4.3 Impacts of Proposed Action

Section 4.3 discusses the impacts of the proposed action, i.e., renewal of the TAPS ROW for the period 2004-2034. This section is divided into three main subsections:

- Physical Characteristics
- Biological Resources
- Social Systems

The impacts in this section are the direct and indirect ones associated with continued operation of TAPS. Cumulative effects of the proposed action are addressed in Section 4.5, while Section 4.4 covers direct and indirect impacts of the no-action alternative.

These analyses follow as closely as possible the definitions provided by the Council on Environmental Quality (CEQ):

- **Direct effects** are “caused by the action and occur at the same time and place” (40 CFR 1508.7).
- **Indirect effects** are “caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems” (40 CFR 1508.7).
- **Cumulative impact** is “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time” (40 CFR 1508.7).

In general, Section 4.3 discusses direct and indirect effects. ANS and PWS effects are treated as cumulative effects in Section 4.5 because these regions are not directly affected by TAPS as defined in Stipulation 1.1.1.22 of the Federal Grant. (However, the economic analysis in Section 4.3.3 treats them because of the model used for the analysis. See the introduction to Section 4 for an explanation of how these various effects are treated.

4.3.1 Physical Characteristics

4.3.1.1 Terrestrial Environment

By R. Dugan and Golder Associates

Continued operation of TAPS will impact some parts of the terrestrial environment because of maintenance activities, corrosion digs, construction projects for pipeline-related facilities, and the continued presence of a buried warm-oil pipeline in permafrost terrain. Maintenance since startup has caused localized temporary land disturbance but has generally stabilized the ground on and adjacent to the ROW. Since nearly all maintenance activities occur on or along existing stabilized embankments, new major long-term changes to the terrestrial environment are not expected.

Geology and Physiography

Impacts on the geology and physiography along TAPS are expected to be localized to the workpad, access roads, and their immediate margins and will generally include temporary soil erosion and accelerated riverbank erosion. Modification to the permafrost regime is discussed below. There will be essentially no direct impact to the underlying bedrock or topography except for possible new material-site developments. Maintenance work could cause minor local changes to terrain similar to those during original construction but on a much smaller scale. The pipeline will not affect seismicity, although seismic activity may impact the pipeline.

Paleontological Resources

Large portions of the pipeline overlie rocks containing plant and animal fossils, particularly marine plant and invertebrate species. Damage to these resources could result from excavation or spills. However, these fossils are so widespread and numerous that potential impacts from the pipeline are minor. Vertebrate fossils are much less common but are more likely to be affected by pipeline maintenance activities. Vertebrate fossils would likely be encountered during gravel mining or erosion of river banks.

Other activities that could lead to the disturbance of near-surface remains are reroutes of the pipeline, cleanup of spills, and changing the pipeline mode from below-ground to above-ground or vice versa. Since the location and type of the vertebrate remains are unknown until these activities occur, the severity of the potential impacts is difficult to assess. There have been no significant discoveries of fossil remains on the TAPS ROW during operation (Kunz, 2000, pers. comm.).

Soils and Permafrost

With respect to soils and permafrost, the impacts of continued TAPS operation are minimal. Most of the thermal impacts have already occurred or are significantly slowing. Continued monitoring and maintenance will identify and repair any areas where settlement or heave may exceed operational standards.

The pipeline was designed and built to maximize pipeline stability and minimize environmental impact. It was typically buried conventionally where the soils were unfrozen or thaw-stable and was elevated in zones of thaw-unstable permafrost. Since construction, the soils in permafrost zones have been affected by thawing. The thaw bulb that has developed around the buried pipe has reached equilibrium and is unlikely to continue to grow because the pipeline temperature is decreasing with decreased throughput. The thaw bulb could eventually shrink in the cold continuous permafrost north of the Brooks Range. Shrinkage of the thaw bulb could contribute to frost heave in some areas.

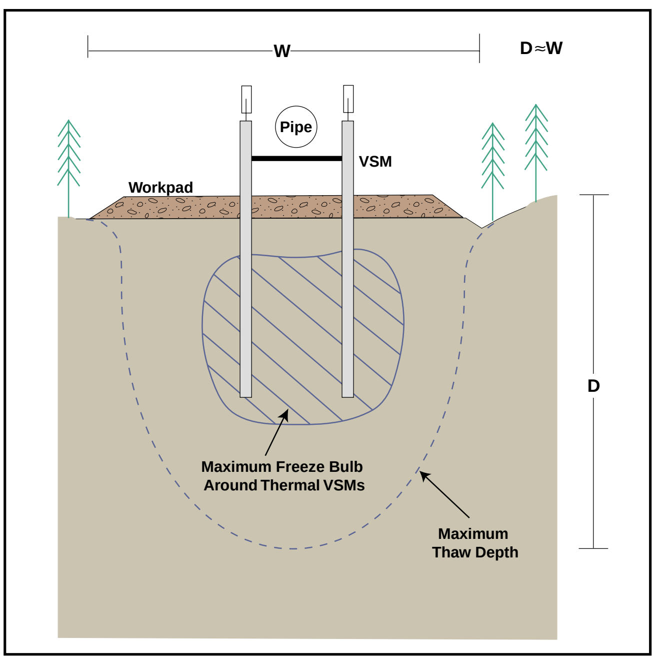


Figure 4.3-1. *Conceptual maximum thaw-bulb development for above-ground pipe.*

However, the impact of continued pipeline operation in areas of permafrost is likely to be minimal and well within operational limits.

Workpad and access-road embankments built over the relatively warm permafrost south of the Brooks Range have compressed or disturbed the vegetative cover that formerly protected the permafrost. This has caused the ground to absorb more radiant heat and has resulted in the thawing of near-surface permafrost under the embankments. Because the impact of the workpad controls the gross thermal state around the VSMs, the maximum thaw-bulb development for above-ground pipe could locally approach the configuration shown in Figure 4.3-1. During the life of the pipeline, this thaw-bulb configuration would likely be an unusual case in most above-ground sections and would be limited to a few areas of discontinuous permafrost. Lowering of the permafrost table has caused settlement where the near-surface soils contained excess ice before thawing. The settlement has caused localized disruption of drainage and formation of ponds in the depressions. The ponds rarely extend more than a few yards from the edge of the embankments. Where the underlying soils were particularly ice-rich, ponds have locally extended onto the workpad (Figure 4.3-2).

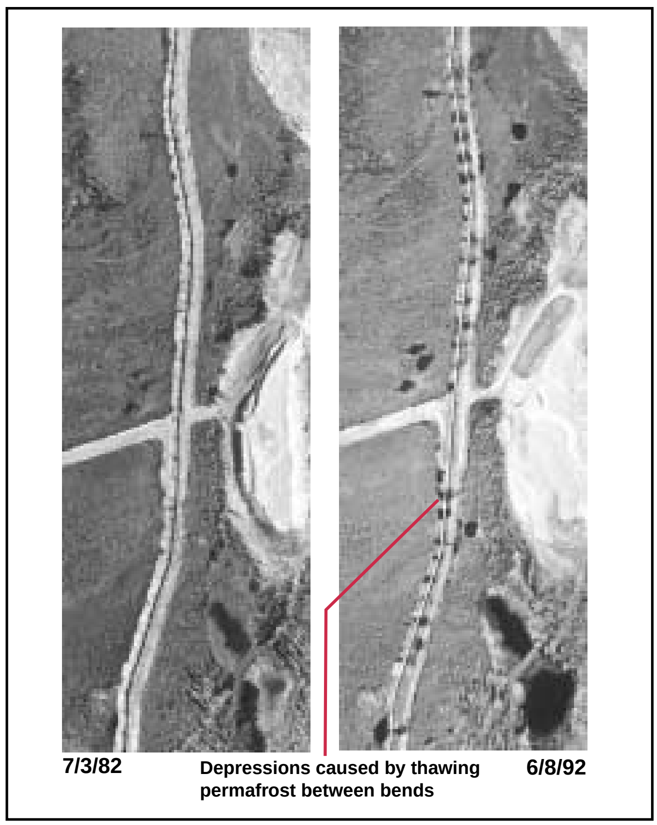


Figure 4.3-2. *Example of localized workpad impact on ice-rich permafrost.*

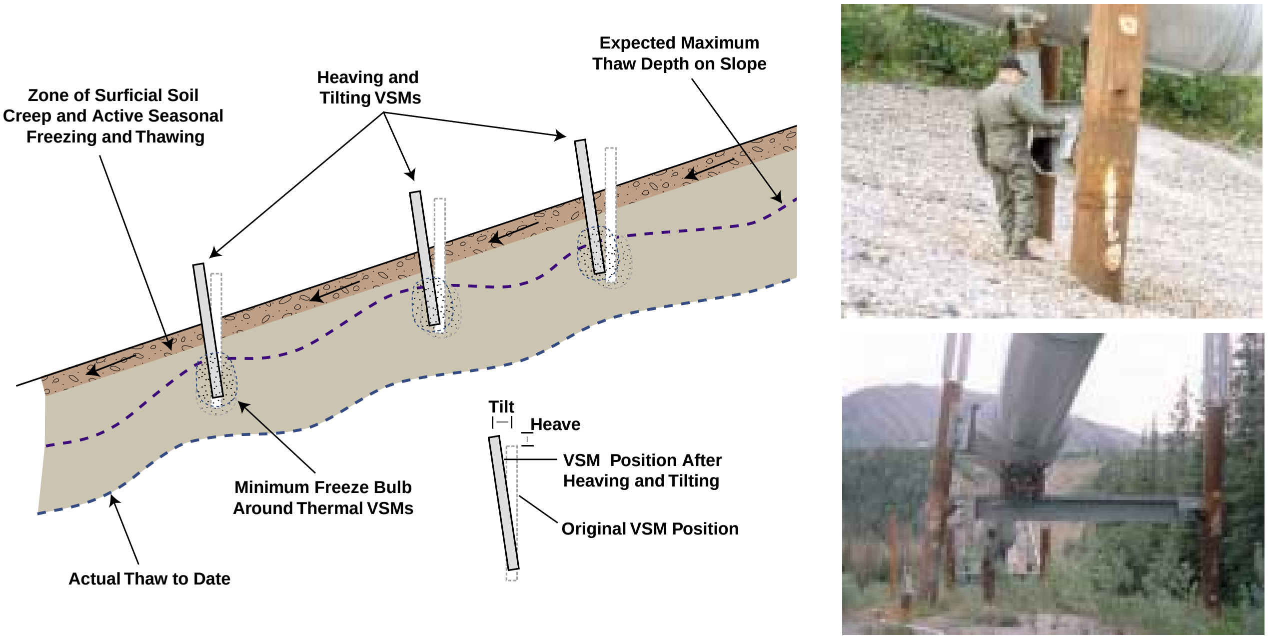


Figure 4.3-3. *VSM tilt resulting from frost heave on slopes.*

As the top of the permafrost continues downward, the rate of thaw generally decreases. Continued operation of the pipeline is not likely to further affect this process significantly because the effect of the above-ground pipeline is minimal compared to the effect of the workpad that is already in place. In addition, the thaw depths under the workpad are already approaching the anticipated maximum in some locations, and the VSMs have settled in only a few areas.

In addition to the effects on drainage, the continued downward migration of the permafrost table may locally affect VSM stability. Where permafrost thaws below the VSMs, settling or seasonal frost-jacking of VSMs may occur. Figure 4.3-3 shows the process of VSM heaving and tilting. A saturated thawed zone provides water for winter ice lenses that grow along the VSM freeze bulbs and at the active-layer freeze front. These growing ice lenses push the VSM and its freeze bulb up and downslope. In the future, localized repairs will likely be necessary, particularly on slopes where VSM movements aggravated by surficial soil creep may cause the support shoes to lose contact with the cross-beam. VSM movements have generally been mitigated by adjusting the height of the cross-beam, adding free-standing heat pipes, and using other techniques such as applying wood chips to insulate the workpad.

Monitoring programs report that about 300 of approximately 78,000 VSMs installed on TAPS show signs of movement (up, down, leaning) that exceeds maintenance standards and may require intervention. None of these affect the structural integrity of the associated above-ground pipeline support system. Most of these VSMs are on slopes in marginal permafrost areas and may have to be replaced with longer VSMs installed to a greater depth (Sorenson, 2000, pers. comm.). All of these impacts have been, and will continue to be, mitigated through Alyeska's routine monitoring and maintenance program.

Future maintenance activities such as corrosion digs and VSM repairs will typically take place on existing embankments, and the vegetative cover outside the embankments is unlikely to be disturbed. Therefore, soils outside the immediate limits of the embankment are unlikely to be affected during routine operation. In the case of oil spills, cleanup plans are designed to minimize the effect of the spill on the environment, including permafrost. However, oil spill cleanup conducted off the workpad could damage the vegetative cover, and this damage could lead to localized thawing of permafrost, causing settlement and ponding.

Loss of pipeline support due to thawing permafrost has occurred since construction in a few areas. Notable examples include:

- Pipe deformation resulting from thaw settlement that resulted in a leak on the north side of Atigun Pass (MP 166) in 1979. The permafrost at this location was not identified during TAPS construction.
- Several feet of vertical settlement for a segment of buried pipeline due to thawing of ice-rich soils in the Dietrich River floodplain at MP 200 in 1985. The

permafrost at this location was not discovered during TAPS construction.

- Minor movement of VSMs on slopes at Pump 11 Hill (MP 687) and Squirrel Creek (MP 717) due to thaw settlement and frost-jacking of VSMs.
- Pipe settlement and deformation at MP 734.

The leak in Atigun Pass reached the Atigun River and caused some impact. The Dietrich River settlement resulted in a realignment, causing temporary disturbance to the ground surface over a limited area. Maintenance and repairs associated with the movement of VSMs on the slopes have not affected areas off the workpad.

Short segments of the pipeline are buried in ice-rich soils. These segments are refrigerated and closely monitored to ensure that the soils under the pipeline remain frozen to prevent pipe settlement. Figure 4.3-4 shows the anticipated maximum thaw-bulb development for the refrigerated-burial segments.

Sand, Gravel and Rock

Continued operation and maintenance of TAPS will require sand, gravel, and quarry rock; workpad repairs; road bedding and surface materials; and flood damage control and revetment projects. Removal of gravel and related construction materials from non-permitted locations is not allowed, although materials can be obtained from privately owned pits. From 1995 to 1999, Alyeska's annual usage ranged from approximately 30,000 to 97,000 cubic yards (Nagel, 2000, pers. comm.). It is thus conservatively estimated that Alyeska will need approximately 100,000 cubic yards of these materials per year. Most of these materials will likely be obtained from the 69 material sites on public lands for which Alyeska currently has mining permits.

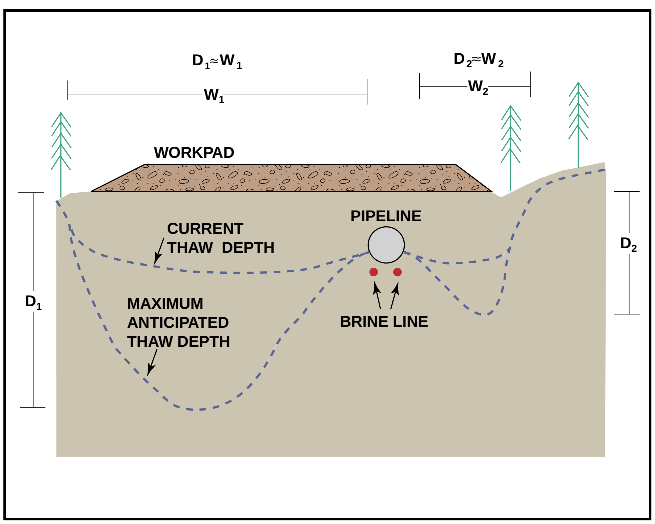


Figure 4.3-4. *Conceptual thaw-bulb development for refrigerated burial.*

Many of these sites have existing stockpiles (Globig, 1999, pers. comm.).

Additional mineral extraction will result in development of previously undeveloped portions of some existing material sites. Development of new material sites or reopening of previously closed material sites may also be required where existing mineral resources have been depleted. Within the footprint of the newly developed areas and access roads, this activity will result in modifications to the topography, loss of existing vegetation, landscape scars, and alteration of natural drainage patterns. The extent of surface disturbance from future material-site development is unknown but is likely to be limited to a few acres at existing material sites. The size of possible new material sites will likely be significantly less than the typical 20- to 40-acre sites opened during construction. The construction-era material sites were used to construct extensive sections of workpad, access roads, pump station pads, and the Haul Road. This required approximately 41 million cubic yards of mineral materials. Future earthwork materials will be primarily for maintenance and will be minimal by comparison.

Soil erosion and siltation may occur temporarily during mining and before stabilization of the disturbed surfaces. Material sites for production of riprap will likely require blasting of rock faces, leaving an enduring visible scar over a small area.

Hazardous Materials

Hazardous materials used in conjunction with the operation of TAPS are procured, handled, used, stored, and disposed of in accordance with regulatory requirements and strict procedures. These materials are not disposed of on the right-of-way. Hazardous materials could impact the terrestrial environment if they are leaked or spilled. Where this occurs, cleanups will be conducted to mitigate damage to the environment.

To minimize the shipping and handling of hazardous materials, crude oil, used oil, and other hydrocarbon-based compounds that meet certain criteria are injected into the pipeline according to specific guidelines and procedures (APSC, 2000b). Strict work-site guidelines and updated secondary containment systems installed at fueling stations and storage facilities have reduced the potential for releases of hazardous materials.

At present, there are 58 contaminated sites on the TAPS ROW. Approximately 90 percent of these sites are contaminated by diesel fuel, and the remaining sites are contaminated by other types of petroleum hydrocarbons. Half of these sites are either closed, requiring no further action, or are pending closure.

Rivers and Floodplains

By W. Veldman

Impact of Existing Facilities. The impact of the pipeline on the behavior of rivers and floodplains depends on whether river training structures are used, the type of structure, and whether the pipeline, particularly when parallel to the river, is located in the active or main channel area or in vegetated floodplain fringe areas.

Buried river crossings with no river training structures have little or no impact on the behavior of rivers. As part of construction, riverbeds were restored to the original grade. Typically, some settlement occurred in backfilled ditches during the first year due to the loose nature of the backfill and/or frozen material or ice in the ditches if constructed in the winter. With the first moderate to high flow during spring runoff or rainfall, the natural bedload transported into the ditches filled in the settled areas. The banks were typically restored to their natural conditions or, for erosion control purposes, cobbles or rock placed on them. After a single year of operation, there was little or no evidence of construction except for loss of vegetation at the banks.

Most of the bridged river crossings have some type of river training structure to guide flow. The structures are necessary to reduce scour and bank erosion and thus protect the integrity of the bridge piers and abutments. The Yukon River bridge and the Atigun River bridge north of Pump Station 4 are examples of crossings with no river training structures. These bridged crossings have little or no impact, except for the local impact of the piers on flow. The piers result in a local deepening of the river immediately in front of and alongside the piers.

Figure 4.3-5 shows bridged crossings and associated river training structures at the Tanana, Middle Fork Koyukuk, and Hammond river crossings. Some additional riprap was placed along the north bank of the Tanana River in 1996; this placement may have not been consistent along the length of the bank. Minor work was also done along the south bank. Neither the north or south bank maintenance work protruded significantly into the river and consequently had little or no impact on the river. The large guidebanks at the Middle Fork Koyukuk River and Hammond River bridges are parallel to the flow and have little impact on the behavior of the rivers except for locally limiting their movement.

Many elevated stream crossings are on VSMs (Figure 4.3-6). Where bank erosion or channel scour could result in significant "stick-up" height on the VSMs, riprap islands are typically placed around the piles, as shown on the photographs. This riprap has only a local effect on flow. The effect of more significant riprapping around VSMs on wide fans such as Snowden Creek is still minimal.

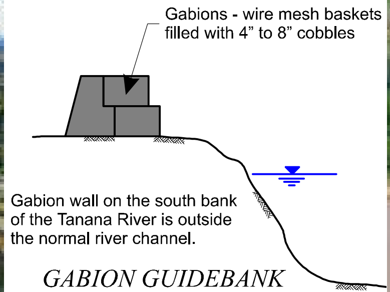
Revetments are armored structures parallel to the flow to prevent further movement of the river towards the pipeline or to protect the pipeline or facilities during operation (Figure 4.3-7). On the Middle Fork Koyukuk and Delta rivers, the impact of the structures on flow patterns and overall river behavior is minimal because the structures are constructed on the edge of wide rivers or following the bank. At the alluvial fan at Trims Creek, the revetment prevents spillage of the creek into Pump Station 10.

Spurs are structures built perpendicular to river flow (Figure 4.3-8) to deflect main-channel high-velocity flow away from the pipeline by limiting the formation of major channels between the structures and thus over the pipeline. The length of the spurs, and therefore their impact on flow patterns, depends on the width of the river, the presence of vegetation, and ice conditions.

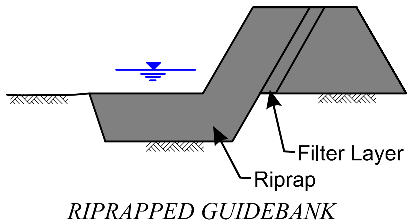
When initially constructed, spurs can have a significant impact on the flow patterns of rivers as the main channel flow is deflected beyond the ends of the spurs. In highly mobile rivers like the Delta (Photo 1 in Figure 4.3-8), the spurs presently have little or no impact on flow as natural features in the river — primarily the noses of alluvial fans upstream — influence overall flow patterns. In the future, the natural flow patterns could change again, resulting in main channel attack into the spurs. When new spurs are built in river systems such as the Sagavanirktok River (Photo 2), the flow deflection created by the spurs will form new channels through bars or even vegetated islands or deepen existing channels. (In the 1993 work at MP 22, a channel was excavated across a high vegetated gravel bar area to ensure the flow could bypass the new spurs). Where spurs are constructed adjacent to subchannels in a vegetated floodplain, like the Middle Fork Koyukuk (Photo 3), the spurs are sized and positioned to ensure the subchannels are not blocked.

Various types of structures are used to protect valve sites and/or the access to the valves (Figure 4.3-9). The armoring required to protect Check Valve (CKV) 29A and CKV 30 in the Atigun River (Photos 1, 2, and 3) is very local in nature and has little effect on the overall behavior of the river. At RGV 34 in the Dietrich River (Photos 4 and 5), more extensive armoring is required. Because this armoring was placed on the eroding bank, the structure has had little impact on the behavior of the Dietrich River. The armoring will prevent further movement of the river but will not restrict the behavior of the river compared to the preconstruction, natural width of the river.

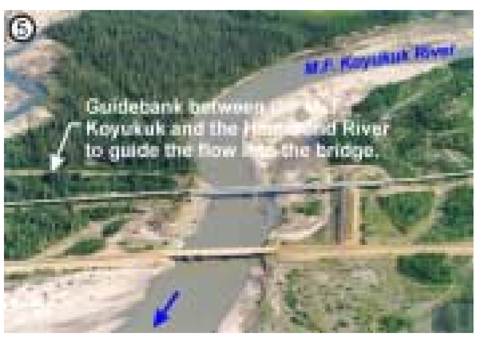
Revetments are also used to protect transitions to shal-



3. North bank before placement of additional riprap, 1996



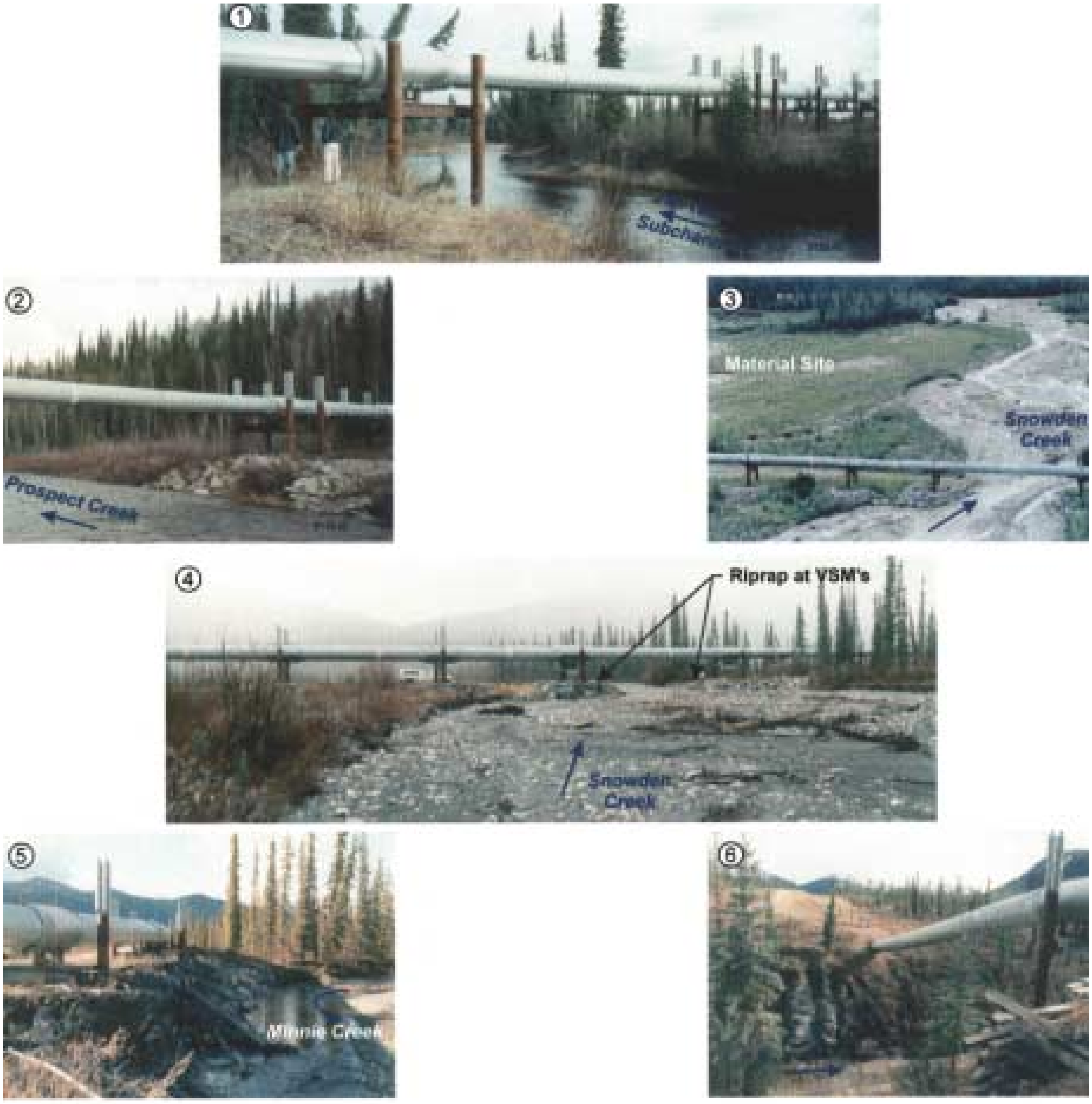
4. After repair



Guidebanks are armored structures built parallel to the river flow to guide the flow into bridge openings and/or to protect the bridge foundations. In the case of the Tanana River bridge near Big Delta (MP 531.0), a vertical gabion wall was constructed on the south bank to protect the main pier and wind anchors (Photo 1). No repairs of the gabion protection have been necessary to date. (Riprap on the bank, a more typical design, was not used due to a prime fish spawning area along this bank.) The north bank was also armored and required a minor repair of the riprap in the mid-nineties (Photos 2-4). The structures at the Tanana River have had little or no impact on the behavior of the river. In the case of the Middle Fork Koyukuk River bridge (Photo 5) and the adjacent Hammond River crossing (Photo 6), extensive guidebanks were required to align the flow, minimize scour at the bridge, and protect the abutments of the bridges. Photo 5 shows the bank erosion upstream of the Middle Fork Koyukuk guidebank compared to the alignment of the river past the structures at the bridge. The structures have been effective and, other than locally limiting the movement of the banks of the river, have had little impact on the overall behavior of the rivers at these locations.

CONCLUSION: Where guidebanks protect the bridge structures from future erosion, they have had little impact to date. In mobile rivers like the Hammond, they are key to controlling the flow through the bridges.

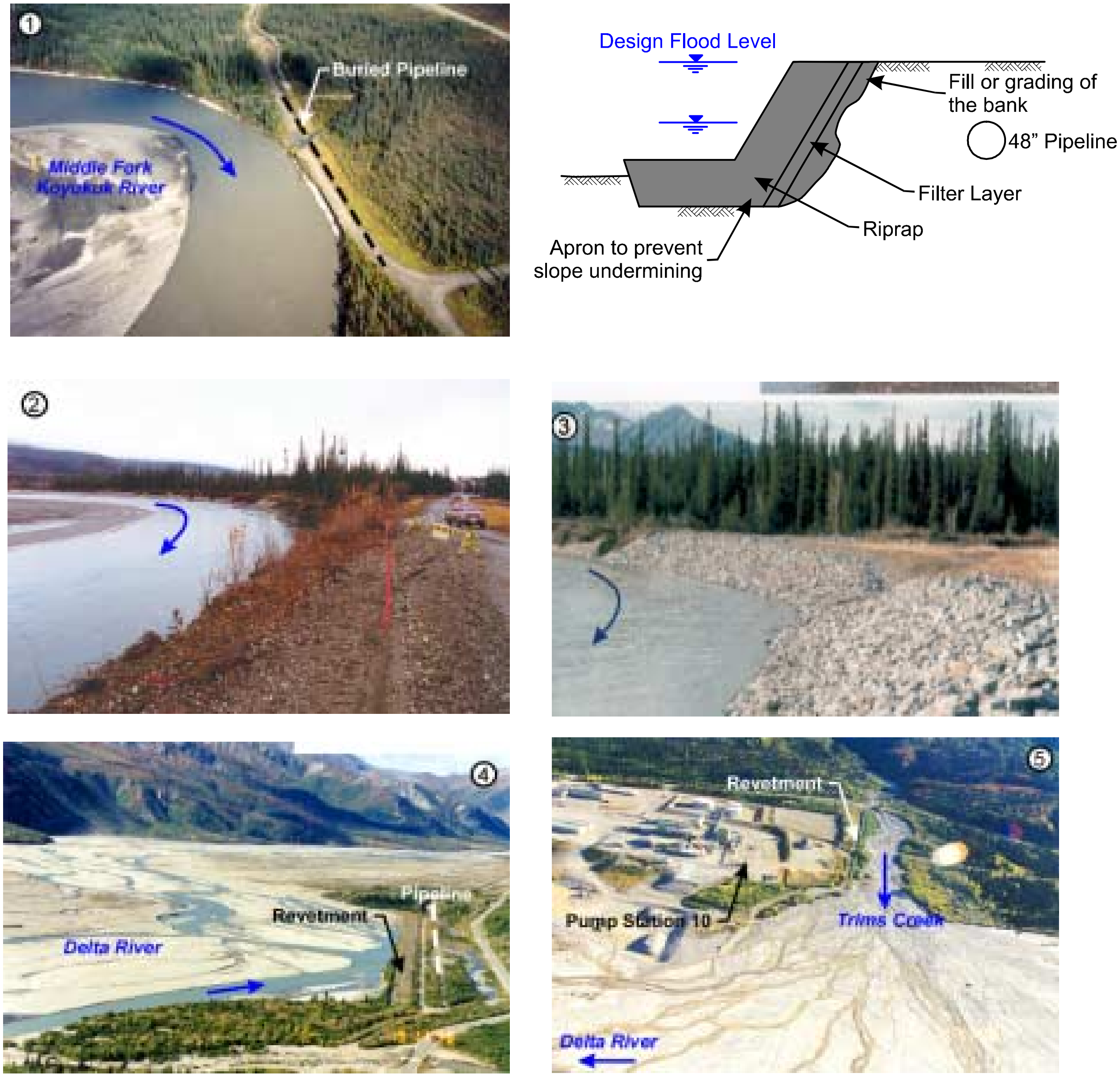
Figure 4.3-5. *Guidebanks to align flow at major bridges.*



Variations of the standard VSM span and pile design were effectively used for minor to moderate-sized crossings to accommodate a wide range of flow, bank, and potential erosion conditions. At a crossing of the Jim River subchannel (MP 271.6, Photo 1), 4-pile bents were used on both banks to accommodate potential additional “stick-up,” or unsupported length, resulting from bank erosion and scour. (Note that to date there has been little bank erosion.) At the larger crossing of Prospect Creek (MP 248.0, Photo 2), a 4-pile bent with riprap to limit scour was used. The effect of these crossings on the behavior of the creek has been minimal to nil. At Snowden Creek (MP 198.0, Photos 3-4), riprap is used to limit scour at the VSMs in the event of a channel change into the abandoned flood-plain material site on the downstream side. At Minnie Creek (MP 225.7, Photo 5), the flow is parallel to the pipeline. If the flow crosses the line, riprap around the VSMs will limit erosion with little impact on the overall behavior of the creek. As the pipeline profile here is relatively low, scour or loss of fill around the VSM’s would not result in significant stick-up and thus would not be a structural concern. The versatility of a VSM-type crossing, as well as the pipeline itself, is clearly illustrated at Linda Creek (MP 215.3, Photo 6) where the clear-span and transition from elevated to buried resulted in no disturbance of the narrow, deep creek valley.

CONCLUSION: VSM-type crossings have minor to no impact on the behavior of creeks.

Figure 4.3-6. *Elevated crossings on vertical support members.*



Revetments are composed of armor, usually riprap, placed on a natural bank or on a dike to stop erosion and limit the movement of the river. The 1994 flood in the Middle Fork Koyukuk River, in excess of the 100-year event, resulted in significant bank erosion at a sharp bend at MP 231.5 (Photos 1-3). To prevent further encroachment of the river into the right-of-way, the natural bank was graded and armored with large rock (Photo 3). Work was done during the 1994-1995 winter season with nominal in-stream activity required — the equipment worked on the riprapped apron at the toe of the slope. The structure has minimal impact on the behavior of the river as it follows the natural bank. At the wide braided stream of the Delta River near Pump Station 10 (MP 585, Photo 4), a revetment guides the flow to protect the shallow-buried line behind it. The revetment’s impact on the river behavior is local — only a minor narrowing of the river is apparent. At Trims Creek immediately south of Pump Station 10 (MP 586, Photo 5), a revetment has been very effective in preventing spillage of the creek into the pump station. Both the Delta River and the Trims Creek structures were built as part of the original construction and have required little or no maintenance. In fact, vegetation is present along the Trims Creek dike.

CONCLUSION: Revetments limit the movement of rivers and are key to protecting the pipeline. They typically “hold” the river at a specific location rather than diverting the river.

Figure 4.3-7*. Revetments to limit riverbank erosion or movements.*

Spurs are gravel and riprap armored structures that, by projecting out perpendicular from the bank, reduce velocities and scour over the pipeline which is buried or elevated parallel to the floodplain. Long structures were used on the Delta River north of Pump Station 10 (Photo 1), and the effectiveness of the spurs is clearly visible. Subchannels form between the spurs, but the spacing of the spurs prevents significant flow and thus scour over the pipeline, as evidenced by the vegetation. In the Sagavanirktok River, the 1992 flood of record caused significant bank erosion at MP 47.0. Spurs were constructed in the winter of 1992-1993 to deflect the flow away from the buried pipeline (Photo 2). In the Middle Fork Koyukuk River (MP 243.0, Photo 3), spurs were used to prevent the enlargement and movement of subchannels to and over the buried pipeline. High flows in 1994 required the addition of a short spur to prevent the further movement of the river. A close-up of the riprapped end of a spur is provided in Photo 4. (Note the extent of riprap versus the length of the spur).

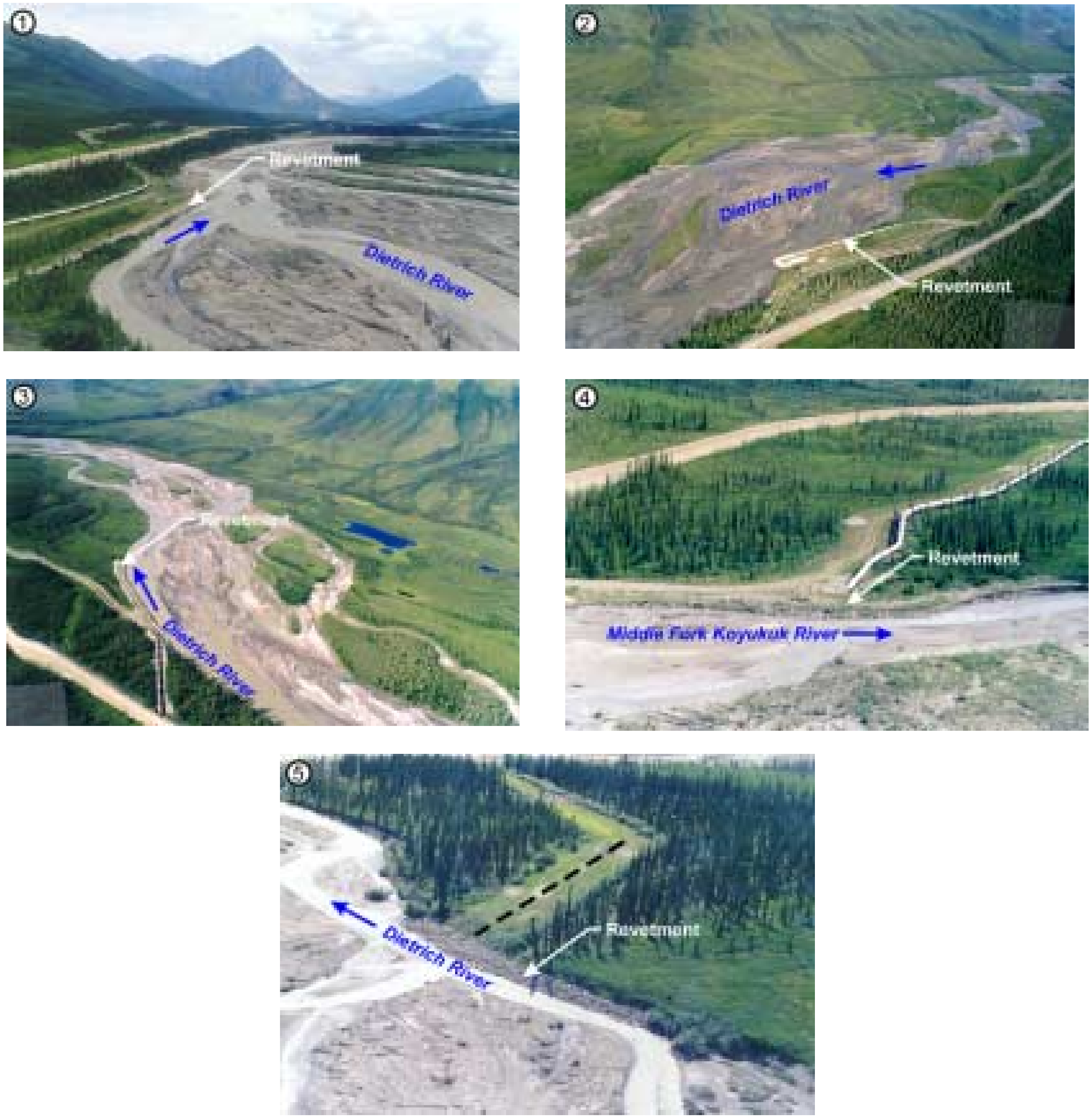
CONCLUSION: Spurs are effective means to deflect the main channel flow away from the pipeline or to minimize the formation of new channels. As they are only used on wide braided rivers, they have little effect on the overall behavior of the rivers.

Figure 4.3-8. *Spurs to deflect main channel flow from the pipeline.*

Armoring around valve sites and along the workpad is required at times. Protection of valve pads is key to their safe operation, but the need for and timing of access via a workpad depends on the valve type and the operational mode of the pipeline. Check valves with a manual actuator need little or no vehicle access or maintenance — the valves need to be open with the present throughput rate to allow the passage of pigs without damage. The nitrogen needed to operate powered actuators is delivered by vehicles, thus necessitating a workpad or other route that is passable by truck. Remote gate valves also rely on periodic vehicular access. Photos 1 and 2 show CKV 29A in the Atigun River floodplain. The valve site is well protected from the river; however, the workpad requires periodic maintenance. Just to the south of this location, CKV 30 (Photo 3) is located in the narrower part of the Atigun River as it emanates from the north face of Atigun Pass. The valve site, replaced in 1991 as part of the Atigun River mainline replacement project, is well protected from the river. At RGV 34 (MP 185.8, Photos 4 and 5), adjacent to the Dietrich River, high flows in June 1998 and resultant bank erosion required immediate riprap placement (Photo 5), which was then upgraded during the 1998-1999 winter.

CONCLUSION: Valve sites are key components of the pipeline and need to be well protected from rivers. Surface access to the valve sites, and thus the need to protect the workpad from the river, may be more or less critical depending on the type of valve and the operational state of the pipeline.

Figure 4.3-9. *Armoring at valve sites.*



Various types of river training structures are used to protect mode transitions and elevated lines. At MP 200.0 (the section rerouted and remoded out of the river), a riprapped revetment is used to protect the elevated line prior to it leaving the Dietrich River floodplain area (Photos 1 and 2). At the downstream end of the realignment, the bank is armored to protect the elevated line where is re-enters the floodplain and is close to the main channel (Photo 3). At the Middle Fork Koyukuk River crossing (MP 208.5, Photo 4), a revetment is used to protect the transition to the elevated mode. In locations such as this, proximate to the river where ground conditions dictated the elevated mode, a structure was essential because setback of the buried line into the thaw unstable bank was not feasible. In the Dietrich River (MP 180.6, Photo 5), armoring of the bank was used to protect the transition to a shallow-buried line section. All the structures illustrated have a minimal impact on the behavior of the rivers because they follow the natural bank.

CONCLUSION: Structures are key to protecting elevated lines and transitions proximate to the rivers where, from a geotechnical viewpoint, deep-burial into the riverbank is not feasible.

Figure 4.3-10. *Structures that protect transitions and elevated lines.*

low buried or elevated line sections (Figure 4.3-10). The impact of revetments on flow patterns and river behavior is minor because they are constructed on, or parallel to, the existing banks.

Impact of Maintenance or Construction of New Structures. The maintenance or extension of structures or the construction of new structures is done in accordance with construction plans approved by regulatory agencies. The nature of the plans, with a focus to protecting the water quality of the adjacent rivers, varies from site to site. At the Middle Fork Koyukuk River (Figure 4.3-7), the riprap at the toe of the revetment was placed first and then a gravel driving surface was placed on top of the riprap, thus enabling the machinery to work essentially out of the flow area. Winter scheduling minimizes in-stream work on waterways such as the Dietrich and Sagavanirktok rivers, which have little or no flow in winter.

In the design and layout of all structures and maintenance works, the impact on adjacent structures or on natural vegetation and flow patterns is considered to ensure that the impact is minimal and well within the kinds of changes induced by natural river processes. The new structures will usually have a local impact. For example, the new revetment on the Middle Fork Koyukuk River (Figure 4.3-7) is expected to cause some local bank erosion at its upstream end. On the other hand, the new spurs constructed on the Sagavanirktok River at MP 47 had a more significant impact on flow patterns as the main channel shifted away from the eroding bank next to the pipeline.

Quantifying the impact of future maintenance and new works on the behavior of streams is not possible on a TAPS-wide scale. It varies from location to location depending on river characteristics and the type of remedial measures required. However, it is worth noting that:

- Spurs such as the one at MP 47 can have a significant local impact on flow, but even at this location, their impact is nominal compared to natural changes that can occur in the wide, braided Sagavanirktok River,
- The revetments along the Dietrich River and Middle Fork Koyukuk River since the major 1994 flood, and along the north bank of the Tazlina River bridge in response to the 1997 flood, were built along the post-flood bank alignments and thus had little impact on overall flow patterns.
- Along the Middle Fork Koyukuk River in the MP 243 area, the length of additional spurs, required due to channel changes induced by the 1994 flood, were significantly reduced compared to the original spurs in order to minimize their effect on vegetated islands.
- At small creeks, such as Vanish at MP 145, where high flows in 1999 resulted in significant VSM "stick-ups", it was necessary to deflect the flow into its original location. By careful layout and construction of the transitions from the armored areas back to the original banks, the impact of the works on creek behavior and flow patterns is very limited.

The scope of future maintenance needs depends primarily on the timing, location, and magnitude of high-flow events. The record, widely distributed floods on the Sagavanirktok River and Middle Fork Koyukuk River systems in 1992 and 1994, respectively, and the required response/maintenance plans, are probably representative of the scope of major maintenance initiatives that could be required in the future if record to near-record floods occurred. Work will likely be required at a number of locations along the Middle Fork Koyukuk River in the future where pronounced, well developed channel bends are moving towards the pipeline. (The movement of these bends is being closely monitored in order to be able to implement remedial measures, if and when necessary, in a timely and sound manner.) Future channel changes and possible additional works that might be required along the Sagavanirktok River are more difficult to estimate as the multi-channeled braided nature of this river causes predictions to be largely speculative in nature. Dramatic and rare events such as the simultaneous release of the glacier dammed lakes in the Tazlina River watershed, which required armoring of the north bank in 1998-99 after no maintenance needs at all for more than 20 years, are difficult to predict with accuracy.

4.3.1.2 Water Resources

By B. Jokela, V. Gates, D. Gryder-Boutet

Water Use in Pipeline Operations

Pipeline operations require fresh water for potable water for manned facilities, equipment washing, dust abatement on roadways and pads, and hydrostatic testing.

The Alaska Department of Natural Resources regulates use of Alaska's water resources and issues permits for temporary or long-term water appropriations. Alyeska has certificates of appropriation for water use at permanent facilities, including each pump station except Pump Stations 1 and 6. Water used at Pump Station 1 is purchased from the North Slope Borough's Service Area 10 water utility. A well at 5-Mile Camp is used as a water source for Pump Station 6, for which water is trucked across the Yukon River Bridge. Each active pump station typically consumes between 4,500 and 7,500 gallons a day, mostly for domestic uses. Volumes of camp water use at various facilities is illustrated in Figure 4.3-11.

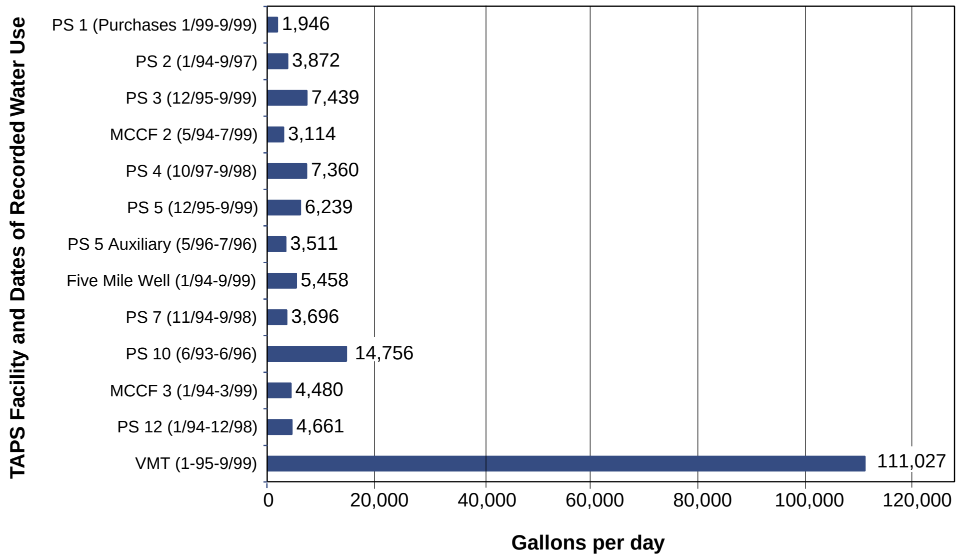


Figure 4.3-11. *Water use at TAPS facilities, 1994-1999.*

The VMT, which uses significantly more water than other facilities, has a certificate of appropriation for withdrawals from Allison Creek. Since October, 1995, average water withdrawals under this appropriation have amounted to over 111,000 gallons per day. Industrial water uses at VMT include power-plant boiler-water, stack-scrubber systems, steam-cleaning of equipment racks, and other washdown processes.

Alyeska maintains additional temporary water-use permits for facilities such as mobile construction contingency facilities (MCCFs) and for special projects. Volumes of water for temporary use vary significantly. The largest single project for which temporary-water-use permitting was necessary occurred in 1997, when 7.4 million gallons were withdrawn from East Lake, near MP 0), for tank cleaning and testing at Pump Station 1.

Potable Water Use

Where living quarters are provided, personnel on duty typically consume and discharge up to 100 gallons of water per person per day for potable water use (i.e., drinking water, food preparation, and personal hygiene). At the pump stations and camps, potable water is generally supplied by local wells built and maintained by Alyeska for that purpose. Pump Stations 1, 8, and 9 do not maintain living quarters for workers, due to their proximity to local communities or other facilities, and potable water use is much less there. Currently, only Pump Stations 1, 3, 4, 5, 7, 9, and 12 are in use, further diminishing total water use. As additional pump stations are ramped down, water use will be diminished or discontinued at those stations as well.

The Valdez Marine Terminal operates continually with a staff of up to 550 people. No living quarters are provided for the staff at the terminal. Most reside in Valdez and use municipal water supplies as a principal source of potable water. As a result, potable water use at the terminal is generally less than 25 gallons per person per day.

Industrial Water Use

Water use for industrial cooling or process needs at the active pump stations is insignificant. Water is used occasionally for washdown of equipment, such as vehicles, turbine fans, and other equipment which is exposed to the environment. Some washwater is routinely contained and collected for co-processing with sanitary wastewater. Other waters are discharged onto the workpad, in accordance with the line-wide NPDES permit (No. AK-005056-3) and best management practices (BMPs). Due to the occasional nature and small volumes of wastewaters, no adverse effects on receiving water quality are apparent or have been reported for permitted discharges.

Sanitary Discharges from Pump Stations and MCCFs

Discharges of sanitary wastewater take place in accordance with state and federal permits, including U.S. EPA (NPDES) permits. Table 4.3-1 summarizes typical sanitary discharges from pump stations and MCCFs. These are treated by various means.

In permafrost areas, discharge to groundwater is impracticable, and long-term discharge of wastewaters across tundra is viewed as increasing potential for thermal erosion. Only Pump Station 5 has ongoing discharge of sanitary wastewater to tundra wetlands. For years, this facility was served by a lagoon system. Wastewater was contained and treated via facultative biological decomposition, with discharge to tundra wetlands. In 1999, the lagoon system was upgraded to conventional aerobic secondary treatment using a small mechanically activated sludge plant. Discharge from this process is distributed through a diffuse outfall across tundra wetlands.

At Pump Stations 1, 3, and 4, sanitary wastewater is screened using a fine-mesh rotary strainer. The screened wastewater is stored in a holding tank and then pumped to the exhaust stacks of the engines powering the crude oil pumps. High-pressure nozzles inject the wastewater into the hot exhaust flow, where it is atomized and evaporated. Any remaining organic material dissolved in the liquid stream is volatilized and disinfected in the hot exhaust. The exhaust-gas flow disperses the relatively small volume of sterilized water vapor into the atmosphere. In order to ensure that full dispersal takes place, Alyeska has established operating procedures in conjunction with ADEC (APSC, 1997d). Sewage injection can commence only when reaction turbines are running at least 2,350 revolutions per minutes (rpm) and exhaust gas temperatures exceed 750ºF. Air is injected in conjunction with the wastewater flow at a minimum pressure of 70 pounds per square inch gauge (psig), and liquid pressure is continuously monitored to ensure appropriate atomization. Nozzles are inspected regu-

Table 4.3-1. *Summary of wastewater discharges from pump stations and MCCFs.*

Pump Station or Camp	Status	Dates of Operation	Permanent Living Quarters	Current Population (a)	Historic Maximum Population	Typical Flow (gpd) (b)	Design Capacity (gpd) (b)	Current Wastewater Disposal	Previous Treatment
1	Open	1977-present	No	50 day-use	60	2,000 (d)	10,000 (c)	Stack injection	—
2	Ramped down 1996	1979-97	Yes	0	40	4,00 (d)	10,000 (c)	Not in use	Stack injection
3	Open	1977-present	Yes	45	45	7,500 (d)	10,000 (c)	Stack injection	—
MCCF #2	Inactive	Various	N/A	0	Up to 80	2,900 (d)	14,000	Secondary biological	—
4	Open	1977-present	Yes	40	45	4,700 (b)	10,000 (c)	Stack injection	—
5	Relief only - no pumps	1977-present	Yes	60	80	6,300 (e)	8,000	Secondary Biological	Lagoon
6	Ramped down 1997	1977-97	Yes	0	100	6,500 (b)	6,000 (b)	Not in use	Stack injection
Fly Camp at PS 6	Open	1998-present	Yes	16	16	950 (d)	850	Septic	—
7	Open	1980-present	Yes	30	30	3,800 (b)	3,400 (b)	Septic	—
8	Ramped down 1997	1977- 97	No	0	20 day-use	600	1,000	Septic	—
9	Open	1977-present	No	25 day-use	30 day-use	780 (b)	1,000 (b)	Septic	—
10	Ramped down 1997	1977-97	Yes	0	38	4,200 (b)	12,000 (b)	Septic	—
MCCF#3	Inactive	Various	N/A	0	Up to 80	3,500(e)	14,000	Secondary biological	—
11	Never constructed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	—
12	Open	1977-present	Yes	35	90	4,200 (b)	9,100 (b)	Septic	—

(a) Gryder-Boutet (1999).
(b) Mikkelsen (1997).
(c) Based on twin-nozzle injection into 850°F exhaust-gas temperature
(d) Estimated from water-use records and water-purchase records
(e) Based on NPDES discharge monitoring reports

gpd = gallons per day
N/A = Not applicable

larly and replaced as needed. Screenings are incinerated at each pump station. Periodically, holding tank sludge is trucked away for disposal to a private wastewater utilities off the pipeline corridor, thereby eliminating local sanitary discharges to surface or groundwater at these facilities. If injection is impractical because of maintenance or inadequate exhaust gas temperatures, wastewater would be trucked to a remote permitted disposal facility.

Sanitary wastewater at Pump Stations 7 through 12 is treated through conventional septic treatment systems. These systems are serviced regularly to maintain appropriate septage levels for waste treatment.

Each MCCF has a self-contained sanitary wastewater secondary treatment system that uses rotating biological contactor technology and a holding tank. Treated wastewater from each site is discharged locally in accordance with the line-wide NPDES permit.

Disposal of Other Wastewater Discharges

Direct discharge of sanitary wastewater, washwaters, hydrotest waters, or stormwater and snowmelt to surface water is uncommon. The linewide NPDES discharge permit specifies rules for discharge of sanitary wastewater, hydrotest waters, and excavation dewatering. In applying for a renewal of that permit in 1998, Alyeska inventoried all kinds of wastewater discharges from normal operation (Table 4.3-2). Wherever possible, discharge to dry channels, tundra, or upland areas is preferred to discharge to surface waters.

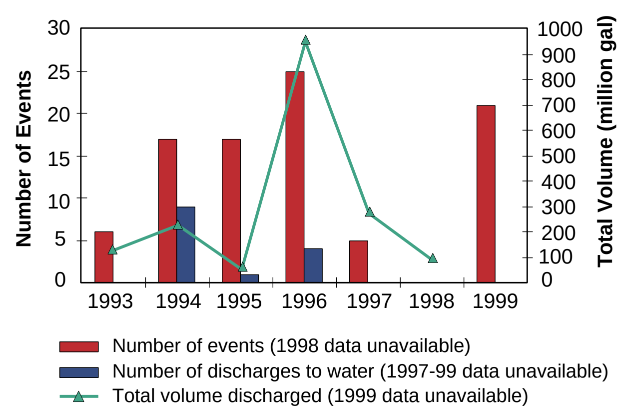
Hydrotesting. Hydrostatic testing is performed on segments of pipe or on tankage brought into service following installation or repair to ensure that construction is soundproof and leakproof. Hydrostatic testing occurs infrequently. The maximum annual volume of water for hydrostatic testing was 3.8 million gallons in 1991 when over 8 miles of pipeline were reconstructed to improve the stability of the pipeline in the Atigun River valley. Water from hydrostatic testing is discharged in accordance with the line-wide NPDES permit, which mandates laboratory characterization, documentation, and erosion protection requirements for the discharge.

Excavation Dewatering. From time to time, excavation of buried pipeline segments is required to confirm pipeline pig findings or other test data. Where groundwater is encountered during maintenance digs, the water must be removed and discharged away from the trench. Dewatering is performed in a manner that permits safe working conditions within the trench, allows for unhindered examination of the portion of the pipeline in question, and poses no significant environmental concerns.

Dewatering discharge has been regulated through various permits, beginning with a State of Alaska wastewater discharge permit since 1983. The current NPDES permit requires notification, volume estimates, and descriptions of procedures employed to minimize erosion and discharge of pollutants from excavation dewatering. Dewatering data for discharges greater than 500,000 gallons has been collected since 1993 (Figure 4.3-12).

Draining of Secondary Containment Dikes. Secondary containment structures at pump stations and the VMT may trap snowmelt and rainwater. The structures must be drained periodically to ensure that the full capacity of the secondary containment systems is maintained. Snowmelt and rainwater removed from the containment systems is typically unaffected by contact with the tanks and containment structures. Dewatering of secondary containment of waters is allowed by State of Alaska Wastewater General Permit 9640-DB004, which established monitoring requirements and effluent limitations. To guard against discharge of pollutants, the discharge is visually inspected for sheen. No discharge of waters bearing hydrocarbon sheen is allowed by the general permit.

In 1997, over 60 different secondary containment structures along the pipeline were drained. There were 297 occasions for dewatering, including over a dozen repeat visits to a few stations. Total water drained was 15,678,000 gallons. Over two-thirds of the volume came from early summer dewatering of the tank farm at Pump Station 1, where the secondary containment volume is highest. At the VMT, discharge from secondary containment structures is di-



Compiled from APSC (various years): dewatering records and discharge monitoring reports, 1993-1999.

Figure 4.3-12. *Discharges from excavation dewatering.*

Table 4.3-2. *Discharges addressed in 1998 line-wide NPDES permit application.*

Out-fall	Category	Sources	Discharge Volumes	Discharge to	Active Dates	Treatment
001	Excavation Dewatering	Maintenance of buried pipeline	380 gpd to 21 MMgpd	Varies; upland discharge preferred	Varies — <1 day to 120 days	BMP, erosion control, infiltration
002	Hydrostatic Testing	Leak testing of new or repaired pipelines and tankage	Varies — 1996/7: 7,800,000 gal/yr	Dry channel, snow	Varies — 3 days per event typical	BMP, erosion control, infiltration
003	Sanitary Wastewater	Pump Stations 5, 6 MCCFs	6,000 gpd 14,000 gpd ea	Tundra wetland	varies	Secondary biological
004	Secondary Containment Dewatering	Tank farms Valve vaults Basements Leading edge flow meters Fuel loading areas	4,000,000 gal/yr 500,000 gal/yr 50,000 gal/yr 30,000,000 gal/yr 10,000 gal/yr	PS workpad	Seasonal, site-dependent, intermittent	BMP, sorbent used if sheen noted
005	Potentially Containing Oil	Petroleum product spill PS air filter cleaning Monitoring well purging Pump test water PS mop water PS meltwater PS equip. shop meltwater PS accumulated rain water Vacuum truck hydrotest	500,000 gal/yr 20,000 gal/yr 100 gal/event 300-900 gal/event 50,000 gal/yr 10,000 gal/yr 10,000 gal/yr 1-500 gal/event 25,000 gal/yr	Facility workpad	Seasonal, site-dependent, intermittent	BMP
006	Containing Particulates	Outdoor vehicle washing Indoor vehicle washing Equip./structure washing	10,000 gal/yr 10,000 gal/yr 100-3,000 gal/event	PS workpad	Seasonal, site-dependent, intermittent	BMP
007	Containing Chlorine	Water truck disinfection Drinking water facility disinfection	2,000-4,000 gal/event 1-500 gal/event	Facility workpad	Seasonal, site-dependent, intermittent	BMP
008	Containing Residual Aqueous Film-Forming Foam	Fire line flushing Fire truck flushing Fire training	100,000 gal/yr 3,000 gal/event 2,000 gal/yr	PS workpad Airport taxiway	Seasonal, site-dependent, intermittent	BMP

BMP = Best management practice

rected to the Ballast Water Treatment Facility.

Stormwater Runoff. Currently, only 11 facilities meet the applicability criteria of the EPA Storm Water Multi-Sector General NPDES Permit for Industrial Activities (MSGP) and have the potential to affect waters. Alyeska operates the sites in conformance with the MSGP standards. The affected sites are all material sites which may discharge rainwater or snowmelt from mined areas to surface waters. No monitoring data are yet available, as sites have not been accessible by Alyeska personnel during run-off events since commencement of coverage under the MSGP.

Construction activities that disturb more than 5 acres, do not involve excavation dewatering, and have the potential to impact waters of the U.S. are covered under the NPDES Permit for Storm Water Discharge from Construction Activities Associated with Industrial Activity (Permit No. AK-R-10-0000). For TAPS projects that meet criteria for coverage under this permit, specific notices of intent are submitted to EPA and regulations are adhered to.

Discharges from Valdez Marine Terminal

Two outfalls at the VMT are covered by NPDES permit No. AK-002324-8. The VMT sewage treatment plant is

authorized to treat 10,000 gallons per day of sanitary wastewater from the Western Operations Area of the VMT. Treated wastewater is discharged into Port Valdez. Additional sanitary wastes from the Eastern Operations Area are processed through a septic treatment system.

The other outfall addressed in the NPDES permit is from the Ballast Water Treatment Facility, which processes ballast water offloaded from incoming tankers and a variety of waste streams collected in the VMT industrial wastewater sewer system (IWSS). Process wastewater, potentially contaminated stormwaters, oily washdown water, filter backwash, bilge waters, and oil spill wastewaters contribute to IWSS flows. Sewers and containment systems have been designed to collect surface runoff from rainfall of 5.1 inches in a 24-hour period. Areas served by IWSS include the following:

- Tank farms.
- Power generation/vapor recovery.
- Fuel storage and loading area.
- Emergency response building/administration area (including laboratory).
- Fire training grounds.
- Sludge tank area.
- Transformer dike areas.
- Tanker berths.
- Fire pump buildings.
- West metering facilities.
- Maintenance/warehouse area.
- SERVS and SERVS contract vessels.

A detailed description of the IWSS is found in the *Oily Water Sewer Manual, Alyeska Marine Terminal* (OW-44). Approximately 93 percent of the wastewater processed by the BWTF is tanker ballast and bilge water.

Tanker Ballast Water. Tankers use seawater for ballast to maintain stability when not carrying cargo. Ballast water carried in clean tanks (segregated ballast) is discharged without treatment. The primary concern with the segregated ballast discharge is the introduction of non-indigenous species (see Section 4.12). Significant quantities of ballast water are carried in the "dirty" cargo tanks. This ballast water contains contaminants and is offloaded at the VMT and treated in the BWTF. The treated water is then discharged to the marine waters of Port Valdez through an outfall pipe to a 63-meter-long diffuser which ranges from 62 to 82 meters in depth.

The BWTF is designed to treat up to 30 million gallons/day of oily ballast water and small amounts of industrial wastewater from VMT maintenance activities. Treatment occurs through three processes:

1. Gravity separation,
2. Dissolved-air flotation (DAF), and
3. Biological treatment.

Figure 4.3-13 provides a simplified schematic of the BWTF. The entire BWTF is controlled by a computerized supervisory control and data acquisition (SCADA) system located in a centralized control room.

Ballast water and other influent wastewaters are pumped from their sources to one of the three 18-million-gallon ballast-water storage tanks, known as the *90's Tanks*. In addition to influent storage, the 90's Tanks provide calm conditions for gravity separation. The tanks are 250 feet in diameter and fill height is 49.5 feet. Pressure from the fluid level in the tanks provides energy to drive wastewater flow through the remainder of the treatment system.

Settling in the 90's Tanks typically occurs for a minimum of four hours, during which the tank is closed to further influent that may disturb the separation process. Oils and emulsions that migrate to the top of the liquid are skimmed and directed to the smaller 100-foot-diameter oil recovery tanks — known as the *80's Tanks* — for further processing by gravity separation. Oil skimmed from the 80's Tanks is returned to the crude oil stream.

Metering pumps are used to inject a polymer into the discharge line from the 90's Tanks to assist in accumulation of oil and other contaminant particles through an electrochemical association called *flocculation*. Groups of aggregated particles called *flocs* are more amenable to separation from the water in the DAF cells due to enhanced buoyancy and reduced surface tension.

Six DAF cells form the second level of treatment for oily wastewater in the BWTF. Each DAF cell is a concrete channel 24 feet wide, 112 feet long, and 12 feet deep. A recycled stream of process water is exposed to high-pressure air in pressure-retention tanks packed with a plastic material that provides a very large surface area to expose the flowing water to the air. As a result, the high-pressure air is forced into solution with the flowing wastewater. Upon mixing with the main flow of wastewater, the water is released to normal pressure. Air comes out of solution in tiny bubbles which attach to oil and floc particles in the wastewater stream and rise to the surface, where they are skimmed and directed to the 80's Tanks for oil recovery. Water is pumped from the DAF outlet channel to the pressure-retention tanks for recycling through the DAF process.

When originally built in 1976, the BWTF employed only gravity separation and DAF processes to remove oil before discharging the saline ballast water to Port Valdez. While this system achieved its original purpose, the waste discharge limitations imposed on the BWTF in the NPDES permit were later revised to include a limit on BTEX.

Alyeska responded to this revision by adding biological oxidation as a third tier of the treatment train in 1989.

Currently, wastewater discharged from the DAF cells is enriched with nutrients (phosphate and ammonia-nitrogen) which promote the growth of organisms that consume any remaining dissolved oils and aromatic hydrocarbons. The process is further enhanced by jet aeration and mixing in two parallel biological treatment tanks (BTTs). Water pumped through a header is aerated by a jet from a parallel air header at a pressure near atmospheric.

Microbial floc materials generated in the BTT are skimmed and redirected to the 80's Tanks. Underflow from the skimming systems is discharged through a baffle and weir system to a submarine outfall in Port Valdez. Temperature, BTEX, and oxygen are continuously monitored to ensure complete treatment. To provide supplemental removal of BTEX when biological upsets occur, a polishing air stripper was installed downstream of the BTTs to remove occasional elevated levels of BTEX before they reach the effluent.

Sludges accumulate in the bottom of the BWTF — mostly in the 90's Tanks, the DAF cells, and the BTTs. Sludges of similar composition also accumulate in sumps and portions of the industrial wastewater sewer system. Normal maintenance requires periodic cleaning of the BWTF tanks, and a separate sludge tank is maintained at the BWTF for such residues. Recovered oil from the sludge tank may be trucked directly to the 80's Tanks or via the

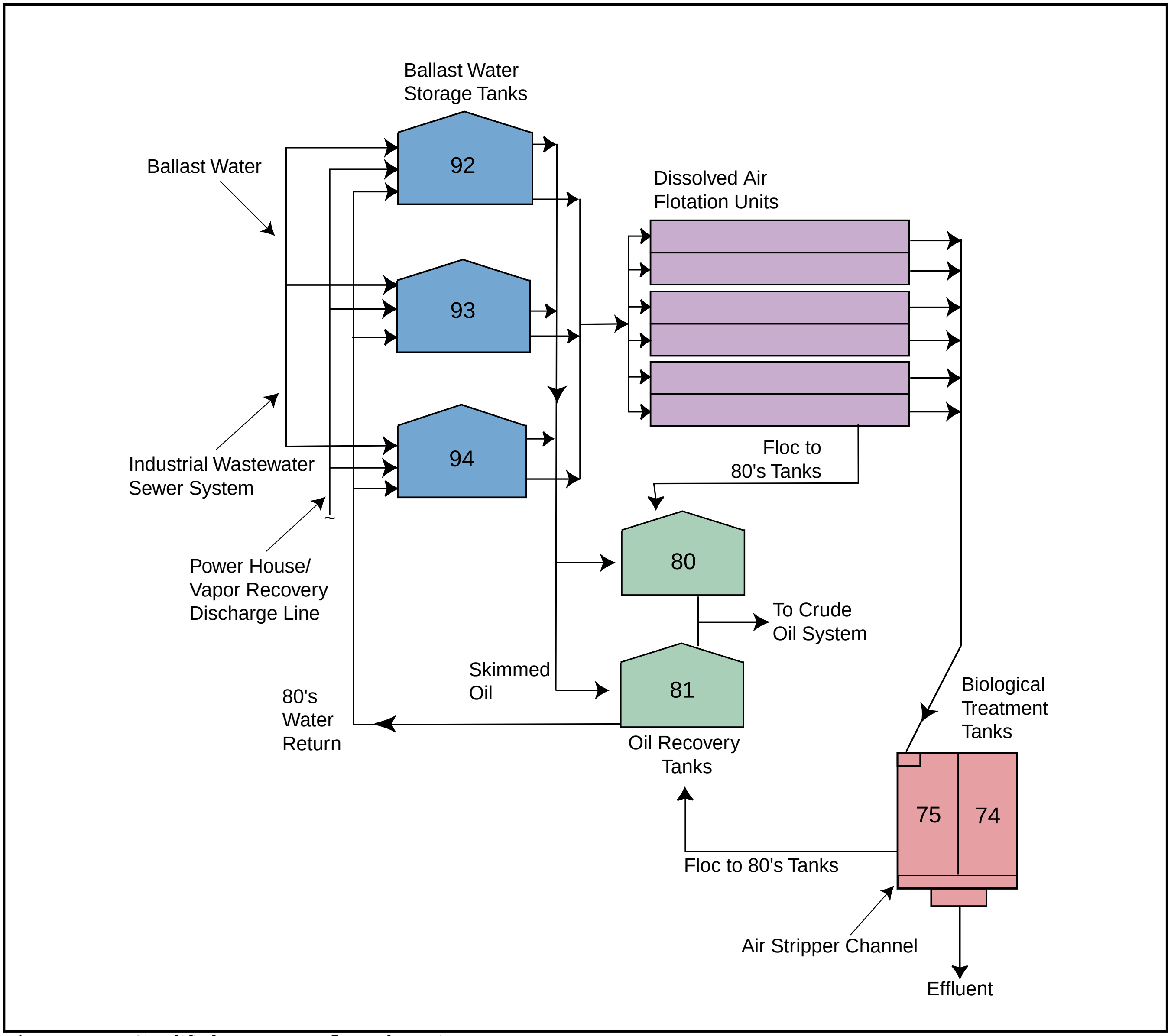


Figure 4.3-13. *Simplified VMT BWTF flow schematic.*

DAF sumps. Process solids from the sludge tank are transported in accordance with state and federal regulations for disposal off site. The BWTF operates under a NPDES permit issued by EPA and certified by ADEC. The original permit was issued in 1974 and has been renewed three times (1980, 1989 and 1997). Significant improvements have been made to the original BWTF to continue to meet effluent limits that have become increasingly stringent over the years.

In addition to certifying the NPDES permit, the ADEC has authorized a mixing zone for the BWTF effluent discharge (APSC, 1995c). The approved mixing zone is in accordance with the water quality standards and was reviewed and concurred with by all relevant state agencies before it was granted. It actually consists of two zones, a small acute zone near the diffuser and a larger chronic zone. Chronic criteria concentrations of target pollutants (derived from tests of the response of marine biota to various concentrations of pollutants) may be exceeded inside the mixing zone. Criteria maximum concentrations (acute exposure criteria) may be exceeded within the acute mixing zone provided that passing organisms will not encounter lethal exposure levels. A human-health risk assessment was part of the referenced mixing zone application.

The BWTF is permitted to treat up to 30 million gallons per day (MMgd) of oily ballast water and industrial wastewater derived from terminal maintenance activities. Typically, the BWTF discharges about 14.5 MMgd of treated water.

Effluent and Environmental Monitoring. Extensive monitoring is required by the VMT NPDES permit to document pollutants discharged through the diffuser and their effects on Port Valdez. Figure 4.3-14 depicts average annual BWTF discharges, as well as concentrations of total suspended solids (TSS) and total aromatic hydrocarbons (BTEX). Figure 4.3-14 also shows the addition of more stringent TSS and BTEX effluent limitations over time, with each re-issuance of the NPDES permit. A more complete summary of the effluent monitoring (including effluent toxicity testing) is included in the mixing zone application (APSC, 1995c).

The effect of treatment improvements is evident from the time series of BTEX. Monitoring of BTEX began in the early 1980s. Biological treatment was added to the process for BTEX removal. A major upgrade of process units was completed in March, 1991. Today, due to continuous process refinements, discharged BTEX is typically less than 0.02 milligrams per liter (mg/l).

Near-field (mixing zone) and far-field monitoring is performed to demonstrate effects of the discharge on marine sediments and benthos. These studies have been conducted by the University of Alaska, Institute of Marine Sciences and are reported to the EPA and the ADEC (see Shaw et al., 1999). Additionally, numerous special studies have been conducted to document the impact of BWTF discharge on the marine environment of Port Valdez.

Since the mid-1990s, the Ballast Water Treatment Working Group has reviewed these annual reports as well as other issues regarding the BWTF. This group is composed of representatives of the ADEC, EPA, Prince William Sound Regional Citizens Advisory Council, National Marine Fisheries Service, and Alyeska.

Impacts of Continued Operations

Continued operation of TAPS for the proposed renewal period will require continued use of water resources to support operations and maintenance activities. Wastewaters will continue to be treated, discharged, and assimilated by upland and freshwater receiving environments along the pipeline. Marine waters of Port Valdez will continue to be used to assimilate treated discharges from the VMT, including sanitary wastewater and ballast water.

Water Use and Sanitary Discharge at Pump Stations and MCCFs. As throughput of oil declines, ramping down of additional pump stations will mean reductions in staff at pump stations that are placed on standby. Furthermore, automation of certain operations will allow reduction of field crews at other sites.

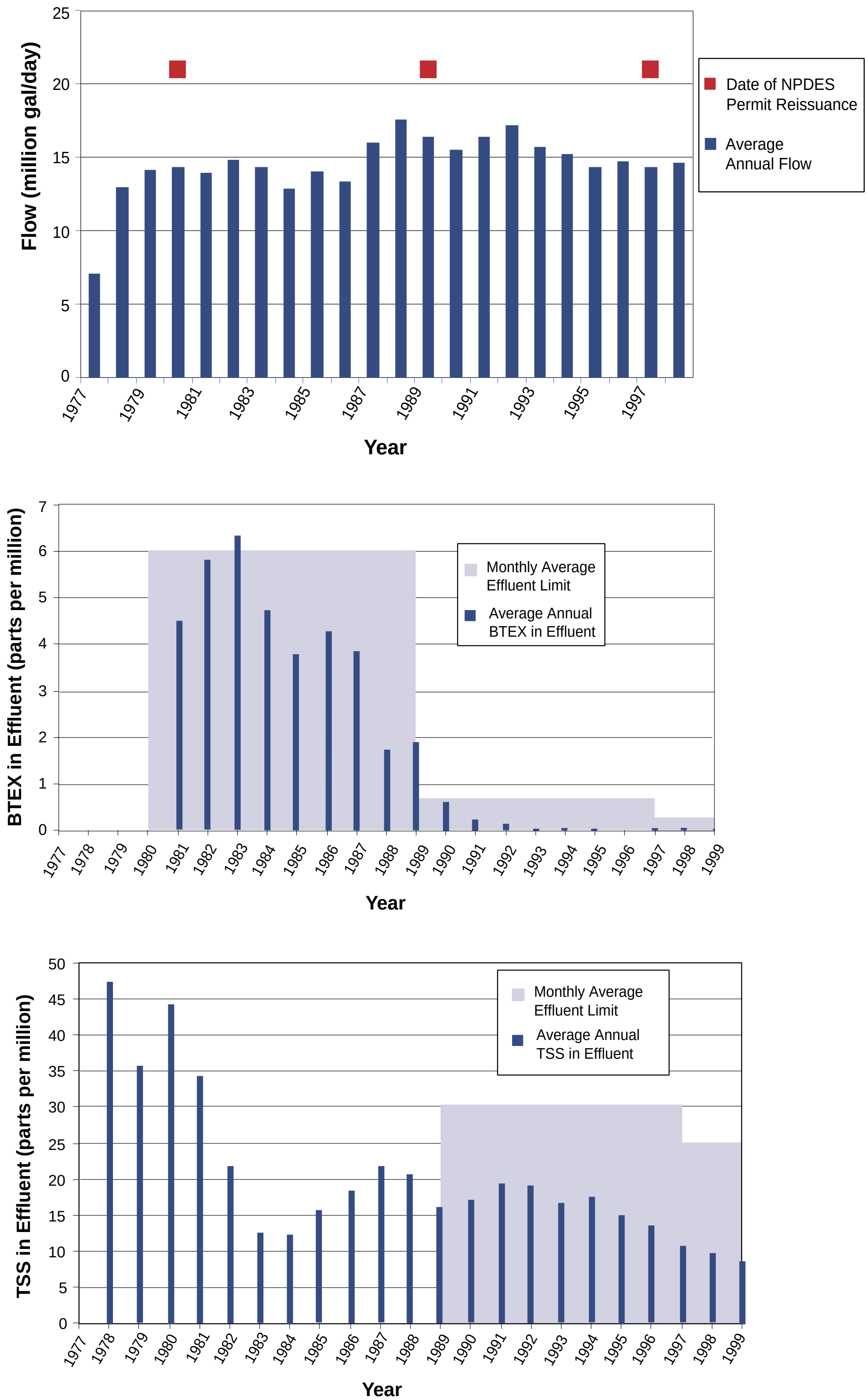
Reductions in staffing at the pump stations and camp facilities will result in a parallel drop in domestic water use for drinking water and sanitation at each facility.

Wastewater injection into stacks at Pump Stations 1, 3, and 4 requires sufficient stack temperatures to ensure vaporization, volatilization, and disinfection of the wastewater plant effluents. Reduced throughput may affect the temperatures of pump engine exhaust, necessitating use of alternative means for wastewater disposal, such as package treatment plants.

Secondary biological sewage treatment and effluent disposal to wetlands are expected to continue for the MCCFs and Pump Stations 5 and 6 (when the permanent living quarters are active) in accordance with discharge limitations imposed by state and federal permits. Permitted discharges are expected to be assimilated by local water resources with no significant effect on productivity or viability of aquatic ecosystems.

The septic systems leachfields at Pump Stations 7, 9, and 12 will be nearing their typical useful life in the next decade and will be replaced if necessary.

Industrial Water Use and Discharges. In addition to



Source: NPDES permit discharge monitoring reports (APSC, 1977-present)

Figure 4.3-14. *Annual flow and levels of BTEX and TSS for VMT treated ballast water discharges.*

the pump station and camp domestic-water needs, water will continue to be used for a variety of industrial activities. Industrial water needs are usually associated with intermittent and temporary activities, and are likely to have a wide variance from the average projected use. Table 4.3-2 illustrates projected discharges from various industrial uses, as described in the linewide NPDES permit renewal application (APSC, 1998a). The permit reflecting these discharges is yet to be re-issued; the previous permit is being enforced by administrative extension.

Discharges will continue to be generated from dewatering of excavations. Maintenance digs may occur for:

- Follow-up investigations from corrosion pig data analysis,
- Mainline valve inspections,
- Mainline cathodic-protection monitoring and remediation,
- Maintenance of existing river-training structures and the addition of new structures, or
- Maintenance and repair of the fuel gas line.

Estimates of the number of excavations, the extent of each, and the prospects for encountering groundwater are uncertain. Based on the history of dewatering to date, Alyeska estimates that approximately two sites per year will need dewatering in excess of the NPDES reporting requirement of 500,000 gallons (see Section 4.1.1.1).

Excavations typically take place in winter to minimize the potential for groundwater handling. The effects of dewatering can be minimized by discharging to vegetated areas or dry channel beds to avoid impacts to surface water. The effects of discharge on nearby surface waters depend on the rate and temperature of the discharge; on the slope, roughness, permeability, temperature, and moisture content of the receiving surface; and on the presence or absence of ice and snow. Water discharged onto a snowy surface in winter will freeze readily if atomized (as in a snow-making operation) or if allowed to spread out over a broad area. Assuming that water is allowed to freeze as a one-inch-thick sheet of ice over existing frozen ground, one million gallons of water will cover approximately 40 acres.

Currently, only 11 of the material sites identified along TAPS are subject to coverage under the MSGP for industrial stormwater discharge. New sites or expansions of existing sites may be located and/or developed in response to particular future project needs. Design of a mining or quarrying plan for each site will require submittal of a stormwater pollution prevention plan to ADEC and will entail development only in conjunction with implementation of BMPs for stormwater pollution prevention. Effects of stormwater runoff into waters along the pipeline route are not significant, because such runoff carries no introduced pollutants and results only in transient increases in sediment load.

Discharges to Port Valdez. Treated ballast water will continue to be discharged from the VMT into Port Valdez throughout the renewal period. Although OPA 90 requires phasing out of single-hull tankers by January 1, 2015, use of double-hulled tankers will not eliminate the need to carry ballast in tanks previously containing crude oil. Clean seawater ballast will continue to be discharged directly to Port Valdez, and the BWTF will continue to treat large volumes of ballast water from the tankers.

Other oily wastewaters derived from VMT operations, as well as liquids cleaned up from spills at the VMT, will continue to be routed through the BWTF. Discharges from VMT operations currently account for approximately 1.36 MMgd of the wastewater treated and discharged by the BWTF (APSC, 1998c). These discharges will continue throughout the renewal period at approximately the same rate.

Reduced throughput of oil will reduce the number of tanker visits, and segregation of ballast water in double-hulled tankers will reduce the average volume of ballast water treated on a per tanker basis. Figure 4.3-15 compares historical and projected annual average throughput of oil to historical and projected ballast water discharge. Projected BWTF flows are based on analysis of the range of ballast water offloaded from each tanker in the existing fleet and expected changes over time as throughput declines and as double-hulled tankers gradually replace the existing fleet. Average annual BWTF discharge is expected to eventually stabilize between one-quarter and two-thirds of the current long-term historical average flow from the BWTF. Additionally, the total loading of pollutants in Port Valdez has significantly decreased due to improvements in BWTF processes that have taken place over the years, such as the installation of the biological treatment tanks, air strippers, and monitoring instrumentation, such as the on-line BTEX analyzers. The pollutant loading is expected to continue to decrease with reduced TAPS throughput.

Reduced hydraulic loadings will affect the dynamics of treatment at the BWTF by increasing the hydraulic retention time in the process units during normal operations. Longer detention times could lead to slightly higher levels of contaminant removal prior to the biological treatment processes. The reduced contaminant load going to the biological tanks, coupled with longer detention times, may require adjustments to keep the biological process viable. BWTF operators currently make adjustments for longer detention times whenever winter storms prevent tankers

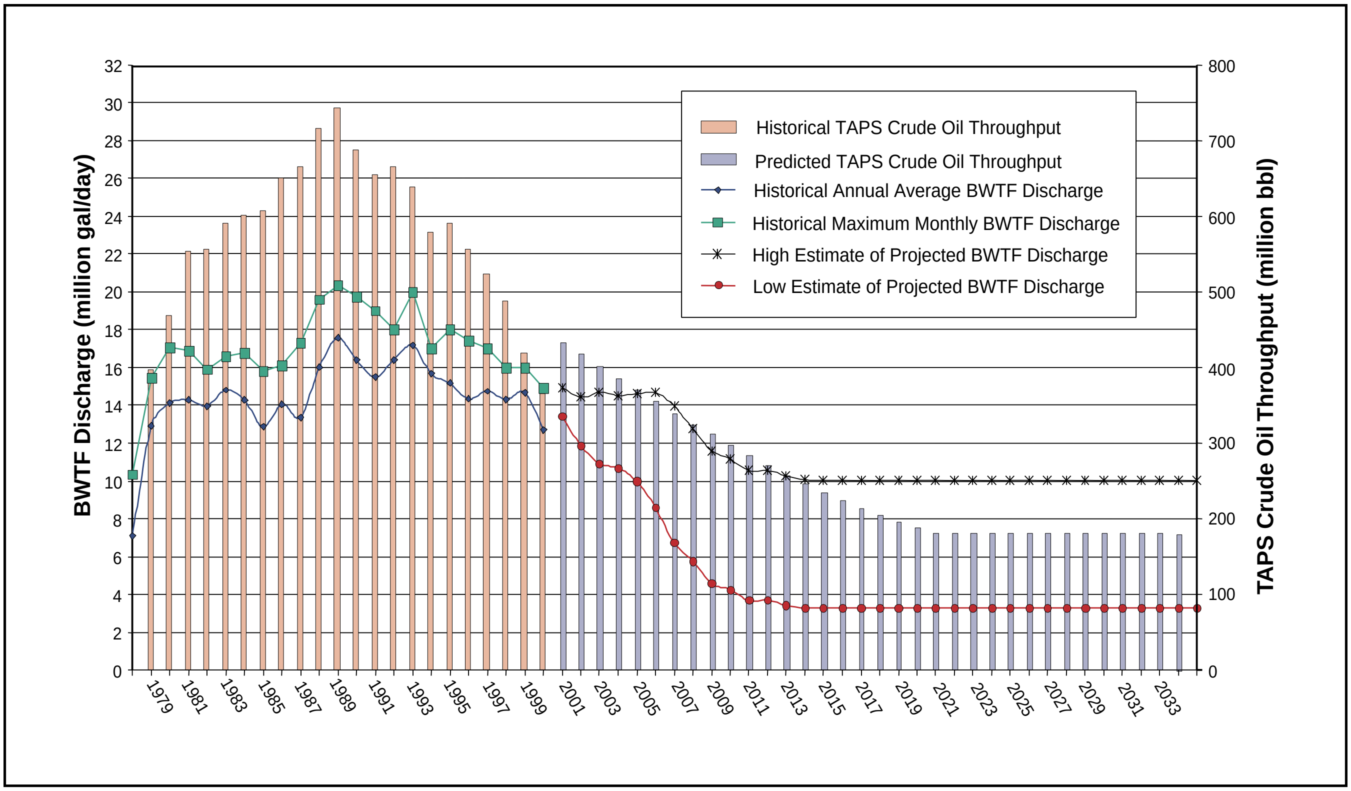


Figure 4.3-15. *Historical and projected BWTF flows and TAPS throughput (based on Alyeska data and authors' estimates).*

from entering Port Valdez. After a storm, queuing of tankers at the VMT is expected. Design maximum rates of ballast-water offloading and treatment will continue to be required, regardless of any overall reduction in flows. Alyeska has sponsored and continues to sponsor research on the response of BWTF processes on variable flows, in conjunction with the engineering faculty of the University of Alaska Anchorage (Woolard and Luetters, 1997).

The existing NPDES permit for the BWT is due for renewal in 2002. The renewed permit (and subsequent renewals) will contain the necessary limitations to ensure the BWTF effluent is in compliance with the water quality standards throughout the ROW renewal period.

No changes are envisioned for the domestic waste discharge from the VMT. The NPDES permit for its effluent will be renewed throughout the ROW renewal period.

4.3.1.3 Atmospheric Environment

By E. Haas

As TAPS throughput has steadily declined since 1989, there has been a corresponding TAPS-wide net decrease in emissions because of the reduced demand on pumping capacity (and the reduced burning of fuel). Consequently, it can be assumed that the ambient air quality impacts associated with the TAPS pump stations are no higher now and are likely lower than they were during the peak throughput years of 1988-89. Major improvements were made to the control of hydrocarbon emissions at the VMT, and no emission increases are expected beyond the 1998 post-startup levels of the tanker vapor-recovery system. The following sections discuss the impacts of TAPS emission sources on various aspects of air quality.

TAPS Emission Sources

TAPS sources emit a number of air pollutants subject to federal and state air-quality regulations. Each pump station is regulated individually as a facility with an air quality permit issued by the State of Alaska. Currently, there are ten active air-quality permits for the pump stations. Pump Station 5 has not required an air permit because the existing emission sources are below the size threshold for a permit under state regulations. No permit was issued for Pump Station 11 because the station was never built. Air quality permits are being maintained for stations in rampdown mode. The VMT has one facility air quality permit that covers all operations (APSC, 1999e). Under the state Title V permitting program, new operating permits will be issued for all existing pump stations (including Pump Station 5) and the VMT.

The equipment at Pump Stations 2 and 7 and the VMT is also subject to various Prevention of Significant Deterioration (PSD) limits under the Clean Air Act. The VMT is currently the only TAPS facility subject to air toxics requirements. Emission limits for the tanker vapor-recovery system are set by 40 CFR 63, Subpart Y.

Emission sources associated with TAPS can be categorized as stationary, mobile, or fugitive. Stationary sources include fuel-burning equipment such as the mainline turbine/pump units, booster pumps, power generation turbines, Therminol process heaters, personnel-living-quarters space heaters, diesel-fired water pumps, and solid-waste incinerators. In addition, the VMT has power boilers and vapor-recovery-system incinerators. Mobile sources include on-road equipment such as Alyeska's fleet of light trucks, as well as heavy construction equipment. In addition to these emission sources, air contaminants are also emitted from open burning at pump stations, the VMT, and along the pipeline. Fugitive-dust emissions occur from heavy equipment and vehicle traffic. Finally, emission sources also have minor fugitive emissions associated with them from equipment leaks (e.g., from valves and fittings).

TAPS stationary, mobile, and fugitive sources emit pollutants listed by federal and state air quality regulations as criteria and non-criteria pollutants. The main criteria pollutants emitted are nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), inhalable particulate matter (PM-10), and volatile organic compounds (VOCs). There are also minor amounts of lead, hydrogen sulfide (H_2S), and other reduced sulfur compounds from combustion sources. NO_x, CO, and SO_2 are the main pollutants emitted by stationary fuel-combustion equipment, as well as by mobile sources. VOCs are the primary pollutants emitted by sources such as the crude-oil breakout tanks and the BWTF. Table 4.3-3 summarizes estimated annual criteria-pollutant emissions for each pump station and the VMT.

Section 112 of the 1990 Clean Air Act Amendments published a list of non-criteria pollutants, or "air toxics." Of the listed air toxics, the following pollutants are the most prevalent in crude vapors (APSC, 1997d): xylenes, toluene, benzenes, naphthalene, hexane, and ethyl benzene.

Pump Stations. Fuel-burning equipment associated with the pump stations is listed in Tables 4.3-4 and 4.3-5, along with the other types of emission sources. The pump stations are limited by permit to burning fuel oil with a sulfur content of 0.24 percent or less. These fuel-sulfur limits are designed to limit the emissions of sulfur dioxide to the atmosphere, and emissions are reported to the agencies. Natural gas from the North Slope production facilities is provided to Pump Stations 1, 2, 3, and 4 via the fuel gas pipeline. All major fuel-burning sources at these stations use natural gas as their primary fuel. Natural gas is one of the cleanest fuels available and provides substantially lower criteria and non-criteria emissions for most pollutants than other types of fossil fuels. Fuel oil is stored at Pump Stations 2, 3, and 4 as a backup fuel in case of interruptions of the gas supply. All stations south of Pump Station 4 use No. 1 or 2 fuel oil for all combustion sources. Other fuel and emission limits apply on a source-by-source basis.

Each pump station (except Pump Station 5) has either two or three mainline turbine packages that drive either a full- or a half-head pump. Each mainline turbine unit produces up to 24,600 exhaust-gas horsepower and can run on either natural gas or oil. Units fired with natural gas at a gas generator speed of 7,900 rpm produce a 640,800 lb/hr exhaust stream (consisting primarily of carbon dioxide and water vapor) with an NO_x concentration of 74 parts per million (ppm) (corrected to 15 percent O_2). NO_x is formed primarily at high combustion temperatures. The TAPS turbines are operated at lower temperatures than newer, more

Table 4.3-3. *Potential annual air emission rates for TAPS facilities (a).*

Pollutant	PS 1	PS 2 (b)	PS 3	PS 4	PS 5 (c)	PS6 (b)	PS 7	PS 8 (b)	PS 9	PS 10 (b)	PS 12	VMT (d)	Total
Particulates	120	33	105	97	0	65	71	89	91	106	95	270	1,142
NO_x	775	608	677	626	175	487	913	1,115	1,207	1,393	1,196	1,740	10,912
CO	587	748	427	400	50	253	389	126	451	298	458	76	4,263
SO_2	39	12	44	45	65	243	373	618	581	1,765	577	1,324	5,686
VOC	28	64	12	8	n/a	18	28	41	37	46	39	3,631	3,952
TOTAL	1,549	1,465	1,265	1,176	290	1,066	1,774	1,989	2,367	3,608	2,365	7,041	25,955

(a) Calculated annual potential emission rates (tons/year) based on maximal allowable annual fuel use rates and source-test emission rates or U.S. EPA AP-42 Emission Factors.
(b) Pump stations are currently in rampdown mode.
(c) PM emission rate assumed as insignificant. VOC emission rate not available.
(d) VOC emission rate does not include loading emissions from uncontrolled berths.

Table 4.3-4. *Permitted stationary emission sources at TAPS pump stations.*

Equipment Unit	PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	PS 7	PS 8	PS 9	PS 10	PS 12
Avon Gas Generator (Mainline Unit)	3	2*	3	3		3	2*	3	3*	3	3*
Solar Turbine Booster Pump	3										
Solar Turbine Injection Pump					2						
Solar Turbine Electric Generator	2	3	2	1	1	2	2		1	1	1
Garret Turbine Electric Generator	3		3	3	3	6		2	1	5	1
Solar Turbine Gas Compressor	2										
Detroit Diesel Electric Generators		1	3			3	1			5	
Eclipse Therminol Heater	3		2	2	2	2		2	2	2	2
Broach Compressor Module Heater	1										
Carotek Heater		2					2				
Weils McClain/Burnham Boiler			2								
PLQ Heater	2			1	2						
Topping Unit Crude (Born) Heater						1		1		1	
Topping Unit Flare Stack						1		1		1	
Therm-Tec Solid Waste Incinerator	1	1	1	1	1	1	1			1	1
Cummins/Detroit Firewater Pump	1	1		1		1	1		1	1	
Vapor Recovery Flare	1										
Crude Breakout Tank	2	1	1	1	1	1	1	1	1	1	1
Turbine Fuel Tank — Diesel/JP-4		6	1	1		2	2	2	2	2	2
Topping Unit Residuum Tank						1		1		1	

*Equipped with rim cooling

efficient units. Thus, the turbine exhaust from the TAPS mainline turbine units contains fairly low NO_x concentrations even without emission controls.

Several of the mainline turbine units are equipped with rim cooling, which increases the power output of the turbine package without significant equipment replacement or modification. With increased power output and fuel consumption due to rim cooling, both criteria and non-criteria pollutants increase proportionately. However, the use of rim cooling does not necessarily increase emissions stationwide. Rim cooling is useful in situations where one or two non-rim-cooled turbines are not sufficient to meet the station's load demand. The use of rim cooling can avoid the need to add or bring online additional turbines. This option is particularly important for load balancing during pipeline rampup or rampdown phases (APSC, 1990). When a pump station is put on rampdown, the remaining stations have to carry the additional load.

One crude oil topping unit (COTU) each is located at Pump Stations 6, 8 and 10. None of the COTUs are currently in operation; however, the equipment is kept in an active permitting status (The COTUs were ramped-down with the pump stations). Each COTU can process up to 14,000 bbl per day of crude and can produce up to approximately 3,000 bbl per day of turbine and diesel fuel. Each COTU includes a crude heater unit with a firing rate of 35 million Btu/hr, a crude distillation unit, an overhead-gas accumulation system, and an overhead-gas vapor relief system with a flare stack. Overhead gas from the crude distillation unit is burned as fuel gas in the crude heater along with supplemental fuel oil. During COTU system upsets, the overhead gas is routed to the COTU flare stack. An emission control system was installed in 1994 to reduce SO_2 emissions from the crude heater. The system includes two gas-adsorption vessels to remove H_2S from the fuel gas before the gas is fired in the crude heaters. The gas-adsorption process can reduce H_2S from the overhead gas stream to single digit parts per million (ppm) levels. A system is in place that monitors H_2S levels in the fuel gas several times each operating day.

Each pump station has either one or two crude breakout tanks with an individual holding capacity ranging from 55,000 to 210,000 bbl. The majority of crude vapor emissions are generated when liquid crude is transferred into the tanks and vapor is vented to the atmosphere. The two tanks at Pump Station 1 are equipped with a vapor recovery system to control VOC emissions. The tanks at Pump Station 1 also function as crude-breakout or pressure-relief tanks when crude has to be diverted during pipeline upsets or slowdowns. All other tanks along the pipeline are consid-

Table 4.3-5. *Permitted Valdez Marine Terminal emission sources.*

Stationary Equipment	No. Units
Stationary Combustion Engines	
Power Boilers	3
Waste Gas Incinerators	3
Solid Waste Incinerator	1
Emergency Generator	1
Lifeline Generator	1
Firewater Diesel Engine	7
Tanks	
Crude Tanks in East Tank Farm	14
Crude Tanks in West Tank Farm	4
Fuel Tanks	16
Used Oil Storage Tank	1
Fire Training Site	
Fire Training Fuel Tanks	3
Fire Training Pit	1
Ballast Water Treatment System	
Recovered Crude Tanks	2
Ballast Water Separation Tanks	3
Dissolved Air Tanks	6
Dissolved Air Effluent Channel	1
Biological Treatment Tanks	2
Air Strippers	4
Marine Vapor Collection System	
Tanker Loading Berth Vapor Collection	2 (berths)
Tanker Loading Berth w/o Vapor Collection	2 (berths)

Mobile Equipment	No. Units
Marine Sources	
Crude Tankers	N/A
Barges	N/A
Tug Boats	N/A
Onshore Sources	
Gasoline-fueled vehicles	
Automobiles	N/A
Snowmobiles	N/A
Bombardiers	N/A
Diesel-fueled vehicles	
Light-duty trucks	N/A
Buses	N/A
Backhoes	N/A
Front-end loaders	N/A
Cranes	N/A
Other diesel-fueled equipment	
Oil-fired heaters	N/A
Welders	N/A
Generators	N/A
Light towers	N/A
Pumps	N/A
Pressure washers	N/A
Snow blowers	N/A

ered breakout tanks. They are not considered storage tanks and are not equipped with vapor emission controls.

Most stations have an incinerator for on-site disposal of solid waste. The majority of the units have design charge rates from 200 to 300 pounds per hour of solid trash and oily materials. Each unit has an auxiliary fired temperature-controlled afterburner in the exhaust stack for emissions control. The afterburners are fired with either natural gas or fuel oil.

Vapors from crude transfer and storage at Pump Station 1 are collected in a common vapor header and routed to the tank-vapor incineration flare. In 1994-95, a new flare tip and a gas-assist combustion system were installed to improve the smokeless combustion of the flare at high vapor-flow rates. The flare's smokeless capacity was also increased in 2000, and an additional increase in capacity is planned for 2001.

Pump Stations 2, 6, 8, and 10 are currently ramped-down. Overall station air emissions are therefore at a minimum and are only from sources that provide life support, such as electric power and space heat for facility maintenance.

Pump Station 5 operates an extensive equipment maintenance facility including a variety of small combustion sources. Pump Station 3 operates a maintenance facility for heavy equipment and consequently has a higher rate of mobile source movement and emissions.

Valdez Marine Terminal. Large stationary and mobile emission sources at the VMT are listed in Table 4.3-5. The larger VMT air emission sources are described below.

All crude storage tanks at the VMT have fixed roofs. The tank emissions are controlled with a vapor return line from each tank, and for each tank farm this line is manifolded into a common low-pressure vapor header which is part of the onshore vapor-recovery system. When a tank is emptied, the resulting additional vapor volume has to be filled with blanket gas (a mix of inert exhaust gas and crude vapors) to prevent air (oxygen) from entering the system and causing an explosive atmosphere inside the tank. Blanket gas is provided via a high-pressure vapor header at each tank farm with an individual supply pipe to each tank. A series of pressure/vacuum vents are located on top of each of the storage tanks to avoid over- or under-pressuring the tanks. These vents are designed to operate to protect tank integrity. All tank vents were extensively upgraded in 2000.

During the 1990s, a number of operational upgrades were made to the power/vapor control system including the installation of an automatic operations control and data recording system, as well as the implementation of improved operational procedures. All of the above measures resulted in a significant reduction of tank vapor losses.

As tanker cargo tanks are emptied of ballast water, they are filled with flue gas from the ship's boilers for pressure equalization and to provide an inert atmosphere in the tank. When the ships are loaded with crude oil, the inert gas is displaced and hydrocarbon vapors are generated through partial evaporation of warm crude. In March 1998 a marine vapor-collection system commenced operation to recover tank displacement vapors at Berths 4 and 5 and to route the vapors to the onshore vapor-recovery system. The collected vapors are available for pressure equalization in the onshore crude storage tanks as crude is withdrawn for loading (vapor balancing). The displacement vapors include the crude loading vapors as well as the tanker inert gases. With the control of two berths and a hydrocarbon destruction efficiency of 98 percent, a reduction of about 27,500 tons per year in VOC emission from the tankers was estimated in the 1995 Tanker Vapor Recovery PSD permit application (APSC, 1997d) .

Berths 1 and 3 are not equipped with vapor control systems but are regulated by 40 CFR 63, which limits the volume loaded from the uncontrolled berths and thus limits the amount of VOC emissions. Section 63.562 (d) requires a reduction in the amount of crude oil loaded at the uncontrolled berths. In 2002, no more uncontrolled loading will be permitted, with the exception of a small loading allowance for berth maintenance purposes.

The vapor recovery system was originally installed to control VOC emissions from the onshore storage tanks. The tanker vapor-recovery system was tied in with the storage-tank vapor-recovery system in 1998. The installation of the vapor recovery system resulted in a slight increase in combustion emissions related to generating additional electricity needed to transport collected ship vapors within the vapor recovery system.

In the present configuration, three vapor compressors are available to move waste gas into and out of the crude storage tanks, while the other two units draw the vapors from the berth vapor lines. The vapors generated in the crude oil storage tanks and those captured from tanker loading are used as blanket gas to maintain tank pressure. Flue gas generated by the facility's power boilers is also used as make-up gas when not enough blanket gas is available from the vapor recovery system.

The flue gas that is used as make-up blanket gas is scrubbed to remove sulfur compounds and compressed in the vapor compressors before it is recirculated into the high-pressure vapor header and returned as blanket gas. Excess gas from the vapor recovery system is compressed and used as fuel in the power boilers or destroyed in the waste-gas incinerators. When there are sufficient quantities of high-heating-value gas, it is preferentially used as fuel in the power boilers. This practice not only results in cost savings by offsetting, on a Btu-per-Btu basis, the amount of distillate fuel required to maintain boiler load but also reduces emissions since gas is cleaner-burning than liquid fuel and the gas does not end up being burned in the waste-gas incinerators.

After berthing, tankers containing ballast water in their cargo tanks discharge their ballast to the onshore BWTF, which consists of three 430,000-bbl ballast-water separation tanks where initial gravity separation of the oil from the ballast water occurs. The ballast water is further treated in six dissolved-air flotation tanks, followed by two biological treatment tanks including a series of air strippers to remove the remaining volatile hydrocarbons during rare biological system upsets. The entire system is permitted to process up to 30 million gallons of ballast water per day. (Current throughput is less than one-half of that capacity.) Criteria air pollutants are emitted in the form of VOCs and include non-criteria pollutants (BTEX).

Tankers at berth operate their boilers and/or generators to run ballast-water transfer pumps (deballasting) and to provide onboard utility power (hoteling). The length of the deballasting operation depends on the size of the tanker but typically takes 6 hours, and since the operation requires increased power loads from the ship's engines, it thus produces more emissions. Following deballasting, the tankers go into hoteling-only mode for loading, and the ship's boilers operate at a reduced load with lower emissions. Loading may take 24 hours or more. Under worst-case emission conditions, up to three tankers may be simultaneously deballasting or hoteling at berth.

Existing Emission Impacts

Section 4.3.1.3 discusses TAPS throughput decline and the likelihood of a TAPS-wide net decrease in emissions and emission impacts. This assumption is supported by the results of several air-quality permit applications and modeling studies and the fact that a number of improvements were made at the pump stations and the VMT. The following sections describe the existing impacts of TAPS in view of seven standard air-quality criteria:

- **Ambient air quality standards:** North Slope moni-

toring data and TAPS modeling data showed a fair margin in meeting ambient standards during years of higher pipeline throughput and worst-case emission rates. Under current throughput, it is expected that ambient standards will be met.

- **Non-attainment areas:** The Fairbanks/North Pole area is the only non-attainment area potentially affected by TAPS operations. With Pump Station 8 in rampdown mode, no pump stations contribute significant amounts of carbon monoxide to the non-attainment area. The small trucks operated by Alyeska in the area are powered by low-CO-emitting diesel engines. Plug-ins are provided to reduce cold-start and idling emissions.
- **Visibility:** Visibility impact analyses on Class I area were performed for Pump Stations 2 and 7 and for the VMT. None of the studies predicted any significant degradations of the vistas for Denali and Tuxedni National Parks and other sensitive Class II areas.
- **Acid rain:** The deposition of acidic air pollutants on sensitive ecosystems in remote regions of the state is predominantly a result of long-range transport from sources outside Alaska. Furthermore, the remote regions of Alaska receive the lowest levels of acidity in the U.S. TAPS emissions do not contribute any significant amounts to acidic depositions within the state.
- **Noise:** No adverse effects are known due to noise from stationary TAPS sources beyond the facility boundary lines. Some disturbances have been observed from air traffic, particularly helicopters, during pipeline overflights (see Section 3.2.4-5).
- **Ice fog:** Pump Stations 1 and 8 are potential contributors to local ice-fog episodes. However, Pump Station 1 is a small source compared to others in the North Slope oil fields, and Pump Station 8 is in rampdown mode. Thus, the overall contribution of TAPS facilities to local ice fog is small.
- **In-situ burning:** In-situ burning may be used for oil spill response, and Alyeska participated in a multi-agency/stakeholder working group developing guidelines for such burning, which can only be used if approved by state and federal authorities after consideration of emission impacts.

Under the Clean Air Act, the EPA is responsible for setting National Ambient Air Quality Standards (NAAQS). Based on the NAAQS, the State of Alaska sets standards (AAAQS) that must be at least as or more stringent than the NAAQS. For most pollutants, the NAAQS and the AAAQS are identical. An area where the monitored level for a specific pollutant exceeds the AAAQS is called a non-attainment area. No pump station or the VMT is located in a non-attainment area. Fairbanks is an non-attainment area for carbon monoxide, but both Pump Stations 7 and 8 are well outside the non-attainment area.

Impacts on Ambient Air Quality. On the North Slope, ambient air quality and meteorological monitoring has been carried out since 1986 near BP's Central Compressor Plant (CCP) and Pad A, and since 1991 near Gathering Center 1 (GC 1) (SECOR, 1995). Pump Station 1 is located at equal distances from the CCP, GC 1, and Pad A (Figure 4.3-16). The emission impacts from Pump Station 1 are included in the monitoring data collected at the monitoring sites and did not contribute to any exceedances of the standards (SECOR, 1995). Table 4.3-6 lists the highest monitoring values observed from 1986 to September 30, 1999, and compares these values to the applicable AAAQS and increments. The ambient impacts from gaseous pollutants emitted by stationary sources like gas turbines, heaters, and diesel generators from Pump Station 1, CCP, or GC 1 are quite low and well within the AAAQS and the increments. The monitored impacts of PM-10 are relatively low, as expected for these types of sources. With the use of natural gas as fuel, the contribution of PM-10 from stationary sources is quite low and cannot be expected to have a significant contribution to the ambient level. The contributions (percentages) of the individual measured air pollutants for the Prudhoe Bay Unit between 1986 and 1992 were statistically determined as follows (SECOR, 1995):

- NO_x: 80 percent
- CO: 16 percent
- SO_2: 1 percent
- PM-10: 2 percent

However, some of the short-term (24-hour) PM-10 monitoring data show excursions above normal during 1990-92 at GC 1. These excursions can be attributed to high winds causing re-entrained fugitive dust from roads and wind erosion from disturbed land. Table 4.3-7 and Figure 4.3-17 show the monitored ambient impacts at Prudhoe Bay from 1989 to 1998. The data lead to the conclusion that there has not been any measurable degradation of the existing air quality since the start of monitoring at Prudhoe Bay.

Actual ambient monitoring data have not been collected for the pipeline region between Pump Station 1 and the VMT; however, a number of ambient modeling studies were performed between 1990 and 1997, evaluating the impacts of a number of air pollutants on the existing air quality, native vegetation, wildlife, and vistas.

Ambient-impact modeling studies were carried out for

Table 4.3-6. *Monitoring and modeling data for TAPS air-quality impacts.*

	AMBIENT VALUES [micrograms per cubic meter ($\mu g/m^3$)]									CLASS II VALUES ($\mu g/m^3$)			
	Ozone	SO_2			NO_X	CO		PM-10		NO_X	SO_2		
Averaging Period	1 hr	3 hr	24 hr	Annual	Annual	1 hr	8 hr	24 hr	Annual	Annual	3 hr	24 hr	Annual
Standard	235	1,300	365	80	100	40,000	10,000	150	50	25	512	91	20
CCP (a)	116	34	24	3	26	—	—	29	6	—	—	—	—
GC 1 (a)	20	131	39	3	20	—	—	155	12	—	—	—	—
A PAD (a)	—	—	—	—	9.4	—	—	—	—	—	—	—	—
CPF 1 (a)	116	44	26	5	16	>1,300	>950	108	11	—	—	—	—
DS-1F (a)	100	55	10	3	4.9	>1,300	>950	57	7	—	—	—	—
PS 2 (b)	—	—	—	—	55	—	—	—	—	2	—	—	—
PS 7 (b)	—	171	76	19	64	—	—	—	—	5	6	2	1
PS 7 (c)	—	211	84	21	—	—	—	—	—	—	—	—	—
PS 8 (c)	—	427	264	66	—	—	—	—	—	—	—	—	—
PS 9 (c)	—	181	80	20	—	—	—	—	—	—	—	—	—
PS 10 (c)	—	244	109	27	—	—	—	—	—	—	—	—	—
PS 12 (c)	—	422	188	48	—	—	—	—	—	—	—	—	—
Generic PS (d)	—	225	187	15	87	4	2	110	15	—	24	26	1
VMT-TVR (e)	112	222	65	10	17	2,100	1,100	87	15	—	—	—	—
VMT-TVR (f)	—	117	34	7	—	—	—	8	0.5	4	—	—	—
VMT-TVR (g)	—	1,187	280	23	33	—	—	—	—	—	—	—	—
VMT-TVR (h)	—	1,155	280	23	—	—	—	65	10	33	—	—	—

(a) Monitored impacts: Highest recorded value between 1986 and September 30, 1999.
(b) Modeled impacts: 1990 PSD application for addition of rim cooling to mainline turbine units.
(c) Modeled impacts: 1991 application for increase in turbine fuel sulfur content.
(d) Modeled impacts: 1997 modeling report for generic pump station; 0.24% fuel sulfur including background concentration; increment consumption based on fuel-sulfur difference of 0.2% to 0.24%.
(e) Monitored impacts: 1990-1993 Valdez Marine Terminal ambient monitoring network.
(f) Modeled impacts: 1995 VMT PSD application for tanker vapor recovery system (maximal impacts from system).
(g) Modeled impacts: 1995 VMT PSD application for tanker vapor recovery system (incremental impacts from system).
(h) Modeled impacts: 1995 VMT PSD application for tanker vapor recovery system (total post-construction facility impacts).

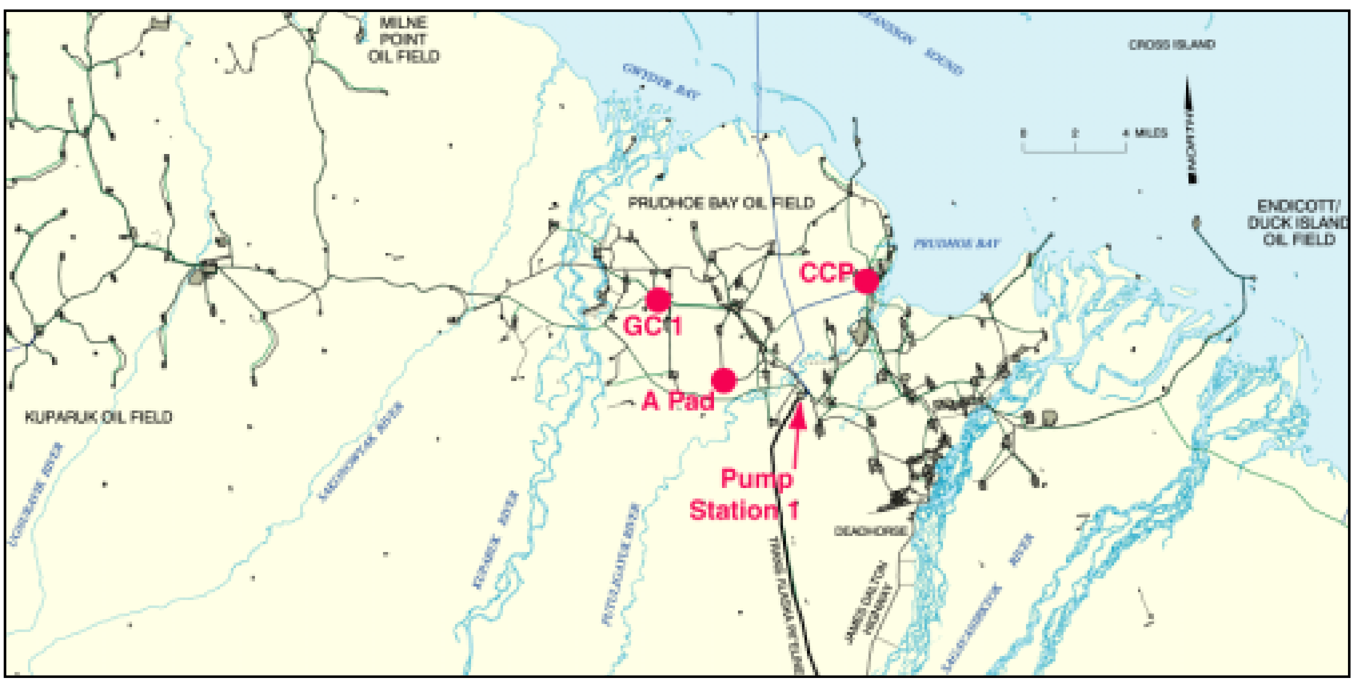


Figure 4.3-16. *Ambient air monitoring stations (shown by red dots) in the Prudhoe Bay oil field in the vicinity of Pump Station 1.*

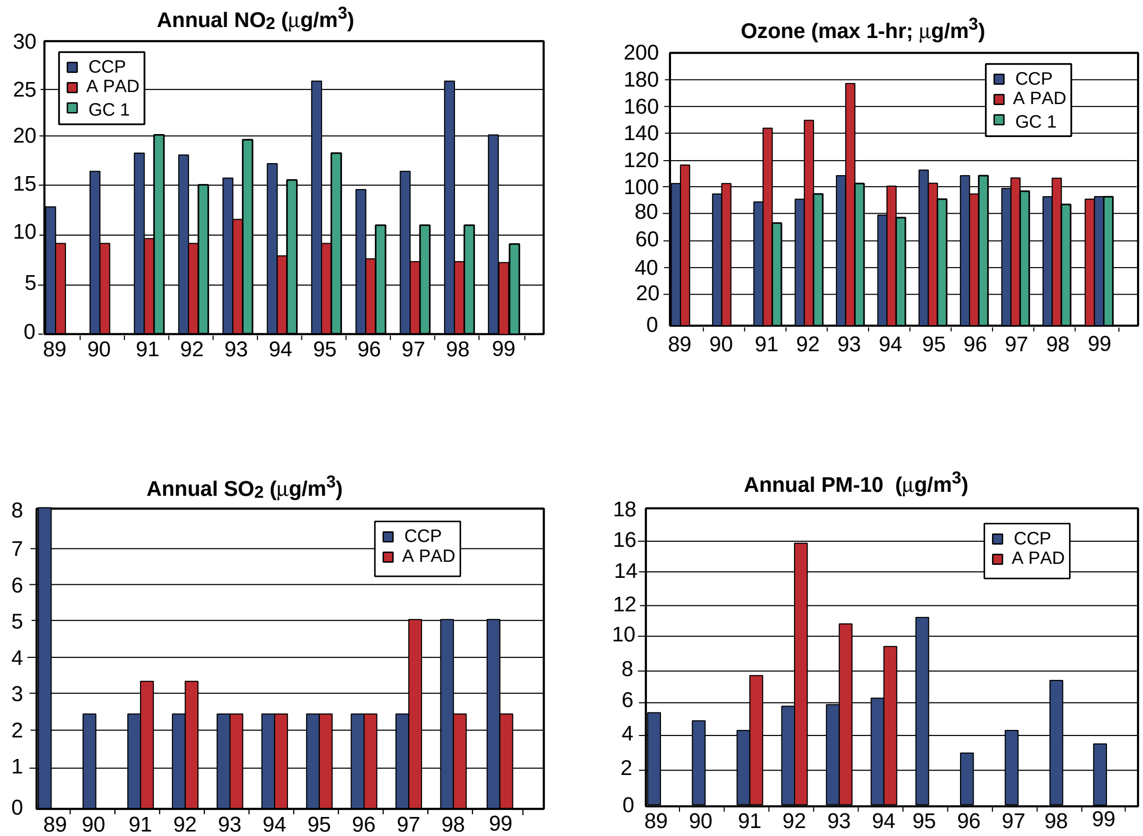
PSD analyses for Pump Stations 2 and 7 for the addition of turbine rim cooling in 1990 (APSC, 1990). Pump Stations 7, 8, 9, 10, and 12 were modeled in 1991-92 for increases in sulfur dioxide emissions with the use of turbine fuel with a higher sulfur content (TAPS Permit Correspondence Files, 1990/91). A generic modeling study with a typical source arrangement was performed in 1996-97 to evaluate the impacts from any TAPS pump station in lieu of modeling each individual station (APSC, 1997c). Table 4.3-8 summarizes the predicted ambient impacts for the modeling studies carried out for the pipeline route and for the VMT compared with the AAAQS and increments. All studies predicted that the impacts from the operating pump stations would be in compliance with the ambient standards and increments.

Background ozone and PM-10 ambient-impact monitoring data are available from a monitoring program carried out by the National Park Service Gaseous Air Pollutant Monitoring Network in Denali National Park and Preserve (NPS, 1997). An analysis of the daily maximum concentrations monitored during the summer months between 1988 and 1997 did not show significant improvements or degradation of the air quality trends. The annual average concentration of total suspended particulates (TSP) was 1.8 µg/m^3 between March 1997 and February 1998, which was the lowest measured concentration among all national park monitoring sites. The above data indicate that it is likely that no deterioration of the natural background values has occurred in the remote areas of Interior Alaska.

From October 1990 through March 1993, Alyeska operated an extensive ambient-air-quality network at the VMT. Five air-quality monitoring and meteorological sites were online throughout the Valdez basin. Three of the sites were decommissioned in November 1991, and two sites (East Gate and West Terminal) adjacent to the VMT continued operating through March 1993 (APSC, 1997d). As shown in Table 4.3-6, the monitored concentrations collected up to March 1992 were well below the corresponding NAAQS. (The table does not include PM-10 measurements for the period October 17-19, 1992. During this time, elevated concentrations of PM-10 were measured as a result of high winds, dry conditions, and the presence of volcanic ash in

Table 4.3-7. *Prudhoe Bay Unit, 10-year ambient-air-impact trend (micrograms per cubic meter).*

Station/ Pollutant	Averaging Period	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	NAAQS
CCP													
NO_X	Annual	13.2	16.9	18.8	18.6	16.2	17.7	26.3	15	16.9	26.3	20.7	100
Ozone (O_3)	1 hr	105.8	98	92.1	94.1	111.7	82.3	115.8	111.7	102.1	96	94.1	235
SO_2	3 hr	15.7	13.1	13.1	13.1	10.5	13.1	13.1	13.1	18.3	23.6	28.8	1,300
	24 hr	13.1	10.5	7.9	10.5	7.9	10.5	10.5	10.5	13.1	18.3	18.3	365
	Annual	7.9	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	5.2	5.2	80
PM-10	24 hr	24.1	15.9	20.8	16.5	29.3	28.4	53.5	12.8	47.1	69.9	28.0	150
	Annual	5.7	5.2	4.6	6.1	6.2	6.6	11.6	3.2	4.6	7.7	3.7	50
A PAD													
NO_X	Annual	9.4	9.4	9.9	9.4	11.9	8.1	9.4	7.8	7.5	7.5	7.5	100
O_3	1 hr	119.6	105.8	147	152.9	180.3	103.9	106	98	110	109.8	96.0	235
SO_2	3 hr	—	—	—	—	—	—	—	—	—	—	—	1,300
	24 hr	—	—	—	—	—	—	—	—	—	—	—	365
	Annual	—	—	—	—	—	—	—	—	—	—	—	80
PM-10	24 hr	—	—	—	—	—	—	—	—	—	—	—	150
	Annual	—	—	—	—	—	—	—	—	—	—	—	50
GC 1													
NO_X	Annual	—	—	20.7	15.5	20.2	16	18.8	11.3	11.3	11.3	9.4	100
O_3	1 hr	—	—	76.4	98	105.8	80.4	94.2	111.7	100.1	90.2	96.0	235
SO_2	3 hr	—	—	131	34.1	101.4	21	44.5	99.6	73.3	15.7	21.0	1,300
	24 hr	—	—	52.4	13.1	39	7.9	15.7	31.4	23.6	7.9	13.1	365
	Annual	—	—	3.5	3.5	2.6	2.6	2.6	2.6	5.2	2.6	2.6	80
PM-10	24 hr	—	—	19.1	155	54.7	64.3	—	—	—	—	—	150
	Annual	—	—	8	16.2	11.2	9.8	—	—	—	0	—	50



CCP = Central Compressor Plant
GC 1 = Gathering Center 1

Figure 4.3-17. *Prudhoe Bay air quality, 10-year trends.*

Table 4.3-8. *Impacts on visibility from VMT tanker vapor recovery.*

Area of Concern	Background	Delta E (a)		Contrast (b)	
		Criteria	Impact	Criteria	Impact
Tuxedni	Sky	2	0.557	0.05	0.008
	Terrain	2	0.241	0.05	0.003
Wrangell-St. Elias	Sky	N/A	4.544	N/A	0.069
	Terrain	N/A	5.727	N/A	0.058
Recreational Vehicle Area	Sky	N/A	31.5	N/A	0.846
	Terrain	N/A	63.4	N/A	0.420

Note: The criteria shown are for Class 1 areas within 100 kilometers of the source. Wrangell-St. Elias and the recreational vehicle area are Class II areas with no established criteria.
(a) Delta E is the degree of light extinction when viewed through an exhaust plume.
(b) Contrast is the degree of change of background visibility when viewed against the sky or terrain.

the Valdez area from the eruption of Mount Spurr in August 1992.)

A PSD analysis was conducted in 1995 for the addition of the marine vapor-recovery system at the VMT (SECOR, 1997b). An ambient-impact modeling study was carried out to assess emissions resulting from the increased power-generation requirements and the additional vapors incinerated in association with tanker vapor recovery. The modeling study (Table 4.3-6) showed that incremental criteria pollutants from the tanker vapor-recovery system and the adjacent Petro Star refinery would not exceed the maximal allowable Class II increments of deterioration for the Valdez area. The PSD increment consumption was predicted to range from of 2.9 to 35 percent, depending on the location of the receptor points. The study also showed that the total impacts from the VMT with the tanker-vapor recovery system were predicted to approach but not exceed the AAAQS for SO_x outside the VMT fence-line or the marine safety-zone boundary under maximum and worst-case operating conditions. The impacts relative to the AAAQS were predicted to range from 21 to 91 percent. Actual VMT operations have been significantly below those modeled by the study.

Atmospheric inversions occur anywhere when the atmospheric temperature gradient is reversed — i.e., the air temperature increases rather than decreases with increasing altitude. Under these conditions, the atmosphere becomes “stable” and loses its ability to disperse air pollution vertically. With extremely strong inversions and calm winds, air-pollutant concentration can exceed standards or even reach danger levels. Monitoring and modeling data collected in connection with TAPS do not indicate the presence of such conditions at any TAPS facilities (Table 4.3-6).

Non-Attainment Areas. Alaska has three air-quality non-attainment areas: the Mendenhall Valley in Juneau for particulate matter, and Anchorage and Fairbanks/North Pole for carbon monoxide. TAPS passes through the Fairbanks/North Pole non-attainment area. Under specific atmospheric conditions, the emissions from Pump Station 8 (currently in standby mode) and the motor vehicles operated by TAPS can contribute emissions to the non-attainment area. The non-attainment pollutant is carbon monoxide, which is emitted primarily from motor vehicles during cold-start conditions in winter. An effective measure to reduce such emissions is the use of engine block heaters. Alyeska provides electrical outlets at TAPS facilities. In addition, Alyeska’s light trucks are powered by diesel engines that have very low CO emissions compared to gasoline engines.

Impacts on Visibility. In the 1977 amendments to the Clean Air Act, Congress established a national goal of preventing any future and remedying any existing impairment of visibility resulting from man-made air pollution in 156 national parks and wilderness areas. Such “Class I” areas in Alaska include Denali National Park, the Bering Sea National Wildlife Refuge, the Simeonof National Wildlife Refuge, and the Tuxedni National Wildlife Refuge.

Visibility measurements were made in and around Denali National Park and Preserve as part of the federal IMPROVE visibility monitoring network administered by the National Park Service during 1997 and 1998 (NPS, 1997). The lowest seasonal visibility, measured during the summer, was 134 km, while the highest readings were taken during the winter at 225 km. Organics and sulfates were the largest contributors to aerosol light extinction.

The evaluation of impacts on visibility in Class I areas is required as part of a PSD analysis for projects causing major air-emission increases if the source is located less than 100 km from the Class I area. In 1990-91, Alyeska performed Level 1 visual effects screening analyses for Pump Stations 2 and 7 for Denali National Park and Preserve, even though TAPS is more than 100 km from the park (APSC, 1990). The results did not predict any adverse impacts on visibility in the park.

The 1995 VMT tanker vapor recovery PSD application evaluated the project’s visibility impacts on the nearest Class I area and selected Class II areas (Fluor and TRC, 1995). The nearest Class I area is Tuxedni National Wildlife Preserve, approximately 200 miles to the west. Visibility impacts related to the project also were assessed at the nearest Class II area, Wrangell-St. Elias National Park and Preserve, located approximately 55 miles to the east, and at a second Class II location frequented by recreational vehicle users approximately 3 miles east of the site.

As shown in Table 4.3-8, project-related impacts in the Class I area are predicted to be well below the EPA-established significance thresholds and did not require a more advanced Level II visibility analysis.

Acid Rain. Acidic deposition, or acid rain, is generally a regional problem caused NO_x and SO_2 emissions from large industrialized areas. The emissions eventually convert to sulfuric and nitric acid mist over significant atmospheric transport distances. Acid rain has been associated primarily with long-range transport of pollutants from major industrial areas over regional, interstate, and intercontinental scales (Cooper and Alley, 1994).

While the acidification of lakes due to wet deposition occurs in the eastern U.S., acid deposition is not considered a problem in the western U.S. and Alaska. The 1990 Clean Air Act Amendments do not require any specific legislation for the western states to control acid deposition.

The quantitative impact of TAPS NO_x and SO_2 emissions on pristine areas in Alaska is not known. However, considering the magnitude of emissions from large industrial centers in northern Europe, Asia, and the eastern U.S., far greater impacts can be expected on pristine regions in Alaska from these sources. In addition, the relatively short intrastate distances do not provide the same time for acid formation compared to regional and global transport. The lowest concentrations of sulfate and nitrate in precipitation measured at four prototype parks in the U.S. were recorded at Denali National Park (NPS, 1997).

Noise Impacts. The original TAPS EIS (BLM, 1972) estimated that the noise levels from a TAPS pump station would be 74 dBA at a distance of 600 feet (183 meters). This estimate was overly conservative when compared with actual sound measurements at similar facilities at the North Slope. Measurements in the Prudhoe Bay area in 1979 identified sound levels from the Central Compressor Plant of 74 dBA at 15 m from the turbine air intake and 60 dBA at 120 m from the vapor-relief flare operation (BLM and USACE, 1988).

Although the TAPS ROW itself is developed, most of the area adjacent to the route is undeveloped and sparsely populated, and ambient noise levels are generally low. Disturbances to wildlife have not been observed in connection with any of the stationary sources at the pump stations, however disturbances have been observed from air traffic, particularly helicopters during pipeline overflights. Wind and other atmospheric conditions can affect ambient background levels. Noise carries considerable distances during calm, cold conditions due to increased air density. Generally, the noise from pump station equipment and activities are not audible outside the facility property lines. Actual noise measurements outside the facility property lines along the TAPS ROW were not found. The author is not aware of any complaints about excessive noise from the public or residences near the TAPS ROW.

Background noise in the Valdez area is quite low, with road traffic and aircraft the most significant sources. Valdez is typical of many small Alaskan cities with moderate traffic and limited sources of noise. Some ambient noise originates from the VMT, mainly from sources associated with power/vapor operations; however, beyond the facility boundaries it is generally not audible. Natural background noise levels are low except when transient boats and aircraft pass by (Fluor and TRC, 1995).

Ice Fog. Ice fog is generated by the emission of exhaust gases from combustion sources in subzero temperatures. The amount of water vapor generated from the combustion process alone is substantial. With the use of wet fuels such as coal, wood, solid waste, etc., and the application of wet emission controls such as wet scrubbers, the amount of water vapor generated can be much higher. In severely cold climates like Alaska's Interior, the formation of ice fog can be a serious visibility problem that can last for days at a time. When winds are from the southeast, water vapor emitted from Pump Station 8 (when in operation) has some potential to contribute to ice fog in the Fairbanks/North Pole area, as do the several hundred cars, trucks and heavy equipment operated by Alyeska in and around Fairbanks and along the pipeline route in the Interior. Pump Station 7 is too far from Fairbanks to have any significant impacts on the greater Fairbanks/North Pole area. Located within the North Slope production area, Pump Station 1 may have the highest potential for impact on periodic ice-fog episodes of all TAPS sources, even though its overall contribution of water vapor compared to most other facilities at the North Slope is minor. All other stations are sufficiently distant from ice-fog-prone areas that they do not contribute significantly to periodic ice-fog episodes.

Oil Spill Response/In-Situ Burning. In-situ burning is a tool for removing oil from a spill on land or water. In-situ burning is only performed when approved by a state or federal on-scene coordinator. In contrast to the combustion of hydrocarbon fuels in a controlled environment like a combustion chamber, in-situ burning produces a wide range of intermediate combustion by-products. By-products can be categorized into airborne components, unburned oil, and combustion residues (ADEC, 1999).

The airborne components of smoke plumes may contain a wide variety of criteria and toxic air pollutants including polynuclear aromatic hydrocarbons (PAHs), CO_2, CO, NO_x, and PM-10. McGrattan et al. (1997) determined that 10 to 15 percent of the original amount of crude oil was converted into smoke or airborne particulate matter when burned. The particulate portion of the smoke is about 90 percent elemental carbon. Particulates from emissions from oil fires appear to pose the greatest health risk. This includes both soot (elemental carbon) and hydrocarbon particulates (unburned oil). While particles larger than 10 microns are considered to be non-inhalable, the fraction less than 10 microns can be inhaled. Other laboratory studies have shown that approximately 95 percent of the fuel was converted to CO_2 and 2 to 3 percent was converted to soot. Concentrations of total particulates measured at experimental burn sites as well as at sites in Kuwait in the aftermath of the war in Iraq showed that the levels can be significantly higher than the levels set by the NAAQS for PM-10. Measurements of gaseous or toxic components did

not show any concerns for exceedances of the ambient or health-related standards.

State and federal agencies, along with the oil transportation industry, are currently developing various tools to predict ambient-air-quality impact levels during or after an in-situ burn operation. These tools involve ambient-impact prediction methods and comparisons with pollution standard index values, supplemented with descriptor words, generalized health effects, and cautionary statements. The proper use of these tools will make it possible to prevent significant short- or long-term impacts on local residents.

Projected Ambient Air Quality Impacts

In order to evaluate the potential impacts of the next 30 years of TAPS operation, several aspects need to be examined. First, the extent of existing impacts from the operation of TAPS during the last 20+ years should be considered. Impacts from the operation and, to a minor extent, from construction need to be evaluated since the continued operation of TAPS may entail some construction activities. Secondly, projected operational configurations subject to long-range operations plans must be evaluated. These plans may increase or decrease future emissions and consequently can impact the environment. For example, standby pump stations will significantly reduce local emissions and ambient impacts. However, the facility air permits contain emission limits that ensure that the ambient impacts are within the allowable standards and increments.

A third aspect is to search for and to evaluate any dynamic effects that may cause future impacts that significantly differ from past effects.

Impacts on Ambient Air Quality Standards. Ambient air-pollutant levels at North Slope operations areas have not shown any measurable changes since the start of the air-quality monitoring program in 1986. It can thus be concluded that no additional degradation of the ambient air quality has occurred beyond any increases in air pollution levels prior to 1986 due to the start of exploration and production activities. An extrapolation into future operating phases may be appropriate. However, careful consideration must be given to any known potentially adverse effects. One such known and potentially adverse effect is the steady increase in the H_2S content of the fuel gas consumed at the North Slope facilities and Pump Stations 1 to 4. The fuel-gas H_2S content has increased from levels in the single digits typical in the early years of operation to approximately the mid-twenties today. On a rough scale it can be concluded that the H_2S content has doubled over the last 20 years — with a resultant doubling of the SO_2 emission rates for all stationary fuel-gas-burning equipment (SO_2 results from the combustion of H_2S). However, before the conclusion is made that emission rates have doubled, the actual fuel-gas consumption rates would have to be assessed for any specific facility.

If the overall station fuel consumption has decreased because of lower oil throughput rate, this would offset emission increases. Also, it is incorrect to assume that actual increases in SO_2 emissions would automatically cause a proportionate increase in measurable ambient impacts. As mentioned earlier, the Prudhoe Bay monitoring sites have not measured any increases in ambient SO_2 levels in recent years despite an increase in fuel-gas H_2S levels. Part of the reason is that actual emissions of SO_2 are quite low (about 1 percent) compared with other pollutants. Thus, any changes in the emission rates of SO_2 will likely have little effect on measured levels or airborne pollution and practically no effect on any climatic factors. Existing global climatic trends like atmospheric warming will likely have a significantly stronger effect on local climate regimes.

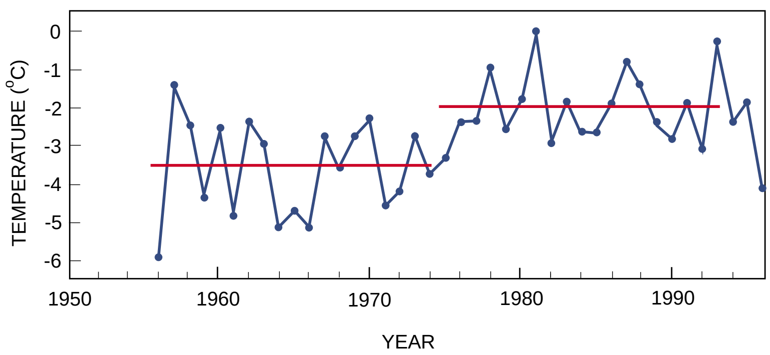
Currently, all pump stations can operate all mainline turbine units and other stationary equipment up to their maximum permitted levels. Generic modeling has been conducted based on the worst-case normal operating conditions (APSC, 1997c). It is unlikely that these operating conditions will be exceeded. Consequently, it is unlikely that the potential emission increases from the remaining stations in future throughput cycles will create any additional impacts over existing or past levels, which were found to be in compliance with all applicable standards.

As stated earlier, the SO_2 emission rates at Pump Stations 1 to 4 will increase at a direct ratio with increased H_2S levels in North Slope fuel gas minus an overall fuel usage reduction due to reduced throughput. However, no matter how high the H_2S level in the fuel gas, the amount of SO_2 emitted from the fuel-gas-fired stations will always be significantly lower than the SO_2 emission rates from the fuel-oil-fired pump stations. The amount of sulfur present in fuel oil is several orders of magnitude higher than in fuel gas. The generic modeling discussed above was carried out with the assumption of liquid fuel-oil use. The expected SO_2 impacts from the fuel-gas-fired stations will be significantly lower than those from the fuel-oil-fired stations.

4.3.1.4 Global Climate Change

By R. Dugan

There are numerous ongoing debates on the rate and duration of the current apparent global-warming trend in Alaska. Global-warming forecasts indicate that the high latitudes of the earth may warm by several degrees by the



NOTE:
The horizontal lines for the air temperature are 20-year averages (Osterkamp and Romanovsky, 1999)

Figure 4.3-18. *Mean annual air temperature at Fairbanks.*

middle of the next century as a result of an effective doubling of carbon dioxide (CO_2) , methane (CH_4) and other greenhouse gases (Esch and Osterkamp, 1991; Nixon, 1991, Vyalov et al., 1993, 1998). One study in interior Alaska indicated that an air temperature shift to a warmer regime began with the winter of 1976. After 1976, the mean annual air temperature in Fairbanks increased 1.5°C for the next 20 years as shown in Figure 4.3-18 (Osterkamp and Romanovsky, 1999). These studies suggest that a warming trend is occurring, although the cause of the temperature increase is not well-understood and may be related to the cyclic nature of the climate.

The likely range of mean annual air temperature increases over the ROW renewal period is 2°C to 5°C if the warming trend observed in the Fairbanks area continues. Over time, warmer air temperatures would increase ground temperatures. This would result in warming of the relatively cold permafrost on the North Slope and Brooks Range and lowering of the permafrost table in southern portions of the pipeline where permafrost temperatures approach 0°C.

A thaw bulb has already developed in some permafrost areas along the ROW as a result of the construction of the workpad and other facilities. Pipeline construction unavoidably compressed or disturbed the vegetative cover that formerly protected the permafrost (see Section 4.3.1.1). A gradual increase in the size if the thaw bulb can be expected as a result of continued climatic warming.

Since the beginning of TAPS operations in 1977, the consequence of any climate change-induced permafrost thawing to pipeline operations has been negligible (Cole et. al., 1999). Continued warming of the air temperature will also have negligible impact on TAPS operations or pipeline integrity for the following reasons:

- Where above-ground pipe is located in areas of relatively warm permafrost, heat pipes are used to help maintain frozen conditions.
- Heat pipes can be added, if necessary, to VSMs that do not currently require them.
- In areas that are ice-rich (i.e., areas of high moisture content), the rate of ground temperature change will be slow, especially at depth.
- Continued monitoring and maintenance will identify and repair any areas where settlement or heave may exceed operational standards.

Continued operation of TAPS will not have a significant effect on global warming. The pipeline currently conveys about 1 million bbl per day compared to world oil production of approximately 75 million bbl per day (World Oil, 1999). Assuming that the oil delivered by the pipeline would impact global warming when it is eventually consumed, it would represent only a small fraction of the world's oil consumption. World demand determines oil production. If the oil were not produced in Alaska, it would be produced elsewhere; therefore, the net impact to global warming would not change. Non-petroleum-related contributors to global warming include volcanic eruptions and burning of coal, wood, and other combustible materials.

4.3.2 Biological Resources

This section assesses the potential biological impacts of the renewal of the TAPS ROW and continued operations. Limited written information is available on the TAPS ROW itself, compared to other areas such as the North Slope oil fields and Prince William Sound. However, much of the in-

formation available for other areas is relevant to TAPS. Written information has been augmented with interviews of Alyeska and government agency managers and regulators who have worked directly with TAPS. These interviews provided practical, first-hand-experienced views of TAPS and its potential impacts.

The written and interview information indicates that routine operation and maintenance of TAPS has not directly affected the size, distribution, or productivity of vegetative communities or fish and wildlife populations. TAPS is a relatively benign feature on the landscape, and maintenance/monitoring activity is well-regulated and restricted in space and time. The potential for impacts to areas other than the TAPS ROW itself that are in some way related to TAPS is dealt with in the Section 4.5 of this report. The literature review and interviews with TAPS managers and regulators suggest that of the extensive list of predicted impacts from TAPS, the major issues with regard to continuing operations of TAPS are:

- Spills of crude oil or refined petroleum products (e.g., diesel fuel) along the TAPS ROW and adjoining sections of the Alaska highway system, and in the marine environment.
- Blockage of fish passage and/or disturbance of fish habitats from culvert failure, improper use or maintenance of low-water crossings, and stream siltation from excavation runoff of TAPS workpads and access roads.
- Increased human access to remote areas resulting from growing public use of the Dalton Highway.

TAPS-related activities and facilities result in a small number of direct mortalities to terrestrial mammals and birds each year. Vehicles on the Dalton Highway occasionally kill caribou, moose, small mammals, and low-flying birds such as ptarmigan; and individual birds may be killed when they collide in flight with the pipeline, pump stations, or terminal facilities. Small numbers of freshwater fish, particularly fry, are sometimes entrained or stranded by local, temporary construction or excavation for pipeline maintenance. Individual mortalities such as these do not affect the species composition or population-level abundance of mammals, birds, or fish along the ROW.

The following sections describe potential impacts of the proposed action on special areas and special management zones, vegetation (including wetlands), fish, birds, terrestrial mammals, and threatened and endangered species. Most of the potential impacts involve habitat disturbance, displacement of individual animals, and direct mortality. Impacts resulting directly from TAPS operation and maintenance will necessarily be limited by lease stipulations that confine pipeline operations to the ROW. The gradual increase in human access from the Dalton Highway to formerly remote areas has the greatest potential to produce lasting population-level changes. This is a matter of public policy that will require management by federal, state, and local jurisdictions, and by the larger private landowners associated with the right-of-way for the Dalton Highway.

4.3.2.1 Special Areas, Special Management Zones, and Zones of Restricted Activity

By H. Whitlaw, R. Ritchie, and J. McKendrick

Evaluation of environmental consequences associated with the proposed action in special areas and special management zones (SASMZ) was based principally on an understanding of the historical impacts of TAPS operation and maintenance on fish and wildlife resources. In addition, several state and federal regulations on mitigation and environmental compliance apply to activities in SASMZs, and impact evaluation was also based on a review of these restrictions. SASMZs in the vicinity of the pipeline include the following (APSC, 1993):

- *Zones of restricted activity (ZRA)* created and implemented under Stipulation 2.5.3.1 of the Federal Grant. Activities are restricted during fish and falcon breeding, nesting, spawning, and migration periods.
- *Areas of critical ecological concern (ACEC)* proposed in BLM (1989) and established with BLM (1991). These pertain to critical and sensitive terrestrial-mammal and falcon habitats.
- *Long-term vegetation monitoring and restoration sites* established for monitoring willows, revegetation efforts, and vegetation response to oil spills.

Vegetation

The proposed action would involve ground-impacting ROW maintenance, in addition to revegetation monitoring and restoration. Long-term vegetation-monitoring SASMZs would not be adversely affected by ROW renewal because maintenance activities in these sites are restricted (APSC, 1993). It is likely that the proposed action would allow for continued opportunities to monitor revegetation efforts and vegetation response to disturbance (i.e., oil spills, TAPS construction, and ground-impacting maintenance).

Fish

The proposed action would involve ground-impacting ROW maintenance, in addition to activities in watersheds, wetlands, riparian areas, and streams. Work in ZRAs (i.e., all fish-bearing streams crossed by the pipeline and its facilities) is restricted during all breeding, spawning, and migration periods. However, there is concern that maintenance activities may obstruct fish movement, alter habitat, and/or increase mortality. In addition to restrictions imposed by ZRA stipulations, activities that may impact fish resources are reviewed under ADF&G Title 16 and Fish Habitat permit processes, and the U.S. Army Corps of Engineers Section 404 (Clean Water Act) permit process for jurisdictional waters (SPCO, 1993, 1995). Through continued and effective use of permit review processes, in addition to compliance with ZRA stipulations, the proposed action will likely have little impact on fish resources in ZRAs within the TAPS ROW.

Terrestrial Mammals

The proposed action would involve ground-impacting ROW maintenance in and near BLM-designated ACECs (APSC, 1993; BLM, 1989). In these special management areas, activities are restricted to meet designated sensitive habitat and management objectives (BLM, 1989 and 1991). ACECs primarily contain Dall sheep lambing areas and mineral licks in the vicinity of the Brooks Range. Through the continued and effective protection provided to terrestrial mammal habitats through ACEC activity restrictions, the proposed action is expected to have little impact on these resources (Sections 4.3.2.5 and 4.2.3).

Threatened and Endangered Species

Two species listed as threatened under the federal Endangered Species Act (Spectacled Eider and Steller's Eider) and two delisted subspecies of Peregrine Falcon (the *tundrius* and *anatum* races) would potentially be affected by activities associated with the proposed action. Occupied peregrine falcon nests, as designated by FWS through the Authorized Officer, constitute ZRAs. In these special areas, precautions must be taken for activities during breeding and nesting periods. In addition, FWS permits under Section 7 of the Endangered Species Act are required for some activities that may affect threatened and endangered species. Through continued and effective use of permit review processes, in addition to compliance with ZRA stipulations, the proposed action is expected to have little impact on threatened and endangered species in ZRAs along TAPS.

4.3.2.2 Vegetation and Wetlands

By J. McKendrick, D. Funk, T. Jorgenson, and J. Kidd

This section describes the environmental consequences of ROW renewal on vegetation and wetlands. This analysis of consequences is based on estimates of the ground-impacting maintenance expected during the period of renewal. The discussion includes a comparison of construction and maintenance impacts, common ecological effects, and characterization of the overall level of impacts to be expected from renewal. Also included is a summary of the extent, frequency, and duration of anticipated impacts, and the mitigative measures that have been taken to minimize changes in the natural vegetation from maintenance activities in the ROW. Impacts to vegetation and wetlands in the ROW and surrounding area have been grouped into the following categories:

- Habitat loss, alteration, and enhancement;
- Drainage and water flow issues;
- Thermokarst;
- Air pollution;
- Oil, fuel, and chemical fuel spills;
- Fire and fire management; and
- Revegetation.

Habitat Loss, Alteration, and Enhancement

Loss of wetlands associated with the TAPS ROW can occur as a result of pipeline replacement, pipeline reroutes, workpad maintenance and construction, and the development of material sites (JMM, 1990). Loss is primarily due to the placement of fill, but also may occur from dredging and excavation of wetlands or oil spills. Wetland loss from pipeline replacement and workpad construction typically occurs in the ROW, while pipeline reroutes, material sites, and oil spills also may include wetlands outside the ROW.

Only three pipeline replacements/reroutes have occurred along the TAPS ROW since startup: Dietrich River (1985), Atigun Pass (1987), and Atigun River (1991). The frequency of pipeline replacements/reroutes is expected to continue to be rare for the next 30 years because of advancements in pipeline integrity monitoring. Less than 1 mile (1.2 km) of pipeline was involved for the Dietrich River and Atigun Pass projects (see Section 4.1). Assuming a mean construction width of 80 ft (24 m), a maximum of 7 acres (15.4 ha) would have been affected for both sites if the two project areas included only wetlands. The pipeline replacement at Atigun Pass in the Brooks Range affected up to 11.9 acres (26.18 ha) (JMM, 1990). The losses were attributed to workpad, trench, and access-road construction.

The development of material sites during pipeline construction was one of the greatest impacts to wetlands, mostly riverine and palustrine, because many of the sites were located in floodplains (Pamplin, 1979). During construction, the Joint Federal/State Fish and Wildlife Advisory Team found numerous problems associated with the selection and development of several TAPS material sites

(Burger and Swenson, 1977). The most common problems included alteration of hydrology and increased siltation, but the loss of riparian habitat also occurred.

Because future maintenance of the ROW is not expected to require frequent pipeline replacements or reroutes, wetland losses should be minimal. The development of new material sites is expected to be limited as large volumes of gravel fill will not be needed for future ROW maintenance activities.

The alteration of wetland habitats along the TAPS ROW can occur from de-watering, water impoundment, thin gravel fill or dust outfall, compaction, and contamination from oil spills. Natural occurrences such as stream migration or erosion can also impact wetland habitat. No surveys of wetland alteration have been conducted along the ROW, but studies in the Prudhoe and Kuparuk oil fields (Walker, Cate et al., 1987; Kertell, 1993) found localized impacts to wetlands. It is reasonable to expect similar impacts from structures or activities that occur along the ROW.

Wetlands may be enhanced in areas adjacent to roads and pads where soil temperatures are higher and water impoundments have formed. Impoundments alter both the hydrology and species composition of wetlands. Plant productivity may increase biomass in a few species, or productivity may decrease as plants are lost to the development of deep open-water areas. In most cases, impoundments lead to a decrease in plant species richness (Klinger et al., 1983; Walker, Cate et al., 1987).

Hydrocarbon spills affect wetland communities by physically covering and killing vegetation, creating toxic soil conditions (Haag and Bliss, 1973; Deneke et al., 1974; Brown, J. and Grave, 1979; Jorgenson and Cater, 1996; Everett, 1978) and increasing the depth of the active layer in permafrost soils (Brown, J. and Grave, 1979; Lawson, D.E. et al., 1978). The effects of oil spills on vegetation are detailed under a separate heading in this section.

Dust. No studies have examined dust effects on vegetation along the TAPS ROW. However, impacts are probably minimal because of low vehicle speed and the limited frequency of vehicle passes. The effects of dust on vegetation have been documented along the Dalton Highway (Everett, 1980; Spatt, 1978; Walker, D.A. and Everett, 1987; Auerbach et al., 1997). These studies found early snowmelt, reduced soil-nutrient concentrations, lower moisture, altered soil organic horizon, and higher bulk density and depth of thaw. Plant species richness was reduced near the road, especially in naturally acidic soils. A decrease in acidophilous mosses, some lichen species, and certain heath taxa (Walker, D.A. and Everett, 1987) altered species composition. In areas with heavy dust fallout, native plant communities have been killed and replaced by early-successional colonizers. The magnitude of these effects depends on the duration of dust exposure (i.e., road traffic intensity) and the distance from the source. Dust loads decrease logarithmically with distance from the road (Everett, 1980). The zone of maximum dust fall is within the first 300 m from the road, and the area beyond this distance is essentially undisturbed (Everett, 1980).

Off-Road Use. Most off-road use along the TAPS ROW occurs in the winter by snow machines. Off-road terrain along the ROW is not easily traversed by off-road vehicle (ORV) in the summer. Alyeska activities are restricted to developed roads or workpads, and Alyeska can operate off these with agency approval only in winter snow-cover conditions. In areas where a heavy snow cover exists, impact to vegetation is minimal. However, in low snow years, prior to freeze-up, or in mountainous areas where windblown ridges are frequently free of snow, damage to vegetation from snow machines can be considerable. Based on studies of seismic trails on the Arctic Coastal Plain, the plant communities most sensitive to ORV traffic along the ROW include Tussock Tundra, shrub-dominated communities, and Sedge-Willow Tundra (Felix and Raynolds, 1989; Emers et al., 1995). Alpine plant communities sensitive to ORV use include Mesic Shrub Birch-Ericaceous Shrub, Mountain-Heath Dwarf Shrub Tundra, and Cassiope Dwarf Shrub Tundra (Racine and Johnson, 1988). The impacts associated with ORV use include torn and crushed vegetation mats with broken or abraded terminal branches, loss of mosses and lichens, and disturbance of the surface organic mat (Walker, Cate et al., 1987; Slaughter et al., 1989). In permafrost-rich soils, permafrost degradation and water ponding can occur when vehicle disturbance goes beyond the vegetative mat into the underlying soil. This can happen from either soil churning or extensive compaction of the vegetation that exposes the underlying soil. Water impoundment, especially in moist shrub-dominated communities, will likely alter the species composition in favor of sedges and other wetland graminoids. Disturbance of the vegetative mat alters plant community composition, favoring early successional grasses and forbs.

Drainage and Water Flow Issues

Drainage and water flow impacts likely to occur include permanent impoundments, erosion and sedimentation along stream channels and near culverts, sedimentation associated with erosion-control structures in floodplains, alteration of natural drainages through channelization and concentration of flow, and icings.

Impoundments typically occur in flat, wet areas where surface runoff is blocked by gravel roads and pads that have inadequate cross-drainage structures. Along the ROW, impoundments are primarily restricted to the Arctic Coastal Plain, where the flat topography, indistinct drainage, and the presence of thaw-lake basins promote their occurrence. In the Prudhoe Bay oil field, impoundments covered 22 percent of a highly developed portion of the oil field and 3 percent of a broader portion of the oil field (Walker, Webber et al., 1987). Noel et al. (1996) put the percent of impoundment coverage in the Prudhoe Bay Unit at 0.8 percent based on more recent photos. Along the West Dock Road, Klinger et al. (1983) measured 331 acres (134 ha) of impoundments, although most of the flooding was only temporary. Impoundments also were noted at numerous locations on the upslope sides of material-site access roads which initially did not have culverts or low-water crossings (Berg, 1980). Along the ROW, approximately 2,225 acres (900 ha) of terrestrial habitat were converted to areas of ponded or flowing water, although most of this was associated with flooded mine sites (Pamplin, 1979). Many temporary impoundments are due to icing and temporary blockage of culverts during breakup (Hickok, 1981; Walker, Cate et al., 1987).

On the Arctic Coastal Plain, impoundments cause a wide range of ecological effects depending on depth and duration of water levels. These effects include thermokarst, large water-level decreases during the summer, increased plant productivity, and changes in species composition. In shallow areas, sedges become more common, whereas in deeper areas, complete plant mortality may occur (Klinger et al., 1983; Walker, Cate et al., 1987). These changes can in turn affect habitat use. Kertell (1993) found that although overall invertebrate and bird abundance was similar between impoundments and natural ponds, the modification of wetland habitats may benefit some species at the expense of others. Overall, impoundments probably will continue to impact vegetation adjacent to the workpad on the Arctic Coastal Plain, but current construction practices are helping to minimize impoundments. Along the remainder of the ROW, impoundments will be of only minor concern where drainages on sloping terrain are more distinct and culverts generally are more effective.

Erosion and sedimentation were widespread problems during initial ROW construction, but have mostly been eliminated by corrective maintenance. While 190 noncompliance reports related to erosion control and surface drainage problems were issued by Alyeska's environmental monitors in 1977, identified problem areas were reduced to 24 in 1979, and to 3 in 1980 (GAO, 1981) and have occurred only sporadically since 1980. The most serious problems were associated with cross-drainage, caused by combined thermal and hydraulic erosion downslope from the Haul Road, because of altering or concentrating drainage patterns in areas where runoff was more diffuse. In a few instances, such as adjacent to the road at Alyeska Material Site 135-A, the erosion channels formed a deep polygonal pattern in the ice-rich permafrost (Berg, 1980).

The ecological effects from the erosion and sedimentation included habitat destruction from gully formation, and minor habitat alteration and degradation of water quality and fish habitat from sedimentation. These problems, however, were generally confined to the Brooks Range. Although no data are available on the extent of habitat impacts, they were sufficiently small as to be a negligible component of habitat impacts (Pamplin, 1979). Mitigative measures included use of mulches, benches, diversion barriers, and sandbars for land-surface protection and use of rock-filled wire baskets, rock armoring, and revegetation for stream-bank protection. Many culverts were replaced with low-water crossings. Overall, maintenance of the TAPS ROW and work pad were considered excellent by the U.S. General Accounting Office (GAO, 1981) given the size of the project. Because stream channels and hydrologic processes are dynamic, monitoring and maintenance will continue after the ROW renewal to address minor continuing problems.

Sedimentation of barren riverbars and riverine willow communities can occur in slackwater areas behind erosion control structures constructed in floodplains. In the floodplain of the Sagavanirktok, Dietrich, and Delta rivers, most of the pipeline is buried in thaw-stable gravel, and numerous dikes and other erosion-control structures are in place. Data are lacking on the potential impacts of sedimentation behind these structures, but conceptual models of floodplain development in the Arctic (Bliss and Cantlon, 1957; Peterson and Billings, 1978; Jorgenson et al., 1998) and Subarctic (Viereck et al., 1993) indicate that the areas receiving siltation should be prime habitat for colonization by willows and other fast-growing colonizers.

Icings on large floodplains and along small stream and hillside watercourses are common occurrences in the Brooks Range and Alaska Range regions, and to a lesser extent in the Interior Forest region (Sloan et al., 1975). Icings at stream crossings are a continuing maintenance problem which can cause culvert blockage and delayed drainage during breakup (Berg, 1980), and tree mortality in small areas where icings persist in early summer.

Aufeis may also cause maintenance problems at stream crossings. Aufeis forms during winter when water flowing in a deep stretch of river is dammed by ice that has formed

in a more shallow stretch of river. The dammed water overflows the banks of the river and freezes. This may happen repeatedly, forming extensive layers of ice several meters thick (Pielou, 1994). Because of its thickness, this ice is slow to melt and may cause culvert blockage, flooding, and drainage problems along watercourses.

Thermokarst

Permafrost is sensitive to changes in surface conditions that alter the surface energy balance and increase heat flow into the ground. Even small disturbances to vegetative cover and soil moisture regime can increase the depth of the active layer, melt ice-rich permafrost below the active layer, and lead to the development of thermokarst — i.e., settlement of the ground after thawing (MacKay, 1970; Webber and Ives, 1978; Brown and Grave, 1979; Lawson, 1986; Jorgenson, 1986; Walker, Cate et al., 1987). The magnitude of the impact, however, depends mostly on the volume and type of ground ice, its distance from the surface, the soil texture, and the degree of initial disturbance (Brown and Grave, 1979; Lawson, 1986). Thermokarst is particularly problematic because small initial settlement can increase moisture at the surface. This change alters the energy balance and increases heat gain, and can lead to additional thermokarst (Jorgenson, 1986; Hinzman et al., 1997).

Thermokarst has resulted from a variety of disturbances associated with the North Slope oil fields and TAPS ROW, including:

- Impoundments (Lawson, 1986; Walker, Cate et al., 1987; Truett and Kertell, 1992);
- Dust deposition (Walker and Everett, 1987);
- Placement of thin gravel fill (Nelson and Outcalt, 1982; Lawson, 1986; Jorgenson and Joyce, 1994);
- Heavily used seismic trails (Felix and Raynolds, 1989; Emers and Jorgenson, 1997);
- Off-road traffic (Rickard and Brown, 1974; Brown and Grave, 1979; Walker, Cate et al., 1987; Slaughter et al., 1989; Racine and Ahlstrand, 1991);
- Heated structures (Burgess, Grechischev et al., 1993);
- Buried pipelines where adjacent surficial material is ice-rich (Thomas and Ferrell, 1983);
- Cleanup of oil spills (Jorgenson et al., 1991); and
- Removal of gravel for rehabilitation (Jorgenson and Joyce, 1994; Kidd et al., 1995).

In a heavily developed portion of the Prudhoe Bay oil field, 3 percent of the total area was affected by construction-related thermokarst, and this area appeared to be increasing with time (Walker et al., 1986). Along the ROW, permafrost degradation also is widespread (Brown, 1980; Hickok, 1981; Cuccarese, 1990), but has not been quantified. Most of the thermokarst along the ROW is associated with impoundments and cross-drainage problems. A limited amount of thermokarst was associated with buried sections of the pipeline and affected adjacent terrain, such as at MP 19, 574, and 734 (Thomas and Ferrell, 1983). These features usually were evident within the first few years after burial, and thermokarst was mitigated by filling sinkholes with gravel.

The ecological effects of thermokarst usually include increased thaw depths and soil temperatures, enhanced organic-matter decomposition and nutrient release associated with the increased temperatures, increased moisture, enhanced primary productivity, and shifts in species composition due to changes in soil properties (Ebersole and Webber, 1983; Emers et al., 1995). Thermokarst also is a natural process that is fundamental to plant distribution in many regions.

Ecological responses, however, can be as varied as the ecosystems involved. In the Arctic Coastal Plain and Arctic Foothill ecoregions, impoundments and dust typically cause ice wedges to melt, leading to development of permanent water in polygonal troughs and shifts in species composition to aquatic sedges (Brown, 1980; Ebersole and Webber, 1983; Walker, Cate et al., 1987). Much less information is available on thermokarst along the ROW in other ecoregions. In the Interior Forest ecoregion, impoundments, icings, dust, and clearing have much less effect on thermokarst development because ice wedges and segregated ice in general are less abundant. In the Copper Plateau ecoregion, where glaciolacustrine sediments are fine-grained, ice-rich, and near the melting point, substantial thermokarst has been noted along roads and clearings under powerlines (Ferrians et al., 1969; Péwé and Reger, 1983). Thermokarst associated with VSMs on slopes at Pump 11 Hill (MP 687) and Squirrel Creek (MP 717) are confined to the workpad (Thomas and Ferrell, 1983).

ROW renewal probably will cause few additional impacts. Thermokarst impacts from impoundments, icings, and dust are likely to persist with small amounts of additional settlement, but impacts to new areas should be negligible. Effects of clearings are poorly known, and it is likely that maintenance work could lead to minor thermokarst from changes in surface thermal regimes.

Air Pollution

The pump stations and the VMT emit air pollutants including nitrogen oxides (NO_x), O_3, and SO_2. Numerous studies in other locations have shown impacts of these pollutants on both vascular and non-vascular plants (Treshow, 1970; Nash, 1973; and others). The ambient-impact modeling studies carried out for Pump Stations 2 and 7 for turbine rim cooling in 1990 included an evaluation of impacts of gaseous emissions on the local vegetation (APSC, 1990). No detrimental effects were predicted from the impacts of the modeled air emissions. The 1995 tanker vapor recovery air permit application evaluated impacts to soils and vegetation based on projected emission increases (APSC, 1990). It was determined that it is highly unlikely that there will be significant impacts on soils and vegetation due to project emission increases.

No direct studies of pollutant effects on vegetation near the pump stations or VMT have been conducted. However, Kohut et al. (1994) measured air-pollutant concentrations and their effects on vegetation adjacent to the Prudhoe Bay CCP, where gas-powered turbine pumps compress natural gas prior to injection. The CCP is the oil field's largest source of nitrogen oxides and produces O_3 and SO_2. Emissions from the CCP did not adversely affect local vegetation (Kohut et al., 1994). Results did show an increase in foliar nitrogen near the CCP, but no visible injury to plants was found. Physiological changes (photosynthesis and respiration) in plants were not apparent in either field or growth-chamber experiments for any of the pollutant gases, even at concentrations greater than those measured near the CCP. It is unlikely that pollutant emissions from the pump stations or the VMT exceed those of the CCP, and detrimental effects on vegetation around these facilities would not be expected. However, primary productivity in arctic and alpine tundra is often limited by nutrient supply, particularly nitrogen and phosphorus (Chapin et al., 1980; Chapin and Shaver, 1985; Funk and Bonde, 1986; McKendrick et al., 1978). Fertilizing leads to higher productivity and changes in the structure of arctic plant communities (Chapin and Shaver, 1985; McKendrick, 1997) and may alter carbon balance at the ecosystem level (Billings et al., 1984). Chronic pollution has been shown to have fertilizing effects on nutrient-limited vegetation (Funk and Bonde, 1986). Over a 30-year period, even low-level emissions may provide a nutrient source that alters the productivity of some plant species in communities near the pump stations and VMT, but these emissions are unlikely to have large impacts on nutrient availability.

Fire and Fire Management

Fires along the TAPS ROW are subject to the jurisdiction of various state or federal agencies. The Alaska Division of Forestry provides fire protection and management for the southern half of the ROW, while the northern part is covered by BLM's Alaska Fire Service and the U.S. Forest Service. The Alaska Interagency Fire Management Plan (ADNR, 1999b) provides for a full range of suppression responses from aggressive control that extinguishes the fire to surveillance. Suppression action is based on the fire's threat to human life, inhabited property, designated physical developments, and structural resources such as those designated as National Historic Landmarks, high-value natural resource areas, and other high-value areas such as identified cultural and historical sites. Decisions on fire suppression are at the discretion of the state or federal agency involved. Fires that threaten pump stations receive more control action than most of the pipeline route.

Operation and maintenance of TAPS do not directly affect fire-suppression decisions. Fire is a natural force in the Alaskan Interior, and most forest communities have been extensively influenced by recurring fire (Dyrness et al., 1986). There has been much debate on the effect that fire suppression has on the natural fire cycle, which has been estimated to range from 50 to 200 years (Heinselman, 1978; Yarie, 1981; Dyrness et al., 1986). Gabriel and Tande (1983) suggest that Alaska may still be in a "wilderness fire" stage and that fire suppression has had no pronounced effect on the natural fire cycle.

Oil, Fuel, and Chemical Spills

Responsibility for oil spill monitoring along TAPS has been delegated by EPA to the BLM for federal lands crossed by the pipeline. The Alaska Department of Environmental Conservation was designated to monitor spills on state lands by EPA (BLM, 1984). Most of the spills reported along TAPS occurred on the workpad and were small product leaks. Only a few significantly impacted vegetation.

Information on revegetating oil-damaged sites along TAPS has not been published and is confined to observational comments and photos. Before construction of TAPS, there was much interest and research on oil spill mitigation and revegetation in Alaska and Canada, and controlled experiments were conducted (Wein and Bliss, 1973; Mitchell and McKendrick, 1975). The Alaska oil industry, including Alyeska, sponsored meetings between Alaskan and Canadian researchers to exchange findings and report on progress. The first Joint Canadian-Alaskan Arctic Workshop was held November 6-7, 1974 in Anchorage. The second was held in Banff, Canada, the following year. Subsequently, interest in controlled research diminished, and much of the information available has since been derived from studies of spills. One exception was an ARCO-sponsored experiment on oil recovery from tundra (Cater et al., 1996). With the discontinuance of controlled studies and the Alaska-Canada meetings, progress on oil spill

revegetation research in Alaska has been slower than previously.

One of the first field investigations of spills of opportunity in Alaska was an evaluation of oil spills along the Haines-Fairbanks military pipeline (Richard and Deneke, 1972). Conclusions from observing 15-year-old accidental jet-fuel spills were that plants recovered better in wet drainages than in drier habitats. Authors attributed that to leaching, which removed the contaminant. However, controlled studies lead to conclusions that wet areas are more resistant to oil spills, probably because water perches the oil, preventing it from penetrating deeply into the soil (Walker et al., 1978; McKendrick, 1999a). Reserve pit leaks in NPR-A provided an opportunity for investigation in 1983 (McKendrick, 1986). Subsequent inspections revealed significant recovery of tundra vegetation in leak areas, primarily by hydrophytic sedges and grasses (McKendrick et al., 1992).

The BLM monitored and documented the vegetation recovery on six crude oil spills along TAPS (Table 4.3-9). That report contains photos showing that certain indigenous plants affected in the tundra region and the forest zones were able to recover. Only one site affected by crude oil spills in the BLM monitoring report was seen during the 1999 field evaluation (Check Valve 7) (Table 4.3-9), and the 1999 observers were unaware that a spill had occurred at that location. Apparently, tundra recovery during the 22-year period following the spill was satisfactory (McKendrick et al., 1992).

After inspecting one of the earliest tundra spills, Mitchell (1977) warned that cleanup activities could intensify the damage to vegetation, and recommended that minimal efforts be expended where possible. The BLM observers and L.A. Johnson (1981) reported such was the case at that spill site. Damage from cleanup activities was also intensified at a crude oil spill in the Kuparuk oil field (Cater et al., 1996).

Revegetation

No revegetation project in Alaska has equaled the scope of TAPS revegetation, which was conducted to protect soils from erosion, restore wildlife habitat, and improve visual appearances where vegetation was removed.

Before TAPS, expertise, crucial information, suitable plant materials, and application industries for revegetation were minimal in Alaska. Because the route spanned arctic and subarctic environments, difficulty for planning and review of the proposal by agencies and environmental groups was compounded. It was hoped that the TAPS route could be revegetated with native plant species (Dabbs, 1976; Johnson, L.A., 1981). Research on plants and soils along the route began in 1970 and extends to the present at some locations (Anonymous, 1970; Johnson, L.A., 1981; McKendrick, 1976, 1991, 1997; Mitchell, 1970a, 1970b, 1971, 1973, 1974, 1976, 1978, 1979, 1981, 1982, 1986, 1988; Mitchell and Allen, 1973; Mitchell et al., 1972; Mitchell and McKendrick, 1974; Mitchell et al., 1974; Neiland, 1978; Van Cleve and Manthei, 1973). Studies were conducted along the proposed ROW at Prudhoe Bay and in the Matanuska Valley. Results of these studies and need for commercial seed production in Alaska prompted the state legislature to create a Plant Materials Center in Alaska (Logsdon, 1973).

However, it was not possible to use indigenous plant seed for much of the ROW. The availability of plant materials developed more slowly and in insufficient quantities for project needs. Thus, most of the grass seeds applied were introduced forage, pasture, and turf varieties. Four mixtures were specified for various sections of the route, according to environmental conditions. Grass seed mixtures

Table 4.3-9. *Six crude oil spills monitored by BLM along the TAPS ROW (McKendrick et al., 1992).*

Location Name	Spill Date	Gallons	Cause	Revegetation Action	Photo Record
Check Valve 7	July 19, 1997	75,600	Valve damaged	Mulch + seed + fertilizer	July 19, 1977 July 11, 1988
Check Valve 68A Washington Creek	October 11, 1977	3,700	Valve not tight	Unknown	August 1978 July 9, 1986
Steele Creek	February 15, 1978	672,000	Sabotage	Burned, buried, seeded 1981-82	February 15, 1978 June 10, 1986
Atigun Pass	June 10, 1979	221,200	Pipe cracked	Hydroseeded 1979	June 1983(?) August 5, 1986
MP 734	July 15, 1979	168,000	Pipe cracked	Seeded & fertilized Proposed burial	June 1979 June 14, 1988
Check Valve 23	January 1, 1981	84,000[a]	Valve failed	Applied 300 lb/a	January 1981 July 12, 1988

(a) From JPO records. Alyeska records indicate that the spill volume was 63,000 gallons.

included: *Agrostis alba* (creeping bentgrass or redtop), *Alopecurus pratensis* (meadow foxtail), *Arctagrostis latifolia* (polargrass; indigenous selection), *Bromus inermis* (smooth brome), two varieties of *Festuca rubra* (red fescue; one indigenous selection), *Festuca ovina* var. *duriuscala*, *Lolium multiflorum*, *Phleum pratense*, and two varieties of *Poa pratensis* (bluegrass; one originating in Alaska). Hultén (1968) listed *Poa pratensis* as an introduced weed to Alaska, even though it is a major turf grass in this state. These mixtures were modified slightly in 1977 (Johnson, L.A., 1981). *Poa glauca* (glaucous bluegrass), *Deschampsia beringensis*, and *Calamagrostis canadensis* (bluejoint) were added to, and *Agrostis alba* and *Poa pratensis* were removed from, the arctic seed mix in 1984 (McKendrick et al., 1992). Modified mixtures are now used where pipeline maintenance disturbs vegetation along TAPS.

Concerns were raised over introducing weeds and exotic plant species along TAPS. The bulk of the grass seed was produced outside Alaska, in Canada, Oregon, and Washington (Johnson, L.A., 1981). Straw and hay mulches were applied. The imported seed and mulches were likely sources for exotic species. L.A. Johnson (1981) and Johnson and Kubanis (1980) reported on the presence and distribution of weeds along TAPS. During the summer of 1999, locations along the ROW were investigated for presence of weeds (Table 4.3-10) (McKendrick, unpubl. data). Most exotic species were seeded grasses, with *Festuca rubra* the most common and widely distributed. Broad-leaved weeds (forbs) were most common in the Interior from about MP 250 south. Numbers of exotic species were elevated in the vicinity of settlements such as Fairbanks and Delta Junction, where agriculture and landscaping are practiced, suggesting introductions on the ROW were related not only to revegetation practices, but also to the surrounding human activities.

None of the plants found is classified as a noxious weed. Species that L.A. Johnson (1981) specifically mentioned as possible problems were: *Chenopodium album* (pigweed) and *Bromus tectorum* (cheat grass) (both exotics), and *Corydalis sempervirens* (rock harlequin) and *Senecio congestus* (marsh fleabane) (both indigenous). During the 1999 survey, *Chenopodium album* was found at two sites near Delta Junction. *Bromus tectorum* (cheat grass) and *Senecio congestus* were not observed at any of the locations in 1999; however, it has been observed as a common pioneer in wet areas along the Dalton Highway and was recorded at the Franklin Bluffs pad in 1987 (McKendrick et al., 1992). *Corydalis sempervirens* was found in one location, a recent black spruce forest burn next to the ROW on

Table 4.3-10. *Numbers of graminoid and forb "weeds" and/or introduced vascular plant species found at each of 52 locations along the TAPS ROW during July-September 1999 survey (McKendrick, unpubl. data).*

Pipeline	Latitude		Number of Species		
			Weeds		
MP	Degree	Minute	Graminoids	Forbs	Total Weeds
0.25	70	1.5	1		1
16.00	70	2	2		2
31.00	69	49	2		2
58.70	69	30	1		1
69.00	69	19	1		1
85.00	69	5	1		1
100.00	68	53	1		1
119.70	68	40	1		1
139.60	68	28	1		1
154.00	68	17	1		1
163.40	68	11	1		1
165.10	68	8	2		2
166.00	68	7	2		2
168.50	68	6	2		2
173.70	68	2	2		2
176.50	68	1	1		1
188.00	67	52	2	1	3
190.00	67	51	1		1
208.30	67	36	2		2
226.00	67	24	1		1
245.40	67	9	3	2	5
258.25	66	59	2	2	4
276.00	66	47	3	2	5
299.70	66	29	2	1	3
322.60	66	12	2	1	3
346.90	65	55	3	3	6
360.20	65	50	3	5	8
396.00	65	29	4	5	9
406.00	65	23	5	5	10
412.30	65	19	4	6	10
420.60	65	10	4	5	9
438.70	65	2	3	0	3
441.80	65	1	3	7	10
461.00	64	49	3	2	5
489.20	64	33	4	5	9
521.10	64	15	3		3
542.00	64	1	3	3	6
547.70	63	56	1	3	4
559.40	63	47	1	1	2
587.50	63	23	2		2
599.00	63	15	1		1
606.50	63	12		1	1
613.40	63	5	2	1	3
639.80	62	43	3		3
654.80	62	31	2	4	6
685.15	62	6	2	3	5
688.90	62	2	3		3
709.70	61	47	2	1	3
724.60	61	35	2	3	5
745.20	61	22	3	2	5
769.00	61	11	3		3
777.50	61	6	4	4	8

Ft. Greely.

Concerns have also been raised over the possibility that grasses seeded to the ROW and other disturbances may interfere with the recovery of natural vegetation on such sites (Johnson, L.A., 1981; Cargill and Chapin, 1987; Densmore et al., 1987; Densmore, 1992; McKendrick, 1997; Strandberg, 1997; Forbes and Jeffries, 1999). That was apparent along the ROW in 1999 (McKendrick, unpubl. data). Generally, native plant invasion was greater in locations where seeded grasses failed to persist. In the Arctic, *Festuca rubra*, *Arctagrostis latifolia*, and *Poa glauca* often prevail over indigenous plant species. In the Subarctic, *Festuca rubra*, *Alopecurus pratensis*, *Bromus inermis, and Phleum pratense* (alpine timothy) will endure and prevent natural reinvasion. Indigenous graminoids can also dominate open ground and prevent other species from recolonizing. *Calamagrostis canadensis* often slows the return of trees and browse species in the mixed forests of the Interior and coastal regions.

For the TAPS ROW, however, the effects of seeding introduced grasses, applications of fertilizer — which also redirect natural succession — and construction of a drier, gravelly workpad (Table 4.3-11) cannot be individually distinguished. Thus, it is impossible to quantify effects of these factors on natural species reinvasion. The 1999 survey of the ROW shows that at least two introduced species in the seed mixtures [*Agrostis alba* and *Lolium multiflorum* (Italian ryegrass)] failed to persist and were least likely to alienate natural species from the ROW. *Poa pratensis* failed to persist when seeded to abandoned drilling pads in NPR-A (McKendrick, 1987). This suggests that revegetation research objectives would better serve projects such as TAPS if the species selected established readily to control erosion, but are either short-lived or poorly adapted to the environment and thereby noncompetitive to indigenous species. Examples of such species for the Prudhoe Bay region are the arctic alkali grasses *Puccinellia arctica* (*P. borealis)* (McKendrick, 1987, 1991) and *Puccinellia langeana.*

Vegetation along the ROW from Atigun Pass south has often been dominated by the reinvasion of native shrubs and trees, including alder, willow, blueberry, soapberry, dwarf birch, cottonwood, paper birch, spruce, and at some locations, larch. Since this invasion of woody plants has created a maintenance problem for the safe operation of the pipeline, the ROW is periodically cleared of brush. In locations near Fairbanks, the cut brush has been observed to regrow as much as 3 ft (1 m) during the balance of the growing season, if cut in spring (Duncklee, 1999, pers. comm.). Seeding of a persisting herbaceous cover to prevent invasion by tall shrubs and trees in that ecoregion appears desirable for the safe operation of the pipeline.

Soil conditions were altered in the ROW with the application of soil and gravel to provide a firm surface for construction and maintenance operations. With respect to vegetation, this fill created a drier and more rocky substrate with less total carbon and nitrogen (Table 4.3-11). Applications of fertilizer were still apparent in levels of available phosphorus (P) and potassium (K) in 1999, more than 25 years since construction began. Nitrogen applications were no longer apparent in the soil tests. Even though the substrate was markedly altered throughout much of the ROW, recolonization of natural vascular plants was apparent in varying amounts throughout. Cryptogams (mosses, liverwort, and lichens) had also colonized, particularly in the boreal zone, accounting for part of the organic mat accumulation recorded in the 1999 survey (Table 4.3-11).

Most of the land disturbed during TAPS construction was seeded to grasses to control soil erosion, including thermokarst in permafrost zones. In some areas, trees were transplanted to screen the view of disturbances from roadways (Johnson, L.A., 1981), and willow cuttings were used to create wildlife habitat at several locations in 1977 and 1978. Rooting potentials for *Salix alaxensis, S. novae-angliae, S. scouleriana, S. glauca*, and *S. bebbiana* were

Table 4.3-11. *Means from 49 locations along TAPS (July-September 1999) from within the ROW (either under elevated or over buried pipe) and adjacent control sites. Standard errors are given in parentheses. Upper 15 cm (6-in) of soil beneath organic mat were sampled and analyzed in Alaska Agricultural & Forestry Experiment Station Laboratory, Palmer, AK. Thickness of surface organic mat was recorded. Fifty-two locations were examined, and three had no soil to sample.*

Soil Moisture (%)		Gravel (%)		Organic Mat Thickness (cm)		Total Carbon (%)		Total Nitrogen (%)	
ROW	Control	ROW	Control	ROW	Control	ROW	Control	ROW	Control
9.2 (.782)	62.1 (13.651)	60.3 (2.061)	19.1 (3.254)	2.0 (.205)	12.6 (1.226)	1.7 (.201)	5.4 (.852)	.056 (.007)	.236 (.039)

pH		Available NH_4-N		Available NO_3-N		Available P		Available K	
ROW	Control	ROW	Control	ROW	Control	ROW	Control	ROW	Control
7.45 (.131)	6.40 (.151)	1.4 (.245)	0.9 (.286)	1.4 (.236)	1.6 (.277)	8.2 (2.394)	7.6 (3.208)	39 (3.325)	33 (3.533)

tested by Densmore and Zasada (1978). The use of non-rooted cuttings was reported to have been more successful than rooted cuttings (Johnson, L.A., 1981); however, there were other complicating factors that may have been as much or more influential than whether or not cuttings were rooted. In 1999, a vigorous stand of *Salix alaxensis* at MP 122 in the Saganavirktok River channel was observed and photographed. This planting is part of a long-term monitoring of large-scale willow reintroduction (Zasada et al., 1981).

L.A. Johnson (1981) reported that Alyeska transplanted trees and shrubs at select locations where the pipeline crossed roads and material sites were particularly visible. Species included *Betula papyrifera* (paper birch), *Picea glauca* (white spruce), *Picea mariana* (black spruce), *Populus tremuloides* (quaking aspen), willow, and alder. Most obvious to the public were the staked spruce (*Picea* spp.) transplants at pipeline crossings. These stands can still be observed.

Following construction and seeding of the ROW, the industry and agencies measured revegetation success by estimating plant canopy cover, which included litter and standing dead. Plant vigor was also rated. The target cover was reduced where soils were obviously limiting vegetation in natural communities and in those remaining after disturbance (Alaska Pipeline Office, 1978; Johnson, L.A., 1981). Roads used for pipeline maintenance and operation were also excluded from revegetation criteria.

Fertilization was considered necessary to encourage rapid establishment of plants on the open soil and to control erosion. Surface soils were extensively sampled along the route and analyzed to evaluate nutrient status before construction (Johnson, L.A., 1981). Fertilizers were formulated to supply macro- and micronutrients according to information acquired from those laboratory data and short-term tests (Van Cleve and Manthei, 1973). Where seedlings were not developing quickly, fertilizer containing only the macronutrients was applied again. Just as there was a necessary compromise between species desired and those available for seeding, so too there was a compromise on fertilizer use. Practically no correlation data existed among laboratory soil tests, fertilizer applications, and indigenous plant responses in Alaska at the time the pipeline was built. Consequently, fertilizer formulations were based on correlations derived from temperate-zone agricultural production. Furthermore, the soils on the surface following construction were often subsoils and geologic rubble (gravel). How their nutrient-supplying capacities related to the surface soils which were sampled and used to derive fertilizer recommendations is entirely unknown. Most likely, their nutrient status differed markedly from those soils which were sampled and tested.

There were incidences of erosion even on seeded areas. These occurred primarily in cuts where slopes failed (Johnson, L.A., 1981). It is impossible to know whether or not the grass seedings were effective in limiting the extent of that erosion or not, because there were no controls for comparison. No serious erosion problems related to the pipeline construction and operation were observed in the 1999 survey. The only erosion that presented a significant risk to the elevated pipe was actually a natural landslide in the Atigun Canyon. High amounts of precipitation in the mountains created rock and mud slides that carried debris including large boulders down side canyons. The mass moved down the alluvial fan, across the Dalton Highway, and under the elevated pipe. This type of erosion has been periodically observed in the Atigun and Dietrich valleys since TAPS construction, and may occur any time during summer.

4.3.2.3 Fish

By R. Fechhelm and L. Moulton

Impacts on fish and their habitat can occur from continued operation and maintenance of TAPS as a result of a number of activities that can potentially alter habitat or water quality. These impacts fall into four general categories: (1) obstructions to movement, (2) habitat alteration or loss, (3) mortality, or (4) overharvest.

Obstructions to Movement

Obstructions to fish movement are most common when culverts or low-water crossings are not properly sized to allow passage at the desired migration time (Gustafson, 1977; Rockwell, 1978; Elliott, 1982). Movement can be obstructed at either high or low flow (Elliott, 1982). Elliott (1982) investigated stream crossings and channel modifications in the Atigun River in 1980 and described a number of fish passage problems associated with culvert placement and design. DenBeste and McCart (1984a) concluded that most of the passage problems were from pipeline construction, with substantially fewer problems during pipeline operation. However, in low-water crossings, vehicular traffic causes rutting and accumulation of cobbles that can interfere with fish passage during low flow. Low-water crossings, which were identified as creating passage problems early in construction (Gustafson, 1977; Rockwell, 1978), continue to be an issue (Brna, 1999, pers. comm.; Montgomery, 1999, pers. comm.).

Obstructions to fish movement can occur where work in

active channels, such as instream gravel mining, spread flow or cause flow to go subsurface (Woodward-Clyde Consultants, 1980; Elliott, 1982). Such a loss of surface flow occurred at the Atigun River where flow went subsurface into the pipeline trench, which was buried in the active floodplain (Elliott, 1982). These obstructions to movement were recognized either during the construction phase or early in operation and have been addressed with subsequent permitting and monitoring.

Activities that can obstruct movements are reviewed under the ADF&G Title 16 and Fish Habitat permit processes. ADF&G issues notices of permit violations when a passage problem is identified, at which time Alyeska corrects the problem (Brna, 1999, pers. comm.). Effective use of these review processes has minimized, and will likely continue to minimize, obstructions to fish movement along TAPS (SPCO, 1993, 1995).

Habitat Alteration or Loss

Habitat alteration from erosion and siltation during pipeline construction and maintenance was recognized early as potentially having the greatest impact on fish habitat (FWS, 1970). Sedimentation occurred from instream gravel mining during pipeline construction (Woodward-Clyde Consultants, 1980). Erosion of workpads may also increase sedimentation, which in turn affects the productivity of streams crossing the pipeline alignment (DenBeste and McCart, 1984a). Increased sediment can reduce levels of invertebrate prey species and can affect fish spawning success and egg survival. Introduction of fine materials into spawning gravels can adversely affect incubating eggs and alevins.

In some cases, habitat alteration may provide some benefit to aquatic systems. For example, at MP 47, a spur dike caused a scour pool that added overwintering habitat in the Sagavanirktok River (Martin et al., 1993). Increased overwintering habitat in pits created by gravel mining in inactive floodplains has been well-documented (Woodward-Clyde Consultants, 1980; Hemming, 1993, 1994, 1995).

During operation and maintenance of TAPS, there has been progressive restoration of stream banks and erosion control (Thompson, 1999, pers. comm.). Effective use of the ADF&G permit review processes will likely continue to minimize habitat alteration and loss along TAPS (SPCO, 1993, 1995).

Anadromous fish species may be affected by deposits of airborne pollutants onto surface waters that can be subsequently dissolved into the water column. The ambient-impact modeling studies carried out for TAPS Pump Stations 2 and 7 for the addition of turbine rim cooling in 1990 included an evaluation of impacts of gaseous emissions on nearby wildlife species (APSC, 1990). Air quality effects on anadromous fish streams were examined for the Sagavanirktok and Chatanika rivers. The Sagavanirktok is approximately 1/8 mile east of Pump Station 2, while the Tatalina River (a tributary to the Chatanika) is approximately 1.6 miles north of Pump Station 7. The Tatalina flows into the Chatanika approximately 50 miles southwest of the pump station. The levels found in modeling studies carried out for the pathway of deposition of the main criteria pollutants NO_X and SO_2 for both river systems were below EPA screening levels. The studies did not predict significant impacts on existing anadromous fish species.

Mortality

Direct mortality is a potential impact when overwintering habitat is altered or lost, when flow is altered, or water quality degraded. Overwintering has been identified as the most critical life stage for fish inhabiting arctic and subarctic freshwater environments (Power, 1997; Reynolds, J.B., 1997; Moulton and George, 2000). Because overwintering areas are scarce in many river systems, mortality to a large segment of the fish population in a stream system can result when flow is diverted from an overwintering area or water quality is degraded by increased turbidity or toxic materials. Potential effects to overwintering areas were identified as concerns during Sagavanirktok River flood repairs and corrosion digs in 1993 and 1994, Dietrich River spur dike construction, and Phelan Creek corrosion digs in 1993 (SPCO, 1993, 1995).

Entrapment during low summer flow is another source of mortality associated with pipeline construction and maintenance. Entrapment occurs where decreasing flow strands fish in isolated pools, which can then dry out, become too hot to support fish, or freeze during winter. Flow often becomes discontinuous when the stream bed is disturbed by activities that increase porosity or spread flow. Gravel mining in active floodplains has been found to lead to entrapment (Woodward-Clyde Consultants, 1980; Elliott, 1982; DenBeste and McCart, 1984a).

Another source of entrapment is the attraction of fish to water heated by the pipeline. In these cases, the pipeline buried in an active floodplain heats subsurface water. The water emerges at a higher temperature than the receiving water, and fish are attracted during fall as they search for overwintering areas (DenBeste and McCart, 1984a). Mortality occurs when water freezes during the following winter or the pools become anoxic. Thermal irregularities were found in the Atigun, North Fork Chandalar, Dietrich, and

Middle Fork Koyukuk rivers. DenBeste and McCart (1984a) concluded that small numbers of fish were being lost in those streams where extensive instream pipeline burial caused such thermal irregularities.

Oil and Chemical Spills. Potential sources of spills during pipeline maintenance and operation include fuel spills from vehicles, spills of various chemicals used at the pump stations, and spills of crude oil from the pipe itself. Oil spills have a range of effects on fish depending on the concentration of oil present, the length of exposure, and the life-history stage of the fish involved (Starr et al., 1981; Hamilton et al., 1979; Malins, 1977; Neff and Stubblefield, 1995; MMS, 1996a). Fish eggs, larvae, and juveniles are the most sensitive life-history stages. Mortality caused by petroleum is seldom seen outside the laboratory, and most acute toxicity values for fish are on the order of 1 to 10 ppm (BLM and MMS, 1998). Even during the *Exxon Valdez* spill, the concentration of oil in water was not sufficient to cause fish mortalities (Neff and Stubblefield, 1995). Sublethal effects may include changes in growth rates, feeding, fecundity, and survival rates, as well as reductions in food resources and consumption of contaminated prey (BLM and MMS, 1998). Temporary displacement may occur through interference with movements to feeding, overwintering, or spawning areas.

Most oil and chemical spills are small and confined to workpads where they would not impact fish. A large off-pad spill to water could have lethal or sublethal effects on fish and their food resources in the immediate spill area. Effects would be greatest if the spill occurred where and when fish were migrating, in overwintering areas while fish were present, or in small waterbodies with restricted water exchange. A spill of sufficient size under the above conditions would be expected to have lethal and sublethal effects on most of the fish present. BLM and MMS (1998) suggested that recovery of a small waterbody with restricted water exchange would take more than 5 years. Water with high exchange rates would recover more quickly, although flushing of contaminated water would impact a greater area with lower concentrations of oil.

Overharvest

Potential overharvest of fish populations by humans was identified as an issue early in the original TAPS evaluation process (FWS, 1970). Overharvest can occur when access is provided to desirable resources and fishing regulations and enforcement do not adequately control harvest. Developments in remote areas, such as the TAPS ROW and associated road, can allow access to previously unavailable harvest opportunities, and concern was expressed that such access may lead to excessive harvests (FWS, 1970). The problem is magnified in northern areas because productivity is low and populations are more susceptible to excessive harvest. BLM and USACE (1988) state that sport fishing pressure has increased since construction of the TAPS haul road (now the Dalton Highway) and that fish are smaller and less numerous than before road access. Issues regarding overharvest of fish on the North Slope are described in detail in the cumulative effects section of this document (Section 4.5).

4.3.2.4 Birds

By B. Anderson, R. Day, S. Johnson, R. Ritchie, and D. Troy

The effects of the proposed action on birds can be grouped into the following general categories:

- Obstructions to movements by the ROW and pipeline, activities at pump stations, and during maintenance along the pipeline and, at the northern end of the corridor, by TAPS-related vehicular activity on the Dalton Highway;
- Disturbance and/or displacement of birds by operational or maintenance activities (e.g., vehicular traffic, human activity, noise);
- Habitat loss, alterations, or enhancement from operational or maintenance activities;
- Mortality or injury associated with operational or maintenance activities, including oil spills; and
- Changes in harvest of game species associated with the TAPS ROW, primarily via increased hunter access.

Obstructions to Movements

The pipeline, associated facilities, and access roads along the TAPS ROW do not obstruct bird movements because birds can fly. There is no evidence that TAPS has caused population reductions in birds. Collisions of birds with pipelines or TAPS facilities are rare. The elevated pipeline, facilities, or roads would possibly act as barriers to movement only when birds are flightless, such as waterfowl during molt and brood rearing. Roads can temporarily obstruct movements of brood-rearing waterfowl in the North Slope oil fields when traffic levels are high (>10 vehicles/hr; Murphy and Anderson, 1993), but long-term studies have shown that molting and brood-rearing Snow Geese are not affected by roads and pipelines (Johnson, 1998). Elevated pipelines adjacent to roads appear to have little effect on movements of brood-rearing waterfowl in the oil fields (Murphy and Anderson, 1993). In 1987, brood-rearing Snow Geese showed some "initial hesitancy"

in crossing under the new Endicott pipeline (Burgess and Ritchie, 1991). The birds became habituated, and this reaction disappeared in later years as these long-lived birds repeatedly encountered the pipeline and adjacent roads while using their traditional brood-rearing areas (Johnson, 1998; Burgess, 1999, pers. comm.). Disturbance reactions by birds, which may affect local movements, probably do not apply to the TAPS pipeline because it has been in place for over 20 years. The cited studies suggest that in the absence of traffic on adjacent roads, most elevated pipelines do not affect bird movements.

Disturbance and Displacement

Equipment noise, vehicles, pedestrians, aircraft operations, boats associated with spill response drills, and other maintenance and operation activities of TAPS could result in some disturbance of birds near facilities. Disturbance due to pipeline construction may have reduced nest densities near Franklin Bluffs on the northern end of the TAPS ROW (Hanson and Eberhardt, 1982). Scheduling of most construction activities during winter would minimize disturbance and mitigate most impacts on birds. Most bird species along TAPS are not residents and few birds are present in winter. Exceptions include resident Gyrfalcons near traditional nesting sites, ptarmigan, grouse, and ravens.

At the northern end of the TAPS ROW, disturbance from operations at pump stations is similar to the well-documented effects of oil field operations (Hampton and Joyce, 1985; Woodward-Clyde Consultants, 1985; Anderson et al., 1992; Burgess and Rose, 1993; Murphy and Anderson, 1993; TERA, 1993b; Troy, 1993). Vehicles are the most ubiquitous source of disturbance, but are less disturbing than humans on foot or natural predators (bears, foxes or gulls). The level of disturbance increases with increasing traffic rate and the numbers of large, noisy vehicles (and those with unusual profiles such as boom cranes) (Murphy and Anderson, 1993). Most human disturbance occurs close to roads and pads. In the Lisburne Development Area at Prudhoe Bay, most reactions of geese and swans occurred within 500 to 700 ft (150 to 210 m) of pads and roads (Murphy and Anderson, 1993). The greatest disturbance occurred within 600 ft (180 m) of roads when traffic exceeded 6 vehicles/hr, although less than 1 percent of all vehicles elicited reactions from geese and swans (Murphy and Anderson, 1993).

Based on these findings, traffic-related disturbance would be highest for waterfowl and other birds using habitats within 700 ft (210 m) of the pump stations and within 500 ft (150 m) of access roads and the Dalton Highway. South of Fairbanks, most traffic is on the Richardson Highway (the closest adjacent road) and is not related to TAPS. Although some disturbance would occur from TAPS traffic related to the proposed action, the incremental contribution would be small. Disturbance effects at the pump stations in this region would be similar to those reported above, although the magnitude probably would be lower due to sound dampening by the taller vegetation found in Interior Alaska.

Continued brush clearing along the TAPS ROW would cause short-term disturbance of birds in the immediate vicinity and would displace nesting birds that use shrub vegetation. This disturbance may cause nesting birds to shift into adjacent undisturbed habitats. Disturbance and displacement of birds in the immediate area of the clearing operations also could occur from the high noise levels and visual impacts of humans and equipment removing brush along the ROW. The magnitude of this impact would be moderate to severe in the short term for passerine birds nesting in the habitats being cleared, but the low frequency of this activity and its short duration would minimize its impact on most birds. Adjusting the seasonal timing to avoid the early summer nesting period of most birds could mitigate brush-clearing impacts.

Potential disturbance effects on birds also could occur from the regular (about once a week) helicopter surveillance flights along the TAPS ROW by Alyeska Security at approximately 500 ft (150 m) above ground level. Most studies of aircraft disturbance in the Arctic have focused on low-flying helicopters (LGL, 1974; Barry and Spencer, 1976; Simpson et al., 1982; Ritchie, 1987; Derksen et al., 1990, 1992). Some waterfowl species, such as Brant and Snow Geese, are more sensitive to disturbance by helicopters, particularly at altitudes less than 800 ft (240 m), than are other geese (Canada and Greater White-fronted Geese) and other birds species groups (LGL, 1974; Derksen et al., 1992; Murphy and Anderson, 1993; Ward et al., 1994). Other studies on the North Slope have shown that some species of nesting and molting ducks may be displaced by disturbance (Johnson, 1982, 1983, 1984, 1990a, b, 2000b). The visual and auditory impacts of helicopter overflights on birds inhabiting forest habitats along TAPS would be mitigated to some extent by the visual and sound barrier provided by surrounding vegetation. The low frequency and short duration of surveillance flights and the potential habituation by some birds would also mitigate these impacts.

Chronic disturbance by human activities at facilities may cause adjacent habitats to be less attractive to some birds. This change is less an immediate behavioral reaction to noise than a long-term reduction of bird use in areas exposed to constant disturbance. Early studies of noise effects on birds in the Arctic found that simulated compressor noise did not affect nesting Lapland Longspurs (Gollop and Davis, 1974a), but decreased habitat use by fall-staging Snow Geese (Gollop and Davis, 1974b). More recently, a study of the effects of increased noise at the Central Compressor Plant in the Prudhoe Bay oil field found that Spectacled Eiders and pre-nesting Canada Geese were displaced from habitats near noise sources (Anderson et al., 1992). Most species, including nesting Canada Geese and brood-rearing Brant, habituated to the noise levels (Anderson et al., 1992). Other studies (Johnson et al., 1987) showed that mitigation greatly reduced disturbance impacts on eiders. A study to quantify the effect of a new processing facility (CPF-3) in the Kuparuk oil field provided equivocal results (Hampton and Joyce, 1985). However, the Brant nesting colony located approximately 0.5 mi (0.8 km) from CPF-3 has not been affected adversely by the constant noise from the facility, and this nesting location has been used continuously since operation began (Stickney et al., 1994; Anderson et al., 1995, 1996). Because facilities along TAPS have been operating for over 20 years, most birds using adjacent habitats probably have habituated to the noise.

Habitat Loss, Alteration, and Enhancement

Thick gravel fill used for most workpads and roads in the TAPS ROW covers some wildlife habitats. New placement of gravel fill during the next 30 years is expected to be minimal. Studies in the Prudhoe Bay oil field suggest that birds, particularly shorebirds, that lose nest sites to gravel placement are not prevented from nesting in subsequent years, but shift their nesting efforts to adjacent undisturbed habitats (Troy and Carpenter, 1990). Given the relatively small area that would be covered by newly placed gravel, the direct effects on bird populations of gravel placement are expected to be minor.

Bird use of habitats adjacent to the Dalton Highway and pump stations could be affected by dust fallout, gravel spray, persistent snowdrifts, impoundments, thermokarst, contaminants, and water withdrawal. The magnitude of these impacts depends on habitat type, volume of ground ice, and hydrologic regime (Brown and Grave, 1979; Walker, Webber et al., 1987). Temporary loss of habitats along TAPS would occur from ground-impacting activities (primarily trenching) associated with pipeline corrosion maintenance and testing (<1 ha/yr), cathodic protection monitoring and remediation (~0.5 to 5 ha/yr), and installation of "coupons" for testing cathodic protection (no estimate of area affected, but substantially less than that for corrosion maintenance; see Section 2.2). Temporary habitat losses also occur from delayed snowmelt in areas where snow is dumped or compacted during winter maintenance activities. The effects of delayed snowmelt would be confined primarily to the first growing season following use, whereas the effects of vegetation compaction may persist longer. Changes in timing of snowmelt are a function of the amount of traffic-generated dust; early melt is the rule along the Dalton Highway, but persistent snowdrifts occur along the pipeline. At TAPS MP 12, persistent snowdrifts occupied a 250-m-wide band along the pipeline, precluding nesting by all but late-nesting birds (Hanson and Eberhardt, 1982). These indirect impacts affected 3.5 times as much breeding habitat as the footprint of the pipeline, workpad, and access road in their study area (14 ha vs. 4 ha; Hanson and Eberhardt, 1982). TERA (1993b) found that dusting by light traffic could have beneficial effects on birds and bird habitats by counteracting the snowdrift effect without increasing disturbance or other indirect effects associated with higher traffic loads. The small geographic extent of these temporary losses would limit their impacts on birds and bird habitats along TAPS.

Dust fallout from gravel structures can advance snowmelt by up to 2 weeks along the downwind side of roads and pads. The magnitude of dust effects depends on traffic intensity and the distance from the source, and is greatest within 35 ft (10.5 m) of the road or pad (Everett, 1980; Walker and Everett, 1987). Advanced snowmelt in dusted areas also occasionally results in impoundment of runoff and can lead to early green-up of plant species (Makihara, 1983; Walker and Everett, 1987). In spring, open water and available plants attract waterfowl, shorebirds, and ptarmigan to habitats near roads (Walker and Everett, 1987; Murphy and Anderson, 1993; Noel et al., 1996). These areas provide early access to forage but increase exposure to traffic-related disturbance and potential vehicle strikes. Near the Lisburne Development, snow-free areas near roads supported large numbers of foraging geese and swans during pre-nesting, although birds moved away from roads to rest and sleep (Murphy and Anderson, 1993). However, high bird use of dust shadows does not carry over into the breeding season. Nesting density in the Dalton Highway dust shadow was approximately half that in the rest of a study area at Franklin Bluffs (Hanson and Eberhardt, 1982).

The presence of birds in the dust shadow and the availability of perches (e.g., snow depth markers, road markers and signs, pipeline and VSMs) also attracts predatory birds to the road, including Golden Eagles, Rough-legged Hawks, Short-eared and Snowy owls, Gyrfalcons, and Peregrine Falcons. This increases the risk of vehicular collisions. Some species (e.g., Rough-legged Hawk) have

nested in this dust shadow because earlier snowmelt provided a substrate for nesting while the rest of the tundra was still snow-covered (Ritchie, 1991).

Water impounded by gravel roads and pads along the northern end of the TAPS ROW displaces or attracts birds, depending on the species (Hohenberger et al., 1981; Kertell and Howard, 1992; Kertell, 1993, 1994; Troy, 1993; Noel et al., 1996). Impoundments can be temporary, disappearing by mid-June, or can persist through the summer. Temporary impoundments eliminate habitat for ground-nesting birds (Walker, Webber et al., 1987; Noel et al., 1996), but create and enhance feeding habitat for other birds (Kertell, 1993, 1994; Troy, 1993; Noel et al., 1996). Troy (1993) found that some shorebirds and Lapland Longspurs avoided a 330-ft-wide (100-m) zone along the West Road in the Prudhoe Bay oil field, whereas other shorebirds and Snow Buntings (this species nests in pipeline supports) were more abundant than expected. These changes were attributed to impoundments adjacent to the road, early availability of some habitats because of the dust shadow produced by traffic, and reduced habitat availability from persistent snowbanks created by snow removal and drifting (Troy, 1993). Most of these impacts have been or can be reduced by ensuring cross-pad drainage to reduce development of permanent impoundments, but temporary impoundments would likely occur each spring (Noel et al., 1996).

For several bird species, the Dalton Highway has resulted in habitat enhancement by creating a dust shadow that initially provides open water and ground for use during spring arrival and later, early green-up for nesting birds, as discussed above. Also, TAPS and oil field facilities have provided structures for nests and perching and resting sites for birds such as ptarmigan and raptors. Semipalmated Plovers nest on gravel pads and disturbed roadsides at Prudhoe Bay. This species occurs along the entire TAPS ROW and likely makes use of workpads throughout the length of TAPS. On the North Slope, Baird’s Sandpiper and Ruddy Turnstone colonize areas of tundra disturbances (Troy, 1991; Troy and Carpenter, 1990) and may do so along the northern portion of TAPS. At the northern end of TAPS, the pipeline and VSMs are used for nesting by Gyrfalcons, Common Ravens, and Snow Buntings (Ritchie, 1991). Along the middle and southern sections of the ROW, Cliff Swallows construct nests on the pipeline and on nearby facilities (turbine buildings; Shoulders, 1999, pers. comm.), and an American Kestrel has nested on a check valve (Lawlor, 1999, pers. comm.).

The removal of brush in the ROW probably has affected the relative numbers of various species, increasing habitats for some species and reducing habitats for others. For example, the presence of low shrub or grassy habitats in forested regions provides habitats for some sparrow species (e.g., Savannah Sparrow) that might not otherwise occur in the area. Conversely, the loss of tall shrub and forested habitats probably reduces populations of birds associated with these habitat types (e.g., Varied Thrush).

Mortality

Along the TAPS ROW, bird mortalities directly associated with the pipeline and facilities have been relatively few, consisting of an occasional collision of birds with the pipeline or with facilities (Shoulders, 1999, pers. comm.). Another minor source of mortality was deaths of swallows drawn into pump station turbines (Shoulders, 1999, pers. comm.) This source of mortality has been limited by putting screens on turbines at pump stations and by removing nests (with federal permits) from turbine areas. The largest identified source of bird mortality associated with the TAPS ROW is road kills along the Dalton Highway (Brown, D., 1999, pers. comm.; Schmidt, 1999, pers. comm.; Shoulders, 1999, pers. comm.). Ptarmigan, grouse, and passerines are the primary species groups killed by vehicle collisions. Although numbers of individuals are not known, total mortality is likely low compared to area populations of these species. These collisions occur mainly in the north where the Dalton Highway dust shadow causes early snowmelt that attracts birds close to the road. Raptors have infrequently been identified as collision victims along the Dalton Highway, primarily in the north (Ambrose, 1999, pers. comm.). Raptors that hunt along the road and dust shadow, including Rough-legged Hawks, Northern Harriers, and Short-eared Owls, would be most susceptible to collision with vehicles. Mortality due to early fledging of young raptors or increased predation from human disturbance of nests has not been reported along TAPS.

Increased predation due to larger predator populations because of anthropogenic food sources is also an indirect effect for some birds, primarily tundra-nesting waterfowl, shorebirds, and passerines (Truett et al., 1994; Day, 1998; Johnson, 2000a, b). Impact levels are inferred from the higher number of foxes and increased density of fox dens, (Eberhardt et al., 1982; Burgess and Banyas, 1993; Burgess, Rose et al., 1993) and higher numbers of brown bears (Shideler and Hechtel, 1995), gulls, (Murphy et al., 1987), and ravens (ABR, Inc., unpubl. data) in the oil fields now compared to 20 to 30 years ago and compared to undeveloped areas on the North Slope today. Gulls and ravens prey on bird eggs and young; foxes prey on birds and their eggs and small mammals; and bears prey on caribou, muskoxen,

ground squirrels, and ground-nesting birds (primarily colonial nesting waterfowl). Along TAPS, proper garbage handling at pump stations, worker education, and disciplinary actions to eliminate feeding of wildlife have substantially reduced this impact (Montgomery, 1999, pers. comm.; Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.).

Oil Spills

Birds exposed to spilled oil usually do not survive moderate to heavy contact. Oil ingestion during preening or feeding may impair endocrine and liver function and may reduce breeding success and nestling growth (King and Lefever, 1979; Peakall et al., 1980; Harvey et al., 1982; Holmes, 1985; Holmes and Cavenaugh, 1990; Hughes et al., 1990; Burger and Fry, 1993; Stubblefield et al., 1995). Egg contamination by adults can significantly reduce hatching success (Stickel and Dieter, 1979; Albers, 1980; Butler et al., 1988; Harfenist et al., 1990). Oil reaching ponds or lakes can have longer-term effects on invertebrate prey populations and emergent vegetation. These effects could reduce food availability and escape cover for birds in the area impacted by the spill (Barsdate et al., 1980; Hobbie, 1982). Spills entering streams or rivers during the breeding season could contact waterfowl adults and young and would potentially affect the greatest number of individuals. Spills on terrestrial habitats generally remain in limited areas and would usually affect only a few brood-rearing or foraging passerines or waterbirds in the immediate area.

Most oil and fuel spills are small and are confined to workpads, and the potential for contact with birds is low. Larger-scale oil spills from a major pipeline break or valve malfunction could cause high bird mortality depending on the location and time of year. During a visit to the site of the 1979 Atigun River spill, two nests and one incubating Semipalmated Plover were seen with moderate oiling (Rothe et al., 1983). The effects of larger spills on wildlife have been well-documented (e.g., *Exxon Valdez* Oil Spill Trustee Council, 1994; Wells et al., 1995; Day et al., 1995; Wiens, 1996; Wiens et al., 1996) and include mortality, displacement, habitat loss, and secondary effects on breeding success and propensity.

Harvest and Recreational Effects of Humans

Construction of TAPS increased access for hunters, but the resulting post-construction changes in harvest of game birds that likely occurred are not documented. The primary species affected by increased hunting effort would be grouse (Spruce, Ruffed, and Sharp-tailed grouse) and ptarmigan (Willow, Rock, and White-tailed ptarmigan). Increased access also has likely resulted in increased sport harvest of waterfowl, Sandhill Cranes, and Common Snipe, particularly in the area between Fairbanks and Thompson Pass, where the ROW crosses waterfowl habitats. The proposed action would continue to provide access for harvest of game birds. Although much of the northern end of the ROW passes through waterfowl habitat, the timing of bird use of the area and prohibitions on firearms use along TAPS currently limit harvest by humans.

Increased recreational use of areas along TAPS has occurred, particularly since the opening of the Dalton Highway to the public. To variable extents, wildlife tours, birding groups, and individual recreationists all use the Dalton Highway to access habitats adjacent to the TAPS ROW. Although these non-project-related activities do not involve harvest for human consumption, they are not entirely benign in their impacts on animal resources. For most bird species, the relative impacts of recreational activities are probably minor, but for rare birds, such as the Bluethroat, increased access to their nesting habitats near Pump Station 2 may have some detrimental effects, although the magnitude is unknown. Falconry permits from the State of Alaska allow for the taking of Arctic Peregrine Falcons and Gyrfalcons along the TAPS ROW. Gyrfalcons have not been taken in this region, although they nest close to the ROW north of the Brooks Range and along the Sagavanirktok River (Wright, 1999, pers. comm.).

4.3.2.5 Terrestrial Mammals

By W. Ballard, H. Whitlaw, B. Lawhead, B. Burgess, S. Murphy, and M. Cronin

Potential impacts of the proposed action on terrestrial mammals were identified from several sources including review of the original TAPS EIS (BLM, 1972), review of scientific literature and unpublished reports, and interviews of personnel with TAPS-related field experience. Evaluation of environmental consequences was based largely on an understanding of the impacts of TAPS operation and maintenance over the past 30 years. Difficulty in assessing these effects occurred as a result of the paucity of baseline studies before TAPS construction (Norris, 1997; Klein, 1991a). In addition, as summarized by Klein (1991a, p. 378), "studies of wildlife populations adjacent to the pipeline…often lack the ability to evaluate the complicating variables, such as differences in weather conditions, predator levels, and human hunting pressure that also, and perhaps independently, may have influenced the population dynamics of the wildlife species being studied."

Impacts on terrestrial mammals can be placed in the fol-

lowing categories:

- Obstructions to movements;
- Disturbance and displacement;
- Habitat loss, alteration, or enhancement;
- Mortality;
- Harvest by humans.

Obstructions to Movements

Issues. Impacts addressed in this section resulted from a synthesis of the originally predicted impacts (BLM, 1972), and review and evaluation of research conducted over the last 30 years (Cronin, Amstrup et al., 1998; Forman and Alexander, 1998; Cronin et al., 1994; Smith and Cameron, 1992; Carruthers and Jakimchuk, 1987; Curatolo and Murphy, 1986; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Bergerud et al., 1984; Banfield et al., 1981; Van Ballenberghe, 1978). BLM (1972) predicted that the TAPS ROW (i.e., the pipeline, roads, and associated traffic) would present a barrier or obstruction to movement, restricting the free passage of terrestrial mammals. Predicted barrier effects of pipelines and roads included isolation of habitat, alteration of distributions, obstruction to range expansion, alteration of migrating group composition, and range abandonment.

Pipelines. Caribou, moose, and bison encounter the pipeline during seasonal migrations, and as components of their annual home range (i.e., nonmigratory populations). During TAPS construction, designated big-game crossings were built along sections of the pipeline to ensure free passage and movement of big game animals (JSFFWAT, 1977). Elevated big-game crossings were built to a minimum height of 3 m above the workpad, extending for a distance of at least 18 m, and were located at sites “known to be regularly used by bison, moose and/or caribou as well as those sites with a high probability of utilization based on tradition or habitat characteristics” (JSFFWAT, 1977, p. 1). In addition, buried sections (i.e., sagbend crossings) were built to accommodate caribou movement. Evaluations of the use of these crossing sites provide the majority of our understanding of the effects of the pipeline as a barrier, or obstruction to movement, for terrestrial mammals (see Carruthers and Jakimchuk, 1987; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Van Ballenberghe, 1978).

The Nelchina Caribou Herd (NCH) crosses the TAPS ROW in the Copper River Basin during spring and fall migrations (Eide et al., 1986; Carruthers et al., 1984). Traditional migration routes were established by the NCH prior to pipeline construction (Eide et al., 1986). During the first winter of pipeline operation, Eide et al. (1986) reported that migrating NCH caribou tended to select buried, rather than elevated, pipeline sections. When caribou crossed under elevated sections, they selected heights greater than 2.4 m and against those less than 2.1 m. Deflections were recorded for 2.7 percent of the caribou that encountered the pipeline; 99 percent of these deflections occurred at elevated sections. Eide et al. (1986) and Carruthers and Jakimchuk (1987) both determined that NCH caribou showed strong selection for long buried-pipeline sections that were intentionally located in traditional migration locations and agreed that caribou did not show selection for designated big-game crossing locations. Eide et al. (1986, p. 207) concluded “efforts to assure free passage of caribou across the pipeline appear to have been adequate.” There is no evidence that the TAPS pipeline has been a barrier to NCH caribou movements, although it may obstruct or deflect a small proportion of individuals (Trudgen, 1999, pers. comm.; Tobey, 1999, pers. comm.; Carruthers and Jakimchuk, 1987; Dixon, 1984; Eide et al., 1986). The NCH has grown since TAPS construction, and no population-level impacts of TAPS have been reported (Section 3.2.5).

The Delta Caribou Herd (DCH) has recently grown in numbers resulting in a general range expansion, and individual caribou have been observed east of the Delta River and the TAPS ROW (Section 3.2.5.2). Although the TAPS ROW has not traditionally been in the range of the DCH, its presence has not hindered recent eastward range expansion of DCH caribou.

The Central Arctic Herd (CAH) crosses the TAPS ROW during spring and fall migrations (movements between the coastal plain and the Brooks Range), and during the summer insect season (movements between the coast and inland feeding areas) (Pollard et al., 1996b; Carruthers et al., 1984). Cameron et al. (1985) reported that crossings of the TAPS ROW were predominately by bulls, with calves comprising only 3 percent of the caribou crossing during spring and summer 1977-82. They concluded that maternal cows were sensitive to human activities. Whitten (1999, pers. comm.) indicated that the pipeline was a “hindrance to movement, rather than a barrier.” He elaborated that caribou did not fail to cross the pipeline, although they did not “linger” near it. Mumford (1999, pers. comm.) commented, “In my opinion, the pipeline did not affect the migratory path of caribou” north of Fairbanks. The combined studies and observations along the length of TAPS indicate that the pipeline is not a barrier to free passage of caribou, although it may deflect or hinder movements to some extent.

Moose in the Copper River Basin and Interior Alaska cross the TAPS ROW during spring and fall migrations, and some nonmigratory moose encounter the pipeline as a component of their annual home range (Van Ballenberghe, 1978; Gasaway et al., 1983; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Ballard et al., 1991; Hundertmark, 1997). Van Ballenberghe (1978) reported that both migratory and nonmigratory moose populations came into contact with TAPS while it was still under construction. Of 1,068 recorded successful crossings of the TAPS pipeline, 87 percent occurred where the vertical clearance between pipeline and ground was less than 2.4 m. Of 466 radio-collared moose crossings, 84 percent were successful crossings, 13 percent were deflections followed by successful crossing, and 3 percent were unsuccessful crossings. Van Ballenberghe's (1978) study occurred during a winter of below-normal snowfall, and he speculated that at snow depths greater then 0.75 m, the pipeline would cause more deflected movements.

During the first winter of pipeline operation, Eide et al. (1986) found no consistent pattern of selection by moose for vertical heights of elevated pipeline, for buried versus elevated pipe, or for designated big-game crossing sites. They indicated that moose were not influenced in their selection of crossing sites by pipeline characteristics and concluded "moose populations appear unaffected by the pipeline" (Eide et al., 1986, p. 207). Similar to the cautions provided by Van Ballenberghe (1978), they suggested that winters with deep snow might change pipeline characteristics and hinder moose crossings.

During 1982-83 in Interior Alaska near Big Delta, Sopuck and Vernam (1986a, b) found that 94 percent of 175 nonmigratory moose trails examined successfully crossed the pipeline upon entering the ROW, independent of pipe mode (i.e., buried or elevated) or pipe height. Of those animals that crossed under elevated sections, heights between 1.5 and 2.7 m were adequate. Moose did not select for designated big-game crossing sites. Sopuck and Vernam (1986a, b) concluded that in the Delta area, habitat appeared to be the most important factor influencing the selection of moose crossing sites, rather than the physical characteristics of the pipeline.

There is no evidence that the TAPS pipeline has been a barrier to moose movements, although it may obstruct or deflect a small proportion of individuals (Trudgen, 1999, pers. comm.; Tobey, 1999, pers. comm.; Sopuck and Vernam, 1986a, b; Eide et al., 1986; Dixon, 1984; Van Ballenberghe, 1978).

Bison in the Delta area encounter and cross the TAPS pipeline during spring and fall migrations. Kiker and Fielder (1980) reported that bison used the TAPS ROW as one of several traditional migration corridors. Muskoxen have been observed bedding on the workpad within 2000 yards of the highway for several days (Comins, 1999, pers. comm.). There is no evidence that the TAPS pipeline is a barrier or obstruction to the free passage of bison.

Ballard et al. (1987) studied wolves in the Copper River Basin with radiotelemetry during the 1970s and 1980s. Radio-collared wolf packs maintained territories that were bisected by TAPS ROW. Ballard (1999, pers. comm.) observed that the movements and behaviors of these packs were unaffected by the presence of the pipeline. There is no evidence that the TAPS pipeline is a barrier or obstruction to the free passage of wolves (Ballard and Gipson, 2000; Ballard et al., 1987; Gasaway et al., 1983).

Roads and Traffic. The effects of roads as barriers to movements for terrestrial mammals depend on traffic volume and speed, roadside vegetation, proximity to pipelines, traditional movement patterns, and environmental factors concurrently affecting animal movement (i.e., insect harassment, predator avoidance) (Curatolo and Murphy, 1986; Cronin et al., 1994).

Caribou, moose, and bison encounter roadways and associated traffic during seasonal migrations and as components of their annual home range (i.e., nonmigratory populations). The CAH crosses the Dalton Highway during spring and fall migrations (movements between the coastal plain and the Brooks Range), and during the summer insect season (movements between the coast and inland feeding areas) (Pollard et al., 1996b). As with the TAPS pipeline, the Dalton Highway may impede caribou movement, although it is not an absolute barrier (Cameron et al., 1985; Whitten, 1999, pers. comm.). As indicated by Shoulders (1999, pers. comm.), caribou "may be more cautious about the road with traffic," and barrier effects of the highway will need to be evaluated as traffic levels change.

The NCH crosses the Richardson Highway between Paxson Lake and Squirrel Creek during its spring and fall migrations. Traditional routes crossing the highway were established by the NCH and recognized by biologists before the pipeline was built (Eide et al., 1986). Carruthers and Jakimchuk (1987), Eide et al. (1986), and Carruthers et al. (1984) documented the continued use of traditional migration routes after TAPS construction. The DCH has recently grown in numbers, resulting in a general range expansion, and individual caribou have been observed east of the Delta River, the Richardson Highway, and the TAPS ROW. Although the highway has not traditionally been in the range of the DCH, its presence has apparently not hindered range-expansion movements. Available evidence thus suggests that the Richardson Highway is not an obstruction to NCH and DCH caribou movements.

Studies on the effects of roads as barriers to movement

have been conducted in other areas. Russell and Martell (1984) and F. Miller (1984) documented successful crossing of the Dempster Highway by the Porcupine Caribou Herd (PCH) involving seasonal migrations and crossings while on winter range. In addition, Russell and Martell (1984) concluded that no significant energetic disruption could be attributed to the presence of the highway under moderate traffic levels. Dyer (1999) reported that in the boreal forests of Alberta, woodland caribou crossed roads less than expected, and that crossing was lower with higher road density.

Since the early 1980s, muskoxen have been reported near the Dalton Highway and west of the TAPS ROW (Reynolds, P.E., 1998). This range expansion as far west as the Colville River required movement across the ROW and/or travel through the oil-field complexes of the North Slope. Muskoxen have been regularly observed near Pump Station 3 and along the Dalton Highway (Thompson, 1999, pers. comm.; Stephenson, B., 1999, pers. comm.; Hunter, 1999, pers. comm.). Concerns regarding muskox response to traffic have been raised (Martin, P., 1999, pers. comm.); however, there are no data to suggest that the presence of the Dalton Highway has been a barrier to movements of muskoxen on the coastal plain.

Moose in the Copper River Basin and in Interior Alaska encounter the Richardson Highway during spring and fall migrations and as part of annual home ranges (i.e., nonmigratory populations) (Van Ballenberghe, 1978; Sopuck and Vernam, 1986a, b). Delta bison also encounter and cross the Richardson Highway during spring and fall migrations. There are no data to suggest that the Richardson Highway is a barrier to either moose or bison movements.

Jakimchuk et al. (1984) observed sheep in the northern Brooks Range successfully crossing the Dalton Highway in spring and fall. In contrast, Dalle-Molle and Van Horn (1991) reported two observations of Dall sheep unsuccessfully attempting to cross the Denali National Park Road during a seasonal migration. They concluded that sheep became habituated to traffic where the road passes through their home range, whereas those individuals occupying ranges away from the road and encountering it during seasonal migrations had not become habituated. There are no reports of sheep movements being adversely affected or obstructed by roads or traffic associated with TAPS.

Singer and Doherty (1985) reported the successful use of highway underpasses in managing mountain goats across a roadway in Glacier National Park, Montana. Disturbance of goats was greatest during the pre-construction period and decreased during general construction and after completion of the underpasses. Only 0.4 percent of all crossing goats moved around the ends of the facilities to cross the highway. Crossing success was reduced from 100 to 85 percent when traffic or humans were present on the bridge (Singer and Doherty, 1985). There are no reports of mountain goat movements being adversely affected or obstructed by roads or traffic associated with TAPS.

Summary: Obstructions to Movements. The TAPS ROW (elevated and buried pipeline) and the Dalton Highway are not barriers to movements of terrestrial mammals. There is evidence of deflected movements of individual moose and caribou, and of unsuccessful crossing attempts, but the proportions are minimal and there are no data indicating adverse effects at the population level. North of the Brooks Range, there is evidence that maternal cows are hesitant to cross the TAPS ROW during the calving and post-calving periods, although the majority do cross. There is no evidence of TAPS serving as a barrier to range expansion in caribou or muskoxen. It has been demonstrated that wolves incorporate the TAPS ROW into pack territories. Population data for terrestrial mammals in the vicinity of TAPS show increasing or stable numbers, and state management objectives are being met. Therefore, although a small proportion of animals are unsuccessful in crossing the TAPS ROW, traditional migration routes are still in place, populations are stable or increasing, and several populations have expanded their range across the ROW.

On the basis on this review of scientific and unpublished literature and information provided by knowledgeable personnel, the proposed action will have no adverse effects on the movements and free passage of terrestrial mammals in the vicinity of the TAPS ROW.

Disturbance and Displacement

Aircraft and Vehicle. Terrestrial mammals encounter various types of disturbances associated with maintenance and operation of TAPS. These include disturbances from aircraft, vehicles, snow machines, off-road vehicles, foot traffic, and disruptions of wildlife feeding activities.

The effects of aircraft overflights on wildlife vary among species, populations, environmental variables, and habitat types (McKechnie and Gladwin, 1993; Miller and Gunn, 1984). In addition, aircraft disturbance responses are dependent on aircraft type and flight altitude, with helicopters and low-flying military jet aircraft being generally more disturbing to terrestrial mammals than light fixed-wing aircraft (Maier et al., 1998; Côte, 1996; Bleich et al., 1994; McKechnie and Gladwin, 1993; Murphy et al., 1993; Davis et al., 1984; Valkenburg and Davis, 1984; Fancy, 1982). Animals that range near airports or other continuous sources of aircraft disturbance may be exceptions to this pattern and appear to become habituated (Maier et al., 1998; McKechnie and Gladwin, 1993; Davis et al., 1984; Valkenburg and Davis, 1984).

Côte (1996) investigated mountain goat responses to helicopters in Alberta. Between June and August, goats were disturbed by 58 percent of the flights and elicited greater disturbance responses when helicopters flew within 500 m. Helicopter altitude, goat group type, behavior, or group size did not appear to influence reactions of goats. He indicated that helicopter flights caused social group disruption and on one occasion, injury to an adult female. Côte (1996) recommended that helicopter flights over goat habitat be restricted to more than 2 km from these areas. No reports of adverse effects of aircraft on mountain goats in the TAPS ROW were found.

Sheep elicit stronger responses to helicopter disturbance than to fixed-wing aircraft (Bleich et al., 1994; McKechnie and Gladwin, 1993; Krausman and Hervert, 1983). Bleich et al. (1994, p. 1) reported that bighorn sheep in California responded “dramatically” to helicopter disturbance. Effects on individuals included abandonment of sampling blocks and changes in habitat use before and after helicopter surveys. Bleich et al. (1994) also observed that sheep did not habituate or become sensitized to repeated helicopter overflights. Krausman and Hervert (1983) determined that fixed-wing flights less than 100 m in altitude elicited disturbance responses from sheep (i.e., increased heart rate and escape response). No reports of adverse effects of aircraft on sheep in the TAPS ROW were found.

Andersen et al. (1996) demonstrated that responses of moose in Norway were greater to human disturbance (i.e., individuals or groups on foot and on skies) than mechanical disturbance (i.e., ATV, snowmachine, helicopter and F-16 jet). Human stimuli elicited flight responses at greater distances than mechanical stimuli, and heart rates were elevated for longer periods. They suggested that moose were reacting to a fear of hunters, were becoming habituated to nonthreatening vehicles, and were able to adapt to predictable activities. Moose moved distances greater than 1 km only in response to extreme stimuli from snowmachines driven to within 5 m and helicopters flying at altitudes of less than 50 m (Andersen et al., 1996). Colescott and Gillingham (1998) reported that in Wyoming, moose that were bedded within 300 m and feeding within 150 m of passing snow machines altered their behavior in response to the disturbance. The average duration of response was 7 minutes. They concluded that snow machine traffic did not appear to alter moose activity significantly, although individuals within 300 m of the snowmachine trail were displaced to less favorable habitats. No reports of adverse effects of aircraft on moose in the TAPS ROW were found.

Miller and Gunn (1984) examined muskoxen-herd defense formations in response to helicopter overflights. The majority (75 percent) of muskoxen that moved in response to helicopters came together into defense formations. They reported that the durations of defense formations were brief (average of 5 minutes, range 2 to 12 minutes) and concluded that much of the defense formation behavior was moderated by exposure to many environmental variables and augmented by past learning experience. McLaren and Green (1985) also concluded that although disturbance to muskoxen raises energy costs of individuals, these costs would be reduced as muskoxen habituate to disturbances. They reported that the mean initial reaction distance by muskoxen to snowmachines was 345 m (range 162 to 650 m), distance of closest approach averaged 267 m (range 87 to 645 m), and duration of reaction varied from 2 to 6 minutes. P. Reynolds (1998) cautioned that because muskoxen are present on the Arctic Coastal Plain year-round and are limited by winter weather and food availability, they are vulnerable to human activities and should be avoided before, during, and after calving (April to mid-June).

Numerous studies have investigated the reactions of brown bears to aircraft disturbance (McKechnie and Gladwin, 1993; Harting, 1987; Quimby, 1974). Brown bears are more sensitive to helicopters than light fixed-wing aircraft and often run and/or seek cover in response to aircraft disturbance (Harding and Nagy, 1980; Klein, 1974). Klein (1974) documented that brown bears reacted more severely to all types of aircraft than did ungulate species, although Harting (1987, and references therein) reported that individual bears vary in their tolerances to helicopter disturbance. Responses to helicopters and fixed-wing aircraft depend on degree of habituation, availability of cover, and flight characteristics (Harting, 1987 and references therein). No reports of adverse effects of aircraft on brown bears in the TAPS ROW were found.

The effects of disturbance by helicopter and light fixed-wing aircraft on caribou have been studied extensively (McKechnie and Gladwin, 1993; Valkenburg and Davis, 1984; Davis et al., 1984; Miller and Gunn, 1979; Calef et al., 1976; McCourt and Horstman, 1974). Most studies reported a fixed-wing tolerance threshold of 60 m, below which panic and escape responses in individual caribou were apparent. Above 150 m, reactions were rarely observed (McKechnie and Gladwin, 1993 and references therein). As with most other terrestrial mammals, responses elicited from helicopter disturbances are greater than those from light fixed-wing planes. The tolerance threshold for helicopters was estimated to be 330 m in altitude (Miller

and Gunn, 1979).

Responses of caribou to aircraft disturbance are also dependent on season, activity before overflights, and habituation. Valkenburg and Davis (1984, p. 9) concluded that "aircraft disturbance has been overemphasized." They reported that the DCH had become habituated to aircraft (or had never learned to fear them), whereas Western Arctic Herd caribou, which had minimal exposure to aircraft overflights, appeared to react adversely because such flights were likely life-threatening since WAH caribou are hunted from snowmachines and aircraft. Valkenburg and Davis (1984, p. 7) suggested that disturbance response studies should move away from documenting overt reactions and focus on "determining predictable aspects of inherent and learned behavior." Davis et al. (1984, p. 5) concluded that sensory disturbances had been of "minor importance" to the growth of the Delta herd.

Caribou and reindeer also exhibit disturbance responses to snow machines and other moving vehicles (Tyler, 1991; Horejsi, 1981). Horejsi (1981) reported that 86 percent of individual caribou (n = 34) approached by vehicles along the Dempster Highway in northwestern Canada at speeds of 56 km/hr ran or trotted away, with mean flight duration of 73 seconds for females and 38 seconds for males. Twenty-nine percent of individual caribou reversed their direction of movement or split from their group. Responses of females with calves were not different from males or non-maternal females (Horejsi, 1981). Tyler (1991) reported that the first visible responses of reindeer to an approaching snowmachine involved independent behavior by several different individuals, whereas the secondary flight response was a coordinated group response. Groups fled an average of 160 m, with maximum response duration of less than 5 minutes. Tyler (1991) concluded that he was unable to detect effects of snowmachine disturbance on Svalbard reindeer.

Animal Feeding. The intentional feeding of wildlife and/or the use and habituation of some species to anthropogenic food sources such as garbage was a common problem during construction of TAPS, particularly in camps and at pump stations (Schmidt, 1999, pers. comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.; Follmann and Hechtel, 1990; Milke, 1977). During this time, active feeding of bears, wolves, foxes, squirrels, gulls, and ravens by pipeline workers, in addition to improper garbage handling and disposal, resulted in "large numbers" of animals being attracted to camps and areas of human activity (Milke, 1977, p. 1). In the late 1970s, Milke (1977) reported that animal feeding problems initiated during construction continued during operation, although the frequency and magnitude had decreased. Current Alyeska policy mandates that employees be disciplined and/or fired for intentionally feeding wildlife. On occasion, foodstuffs are inadvertently made available at specific job sites; for example, at RGV 60, food was left in vehicles, and garbage management by external contractors was not appropriate (Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.; Brown, D., 1999, pers. comm.). Nuisance animals are hazed by trained Alyeska personnel, and may be translocated or killed if problems persist. There is general consensus among state and Alyeska biologists and environmental personnel that animal feeding by Alyeska personnel is no longer a problem within the TAPS ROW (Stephenson, 1999, pers. comm.; Schmidt, 1999, pers. comm.). However, animal-feeding problems associated with public and commercial use of the Dalton Highway may still occur (Brown, D., 1999, pers. comm.). Black bears continue to be a problem in Valdez as a result of city garbage management and lack of fencing at the Valdez Marine Terminal (Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Brown, D., 1999, pers. comm.).

Displacement. BLM (1972) predicted that terrestrial mammals would be displaced as a result of activities associated with TAPS construction, operation, and maintenance. Displacement could potentially occur as a result of disturbances, obstructions to movements, and/or habitat change. Potential effects of displacement could be realized at the individual and/or population levels, including displacement to adjacent habitats, increased mortality, increased activity budgets, and/or changes in group composition. Most displacement research has investigated the effects of oil-field development and associated disturbances on CAH caribou (Cronin, Amstrup et al., 1998; Cronin, Ballard, et al., 1998; Cameron et al., 1995; Cronin et al., 1994; Pollard et al., 1996b; Cameron et al., 1992; Smith and Cameron, 1992; Klein, 1991a, b; Murphy and Curatolo, 1987; Dau and Cameron, 1986a; Smith and Cameron, 1983; Whitten and Cameron, 1983a; Banfield et al., 1981). These research efforts have focused primarily on the relationships between roads, road/pipeline configurations, and associated traffic, and caribou distributions, movements, and group composition. Although general disturbance patterns from aircraft and traffic on the North Slope may be comparable to those encountered during operation and maintenance of TAPS, the level of infrastructure development is dissimilar in terms of pipeline and road configuration and density. Therefore, this discussion focuses on the TAPS ROW and draws on relevant conclusions from North Slope studies. (See Section 4.5 section for a discussion of North Slope caribou.)

Roby (1978) reported that during summer, caribou with calves were the group most sensitive to the Dalton Highway. His activity-budget analyses indicated that groups tended to bunch up and move more rapidly after being disturbed by traffic. Cameron et al. (1979) investigated caribou distribution, group size, and composition along the Dalton Highway between Pump Station 4 and Prudhoe Bay. During 1975, systematic road surveys indicated that the mean summer calf percentage of the herd was approximately one-third lower in the TAPS ROW than adjacent areas. However, mean percentages in the fall were not different. Mean group size was also generally lower along the Dalton Highway compared to adjacent areas (Cameron et al., 1979). Cameron and Whitten (1980a) examined 1975-78 survey data and reported that caribou, primarily cows with neonatal calves, avoided the TAPS ROW. They suggested that this was a group response to vehicular traffic and construction activity, and concluded "Human activity apparently represents the principal impediment to local movement since avoidance of the ROW occurs irrespective of the pipe structure…" (Cameron and Whitten, 1979, p. 483). Upon examination of additional road-survey data from 1978 to 1982, Cameron et al. (1985) concluded that parturient and maternal cows were sensitive to human activities along the Dalton Highway north of Pump Station 4. Based on marked animals, Whitten and Cameron (1983a) concluded that in spring, the cow/calf segment of the CAH appeared to avoid disturbed areas more so than bulls.

In contrast to Cameron and Whitten (1979), Carruthers et al. (1984) investigated factors besides human activity which may affect the distribution of cows and calves adjacent to TAPS. Their 1981-83 survey results indicated that the CAH had "strong habitat associations, which varied according to the sex of the animals" (Carruthers et al., 1984, p. 11). In particular, they reported that cows with calves avoided river valleys and riparian habitats, whereas bulls preferred riparian habitats, and that the habitats preferred by females were not associated with the TAPS ROW. They concluded that variables such as habitat and sexual segregation influenced the distribution of caribou adjacent to the ROW.

Jakimchuk et al. (1987) further proposed that cows with calves avoided riparian habitats, not the TAPS ROW, as a predator avoidance strategy. These antipredator tactics were also proposed for caribou in British Columbia (Bergerud and Page, 1987). However, Young and McCabe (1998) reported that calving PCH caribou did not avoid river corridors, and hypothesized that nutritional demands ultimately regulated habitat-use patterns.

There is no evidence that other caribou herds in the vicinity of the ROW (i.e., NCH, DCH) have been displaced as a result of TAPS operation and maintenance (Valkenburg, 1999; Carruthers and Jakimchuk, 1987; Eide et al., 1986; Gasaway et al., 1983). Caribou south of the Brooks Range have maintained traditional migratory routes and in some cases have expanded their ranges across the ROW. BLM (1972) reported that the range of the Fortymile herd overlapped the ROW. However, Valkenburg and Davis (1986) demonstrated that this herd had frequently changed its calving distribution since the mid-1950s and that the herd's greater range had gradually decreased since the 1920s.

There is no evidence that populations of Dall sheep, muskoxen, bison, or moose have been displaced as a result of the operation and maintenance of TAPS (DuBois and Rogers, 1999; Reynolds, P., 1998; Eide et al., 1986; Jakimchuk et al., 1984). Aircraft and vehicle disturbances have been reported to elicit behavioral and physiological responses in individual ungulates, but they are generally short-term and are not reflected at the population level. In California, Bleich et al. (1994) reported that mountain sheep were sensitive to helicopter disturbance and may alter their habitat use as a result, but this has not been demonstrated for Dall sheep in the vicinity of TAPS.

Brown bears have been locally displaced from roads in British Columbia, Montana, Alaska, and Yellowstone National Park, Wyoming (Mattson, 1988; McLellan, 1988; Archibald et al., 1987; Harting, 1987 and references therein). In most cases, individual bears avoided areas within 1 km of roads, but no population-level effects were reported. McLellan and Shackleton (1989) reported that predictable human activities might displace bears and that the strongest responses were to the presence of humans on foot in open areas of low human use. S. Miller and Ballard (1982) reported that following translocation, three sows with cubs were delayed or deflected by the Glenn Highway.

Habituation. Many wildlife species have developed situation-specific responses to humans (Valkenburg, 1999; Whittaker and Knight, 1998; Thompson and Henderson, 1998; Van Dyke and Klein, 1996; Cronin et al., 1994; Thurber et al., 1994; Mattson et al., 1992; Klein, 1991b; Mattson, 1988; Valkenburg and Davis, 1984). Although individual and group responses to humans and their activities vary, Whittaker and Knight (1998) proposed that it was necessary for wildlife managers to use descriptions of wildlife responses. Knight and Cole (1991) suggested the following broad response classes:

- *Attraction* (the strengthening of an animal's behavior

due to positive reinforcement, and movement toward the stimuli);

- *Habituation* (the waning response to a repeated neutral stimuli); and
- *Avoidance* (aversion to negative consequences associated with a stimulus).

As proposed by Thompson and Henderson (1998), habituation is a management issue of emerging importance as wildlife and human populations expand and overlap. Whittaker and Knight (1998) suggested that responses of a few animals to stimuli are often extrapolated to characterize the entire population. In contrast, Whitten and Cameron (1986) proposed that data must be based on individuals for distribution determinations. These views are not mutually exclusive and can be resolved by ensuring clarity about whether observations refer to past behavior or distribution, or predicted future tendencies (Whittaker and Knight, 1998).

Summary: Disturbance and Displacement. Ground- and air-based disturbances have been reported to elicit responses in individuals of various terrestrial mammal species. In general, helicopters create stronger responses than light fixed-wing aircraft. Disturbance responses are also dependent on levels of habituation; group size; age and sex structure of the group; activity prior to disturbance; disturbance characteristics (i.e., height above ground level, speed of vehicle); season; habitat characteristics; and availability of cover. The above-discussed disturbances affect individuals, and there is no evidence of effects at the population level for any of the terrestrial mammals addressed here.

The intentional feeding of wildlife was a major concern during TAPS construction, but Alyeska policy and state regulations now prohibit this practice. Animal-feeding problems associated with public and commercial use of the Dalton Highway are still of concern.

Available evidence suggests that most terrestrial mammals in the vicinity of the TAPS ROW have not been displaced as a result of pipeline operation and maintenance. Caribou cows with calves may be under-represented along the Dalton Highway during the calving season. This may be due to avoidance of the road, habitat selection, or predator avoidance. Regardless, the CAH has grown in numbers since the mid-1970s, and any redistribution of caribou in the spring has apparently not affected population growth.

On the basis of this review of published and unpublished literature, and information provided by personnel with direct TAPS experience, the proposed action will not displace terrestrial mammals in the vicinity of the TAPS ROW. Air and ground disturbances associated with the proposed action may affect individuals locally and in the short-term. However, available evidence suggests that they may become habituated to these regular activities and that current stipulations and mitigation are effective in minimizing effects. In addition, management data indicate that disturbances to individuals are not realized at the population level (Section 3.2.5).

Habitat Loss, Alternation, and Enhancement

Some habitat alteration and loss occurred as a result of TAPS construction. Impacts of these activities are now part of the affected environment and will not change with implementation of the proposed action. Construction-related habitat impacts are not addressed in this review of habitat issues for the proposed action. Predicted impacts of TAPS operation and maintenance on terrestrial mammal habitat are related to wetlands and riparian areas, oil spills, fire suppression, habitat loss and reclamation, and species-specific sensitive habitats (McKendrick, 1999a, b; Cronin and Bickham, 1998; Bridges et al., 1997; Dominske, 1997; Doucet and Garant, 1997; Hurst, 1997; Duffy et al., 1996; Cameron et al., 1995; Armentrout and Boyd, 1994; Jorgenson and Joyce, 1994; Truett et al., 1994; Garant and Doucet, 1993; Maki, 1992; Walker and Walker, 1991; Gasaway et al., 1989; Senner, 1989; MacCallum, 1988; Morgantini and Bruns, 1988; Morgantini and Worbets, 1988; Walker, Webber et al., 1987; Gasaway and DuBois, 1985; Hartley et al., 1984; BLM, 1981; Kavanagh and Townsend, 1977; BLM, 1972).

Wetlands. Wetlands and riparian areas provide habitat in the form of feeding areas, travel corridors, cover, and shelter for many terrestrial mammal species (Senner, 1989). Concern has been expressed about the role of wetlands in limiting wildlife, primarily in arctic regions (Senner, 1989). Statewide wetland losses due to the petroleum industry are estimated to be about 0.02 percent of Alaska's total wetlands (Senner, 1989). The TAPS ROW and the Dalton Highway account for approximately 68 percent of these petroleum-related wetland losses (Pamplin, 1979) and about 25 percent of statewide wetlands reductions due to human activities since 1867 (Senner, 1989). The greatest amount of wetland loss occurred from the development of material sites followed by workpad construction and construction of the Haul Road (Pamplin, 1979). Although wetlands provide seasonal habitat for terrestrial mammals in the TAPS ROW, minimal losses in these areas due to corrosion digs and other TAPS operation and maintenance activities should not adversely affect nearby wildlife populations.

Oil Spills. Diesel and other product spills were common during TAPS construction (Kavanagh and Townsend, 1977). However, since operation began, spill prevention and response plans have been prepared for TAPS, spill reporting and consistency have improved, employee training and education have been enhanced, and spill regulations are strictly enforced.

The effects of land-based oil spills on terrestrial wildlife have not been thoroughly investigated. Duffy et al. (1996) reported that after exposure to crude oil, individual animals might exhibit acute and/or chronic immune system responses. They suggested that any subsequent secondary infections or tissue damage could lower individual survivorship and thus impact the population. No data were presented to support this hypothesis.

The effects on terrestrial mammals of land-based oil spills occurring as a result of TAPS operation and maintenance have not been directly investigated. Assuming that oil spills associated with the proposed action will be similar to those over the past 30 years, land-based spills will not adversely affect terrestrial mammals in the vicinity of TAPS.

Wildfire. Wildfire is a natural occurrence in Alaskan ecosystems and is a primary agent of change in the boreal forest. Periodic fires create or improve habitat for many browsing and grazing species such as moose and bison (BLM, 1981). Moose populations may increase following fire due to increased browse production, unless they are limited by factors other than habitat — such as predation and hunting. Many of the moose populations near the TAPS ROW seasonally use burned areas (Gasaway et al., 1989; Gasaway and DuBois, 1985). Wildfires are also beneficial to bison because fire stimulates new growth of grasses and forbs (DuBois and Rogers, 1999; BLM, 1981). Caribou may be adversely affected by fire in the short-term; however, long-term benefits of fire include rejuvenation of stands of lichen with declining production (BLM, 1981). Available evidence suggests that terrestrial mammal populations in the vicinity of TAPS are not limited by food and have not been adversely affected by state-mandated and TAPS-associated fire-suppression efforts. Fire suppression associated with the proposed action should not adversely affect terrestrial mammal populations.

Direct Habitat Loss and Reclamation. Minimal direct loss of terrestrial mammal habitat occurred with TAPS construction (Jorgenson and Joyce, 1994; Truett et al., 1994; Pamplin, 1979). Many disturbed areas have since been revegetated to restore wildlife habitat and are used by a variety of species (McKendrick, 1999b; Jorgenson and Joyce, 1994; Senner, 1989). Small-scale disturbed areas are also used by wildlife (Truett et al., 1994). Structures such as gravel pads and elevated pipelines and buildings provide insect-relief habitat for caribou (Schmidt, 1999, pers. comm.), and abandoned materials sites and gravel mines have also been restored for wildlife use as forage sites, escape cover, and mineral licks (MacCallum, 1988; Morgantini and Bruns, 1988; BLM and USACE, 1988; Jorgenson and Joyce, 1994). Rights-of-way and associated maintenance activities in other areas of North America have been reported to provide and enhance wildlife habitat by creating edge habitats, successional stages, habitat diversity, and travel corridors (Dominske, 1997; Doucet and Garant, 1997; Hurst, 1997; Hartley et al., 1984).

Ground-impacting maintenance activities associated with the proposed action are described in Section 4.1.1. These activities will disturb and perhaps alter vegetation patterns, but are not likely to adversely affect terrestrial mammal populations in the vicinity of TAPS.

Species-Specific Sensitive Habitats. Loss or alteration of species-specific sensitive habitats are potential impacts associated with continued TAPS operation and maintenance. Calving areas and mineral licks have been identified as critical areas for caribou, moose, and bison along the ROW. Many of these sensitive habitats have been protected through implementation of BLM-designated areas of critical ecological concern (BLM, 1989). Activities in all identified sensitive habitats for terrestrial mammals near the TAPS ROW are regulated by federal and state mitigation stipulations, which are in place to minimize adverse impacts on wildlife. Assuming all current stipulations and mitigation measures continue with the proposed action, renewal of the TAPS ROW is not expected to adversely impact sensitive habitats.

Summary: Habitat Loss and Alteration. Available evidence and experience suggest that the proposed action will not adversely affect terrestrial mammal habitat. Ground-impacting maintenance activities and minor land-based spills will create small-scale and short-term disturbances in a variety of habitats. These disturbances will not adversely impact terrestrial mammal populations and will continue to be regulated under existing mitigation measures. Current fire suppression have likely reduced browse, grass, and forb productivity along TAPS, but most terrestrial mammal populations in these areas are not limited by forage.

Mortality

Sources of mortality that were predicted to occur in association with TAPS operation and maintenance included increased vehicle collisions, increased kills in defense of life and property and for nuisance animals, increased predation, and mortality from oil spills (BLM, 1972). As described below, mortality of wildlife directly associated with

TAPS has been small in magnitude and has not measurably affected populations.

To put the impact of TAPS operation and maintenance on wildlife mortality in perspective, consider other causes of human-induced mortality in the Alaska. These causes include intentional mortality (i.e., sport and subsistence harvest; management and research mortality) and unintentional mortality (i.e., railroad and road kills; unreported harvests; defense of life and property mortality). These are considered by resource agencies in defining management objectives and policies. Sport and subsistence harvests are often the primary objective of ADF&G management activities, and are considered desirable causes of mortality. Road and railroad kills are not planned or desired, but they are accepted as consequences of highway and railroad operation. Prevention or mitigation measures may be implemented (e.g., warning signs for animals crossings), but highways and the railroad continue to operate and related mortalities occur annually.

A review of the literature and agency data sources indicates that direct mortality associated with TAPS is negligible compared to the other sources of human-induced mortality in the area. The average annual number of non-TAPS human-caused mortalities is summarized in Table 4.3-12 for the major wildlife species. The harvest of wildlife by sport and subsistence users is considerable. Estimates of the unreported harvests are also shown. Tables 4.3-13, 4.3-14 and 4.3-15 show data for moose and caribou. Note the annual toll of hundreds of moose killed on State of Alaska roads and the Alaska Railroad. In addition, University of Alaska researchers killed 193 caribou on the North Slope for research projects, and the FWS killed approximately 800 feral reindeer on Hagemeister Island in a management action.

As described in Section 3.2.5, it is important to note that the population or herd is the unit of management for fish and wildlife in Alaska. As a result, management objectives are set for population and herd numbers, as well as for sport harvest numbers. Intentional and unintentional mortality of individual animals results from various activities (e.g., human harvest, road and railroad kills), but objectives are often achieved nevertheless. As summarized in Table 4.3-12, the number of mortalities due to non-TAPS causes (e.g., sport and subsistence harvest) is much greater than those associated with TAPS operation and maintenance. There is no evidence that TAPS operation and maintenance has prevented ADF&G's management objectives from being met.

Two primary points should be noted from these data. First, fish and wildlife populations can sustain substantial levels of human-induced mortality. Second, the amount of mortality associated with TAPS is small compared with other actions.

Vehicle Collisions. Vehicle collisions with terrestrial mammals, particularly moose, are an issue of public safety as well as a notable source of wildlife mortality. In 1996, the Alaska Department of Transportation (ADOT) identified rural two-lane highway segments with the highest moose/vehicle accident reports (ADOT, 1996) and concluded that most accidents occurred on rural highways surrounding major cities and towns. None of the identified segments was on the Richardson or Dalton Highways, but rather in areas near Soldotna and along the Glenn and Parks Highways (ADOT, 1996). Mitigation measures employed by ADOT to reduce moose/vehicle collisions on high-accident segments include moose fencing and underpasses, one-way gates, continuous illumination, and increased public awareness (ADOT, 1996; Del Frate and Spraker, 1991; McDonald, 1991).

In Alaska, moose/vehicle collisions averaged 630 per year between 1995 and 1997 (ADOT, 1997). In comparison, a minimum of 1,200 moose — a number that is approximately 10 percent of the annual allowable harvest — is killed each year on highways and railways in British Columbia (Child et al., 1991). In Game Management Unit 13, which is bisected by the TAPS ROW and the Glenn Highway, approximately 50 moose are killed per year (1994-98) as a result of collisions with motor vehicles (Sinnott, 1999, pers. comm.). A small proportion of these occur near the ROW (Sinnott, 1999, pers. comm.; Martin, 1999, pers. comm.; Billbe, 1999, pers. comm.). Vehicles annually kill fewer than 10 bison in the Delta area (Kiker and Fielder, 1980). Numbers of other terrestrial mammals killed in vehicle collisions are unknown. Whitten (1999, pers. comm.) and Billbe (1999, pers. comm.) indicated that vehicle collisions with wildlife are rare along the Dalton Highway.

Wildlife/vehicle collision rates increase as a result of increased traffic volumes and the proximity of wildlife to roadways. Attraction to roadways occurs because of roadside maintenance procedures, road-salt accumulation, and the presence of roads in concentration areas and travel corridors. The mitigation measures noted above are designed to reduce the number of collisions based on these wildlife attractants. Increased traffic volumes are a result of increased human population and improved access. As the Dalton Highway increases in recreational value and its use is advertised and encouraged (BLM, 1998), traffic volumes may increase.

None of the terrestrial mammal populations examined in this review is limited by vehicle-collision mortality. Numbers are limited primarily by predation, severe weather, and

Table 4.3-12. *Causes of human-induced mean annual animal mortality by species in Alaska (most representative data used as available; all numbers are estimates; decimals rounded to nearest whole number).*

Species	Rail-road Kill	Road Kill	Reported Sport Harvest [1]	Unreported Harvest [2]	Estimated Subsistence [3]	Management Mortalities [4]	Research Mortalities [5]	DLP	Total
Bison	—	2[7]	109[7]	10[8]	24	—	—	—	145
Black Bear	—	6[9]	1,674[10]	74[11]	1,178	—	—	32[12]	2,964
Brown Bear	—	1[13]	1,149[10]	59[13]	235	—	—	61[10]	1,505
Caribou	50[14]	3[15]	5,065[16]	30,639[17]	14,742	114[18]	19[19]	—	50,632
Dall sheep	—	—	1,092[20]	35[20]	198	—	—	—	1,325
Deer	—	52[21]	24,115[21]	5,905[22]	21,002	—	—	—	51,074
Elk	—	—	120[23]	1[23]	117	—	—	—	238
Fox	—	—	—	1,737[24]	9,006	146[25]	—	—	10,889
Moose	199[26]	759[27]	6,221[28]	1,010[28]	3,857	—	—	19[28]	12,065
Mtn. Goat	—	—	476[29]	7[30]	362	—	—	—	845
Muskox	—	—	63[31]	1[31]	23	—	—	—	87
Polar Bear	—	—	—	—	99	—	—	0[32]	99
Sea Otter	—	—	—	—[42]	2,146	—	—	—	2,146
Wolf	—	1[34]	1,276[34]	78[34]	732	20[34]	—	0[35]	2,107
Total	249	824	41,360	39,556	53,721	280	19	112	136,376

NOTES:

1. Most figures derived from 5-year mean taken from early to late 1990s. Includes some extrapolated results of hunter surveys and a small percentage of reported subsistence — excludes Tier II and other subsistence hunts when specified in cited reports.
2. Includes some estimates for wounding loss and illegal and unreported kills. Most of these numbers are greatly underestimated, as many regional biologists do not regularly publish their estimates in the cited reports. Unreported local harvests are difficult to estimate and are a persistent problem for regional wildlife managers (Carroll, 1995a; Anderson and Alexander, 1992). Excluding caribou, most unreported local harvest is not accounted for in this column.
3. Data by community taken from "most representative" year (Scott et al., 2001).
4. Single events including predator control, research mortalities, and local eradication divided by the number of years between the event and year 2000.
5. Most collaring deaths not accounted for.
7. Hicks (1996d, 1998h, 1998i).
8. Estimated wounding loss assuming 7 percent of permits issued for GMU 20D hunt (Hicks, 1998h, 1998i).
9. Hicks (1999a).
10. Miller and Tutterow (1997).
11. Estimated wounding mortalities and illegal kills from GMU 6, estimate from GMU 14 assuming 10 percent of reported harvest, and estimates from GMUs 16A and 16B assuming 15% and 20% of reported harvests (Hicks, 1996e).
12. Defense of life and property underestimated more for black bears than for brown bears due to more liberal sport hunting seasons (Miller and Tutterow, 1997).
13. Hicks (1995c).
14. Depending on snow depth, up to fifty caribou per year are killed by trains near Cantwell (See Note 16: Hicks, 1997d).
15. This number represents average annual roadkill of the Kenai Lowland Herd, consisting of approximately 100 animals, from 1991 to 1995; caribou roadkills for other parts of the state are undocumented (Hicks, 1997d).
16. Hicks (1997d).
17. Over 90 percent of this figure is attributed to unreported local harvest — 70 percent of which comes from the Western Arctic Herd (Hicks, 1997d).
18. Stimmelmayr and Renecker (1998).
19. Allaye-Chan (1991); Gerhart (1995); Manning (1998).
20. Hicks (1996f).
21. Hicks, (1997e).
22. Estimated illegal take and wounding loss by boat hunters (Hicks, 1997e).
23. Hicks (1998j, k, 1999b)
24. Includes arctic and all red fox phases. The State does not require sealing of foxes, so this figure is underestimated. Some estimates were made for certain GMU's by anecdotal information, fur acquisition and fur export permits. Due to low fur prices and relatively low populations in areas due to coyote competition, trapping effort for foxes was considered low during this reporting period (Hicks, 1995d).
25. Ballard et al. (2000a); Bailey (1993); Bailey and McCargo (1984); Byrd et al. (1996); Deines (1985); Deines and Willging (1985); Fischer and Palmer (1993).
26. Railroad data for moose-kills collected from GMUs 7, 13, 14 and 20, November through April, 1984-2000 (Reese, 2000, pers. comm.).
27. Road data for moose-kills collected from GMUs 7, 14, 15, 16 and estimated for GMU's 12, 13 and 20 from 1994 to 1999 (Sinnott, 1999, pers. comm.).
28. Hicks (1996g).
29. Hicks (1999c); Hicks (1998l).
30. Mostly from Unit 8 estimates for wounding loss/illegal take assuming 10 percent of reported harvest (Hicks, 1998f, g, i).
31. Hicks (1999d).
32. Polar bears taken as DLP categorized as subsistence (Shideler, 2000, pers. comm.).
34. Hicks (1997f).
35. One reported DLP kill of a radio-collared wolf on Fort Richardson in 1997 (Hicks, 1997f).
36. Carroll (1995a); Anderson and Alexander (1992).
37. Scott et al. (2001).
38. Hicks (1996e).
39. Hicks (1995d).
40. Reese (2000, pers. comm.).
41. Sinnott (1999, pers. comm.): Moose killed as a result of collisions with motor vehicles — documented kills; actual number killed by vehicles is certainly greater.
42. An unknown number — perhaps more than 100 — sea otters are intentionally killed every year by fisheries and recreational activities.

Table 4.3-13. *Caribou and reindeer killed in Alaska for wildlife management and research.*

Affiliation	Location	Years	Animals Taken	Rationale
U.S. Fish and Wildlife Service (a)	Hagemeister Island	1992/1993	Approx. 800	Removal of non-indigenous reindeer
University of Alaska Fairbanks (b)	North Slope	1989/1990	65	Research
University of Alaska Fairbanks (c)	North Slope	1987/1988	128	Research
Total	—	—	993	—

(a) Stimmelmayr and Renecker (1998).
(b) Gerhart (1995).
(c) Allaye-Chan (1991).

Table 4.3-14. *Moose killed by trains in Alaska.*

Winter	November	December	January	February	March	April	Total
1984-85	1	4	39	103	199	25	371
1985-86	1	3	3	9	5	0	21
1986-87	4	22	51	29	16	4	126
1987-88	11	81	60	98	64	14	328
1988-89	11	30	68	83	60	3	255
1989-90	28	65	306	160	123	29	711
1990-91	18	41	70	43	30	21	223
1991-92	3	23	34	40	35	7	142
1992-93	5	26	93	47	11	2	184
1993-94	1	12	21	20	15	4	73
1994-95	28	76	44	29	15	7	199
1995-96	4	0	2	15	26	7	54
1996-97	27	14	16	6	7	6	76
1997-98	9	25	29	16	1	7	87
1998-99	3	10	24	28	16	8	89
1999-2000	5	30	95	109			239
Total	159	462	955	835	623	144	3178
Average	10	29	60	52	39	9	199

Source: Reese (2000, pers. comm.)

Table 4.3-15. *Moose killed by documented collisions with motor vehicles in Southcentral Alaska (listed by GMUs).*

Year	7	13	14A	14B	14C	15A	15B	15C	16	Total
1994-95	34	50	260	34	239	168	59	53	4	901
1995-96	18	50	85	6	14	90	70	63	15	511
1996-97	27	50	185	10	136	160	80	44	4	696
1997-98	28	50	168	13	137	143	68	84	14	705
1998-99	46	50	130	15	152	178	74	76	10	731
Total	153	250	828	78	678	739	351	320	47	3,544
Average	31	50	166	16	156	148	70	64	9	709

Estimates made for Unit 13.
Very few roadkills in other parts of the state — perhaps 50 per year between GMUs 12 and 20.
As of 2/11/00, there were approximately 370 roadkills this winter (*Anchorage Daily News*).
Sinnott (1999): Moose killed as a result of collisions with motor vehicles — documented kills; actual number killed by vehicles is certainly greater.

hunting; and population management objectives are being met. The proposed action is not expected to adversely affect terrestrial mammal populations in the vicinity of the TAPS ROW at current traffic volumes.

Non-hunting (Human-Caused). Brown and black bears and wolves can become habituated or attracted to human activities, often leading to conflicts with people in many areas of Alaska (Whittaker and Knight, 1998; McCarthy and Seavoy, 1994; Mattson et al., 1992; Follmann and Hechtel, 1990; Follmann, 1989; McLellan, 1989; Miller, S. and Chihuly, 1987). S. Miller and Chihuly (1987) examined the circumstances during which non-hunting deaths of brown bears occurred throughout Alaska between 1970 and 1985. Human activities associated with TAPS operation and maintenance were not addressed in S. Miller and Chihuly (1987). They reported that of 224 persons who reported killing bears, 72 percent shot to avoid perceived danger, 21 percent to protect property, and 7 percent to eliminate nuisances. The number of non-hunting bear kills increased during the study period, with an average of 40 percent being reported from coastal areas near Juneau, Kodiak Island, and the Alaska Peninsula. S. Miller and Chihuly (1987) concluded that non-hunting kills were most prevalent when humans were in bear habitat and that areas with highest human densities (Anchorage, Kenai Peninsula, Matanuska Valley) had the highest ratio of non-hunting to sport harvests. Therefore, most non-hunting kills were related to human activities in bear habitat.

Follmann and Hechtel (1990) reviewed the history of nuisance-bear problems and TAPS between 1971 and 1979. They reported that 71 percent of the problems with bears occurred north of the Yukon River, where inadequate garbage disposal and widespread animal feeding created dangerous situations. Of the 192 officially reported bear problems associated with TAPS, 65 percent involved the presence of bears in camps or dumps, while remaining problems were associated with feeding of bears on garbage or handouts (13 percent), property damage or economic loss (10 percent), bears in and under buildings (7 percent), and charges by bears (5 percent) (Follmann and Hechtel, 1990). Control measures for nuisance bears included hazing, relocations, and/or shooting; 25 black bears and 13 brown bears were shot between 1971 and 1979 (Follmann and Hechtel, 1990).

Non-hunting kills of bears and wolves have not been identified as significant limiting factors for populations in the vicinity of the TAPS ROW. With improved garbage management by Alyeska and enforcement of their animal feeding policy, in addition to increased public awareness programs, it is not expected that the proposed action will adversely affect bear and wolf populations as a result of increased non-hunting kills. However, as human population numbers continue to increase in all areas of the state, concerns for human safety will continue to be the main factor in non-hunting mortality of bears and wolves. In particular, with increasing access and recreational use of remote areas such as the Dalton Highway (BLM, 1998), non-hunting mortalities of brown bears may increase. Accidents may sometimes result in mortality. For example, three moose have run into fences at TAPS facilities and died (Shoulders, 1999, pers. comm.)

Predation. BLM (1972) expressed concern that predator numbers might increase as a result of increased human activities during TAPS construction, operation, and maintenance. It was proposed that anthropogenic food sources would increase bear and wolf numbers, thus increasing predation pressure on prey species such as moose and caribou. Predator populations were low before TAPS construction due to federal wolf-control programs and increased through the early 1970s with the end of control efforts.

Many moose and caribou populations in Alaska are limited by predation. In efforts to increase the availability of these big game species, ADF&G has conducted several predator-control studies and projects in GMUs near TAPS over the past 20 years. These have included aerial killing of wolves from fixed-wing aircraft and helicopters, aircraft-assisted trapping, relocation of brown bears, liberal trapping seasons and bag limits for wolves, and liberal hunting seasons and bag limits for brown bears (Miller, S., 1997; Reynolds, 1997; Boertje et al., 1996; Ballard et al., 1991; Ballard and Miller, 1990; Bergerud and Ballard, 1989; Bergerud and Ballard, 1988; Van Ballenberghe, 1988; Ballard et al., 1987; Van Ballenberghe, 1985; Gasaway et al., 1983). Authors of this research did not indicate that predator numbers were influenced by TAPS construction, operation, and/or maintenance.

The proposed action is unlikely to adversely affect prey populations through increased predation in the vicinity of the ROW. Prey populations are largely limited by harvest by humans, predation, and severe weather; and ADF&G is successfully controlling predator numbers.

Oil Spills. Few data are available on oil-spill-related mortality of terrestrial wildlife; most information is anecdotal. This review found no reported terrestrial mammal mortalities due to land-based oil spills along the TAPS ROW, and available evidence does not indicate that this is a major source of mortality at the population level (Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.). Deer, mountain goats, and brown bears around Prince William Sound were potentially exposed to the

Exxon Valdez oil spill; an unknown amount of deer mortality occurred (Nowlin, 1993a, b, 1994, 1995a, b). Based on available evidence, no population-level impacts on terrestrial mammals occurred as a result of the *Exxon Valdez* oil spill. Assuming that oil spills associated with the proposed action will be similar to those over the past 30 years, land-based spills will not adversely affect terrestrial mammal populations through increased mortality along the TAPS ROW.

Summary: Mortality. Available evidence and experience suggest that the proposed action will not increase terrestrial mammal mortality. ADF&G population management objectives are being met for wildlife in most GMUs (Section 3.2.5). Terrestrial mammal populations examined in this review are not limited by mortalities due to vehicle collisions, non-hunting deaths, or mortality due to spills. Ungulate population numbers are controlled primarily by predation, severe weather, and hunting. In many areas, ADF&G actively manages predator populations.

Harvest by Humans

There are potential impacts of harvest by humans on terrestrial mammals with respect to TAPS operation and maintenance. The majority of this concern relates to impacts in previously undisturbed wilderness areas that are now accessed by the Dalton Highway. Issues are related to management and population objectives (i.e., harvest numbers, hunting pressure, animal wounding); compliance with regulations (i.e., Dalton Highway Corridor Management Area, firearms, monitoring and enforcement effort); and access. These issues are not unique to the TAPS ROW and have been addressed in other areas of North America (James and Stuart-Smith, 2000; Hay and Mohrman, 1993; Ricard and Doucet, 1993).

South of the Yukon River, relatively few concerns have been identified with respect to the TAPS ROW and harvest by humans. Since the Richardson Highway was in place before construction of TAPS, access into a previously undisturbed large area is not a new issue. However, public access has been created with trespass permission on Alyeska property (Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm; Shoulders, 1999, pers. comm.). In these cases, although hunting is not allowed from or within the ROW, the hunting and recreating public may travel within and across the ROW to previously isolated areas.

North of the Yukon River, the Dalton Highway has provided access to a previously remote area. Concern exists that this increased access has adversely affected moose, caribou, wolf, and bear populations with increased harvests (Yokel, 1999, pers. comm.) and the wounding of animals. Monitoring and enforcement of regulations along the Dalton Highway have been inconsistent and variable (Smith, W., 1999).

Beginning in 1980, summer traffic on the Dalton Highway was allowed as far north as Dietrich Camp, and year-round access was permitted starting in 1984. Travel was restricted to commercial vehicles north of Dietrich Camp (Smith, W., 1999). In 1991, the Dalton Highway was opened to public traffic along its entire length, but shortly thereafter was officially closed north of Dietrich Camp as a result of court challenges. The highway's entire length was reopened by state administrative order in December 1994 (Smith, W., 1999). According to W. Smith (1999, p. 1), "Although the northern section of the Dalton Highway was officially closed [between 1991 and 1994], the prohibition was largely ignored, and there was extensive hunting from the road. State policy dictated that the closure was not enforced as a primary statute, but was placed on a secondary status, similar to Alaska's seatbelt law. This meant violations of the road permit regulation were only cited in association with other violations."

Current hunting regulations north of the Yukon River include the Dalton Highway Corridor Management Area (DHCMA) in addition to regulations for each game management unit (GMU). DHCMA boundaries extend 8 km from each side of the Dalton Highway — including the highway's drivable surface — from the Yukon River to the Prudhoe Bay Closed Area. Restrictions in the DHCMA include the following:

- The DHCMA is closed to hunting with firearms, but big game may be taken by bow and arrow;
- No motorized vehicles, except aircraft, boats, and licensed highway vehicles, may be used to transport game or hunters within the DHCMA; and
- Any hunter traveling on the Dalton Highway must stop at any check station operated by ADF&G in the DHCMA (ADF&G, 1999g).

ADF&G has maintained a hunter check station on the Dalton Highway since 1991 to monitor hunting effort and to provide information to hunters in the Dalton Highway Corridor (DHC) and in GMUs adjacent to the road (Smith, W., 1999). More than half of all hunters registering at the check station were making their first trip up the Dalton Highway. Most (75 percent) hunters are Alaska residents, 69 percent of whom reported home addresses in Fairbanks, the northern Interior, Anchorage, Chugiak, or Eagle River. Approximately one-fourth of hunters using the DHC were on active military duty (Smith, W., 1999).

W. Smith (1999) reported that in any year, several factors combine to influence the number of hunters using the

DHC. Factors that encourage hunter use of the corridor include good weather, good road conditions, early-August influx of caribou near the road in GMU 26B, reduced availability of Tier 1 permits for the Nelchina Caribou Herd, lowered bag limits for other registration hunts, and state promotion of tourism. The State does not specifically promote use of DHC, although the BLM-Dalton Unit does (see BLM, 1998). Promotion of tourism is likely to increase use of the DHC (Smith, W., 1999). Factors that discourage hunter use of the DHC include the 8-km walk with firearms, closure of moose and non-resident brown-bear hunts in GMU 26B, reduced numbers of caribou near the road after August 15, lack of facilities from Coldfoot to Prudhoe, and lack of paving (Smith, W., 1999).

W. Smith (1999) concluded that although use of the DHC has increased since 1991, populations of moose, caribou, brown bears, and wolves have not been adversely impacted. The following is an excerpt from W. Smith (1999, pp. 7-8) regarding harvests of these populations:

> "The number of hunters for the 4 major big game species increased substantially in 1998, but harvest remained similar to previous years. As in the past few years, most caribou were taken in August near Toolik Lake, probably from eastward excursions of the large Western Arctic Herd (ca. 460,000) to the Dalton Highway. Consequently, the resident Central Arctic Herd in Unit 26B remains lightly harvested and, with current firearms restrictions with the DHC, should not be much affected by increased hunting pressure. Since the closure of Unit 26 to moose hunting, hunters using boats for access have shifted to waterways south of the Brooks Range such as the Koyukuk River and Bonanza Creek. This, along with increasing number of hunters using the road for access, resulted in the highest take of moose in Units 20F and 24 since 1991. Although hunting pressure has been localized along the road and the few navigable waterways off the Dalton Highway, moose harvest should be monitored in these units. Sheep brought through the check station represent only a small proportion of sheep harvested in units adjacent to the Dalton Highway. Since most successful sheep hunters use aircraft, increased hunting pressure from the road and by boat will have only minimal effects on sheep harvest. Changing the Unit 26B brown bear regulations caused a significant decrease in brown bear harvest to below the harvest quota. The increased harvest in Unit 24 was not caused by incidental take by higher numbers of hunters using the road or boats, but by an increased take by hunters using aircraft. However, similar to moose, brown bear harvest in Unit 24 should continue to be monitored carefully for increased incidental harvest."

The increase in Alaska's human population since TAPS construction has undoubtedly increased the hunting pressure on the state's wildlife. ADF&G has responded to this pressure where necessary by restricting seasons and bag limits. Many moose and caribou populations in the state are limited by predation, and ADF&G has implemented predator control programs to increase the number of ungulates available to hunt (Miller, S., 1997; Reynolds, H., 1997; Boertje et al., 1996; Ballard et al., 1991; Ballard and Miller, 1990; Bergerud and Ballard, 1989; Bergerud and Ballard, 1988; Van Ballenberghe, 1988; Ballard et al., 1987; Van Ballenberghe, 1985; Gasaway et al., 1983). Although these programs have been controversial, ADF&G management policies include direction to provide recreational harvest opportunities, which requires management for productive moose and caribou populations.

In addition, changes in land ownership and land uses in the early 1980s redistributed hunting pressure in the entire state by changing access for hunting and fishing. Areas that had previously been available for hunting were restricted due to federal land-use regulations for National Park Service lands such as Wrangell-St. Elias National Park and Preserve and Gates of the Arctic National Park (Mumford, 1999, pers, comm.; Heimer, 1980). Thus, hunting pressure in those areas not taken over by the federal government increased concurrently with TAPS-related accessibility.

Hunting pressure and harvests have increased for many wildlife species near TAPS since its construction. However, ADF&G management objectives are being met for most wildlife populations. Bag limits and seasons have been adjusted to allow for maximum sport-hunting opportunities without adversely impacting the population. Many populations are successfully managed through hunting. Increases in harvest and hunting pressure have not produced adverse population-level effects.

Furbearers and Small Mammals

Obstructions to Movements. Continued operation of TAPS would maintain a cleared area approximately 50 to 150 ft wide that may hinder or prevent movements of some small mammals. In particular, species preferring heavy cover in forested areas may be affected (Oxley et al., 1974; Forman and Alexander, 1998). Localized habitat fragmentation would result from vegetation clearing and operational maintenance, as well as from snow removal and compaction during winter maintenance activities. Compaction of snow under snow disposal areas and vehicle tracks eliminates narrow linear areas of subnivean space used by small mammals that are active through the winter (Schmid, 1971). These impacts would be restricted to small-mammal populations immediately adjacent to the TAPS workpads and access roads, and are not likely to result in large-scale population declines or reduced prey availability for predators feeding on the small mammals.

Disturbance and Displacement. Most furbearers and small mammals residing near TAPS facilities probably have habituated to routine operations and are not expected to be disturbed by their continuation. Operation and maintenance activities could disturb individual animals residing in more remote portions of the ROW where human presence is less common. Such effects would be localized and unlikely to have significant consequences for the disturbed individuals. Foxes, coyotes, river otters, wolverines, or lynxes denning in these areas may be affected to a greater degree and could abandon dens if disturbance was great enough. However, it is unlikely that normal operation and maintenance activities would cause this type of disturbance. Routine overflights by surveillance aircraft would temporarily disturb animals along or near the ROW. However, because of habituation, such disturbance would constitute a minor impact to animals residing in those areas, provided that deliberate harassment did not occur.

Similarly, human presence and activities associated with response to spills of oil and other hazardous substances would disturb small mammals and furbearers in the vicinity of the spill site and spill-response staging areas. Such activities would be more intensive and prolonged than normal maintenance and operation and would disturb and displace larger numbers of animals. The magnitude of the disturbance would depend on the size of the spill. Furbearers and small mammals residing inside spill-zone boundaries, especially those denning, would be displaced. For medium and large furbearers, spill impacts would exclude them from relatively small portions of their home ranges, although behavioral disturbance by spill response activities would extend the functional loss of habitat area. The magnitude of disturbance associated with localized spill events would be small for furbearers and small mammals, increasing with spill size and response requirements.

Wildlife/human interactions can pose a threat to safety because of increased human risk of exposure to disease such as rabies. As with bears, some furbearers such as canids and squirrels are readily habituated and even attracted to human activities, primarily when a food source is accidentally or deliberately made available (Milke, 1977; Follmann et al., 1980). Beavers can also become problem animals because of their dependence on easily constricted flowing water that may occur near, or be enhanced by, human alterations of local terrain. A beaver dam may flood storage areas or sites and equipment critical to the safe functioning of the pipeline. Because wildlife/human interactions can pose a threat to both safety and property, attempts currently are made to displace or drive away problem animals (Brown, D., 1999, pers. comm.; Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Preston, 1999, pers. comm.).

Deliberate displacement or hazing of problem animals to protect human life and property would continue to be used as a control measure at levels similar to those presently employed (APSC, 1998e). A permit is not required for such hazing. Although a fairly common practice for problem bears, available records do not indicate deliberate displacement by Alyeska of foxes, coyotes, or ground squirrels. The removal of beaver dams from culverts and other sites would continue to be a common practice along much of the TAPS ROW. This activity requires a Title 16 permit from ADF&G for alteration of aquatic habitats. Beavers would continue to be live-trapped and physically relocated, although such efforts typically provide only short-term relief (APSC, 1998e), and exclusion devices would be employed to mitigate the effects of damming culverts. For furbearers and small mammals, the impacts of deliberate displacement would be unlikely to have significant population-level impacts.

Use of the TAPS ROW by snowmachines and all-terrain vehicles (ATVs) would disturb and cause temporary local displacement of furbearers. The ROW is used extensively for snowmachine and ATV access in recreational activities, mining, trapping, and subsistence hunting (Schmidt, 1999, pers. comm.; Trudgen, 1999, pers. comm.). In response to past vehicle accidents, especially near population centers, Alyeska has installed fluorescent tape on access gates and VSMs to improve their visibility at night (Brown, D., 1999, pers. comm.). Although state regulations forbid the use of motorized vehicles for the harvest or transport of game taken with a hunting license within 5 miles of each side of the pipeline along the Dalton Highway, motorized-vehicle use is allowed for trapping and other purposes in the highway corridor. The state specifically prohibits restriction of motorized access for mineral exploration and extraction. Federal rules allow use of motorized vehicles and firearms in the ROW for subsistence purposes by qualified residents.

The ROW is the main winter trail between Wiseman and Coldfoot (Brown, D., 1999, pers. comm.). Furbearers and small mammals in the vicinity could be disturbed by motorized vehicles. The consequences of such disturbance would likely be minimal for most furbearers. However, foxes, coy-

otes, lynxes, river otters, and wolverines that actively avoid humans to avoid being shot and which would be susceptible to disturbance during denning (Olliff et al., 1999). Although the magnitude of vehicle disturbance in the ROW is difficult to estimate due to a lack of specific data, it may occur in high-use areas.

Habitat Alteration/Enhancement. Habitat alteration would result from:

- Gravel placement and other earthwork during maintenance activities;
- Periodic clearing of vegetation in the ROW;
- Fire suppression in the vicinity of TAPS;
- Dust fallout along the highway, particularly the Elliott and Dalton Highways north of Fairbanks; and
- Waste discharges and spills.

Gravel placement and earthworks, waste discharges, and spills would normally alter small areas, primarily affecting small mammals such as shrews, voles, lemmings, and squirrels inhabiting those sites. Clearing of the ROW would occur mainly in forested areas and would act to maintain those sections of the ROW in an early stage of plant community succession. Vegetation management benefits small mammals that use early-successional habitats and their predators (such as hares and lynx), and adversely affects small mammals and their predators that occur in late-successional or forested habitats (such as red squirrels, red-backed voles, and marten). Fire suppression has the opposite effect, favoring species of late-successional or forested habitats. The immediate effects of dust fallout adjacent to unpaved highways are early snowmelt and vegetation green-up, making such areas highly attractive to many herbivorous animals and consequently, their predators (Thompson, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Martin, P., 1999, pers. comm.; Bright, 1999, pers. comm.; McIntosh, 1999, pers. comm.). The continued maintenance of the TAPS ROW will have little effect on small mammal and furbearer populations.

Poor garbage management and lack of instruction and control of personnel during TAPS construction resulted in large numbers of wildlife incidents involving bears, wolves, coyotes, red and arctic foxes, wolverines, and squirrels. Repercussions included attacks on people, roadkills, kills in defense of life and property, and damaged property (Milke, 1977; Follmann et al., 1980; Schmidt, 1999, pers. comm.). Improved food and garbage handling, education, and strict prohibition of wildlife feeding (APSC, 1998e), coincident with a large decrease in human presence throughout the ROW after the construction phase, largely removed these problems (Brown, D., 1999, pers. comm.; Shoulders, 1999, pers. comm.). However, occasional instances of property damage, inadvertent or deliberate feeding, and animal control measures, including shooting of offending animals, continue to be reported (Brown, D., 1999, pers. comm.; Schmidt, 1999, pers. comm.). Because they are the most serious and conspicuous, bear incidents are reported most frequently, but observations suggest that incidents involving other species occur more frequently than is reported, in part because workers are aware of penalties and enforcement is difficult. For example, similar regulations exist in the North Slope oil fields. However, the density of arctic foxes is higher and populations more stable in the oil field than in adjacent areas. The widespread use of dumpsters by arctic foxes and their habituation and attraction to parked vehicles with humans inside both suggest that human food sources remain available (Burgess, 2000). Reported incidents along the TAPS ROW, although uncommon, have included ground squirrels, wolverines, and red foxes, often resulting in property damage (Shoulders, 1999, pers. comm.; Brown, D., 1999 pers. comm.). Although any amount of deliberate or inadvertent attraction of wildlife poses a serious legal and health risk, occurrences are limited by Alyeska facilities being fenced, widely spaced, and relatively small. The attraction of predators and scavengers to Alyeska facilities is thus unlikely to result in regional population-level impacts.

Mortality. Accidental mortality of furbearers and small mammals can occur due to collisions with vehicles and to accidental oil or chemical spills. Although the magnitude of mortality events is difficult to document or predict, the history of TAPS does not suggest that significant population-level impacts for furbearer and small mammals are likely. As previously mentioned, concentrations of wildlife near the highway occur during spring snowmelt, and observers note increased numbers of roadkills during that period. Furbearer and small mammal species known to have been killed by vehicles include arctic and red foxes, ground squirrels, and porcupines (Brown, D., 1999, pers. comm.; Shoulders, 1999, pers. comm.).

Accidental oil or chemical spills and waste discharges may cause mortality in the spill area, potentially affecting small numbers of all species present. Aquatic or semi-aquatic mammals would be most vulnerable, including beaver, muskrat, mink, and river otter. Small spills would result in correspondingly minor impacts on small-mammal and furbearer populations. Larger spills are less likely but would impact larger numbers of small mammals and furbearers. Population-level impacts would not be expected unless the spills were very large.

Mortality of furbearers or small mammals may result from deliberate action taken against problem animals. Al-

though hazing is the preferred means of dealing with problem animals, nuisance animals have been destroyed (Brown, D., 1999, pers. comm.; Shoulders, 1999, pers. comm.; Preston, 1999, pers. comm.). Foxes or other animals exhibiting signs of rabies are shot and their heads sent to the University of Alaska for testing (APSC, 1998e). Alyeska periodically hires or cooperates with trappers to remove beavers (Preston, 1999, pers. comm.). Other furbearers and small mammals that may be killed to prevent disease transmission or property damage include red foxes, coyotes, ground squirrels, and voles and mice. Although nuisance animals are viewed as a serious problem and threat to human health, historically the number of animals killed is small, and such mortalities are unlikely to have population-level impacts on furbearers or small mammals.

Increased densities of predators and scavengers attracted to areas of human activity may result in increased predation pressure on prey populations. This has recently become a management issue, mainly for ground-nesting birds on the North Slope (Day, 1998), but it is difficult to document. Increases in the abundance of foxes are well-documented in the North Slope oil fields (Burgess, 2000). However, because pipeline facilities are more dispersed than oil-field facilities, this problem would be small south of Pump Station 1.

Similarly, increased densities of predators/scavengers may increase the occurrence and rate of transmission of enzootic diseases, including rabies (Follmann et al., 1988). The primary reservoir of rabies in the Arctic is arctic foxes, whereas south of the Brooks Range, red foxes and other carnivores are a greater concern (Winkler, 1975). As with other impacts associated with nuisance animals, the magnitude of this impact directly associated with TAPS would likely be minor.

Harvest by Humans. Access provided by pipeline access roads for hunting and trapping could result in continued harvest of all furbearer species. Alyeska currently allows vehicular use of access roads and work pads with prior notification and permission, although most such use occurs without permission (Brown, D., 1999, pers. comm.). Hunting with firearms and motorized access is legally prohibited by the state within 5 miles of TAPS along the Dalton Highway. Trapping in the Dalton corridor is allowed by the state (Whitten, 1999, pers. comm.), and federal rules allow the use of both firearms and motorized vehicles by qualified subsistence users. The ROW and access roads currently receive heavy use, and illegal harvest is a recognized problem (Montgomery, 1999, pers. comm.; Brna, 1999, pers. comm.; Schmidt, 1999, pers. comm.; Thompson, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.; Whitten, 1999, pers. comm.; Shideler, 1999, pers. comm.). Decreased monitoring and enforcement following TAPS construction dramatically increased the illegal take of animals along the TAPS ROW (Whitten, 1999, pers. comm.; Shideler, 1999, pers. comm.). In recent years, trapping pressure has been heavy, and there is competition for traplines along the TAPS ROW between Fairbanks and the Yukon River bridge. Trapping pressure is lower north of the Yukon River (Whitten, 1999, pers. comm.; Shideler, 1999, pers. comm.). Legal and illegal take by hunters and trappers who use the ROW and access roads would constitute the largest single impact of ROW renewal and continued operation of the TAPS system on furbearers. However, management regulations are designed to prevent serious impacts on populations. Hunter access would be available with or without ROW renewal.

The legal take of problem animals through notification (and occasional hiring) of local trappers by Alyeska would continue with renewal of the TAPS ROW Grant (Brown, D., 1999, pers. comm.; Schmidt, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Preston, 1999, pers. comm.). Decreased beaver trapping has resulted in increased populations (Preston, 1999, pers. comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.), which in turn has caused more problems with flooding of Alyeska facilities. There are no records of Alyeska hiring trappers to remove other species, although oil companies have done so periodically to remove arctic foxes on the North Slope. The legal take of problem animals attributable directly to TAPS would be unlikely to have significant impacts on furbearer and small-mammal populations.

4.3.2.6 Threatened and Endangered Species

By R. Ritchie, D. Troy, and J. Kidd

Two species listed as threatened under the federal Endangered Species Act (ESA) (Spectacled Eider and Steller's Eider) and two delisted subspecies of Peregrine Falcon (the *tundrius* and *anatum* races) may be affected by activities associated with renewal and continuation of existing operation and maintenance of TAPS. The endangered Short-tailed Albatross occurs in the tanker shipping lanes, mainly beyond Prince William Sound. The endangered Eskimo Curlew evidently no longer occurs in Alaska. No ESA-listed terrestrial mammals or plants occur along TAPS. Because of similarities among the remaining listed species, the discussions of environmental consequences have been combined for both eider species and for both peregrine subspecies. Recent EISs have also addressed endangered species (e.g., BLM and MMS, 1998; USACE, 1999). Possible issues regarding other sensitive species are covered in the discussion of terrestrial mammals above.

Spectacled and Steller's Eiders

The continued operation of TAPS would have negligible effects on Spectacled or Steller's eiders. Spectacled Eiders occur regularly in low numbers in the general vicinity of the TAPS ROW in the northern end. Records near the area of operations or facilities are few, but not all areas of potential occurrence have been thoroughly surveyed. Spectacled Eiders have been reported at TAPS MP 12 (Hohenberger et al., 1981), and nesting has occurred adjacent to the Dalton Highway near Deadhorse (TERA, unpubl. data). Overall, the opportunities for interaction between Spectacled Eiders and TAPS operations are few. There are no records of Steller's Eider within the ROW, indicating that its occurrence is infrequent at best and that the chance or simultaneous occurrence of eiders and a deleterious event is unlikely. FWS recently proposed designating a large portion of the Alaska North Slope as critical habitat for these two species (65 FR 6114; 65 FR 13262).

Obstruction to Movements. Roads and pipelines do not appear to be major barriers to eider movements. The greatest potential for obstruction of movements would occur during brood-rearing, when flightless Spectacled Eiders with broods cross roads in the Prudhoe Bay oil field (TERA, 1995, 1996b). A minor gravel corridor structure, such as the pipeline workpad without traffic, would not be an obstacle. The Dalton Highway would be a more imposing barrier, posing some risk of mortality for eiders attempting to cross.

Disturbance and Displacement. The evidence for sensitivity of Spectacled Eiders to disturbance is mixed. Anderson et al. (1992) found evidence of some avoidance of a high-noise facility (Prudhoe Bay Central Compressor Plant); however, Spectacled Eiders make regular use of areas close to other noisy environments such as Prudhoe Bay Flow Station 1 (e.g., TERA, 1996b). Anderson et al. (1996) suggested that nest sites tended to be farther away from facilities than where pre-breeding birds were seen, perhaps indicating some sensitivity to disturbance. The only facility along TAPS within the range of Spectacled Eiders, Pump Station 1, is not situated near any known areas of use; hence, disturbance of this nature is unlikely. Helicopter overflights, such as for pipeline surveillance, can result in the disturbance of waterfowl. Spectacled Eiders appear to be relatively tolerant of low-flying helicopters during the breeding season, and the occurrence of Spectacled Eider use areas along TAPS is limited. The greatest potential for TAPS-related disturbance of Spectacled Eiders would occur along the Dalton Highway. As with many other waterfowl, eiders appear tolerant of, or habituate to, vehicular traffic but are prone to flush when approached on foot (Murphy and Anderson, 1993).

Habitat Alteration and Enhancement. Spectacled Eiders use roadside impoundments in the Prudhoe Bay and Kuparuk oil fields (Warnock and Troy, 1992; Anderson et al., 1996). Thus, this type of habitat modification along the TAPS workpad and Dalton Highway would potentially enhance those areas for Spectacled Eiders. However, use of TAPS or Dalton Highway impoundments away from Deadhorse has not been reported for Spectacled Eiders.

Mortality. No mortality of Spectacled Eiders due to TAPS infrastructure has been documented. Use of roadside impoundments poses a limited risk for traffic-associated mortality, especially near Prudhoe, although no records of such mortality have been located. To the extent that predator populations may be augmented by TAPS activities, Spectacled Eider nest success could be depressed to a minor degree. Oil spills would be a risk factor; however, the low use of areas adjacent to the TAPS ROW makes this a small risk. A Spectacled Eider successfully nested in an area affected by a spill the prior winter (Drill Site 5; Burgess, Jorgenson et al., 1995). A female Spectacled Eider died from oiling after landing in a waste pit with a light oil sheen in the east Prudhoe Bay oil field in 1983 (ABR, Inc., unpubl. data).

Harvest by Humans. Hunting of Spectacled and Steller's eiders is prohibited throughout Alaska. Even before the prohibition, it is unlikely that any shooting of these species occurred along TAPS. Limited waterfowl hunting takes place in the eiders' range near TAPS, and few, if any, eiders are present during waterfowl hunting season. Spectacled Eider eggs have been taken under federal collecting permits — perhaps due to mis-identification as King Eider eggs — in the Prudhoe Bay area as recently as the early 1990s. Permits are no longer given to collect eider eggs in Alaska for captive propagation.

Peregrine Falcon

The continued operation of TAPS is expected to have negligible effects on both the *anatum* (American) and *tundrius* (Arctic) subspecies of the Peregrine Falcon. Both populations continue to increase in numbers adjacent to the TAPS ROW, and no traditional sites appear to have been abandoned. Regular surveys monitoring productivity and success have not referenced specific concerns regarding TAPS and its activities (e.g., Wright and Bente, 1999; Ritchie and Rose, 1999).

Obstructions to Movements. Roads, elevated pipelines, and normal maintenance and operation activities along TAPS probably have little effect on the movement of Peregrine Falcons. No research has been conducted to determine whether individuals avoid TAPS. However, anecdotal observations of peregrines perching on the pipeline, VSMs, Dalton Highway signs, snow markers, and other elevated perches suggest regular use of the area.

Disturbance and Displacement. Ritchie (1987) documented the disturbance effects of pipeline operation and maintenance activities on *tundrius* Peregrine Falcons on the North Slope. Activities included surveillance helicopter monitoring of the pipeline, light trucks and ground parties along the ROW, heavy equipment associated with pipeline repair, and boats associated with spill-response drills. Behavioral observations of Peregrine Falcons — which were limited to a small sample of nest sites primarily during incubation through late nestling periods — documented few severe reactions or behaviors, suggesting that none of these activities influenced major behaviors including incubation, nest attendance activities, and provisioning (Ritchie, 1987). Productivity was similar between experimental and control groups. Similar results showing short-term behavioral reactions with little or no apparent effect on productivity have been reported in investigations of aircraft disturbance of peregrines (Windsor, 1977; Ellis et al., 1991).

Peregrines continue to occupy traditionally used cliffs within 1 mile of TAPS and the Dalton Highway, suggesting that long-term displacement has not occurred during operation of TAPS. If some sites were not used during construction of TAPS, explanations for those presumed displacements were masked by natural variation in numbers (White et al., 1977) and the smaller size of peregrine populations in the mid-1970s when both subspecies were at historical lows (Roseneau et al., 1981). Since then, numbers have recovered and now exceed population estimates made in the 1960s (Wright and Bente, 1999).

Habitat Alteration and Enhancement. Maintenance and operation activities along TAPS could result in both permanent and temporary changes in nesting and foraging habitats of Peregrine Falcons. Permanent actions would be limited to minor amounts of additional fill covering some prey habitats and to cliff modifications at quarries. Effects of these actions have not been quantified and may be positive. As *anatum* populations have expanded in Interior Alaska, rock quarries have been used for nesting (Ritchie et al., 1998). Quarries associated with TAPS may provide similar nest substrates, which would be disturbed if quarrying activities resumed during the nesting season. Mitigation would be achieved through adjustment of seasonal timing of such activities.

Temporary losses or enhancements of habitats for peregrines would include excavations associated with pipeline inspection, delayed snowmelt in the shadows of some facilities and gravel structures, dust fallout and impoundments associated with the Dalton Highway, and elevated structures including the pipeline, buildings, and snow markers. The impacts of these habitat modifications are difficult to quantify, however. In general, most of these actions probably would attract Peregrine Falcons, either as areas attracting prey (e.g., impoundments, dust shadows) or as platforms for resting and perching (e.g., VSMs). Although Peregrine Falcons have not been recorded nesting on TAPS facilities, other raptors have used TAPS facilities (Ritchie, 1991). Use of towers by tundra peregrines elsewhere on the Arctic Coastal Plain (Mauer, 1999, pers. comm.) indicates the potential value of elevated structures along TAPS for nesting, particularly at the northern end.

Mortality. Potential sources of mortality of Peregrine Falcons associated with pipeline operations and maintenance activities could include collisions with vehicles, aircraft, and facilities; disturbance of nesting adults causing egg and nestling death or premature fledging of young; contact with oil or other contaminants; and increased predation from increases in predator populations (Roseneau et al., 1981). The occurrence and frequency of such risks are poorly documented. Some vehicle-caused mortality of raptors, including Peregrine Falcons, has been documented along TAPS, but probably occurs infrequently. At least one dead immature falcon, whose death was attributed to a collision with a vehicle, was recorded near Pump Station 2 (Ambrose, 1999, pers. comm.).

No other references to direct mortality of peregrines due to pipeline activities have been identified, but monitoring for loss of nestlings or eggs due to human disturbance has not been undertaken. Some mortality probably has occurred due to curious or inadvertent visitation by recreationists and naturalists along the Dalton Highway.

Harvest by Humans. Falconry permits from the State of Alaska have allowed the taking of three Arctic Peregrine Falcons annually along TAPS since the delisting of the *tundrius* subspecies in 1995 (5 AAC 92.037. Permits for falconry). Since that time, two to three *tundrius* nestlings have been removed from nests each year along the Sagavanirktok River (Wright, 1999, pers. comm.). The FWS is currently defining conditions for allowable take of the *anatum* subspecies of Peregrine Falcon, which was delisted in 1999 (FWS, 1999e). No other type of harvest by humans for such uses as subsistence or research has been recorded along TAPS.

Plants

No threatened or endangered plants occur along TAPS.

Terrestrial Mammals

No threatened or endangered terrestrial mammals occur in Alaska.

4.3.2.7 Effects of Treated Ballast-Water Effects on Benthos in Port Valdez

By B. Haley

Studies to monitor environmental consequences of effluent discharge from Alyeska's ballast water treatment facility have been conducted in the vicinity of the VMT since the late 1960s. Biological information for the subtidal benthos has been collected between 1971 and 1999 for Port Valdez. The objectives of the program are to document and interpret distribution, abundance, and biomass of benthic organisms and detect changes in benthic fauna. Stations were assigned in 1987 to compare data between remote (far-field) stations, shallow near-field stations, and shallow and deep mixing-zone stations.

Fluctuations in distribution and abundance are common throughout the benthic communities studied. Several factors influence the health of the benthos there, including sediments from glacial stream and river runoff, seismic activities, and sediment deposition during coastal construction. Feder and Jewett (1988) suggest that the benthic system in Port Valdez is carbon-limited and that a "feast or famine" hypothesis is reasonable. Cyclic highs and lows in benthic community abundance and biomass noted from 1971 to 1996 are credited to variable carbon availability.

Station D25 is within approximately 120 m of the treated-ballast-water diffuser, and Station D33 is adjacent to the diffuser. Trends in abundance and number of benthic taxa at both stations indicate impacts potentially related to ballast-water disposal when compared to reference stations.

A potential change in benthos related to ballast water treatment discharge was apparent in 1995-97. Decreasing abundance and taxa number trends were measured at Station D25 in that period. Two replicates from D25 were visibly contaminated with petroleum product in 1997. Increased taxa dominance and lower diversity at D25 indicated a distinct difference in the benthic profile at D25 from other stations. In 1998, fauna abundance and number of taxa and biomass increased, suggesting that the environmental influences had moderated and that the benthos was recovering. The taxa ranking at D25 approached that which was previously common to the station, further indicating a moderation of negative effects. No difference in mean values at D25 from reference stations were observed in 1999.

The abundance of benthic suspension feeders (thyasirid bivalves) has occasionally been very high at D33, relative to other shallow stations. This fact supports the suggestion that enhanced elevated food levels exist there, presumably from particulate matter emitted in the treated ballast-water. Underwater television recordings of dense communities of suspension feeders and particulate material flowing from the diffuser ports support this (Feder and Shaw, 2000).

Little or no evidence of petroleum contamination was found in benthic communities in Port Valdez in 1973 (Hood et al., 1973). Under terms of the first NPDES permits, hydrocarbon in sediment measurements were conducted in the 1970s and 1980s. Detectable concentrations of petroleum hydrocarbons were measured in the vicinity of the VMT after operations began in 1977. Analysis of sediment samples taken between 1989 and 1996 measured higher concentrations of hydrocarbons in the vicinity of the terminal than at remote locations in Port Valdez. With rare exceptions, near-terminal hydrocarbon concentrations were well below the guidelines for marine sediment quality (i.e., Washington State Marine Sediment Quality Standards and EPA Draft Sediment Quality Criteria). Concentrations of hydrocarbons in Port Valdez mussels from 1989 to 1996 were apparently unrelated to terminal operations; compounds and concentrations present were highly variable and mostly biogenic in origin (Feder and Shaw, 2000).

Analysis of data on Port Valdez benthic fauna indicates that treated ballast-water does not negatively impact benthic communities at the deep-water stations and only rarely influences benthos at the shallow-water stations.

4.3.3 Social Systems

This section provides information on the likely impacts on social systems from renewal of the TAPS ROW.

4.3.3.1 Economy

By O.S. Goldsmith, L.D. Maxim, and R. Niebo

This section provides estimates of the economic effects of TAPS ROW renewal for the pipeline, Alaska North Slope (ANS) fields, marine transportation link, and other industries in Alaska. Included are direct, indirect, and cumulative economic effects. Economic effects are calculated by a model that addresses the pipeline and the ANS fields as a combined unit. Largely based on geography, it is possible to separate other social impacts of the proposed action, so that only direct and indirect impacts of the pipeline

are addressed here. Cumulative social effects are included in Section 4.5.

The economic effects of the proposed action alternative are beneficial, substantial, and wide-ranging. Moreover, these have not been addressed in any previous EIS or EA, which necessitates a more complete explanation.[1]

Except where noted, projected North Slope oil revenues are based on a constant real price for North Slope crude of approximately $16 per barrel (1998 dollars). Since completion of the economic analysis summarized here, oil prices have increased substantially (to more than $30 per barrel as of March 2000). It is not feasible to replicate this analysis in response to every crude-oil price movement. However, an upward shift in oil prices will magnify the economic impacts presented here. First-order impacts of this change include substantial (factor of 2) increases in revenues to various levels of government. If higher prices persist, marginal fields and other oil and gas developments become more attractive. Developing these fields would increase future ANS production and pipeline throughput and, therefore, revenues. In turn, greater revenues result in “ripple” (multiplier) effects throughout the Alaskan economy. Although some of these effects — such as higher prices for gasoline, diesel fuel, heating oil — would be adverse, most are beneficial for oil-producing regions. Thus, if crude oil prices increase above $16 per barrel, the economic benefits will increase as well.

Key Assumptions: The Pipeline

- **Pipeline Throughput:** Appendix A provides the baseline assumption for ANS production and TAPS throughput if the pipeline ROW is renewed until 2034.
- **Pipeline Operation:** The pipeline continues to operate until 2034. Operating employment declines as pump stations are closed due to reduced throughput. Contract workers and special project employment also decline. From 2,096 operations, contract, and special projects workers in 1999, employment falls to 1,716 in 2010 and remains there.
- **DR&R:** Pipeline dismantling, removal and restoration occurs sometime after 2033.
- **Oversight:** Government and other oversight of TAPS continues at the current level throughout the period of the proposed action.

[1]Each North Slope EIS addresses the proposed action, but these discussions do not include the total effects of oil and gas operations on the Alaska North Slope. Nearly all material in Section 4.3.3.1 is original, and all tables and figures in the section are from original analysis by the authors.

Key Assumptions: North Slope Oil-Related Activity

- **Oil and Gas Exploration, Development, and Production:** This activity continues on lands currently open for oil exploration, development, and production, but no activity occurs on lands currently closed, specifically the Arctic National Wildlife Refuge. Oil production gradually declines as the depletion of older fields is only partially offset by production from newly discovered fields (Appendix A). Oil and gas employment remains constant as smaller, marginal fields requiring more labor replace larger and more productive but depleted fields. Efforts continue to develop the substantial gas resources on the North Slope, but no specific project — such as gas to liquids, a gas pipeline parallel to the oil pipeline, or a gas pipeline through Alaska into Canada — is included in this economic analysis.
- **DR&R:** North Slope oil and gas facilities DR&R occurs sometime after 2033.
- **Module Construction:** Construction of some modules for North Slope oil production continues in Anchorage, Fairbanks, and Nikiski.
- **Refining:** Refineries at Fairbanks and Valdez operate throughout the renewal period using a constant volume from TAPS to produce petroleum products for the Alaska market.
- **Air Cargo:** The international air-cargo industry, centered in Anchorage, expands until 2010 in response to growth in the market, and then remains stable. This growth is facilitated by the availability of competitively priced jet fuel refined in the state.
- **Other Industries:** Competitively priced petroleum products are important to the health of all of Alaska’s natural-resource-based private industries — fishing, timber, mining, and tourism. The military, particularly the Air Force, is a large consumer of petroleum products. The gradual decline of North Slope production does not adversely affect the availability of competitively priced petroleum products, and these industries are not impacted.
- **Shipping:** Lower TAPS throughput reduces the number of tanker trips taking crude oil to market from Valdez. Economic growth without increased capacity of existing refineries in the state slowly increases the number of tanker trips bringing petroleum products into Southcentral Alaska from refineries outside the state.
- **Oversight:** Government oversight of oil and gas con-

tinues at the current level throughout the ROW renewal period.

Key Assumptions: Other Economic Activity

- **Basic Industries:** Employment in Alaska's basic industries grows at an annual rate of 1 percent between 2000 and 2010, slows to half that rate between 2010 and 2025, and is constant thereafter (Table 4.3-16).
- **Tourism:** Tourism is projected to add the most jobs, with growth between 2000 and 2010 of 3.3 percent annually. Consequently, tourism surpasses seafood as the largest private basic industry in the state measured by jobs. However, because of the relatively low wages paid in tourism, its total economic impact is less than most other basic industries.
- **Mining:** Mining is projected to grow at 3.7 percent annually between 2000 and 2010, although it is starting from a relatively low base.
- **International Air Cargo:** This relatively new industry for the state is expected to expand through the next decade at an annual rate of 2.2 percent.
- **Other Industries:** The other private basic industries contribute little to growth in the number of jobs. Petroleum shows some growth between 2000 and 2010 as it recovers from the very low oil prices of early 1999. Seafood harvesting and processing employment remains constant. Timber has a modest recovery from the slump in the second half of the 1990s. Active-duty military employment remains constant.
- **Federal Government:** Federal civilian employment will trend upward at 0.3 percent per year. Federally funded construction activity continues at a high level through 2010 and then declines 5 percent annually.
- **State Government:** The state government has experienced a chronic General Fund deficit since the early 1990s precipitated by the decline in petroleum revenues as North Slope production decreased. The deficit has been covered through a combination of reductions in spending and the use of cash reserves. In the future, balancing the budget will also require the re-imposition of the state personal income tax and the use of a portion of the earnings of the Alaska Permanent Fund. Real General Fund expenditures grow, but real expenditures per capita fall 1 percent a year. State government employment increases slowly as budget reductions are concentrated in transfer programs.
- **Permanent Fund:** The Alaska Permanent Fund grows at 0.6 percent per year in real value from continued contributions of a share of petroleum royalties and reinvestment of earnings to inflation-proof the fund balance. These contributions increase the fund balance from $24.2 billion in 2000 (1998 dollars) to $26 billion in 2010 and $28.1 billion in 2025. In the early years 70 percent of fund earnings (net of inflation proofing) are used to pay the Permanent Fund Dividend (PFD) to eligible Alaskans. The rest of the earnings is retained in the Earnings Reserve Account. Later it becomes necessary to use the Earnings Reserve Account, as well as a portion of the PFD, to maintain government services. The share of earnings used to pay the PFD falls to 30 percent in 2010 and 10 percent in 2025.
- **Local Governments:** State government support for local government, primarily education, grows with the state budget but does not keep pace with the increase in population. The drop in revenues from smaller petroleum-property-tax receipts is concentrated in the North Slope Borough (NSB) and the City of Valdez. In other communities there is growth in property tax receipts from other sources to help support necessary locally provided public services.

Economic Effects

Renewal of the TAPS ROW will result in substantial economic effects — some directly associated with the pipeline and others related to continued operation of the ANS fields and the marine transportation link. Economic effects associated with operation of the ANS fields and the marine

Table 4.3-16. *Basic-sector employment and projected growth rates for the proposed action.*

	Petroleum	Mining	Seafood	Timber	International Air Cargo	Tourism	Military	Federal Civilian	Total
Employment in 2000	8,800	1,797	19,115	2,029	2,100	16,518	18,054	17,429	85,842
Annual Growth									
2000-2010	0.8%	3.7%	0.0%	0.2%	2.2%	3.3%	0.0%	0.2%	1.0%
2010-2025	0.0%	1.3%	0.0%	0.3%	0.0%	1.7%	0.0%	0.2%	0.5%
2025-2034	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: Results of analysis using the model from the Institute of Social and Economic Research (ISER) of the University of Alaska, Anchorage.

transportation link, as well as indirect effects associated with all oil and gas activity, are cumulative effects. However, the econometric model used in this analysis treats these elements as one econometric system, and it would be difficult to disaggregate effects. Therefore, the economic analysis presented here addresses direct, indirect, and cumulative economic effects.

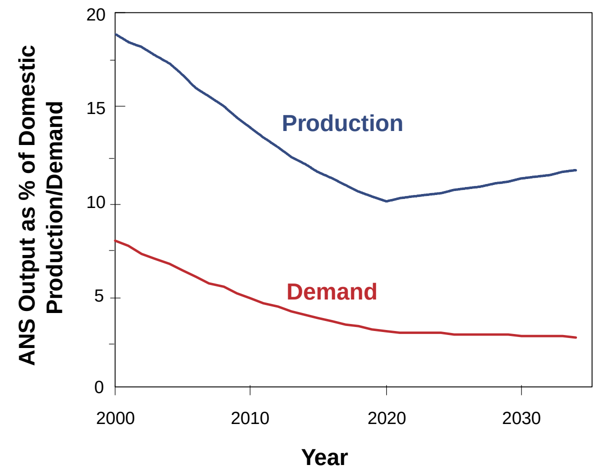
Continued operation of ANS/TAPS is expected to have significant positive economic impacts compared to the no-action alternative. ROW renewal provides additional revenues to federal, state, and local governments, and employment and income for U.S. workers in Alaska and elsewhere, and supports government policy objectives ranging from the National Energy Strategy to maritime policy (the Jones Act).

Equally important, continued operation of ANS/TAPS provides additional time for Alaska's economy to become more diversified and gradually adjust to reduced dependence on oil. As other countries dependent on a single industry have learned, such transitions are often painful, particularly if abrupt (Amuzegar, 1999). The more gradual the transition, the more time is available to develop other industries and government policies to cushion the impact of change.

Finally, renewal of the ROW preserves the pipeline and thus increases the possibilities for development of additional oil fields and/or commercialization of natural gas resources.

National Impacts. In a national context, the economic benefits provided by ROW renewal are projected to be smaller than in the past as production decreases, but very significant nonetheless. National impacts associated with continued TAPS operation include increased domestic crude-oil production, an improved balance of trade in crude oil, increased federal revenues, construction of additional double-hull tankers to serve the ANS trade, and increased employment for workers in U.S. shipyards and for U.S. seafarers. These impacts are summarized as follows:

- **Increased Domestic Crude Production:** Continued operation of the ANS oil fields will increase domestic crude production by an aggregate amount of approximately 7 billion bbl over the ROW renewal period. Figure 4.3-19 shows ANS production as percentages of estimated domestic crude production and demand. ANS production accounts for a declining but substantial percentage of estimated (EIA, 1998) domestic crude production through the year 2020. Key components of the National Energy Strategy are increased energy conservation and increased domestic production. Continued operation of ANS/TAPS serves the latter policy objective of ensuring against energy disruptions and of increasing domestic energy production in an environmentally responsible manner (USDOE, 1998).



Note: The apparent increase in ANS share of domestic production after 2020 is an artifact of the assumption that the baseline ANS throughput remains constant while U.S. production continues to decline between 2020 and 2034; see Appendix A)

Figure 4.3-19. *ANS output as percent of domestic crude production or consumption under the proposed action.*

- **Improved Balance of Trade:** The availability of ANS crude oil reduces the amount of crude that must be imported to meet estimated domestic demand and thus improves the balance of trade, which for petroleum has been negative for some years. Domestic petroleum demand is projected to increase and domestic crude production to decrease even if ANS production continues. Therefore, the trade deficit in petroleum will grow worse whether or not the ROW is renewed. However, the projected deficit will be smaller if ANS production continues. If the ROW is renewed, the cumulative value of ANS production is projected to be approximately $112 billion (1998 dollars), assuming a world oil price of $16/bbl or $150 billion (1998 dollars), based on world oil price forecasts made by the U.S. Department of Energy[2], and the trade deficit would be reduced by this same amount.
- **Increased Federal Revenues:** ANS production generates federal revenues from federal income taxes and lease royalties. From 2004 to 2034, continued operation of the ANS fields and TAPS is estimated to yield

[2]Cumulative ANS production value is calculated from throughput assumptions (Appendix A) and the 2000 EIA World Oil Price Forecast (EIA, 1999e).

approximately $10.8 billion in 1998 dollars (ECA, 1999b).

- **Tankers and Related**: Under OPA 90, existing single-hull tankers must be phased out over time and new double-hull tankers constructed to transport ANS crude from Valdez to destination ports. Based on the published phase-out schedule for the present ANS fleet and projected ANS output, it is estimated that nine 125,000-deadweight-ton tankers will have to be constructed at approximately $166 million (1998 dollars) each (ECA, 1999a). Thus, approximately $1.5 billion will be spent at U.S. shipyards for these tankers. Since approximately 1,000 shipyard jobs are generated for the 18 months that it takes to construct a tanker, nine tankers will support 162,000 worker-months of employment in these yards. Periodic tanker inspection and maintenance will provide additional jobs for workers in U.S. shipyards. Employment for U.S. seafarers will gradually decrease as the number of tankers required to carry ANS output decreases. At the beginning of the ROW renewal period, ANS tankers will employ approximately 1,330 U.S. seafarers. This number will decrease to approximately 530 over the renewal period. Indirect (multiplier) effects would add to the total economic activity associated with construction and operation of these tankers.

State Impacts Modeling. State impacts were calculated using a model developed by the Institute of Social and Economic Research (ISER) of the University of Alaska Anchorage (UAA) (Goldsmith, 1999b). Following is a brief description of the econometric methodology.

The projections of Alaska state and regional economic and demographic variables in both the proposed action and the no-action alternative were generated using the Man in the Arctic Program (MAP) Economic Modeling System of UAA. The MAP system was developed at ISER in the early 1970s to demonstrate the economic, demographic, and fiscal impacts on Alaska of different schedules of federally imposed petroleum-development scenarios (Kresge and Seiver, 1978; Kresge et al., 1984). It has since been used for a variety of purposes including analyzing the economic and fiscal effects of specific private-sector development projects (Goldsmith et al., 1976), analyzing the cumulative impacts of energy development (Huskey, 1979), and projecting likely economic futures for the state for transportation planning purposes (Goldsmith and Hill, 1997).

A set of statewide and regional economic and demographic projections has been produced using MAP nearly every year since 1990. The most recent set of projections, *Economic Projections for Alaska and the Southern Railbelt: 1999-2025*, prepared in July 1999, assumed the continued operation of the oil pipeline through 2025 (Goldsmith, 1999b). Those projections form the basis for the employment, income, gross state product, and population estimates for the proposed action.

To develop the economic and demographic estimates for the no-action alternative (Section 4.4.3), a different set of assumptions was developed and run through the models. These assumptions described the direct employment effect of shutting down the pipeline and North Slope operations — including DR&R — as well as the direct revenue effect on state and local governments. The models were run to estimate state and regional economic activity, state and regional fiscal activity, and state and regional demographic activity for the no-action alternative. Comparison of these results with the output from *Economic Projections for Alaska and the Southern Railbelt: 1999-2025* (including some variables not included in the earlier written report) produced estimates of the impact of the no-action alternative compared to the proposed action.

The MAP Economic Modeling System consists of both statewide and regional models. The statewide model has three modules: economic, fiscal, and demographic, while the regional model includes census-division-level simplified economic and demographic elements which can be aggregated into larger regions.

In the economic module of the state model, the level of economic activity is a function of production for export as well as production for local consumption. The output of the export sectors is determined exogenously, while that of the support sectors is a function of local demand reflected by disposable personal income and wealth. Production from both sectors generates wages and salaries which form the major portion of disposable personal income after personal taxes. Thus, demand and supply are simultaneously determined in this module. Time-series econometric equations underestimate most of the relationships in the model.

The economic module is linked to both the fiscal and demographic modules and depends as well on national economic activity measured by movements in the price level, wage rates, per-capita income, and other variables. Output of the public sector is an important element of total production, and government tax and expenditure policies directly affect the level of aggregate and per-capita disposable income. Population also influences both production, via local demand for goods and services, and personal income, via transfers and other payments related to the size of the population.

In the fiscal module, state and aggregate local government revenues and expenditures are determined. Since

most state revenues are from oil production and financial asset earnings, and expenditure patterns have changed with variations in the availability of revenues, this part of the module is a combination of econometric equations and accounting relationships. A particularly challenging part of any projection is developing a set of assumptions (a fiscal policy package) for dealing with the projected continued decline of state revenues. Local revenues and expenditures are represented by time-series econometric equations with revenues determining the level of expenditures.

The fiscal module is linked to the demographic module in that population is a determinant of the level of some revenues as well as some categories of expenditures. The level of economic production is also a factor in determining revenues, but there is no direct link between economic production and public spending.

In the demographic module, age and sex projections for Alaska Natives, non-Native civilians, and active-duty military are generated using a cohort survival methodology. There is a strong link with the economic module because the determinants of net migration (an important component of the change in population over time) include Alaska wage rates and unemployment rates relative to the rest of the national economy. Migration is also influenced by tax and expenditure policies reflected in the fiscal module.

The regional model consists of procedures that allocate Alaska employment, personal income, and population categories among the census areas of the state. Total employment estimates take into account the concentration of purchasing power and thus support employment in regional centers and away from outlying areas. Resident employment estimates account for the large number of workers in some census areas who reside elsewhere in the state or outside Alaska. Population estimates account for the movement of Alaskans toward those census areas where employment opportunities are increasing relatively faster. The relationships in this model are based on a variety of primarily cross-sectional data sources such as the U.S. Department of Commerce, Bureau of the Census, and point-in-time surveys. This model does not produce as much employment and demographic detail as the state model, and there are no local government fiscal modules for individual communities.

The model structures have evolved over time, primarily in response to changes in the structure of the economy of Alaska but also in response to the needs of users and to computer capabilities. It is standard practice to review and revise, as appropriate, model structures, input assumptions, initial values, and coefficient and parameter values each time the models are used.

State Impacts. Renewal of the TAPS ROW will provide substantial benefits to the State of Alaska and its residents. Continued operation of the pipeline and of North Slope oil- and gas-related activity generates a large and stable level of basic sector employment (Table 4.3-17) that contributes to the economic base of communities throughout the state. Since these jobs are among the highest paid in the state, each job makes a large contribution to the economy. Many jobs linked to oil field operations, particularly in refining, module construction, air cargo, and government oversight, are located outside the pipeline corridor. In addition, most North Slope oil and gas workers live in other parts of Alaska (ADOL, 2000).

Cumulative North Slope oil production during the ROW renewal period will be approximately 7 billion barrels. Total state petroleum revenues from North Slope oil production and pipeline operations are projected to be $14.2 billion (1998 dollars) between 2004 and 2033 (Figure 4.3-20). Revenues from ANS production represent 95 percent of all statewide petroleum revenues and 65 percent of total state General Fund revenues in 2004. The North Slope oil share of General Fund revenues from current sources falls to 36 percent in 2010 and 18 percent in 2025.

Projected North Slope oil revenues are based on a constant real price for North Slope crude of $16 (1998 dollars) and a production decline rate of 4.1 percent through 2020, with production constant thereafter (Appendix A). The North Slope share of state oil and gas royalties is 92 percent in 2004, falling to 80 percent in 2025. The North Slope share of state severance taxes is 96 percent in 2004, falling to 75 percent in 2025.

Revenues from the property tax on North Slope oil-production-related facilities and TAPS continue to be an important source of local government revenues (Figure 4.3-21). The North Slope Borough receives $1.896 billion (1998 dollars) in revenues from this source between 2004 and 2033, while the City of Valdez receives $126 million over the same period. Anchorage and Fairbanks receive smaller amounts.

Other local-property and state-income tax revenues associated with refining, module construction, and air cargo are the direct result of ROW renewal.

The Joint Pipeline Office (JPO), staffed by federal and state employees, provides regulation and oversight of the pipeline. Alyeska funds its TAPS-related activities. Other government agencies not part of the JPO also have oversight and regulatory authority over the pipeline. Various offices of state and federal government are involved with the regulation of North Slope oil activity and the management of state leases on the North Slope. State government

Table 4.3-17. *Direct full-time employment from pipeline and North Slope-related activity associated with the proposed action.*

Year	Total	Pipeline Subtotal	Pipeline Operations	Pipeline Oversight	North Slope Oil Field Subtotal	North Slope Oil Field Operations	North Slope Oil Field Oversight	Module Construction	Refining	Air Cargo
2000	11,601	2,638	2,538	100	8,963	5,823	325	500	215	2,100
2001	11,244	2,307	2,207	100	8,937	5,747	325	500	215	2,150
2002	11,062	1,998	1,898	100	9,063	5,823	325	500	215	2,200
2003	11,176	1,987	1,887	100	9,190	5,899	325	500	215	2,250
2004	11,320	1,928	1,828	100	9,392	6,052	325	500	215	2,300
2005	11,437	1,843	1,743	100	9,594	6,204	325	500	215	2,350
2006	11,630	1,834	1,734	100	9,796	6,356	325	500	215	2,400
2007	11,671	1,825	1,725	100	9,846	6,356	325	500	215	2,450
2008	11,712	1,816	1,716	100	9,896	6,356	325	500	215	2,500
2009	11,762	1,816	1,716	100	9,946	6,356	325	500	215	2,550
2010	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2011	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2012	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2013	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2014	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2015	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
CONSTANT AFTER 2015										

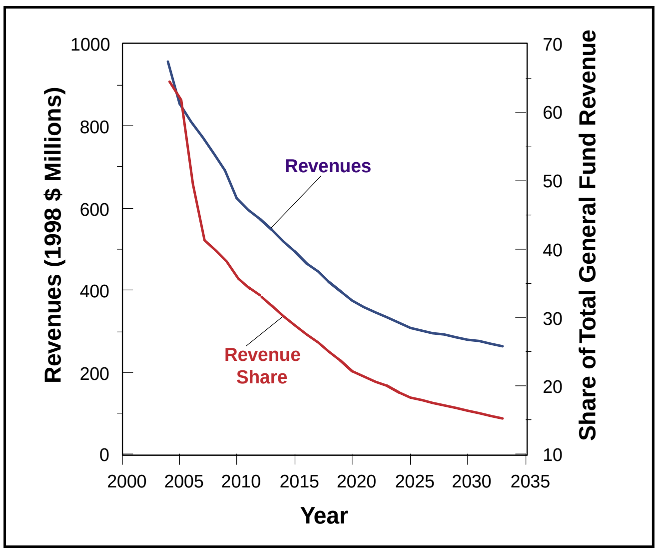


Figure 4.3-20. *Proposed action, state oil revenues and share of total General Fund revenues, 2004 to 2033.*

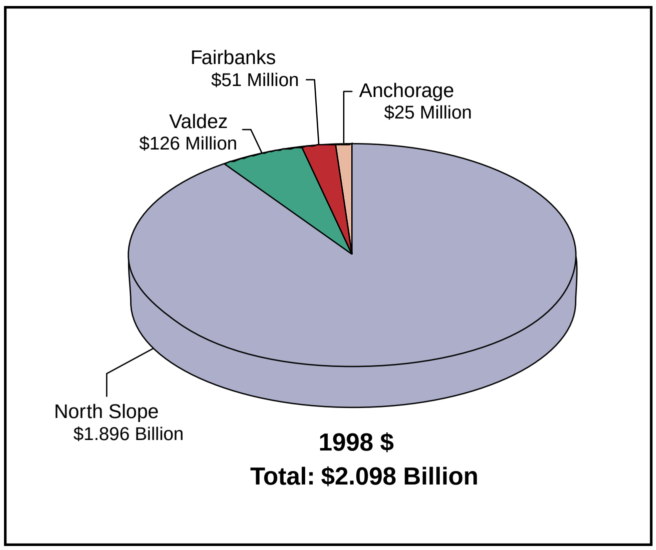


Figure 4.3-21. *Property tax revenues for proposed action for several communities, 2004 to 2033 (1998 $).*

spends $44 million annually on various oil- and gas-related activities (Gladziszewski, 1996).

The continuation of the direct jobs, business opportunities, income, and state and local government revenues in the proposed action has a multiplier effect on the economy resulting in the maintenance of additional jobs and income throughout the state. This following discussion examines the direct and indirect economic impacts of the proposed action.

Wage and salary employment grows 1.1 percent annually from 2000 to 2010, 1.4 percent from 2010 to 2025, and 1.0 percent thereafter (Table 4.3-18). This is slower than in the decades since statehood because the economy has matured and is shifting to reduced dependence on the petroleum industry. Because job growth is concentrated in support and infrastructure industries where the average wage is lower than in either basic industry or government, the average annual real civilian wage trends slowly down-

Table 4.3-18. *Annual average growth rates for economic indicators under the proposed action.*

History	Wage and Salary Employment	Total	Real Income Per Capita	Disposable Per Capita	Non-oil Gross State Product	Population
1961 - 1970	5.5%	8.1%	5.2%	4.9%	3.9%	3.0%
1970 - 1980	6.3%	5.9%	2.9%	2.8%	7.9%	3.1%
1980 - 1990	3.3%	4.2%	1.0%	1.1%	1.2%	2.8%
1990 - 1997	1.7%	1.0%	-0.4%	-0.6%	0.6%	1.4%
Projection						
2000 - 2010	1.1%	1.4%	-0.0%	-0.3%	1.0%	1.5%
2010 - 2025	1.4%	1.9%	0.3%	0.2%	1.4%	1.6%
2025 - 2034	1.0%	1.4%	0.2%	0.1%	1.0%	1.2%

ward. This slows the growth in real personal income, and real per-capita personal income remains virtually unchanged between 2000 and 2010 before resuming very slow growth.

Declining petroleum revenues for state government leads to reintroduction of a state personal-income tax and reduction in the PFD. These measures reduce disposable personal income and slow growth in private support jobs, particularly in trade and services, but help maintain state public services.

Non-oil gross state product (GSP) grows 1 percent annually through 2010 and 1.4 percent annually from 2010 to 2025. This slow growth reflects the drag on the economy produced by the slow decline in oil production and the movement to marginal and frontier fields with higher production costs.

Even though growth in employment opportunities slows, population growth continues at about the same rate as in the 1990s. Growth comes from natural increase, which occurs faster for the Alaska Native population than for the non-Native population, and from some migration of non-Natives in response to job opportunities. Some of the increase comes from the continued rapid growth of the over-65 population.

The continued operation of TAPS and production of North Slope oil facilitate gradual transition of the economy away from high dependence on one basic industry. The slower the decline in North Slope oil production, employment, and public revenues, the more time that is available for the growth of other basic sectors of the economy and the easier the transition. The replacement of North Slope oil activity with growth in other basic sectors is slow because of the small employment and gross product contribution of many of these other basic sectors and their modest rates of growth. Growth of the natural-resource-dependent industries, particularly seafood and timber, is also constrained by the size of the resource base.

North Slope oil activity increases the stability of the economy and reduces its seasonality. Since the Alaska economy is heavily dependent on natural resource production, it is particularly susceptible to economic “boom and bust” cycles (Rogers, 1999). The stability and diversification of the economy provided by North Slope oil production reduce the frequency of economic cycles, and the state revenues from North Slope production give the state the ability to reduce those cycles that do occur, particularly in regions that depend on resources such as fishing and timber. Furthermore, the seasonality of pipeline operations and North Slope oil activity is low compared to fishing, timber, tourism, and mining. This leads to increased stability of employment and income over the year, which in turn contributes to a larger support economy.

The continued operation of the pipeline and production of North Slope oil also increase the options for the eventual production of the large crude oil reserves on the North Slope that currently are not technically feasible to produce. The existing North Slope infrastructure and the transportation link provided by the pipeline lower the cost of applying any new technology to these reserves.

Continued TAPS operation and North Slope oil production also increase the options for eventually bringing North Slope natural gas to market. First, in fields containing both crude oil and natural gas, sharing the production costs between oil and gas in general reduces the unit production cost of both. Second, the most cost-effective method of transporting North Slope natural gas to market may entail converting the gas to a liquid on the North Slope and transporting the liquid. Without a liquids pipeline in place, that option becomes much more expensive, reducing the likelihood of marketing the gas.

Maintaining TAPS and ANS production extends the transition period for the Alaska economy away from its dependence on petroleum. The additional employment and public revenues provided by developing oil reserves that currently are not feasible to produce and by marketing ANS natural gas allow more time for alternative basic industries to expand.

Regional Effects along Pipeline Corridor. Regional economic impacts of the proposed action are estimated below for the North Slope Borough, Yukon-Koyukuk Census Area, Fairbanks North Star Borough, the Southeast Fairbanks Census Area, and the Valdez-Cordova Census Area (Tables 4.3-19 through 4.3-22, and Figure 4.3-21).

- **North Slope Borough:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in the borough. Property tax revenues of $1.896 billion (1998 dollars) are collected by the borough between 2004 and 2033 from pipeline and North Slope oil facilities. The sharing of state rev-

Table 4.3-19. *Total wage and salary employment by region for the proposed action (thousands).*

Year	State	North Slope	Fairbanks	Anchorage	Kenai Peninsula	Valdez-Cordova	Rest of State*
2000	277.1	7.6	32.1	130.9	17.0	4.8	84.8
2001	282.5	7.7	32.8	133.2	17.3	4.9	86.7
2002	287.1	8.0	33.2	135.8	17.5	4.9	87.7
2003	292.0	8.1	33.6	138.3	18.1	5.0	88.9
2004	297.0	8.4	34.0	140.6	18.5	5.1	90.4
2005	300.7	8.7	34.4	142.5	18.5	5.1	91.6
2006	299.5	8.9	34.1	141.5	18.4	5.1	91.4
2007	301.0	8.9	34.2	142.2	18.5	5.2	92.0
2008	303.8	8.9	34.5	143.7	18.7	5.2	92.7
2009	306.1	8.9	34.7	145.1	18.9	5.2	93.3
2010	310.3	8.9	35.1	147.4	19.2	5.3	94.5
2012	314.7	9.0	35.5	149.7	19.4	5.4	95.7
2013	319.1	9.0	35.9	152.1	19.7	5.4	96.9
2014	324.5	9.1	36.4	155.0	20.1	5.5	98.4
2015	330.7	9.2	37.0	158.4	20.4	5.6	100.1

*Rest of the state includes Yukon-Koyukuk and Southeast Fairbanks census areas.

Table 4.3-20. *Total resident employment by region for the proposed action (thousands).*

Year	State	North Slope	Fairbanks	Anchorage	Kenai Peninsula	Valdez-Cordova	Rest of State*
2000	311.9	3.8	36.9	147.7	19.6	5.1	98.8
2001	317.3	3.8	37.4	150.3	19.9	5.1	100.8
2002	322.2	3.9	37.7	153.1	20.3	5.2	102.1
2003	327.3	3.9	38.1	155.7	20.9	5.3	103.4
2004	332.5	4.0	38.5	158.2	21.3	5.3	105.1
2005	336.4	4.1	38.7	160.3	21.4	5.4	106.5
2006	334.8	4.1	38.4	159.2	21.3	5.4	106.4
2007	336.3	4.1	38.5	159.8	21.4	5.5	107.0
2008	339.2	4.1	38.7	161.4	21.6	5.5	107.8
2009	341.5	4.1	38.8	162.8	21.8	5.5	108.5
2010	346.0	4.1	39.2	165.2	22.1	5.6	109.9
2012	350.7	4.2	39.6	167.8	22.4	5.6	111.2
2013	355.5	4.2	40.0	170.4	22.7	5.7	112.6
2014	361.3	4.3	40.5	173.6	23.0	5.8	114.2
2015	368.1	4.3	41.1	177.3	23.4	5.8	116.1

*Rest of the state includes Yukon-Koyukuk and Southeast Fairbanks census areas.

Table 4.3-21. *Real per-capita income by region for the proposed action (thousands).*

Year	State	North Slope	Fairbanks	Anchorage	Kenai Peninsula	Valdez-Cordova	Rest of State*
2000	$25,673	$20,135	$22,436	$30,569	$23,431	$25,318	$21,711
2001	$25,868	$20,516	$22,718	$30,738	$23,645	$25,552	$21,889
2002	$26,067	$20,907	$22,916	$30,908	$23,825	$25,764	$22,091
2003	$25,995	$20,934	$22,845	$30,835	$23,632	$25,679	$22,023
2004	$25,895	$20,955	$22,759	$30,721	$23,637	$25,567	$21,907
2005	$25,771	$20,949	$22,664	$30,562	$23,694	$25,439	$21,768
2006	$25,496	$20,749	$22,453	$30,315	$23,400	$25,125	$21,476
2007	$25,441	$20,625	$22,419	$30,263	$23,383	$25,098	$21,421
2008	$25,561	$20,714	$22,552	$30,370	$23,535	$25,265	$21,535
2009	$25,460	$20,561	$22,485	$30,265	$23,447	$25,157	$21,417
2010	$25,581	$20,612	$22,602	$30,381	$23,603	$25,303	$21,527
2012	$25,663	$20,617	$22,674	$30,442	$23,727	$25,418	$21,612
2013	$25,735	$20,600	$22,743	$30,497	$23,846	$25,520	$21,685
2014	$25,837	$20,608	$22,831	$30,580	$23,989	$25,656	$21,785
2015	$25,940	$20,618	$22,916	$30,664	$24,129	$25,799	$21,886

*Rest of the state includes Yukon-Koyukuk and Southeast Fairbanks census areas.

Table 4.3-22. *Population by region for the proposed action (thousands).*

Year	State	North Slope	Fairbanks	Anchorage	Kenai Peninsula	Valdez-Cordova	Rest of State*
2000	631.2	7.2	83.6	263.0	49.8	10.3	217.4
2001	641.4	7.3	84.5	267.4	50.5	10.4	221.5
2002	649.9	7.3	85.1	271.7	51.2	10.5	224.2
2003	663.2	7.4	86.3	277.7	52.9	10.6	228.2
2004	676.2	7.6	87.5	283.2	54.3	10.8	232.8
2005	688.5	7.7	88.6	288.5	54.9	11.1	237.7
2006	695.4	7.9	89.1	290.4	55.4	11.2	241.4
2007	701.3	8.0	89.5	292.4	55.9	11.3	244.1
2008	709.5	8.1	90.2	296.1	56.6	11.4	247.2
2009	718.6	8.2	90.9	300.1	57.3	11.6	250.5
2010	729.6	8.3	92.0	305.1	58.2	11.7	254.4
2012	742.1	8.4	93.2	310.9	59.1	11.9	258.6
2013	755.1	8.5	94.5	316.8	60.1	12.1	263.1
2014	769.0	8.7	95.9	323.3	61.2	12.2	267.7
2015	784.5	8.8	97.5	330.7	62.4	12.4	272.8

*Rest of the state includes Yukon-Koyukuk and Southeast Fairbanks census areas.

enues from pipeline operation and North Slope oil production contributes to a continuing high level of public services in borough communities. The option for additional jobs, income, and revenues from future activities not currently technically feasible is retained. Population continues to grow.

- **Yukon-Koyukuk Census Area:** The proposed action provides an opportunity for employment and income for local residents. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities in the region.
- **Fairbanks North Star Borough:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in the borough. Property tax rev-

enues of $51 million (1998 dollars) are collected by the borough between 2004 and 2033. Additional property taxes are produced by refinery operations in the borough. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in borough communities. The option for additional jobs, income, and revenues from future activities not currently technically feasible is retained. Population continues to grow.

- **Southeast Fairbanks Census Area:** The proposed action provides an opportunity for employment and income for local residents. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities in the region.
- **Valdez-Cordova Census Area**: The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in the census area. Property tax revenues of $126 million (1998 dollars) are collected by the City of Valdez from pipeline facilities between 2004 and 2033. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities in the borough. The option for additional jobs, income, and revenues from future activities not currently technically feasible is retained. Population continues to grow.

Regional Effects in Other Areas: Regional economic impacts of the proposed action are estimated below for Anchorage, Kenai Peninsula Borough, and the rest of the state (Tables 4.3-19 through 4.3-22, and Figure 4.3-21).

- **Anchorage:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in Anchorage. Property tax revenues on facilities associated with the pipeline and North Slope oil production activities are $25 million (1998 dollars) between 2004 and 2033. Additional property taxes are generated by international-air-cargo activity and by module construction for North Slope production facilities. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the municipality. The option for additional jobs, income, and revenues from future activities not currently technically feasible is retained. Population continues to grow.
- **Kenai Peninsula Borough:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in the Kenai Peninsula Borough. Property taxes are generated by module construction for North Slope production facilities. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities in the borough. The option for additional jobs, income, and revenues from further activities not currently technically feasible is retained. Population continues to grow.
- **Rest of the State:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in every other part of the state. Jobs and income earned by oil workers on the North Slope affect all parts of the state because these workers live in all parts of Alaska. They provide a stable and nonseasonal source of employment and income to the communities in which they live. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities throughout the state. The option for additional jobs, income, and revenues from further activities not currently technically feasible is retained. Population continues to grow.

Impact on Alaska Natives. Estimated economic impacts of the proposed action on Natives include:

- **Employment:** Employment opportunities for Alaska Natives will continue to exist in pipeline and oil- and gas-related industries and will expand in other parts of the economy, particularly trade and services, as the total number of jobs in the economy expands.
- **Unemployment:** Unemployment among Alaska Natives will be lower with the proposed action compared to the no-action alternative because the number of job opportunities will be higher while the size of the Alaska Native population will be the same.
- **Population:** The size of the Alaska Native population is insensitive to whether the proposed action is selected because Alaska Native migration into and out of the state has been small (ADOL, 1998a) and is likely to remain so. The Alaska Native population is mobile within the state, and a portion of the population moves in response to both job opportunities and the availability of public and private services. The proposed action increases jobs in the larger urban areas and commuter jobs, particularly on the North Slope, that are filled by residents who live in other parts of the state. Public spending of pipeline and oil revenues will increase the availability of public ser-

vices throughout the state. The effect of the proposed action on the spatial distribution of the Alaska Native population is unpredictable.

- **Income:** The proposed action contributes to higher money income for Alaska Natives through the availability of high-wage jobs, the continuation of the PFD, and the public expenditures made possible through state and local revenues from pipeline operations and North Slope oil production.
- **Public Resources:** State revenues of $14.209 billion (1998 dollars) combined with local revenues of $2.098 billion (1998 dollars) — the local share of oil- and gas-related property taxes — allow state and local governments to fund a higher level of public services than would otherwise be possible. These public services are provided to all communities in the state.
- **Alaska Native Communities:** The viability of Alaska Native communities is enhanced because the additional personal income and public revenues increase Alaska Native personal income and the public services in communities where Alaska Natives live.
- **Pressure on Natural Resources**: The proposed action results in a higher non-Alaska-Native population than the no-action alternative. This may put more pressure on resources used in subsistence activities.

4.3.3.2 Sociocultural Systems

By M. Galginaitis, C. Gerlach, P. Bowers, and C. Wooley

Sociocultural systems for communities on the North Slope and along the pipeline and transportation route have adapted to the presence of the ANS fields and the pipeline and have become dependent on the resultant economic benefits. Initial predictions of the impact of TAPS on Alaska Native and non-Native communities recognized that Alaska was already undergoing cultural change and that oil revenues would accelerate existing patterns of change (Education Systems Resources Corporation, 1971). Most sociocultural effects of TAPS construction and initial operation were indirect and occurred in combination with the effects of other developments such as passage of the Alaska Native Claims Settlement Act (ANCSA); creation of the NSB (1972); establishment of rural school boards (1976); improvements in village health, utilities, and communications systems; and the sociocultural contributions of nonprofit Alaska Native regional corporations (Strong, 1977). Together, these developments have profoundly affected the lives of Alaska Natives and other rural Alaskans; however, TAPS construction and operation was one of the many causes of these changes.

Social interdependence has been the cultural norm in rural Alaska, particularly in locations with few wage-employment opportunities. Major factors affecting cultural change in rural Alaska include increased material wealth from increased employment opportunities and increased infrastructure from capital construction projects (both indirect results of state oil revenues or local government revenues from property taxes on petroleum facilities). These processes are expected to continue with ROW renewal.

As discussed in Section 4.3.3.1, economic benefits will be realized through continued oil-derived revenue streams to the state General Fund, which is subsequently distributed for the support and benefit of all Alaskan communities. Benefits also are derived from employment opportunities provided by the oil and gas industry. The renewal of the TAPS ROW is not expected to cause any incremental impacts to ongoing sociocultural dynamics in areas such as indigenous languages, social structure, and family. The availability of wage income in rural areas should continue to give rural residents more lifestyle choices. People may choose to remain in smaller communities and follow a mixed cash/subsistence lifestyle, which helps promote family and community ties. As noted above, impacts of the proposed action include those directly and indirectly associated with the operation of the pipeline and those associated with operation of the ANS fields and the marine transportation link. These latter impacts are discussed as cumulative effects.

The area is subdivided into the North Slope, the Central TAPS, and the Valdez/PWS study areas (Section 3.3.2). From a geographic perspective, the direct effects of the pipeline itself can be identified and isolated. These principally affect the Central TAPS study area, whereas indirect and cumulative effects of the ANS fields and the marine transportation link pertain to the North Slope and Valdez/PWS study areas, respectively. For this reason, sociocultural and subsistence impacts on the North Slope and Valdez/PWS study areas are addressed in the cumulative effects section (see Section 4.5). The focus of this section is the Central TAPS area.

The principal impacts of TAPS ROW renewal in the Central TAPS study area would be continued revenues earned by state and local governments (albeit at lower levels than in the past), and earnings derived from operating and maintenance contracts held by Alaskan-owned and non-Alaskan-owned businesses and by Alaska Native corporations. In the absence of any planned major new construction activities associated with TAPS, there will be no temporary or seasonal upward spikes in local employment. No growth in population of local communities, and no need for additional government services (new housing, etc.) associated with such growth are anticipated. The main negative impacts will result from reduction of TAPS throughput and the consequent decline in tax and business revenues.

4.3.3.3 Subsistence

By M. Galginaitis, C. Gerlach, P. Bowers, C. Wooley, and D.L. Maxim

Subsistence is important to many communities in Alaska, both for economic and sociocultural reasons. As a result, any activities that could adversely affect subsistence resources, harvest levels, access, competition for these resources, and related variables are potentially of concern and warrant investigation. Possible subsistence impacts for the North Slope and Valdez/PWS study areas are included in the cumulative effects discussion. This section addresses only subsistence impacts in the Central TAPS study area.

The key potential subsistence-related concerns associated with continued operation of TAPS and applicable to the Central TAPS study area are: (1) direct impacts resulting from oil spills and (2) indirect effects related to access to, and competition for, subsistence resources.

Oil Spills

As noted in Section 4.3.2, there are no biological or subsistence-harvest data indicating that routine pipeline operations have adversely impacted the abundance of fish and wildlife over the operating history of the pipeline. In principle, a major oil spill and resulting cleanup activities could release pollutants into streams and watercourses and cause fish stocks, local resident wildlife populations, and watersheds and critical habitat to be directly and negatively impacted at least for a time. This possibility has been a concern historically for some residents who value subsistence activities (Coates, 1993).

Data presented in Section 4.1.2 and Appendix B indicate that from 1977 to 1999, most pipeline spills were relatively small. For example, 88.0 percent of crude spills and 96.3 percent of product spills were less than 2 bbl. Most small spills are contained on site. Even if not contained on site, small spills are relatively easy to clean up and are not likely to threaten the environment. Rather, it is the relatively infrequent large spill that is potentially of concern.

From 1977 to 1999, there were five “large” (>1,000 bbl) pipeline spills (Table 4.1-2 in Section 4.1.2). The calculated number of large spills/billion bbl throughput for the pipeline is 0.39 over this time period. At this rate and based on a total future throughput of 7.02 billion bbl, there would be an average of 2.75 large pipeline spills over the 30-year ROW-renewal period. However, all the large pipeline spills occurred during the first five years of operation of TAPS — none has occurred since 1981. In the EIS for NPR-A (BLM and MMS, 1998), only pipeline spills occurring after 1989 were used to compute the number of spills on the pipeline.

Based on the conservative assumption that volumetric spill rates have remained constant for the pipeline, the average annual spill volume is calculated to be 573 bbl. (As noted in Section 4.1.2., volumetric spill rates for the pipeline have decreased over the years and may be lower than this conservative projection in the future.)

Spills onto land — even large spills — are likely to be confined to a relatively small area by the topography. Even on the North Slope, where the tundra relief is low (BLM and MMS, 1998), conditions combine to limit the spread of spills. For example, during the summer, flat coastal tundra develops a dead-storage capacity averaging 0.5 to 2.3 inches, which could retain 300 to 1,500 bbl of oil per acre (BLM and MMS, 1998). For example, the largest pipeline spill (16,000 bbl at Steele Creek, MP 457.53) affected an area no larger than 2.1 acres (Holland, 2000, pers. comm.).

Section 4.3.2.5 concludes that land-based spills will not adversely affect terrestrial mammal populations through increased mortality in the vicinity of TAPS. Likewise, spills that remain on land do not adversely impact fish. Therefore, the effects on subsistence of a pipeline spill that remains on land are likely to be negligible.

Large pipeline spills that enter rivers, streams, or groundwater will not be so confined and could result in fish and bird mortality over a much larger area. Crude residues might persist in sediments and river banks for several years. Ultimately, the affected water body will recover, but the recovery time is not known with certainty. Reduction in fish populations could change location patterns of terrestrial species that feed on these fish. The severity of these effects depends on the quantity discharged, season, location, and other factors. The pipeline has 34 major and about 800 other river and stream crossings. A spill at these locations would have greater potential for adverse environmental impact than would spills that stay on land.

None of the five largest pipeline spills to date has resulted in more than localized and temporary impacts. Four of these five spill sites are shown as special areas on the *Environmental Atlas of the Trans Alaska Pipeline System* (APSC, 1993; Maps 2, 5, 6, and 15). All five sites have been the subject of long-term monitoring, and there is no evidence of any lasting adverse environmental impact.

Any large spill that reduced fish populations materially could significantly and adversely effect subsistence harvests, because fish are an important part of the overall sub-

sistence harvest, particularly for communities in the Central TAPS study area. The severity of the subsistence impact depends on the amount of oil entering the water, season, effectiveness of cleanup activities, recovery time for the fish population, and the extent to which the contaminated stream/river were used by local residents.

Access Competition

Access issues are complex and are not under the direct control of the ROW applicants. Changes in access to subsistence resources (e.g., increased competition from new users, decreased or more difficult access for current users) potentially arising from the renewal of the ROW are likely to be the primary impacts on federally qualified subsistence users in the Central TAPS study area. Most concerns raised by rural Interior residents are related to difficult access and to the increased number of nonlocal hunters from urban Alaskan communities and from outside the state. The direct impact of more nonlocal hunters or more difficult access for local hunters is a real and/or perceived threat of an increase in hunting pressure and consequent reduction in harvest by local residents. These issues are commonly confounded with the indirect and cumulative effects from the Dalton Highway (now under state management), other state highways, and development activities not directly related to TAPS.

Construction and operation of the Dalton Highway provided improved access to subsistence harvest areas near the pipeline. If improvements to this highway are made which either permit or encourage greater access by recreationists, tourists, sports hunters and fishers, then adverse impacts on traditional subsistence users may result. It is important to note, however, that federal regulations will continue to grant priority to subsistence uses on federal lands in times of scarcity of individual subsistence species. Game management regulations enforced by ADF&G and federal land management agencies (including the BLM, U.S. Fish and Wildlife Service, and National Park Service) are expected to continue. Use of firearms in the DHCMA is authorized only for the residents of Alatna, Allakaket, Anaktuvuk Pass, Bettles, Evansville, and Stevens Village, and Alaska residents who live in the DHCMA (FSB, 2000).

The proposed action does not require any new access routes to subsistence harvest areas to be built along TAPS from the Yukon River south to Valdez. This entire route is currently served by the Alaska highway system. ADF&G and federal game management regulations govern use based on access from this existing road system. The TAPS ROW renewal would not affect these access points and would not affect subsistence use.

4.3.3.4 Cultural Resources

By C. Gerlach, P. Bowers, and C. Wooley

Renewal of the TAPS ROW has the potential to impact cultural resources. Although the construction phase was completed many years ago, ongoing activities (e.g., corrosion digs, slope/workpad maintenance, pipeline reroutes, below ground valve inspections, repairs of washouts and river training structures) have the potential to damage cultural resources. Oil spills could also result in adverse impacts, depending on factors such as the spill size, location, season, etc. This section addresses possible impacts of the proposed action alternative on cultural resources

Cultural resources can be impacted in various ways. Adverse impacts include removal of surface artifacts, surface disturbance resulting in artifact and feature dislocations, subsurface disturbance, and site contamination (36 CFR 800). Historically, the major sources of potential direct impact on cultural resources in the TAPS area included construction and maintenance of the pipeline; construction of access roads (including the Haul Road, now the Dalton Highway), material sites, disposal sites, and storage sites; and similar activities. Major direct impacts to TAPS-related historic properties were avoided or minimized during and after construction by following the Federal Grant stipulations and the Section 106 process (e.g., Cook, 1970, 1971, and 1977). During construction, Alyeska was in overall compliance with Stipulations 1.9.1 and 1.9.2, which provide for archaeological survey and mitigation (Campbell, 1973; Ecology and Environment, Inc., 1977). However, at least 145 known sites (15 percent) have been disturbed, and 229 have been archaeologically tested or excavated. Post-European-contact sites do not appear to have been included systematically — there were cases such as the Fort Liscum site at the VMT where historic sites were present but not inventoried or assessed before construction (Wooley, 1994).

The major indirect impacts can be divided into three categories: access-related impacts, ground-impacting activities, and oil spills.

Access-Related Impacts

Construction of the Haul Road (Dalton Highway) led to increased recreational traffic (especially since unlimited public access was granted), increased all-terrain-vehicle use near the highway, increased wilderness recreation activities such as hunting and hiking, increased scientific investigations, and ultimately increased visitation of archaeological sites by the public. Ongoing erosion has affected several surface sites, and several instances of accelerated erosion were caused by lack of backfilling during Alyeska-sponsored archaeological clearances (e.g., LIV-030, 041, 043, 046, 047). Sites near the Dalton Highway are more likely to suffer adverse impacts, since recreational use is inversely proportional to the distance from the highway. The impacts of TAPS on sites near other highways such as the Elliot and Richardson Highways cannot be estimated because these are confounded with the impacts of other development (mining, military, etc.). Some prehistoric sites are located in the same places where Alyeska and ADOT mine gravel, and any increase in material site use could result in cultural resource impacts (e.g., archaeological site identification, evaluation, or damage).

Ground-Impacting Activities

Ground-impacting activities associated with TAPS renewal include below-ground pipeline corrosion investigations, slope/workpad maintenance, potential reroutes, mainline valve inspections, river crossing repairs, fuel gas line maintenance and repair, and development of new material sites/rock quarries (Section 4.1.1).

- Alyeska has performed a large number of digs to address potential corrosion problems. Technological improvements have reduced the number of digs substantially (Section 4.1.1). Digs can disturb cultural sites; however, Alyeska minimizes disturbance by digging relatively small holes (generally 50 feet wide by 150 feet long) near the buried pipeline. Using this method, no new sites are disturbed because the excavated material was disturbed when the pipeline was originally buried.
- Slope/workpad maintenance may result in small areas of ground disturbance (typically less than 5 acres) that have not been evaluated archaeologically. Activities in such areas would be coordinated with the Authorized Officer and a qualified archaeologist to verify what historic sites, if any, are present and whether or not site evaluation is required.
- Potential pipeline reroutes constitute the greatest potential impact to cultural resources with TAPS ROW renewal. Impacts from reroutes are larger than for normal maintenance and approach original construction impacts in localized areas. Only three pipeline reroutes have been made: Dietrich River (1985), Atigun Pass (1987), and Atigun River (1991). The latter reroute involved a cultural resource survey of 8 miles (Gerlach, 1990). Future reroutes would have to follow the Stipulations and the Section 106 process.
- Below-ground valve inspections would occur in areas that have already been cleared archaeologically and would require no further mitigation.
- Repairs of washouts and river training structures would most likely not require use of, or damage to, archaeologically sensitive areas. Construction activities in active stream channels would not require consultation and/or mitigation. However, at least 355 sites (37 percent of total) are near rivers and streams; therefore, the State Historic Preservation Office would have to be consulted to verify site locations and the need for Section 106 actions. Several areas of the pipeline, such as the stretch along the Atigun River, lie in river drainages with high site concentrations.
- Maintenance and repair of the fuel gas line may result in ground disturbance in areas that have not been evaluated archaeologically. Activities in such areas would be coordinated with the Authorized Officer to verify what sites are present, if any, and whether or not site evaluation is required.
- Development of new material sites/rock quarries could adversely impact cultural resources. Many known cultural sites, especially in tundra areas, occur on topographic features that also are favored gravel sources. Material sources present a potential cultural-resource issue. Problems have occurred in cases where an archaeological site was investigated, provisional or limited construction clearance was issued, and later expansion of the material source damaged the site. By following the Section 106 process, historic properties can be identified and evaluated, and if the project will impact sites, mitigation measures can be implemented. Should cultural sites be located during ground-disturbing activities, mitigation measures will be undertaken as appropriate.

Oil Spills

Potential oil spills could impact cultural resource sites in the TAPS study area, including Prince William Sound, the Copper River delta, and the Yukon River. Contamination from crude oil is a direct impact, and various cleanup-related impacts could also harm sites if not mitigated. Federal and state agencies, in cooperation with the oil and gas industry, have taken steps to ensure that known cultural resource sites are identified and protected during emergency oil-spill-response operations. The Programmatic Agreement (1997) among federal and state agencies specifies when the Federal On-Scene Coordinator is advised to take action to protect sites, what type of expertise is required for site protection, and what process is needed whereby cleanup operations can proceed while considering the impact of the action on sites.

Efficient site protection during a spill response along the pipeline poses difficulties because reliable site locations are known for only 38 percent (364) of sites. However, 65 to 80 percent of spills reported to date occurred on gravel workpads and involved only small discharges. These spills are categorically excluded from cultural resource considerations (Programmatic Agreement, 1997).

In an effort to quantify the potential effect of crude oil spills on cultural resources along the pipeline, known cultural sites have been plotted by river drainage and pipeline segment as shown in Alyeska's oil spill contingency plan (APSC, 1999f). The number of sites is aggregated by drainage, the length of each pipeline-affected drainage is determined, and the site density is calculated given a standardized project width of 10 miles. The Arctic Foothills drainage (Itkillik River, Galbraith Lake, and Atigun River) has the highest site density and hence the highest potential for spill-related damage. Moving south along the pipeline, areas high in potential sensitivity are the South Fork Koyukuk River, Jim River, Bonanza Creek, Kanuti River, Tolovana River, Goldstream Creek, Moose/French creeks, Jarvis Creek, Phelan Creek, Tazlina River, Klutina River, and Little Tonsina River. Two of the largest rivers, the Yukon and Copper, while critical areas in many respects, are traversed by relatively short pipeline segments (7.1 mi. and 6.4 mi., respectively) and have few recorded sites on either side of the crossing (2 and 1, respectively). Site densities for stream crossings beyond the 10-mile width of the study area were not calculated; however, downstream sites would require identification and protection during a response in accordance with the Programmatic Agreement.

To help mitigate the potential impact of spills on cultural resource sites in Prince William Sound, Alyeska added cultural resource data to the Graphical Resource Database (GRD) for Prince William Sound and adjoining areas (Wooley et al., 1997). The GRD is part of the *Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan* and consists of digital data layers of sensitive environmental areas. The known cultural-resource-site data for Prince William Sound and the Copper River area are digitized and included in a confidential layer of the GRD to assist the Federal On-Scene Coordinator with protection of cultural resource sites during a spill response.

4.3.3.5 Land Ownership

By ClearWater Environmental, Inc. staff

In the TAPS ROW renewal, no lands other than those already lying within the TAPS easement will be required. There are no outstanding land ownership issues directly associated with the existing ROW; however, continuing land-use issues have been raised by at least two villages with lands in the ROW. These aside, no present or reasonably foreseeable land-ownership impacts are associated with TAPS ROW renewal.

4.3.3.6 Land Use

By ClearWater Environmental, Inc. staff

The most clearly observable impact on federal, state, and private land uses resulted from the construction of the 400-mile Dalton Highway. The highway and other roads and airstrips built to service TAPS and ANS oil development provide greater access to recreation-seekers, sports hunters and fishers, tourists, and subsistence users. These areas previously were accessible only over trails and from remote landing sites.

While no spur roads have been built that give direct vehicular access to lands outside the TAPS ROW, the Dalton Highway and associated airstrips make access to such lands much easier. If the highway were improved to meet state and federal highway construction standards and if tourist and vehicle services presently available only at Coldfoot were expanded, increases in visitor use can be expected beyond those seen since the opening of the entire highway to public access in 1994. Native landowners and land managers have noted that improved access for nonresident hunters, fishers, and recreation-seekers has created use conflicts even though federal and state land managers make every effort to alert visitors to private landowners' rights (Dalton Highway Advisory and Planning Board, 1998).

Such use conflicts also occur along the road system from the Yukon River to Valdez, but these access-related conflicts and land use impacts are not directly related to TAPS.

4.3.3.7 Coastal Management

By ClearWater Environmental, Inc. staff

Two segments of the TAPS ROW fall within approved coastal zone management districts: the North Slope Borough from Pump Station 1 south to Atigun Pass, and the Valdez city limits which include the shorelines and waters of Prince William Sound from Keystone Canyon to Tongue Point and Jack Bay just beyond the Valdez Narrows. In addition, the City of Cordova, Orca Inlet, and the Copper River Delta and flats facing the northern Gulf of Alaska lie in a coastal district defined in a coastal management plan. Plans for these three coastal districts all provide for the presence and use of the TAPS, the Valdez terminal, and shipping of North Slope crude oil by tanker.

All Alaska coastal zone management plans undergo periodic review and possible revision. None of the reviews for the NSB, Valdez, and Cordova district plans presently targets TAPS and its associated facilities and shipping activities for revision. Each requires acceptable oil spill response plans. The recently updated Prince William Sound Subarea Plan (APSC, 1999f) includes many features involving the Valdez terminal, and tanker loading and traffic created since OPA 90 and the *Exxon Valdez* oil spill cleanup and restoration (Section 4.1.2). No other impacts from TAPS and associated activities are likely to be addressed in the coastal zone management plans during the 30-year period of TAPS ROW renewal.

4.3.3.8 Recreation

By ClearWater Environmental, Inc. staff

Selection of the proposed alternative could result in direct, indirect, and cumulative effects on recreation. For the proposed action, the pipeline will continue operations, and the recreational benefits (see Section 3.3.6) afforded by scenic overlooks and visitor centers will continue throughout the duration of the ROW renewal period. Continued operation of the pipeline entails the risk of pipeline oil spills, which could affect recreational resources. As with other segments of the TAPS, most pipeline spills are relatively small. From 1977 to 1999, there were five large oil spills greater than 1,000 bbl along the pipeline. All resulted in minor, localized, and temporary effects.

Effects also include oil spills at ANS or marine transportation facilities and effects associated with improved access to lands adjacent to the Dalton Highway. These cumulative effects are addressed in Section 4.5.

4.3.3.9 Visual Resources

By ClearWater Environmental, Inc. staff

The above-ground segments of TAPS account for slightly more than one-half of its entire 800-mile length. These segments are clearly visible from the air, and the majority can also be seen from adjacent public roads. There are various designated viewing locations (Pump Station 1, Yukon River bridge, near Fox north of Fairbanks, near Copper Center, and elsewhere). Some of the pump stations are also clearly visible. Temporary visual air impacts (i.e., opacity) have occurred during tank-vent flaring at Pump Station 1. These opacity incidents have been few in recent years, and air emissions are stringently regulated by ADEC. Since no new TAPS infrastructure construction is planned during the TAPS ROW renewal period, no incremental visual impacts would occur.

4.3.3.10 Wilderness

By ClearWater Environmental, Inc. staff

Enhanced access to both federal wilderness areas and other state, federal (e.g., wildlife refuges), and certain private lands from the Dalton Highway are not related to TAPS renewal, but are made possible by the existence of the Dalton Highway. TAPS ROW renewal will have no direct impacts on wilderness or on primitive or undeveloped lands in any portion of the TAPS ROW. No parts of the ROW would be reclassified under wilderness designation.

4.3.3.11 Transportation

By ClearWater Environmental, Inc. staff

The TAPS ROW renewal would have no direct impact on existing transportation systems, which adequately serve the operation and maintenance requirements of TAPS. The following conditions for the various transportation modes are expected for the term of the renewal:

- All public road systems along TAPS are currently, and would continue to be, maintained by the State of Alaska. No new roads should be required to serve TAPS operation through 2034.
- Marine transportation facilities are in place to meet the anticipated demands of TAPS throughput through 2034. New double-hull tankers will be built to meet the requirements of OPA 90.
- Inland waterways are currently used to supply and maintain spill response equipment. This would continue as the only use of inland waterways to support TAPS and requires no additional improvements.
- TAPS would continue to exist with minimal expansions. Additional gathering or common carrier lines may be constructed on the North Slope to supply oil for transportation through TAPS. If TAPS did not exist, these additional pipelines would not be constructed. This is a cumulative effect discussed in Section 4.5.
- Renewal of the ROW will result in continued operation of passenger and cargo flights to North Slope oilfield facilities at or beneath present levels.
- No new aviation support facilities would be constructed as a result of TAPS ROW renewal, and no impact to the air support industry would occur.