Overview of Environmental and Hydrogeologic Conditions at Chandalar Lake, Alaska

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U.S. GEOLOGICAL SURVEY

Open-File Report 95-348

Prepared in cooperation with the

FEDERAL AVIATION ADMINISTRATION

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By James R. Cowan

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Anchorage, Alaska
1995

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
centimeter (cm)	0.3937	inch
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
cubic meter per second (m^3/s)	35.31	cubic foot per second
liter per day (L/d)	0.2642	gallon per day
degree Celsius (°C)	°F=1.8 (°C)+32	degree Fahrenheit (°F)

Sea level:

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—A geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality unit used in this report:

(µg/L), microgram per liter

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Abstract

The Federal Aviation Administration facility at Chandalar Lake is on the east shore of the lake in the eastern Brooks Range of Alaska. The Federal Aviation Administration is considering the severity of contamination and the environmental conditions near their Chandalar Lake facility when evaluating options for compliance with environmental regulations. The area has long cold winters and short cool summers. Floods are not a significant threat at the facility. The facility and a nearby private lodge currently obtain drinking water from Chandalar Lake. Alternative drinking-water sources may be available, but little is known about the quantity or quality of these sources. Surface spills and disposal of hazardous materials, should they occur, could affect the quality of the surface water and ground water in the area.

INTRODUCTION

The Federal Aviation Administration (FAA) owns and (or) operates airway support and navigational facilities throughout Alaska. At many of these sites, fuels and potentially hazardous materials such as solvents, polychlorinated biphenyls, and pesticides may have been used and (or) disposed of. To determine if environmentally hazardous materials have been spilled or disposed of at the sites, the FAA is conducting environmental studies mandated under the Comprehensive Environmental Response, Compensation, and Liability Act and the Resource Conservation and Recovery Act. To complete these more comprehensive environmental studies, the FAA requires information on the hydrology and geology of areas surrounding the sites. This report, the product of compilation, review, and summary of existing hydrologic and geologic data by the U.S. Geological Survey (USGS), in cooperation with the FAA, provides such information for the FAA facility and nearby areas at Chandalar Lake, Alaska. Also presented in this report is a description of the history, socioeconomics, and physical setting of the Chandalar Lake area.

BACKGROUND

Location

The FAA Chandalar Lake facility is in the Brooks Range in northeastern Alaska at approximate latitude 67°30' N. and longitude 148°29' W (fig. 1). The elevation of the facility is about 585 m above sea level. The facility is approximately 300 km north of Fairbanks and about 300 km south of Deadhorse. The Dalton Highway-TransAlaska Pipeline corridor is about 60 km west of the facility. The FAA facility is on the east shore of Chandalar Lake, a natural impoundment of the North Fork of the Chandalar River in the Yukon River drainage basin. The FAA Chandalar Lake facility should not be confused with the Chandalar Shelf airfield at the Chandalar pipeline camp approximately 80 km to the northwest.

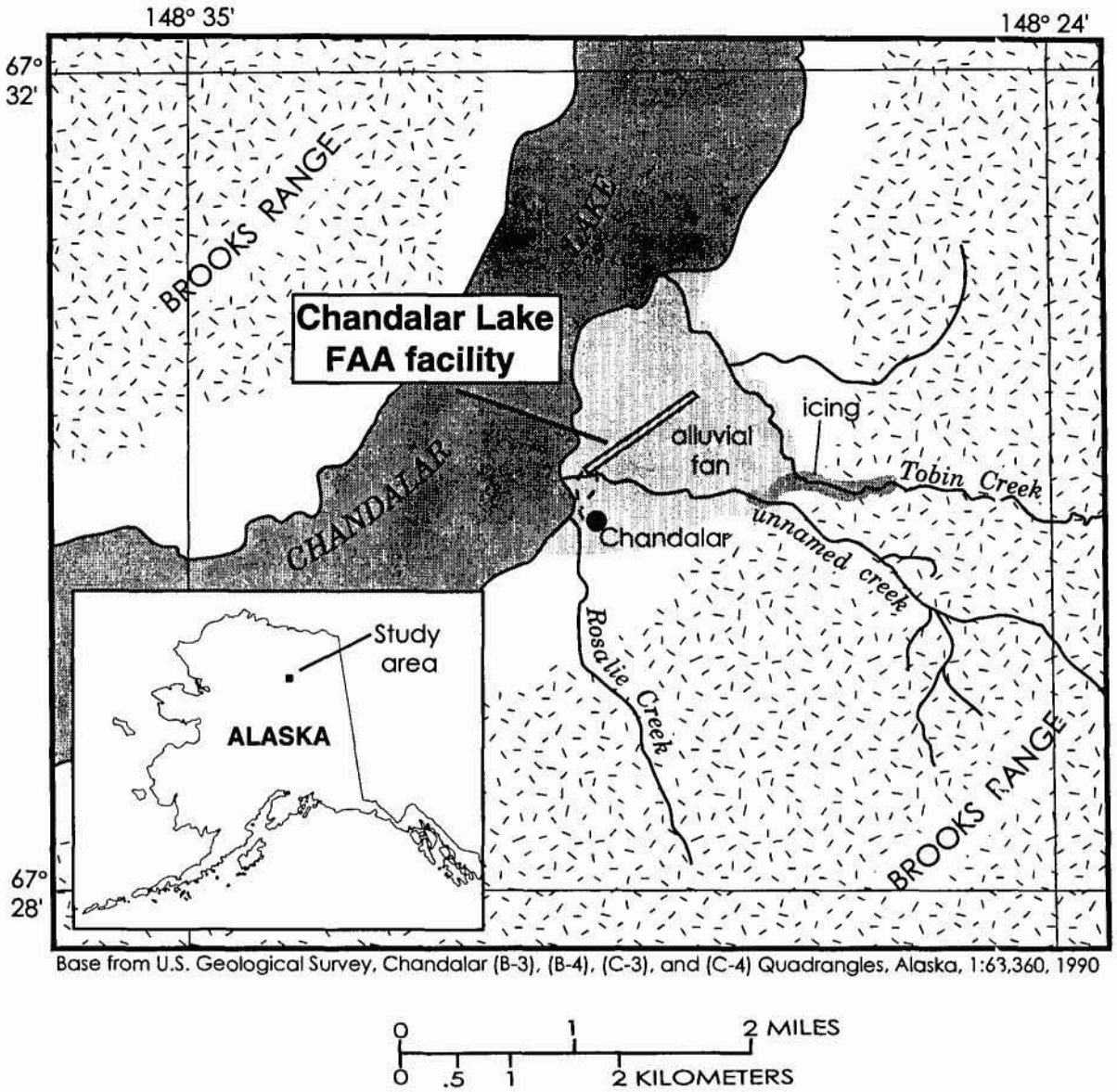

Figure 1. Location of Chandalar, Alaska, and Federal Aviation Administration facilities.

History and Socioeconomics

"Chandalar" is derived from the name given to the Kutchin Indian inhabitants by French trappers employed in the area by the Hudson Bay Company (Orth, 1967). In the early 1900's, a mining camp was established near Chandalar Lake. A post office was maintained there from 1908 until 1944.

The remote Chandalar Lake airstrip was constructed in the 1950's to support mining activity in the area (M. Kunes, Bureau of Land Management, oral commun., 1995). Today, its primary use is as a point-of-entry for hunters, fishermen, outdoor recreationists, and scientists seeking access to the eastern Brooks Range. The FAA has operated a remote navigational facility at Chandalar Lake since 1968 (Ecology and Environment, Inc., 1992). The FAA facility includes a nondirectional beacon antenna and two buildings near the northeast end of the airstrip and a generator building, fuel tanks, and pipeline near the southwest end of the runway. The remote facility is maintained by FAA employees who visit the site about four times a year (Kathleen Edie, Federal Aviation Administration, written commun., 1995). A detailed account of properties owned, leased, or transferred by the FAA at Chandalar Lake and a listing of suspected sources of contamination near these facilities is in the Environmental Compliance Investigation Report (ECIR) prepared by Ecology and Environment, Inc. (1992).

Chandalar Lake is principally a recreational area. A privately owned facility, McManus camp, is the only residential area near the FAA Chandalar Lake facility. The McManus camp is located on the eastern shore of Chandalar Lake about 400 m south of the FAA facility and is occupied primarily during the summer season. The FAA supplies the McManus camp with electricity (Ecology and Environment, Inc., 1992). Chandalar Lake is without road access, and aircraft are the most common means of access to the FAA facility. A winter trail allows limited surface access to the area (Jack McManus, McManus camp, oral commun., 1995).

PHYSICAL SETTING

Climate

Chandalar Lake is in the continental climate zone and is subject to large daily and seasonal temperature variations (Hartman and Johnson, 1978). Low precipitation, clear skies and low humidity are typical during the long winter; cloudy, humid conditions characterize the short summer. The mean annual temperature is -8.2 °C, but temperatures range from a July mean maximum of 19.9 °C to a February mean minimum of -32.4 °C. Mean total annual precipitation is about 240 mm. July and August are the months of greatest rainfall. Approximately 1,000 mm of snow falls annually. Mean monthly and annual temperature, precipitation, and snowfall data are summarized in table 1 (Leslie, 1989).

Vegetation

Vegetation near Chandalar Lake consists of closed spruce-hardwood forest in the valleys and on lower slopes and alpine tundra at higher elevations (Viereck and Little, 1972). Stands of white spruce grow on south-facing slopes, and black spruce grow on north-facing slopes and on poorly drained lowland areas. Undergrowth consists of mosses, grasses, and brush. The alpine tundra areas are predominantly barren with local accumulations of low heath shrubs, white mountain-avens, and dwarf herbs.

Table 1. Mean monthly and annual temperature, precipitation, and snowfall for the period 1968–1987, Federal Aviation Administration facility, Chandalar Lake

[Modified from Leslie (1989); °C, degree Celsius; mm, millimeter]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Annual
						Temperature (°C)							
Mean maximum	-19.6	-18.9	-10.4	-1.8	10.2	18.4	19.9	16.4	8.3	-4.1	-15.1	-19.1	-1.3
	(Record maximum 30.6 °C, July 1986)												
Mean minimum	-31.7	-32.4	-27.1	-19.1	-3.8	3.6	4.9	1.2	-3.9	-14.4	-26.4	-31.0	-15.0
	(Record minimum -55.6 °C, February 1974)												
Mean	-25.7	-25.7	-18.8	-10.4	3.3	11.0	12.4	8.8	2.2	-9.2	-20.8	-25.1	-8.2
						Precipitation (mm of moisture)							Total
	9.7	8.4	7.1	5.3	10.9	35.6	45.7	41.7	31.5	19.8	11.2	11.7	238.3
						Snowfall (mm)							Total
	111.8	109.2	96.5	96.5	20.3	0.0	0.0	0.0	40.6	195.6	154.9	177.8	1,003.3

Geology

Wahrhaftig (1965) includes the area surrounding the FAA Chandalar Lake facility in the central/eastern Brooks Range area of the Arctic Mountains physiographic province. The nearby glaciated mountains rise to elevations of approximately 1,500 to 1,800 m.

Brosgé and Reiser (1964) describe bedrock in this area of the Brooks Range as quartzite- and mica-rich schist of Devonian age. These rocks are well exposed and complexly faulted in the nearby mountains where Devonian volcanic sills and flows are common along fault and bedding planes in the bedrock sequence. Heavily glaciated, the bedrock is fractured and frost-shattered where exposed. Depth to bedrock beneath the FAA Chandalar Lake facility is unknown.

The FAA facility is on one of three large fan deltas bordering Chandalar Lake. The shallow geologic section is composed of alluvial and glacial deposits of late Pleistocene and Holocene age (Hamilton, 1978). In general, the stratigraphy of these deposits consists of poorly sorted, sandy to gravelly alluvium overlying till. The thickness of these deposits is unknown.

Ferrians (1965) characterizes this area of Alaska as being underlain by continuous permafrost. Soils near the facility are classified as inceptisols, a soil order in which most permafrost-bearing soils are included (Rieger and others, 1979). Inceptisols include somewhat underdeveloped soils that exhibit only minor modification of the parent material. Soil in the immediate vicinity of the FAA Chandalar Lake facility is a gravelly to sandy loam derived from the surrounding glacial deposits (Schoephorster and Preator, 1973). Highly permeable, this soil retains little moisture and permafrost is either deep or absent. A poorly drained, fine, sandy loam is present in low-lying flat areas near Chandalar Lake. This sandy loam is covered by a peaty organic mat about 20 cm thick. The seasonally thawed active layer is as much as 40 cm in thickness and is saturated throughout the summer (Schoephorster and Preator, 1973).

HYDROLOGY

Surface Water

The primary surface-water feature at the FAA Chandalar Lake facility is Chandalar Lake. This natural impoundment of the North Fork of the Chandalar River is approximately 15 km long and 2 km wide. Several perennial and intermittent streams flow into Chandalar Lake, three of which are within 1 km of the FAA facility. Each of the three nearby streams flows west into the lake from the mountains east of the facility.

Many streams in arctic Alaska flow only during the summer and typically are frozen to the streambed during the winter. The hydrograph showing discharge at USGS streamflow-gaging station 15564875 on the Middle Fork of the Koyukuk River, near Wiseman (fig. 2), illustrates the characteristic streamflow pattern of many arctic rivers and streams. The gaging station is approximately 75 km west of Chandalar Lake, is at a similar elevation, and has a drainage basin area (3,100 km^2) approximately the same size and character as that upstream from Chandalar Lake (2,700 km^2). There is little or no measurable discharge between mid-November and early May. Streamflow tends to peak in June and then declines, with periodic rainstorm peak flows, until freezeup in November. Average discharge for 8 years of record through water year 1978 was 20.1 m^3/s (U.S. Geological Survey, 1979).

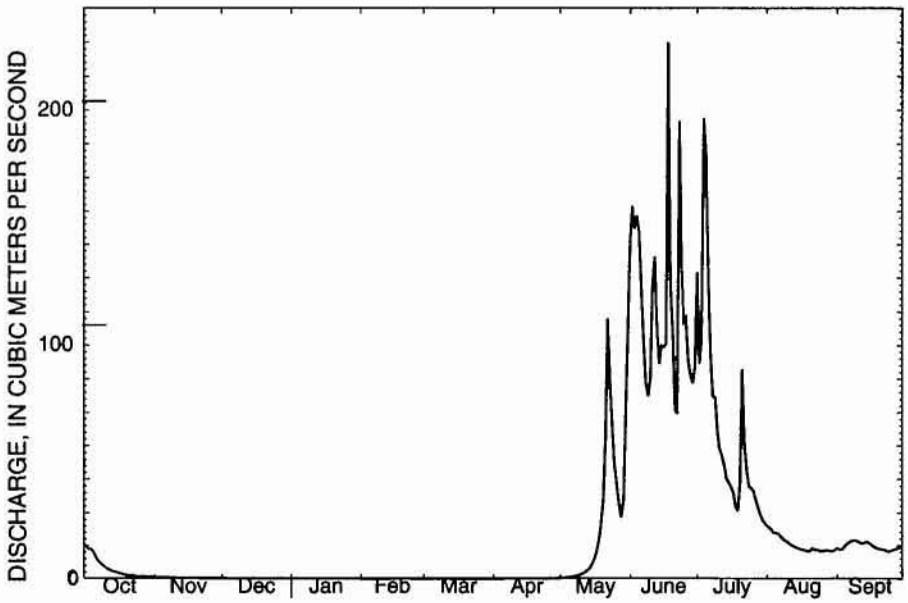

Figure 2. Discharge of the Middle Fork Koyukuk River near Wiseman, water year 1978.

There are no stream-discharge data for the North Fork of the Chandalar River or for the three streams near the FAA Chandalar Lake facility. However, the average annual discharge and low-flow discharge can be estimated using equations developed to characterize the streamflow of rivers and streams in Interior Alaska basins (T.P. Brabets, U.S. Geological Survey, written commun.,

1995). These equations use drainage basin area in square miles and mean annual precipitation in inches to estimate streamflow.

The average annual discharge (Q_{AVE}) is calculated using:

$$Q_{AVE} = 0.009(AREA)^{1.064}(PRECIP)^{1.354}$$

Where:

AREA is drainage basin area, in square miles; and

PRECIP is mean annual precipitation in the drainage basin, in inches (determined from Jones and Fahl, 1994, plate 2).

March is considered to be the period of low streamflow in Interior Alaska. Many small streams, such as those near the FAA Chandalar Lake facility, freeze to the streambed during winter and cease to flow. However, an estimate of the low-flow discharge for an Interior Alaska stream can be made using the following equation:

$$Q_{MAR} = 0.132(AREA)^{0.977}$$

The computed average and low-flow discharge for the North Fork of the Chandalar River and the three streams near the FAA Chandalar Lake facility are shown in table 2. The metric equivalents of the variables and the calculated streamflow values are listed in the table. Because of the paucity of winter streamflow data for rivers and streams of interior Alaska, the standard error of prediction for the computed average and low-flow discharges is relatively high (29 percent and 92 percent, respectively) (T.P. Brabets, U.S. Geological Survey, written commun., 1995). The standard error of prediction is a non-symmetrical function derived by conversion of the logarithmic units used in the regression analysis to percent (G.D. Tasker, U.S. Geological Survey, written commun., 1978).

Table 2. Computed average and minimum streamflow for streams near the Federal Aviation Administration facility, Chandalar Lake

[km^2, square kilometer; mm, millimeter; m^3/s, cubic meter per second; <, less than]

Drainage basin	Drainage basin area (km^2)	Mean annual precipitation (mm)	Discharge (m^3/s)	
			Q_{AVE}	Q_{MAR}
North Fork Chandalar River	2,720	685	36	3
Tobin Creek	52	533	<1	<1
Rosalie Creek	10	533	<1	<1
Unnamed creek	8	533	<1	<1

The drainage basin area for the river and each of the three streams near the FAA Chandalar Lake facility was estimated from U.S. Geological Survey State of Alaska Map E (1973, rev. 1987) and U.S. Geological Survey Alaska Topographic Series, Chandalar, Alaska (1956, rev. 1982). The largest of the three nearby streams is Tobin Creek which enters Chandalar Lake about 1 km north of the FAA facility. The FAA Chandalar Lake facility lies within the small drainage basin of an unnamed creek that flows south of the airstrip, between the FAA facility and the McManus camp,

and into Chandalar Lake approximately 400 m from the facility (fig. 1). Aerial photographs of the area indicate that the lower reach of the unnamed creek may have been diverted by runway fill near the southwest end of the runway. Rosalie Creek enters the lake approximately 500 m south of the FAA facility and drains an area south of the unnamed creek drainage basin.

The mean annual precipitation was estimated from a map of mean annual precipitation for Alaska and conterminous basins of Canada (Jones and Fahl, 1994, plate 2). In the three small stream basins, the mean annual precipitation is approximately 533 mm (21 in.). The larger drainage area of the North Fork of the Chandalar River receives approximately 690 mm (27 in.) of precipitation each year.

A single icing approximately 2,000 m long was observed in Tobin Creek at the head of the alluvial fan during an aerial reconnaissance in 1972 (C.E. Sloan, U.S. Geological Survey, written commun., 1972). Icings, known also as aufeis, are masses of ice formed by the breakout, overflow, and subsequent freezing of sheets of emergent surface water and ground water (Sloan and others, 1976). Icings can divert surface-water flow and cause flooding and erosion if the temperature rises quickly and substantially, thereby posing a hazard to structures. The icing feature observed near the FAA Chandalar Lake facility is approximately 1 km southeast of the runway's northeastern end. Documented only during the 1972 overflight, it is not known if the Tobin Creek icing occurs annually.

The U.S. Army Corps of Engineers (1993) documents no record of floods in the Chandalar Lake area or of flood insurance studies for the area. The ECIR report prepared by Ecology and Environment, Inc. (1992) also documents no flood history at the facility. Lack of flooding was also confirmed by the owner of the neighboring McManus camp (Jack McManus, oral commun., 1995), and by the National Weather Service (P. Meyer, National Weather Service, oral commun., 1995). Because there is no history of flooding at the FAA Chandalar Lake facility, a flood frequency analysis was not undertaken. However, intense rainfall events in the small drainage basins near the FAA facility might result in short periods of high water in the nearby streams. The large capacity of Chandalar Lake should attenuate floods in the North Fork of the Chandalar River and reduce any significant threat of flooding to the FAA facilities, which are about 3 to 4 m above lake level.

Ground Water

Ground-water resources at the FAA Chandalar Lake facility have not been explored (Ecology and Environment, Inc., 1992). The facility is in the zone of continuous permafrost (Ferrians, 1965), and the distribution of aquifers will be affected by the distribution of permafrost. Aquifers are most likely to exist in sediments near the lake and in the alluvial fans (Sloan and van Everdingen, 1988). An aquifer near the lake may remain unfrozen throughout the winter because of the warming effect of the lake water. In the alluvial fans, relatively warm summer streamflow may advect sufficient heat into an aquifer near the streambed to prevent freezing during the winter. Ground water at the facility probably flows west toward Chandalar Lake or south toward the unnamed creek.

The presence of the large icing in Tobin Creek indicates that base flow continues after the stream freezes. Base flow, that component of streamflow contributed by ground water, requires the presence of an aquifer as a water source above the reach where the icing occurs. Therefore, the presence of the icing indicates that an unfrozen aquifer persists in the Tobin Creek watershed above the head of the alluvial fan for at least part of the winter.

DRINKING WATER

Ecology and Environment, Inc., (1992) reported that the McManus camp obtains drinking water from a water intake in Chandalar Lake. The intake is near the mouth of the unnamed creek, which is approximately 400 m downstream from a fuel storage site at the facility (Ecology and Environment, Inc., 1992). A suspended fuel line crosses the unnamed creek near the south end of the runway. Ecology and Environment, Inc., while preparing the ECIR in 1992, collected three water samples from the unnamed creek that flows immediately south of the facility. Analyses showed that zinc was present in all three samples at concentrations of 18 to 51 µg/L, and lead was detected in the upstream (background) sample at concentrations of 20 µg/L (Ecology and Environment, Inc., 1992). No other surface-water-quality information is available.

Chandalar Lake is an abundant source of drinking water for the area's small seasonal population. The estimated per-capita water withdrawal from rural surface-water sources for domestic use in Alaska is about 38 L/d (U.S. Geological Survey, 1986). The nearby streams also could provide water in quantities sufficient to meet the small seasonal needs if Chandalar Lake became contaminated. However, the streams probably freeze to their streambeds during the winter and discharge no water. Snow and ice also provide an alternative water source throughout much of the year if suitable heating and filtering means are available. Ground water might be available on a year-round basis from unfrozen aquifers beneath and in close proximity to Chandalar Lake. Alternative water resources may be available in adequate quantity from these local sources to supply a small population should an alternative water supply be required. The quality of ground water in unfrozen aquifers beneath and adjacent to Chandalar Lake probably is good (Sloan, 1987).

SUMMARY

The Federal Aviation Administration facility at Chandalar Lake is on the east shore of the lake in the eastern Brooks Range of Alaska. In the continental climate zone, the area has long cold winters and short cool summers. Floods are not a significant threat at the facility. The facility and a nearby private lodge currently obtain drinking water from Chandalar Lake. Although alternative water sources exist and may be adequate to supply a small population, their quantity and quality have not been documented. Surface spills and disposal of hazardous materials could affect the quality of the surface water and ground water in the area.

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