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## Sector 1: Public Infrastructure

*All of the impacts included in the Public Infrastructure sector are described below and organized according to subsector. This sector addresses the physical impacts of climate change on Alaska's built environment and transportation options.*

### HIGHWAYS, ROADS, AND BRIDGES

1. **Highway, road and bridge damage from thawing permafrost:** Current impacts -- costly (ADOT's estimate is at least \$10 million/year) and potentially dangerous damage (e.g., highways surrounding Fairbanks); larger construction costs (e.g., need embankments at least 4 feet thicker, and air convection embankments); damage to the highway's surface, road bed, and integrity. *Future projections – degrading permafrost predicted to double in next 50 years, leading to additional damage; substantial rehabilitation, reconstruction and/or relocation will be needed; road slope sloughing may fill ditches and plug culverts; overall \$0.9 to \$1.5 billion additional damage costs by 2030 (ISER estimate).*
2. **Highway and road damage from temperature changes:** Current impacts – more freeze/thaw cycles from milder winters, with accelerated road damage (e.g., in Anchorage). *Future projections – accelerated damage from milder winters and more freeze/thaw cycles; pavement damage from higher temperatures, resulting in softening asphalt and rutting.*
3. **Damage to and loss of roads from coastal and river erosion:** Current impacts – coastal roads have been lost (e.g., Shishmaref); need to rebuild roads (e.g., Nome “Council Road”) and increased costs associated with activities to avoid loss of roads (e.g., Kotzebue “Shore Ave” and Unalakleet “Beach Road”). *Future projections – greater loss of roads from coastal and river erosion; greater costs to avoid erosion; loss of roads from sea level rise.*
4. **Boardwalks:** Current impacts – buckling and submersion of boardwalks in village communities (e.g., Newtok). *Future projections – greater buckling and submersion of village boardwalks.*
5. **Icing and ice control:** Current impacts – more extensive and more costly ice control due to more ice from longer seasonal transition periods (e.g., Fairbanks' fall period has increased from 2 weeks to 2 months); increased frequency of black ice conditions; need

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for new machinery. *Future projections – even more costly ice control due to greater ice from longer seasonal transition periods (e.g., Fairbanks).*

6. **Damage from increased glacier melting, flooding, avalanches, debris flows, etc.:** Current impacts – highway and bridge damage from glacier melting, flooding, avalanches, debris flows, etc. (e.g., Richardson Highway and One Mile Creek). *Future projections – more glacial melt and more flooding may require larger culverts and/or bridges; more maintenance needs from increased precipitation events, debris flows, avalanches and floods.*
7. **Vegetation management:** *Future projections – increasing demands for highway/road vegetation management on North Slope and elsewhere.*

## **AIRPORTS, LANDING STRIPS, AND AIR TRANSPORTATION**

8. **Impacts on airports and landing strips from thawing permafrost:** Current impacts – damage to airports and landing strips (e.g., Bethel and remote communities in Y-K Delta); more difficult and expensive airport and landing strip construction conditions due to thawing permafrost. *Future projections – degrading permafrost expected to double in next 50 years, leading to additional damage from thawing permafrost; substantial rehabilitation, reconstruction, and/or relocation may be necessary; increasingly difficult and expensive construction.*
9. **Relocation, realignment, and emergency response needs for coastal and river-adjacent airstrips:** Current impacts – have relocated (e.g., Allakaket, Barrow) or planning to modify or relocate (e.g., Alakanuk, Shishmaref) airport landing strips due to coastal or river erosion and flooding; airports that have been covered by water (e.g., Pt. Hope, Newtok, Shishmaref) require emergency repairs; others (e.g., Kivalina) require protection. *Future projections – greater modification and protection needs (e.g., Kotzebue, Kaktovik) and more relocation needs, especially with sea level rise.*
10. **Other maintenance issues:** *Future projections – increased maintenance needs for vegetation management (especially on the North Slope); increased precipitation events (e.g., ice, heavy precipitation).*
11. **Flying conditions:** Current impacts – problems with icing (e.g., dangerous icing currently occurring in fall and winter along coasts of Beaufort, Chukchi, and Bering Seas from Seward Peninsula northward from clouds of supercooled water); increased coastal fog; increased hazardous flying due to nontraditional storms; and other dangerous conditions when flying. *Future projections – likely additional problems with icing, fog, and nontraditional storms.*

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## BUILDINGS

12. **Building damage, loss, and relocation near the coast:** Current impacts – loss of and damage to buildings due to shoreline erosion, less shorefast ice, thawing permafrost, and storms (e.g., Shishmaref and Barrow/Browerville have lost buildings to the ocean); relocation of buildings (e.g., Shishmaref, Kivalina); need for emergency shelters in new sites (e.g., Newtok and Shishmaref). *Future projections – increased sea level rise, thawing permafrost, and loss of shorefast ice will lead to greater loss of buildings and more individual building relocation needs; need to relocate entire communities (e.g., Shishmaref, Kivalina, and Newtok in next 10-15 years).*
13. **Building damage, loss and relocation near rivers:** Current impacts – building damage and loss due to realignment of rivers, thawing permafrost, and flooding; need to relocate buildings (e.g., Koyukuk). *Future projections – greater building damage and relocation needs as more permafrost melts and flooding occurs.*
14. **Building damage from thawing permafrost:** Current impacts – there has been damage to non-coastal buildings from thawing permafrost (e.g., structural damage to buildings in Fairbanks) and land subsidence (e.g., increased flood risk to sinking homes in Kwigillingok). *Future projections – degrading permafrost expected to double in next 50 years, leading to additional structural damage from thawing permafrost; substantial rehabilitation, reconstruction, and/or relocation needs; and increasingly difficult and expensive construction.*
15. **Fire risk to buildings:** Current impacts – more damage to buildings from increased fire frequency and intensity, and increased threat from diseased/dead trees (e.g., Caribou Hills fires in 2007 destroyed 94 structures). *Future projections – greater threat from increased fires and diseased/dead trees.*

## SEA WALLS AND RIVER SHORELINE PROTECTION

16. **Sea wall and river protection failures and needs:** Current impacts – existing sea walls have failed (e.g., Kivalina, Unalakleet, and Shishmaref); more walls needed to protect new shoreline and river locations (e.g., Unalaska). *Future projections – greater loss and failure of sea walls, especially with sea level rise; greater need for new sea walls and river shoreline protection in new locations.*

## UTILITY AND FUEL INFRASTRUCTURE

17. **Pipeline damage and relocation:** *Future projections – sea level rise and coastal and river erosion may impact buried or above-ground utility and oil pipelines; thawing permafrost may undermine support for existing buried or above-ground pipelines.*

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18. **Fuel storage and delivery impacts:** Current impacts – impacts from thawing permafrost and erosion on shoreline and river-side fuel delivery, storage, and piping (e.g., in 2007 AVEC paid \$575,000 to empty and relocate storage tanks; in 2005 Newtok lost its barge landing and a 1,000 gallon fuel tank in a storm); barge landing damage from erosion and flooding adversely affecting supply deliveries (e.g., Newtok); less water available in rivers for barge deliveries (e.g., low water prevented fuel delivery by barge to Noatak and Upper Kobuk villages in northwest Alaska). *Future projections – greater threats to shoreline fuel delivery, storage, and piping; increased relocation needs; emergency fuel situations; increased risk to supply deliveries.*

## LANDFILLS

19. **Landfill damage from erosion and thawing permafrost:** Current impacts – there have been landfill problems, failures, and losses associated with shoreline erosion and river erosion (e.g., Newtok). *Future projections – greater landfill problems and failures, especially with sea level rise and more intense storms (e.g., U.S. Air Force Long Range Radar Site near Kaktovik at risk); also landfill problems due to thawing permafrost and warmer temperatures.*

## SEWAGE AND SEPTIC SYSTEMS

20. **Sewage and septic system impacts:** Current impacts – some septic systems are freezing because of less snow cover. *Future projections – sewage system problems and failures, especially with thawing permafrost and sea level rise (e.g., US Air Force Site near Kaktovik); increased organics adversely affecting treatment processes; ultimately significantly warmer temperatures could result in less damage to septic systems.*

## WATER SYSTEMS

21. **Above-ground water systems:** Current impacts – thawing permafrost, eroding shorelines, and drying of lakes leading to diminished community water sources (e.g., in NE Alaska, of 23 lakes studied, 21 decreased in size); water quality compromised from storm surges, etc. *Future projections – increased above-ground water system problems and failures; potential decrease in available non-community based water sources as more lakes, ponds and streams dry and shrink.*
22. **Subsurface water systems:** Current impacts – low interior snowfall causes deep frost levels that freeze well-based water systems. *Future projections – loss and reduction of permafrost to have major impact on subsurface hydrology; loss of some confined aquifers and domestic artesian water wells; increased risks of contamination.*

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23. **Hydroelectricity impacts:** Current impacts – potential impacts on water availability and reduced energy production in some areas (e.g., current reductions in southeast may be due, in part, to climate change). *Future projections – potentially greater impacts on energy production from reduced or modified water availability and greater evaporation; potentially greater precipitation in southeast Alaska would mitigate these impacts.*
  24. **Increased volume of stormwater:** *Future projections – larger or new stormwater management systems needed to address increased precipitation and possible flooding in many locations.*

## OCEAN TRANSPORTATION

25. **Increased shipping opportunities and needs:** Current impacts – less ice in Arctic Ocean and Bering Sea, opening up summer shipping lanes and opportunities (a 10% decline in sea ice per decade since the 1970s); some increase in traffic already observed; rapidly melting glaciers causing navigation problems (such as Columbia Glacier during the first part of its retreat); more activities resulting in higher risk of marine accidents and oil/fuel spills in Bering Sea, Chukchi Sea, and Arctic Ocean; lack of Coast Guard and other infrastructure for emergency response; potential expansion of Coast Guard responsibilities or facilities. *Future projections – even greater opening of Arctic Ocean and Bering Sea for longer periods for shipping and marine activities; increased navigation and safety issues and concerns. NOTE: This item is also addressed in the Other Economic Activities sector.*
26. **Harbor impacts:** Current impacts – increased siltation of harbors from greater glacier melt and flooding events. *Future projections – continued increase in siltation; potential sea level rise impacts.*

## RURAL NON-ROAD GROUND TRANSPORTATION

27. **Rural transportation impacts:** Current impacts – winter ground transportation by snowmachine and dog sled less available and reliable because ground not frozen and insufficient snow; shorter ground transportation season; less reliable and available river and shoreline transportation in the winter because of thinner ice and shorter freeze-up period. *Future projections – increasing problems with winter ground transportation by snow machine and dog sled, and on frozen water bodies.*
28. **Ice road impacts:** Current impacts – season length for ice roads and travel over permafrost has been significantly reduced. *Future projections – even greater reductions in season length for travel over frozen surfaces. NOTE: This item is also addressed in the Other Economic Activities sector.*

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## **RIVER TRANSPORTATION**

29. **River transportation:** Current impacts – river transportation is less available and reliable during some summers and early autumns because of lower water flow (e.g., Newtok, Porcupine River). *Future projections – increased problems with river transportation impacting fuel and material deliveries, interaction among communities, and subsistence activities.*

## **NATIONAL DEFENSE INFRASTRUCTURE**

30. **Damage and closures:** Current impacts – three Early-Warning Radar Sites (including Point Lonely) closed or slated for closure due, in whole or part, to erosion and thawing permafrost. *Future projections – may be more closures of defense infrastructure.*