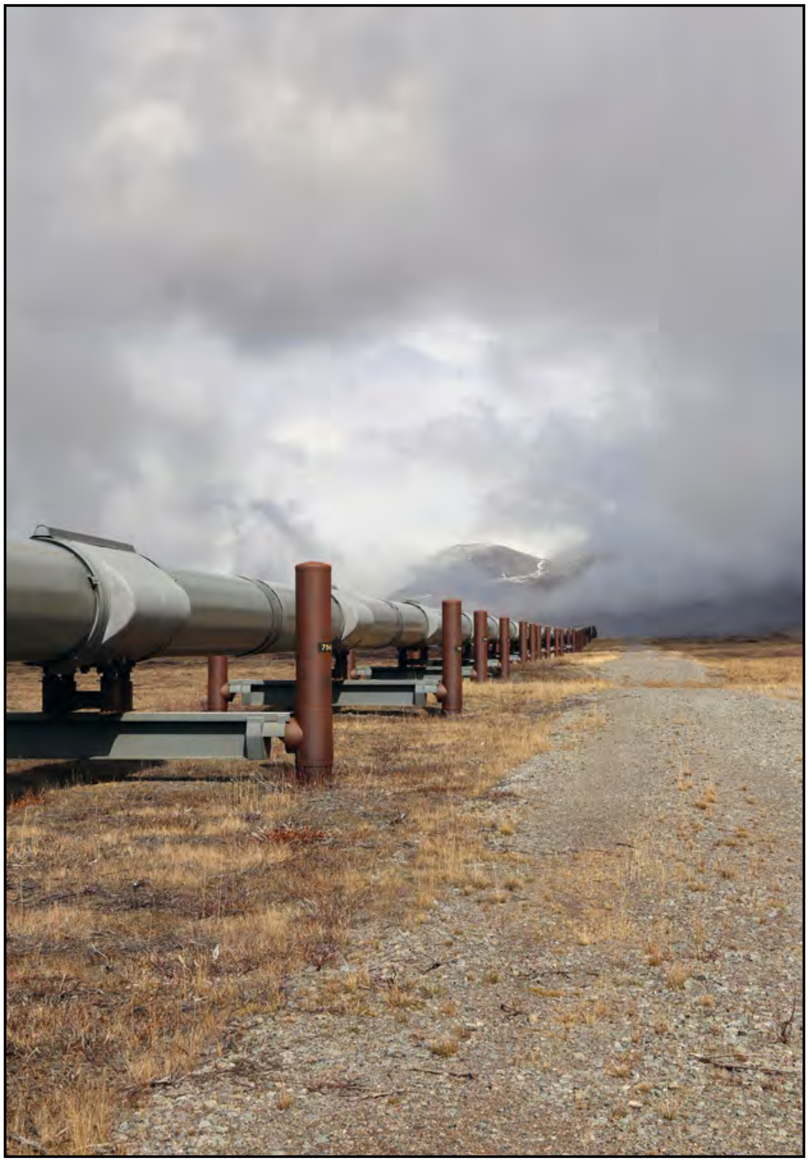
THE POST-TAPS PROJECT

SERC SEED GRANT FINAL REPORT
JULY 2018



Katherine Jenkins
Assistant Professor of Landscape Architecture
The Knowlton School

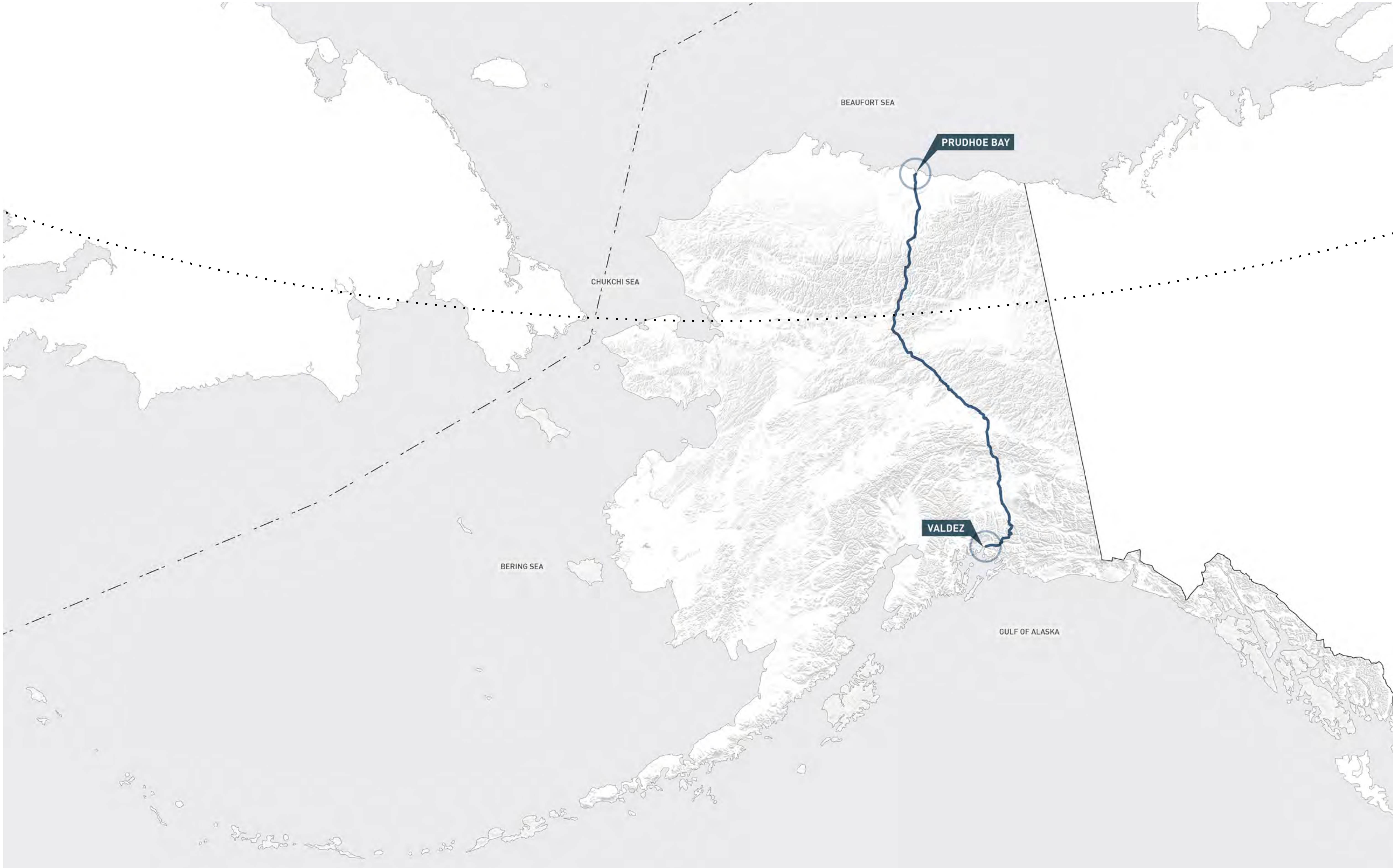
THE POST-TAPS PROJECT

PROJECT SUMMARY

July 22, 2017 marked 40 years since the first barrel of crude oil traveled from the northern plateaus of Prudhoe Bay to the Port of Valdez through the Trans-Alaska Pipeline System (TAPS). A combination of low oil prices and significantly reduced output now point to an imminent decline in operations.

Through mapping, photo-documentation, and a design research course at OSU, this project leverages the pipeline's anniversary to broadcast an alternative future for this infrastructural landscape — a Trans-Alaska Trail — while simultaneously launching a public discourse about the transformative legacy of the pipeline's first forty years.

As an exemplary case study for the adaptation of infrastructural landscapes, this project will challenge design students at The Ohio State University to consider the geospatial politics of oil extraction and changing climates both within and beyond the borders of their state.


BEAUFORT SEA
PRUDHOE BAY
CHUKCHI SEA
VALDEZ
BERING SEA
GULF OF ALASKA

THE POST-TAPS PROJECT

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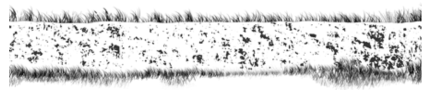
FIELDWORK MAY 16 - MAY 29
PRUDHOE BAY TO VALDEZ, ALASKA

Arctic Coastal Plain_Mile 90

In May 2017 Parker Sutton and I spent twelve days along the Trans-Alaska Pipeline System, completing the 800-mile journey from Prudhoe Bay to Valdez.

≥ 1 DIVING

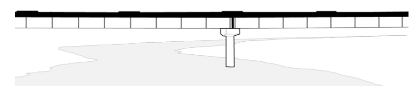


≥ 2 BURIED

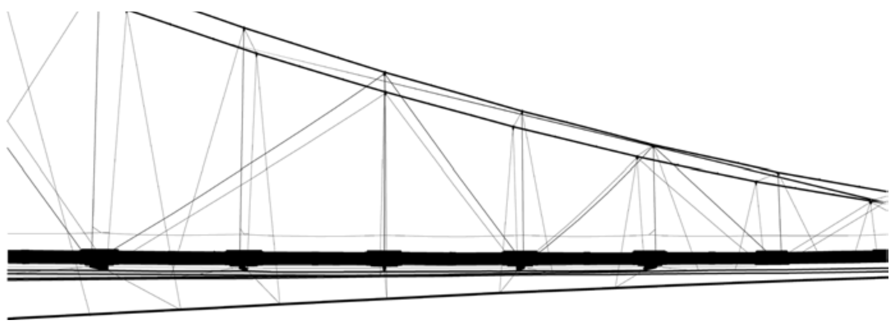
≥ 3 SURFACING

≥ 4 WILDLIFE XING

≥ 5 RIVER XING

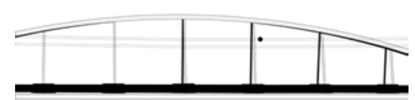


≥ 6 ARCTIC RIVER XING

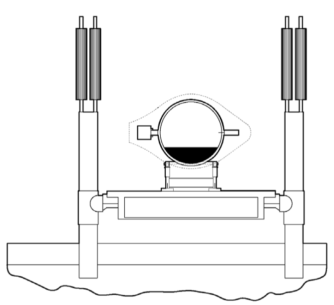


≥ 7 SUSPENSION BRIDGE/TANANA

≥ 8 TRIPOD FRAME/SEISMIC



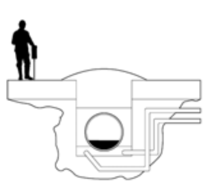
≥ 9 BASKET HANDLE BRIDGE/GULKANA



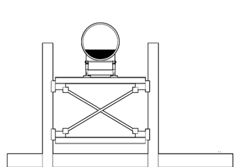
≥ 10 ELEVATED, TYP.

≥ 13 BUZZCUT

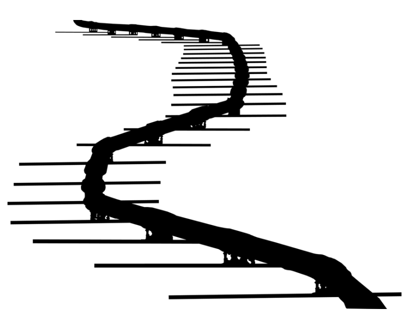
≥ 14 SNAKE



≥ 11 REFRIGERATED



≥ 12 ANCHOR SUPPORT



≥ 15 FAULTLINE FOOTINGS/DENALI

≥ 16 FILAMENT

FIELDWORK MAY 16 - MAY 29

In 2014 I traced 650 miles of the 800-mile pipeline route. During a second trip to Alaska this past May, Parker Sutton and I completed the journey, reaching the point of origin of the Trans-Alaska Pipeline System in the remote Arctic coastal plain, 300 miles north of the Arctic Circle.

Along its 800-mile route, the pipeline must adapt to acute changes in the environment as it moves over and under a gradient of permafrost, the Yukon River, the Denali Fault, the Brooks Mountain Range, and paths of caribou migration. The TAPS passes through 10 distinct ecological zones, crosses 34 major and 500 minor rivers, spans 4 fault lines, and negotiates 3 rugged mountain ranges with summits of 9,000 feet. Each of these instances requires specialized design: unique forms for offing excess heat, traversing frozen rivers, and negotiating seismic zones.

The diversity of constructed forms expressed in this singular pipeline is a reflection of the fluctuating, and often severe, conditions surrounding it. In this way, the TAPS serves as an index for measuring the powerful and variegated Arctic environment.

Prudhoe Bay_Mile 1

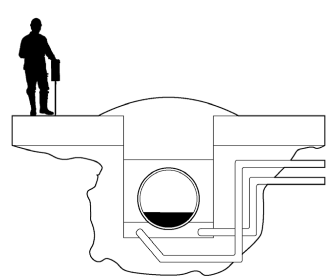
The industry at Prudhoe Bay faces significant problems as a warming atmosphere transforms the fragile permafrost that supports petrochemical operations into a porous, watery landscape. Warming will affect more than the profitability of Prudhoe Bay: ground that collapses when permafrost melts impinges on migratory animals such as caribou and the subsistence communities that rely on them.

The North Slope_Mile 153

Where the north slope of the Brooks Range meets the Arctic Foothills, buttes, knobs, and ridges conjoin in an irregular topography. A treeless tundra presents sweeping views. The metering of the ever present pipeline draws the landscape into relief, bringing scale to extrahuman dimensions. Its "sustained linearity" tracks the shape of the earth, and emphasizes the unique character of the place through which it passes.

Atigun Pass_Mile 169

The highest point along the Trans-Alaska Pipeline System is the 4,739-foot notch in the Brooks Range known as Atigun Pass. Here the pipeline is buried in a refrigerated concrete case to prevent damage from avalanches and rock fall. The heat pipes marking the pipeline's path through the mountain pass are visible protruding from the snow. This is also where the pipeline crosses the Continental Divide, north of which, all runoff drains into the Arctic Ocean.



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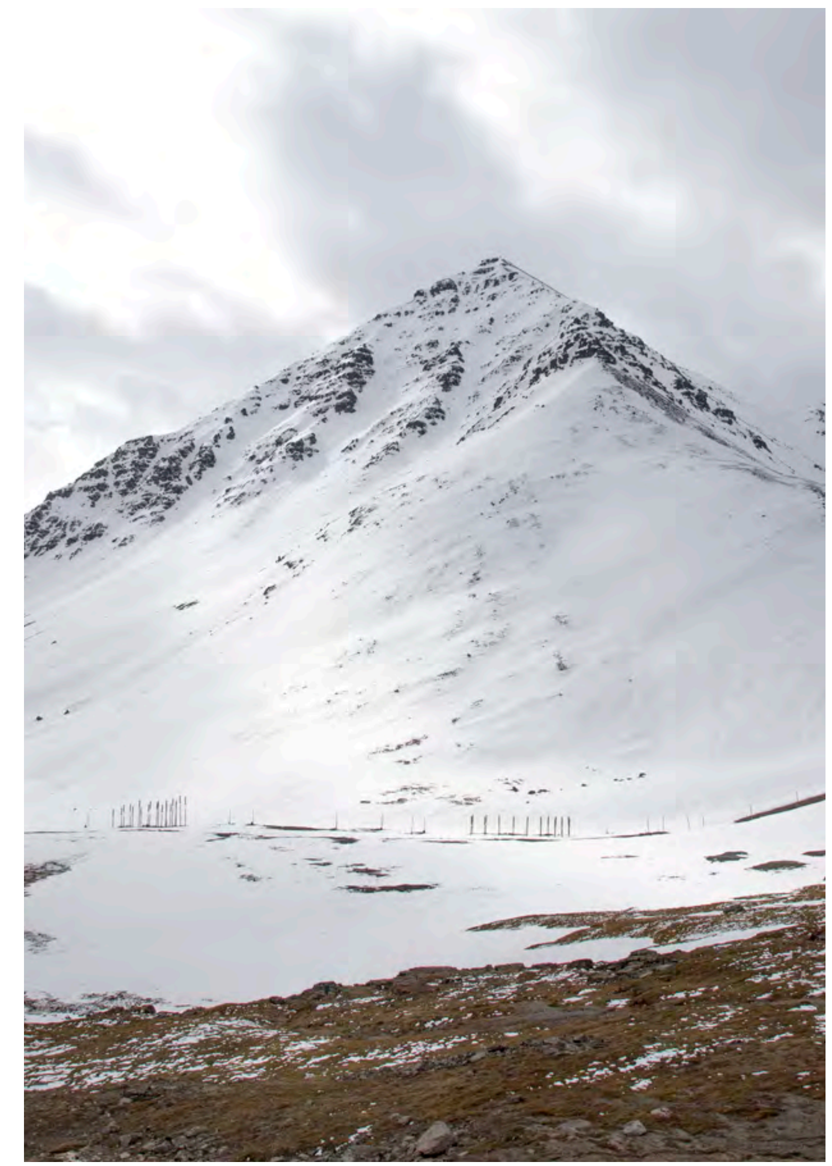


The Brooks Range_Mile 171

The rugged glacier-carved Brooks Mountain Range separates the plants, animals, and weather systems of Alaska's Interior to the south from those of the Arctic Coastal Plain to the north. While the range is mostly uninhabited by people, several massive herds of caribou cross these mountains every year during their migration.

The Interior_Mile 256

The Interior is a vast region in central Alaska bounded by the Brooks Range to the north and the Alaska Range to the south. The northern Interior is covered by bogs, boreal forest, and threaded by the Koyukuk and Dietrich Rivers. Here, the pipeline weaves under and above ground responding to a sporadic distribution of permafrost.

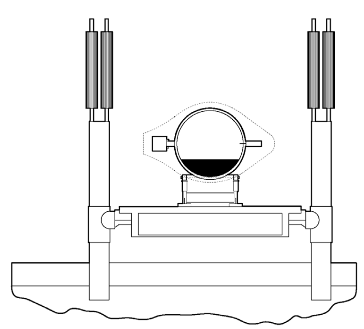
Buried_Mile 341

The elegance of the Trans-Alaska Trail is that, in a sense, it already exists: the pipeline is an orienting device; its maintenance corridor a path. To view it as such, however, requires a perspectival shift. The Trans-Alaska Trail will make use of the pipeline's infrastructure to provides access to remote and previously inaccessible land in Alaska's interior and Arctic territories. Most of this land is managed by the BLM and is public. This trail project, then, endeavors to provide the public real access to their public lands.

BURIED

Permafrost_Mile 357

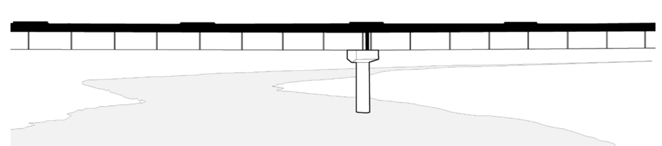
The TAPS established new precedents as the first large-diameter hot oil pipeline to traverse environmentally sensitive permafrost terrain. Most oil pipelines are buried to minimize cost, making them invisible to the casual observer. But here, the 120 degree Fahrenheit oil flowing through the TAPS would melt Alaska's ice-rich permafrost if buried, leading the pipe to rupture. Thus, for 420 miles of its journey, the pipeline rides above the ground on 78,000 vertical supports.



ELEVATED

The Yukon River Crossing_Mile 358

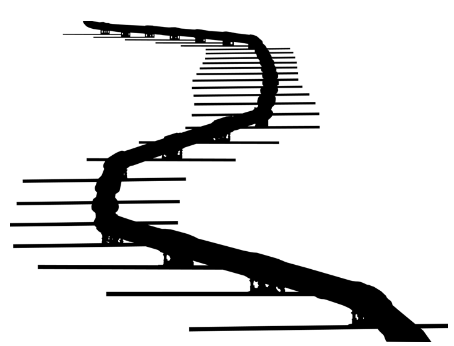
135 miles north of Fairbanks, the pipeline crosses the Yukon River. This bridge is one of just four vehicular bridges that span the 2,000-mile river and it is the only crossing in Alaska. The bridge is almost half a mile long and sloped to negotiate the grade change between the two banks. The TAPS rests in a metal cage on one side of the bridge.



RIVER X-ING

The Denali Fault_Mile 590

At mile 590 the TAPS crosses the Denali Fault, an epicenter of great geologic activity. The fault presents a serious engineering challenge for the pipeline's structure. Here, the pipeline sits on steel sliders and can move up to 20 lateral feet and 5 vertical feet in a seismic event. This design was tested in 2002 when the pipeline withstood an earthquake of magnitude 7.9. This unique structure also alerts visitors to the presence of the fault line, which would otherwise go unseen.



SEISMIC FOOTING

The Lowe River_Mile 785

In its approach to Valdez, the TAPS enters a lowland and follows the braided delta of the Lowe River. The steep peaks and ridges of the Chugach mountain range lie to the north. The Lowe River Delta exports many tons of glacial silt annually and supports salmon runs through the summer and fall. Aspen and Sitka spruce line its banks.

Port of Valdez_Mile 800

Valdez is the terminus of the pipeline and one of the most important ports in Alaska for commercial fishing and freight. The Trans-Alaska Pipeline terminus is located here because it is the northernmost ice free harbor in Alaska. This industrial activity coexists alongside tremendous natural beauty and an abundance of wildlife.

MEETINGS + RESEARCH MAY 16 - MAY 29

In addition to documenting the TAPS, this trip facilitated meetings with key contributors to the trail project in Alaska, including Lee Hart, leader of the land stewardship group, Levitation 49, and Austin Love, a member of the Prince William Sound Citizen's Advisory Council. These face-to-face meetings are important in establishing a stronger connection between team members in Alaska and The Ohio State University and in sustaining a productive exchange of ideas over the coming years.

While in Alaska, we were also able to obtain detailed maps of the route of the TAPS that have been critical to understanding the relationship between the form of the pipeline and the ecologic and geologic conditions around it.

ASLA LA2017
Common Ground

Annual Meeting and EXPO
October 20-23
Los Angeles
#ASLA2017

THE POST-TAPS PROJECT

ASLA CONFERENCE PRESENTATION

The Interior_Mile 452

On October 19, 2017 Parker Sutton and I presented The Post-TAPS Project at the American Society of Landscape Architects annual conference in Los Angeles, CA.

CONFERENCE PRESENTATION OCTOBER 2017

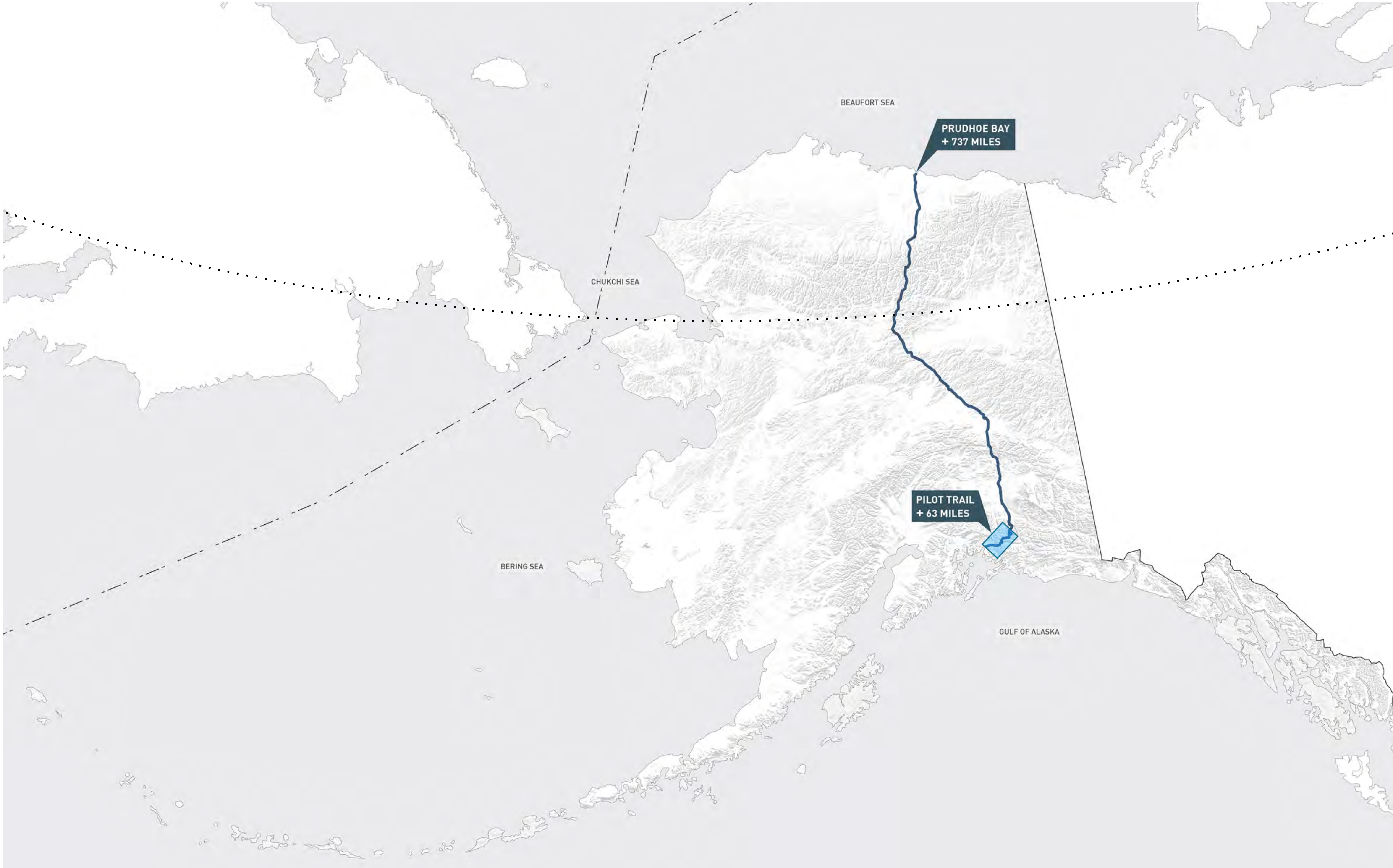
The following themes were discussed in our presentation of The Post-TAPS Project:

I. The political, ecological, and spatial contexts of the Trans-Alaska Pipeline System and oil extraction in America's Arctic

II. Implementation of an 800-mile ocean to ocean recreational trail along the pipeline and detailed analysis of the proposed 63-mile pilot trail segment (Valdez, AK to Little Tonsina, AK)

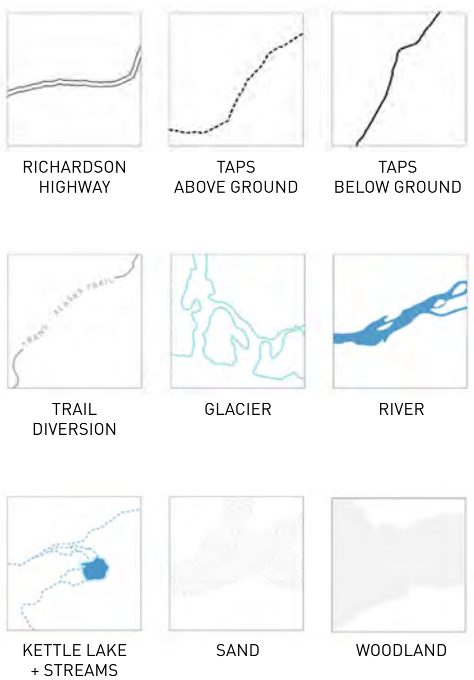
III. The effects of melting permafrost on the pipeline's structure and resource extraction in Alaska

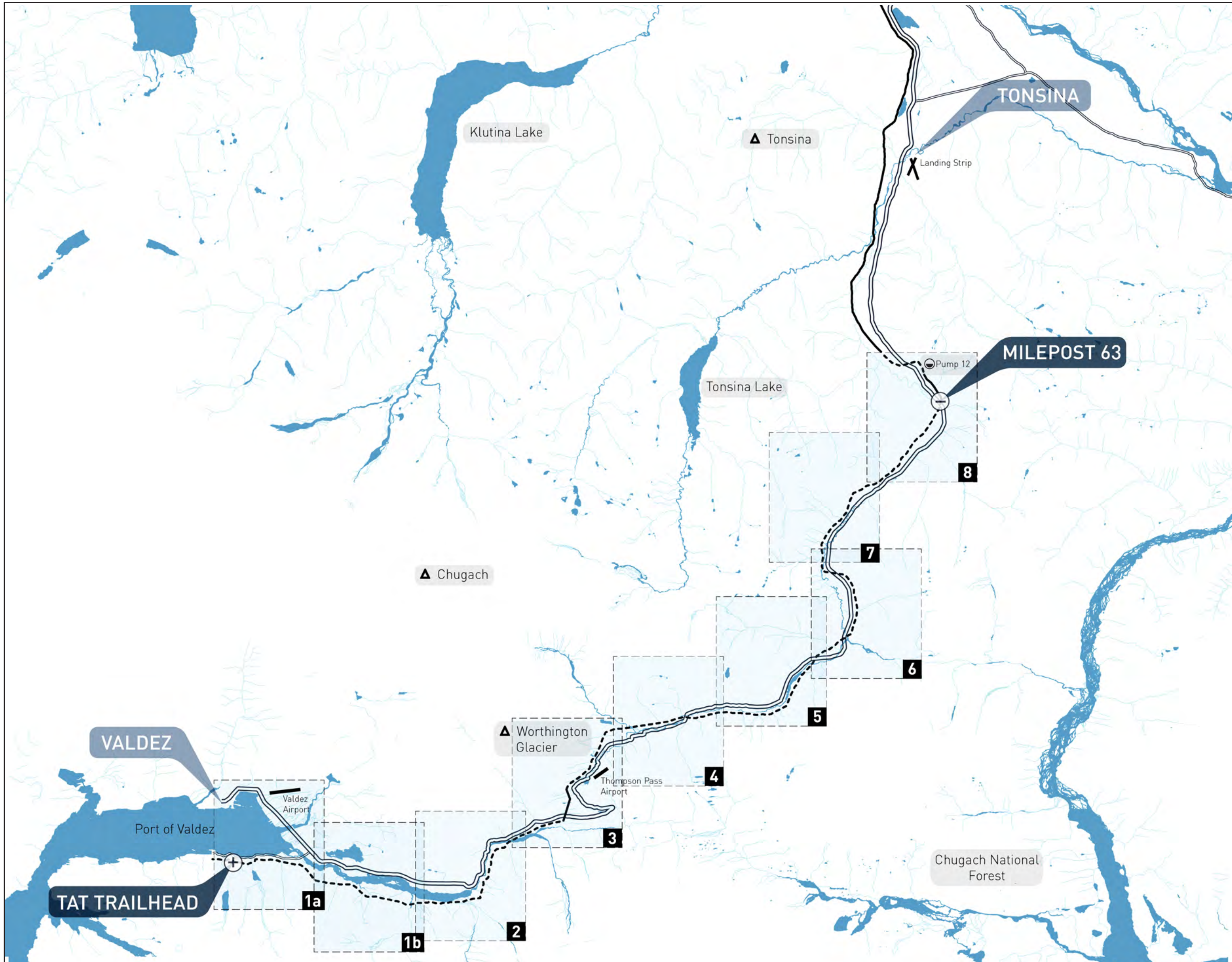
IV. The next wave of energy production in Alaska and its impacts on space, culture, and the landscape

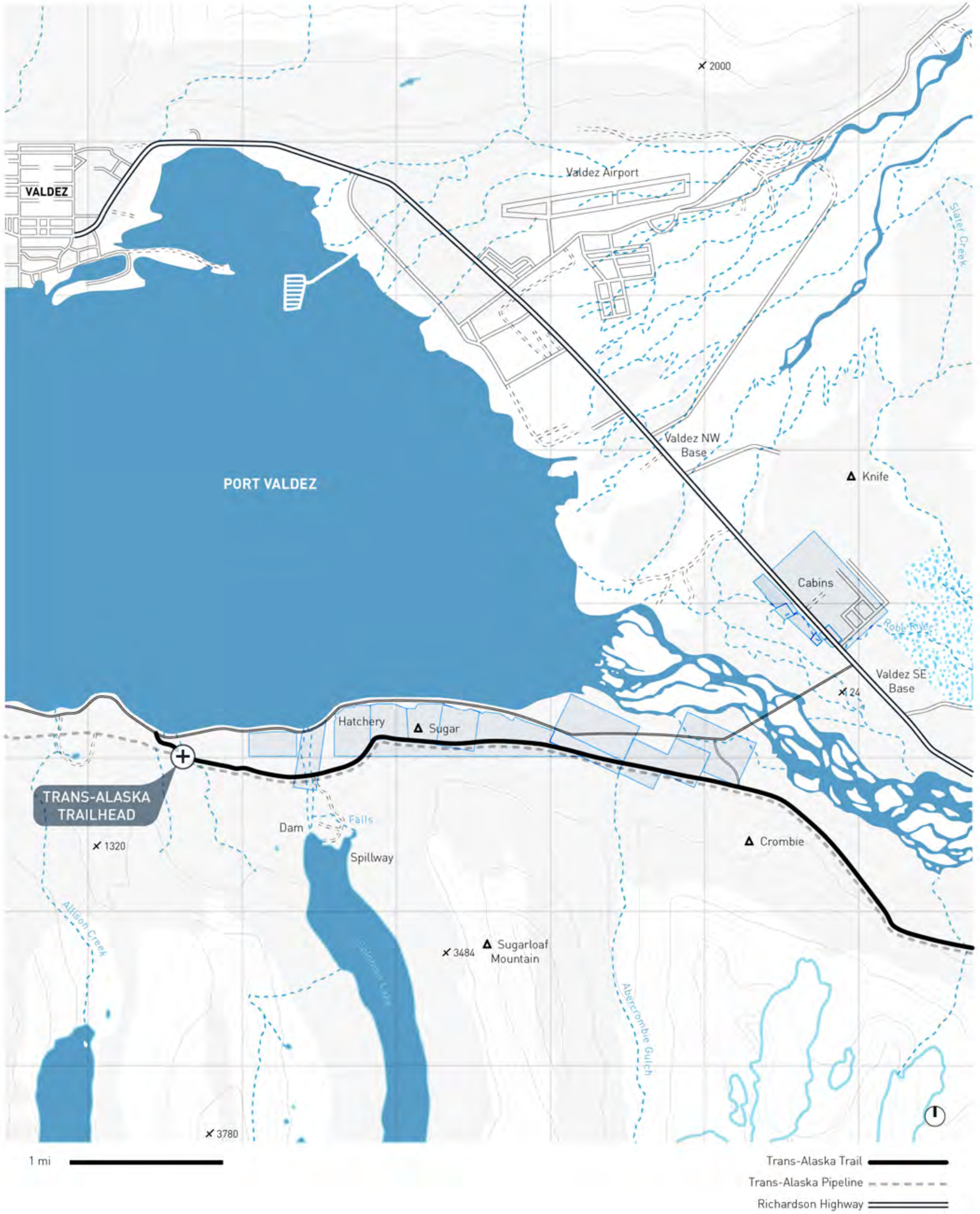


BEAUFORT SEA
PRUDHOE BAY
+ 737 MILES
CHUKCHI SEA
PILOT TRAIL
+ 63 MILES
BERING SEA
GULF OF ALASKA

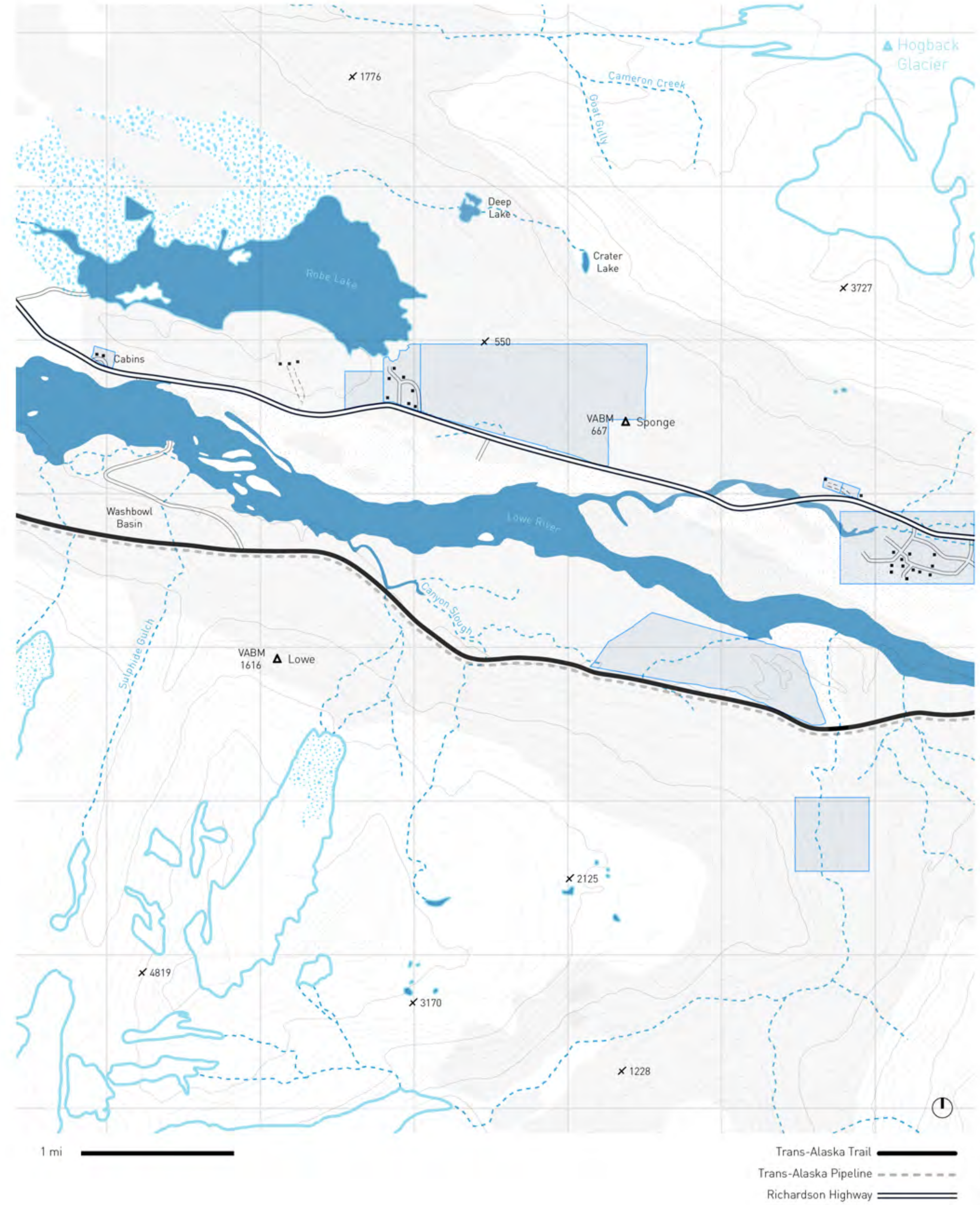
Valdez-Tonsina Route Segment Outlines






VALDEZ
PORT VALDEZ
Valdez Airport
Valdez NW Base
Valdez SE Base
Knife
Cabins
Hatchery
Sugar
TRANS-ALASKA TRAILHEAD
Dam
Falls
Spillway
Crombie
Sugarloaf Mountain
3484
1320
2000
24
3780
Allison Creek
Abercrombie Gulch
1 mi
Trans-Alaska Trail
Trans-Alaska Pipeline
Richardson Highway


0.0 mi
1.0
2.0
3.0
4.2


Hogback Glacier
Cameron Creek
Goat Gully
1776
Deep Lake
Crater Lake
Robe Lake
3727
550
Cabins
VABM 667
Sponge
Washbowl Basin
Lowe River
Canyon Slough
Sulphide Gulch
VABM 1616
Lowe
2125
4819
3170
1228
1 mi
Trans-Alaska Trail
Trans-Alaska Pipeline
Richardson Highway


0.0 mi
1.0
2.0
3.0
4.0
5.0
6.0
7.0
7.3

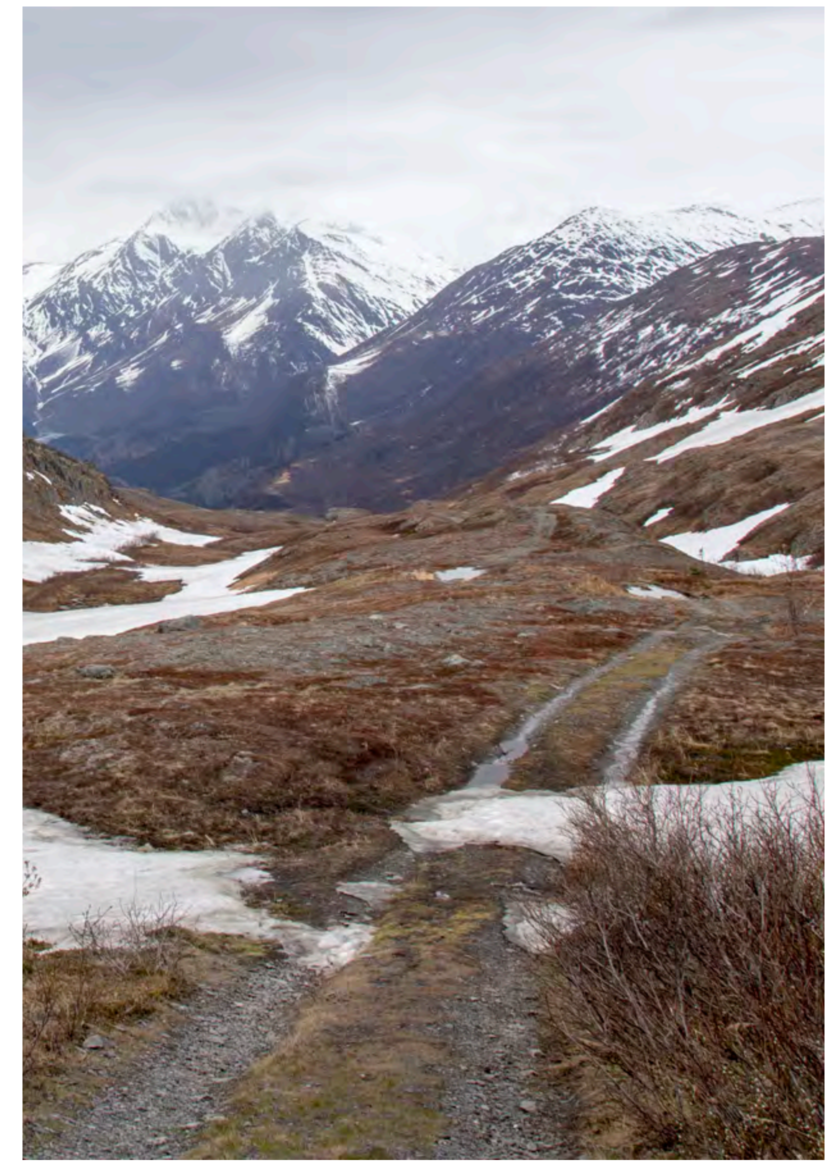
Thompson Pass_Mile 774

The following questions facilitated a lively discussion at the conclusion of our conference presentation:

A. How can designers and policymakers engage with and improve upon the construction of infrastructure at the territorial scale?

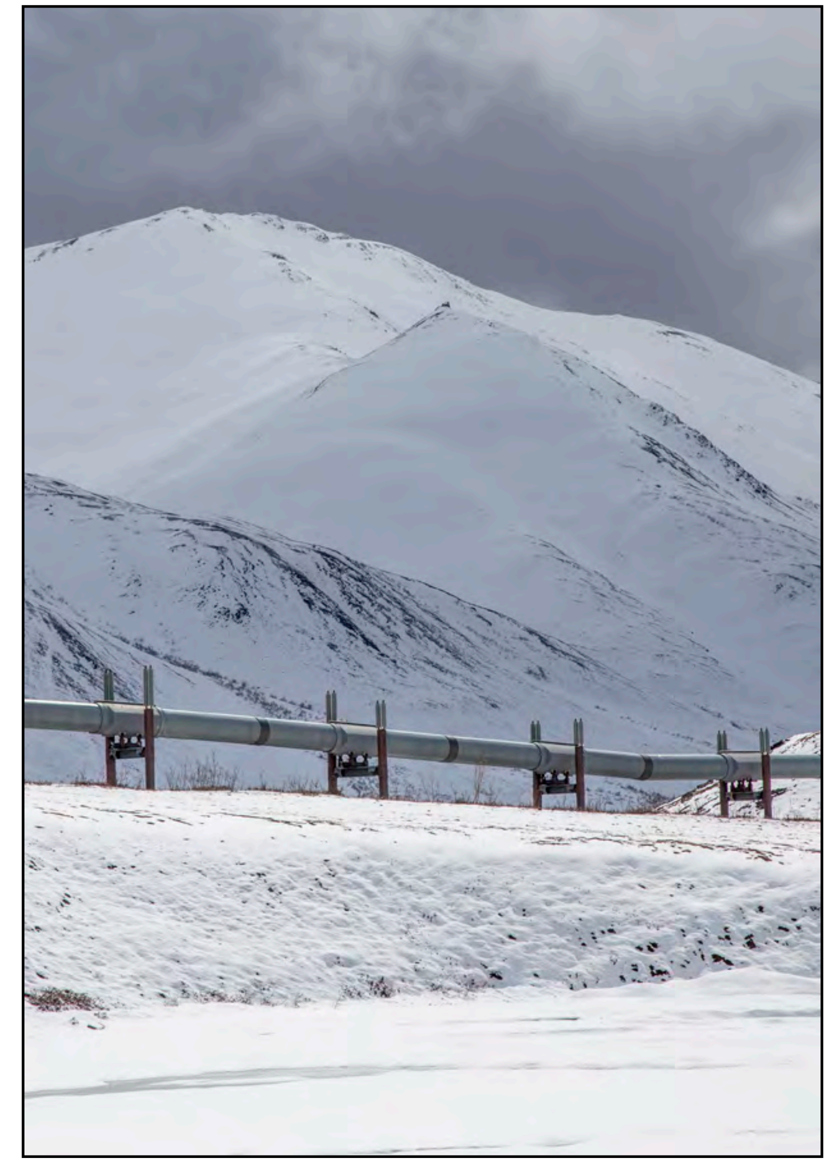
B. Can a recreational trail and an active pipeline co-exist?

C. When oil production ceases, should the pipeline remain as a relic of petrochemical industrialization or should all traces of it be removed?



THE POST-TAPS PROJECT

COURSE DEVELOPMENT



Chandalar Shelf_Mile 172

During the spring of 2018 I taught a graduate level design studio that engaged with the themes of the Post-TAPS Project.

COURSE DEVELOPMENT 2017-2018

During the Spring of 2018 Parker Sutton and I co-taught an explorative graduate level design studio through the Knowlton School that engaged with the themes of the Post-TAPS Project including:

I. The examination of the cultural and environmental impacts of resource extraction and energy production

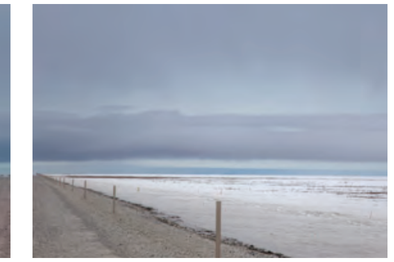
II. The impacts of resource extraction and energy production on space, culture, and the landscape and how designers and policymakers might engage with and improve upon the construction of infrastructure at the territorial scale

III. The effects of warming temperatures and melting permafrost on infrastructure and resource extraction in the Arctic

MWF 1:50 - 5:30
Knowlton Hall

Katherine Jenkins
enkins.1060@osu.edu
(288 KH)

Parker Sutton
sutton.426@osu.edu
(296 KH)



SYLLABUS

Introduction

This studio will study entropic changes that are radically altering the Alaskan Arctic, including severe coastal erosion, thinning sea ice, melting permafrost, the exhaustion of Arctic oil and gas fields, the rapid release of methane gas and the loss of unique landscapes such as Arctic tundra due to atmospheric warming. Entropic change indicates an alteration that cannot be reversed. The Alaskan Arctic, defined socially and economically by resource extraction, typifies this—oil cannot be put back into the ground, permafrost cannot be reconstituted once thawed.

Our investigation will focus on the region surrounding the town of Prudhoe Bay, Alaska, a locus of petrochemical activity and a geographic inflection point in America's Arctic. Here, the air is warming at three times the speed of the continental U.S. and the landscape is reasserting itself, destabilizing human-made infrastructure that relies on predictable conditions. Concurrent with this destabilization is the emergence of new landscapes and a potential surge in population and economic development due to vanishing sea ice and milder temperatures. You will study the cold-weather entropic processes transforming the grounds around Prudhoe Bay, hypothesize about the environments that will replace them, and make proposals for future land use within such speculative hybrid landscapes.

We will also consider what conservation means in an era when boundary lines on a map are growing irrelevant and warming air, not terrestrial activity, is driving landscape change. Conservation was once about setting land aside—this method is no longer effective. How do we preserve landscapes that are vanishing?

Site

Prudhoe Bay Oil Field is the largest oil field in North America. Originally a tiny Arctic village of Native Alaskans, its population swelled in the 1970s with the arrival of thousands of migrant workers imported by oil companies. These employees are typically flown in and out of Prudhoe Bay on two-week rotations. Lodgings are assembled from modular buildings and oil rigs and processing facilities are scattered across the tundra on thick gravel pads. A network of hundreds of feeder pipelines connect the Prudhoe Bay oil fields to the Trans-Alaska Pipeline System (TAPS).

The landscape here is made up of continuous permafrost and thaw lakes. A warming climate means that the period when tundra is entirely frozen is shortening each year. Only when the ground is frozen solid can it support heavy equipment; in the warmer summer months much of the tundra becomes boggy and unnavigable. Thus, oil operations on land are becoming more difficult and more urgent. With accelerating warming and diminishing reserves, extracting oil on land may be more difficult and less economical than drilling in the Arctic Ocean.

Objectives

- Leverage entropic changes spurred by a warming atmosphere to design new landscapes
- Create a highly site-specific design that responds to the phenomenal conditions of the Arctic, including a changeable climate, unstable ground, and annual extremes of darkness and light

Guiding Questions

- What does conservation mean in a era when boundary lines on a map are growing irrelevant and warming air, not terrestrial activity, is driving landscape change?
- How can we preserve landscapes that are vanishing and what opportunities might emerge from their transformation?

PROJECTS

Representation

Templates and a graphic palette will be provided for many assignments. You are asked to work within the given graphic standards. The purpose of these guides are threefold:

- Provided templates will save you time, allowing you to dedicate more of your efforts to the development of your design.
- Graphic standards allow your work to be judged more on the merits of your design than on the merits of the representational style or technique employed.
- A reduced palette renews the importance of lineweight, value, and composition, which are critical to drawing sucessfully in professional contexts.

Graduate school is an important time for testing and developing representational styles, yet we are often taught to employ photorealism as a default style. Photorealism is but one approach to landscape representation. Often, it can inhibit our ability to draw with technical or analytical rigor. It is important that you gain experience in multiple drawing styles while in school; this studio will offer you an opportunity to work with alternative techniques.

Part I: FUTURE FLORAS

As the climate warms, the fragile permafrost surrounding Prudhoe Bay will melt, irreversibly transforming the existing terrain and the plant species found therein. It is estimated that by 2050 50% of tundra will experience changes in the plants that it supports. This project asks you to, first, research and diagram an existing Arctic plant that is at risk of disappearing and then design a new fantastical plant species that is engineered to thrive in future conditions.

Due Monday, January 22

Part II: THE ARCTIC ENTROPIC

The atmospherically driven changes in the Alaskan landscape are characteristically entropic: once altered, they may not be reversed to a previous (or current) state. Through diagramming and analytical modeling, this exercise asks you to interpret a set of entropic changes reshaping the Arctic landscape at Prudhoe Bay.

Due Wednesday, February 7

Part III: TESTING GROUND

This week long charrette will ask you to make metaphorical models of the entropic processes you studied in Part II. The ideas and methods tested here will help you to develop your final project. Consider the materiality, forces, and allegory of the shifting arctic landscape.

Due Friday, February 15

Part IV: ARCTIC ADAPTATIONS

Warming temperatures are poised to transform population centers across the Arctic, but none more than those along the coast. Prudhoe Bay exhibits many of the entropic changes remaking the arctic landscape, including thawing permafrost, vanishing sea ice, and eroding coastlines. It also possesses existing infrastructure and a unique geography, making it a well-situated testing ground for experiments in Arctic adaptation. This final 8-week design project asks you to design a strategy for Prudhoe Bay's future at the territorial and site scale for one of the following themes: methane capture and storage, polar data hub, freshwater export, Inupiaq archeaological conservation, rewilding and migratory systems.

Due Monday, April 23 (at final review)

KEY TERMS

Entropy

Entropy is a term borrowed from physics that can be defined as "a gradual decline into disorder."[1] An example of entropy in nature might be mountains that cleave boulders, that break down into rocks, that erode into sand, that wears down into dust. Broadly speaking, it is an idea that is inextricable from our conception of time—in particular, time's incessant progression forward.

Entropy was central to the work of land artist Robert Smithson, who described entropy as "the inevitable disintegration of all objects in nature." A critical tenet of entropy is that the process of deterioration cannot be reversed: the landscape that breaks down entropically cannot be put back together in the same way. Smithson conveyed this idea with the following anecdote, asking his reader to, "imagine a sandbox filled on one side with white sand and one on the other with black. A little boy begins to run around the enclosure in a clockwise direction, kicking up sand as he goes and mixing together dark grains with light. He is then told to reverse his course and run counterclockwise... As his legs continue to churn, the process of entropy will, irreversibly, only progress."[2]

The changes wrought upon the Alaskan Arctic by warming air are entropic in nature—they cannot be mended or undone. Yet, from entropy comes not only decay but also renewal: a new typology of landscape, an adaptive approach to Arctic design, an evolved understanding of our role within natural systems. Central to your studio prompt is this: what opportunities will emerge from the entropic processes that are reshaping the Arctic?

Frontier

Frontier can be defined as "the extreme limit of settled land beyond which lies wilderness."[3] With the formal closure of the American Frontier in the continental U.S. in 1890, the Alaskan Territory became known to Americans as the "Last Frontier." The construction of the Trans-Alaska Pipeline System, or TAPS, beginning in 1973, was marked by many environmentalists as the dissolution of America's last frontier landscape. Those mourning its demise were mourning the loss of what they believed to be the unique human qualities that the frontier instills (e.g., rugged individualism; self-reliance), the very cultural and political qualities that shape American values, as put forth by Frederick Jackson Turner and his disciples.

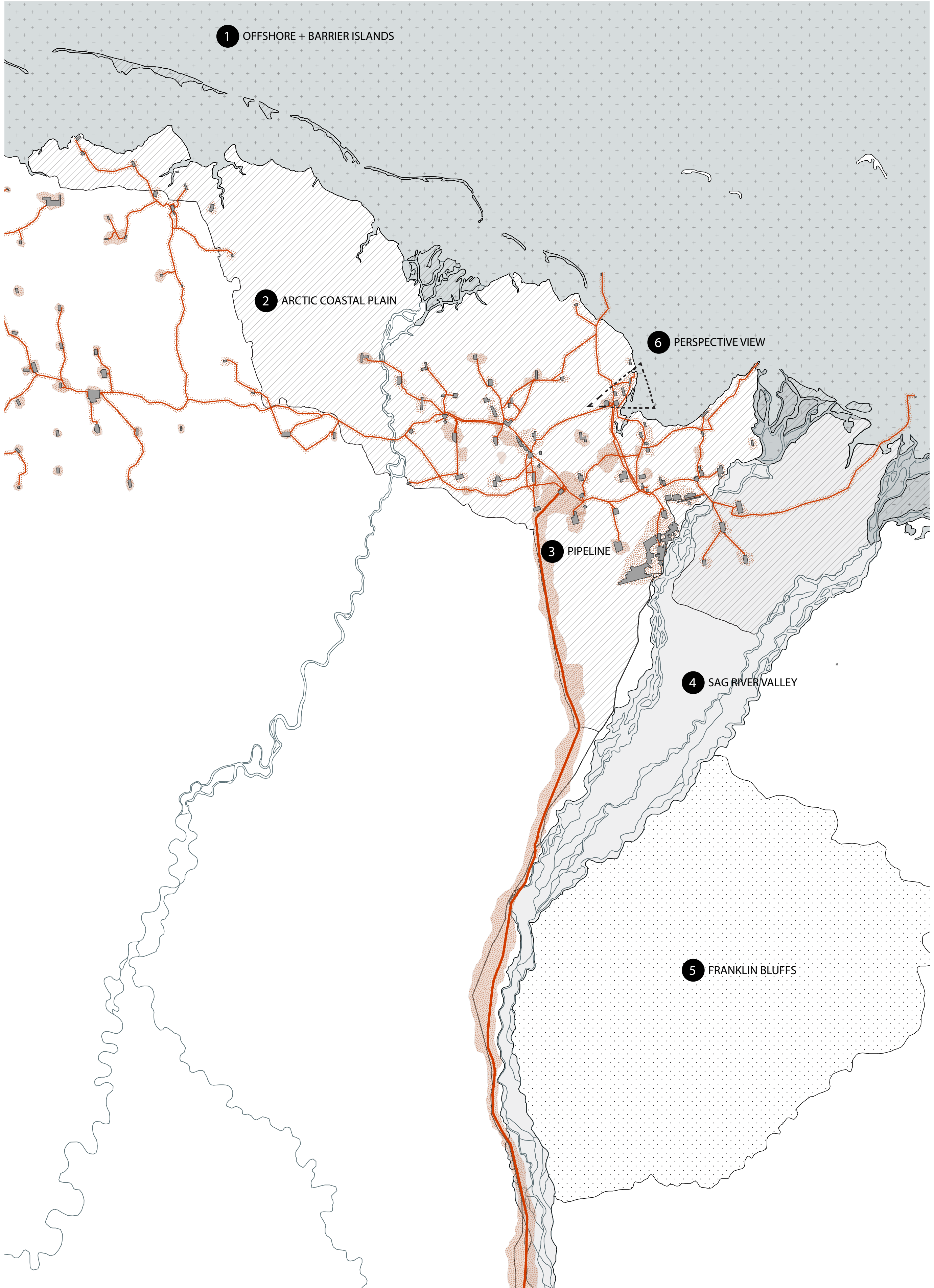
Often overlooked in this argument is the frontier's dual role in the formation of American capitalism. The frontier is, among other things, an economic construct: a ratio of people to resources. Following this idea—famously introduced by historian Walter Prescott Webb in The Great Frontier—the frontier signalled not merely a life close to nature but economic opportunity. Unlike Turner before him, Webb stressed the part of technological innovation in wresting a livelihood from frontier landscapes.

Alaska was once the last frontier in the United States; it is now the first frontier of climate change. What are the human values that this new frontier landscape will instill in its inhabitants and the livelihoods it will enable, and what types of spaces are necessary to accommodate them? What is the wilderness on the other side?

Wilderness

Wilderness, as defined above, is land beyond the "extreme limit of the frontier." Independent of the frontier, wilderness is defined as: "(1) a tract or region uncultivated and uninhabited by human beings (2) an area essentially undisturbed by human activity (3) a confusing multitude or mass."[4] Absent these definitions is the Romantic, human yearning that modernity projects onto wilderness—as places of sustaining purity, sublime beauty, and premodern values.

In "The Trouble with Wilderness," William Cronon writes: "Wilderness offers us the illusion that we can escape the cares and troubles of the world in which our past has ensnared us."[5] It is, moreover, a "human creation:" wilderness cannot exist as a construction without human-led manipulation of the land. It is also, in many ways, a Western notion formed by those alienated from the land and ignorant of the native populations that inhabit it.

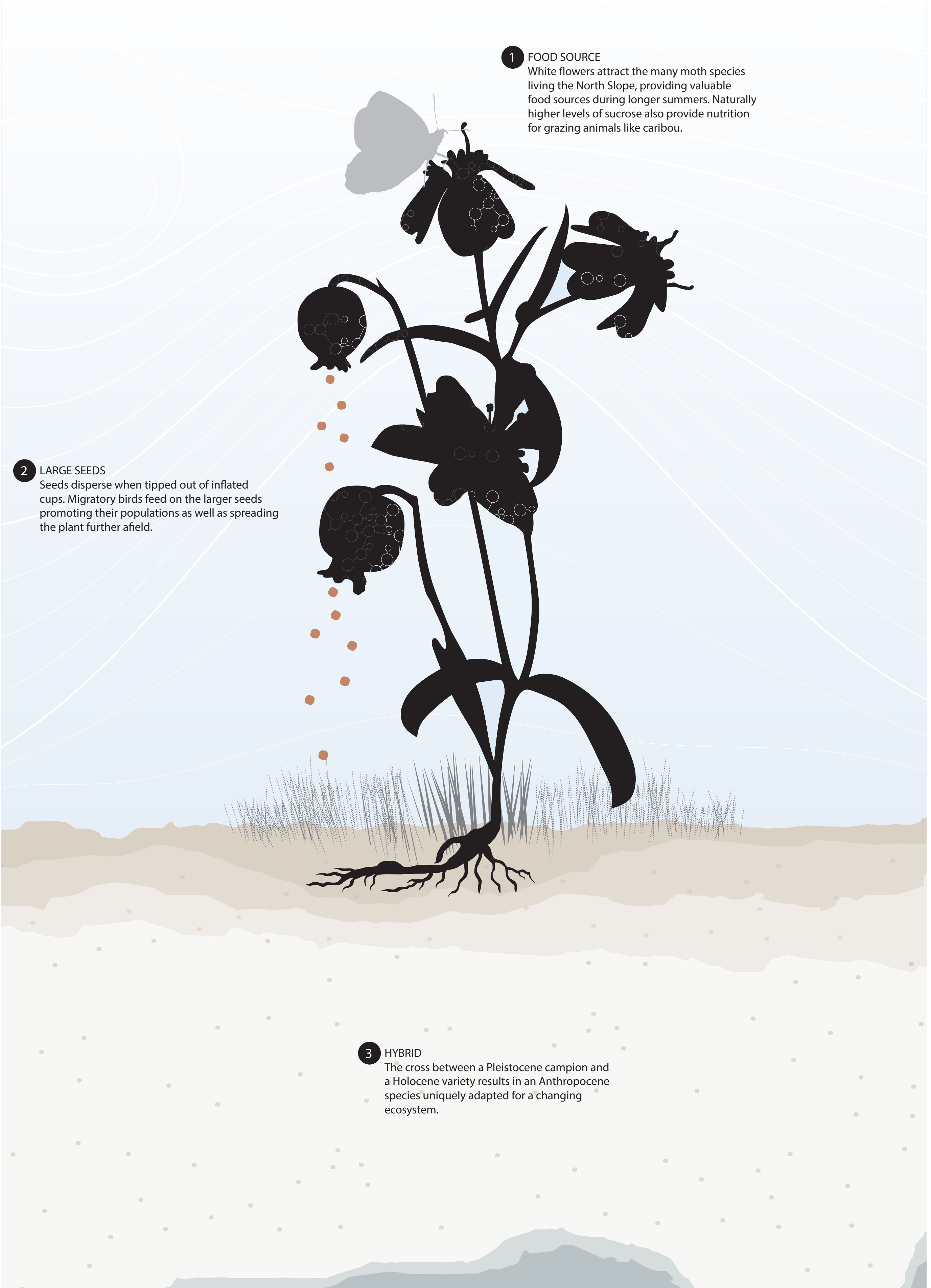


PROJECT EXAMPLE: FUTURE FLORAS

As the climate warms, the fragile permafrost surrounding Prudhoe Bay will melt, irreversibly transforming the existing terrain and the plant species found therein. It is estimated that by 2050 50% of tundra will experience changes in the plants that it supports. Many tundra species that have evolved to meet the extreme climate of the Arctic may not survive the transition. This project asks students to, first, research and diagram an existing Arctic plant that is at risk of disappearing and then design a new plant species that is engineered to thrive in future conditions.

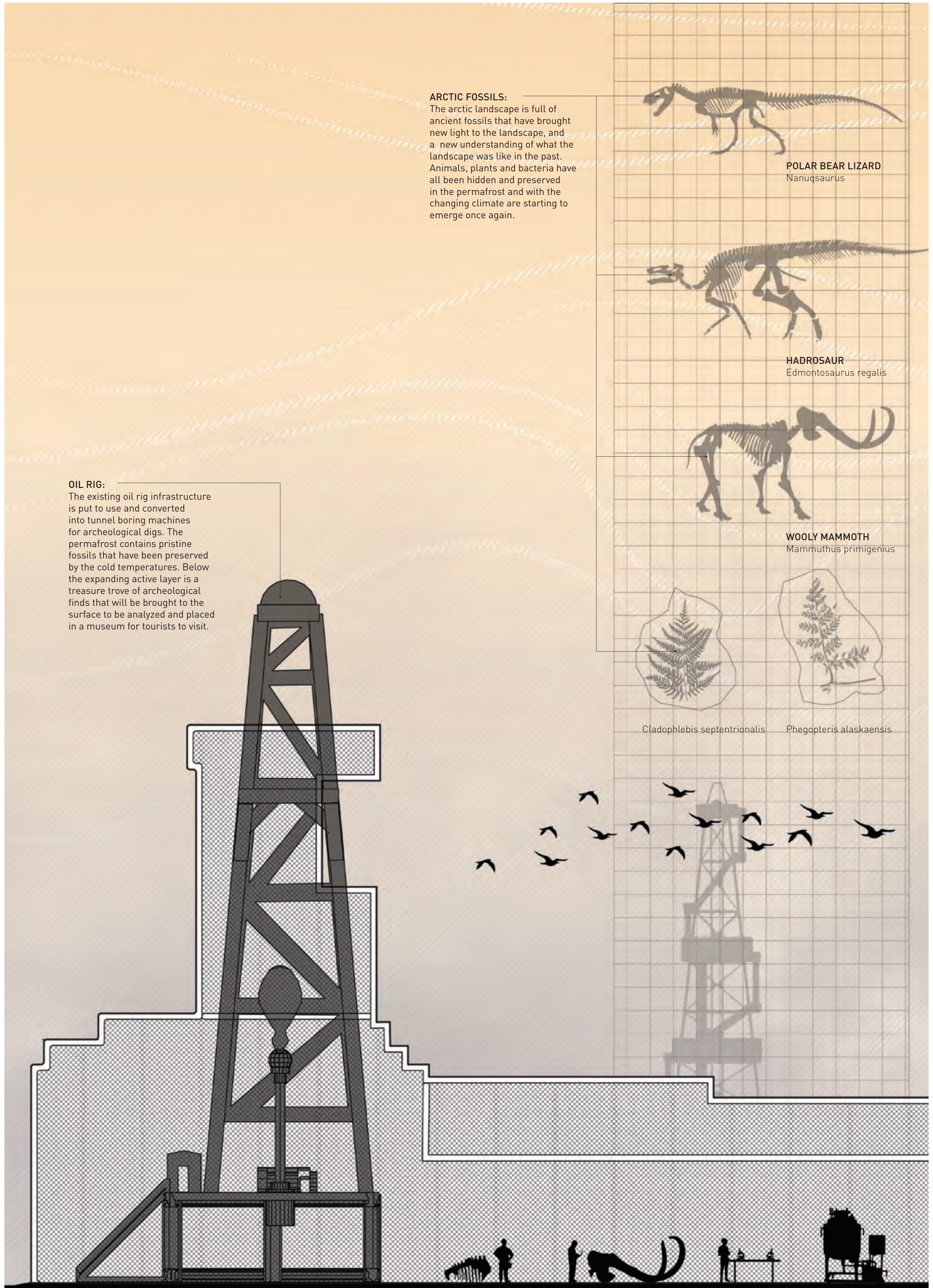
The proposed plant should mitigate a negative aspect of climate change in the north such as warming ground, methane release, salt water inundation, oil contamination, wildlife habitat loss etc. Your plant should be designed for a specific ground condition and location within the Prudhoe Bay region. Site your plant in one of the following areas: the Arctic Coastal Plain and oriented thaw lake terrain, offshore sea ice and barrier islands, active and/or abandoned oil fields and associated infrastructure such as roads, pipelines and drilling pads, the Sagavanirktok river valley, or Franklin Bluffs.

(L) Map by Lauren Shewhart



Byrd Polar and Climate Research Center

Our class visited the Byrd Center twice during the semester to study Arctic sediment core samples and fossils. **(L)** Drawing by Claire Brewer

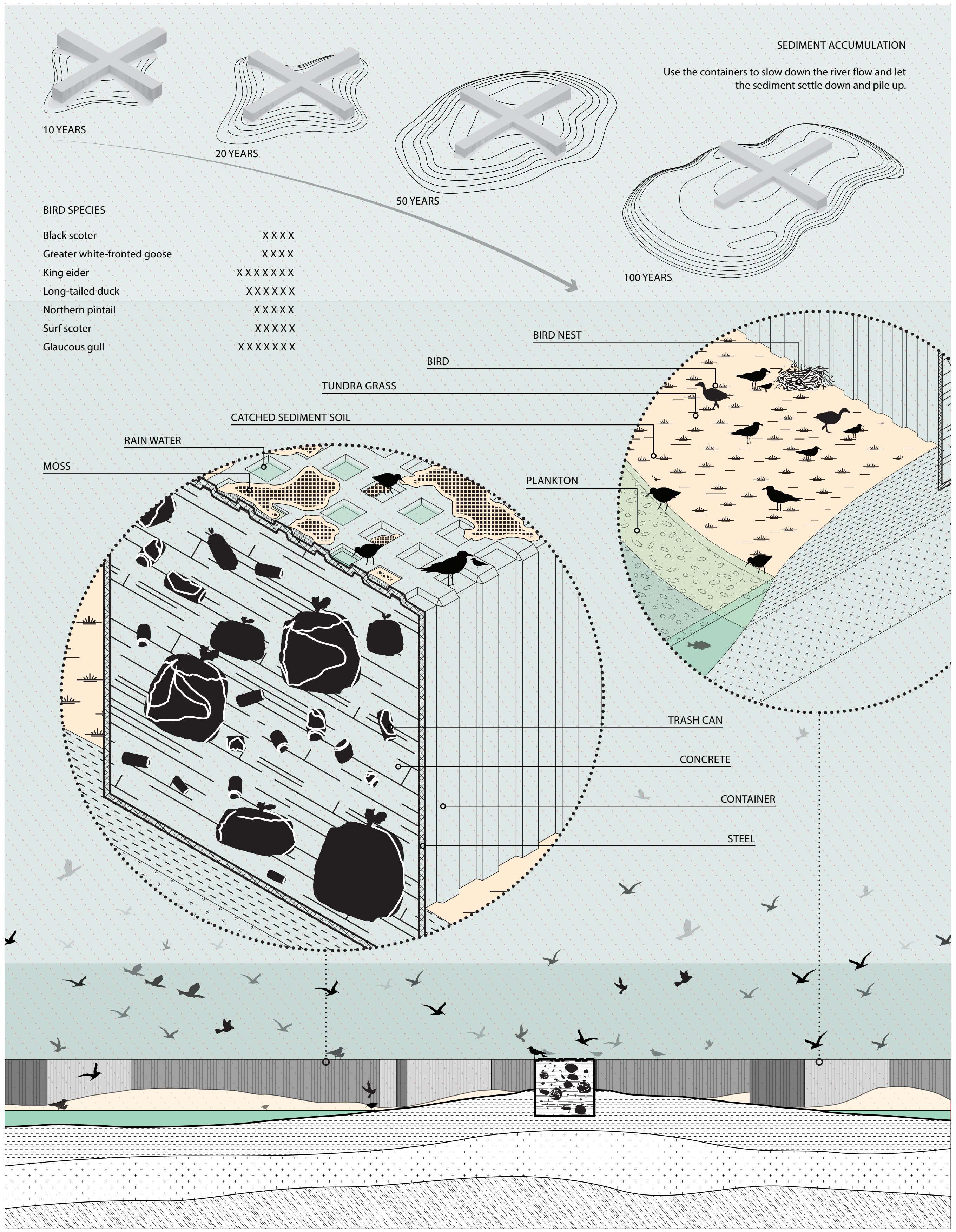


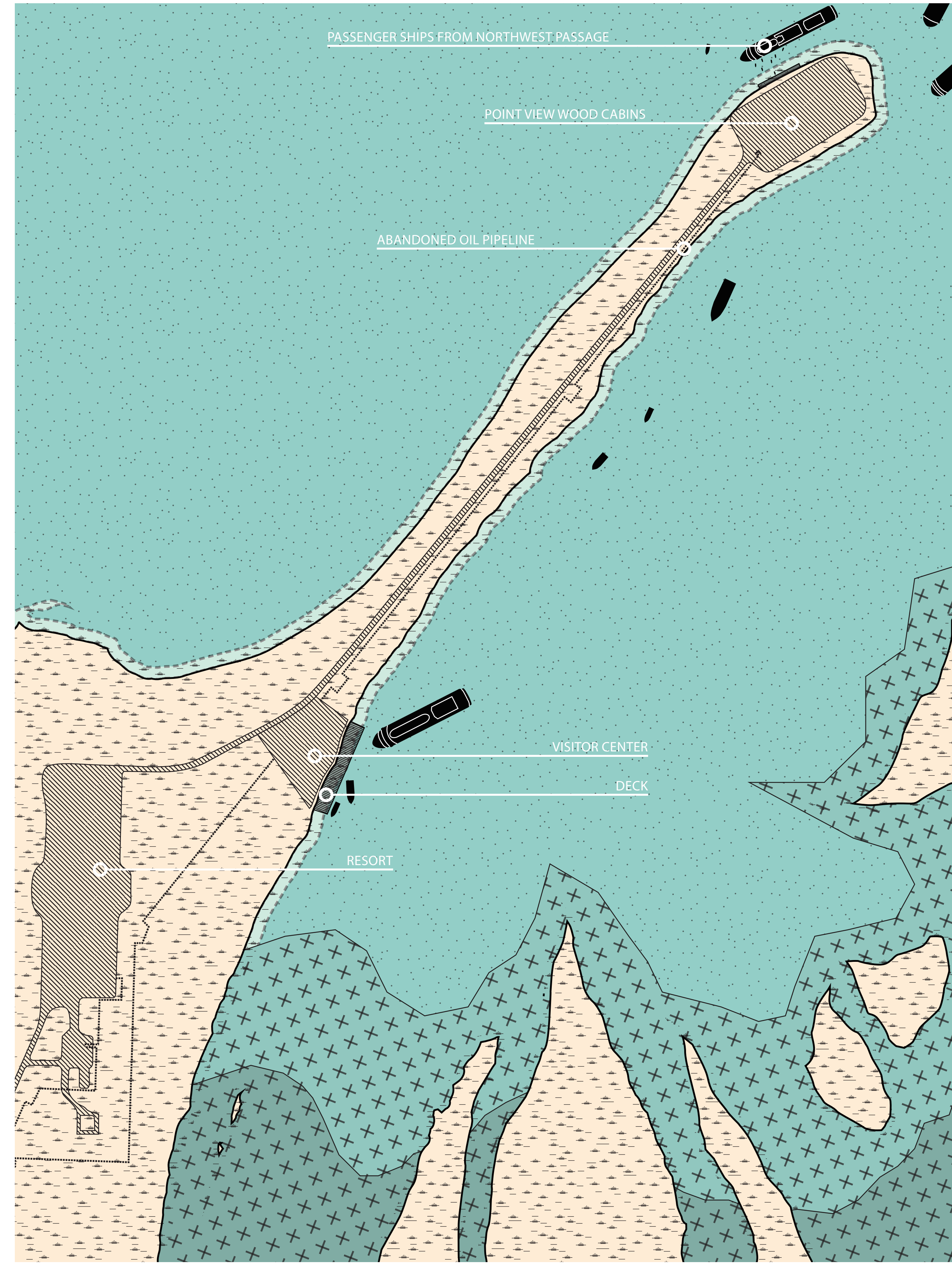
PROJECT EXAMPLE: ARCTIC ADAPTATIONS

The terrain of Prudhoe Bay past was comprised of many overlapping, interdependent pieces: thaw lakes that supported ecological systems; frozen ground that supported petrochemical industries; migratory animals that supported native societies. These relationships are uniquely contingent on the landscape. What are the interdependent systems of your future landscape at Prudhoe Bay and what are the pieces that comprise them? What adaptations have occurred that encourage (demand) the continued habitation of this place?

The entropic forces in the Alaskan landscape are setting in motion a transformation, and with it, loss. The types of loss are many: the loss of plant species; the loss of rituals; the loss of livelihoods; the loss of an aesthetic. At the site scale (1"=1/16'), design an approach for preserving some aspect of the landscape that is being lost or transformed in your future scenario—tangible, ideological, or otherwise. To design an approach to preservation entails you to first identify the part of your landscape that merits preservation and then to posit the most meaningful, authentic, or provocative, approach to preserving it. Define preservation in your own terms.

(L) Drawing by Ben Kohls





Design and drawings by Siyuan Lou

(L) Model by Lizi Huang **(R)** Model by Ben Kohls

(L) Model by Tianchi Zhang **(R)** Model by David Wu

THE POST-TAPS PROJECT

OUTCOMES

Arctic Foothills_Mile 145

SUMMARY OF ORIGINAL OBJECTIVES

The Post-TAPS Project sought to engage the public and design students at The Ohio State University to imagine how Alaska and Ohio's future relationship to resource extraction may be altered and improved. The project intended to expose OSU design students to the social, ecological, and spatial consequences of oil and gas extraction that Ohio is now confronting.

Seed funds were requested to facilitate meetings between key contributors in Alaska, to support outreach efforts (including lectures, exhibitions, community forums, and web platforms), and to conduct fieldwork and research to form the foundation for a new course at the Knowlton School of Architecture.

MANAGEMENT OF FUNDS

I used approximately two-thirds of the funds made available to me by SERC. $2,500 was used to conduct fieldwork in Alaska, $1,500 was used to travel to Los Angeles to present The Post-TAPS Project at the 4-day ASLA conference, and approximately $1,000 was used to purchase materials for the graduate studio I taught this spring.

SUMMARY OF OUTCOMES

+ Documenting the full length (800 miles) of the Trans-Alaska Pipeline System

+ Meeting with key contributors to the Trans-Alaska Trail Project in Valdez, AK

+ Presenting at a national design conference (The American Society of Landscape Architects Annual Meeting, October 2017)

+ Developing and implementing a graduate level course on the spatial and ecological impacts of extraction (Spring 2018)

FOLLOW UP

+ I am continuing to work with representatives in Alaska on the development of the Trans-Alaska Trail Project and have increased my network of collaborators as a result of the travel to Alaska and the national conference facilitated by SERC.

+ My next objective is to publish a paper of my research, photos, and diagrams developed over the last year that also draws on some of the themes and ideas explored in the course I taught this spring.

Credits

Unless otherwise noted, all photographs and diagrams are by Katherine Jenkins and Parker Sutton. For more work visit: www.presentpractice.com/

Many thanks to the Subsurface Energy Resource Center and to the Knowlton School for making this work possible.

(Previous) **The Interior_Mile 385**