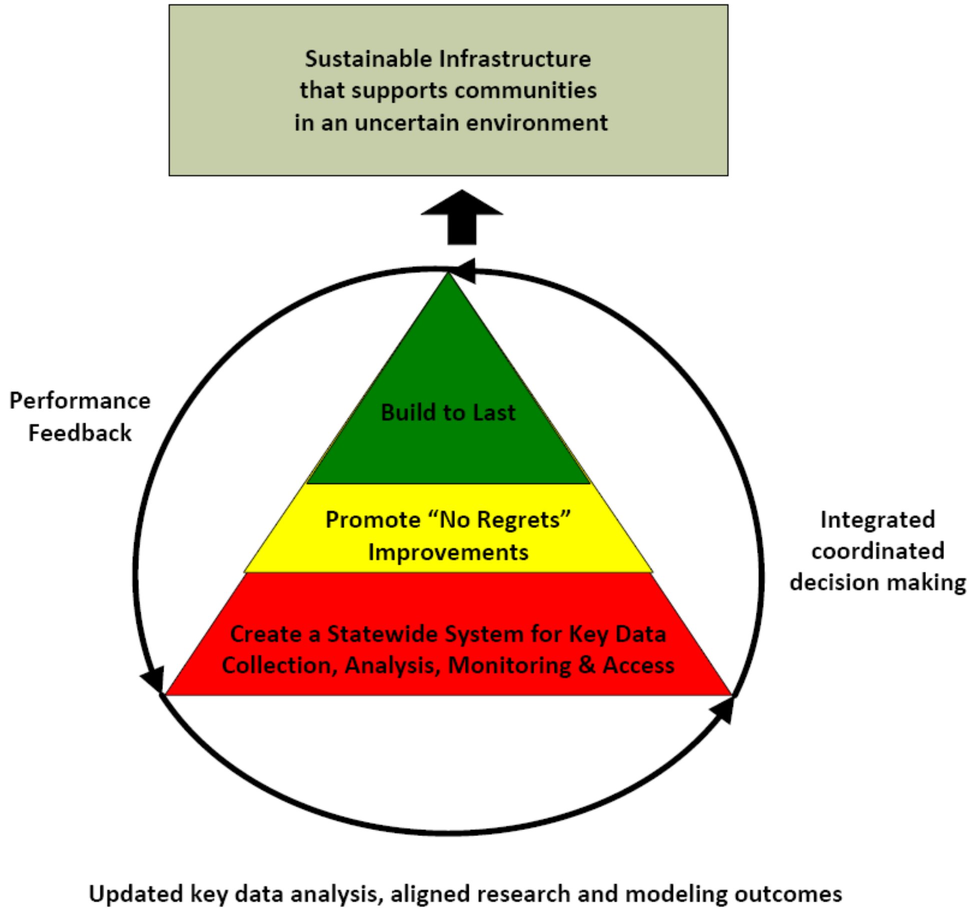
Three policies are recommended to successfully enact this Sustainable Infrastructure System:

1. <u>Create a Statewide System for Key Data Collection, Analysis, Monitoring, and Access.</u> Baseline data needs to be established. We need to know where and what the problems are. We need to know what is working and what is not working. We need to be able to accurately characterize our problems, scope solutions, and estimate the funding needed to implement selected alternatives. 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.

2. <u>Promote "No Regrets" Improvements.</u> Promoting sustainability, reducing operating costs, and protecting/extending the service life of existing infrastructure is always worthwhile. In parallel with component I, create and fund improvements to existing infrastructure that are worth doing regardless of climate change effects.

3. <u>Build to Last, Build Resiliency into Alaska's Public Infrastructure</u>. Based on 1 and 2, new and upgraded facilities need to be planned, designed, and built to be resilient and sustainable in an uncertain environment. A systematic performance review/analysis feed-back loop needs to be integrated into the public infrastructure development, construction, and facilities operations process, so that planners and builders use "what works" and codes and standards are assessed and improved as needed to achieve the best results.

Build to Last, Build Resiliency into Alaska's Public Infrastructure



1. Meet or exceed infrastructure design life.
2. Optimize life cycle costs/asset management practices.
3. Resilience to withstand extreme weather events and a changing environment. Infrastructure uses best science and appropriate building codes and engineering standards.

Promote "No Regrets" Improvements

1. Protect and extend the design service life of infrastructure.
2. Reduce operating costs and complexity.
3. Promote sustainability in the development, design and construction of new infrastructure.

Create a Statewide System for Key Data Collection, Analysis, Monitoring and Access

1. Standardize information to be gathered to enable data comparison and analysis over time, regional geographic areas, and across agencies/parties.
2. Conduct systematic local hazard analysis and vulnerability assessments of existing infrastructure. Do this using an actionable format to facilitate sharing and use of this data by municipal, tribal, state, federal and non-governmental users.
3. Review planning documents for proposed public infrastructure. Analyze and eliminate conflicts for renovation, retrofit, replacement, or relocation of existing infrastructure.
4. Adapt design criteria for public infrastructure.

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

Component Description

Establish a coordinated and integrated system to observe, collect, catalog, and disseminate data on the existing condition of public infrastructure and the environmental conditions where it is located. Use this information and trend data to systematically assess the vulnerability of Alaska's public infrastructure to establish the level of risk, and to better coordinate project planning and development within communities in this environment of uncertainty. Disseminate this information among local communities to provide a better understanding of environmental changes and how these changes may affect their communities.

Four points to achieve:

1. Standardize information to be gathered. Establish a baseline and benchmarks so that data comparison and analysis is possible over time, regional geographic areas, and across agencies/parties.
2. Conduct local systematic hazard analysis based on up-to-date regional climate data for Alaska's regions. Produce vulnerability assessments to rank the risk level or vulnerability of existing infrastructure for each region. Create an actionable format to facilitate sharing and use of this data by local, tribal, state and federal users.
3. Gather and review planning documents for proposed public infrastructure. Analyze and eliminate conflicts for renovation, retrofit, replacement, or relocation of existing infrastructure.
4. Use a performance feedback loop to identify measures to adapt design criteria for public infrastructure Utilize modeling to improve data alignment, scenarios, and assumptions for future infrastructure policies and plans.

A new entity is needed to coordinate the efforts and activities of municipal and tribal governments, state and federal agencies, and non-government organizations involved in accomplishing these four programs. This entity also needs to integrate among scientists, academia and those engaged in applied engineering to ensure a successful feedback loop is established.

Component Design

Structure/Design

Establish a network of professionals across government and academia to identify key data needs and link data on infrastructure, plans, and potential changes to the environment. Only data needed to adapt to climate change effects, not all data need be gathered and linked under this program's auspices. Key or critical data needed must be identified since realistically not all desired data will be able to be gathered and linked. Agencies should identify and agree on parameters and protocol so that data can be compared and linked.

A. 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 where possible.

Targets/Goals

Improve dissemination of existing and new data, of regionally specific trend analysis, and of assumptions important to effective local planning (e.g. flood plain mapping, climate predictions, demographics, and permafrost conditions). Trend analyzes should address extreme events as well as averages. The data to be gathered 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.

Timing

Begin immediately. These efforts are scalable. Begin with existing resources and data that can contribute to significant improvement in project effectiveness using a small cadre of professionals and some active in academia. Enlarge and build the effort overtime as resources permit.

Participants/Parties Involved

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), SNAP, permafrost databases: UAF Geophysical Institute Permafrost Lab (www.permafrostwatch.org), CALM (www.udel.edu/Geography/calm/). This component can begin with existing sources as a proof of concept and expand as needed.

To be successful a lead entity must be designated to integrate the overall effort, whether it is an existing or new state agency. An example of a collaborative group working on similar efforts is the Climate Change Executive Roundtable which is working to data share and prioritize collection efforts with many involved federal and state agencies and NGOs. This group is hampered however, by a lack of designated resources to advance the effort.

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 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 to guide data collection and use?

Research and Data Needs

Climate: Recent trends in air temperature, wind velocity, duration (for gusts) and direction; and precipitation (snow and rain) tailored specifically to observations of changing weather within a region. 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 where we are near or at change points (example: permafrost degradation). In the interim, qualify the best available time projections of the future change in these parameters and correlated projected changes in other environmental parameters to the PI TWG Policy 2, Promote “No Regrets” Improvements.

Coastal: Measurements of Arctic coastline wave frequency and height, storm surge, sea ice formation and seasonal extent.

Remote sensing technologies should be evaluated and recommendations for appropriate applications should be made by all parties investing in data collection. Establishment of locations for remote sensing can be enhanced through corresponding model analysis to optimize interpolation between data collection points.

B. Conduct local systematic hazard analyzes for public infrastructure based on up-to-date regional 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 an actionable format for this system to facilitate sharing and use of this data by municipal and tribal governments, state and federal agencies, and non-governmental users.

Targets/Goals

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 the known vulnerabilities for the region in order to determine the types and levels of risk each community will face. Information derived from this analysis should then be used to focus initial efforts on those communities determined to be at greatest risk from environmental factors.

Timing

Ideally, a baseline of current local environmental and infrastructure conditions is needed before a hazard analysis and vulnerability assessments are completed. However, because establishing this baseline will take several years to complete, and because the public infrastructure in some areas is clearly threatened, the hazard analysis 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 uplift areas in Southeast.

Participants/Parties Involved

Those involved in this effort should include local and tribal governments, Native Corporations, state and federal agencies, academia and state residents who have a broad range of experience in infrastructure.

A lead entity needs to be designated to integrate the overall efforts, whether it is an existing or new state agency.

Evaluation

The information necessary to perform a hazard analysis and conduct a vulnerability assessment is not readily available for most communities.

Evaluation can be measured by determining the status of the state Division of Homeland Security and Emergency Management’s situational awareness and possession of trend analyzes so it can effectively prioritize use of resources to complete state emergency management plans. This can be measured by:

1. DHSEM demonstrated to be in the “data loop” including trend analysis, issuance of new flood plain maps etc.
2. Communities understand the process for raising their concerns for consideration.

Research and Data Needs

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).

C. Gather and review planning documents for proposed public infrastructure. Analyze and eliminate conflicts for renovation, retrofit, replacement, or relocation of existing infrastructure.

Targets/Goals

Coordinate statewide and regional public infrastructure planning oversight and efforts and link to comprehensive community planning. Up to date information on infrastructure plans and efforts is important to feed into PI-3, Build Infrastructure to Last, and to ensure that PI-2, Promote "No Regrets" Improvements are accomplished. Coordinating planning efforts between projects across agencies must become a best management practice.

Timing

Begin immediately. Planning and coordination can occur independently within regions. A first priority is to prioritize the regions for which this is most important.

Participants/Parties Involved

Every municipal and tribal government, state and federal agency, and NGOs that builds infrastructure has a role. An example of what could be done is occurring at the Alaska Department of Environmental Conservation, Village Safe Water Program as it includes a sustainability review in its projects by asking how climate change conditions are being addressed.

A lead entity needs to be designated to integrate the overall efforts, whether it is an existing or new state agency.

A tool toward this effort is the existing DCCED Alaska Capital Projects Database that hosts partial data for on-going projects. The lead agency should apply lessons learned and recommend improvements to develop a collaborative tool for use by all parties.

Evaluation

To evaluate the effectiveness of this policy 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 Policy PI-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 climate change impacts on infrastructure.

D. Identify measures to adapt design criteria for public infrastructure using a performance feedback loop. Use modeling to improve data alignment, scenarios, and assumptions for future infrastructure policies and plans.

Targets/Goals

1. Regional data and trend analysis is a critical component to adapt site specific criteria for infrastructure improvements to provide resilience to climate change conditions.
2. Uncertainties can be reduced by modeling/projecting environmental conditions.

3. Critically evaluate performance of existing models, improve predictive capabilities of these models, develop mechanisms and procedures for how to best use the outcomes of these modeling efforts.
4. Establish a system for identification and tracking of modeling efforts.

These efforts 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.

Timing

This work should begin once data collection and analysis is complete, and recommendations are formulated.

Participants/Parties Involved

Involved parties should include every local, state and federal agency and non-governmental organization that funds or builds infrastructure.

A lead entity needs to be designated to integrate the overall efforts, whether it is an existing or new state agency.

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

Prioritize and coordinate research /computer modeling so that environmental data and modeling as well as the engineering needs are as up-to-date and as accurate as possible to meet the varying infrastructure development needs of each region. 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 Policy PI-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.

Implementation Mechanisms

This policy can be implemented by existing state and federal agencies. However, greater efficiencies could be achieved if a central coordination entity was established to align implementation and communication horizontally among partner agencies and vertically between the various layers of government. Four (could be more – VR) steps required to implement the Sustainable Infrastructure System's policy PI-1 are:

1. Establish a working group to conduct a hazard analysis and vulnerability assessment in Alaskan changing environment. The product will be a regional risk assessment map for the entire 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 which will 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, tribal, state, and federal users.

Related Policies/Programs and Resources

Implementation strategy should consider using existing collaborative forums such as the Climate Change Executive Roundtable hosted by federal Fish and Wildlife Service, and the Memorandum of Understanding (MOU) group meetings hosted by the Denali Commission. The substantial resources and potential of the University of Alaska should be put to use.

Also utilize the National Science Foundation's (NSF) Interagency Arctic Research Policy Committee (IARPC) led by NSF and NOAA, and support by the 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 projects that involve several state, federal, municipal or tribal agencies. There is a potential for significant savings through a common set of planning assumptions and 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

The coordinated, networked approach described here is similar to that instituted 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.

TWG Approval and Deliberations

The PI TWG unanimously recommends approval of, "PI-1, Create a Statewide System for Key Data Collection, Analysis, Monitoring and Access." All agree that implementing this component is critical for adapting Alaska's public infrastructure to a changing climate.

PI-2 Promote "No Regrets" Improvements

Component Description

There are many uncertainties about the impact of climate change on the public infrastructure in Alaska. How we deal with these uncertainties will determine how we adapt to a changing climate. For sure, as our predictions on future climate change become more accurate with the execution of PI-1 (Statewide, Systematic Collection, Analysis, Monitoring and Access of Key Data), the uncertainties are reduced. Also, by accurately forecasting future climate change and its effects, we can better protect our existing infrastructure and better plan and design new infrastructure, thus resulting in infrastructure that can better withstand climate change.

Managing the risks and/or reducing the uncertainties will take time. Meanwhile, as data is being collected and analyzed, the focus should be on public infrastructure improvements that will provide value added regardless of future climate change, i.e. no regrets. This is the focus of PI-2, Promote "No Regrets" Improvements, of the PI TWG Sustainable Infrastructure System. A no regrets approach provides cost-effective and cost-saving benefits regardless of future climate changes. This approach 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.

Component Design

Structure/Design

Sustainable Infrastructure System policy 1 will establish a data baseline, continue data collection over time, and improve trend analysis and forecasting tools is necessary 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 changes processes and the associated impacts in Alaska are incomplete, which makes it extremely difficult to adapt existing and new infrastructure to future climate changes. Due to these uncertainties, the overall infrastructure strategy will have to balance the short term need for agility with the long term need for resiliency of facilities designed and constructed to survive in an uncertain environment.

No regrets projects provide the near term agility and long term resiliency vital to an effective response. Utilizing existing data and technology, these projects focus on protecting Alaska's infrastructure investment regardless of climate change impacts by:

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

Implementing no regrets measures that are sustainable will provide cost-effective benefits to communities even if the underlying climate change assumptions are incorrect. Also, no regrets options will continue to build resilience that starts with Policy PI-1 (Systematic Key Data Collection, Analysis, Monitoring and Access) and ends with Policy PI-3 (Build to Last), which also requires a feedback loop on performance to integrate better no regrets measures and options.

No regrets actions include adaptation of infrastructure to better withstand climate change impacts or mitigation measures designed to address the vulnerabilities of existing infrastructure. Examples of no regrets adaptations include protection of key facilities from erosion/storm damage, energy conservation upgrades, and enhanced water quality protection. No regrets mitigation measures for infrastructure include long term planning and preparedness, capacity development, promoting energy–efficient technologies, using alternative energy sources, or building with better materials.

Targets/Goals/Timing

During the initial phase (first 3 -5 years) of deployment of the Sustainable Infrastructure System, the no regrets component will proceed concurrently with Policy PI-1. As both efforts move forward, Policy PI-3 (Build to Last) will be introduced. This third policy will overtake and replace the no regrets component once the ability to accurately forecast the effects of climate change is firmly in place and the adaptation strategies for future infrastructure are created.

Participants/Parties involved

The no regrets methodology can be readily integrated in current infrastructure prioritization methodologies. This will enable federal and state agencies tasked with infrastructure development, construction and/or operation the opportunity for an orderly transition to the new Build to Last methodology.

A new central coordination entity will be needed to coordinate the transition.

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

Evaluation

Evaluation of the effectiveness of this policy will depend on establishing a regular schedule and process for sharing the results of implementing no regrets improvements. Opportunities for best practices information sharing and project administration/outcome feedback loops will need to be integrated into infrastructure funding awards, reporting and follow-up processes.

Research and Data Needs

While research and data are critical to the other policies of the Sustainable Infrastructure System, the ability to proceed based on existing information provides the opportunity for agility and resiliency that makes this policy so valuable.

Implementation Mechanisms

This policy that is part of the Sustainable Infrastructure System can be implemented by existing state and federal agencies. However, greater efficiencies could be achieved if a central coordination entity was established to align implementation and communication horizontally among partner agencies and vertically between the various layers of government.

Related Policies/Programs and Resources

The other components of the Sustainable Infrastructure System are integrally related to the long term success of this component. All three policies must be initiated as a system to achieve the vision and ensure the maximum return on state investment.

Existing resources of the agencies that currently fund the development, construction and operation of the state's infrastructure can be utilized to implement this policy of the overall Sustainable Infrastructure System. For best results a centralized planning/coordination effort will be required.

Benefits and Costs

Adapting public infrastructure to a changing climate will be expensive. However, the cost of not adapting infrastructure will be greater. Starting with PI-2, utilizing no regrets methodology, the state's investment in existing infrastructure will be better protected. Proven technology will be utilized that will extend infrastructure service life and potentially reduce or contain operating costs.

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 would only require a central coordinating entity be established to ensure existing infrastructure funding, development, construction and operations agencies were better aligned.

Adequate funding is not available. However, this policy will help align funding opportunities.

Sufficient Alaska specific scientific research capacity does not yet exist to assure the long term success of the overall Sustainable Infrastructure System

A coordinated statewide database with key data and analysis 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.

TWG Approval and Deliberations

The PI TWG unanimously recommends approval of, "PI-2, Promote No Regrets Improvements."

All agree that implementing this component is critical for adapting Alaska's public infrastructure to a changing climate.

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

Component Description

To adapt Alaska's existing and future public infrastructure to the effects of climate change we must build infrastructure to last. This means either building it in locations outside of hazard zones (that have been updated and defined using climate change modeling) or hardening it to withstand the expected forces at the location over the life of the infrastructure. This will require climate change modeling that yields updated hazard zone locations and revised data on expected forces and conditions for which infrastructure must be designed. This will also require modification of some engineering design standards, building codes, and operation and maintenance practices. Three points to achieve are:

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

Component Design

A. Meet or exceed infrastructure design life.

Structure/Design

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 not by an engineer but either by the infrastructure owner or public policy. 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 predicating 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 the owners and design professionals; compile best practices for planning, design, and maintenance of infrastructure; and provide continuous feedback during the project development cycle.

Targets/Goals

Two changes are required to ensure public infrastructure achieve its design life. The first is to 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.

The second requirement is sufficient climatic data to include 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 PI TWG Policy 1 must be enacted as the information generated during its implementation is needed to enact PI TWG Policy 3. This shows the Public Infrastructure Systems Approach to this suite of three interrelated policies and why continuous monitoring and feedback are needed.

PI-1 recommends conduct of a vulnerability assessment of all 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.

Finally PI-1 requires collection 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.

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 costs 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 their jurisdiction.

Research and Data Needs

Research and data are critical to successful implementation of the Sustainable Infrastructure system's policies 1 and 3.

There are two major data needs to meet or exceed infrastructure design life. First, 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, fro example, "the snow load has increased to 100 pounds per square foot."

The condition inventory and vulnerability assessment of infrastructure developed under policy PI-1will provide information for updating best practices through a feedback loop.

B. Optimize life cycle costs/asset management practices.

Structure/Design

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/Goals

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 our experiences. 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.

C. Resilience to withstand extreme weather events and a changing environment. Design infrastructure using the best science combined with appropriate building codes and engineering standards.

Structure/Design

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 the power plant beyond the anticipated 50 or 100 year coastal erosion zone. This requires developing models that are able to predict erosion over this time frame. 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 extreme 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/Goals

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 urgency that funding and operating agencies feel. 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 our 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 the Sustainable Infrastructure System's policy PI-3 are:

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

All three policies must be initiated to enact a Sustainable Infrastructure System and help ensure that the state achieves the maximum return on its investments. The first two policies are integrally related to the long term success of the third policy.

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, the 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.

Approval and Deliberations

The PI TWG unanimously recommends approval of, "PI-3, Build to Last. Build Resiliency into Alaska's Public Infrastructure." All agree that implementing this component is critical for adapting Alaska's public infrastructure to a changing climate.