TANANA BASIN AREA PLAN

WATER RESOURCES ELEMENT

PHASE I
RESOURCE INVENTORY
August, 1983

STATE OF ALASKA
Department of Natural Resources
4420 Airport Way
Fairbanks, Alaska 99701

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Chapter 1

Introduction

I. INTRODUCTION

Water is a finite resource with measurable limits. Knowledge about the occurrence and maintaining quality of water is prerequisite to community development and expansion, especially in the arctic and sub-arctic where the water cycle is greatly affected by extreme climatic conditions and the presence of permafrost.

Although the water resources element is one of several resource element sections of the Tanana Basin Area Plan, it does not necessarily address the planning process itself but rather attempts to serve as a convenient summary of regional and local information that can subsequently be used to guide actual planning efforts.

Contributors to this element include Steve Mack, Division of Geological and Geophysical Surveys; Joyce Beelman, Department of Environmental Conservation; Tim Johnson, College intern from the University of Alaska at Fairbanks; Mike Granata, Division of Land and Water Management (DLWM); and Craig Shirley, DLWM.

Chapter 2

Issues, Local Preferences and Policies Concerning Water Resources

A. Issues

The following issues concerning water were drawn from the public meetings, sketch elements and interviews with agency representatives.

ISSUE 1. The effect of land classification, land disposals and resource development on water quality and quality.

ISSUE 2. The effect of mineral-related activity on water quality and quantity.

ISSUE 3. The effect of agriculture on water quality.

ISSUE 4. The effect of land classification for habitat on water quality.

ISSUE 5. The effect of forestry on water quality.

ISSUE 6. Maintenance of greenbelts and setbacks near resource developments and land disposals.

ISSUE 7. The effect of land classification for recreation on water.

B. Local Preferences

The following local preferences for each community in the Basin were listed from notes taken during the public meetings:

ANDERSON

Disposals have been in bogs.

Roads to disposals are poorly planned.

Don't put disposals in swamps.

Leave spaces for habitat - a minimum acreage to protect fish and game.

Habitat should be blended with developments.

CANTWELL

No sewage treatment facilities included in disposals.

They put tracts in as if it were a suburb of Chicago, straight lines right through a swamp or steep cliff.

They just like a neat looking map with straight lines. The placement of disposals seems to have nothing to do with land suitability.

Water from your property has to be a must. You have to be able to get to water from your disposal.

Not necessary to have such large setbacks on river frontage to allow for public use.

Human impact on the habitat and the land is just a chicken scratch. We won't hurt anything. Disposals and settlement won't conflict with habitat.

Fish and game is too restrictive on the sediment in streams. Nature does more damage than most miners.

DOT LAKE

Study the impacts of disposals on local areas: the impact on fish and game, minerals, communities and state residents.

The impact of disposals on Fish and Game and subsistence should be addressed.

People's primary concern here is subsistence -- their subsistence lifestyle.

Forestry and habitat play hand and hand with subsistence. All three of these can be compatible.

We don't really have any concerns about minerals. We aren't interested in mining ourselves. We don't care if people mine gold or drill for oil and gas, as long as they don't destroy the subsistence lifestyle. People value this lifestyle.

Subsistence is most important to us. Use subsistence as the umbrella on which to evaluate whether we are supportive or opposed to an action. If something harms subsistence we are opposed to it. If it doesn't then we don't have any real objections.

With mining, you should discourage something like strip mining which destroys habitat.

We aren't against developments if they are done right. If developed in the right way. Some forestry or a mine, I doubt anyone in Dot Lake would be against.

If it destroys the environment we are against it, if it doesn't then fine.

HEALY

There are trumpeter swan nesting sites in the area. Go with habitat rather than disposals in these areas.

Eight Mile Lake would be good for fishing and water skiing but there isn't any access to it.

MANLEY HOT SPRINGS

I'd like to know if they found areas of good soil in the area; they could place disposals there.

People living kind of subsistence lifestyle here and the impact of state activities on locals should be considered.

MENTASTA LAKE

Protect streams from disposals. Insure that people will continue to be able to use streams.

Hydroelectric - I'd like to see a 10 foot dam so Mentasta can get electricity.

Put disposals from Clearwater to Tok. South of Tok there are problems. People fish just south of Tok and it is swamp there.

We need the area we use for hunting and fishing. Every village needs their hunting area.

Keep land in habitat. Don't sell it. Keep it the way it is.

MINTO

The beaver have all moved out. There are no fish because mining has bothered the rivers. No rats (muskrats), no animals. We have seen animals stuck in the mud because of mining.

There's a place where there used to be a slough - but no slough anymore. Birch, Goldstream Creek. Mining filled it up.

We used to go all the time up to Dunbar but it's no creek anymore because of mining.

All the lakes are getting filled up with sand. This hurts the animals.

Caribou, moose get caught in the mud that is in all the creeks now; they can't get out.

Don't sell it - leave it as it is. DO NOTHING with lands. Nothing. Don't do nothing on it that hurts fish and game.

Livengood - all we care about is the water coming into the flats. Now - nothing but sticks filling up areas. In one area, water is just a foot deep now.

If the state gives mining claims they should control them and protect water. Mining is really changing Minto Flats.

Leave Chatanika alone. It's a lifeline for us.

NENANA

Access, power, water should be available for state land disposals at a reasonable cost to the buyer.

Don't sell lands with 20-40% slope. It's too hard to build on. Sell more level land.

Before disposing of any land make sure that the land is capable of being built on.

Don't sell land that is swampy.

If you sell land that is swampy have state fill the swamp and include the cost of the fill and construction in the purchase price of the land.

When is there going to be an environmental impact study done on agriculture development that addresses habitat, leaching of fertilizers into the river, economics, and wildlife? (Connie will bring documents that address these concerns and are being used to develop the management plan to the next public meeting in April.)

Protect fish from getting harmed by agricultural development.

Do environmental feasibility studies during plan and include fish and game and subsistence.

Consider buffers and setbacks on rivers.

Pollutants from agriculture may affect fish.

NORTHWAY

No water-related comments. Much interest on subsistence lifestyle.

TANACROSS

No water-related comments.

TANANA

Concerned over impact of mining on lakes. Mining filled up Fish Lake.

Fish and wildlife---it's a real priority; especially in Fish Lake area.

There's a lot of fishing in the summer. There are not many fish camps on the Tanana, mostly on Yukon.

Fish Lake is an important use area.

TETLIN

We respect game. We don't want to destroy or pollute the area, that's why we don't build around Tetlin Lake.

TOK

Disposals create conflicts with fishing, hunting and trapping.

A lot of the land the state has for sale is under a bunch of water or is straight up.

I am concerned with critical fish and game habitat areas. Especially high use areas.

There should be buffer zones around creeks. (i.e., fish and game corridors.

At times no development within 10-12 miles of a creek is appropriate and should be done to insure fish and game is protected.

Forests are compatible with fish and game. Local mills can get enough timber and still fish and game can be protected.

Keep water quality.

Include buffers along water bodies (a few hundred yards to 1/4 mile).

Part of getting minerals is getting dirty water too.

Get areas revegetated and get water to come out clean. If miners can't afford to clean up the water, don't let them mine until they can. They should absorb the environmental cost.

High water quality is important to the people of Tok.

When considering mining, it is a one time development. Balance this against the value of renewable resources such as salmon and their long term availability.

If you are going to have agriculture develop it with lots of big buffer zones.

Areas of black spruce that are drained can be used for agriculture.

Include buffer zones to minimize soil erosion and impact on rivers.

Agriculture disposals, if done right--not too large or too many with proper buffers might be okay for this area.

Pesticides used on Tok agricultural lands might seep into the river.

The Tok agriculture disposals will take 2,000 acres of land out of moose habitat. The best land for crops is also best for fish and game. Agriculture and fish and game are not compatible. Leave the land for fish and game.

I am supportive of the proposed agriculture disposal. However, if it is not a good site due to conflicts with fish and game management look north of the Alaska Highway and west of Tok, but south of and excluding Wolf Lake, and south of the Tanana so that there is year-round access.

We need access and some developments on the river. The state should identify and insure boat launching areas.

FAIRBANKS

Need clean water - don't like muddy water from mining.

Settling ponds should be enforced. Clean water regulations are not being enforced, and they should be.

Mining affects fish.

Mining silt interferes with fishing for white fish on the Chatanika in September, before ice forms.

Keep permanent roads out of Shaw Creek and Rapid Creek; that area is good for fish. Float planes use 992 for access. People use White Trail from Quartz Lake to Goodpaster. Old cabins used by public in that area.

Reserve public access to lakes and rivers.

On the Little Salcha it is all private land with no access.

Consider impact of forest development on fish and game and recreation.

State is going about it o.k. if it's going to get into agriculture. But from the perspective of caring about hunting, fishing and trapping I don't like to see agriculture. I want to see Alaska stay the same.

I'm not against agricultural disposals but make sure they are placed in good areas and other interests like fish and game are considered.

Putting lands in agriculture should be #1 priority and is compatible with fish and game.

We should look at the impact of agriculture on water supply, both now and in the future (as well as water quality).

Trappers agree with this.

We are opposed to agriculture in critical fish and game areas and if agricultural disposals are done we would like an assessment of the impacts.

Water use and water rights should be looked at before planning any agricultural development in the area -- especially if large developments are being considered.

Habitat should be protected.

Protect rivers and large creeks with greenbelts 300' wide.

With the disposal program in the past, there has been too much land sold, with too little planning - no water, etc. Too much emphasis on quantity and not quality. Much more emphasis is needed in finding quality land.

Water quality and erosion control must be considered for all resources.

Agencies have been ignoring their own regulations on water quality and this should be changed.

Examine critical habitat areas for fur-bearers as well as big game. When I say critical I mean in the sense that if it was gone the population will really drop. Include waterfowl.

In identifying agricultural land - look into using wetlands rather than maybe forested areas.

Buffer zones and screened off areas are needed for critical habitat. Incompatible uses should be placed to provide least amount of conflict with habitat.

I'm concerned about agricultural effect on fish and game. Not enough is known and if we contaminate the fishing we are destroying a valuable food source.

All these rivers need a greenbelt on both sides of them.

Agriculture is good for fish and game - doesn't have to be harmful. People have to be educated before they open their mouths about this.

Waterways move. What happens to a trail that's eroded away? Buffers and easements should consider this.

Most of Alaska is water - when you drain it, it really changes. Should consider these changes that can happen in this plan. This would require kind of an engineering approach.

With disposals on high areas there's a water problem.

Protect watersheds from mining and agriculture and other things that cause siltation, pollution, etc.

Put a trail 2,000 feet behind private property on south side of Chena Hot Springs Road with an access point at about 12 mile Chena Hot Springs Road where state property crosses. Place greenbelts of 1,000 feet on each side of trail and 1,000 foot greenbelts around any body of water (creeks, streams, ponds, etc.) in the Chena Hot Springs Road area.

Each special interest group tends to square off against the other. But many of these are compatible. Old mining trails grow over into good habitat, the initial impact is short-lived. Siltation is not as serious as a lot of people feel. Gravel areas in tailings become good spawning areas. Mining, if anything, helps to enhance an area for recreation, fish and game and forestry.

This water use regulation is a problem. When a miner starts pumping the water, there may be conflicts with other water users.

Prime farmland in California is the result of sedimentation from mines in the uplands.

Banner Creek has never been known for fish due to heavy metals naturally in the water.

How many fish could be more important than a mine? Fish and Game should be made to say "x" number of fish are more important than a mining operation.

They (Fish and Game) has overstressed this to make their point. Two years after a mine closes you'll have more fish than ever before.

Which is worth more - having people working on a needed resource or a couple of hundred fish? This has been our biggest gripe. They have blown this out of proportion and without proper research.

Problem you get into, where mining is not compatible with habitat, is water quality.

Remember for sewage and wells we need low density lots.

Habitat of streams must be protected.

There is a difference between taking large quantities of water from some creeks versus using the small water streams. Small streams, we should have direct access to.

On small streams the fish and habitat considerations - I don't understand I believe - they talk about those little ecosystems of the Minnie Mouse world -- it gets ridiculous.

Oh no it doesn't; you know I've seen salmon spawning in my berm piles on my farm; they are amazing fish -- you've heard of walking catfish -- well, salmon off Chena Hot Springs Road are doing the same and they need to be protected.

In 20 years this access to water will be a problem. Write into the plan that the farmer has access to water.

Class IV soils are good soils. It appears wet -- but will dry out and be good farming land in time.

The way the Army Corps of Engineers lays out wetlands is WAY out of line with the Alaska situation.

The Clean Water Act will affect development of wetlands. I can testify with people here who don't want regulations on their land. The easiest way to avoid a conflict is not to dispose of land which will require permits before he can develop his land. About 5% of the time, there's a major clash between development and wetland protection.

Are you going to give us credit for giving grain to waterfowl and for draining some of these wet spots? There aren't any ducks in some of these dry muskegs.

We need a new definition of wetlands. (Senator Murkowski will be holding a meeting on this.)

No matter what you do, if you open an area, you increase the harvest of fish and game. People follow the farmers and hunt the area.

There's no conflict between agriculture and mining.

Is there a water conflict with mining?

No, you can't get a pump to the river, so the river water doesn't matter.

If a farmer is careless with fertilizer or pesticides, this is of concern. But there are serious restrictions. In the arctic, cold temperatures mean pesticides don't degrade.

Small-scale farming is a lifestyle, and if the river is dirty and the land is disturbed, mining will be in conflict. Large-scale mining would be a detriment to the lifestyle.

Feedlot and barn yards also cause a decline in water quality.

I think land reclamation should be required and the water should be kept clean. But minerals and energy are one of our biggest resources that will help get renewable resources going.

LAKE MINCHUMINA

The area is pretty well saturated for trapping. What are people in these disposals going to do for a living? What about water going up there? People are going to have a hard time.

Lake pollution is a concern. There has been oil spilled on the runway here. PCB concentrates in fish and then the dogs and people eat the fish. Also we all drink the lake water.

We also hope that you will continue to classify the large, mostly marshy area around the south half of the lake as wildlife habitat. Literally thousands of geese and ducks, and hundreds of swans and cranes, as well as other birds, use it as a resting and feeding ground during migration, and many nest there as well. The area is rich in mammalian wildlife.

The north shore of the lake (Sec. 22, 23, T. 11 S., R. 23 W.) is unsuitable for settlement, timber or other uses, as it is primarily muskeg and black spruce. It is inhabited by a variety of animals and wildlife habitat is, we believe, an appropriate classification.

Forest and habitat are the key concerns here.

DELTA JUNCTION

Greenbelts - restrictions should be placed on highly erodible areas. These areas shouldn't be encroached upon.

Mining - DEC should get on placer miners about their settling ponds. Some of these creeks are as muddy as all get out. Miners make a real mess of things. The settling ponds aren't working.

But regulating miners is a touchy one. Miners are walking around with 357's.

Maybe notes should be dropped from planes to the miners about their water quality.

When I started living in Clearwater there were lots of animals. They started disappearing. They did this because of too many recreational trappers. No one took care of game. Beaver houses got trapped out. Do like British Columbia and register traplines. Give our watershed to people so they can regulate the take in the watershed. The commercial trapper can't make it. I know of one guy who left in 1945 saying there is too much trapping. I mentioned this idea about registering traplines to trappers. They didn't want government in trapping they said as they loaded their guns.

A 300 foot buffer along rivers is ridiculous; it would be like having a continuous public campground.

C. Policies

1. Water Rights

Water rights are the real property right to use surface and subsurface water.

Alaska water law is based on the appropriation doctrine, which holds that beneficial use rather than ownership of the land is the basis for determining rights to use water. The Alaskan constitution states that all waters are reserved to the people for common use, and priority of appropriation shall give prior right. In 1966 the Water Use Act was passed to give statutory definition to the appropriation system of water rights authorized by the constitution (DNR, 1981).

Under the Water Use Act water rights are administered by the Alaska Department of Natural Resources. To obtain a water right, individuals must complete the Application for Water Rights obtained from and submitted to the local district or area office of the DNR Division of Land and Water Management. A permit is then issued to develop the water source and the means to use it. Only after the water is being beneficially used is a Certificate of Appropriation issued. This is the legal document which conveys water rights once the water is in use. Water rights do not reflect the absolute ownership of the water but rather the right to use the water.

Water rights run in perpetuity but they can be lost by non-use. Water rights are attached (appurtenant) to the land where the water is being used. If the land is sold, the water right goes with the land to the new owner, unless the water right has been separated from the land through prior approval of the Commissioner of the Department of Natural Resources.

Conditions may be attached to permits and certificates of appropriation including the guarantee of minimum streamflows for the protection of fish and wildlife, recreation, navigation, water quality, or any other purpose of substantial public interest. If a significant amount of water is needed for a short term use such as a construction project, temporary authorization can be obtained through a written request to the department. The temporary water use permit does not establish a water right but is only intended to avoid problems between those who have a short term need and those who have existing rights.

Several exceptions can be noted to this priority of appropriation rule regarding the water rights. Community water supply appropriations have preference over all others regardless of date of acquisition; of course, if community rights are exercised, appropriate compensation must be paid to those whose rights were preempted.

Indian reservations and any federal lands withdrawn from the public domain (e.g. national parks and refuges, and military reservations) have implied water rights by order of the U.S. Supreme Court. These rights may be established without demonstration of beneficial use and they are not lost by non-use. This can make interpretation and quantification of water rights extremely difficult.

In 1980 the Alaska Legislature passed amendments to the Water Use Act (1966) known as the Instream Flow Bill. This legislation allows private parties and public agencies to apply to DNR for reservations of water for instream uses including fisheries, navigation, recreation, and water quality purposes. Prior to the passage of these amendments, water had to be physically diverted from the stream to acquire a water right.

2. Water Quality

It is the policy of the State of Alaska to conserve, improve, and protect public health and safety, terrestrial and aquatic life, natural resources, and the environment. In order to implement this policy, authority to adopt Water Quality Standards, which provide for the protection of identified uses of Alaska's waters, was given to the Alaska Department of Environmental Conservation by the Alaska State Legislature through Alaska Statutes Title 46, Chapter 3.

Alaska's Water Quality Standard Regulations, (Title 18, Chapter 70 of the Alaska Administrative Code), identify the uses of the state's waters and set criteria which limit man-induced pollution to protect these water uses.

Protective water uses include the following:

1. Drinking water, including food processing,
2. Agriculture, including irrigation and stock watering
3. Aquaculture
4. Industrial, including manufacturing and mining
5. Recreation
6. Growth and propagation of fish, shellfish and other aquatic life and wildlife including water fowl and fur bearers.

Manmade alterations to the water of the state may not exceed the maximum contamnant levels as delineated in the Alaska Water Quality Standard Regulations promulgated in 18 AAC 70.

Water Quality Criteria are established for the following parameters:

1. Fecal coliform bacteria
2. Dissolved Gas
3. pH
4. Turbidity
5. Temperature
6. Dissolved inorganic substances
7. Sediment
8. Toxic and other deleterious organic and inorganic substances
9. Color
10. Petroleum hydrocarbons, oils and grease
11. Radioactivity
12. Total residual chlorine
13. Residues such as floating solids, debris, sludge, deposits, foam and scum.

Water which is classified for more than one use, must meet the most stringent water quality criteria of all the included uses. Presently all waters of the State of Alaska must meet the criteria for all uses with the exception of the Chena River between the confluence of the Chena River and Chena Slough to the confluence of the Chena River and the Tanana River. This section of the Chena River is classified for all uses except drinking water.

Procedures for changing the identified uses of a water body are included in the Water Quality Standard Regulations. Several Mining Districts have initiated this process for reclassification of streams within their district to exclude all uses except industrial.

The Water Quality Standards are used primarily as a basis for:

1. establishing conditions in wastewater discharge permits issued by the Department;
2. developing best management practices to control non-point sources of pollution;
3. determining the effect of man's activities on identified uses of the water; and
4. enforcement actions against operations adversely affecting water quality.

In applying the Water Quality Standards, the Department samples and analyzes state water, associated plant and animal life, and wastewater discharges. The Department also requires dischargers to perform certain wastewater effluent and receiving water analyses to assist in protecting water quality. Monitoring requirements are generally limited to those pollutant parameters in the standards which are appropriate and practical for a particular discharger.

The Water Quality Standard Regulations are reviewed and revised as necessary, at least once every three years, to ensure that they reflect new information on criteria limitations and that existing or potential water uses are accurately identified.

Chapter 3

Water Supply in the Tanana Basin

III. WATER SUPPLY IN THE TANANA BASIN

Information on ground water and surface water characteristics is basic to water resources and land-use planning. Unfortunately,the Tanana Basin is similar to other regions in Alaska which face the difficult situation of having a relatively sparse data base, both in terms of geographical distribution and historical record. This situation precludes much of the traditional hydrometerological analysis such as flow durations, flood and lowflow frequencies, and especially area-specific hydrograph characterization. New methods for estimating flow characteristics of ungaged watersheds are certainly needed for Alaska. Methods are needed that bridge the gap between repeated summaries of sparse data and the site-specific information relevant to planning and decision making. The scope of this current project does not allow research on such new methodologies. However, some potentially fruitful approaches will be discussed.

The quantity, quality and distribution of water resources in any area are affected by geologic, topographic, and climatic characteristics. Table 3-1 summarizes precipitation, elevation, temperature, and wind data for a number of locations in the region.

Table 3-1
PRECIPITATION, ELEVATION, TEMPERATURE, AND WIND DATA FOR SOME LOCATIONS IN THE TANANA BASIN

LOCATION	ELEVATION IN FEET	YEAR OF RECORD	PRECIPITATION (incl. snow)	SNOWFALL	SUMMER TEMPERATURE(°F)	WINTER TEMPERATURE(°F)	EXTREME TEMPERATURE(°F)	AVERAGE WIND	EXTREME WIND
Big Delta	1,268	30	11"	41"	40° to 69°	-14° to 26°	-63° to 92°	ESE 8.9 kts. (12.5 kph), calm 15%	WNW 64 kts. (90 kph)
Chena Hot Springs	1,195	12	14"	61"	33° to 69°	-23° to 19°	-59° to 92°	----------	----------
Clearwater	1,100	11	15"	56"	35° to 72°	-31° to 24°	-72° to 93°	----------	----------
College Magnetic	621	59	12"	51"	40° to 72°	-18° to 28°	-65° to 99°	----------	----------
Eielson AFB	547	28	15"	75"	40° to 70°	-20° to 26°	-62° to 93°	W 6.0 kts. (8.4 kph), calm 21%	SW 50 kts. (70 kph)
Fairbanks Intn'l Airport	436	40	11"	70"	39° to 72°	-22° to 26°	-61° to 99°	N 5.3 kts. (7.4 kph), calm 21%	WSW 35 kts. (49 kph)
Gilmore Creek	959	10	11"	83"	36° to 68°	-20° to 18°	-65° to 89°	----------	----------
Lake Minchumina	701	25	13"	50"	38° to 68°	-14° to 25°	-62° to 89°	ENE 6.1 kts. (8.5 kph), calm 18%	SW 48 kts. (67 kph)
Livengood	730	12	13"	50"	38° to 72°	-18° to 22°	-54° to 90°	----------	----------
Manley Hot Springs	275	34	15"	61"	37° to 72°	-21° to 25°	-70° to 91°	----------	----------
McKinley Park	2,070	50	14"	77"	38° to 72°	-7° to 27°	-54° to 89°	----------	----------
Nenana	356	40	11"	48"	38° to 72°	-18° to 24°	-69° to 98°	E 5.3 kts. (7.4 kph), calm 28.5%	E 40 kts. (56 kph)
North Pole	475	7	10"	61"	38° to 72°	-34° to 25°	-67° to 95°	----------	----------
Northway	1,713	30	11:	37"	37° to 69°	-27° to 20°	-72° to 91°	ESE 5.0 kts. (7.0 kph), calm 24%	NNW 45 kts. (63 kph)
Richardson	875	12	13:	54:	38° to 73°	-15° to 28°	-59° to 98°	----------	----------
Tanana	232	70	13"	52"	38° to 70°	-19° to 28°	-76° to 92°	----------	----------
Tok	1,620	16	11"	34"	33° to 72°	-32° to 25°	-71° to 96°	----------	----------
University Exp. Station	475	59	12"	51"	40° to 72°	-18° to 28°	-65° to 99°	----------	----------

Source: Alaska Regional Profiles, 1974.

A. SURFACE WATER

1. Runnoff

A knowledge of runoff generation helps to delineate those parts of the landscape that are major contributors to either storm runoff or groundwater recharge. Zones that allow groundwater recharge, and therefore supply stream flow during dry weather, should be conserved so that they might continue this function instead of being paved over or polluted. In many situations the controls of runoff are very sensitive to disturbance. The removal of vegetation from a forested area during construction, for example, can lower the infiltration capacity enough to generate large amounts of storm runoff where the previous runoff process was a slow subsurface percolation. Zones that produce storm runoff also yield sediment, plant nutrients, bacteria, and other "pollutants". An understanding of storm runoff production, then, indicates the management techniques that might be used to minimize the discharge of these materials into surface water. (Anderson, 1970).

Runoff is defined as that part of precipitation which leaves an area as stream flow. Because it includes melt water from glaciers, the time lag between precipitation and runoff may be hundreds or thousands of years. In the Tanana Basin, measured annual runoff ranges from 10 to 26 inches per year (Anderson, 1970).

The Tanana Basin includes the drainage of the Tanana River and its tributaries. The Tanana River drains 44,500 square miles of which 500 square miles lie in Canada. The river forms at the confluence of the Chisana and Nabesna Rivers near the village of Northway and flows generally north-westward 531 miles to its mouth where it enters the Yukon River at Tanana. From its beginning to Big Delta, about 230 miles, the Tanana flows in a valley with an average width of 10-15 miles; below Big Delta the valley widens to 50 to 60 miles. Major tributaries are the Kantishna, Toklat, Nenana, Tolovana, Chena, Delta, Wood, Gerstle, and Salcha Rivers (Table 3-2). Figure 3-1 shows the major rivers and streams in the Tanana Basin as well as location of surface-water gaging stations in the Basin.

Drainage areas of streams entering the Tanana River from the north are distinct from those entering from the south. South bank drainage originates in the northern slopes of the Alaska Range, and at the highest elevation, numerous glaciers and relatively heavy precipitation result in different runoff characteristics from that experienced in the less rugged areas contributing to the north side tributaries. Nearly all of the south bank streams are of

Table 3-2

MAJOR RIVERS IN THE TANANA RIVER BASIN

River	Tributary To	At River Mile	Drainage Area ($mi.^2$)	Length of Main Stream (miles)
Tanana	Yukon	720	44,500	531
Kantishna	Tanana	93	6,770	163
Tolovana	Tanana	100	3,360	173
Nenana	Tanana	152	3,920	143
Wood	Tanana	169	1,390	114
Chena	Tanana	200	2,070	141
Salcha	Tanana	242	2,170	136
Little Delta	Tanana	266	690	36
Delta Creek	Tanana	281	720	38
Delta	Tanana	299	1,660	82
Goodpaster	Tanana	308	1,430	71
Healy	Tanana	342	390	42
Johnson	Tanana	369	380	25
Robertson	Tanana	408	530	32
Tok	Tanana	467	960	87
Tetlin	Tanana	500	940	80
Nabesna	Tanana	531	2,130	75
Chisana	Tanana	531	3,270	117

(ARP 1974)

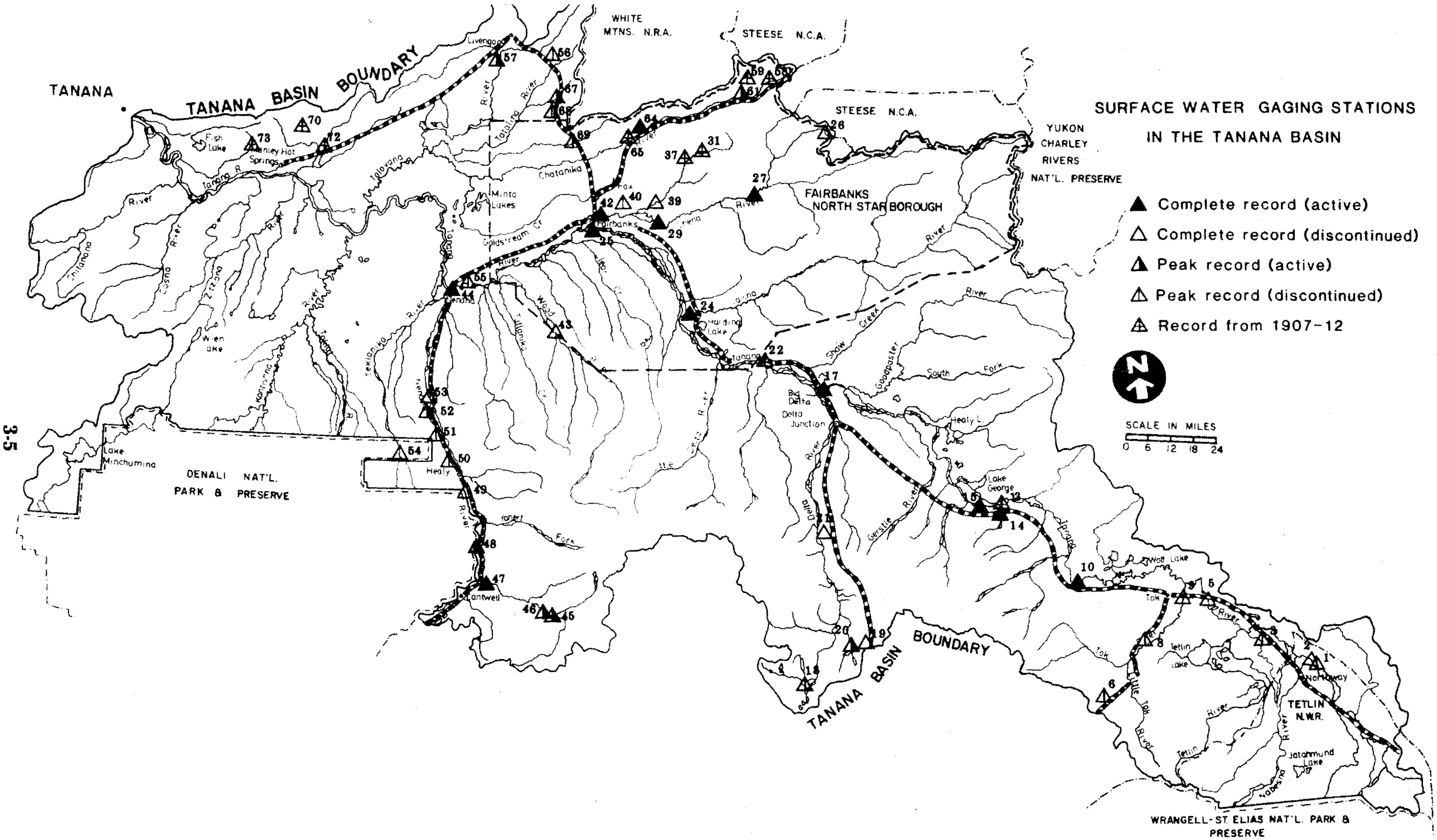


Figure 3-1. Surface Water Gaging Stations in the Tanana Basin.

glacial origin and possess the characteristics of glacial streams. They are generally swift and steep and carry large amounts of suspended sediments during spring and summer. Channels in the lower reaches are braided through extensive gravel deposits in the bottoms of the canyons. In winter flow is at reduced stages and only a small amount of sediment is carried.

Mean annual runoff in the Tanana Basin averages about 0.5 to one cubic foot per second (cfs) per square mile in the lowlands and tributary basins north of the Tanana River. South of the river mean annual runoff probably ranges from about one cfs per square mile adjacent to the river to over four cfs per square mile in the uplands of the Alaska Range. Annual runoff also varies widely from year to year. For example, average annual runoff of the Chena River at Fairbanks was measured at 0.36 cfs per square mile in 1958 and at 1.32 cfs per square mile in 1962. (Ak Regional Profiles (ARP), 1974).

Mean annual peak runoff for small areas ranges from about 10 cfs per square mile in the lowlands to probably as high as 50 cfs per square mile in steep basins in the uplands. Most annual peaks occur in summer and are caused by rain, but spring snow melt occasionally causes annual peaks. Frequent channel icing and icejam flooding contribute to a high susceptibility to floods in the lowlands of the Tanana Basin.

Mean annual low monthly runoff averages about 0.1 to 0.2 cfs per square mile. (ARP, 1974). Low flow usually occurs in late winter or early spring following a long stream flow recession extending through the cold winter. Since streams in small tributary basins usually freeze completely during most winters, the only large source of streamflow during winter is the subchannel water under the large rivers. During low flow some of the streams lose most of their water to the aquifers in the lowlands.

Table 3-3 is a summary of surface-water gaging station records compiled from data from published and unpublished records of the U.S. Geological Survey. Average and peak flows are recorded as well as low flow. Low flows are a statistical analysis used for certain design purposes such as fish survival or recreation. Figure 3-1 shows the location of these stations.

Table 3-4 is a summary of the historical averages of snow depth and water content data from snow courses and pillows in the Tanana Basin. Figure 3-2 shows the location of these courses and pillows in the Tanana Basin. Snow courses consist of a series of sampling locations (usually not less than ten) where snow depth and resulting water content is measured manually. Snow pillows are pillow-like

Table 3-3. SUMMARY OF SURFACE-WATER GAGING STATION RECORDS IN THE TANANA BASIN[1]
Data from Published and Unpublished records of the U.S. Geological Survey

Map No.	Station Number	Stream	Drainage area in sq. miles	Gage Elevation in feet[2]	Period of Record	AVERAGE FLOW Discharge cfs	AVERAGE FLOW Discharge cfs per sq. mi.	PEAK FLOW Discharge cfs	PEAK FLOW Discharge cfs per sq. mi.	PEAK FLOW Date	PEAK FLOW 50-Year Exceedence Probability Discharge[3] estimated cfs	PEAK FLOW 50-Year Exceedence Probability Discharge[3] cfs per sq. mi.	LOW FLOW 7 day, 10 year Low Flow Probability Discharge[4] estimate cfs	LOW FLOW 7 day, 10 year Low Flow Probability Discharge[4] cfs per sq. mi.
1	1546 9900	Silver Creek near Northway Jct.	11.7	---	1963-1972	---	---	355.0	30.3	7-64	558.1	47.7	---	---
2	1547 0000	Chisana River at Northway Jct.	3280.0	1682.9	1950-1971	2337.0	0.71	12,300.0	3.66	6-64	11,412.9	3.48	611.4	0.19
3	1547 1000	Bitters Creek near Northway Jct.	15.4	---	1964-1980	---	---	1010.0	65.6	6-64	773.6	50.2	---	---
4	1547 1500	Tanana River Tr. near Tetlin Jct.	2.43	---	1965-	---	---	45.0	18.5	6-73	52.5	21.6	---	---
5	1547 2000	Tanana River near Tok Jct.	---	---	1950-1953	6980.0	---	---	---	---	---	---	---	---
6	1547 3000	Bartell Creek near Mentasta	---	---	1965-1966	---	---	88.0	---	6-66	---	---	---	---
7	1547 3600	Log Cabin Creek near Log Cabin Inn	10.7	---	1966-1980	---	---	330.0	30.8	7-72	750.8	70.2	---	---
8	1547 3950	Clearwater Creek near Tok	36.4	1960.0	1964-1980	---	---	1040.0	28.6	6-68	1938.4	53.2	---	---
9	1547 4000	Tok River near Tok Jct.	---	---	1952-1954	270.0	---	---	---	---	---	---	---	---
10	1547 6000	Tanana River near Tanacross	8550.0	1489.6	1953-	7994.0	0.93	39,100.0	4.57	6-72	40,632.0	4.75	1707.9	0.20
11	1547 6049	Tanana River Tr. near Cathedral Rapids	3.09	---	1970-	---	---	332.0	107.4	7-70	756.0	245.0	---	---
12	1547 6050	Tanana River Tr. near Tanacross	3.32	1520.0	1964-1972	---	---	297.0	89.5	7-70	845.2	255.0	---	---
13	1547 6200	Tanana River Tr. near Dot Lake	11.0	1400.0	1964-1980	---	---	146.0	13.3	7-64	188.0	17.1	---	---
14	1547 6300	Berry Creek near Dot Lake	65.1	1400.0	1964-	42.2	0.65	2800.0	43.0	7-64	2683.6	41.2	1.4	0.02
15	1547 6400	Dry Creek near Dot Lake	57.6	1330.0	1964-	18.9	0.33	2200.0	38.2	7-64	2860.4	49.7	---	---
16	1547 7500	Clearwater Creek near Delta Jct.	---	---	1978-1979	713.0	---	830.0	---	8-79	---	---	---	---
17	1547 8000	Tanana River at Big Delta	13,500.00	963.0	1949-1957	14,950.0	1.11	62,800.0	---	7-49	69,678.0	5.16	3866.3	0.29
18	1547 8010	Rock Creek near Paxson	50.3	3100.0	1963-	---	---	1800.0	35.8	6-77	2655.5	52.8	---	---
19	1547 8040	Phelan Creek near Paxson	12.2	3700.0	1967-1978	69.7	5.71	2320.0	290.2	8-67	2636.9	216.1	1.0	0.08
20	1547 8050	McCallum Creek near Paxson	15.5	---	1967-	---	---	1010.0	65.2	8-67	1234.4	70.6	---	---
21	1547 8500	Ruby Creek near Donnelly	5.32	1840.0	1963-1979	---	---	400.0	75.2	6-77	865.9	162.8	---	---
22	1548 0000	Banner Creek at Richardson	20.2	900.00	1909-1910	---	---	732.0	36.2	1966	1768.9	87.6	---	---
23	1548 2000	Junction Creek near Richardson	23.6	1000.00	1909-1912	---	---	300.0	12.7	6-12	---	---	---	---
24	1548 4000	Salcha River near Salchaket	2170.0	631.9	1949-	1650.0	0.76	97,000.0	44.7	8-67	63,300.0	29.2	83.6	0.04
25	1548 5500	Tanana River at Fairbanks	undefined	400.00	1967-	18,810.0	---	125,000.0	---	8-67	---	---	3577.5	---
26	1549 0000	Monument Creek at Chena Hot Springs	26.7	1200.00	1912-1967	---	---	1490.0	55.8	8-67	2223.7	83.3	---	---
27	1549 3000	Chena River near Two Rivers	941.0	700.00	1967-	651.0	0.69	16,800.0	17.9	5-75	22,882.3	24.3	35.7	0.04
28	1549 3500	Chena River near North Pole	1430.0	478.1	1972-1980	736.0	0.51	12,300.0	8.60	5-75	20,960.6	14.5	52.4	0.04
29	1549 3700	Chena River below Moose Creek Dam	1430.0	---	1980-	795.0	0.56	5930.0*	4.15	7-81	---	---	---	---
30	1549 4000	Chena River near Fairbanks	1440.0	450.0	1910-1912	---	---	9050.0	6.28	6-12	---	---	8.4	0.01
31	1549 6000	Little Chena River above Sorrels Creek near Chatanika	79.0	900.0	1907-1910	---	---	405	5.13	5-08	---	---	---	---
32	1549 8000	Sorrels Creek near Chatanika	21.0	950.0	1907-1910	---	---	131.0	5.13	5-08	---	---	---	---
33	1550 0000	Elliott Creek near Chatanika	13.8	950.0	1907-1910	---	---	111.0	8.04	5-08	---	---	---	---
34	1550 2000	Fish Creek below Solo Creek near Chatanika	21.5	1100.0	1910-1912	---	---	120.0	5.58	8-11	---	---	---	---
35	1550 4000	Fish Creek above Fairbanks Creek near Chatanika	39.0	850.0	1907-1908	---	---	227.0	5.82	5-08	---	---	---	---
36	1550 6000	Miller Creek near Chatanika	16.7	750.0	1908-1910	---	---	122.0	7.31	5-08	---	---	---	---
37	1550 8000	Fish Creek at mouth, near Chatanika	90.2	740.0	1908-1910	---	---	682.0	7.56	5-08	---	---	---	---
38	1551 0000	Little Chena River near Chatanika	228.0	740.0	1908-1910	---	---	1670.0	7.32	5-08	---	---	---	---
39	1551 1000	Little Chena River near Fairbanks	372.0	490.0	1967-1981	204.0	0.55	17,000.0	45.7	8-67	11,299.7	30.4	---	---
40	1551 1500	Steele Creek near Fairbanks	10.7	---	1967-1974	---	---	340.0	31.8	8-67	263.3	24.6	---	---
41	1551 2000	Chena Slough near Fairbanks	20.0	450.0	1948-1951	---	---	740.0	37.0	5-49	---	---	---	---
42	1551 4000	Chena River at Fairbanks	1980.0	422.9	1948-	1396.0	0.71	74,400.0	37.6	8-67	42,001.7	21.21	148.7	0.08
43	1551 4500	Wood River near Fairbanks	855.0	530.0	1970-1978	473.0	0.55	5510.0	6.44	8-76	6461.1	7.56	51.9	0.06
44	1551 5500	Tanana River at Nenana	25,600.0	338.5	1948-	23,490.0	0.92	186,000.0	7.27	8-67	152,077.4	5.94	4626.9	0.18

(Table 3-3 continued)

Map No.	Station Number	Stream	Drainage area in sq. miles	Gage Elevation in feet[2]	Period of Record	AVERAGE FLOW Discharge cfs	AVERAGE FLOW Discharge cfs per sq. mi.	PEAK FLOW Discharge cfs	PEAK FLOW Discharge cfs per sq. mi.	PEAK FLOW Date	PEAK FLOW 50-Year Exceedence Probability Discharge[3] estimated cfs	PEAK FLOW 50-Year Exceedence Probability Discharge[3] cfs per sq. mi.	LOW FLOW 7 day, 10 year Low Flow Probability Discharge[4] estimate cfs	LOW FLOW 7 day, 10 year Low Flow Probability Discharge[4] cfs per sq. mi.
45	1551 5800	Seattle Creek near Cantwell	36.2	2250.0	1964-	42.2	1.17	3100.0	85.6	6-64	2996.0	82.8	6.5	0.18
46	1551 5900	Lilly Creek near Cantwell	5.63	---	1966-	---	---	191.0	33.9	6-66	335.8	59.6	---	---
47	1551 6000	Nenana River near Windy	710.0	2100.0	1951-	1202.0	1.69	11,900.0	16.8	6-62	11,365.7	16.0	114.5	0.16
48	1551 6200	Slime Creek near Cantwell	6.90	---	1966	---	---	685.0	99.3	7-67	792.1	114.8	---	---
49	1551 8000	Nenana River near Healy	1910.0	1270.2	1951-1979	3506.0	1.84	46,800.0	24.5	7-67	43,271.6	22.7	297.2	0.16
50	1551 8100	L. Panguineque Creek near Lignite	3.44	---	1965-1974	---	---	151.0	43.9	8-67	---	---	---	---
51	1551 8200	Rock Creek near Ferry	8.17	---	1965-1980	---	---	938.0	114.8	6-80	3026.8	370.5	---	---
52	1551 8250	Birch Creek near Rex	4.10	---	1965-	---	---	300.0	73.2	6-80	708.0	127.7	---	---
53	1551 8300	Nenana River near Rex	---	---	1965-1968	4536.	---	---	---	---	---	---	---	---
54	1551 8350	Teklanika River near Lignite	490.0	1550.0	1966-1967	698.0	1.42	33,100.0	67.7	7-67	---	---	114.2	0.23
55	1551 8400	Tanana River Tr. near Nenana	0.6	---	1966-1967	---	---	18.0	30.0	7-67	---	---	---	---
56	1551 9000	Bridge Creek near Livengood	12.6	670.0	1963-1972	---	---	1070.0	84.9	8-64	1801.9	143.0	---	---
57	1551 9200	Brooks Creek Tr. near Livengood	7.8	---	1964-	---	---	168.0	21.5	5-75	475.0	60.9	---	---
58	1552 2000	McManus Creek near Chena Hot Springs	80.0	1450.0	1907-1912	---	---	760.0	9.50	6-10	---	---	---	---
59	1552 6000	Charity Creek near Chena Hot Springs	6.9	2100.0	1910-1912	---	---	77.0	11.2	6-10	---	---	---	---
60	1552 8000	Homestake Creek near Chena Hot Springs	5.6	2130.0	1910-1912	---	---	58.9	10.4	6-12	---	---	---	---
61	1553 0000	Faith Creek near Chena Hot Springs	61.1	1450.0	1907-1912 1963-1972	---	---	4950.0	81.0	8-67	5378.6	88.0	---	---
62	1553 2000	Chatanika River near Chena Hot Springs	132.0	1450.0	1907-1912	---	---	2190.0	16.6	9-07	---	---	---	---
63	1553 4900	Poker Creek near Chatanika	23.1	740.0	1972-1978	10.9	0.47	232.0	10.0	6-73	730.5	31.6	---	---
64	1553 5000	Caribou Creek near Chatanika	9.2	870.0	1970-	4.7	0.51	117.0	12.7	5-75	295.7	32.1	---	---
65	1553 8000	Chatanika River near Chatanika	456.0	650.0	1907-1912	---	---	3480.0	7.63	5-11	---	---	---	---
66	1554 0000	Goldstream Creek near Fox	28.6	800.0	1907 only	---	---	41.0	1.43	9-07	---	---	---	---
67	1554 1600	Globe Creek near livengood	23.0	---	1964-	---	---	1240.0	53.9	8-67	1813.6	78.9	---	---
68	1554 1650	Globe Creek Tr. near Livengood	9.0	---	1963-1972	---	---	490.0	54.4	8-67	685.6	76.2	---	---
69	1554 1800	Washington Creek near Fox	46.7	---	1908-1909	---	---	2500.0	53.5	8-67	4511.7	96.6	---	---
70	1555 2000	California Creek near Eureka	6.7	800.0	1908-1909	---	---	8.7	1.30	9-08	---	---	---	---
71	1555 6000	Pioneer Creek near Eureka	8.1	900.0	1908-1909	---	---	86.0	10.6	5-09	---	---	---	---
72	1556 2000	Hutlinana Creek near Eureka	44.2	900.0	1908-1909	---	---	315.0	7.13	8-09	---	---	---	---
73	1556 4000	Sullivan Creek at Tofty	15.6	650.0	1908-1909	---	---	158.0	10.1	8-09	---	---	---	---

[1]Includes all stream gages gaged 2 years or more; unless otherwise specified.

[2]The National Geodetic Vertical Datum of 1929 (NFVD) is used to determine elevation for gages gaged after 1929. The NFVD is derived from the average sea level over a period of many years, but it does not necessarily represent local mean sea level at any particular place. Prior to 1929, the gage evaluation has been crudely estimated from topographic maps.

[3]The 50-year Exceedence Probability Discharge is the statistically derived discharge that will be exceeded, once in a fifty year period. The 50 year-peak discharges were determined using the Lig-Pearson Type III method.

[4]The 7 day, 10 year, Low Flow Probability Discharge is the estimate for minimum runoff (over a 7-day period) in a 10 year period.

*Gage datum (NGVD) changed during this year.

Table 3-4.

Snow Courses and Pillows in the Tanana Basin, Historical Averages for February, March, April and May

				Historical Average[2]							
				Feb 1		March 1		April 1		May 1	
Site Name	Map No.	Eleva- tion (feet)	Years of Previous Record[1]	Snow Depth (in.)	Water Content (in.)	Snow Depth (in.)	Water Content (in.)	Snow Depth (in.)	Water Content (in.)	Snow Depth (in.)	Water Content (in.)
Big Delta	1	980	23	14	2.2	16	2.7	14	2.7	1	0.3
*Cleary Summit	2	2330	23	24	5.0	26	5.3	29	6.4	26	6.8
*Fielding Lake	3	3000	22	32	7.0	38	8.5	46	12.0	43	12.7
Tok Junction	4	1650	23	17	2.8	18	3.0	17	3.3	4	1.0
*Munson Ridge	5	3050	21	34	7.8	35	8.5	46	13.0	47	14.3
*Mt. Ryan	6	2800	21	28	5.7	30	6.2	32	7.3	30	7.9
French Creek	7	1800	21	24	4.7	26	5.5	27	6.1	17	5.1
*Little Chena Ridge	8	2000	21	22	4.3	26	5.1	27	5.5	19	5.1
Little Salcha	9	1700	21	22	4.1	23	4.8	23	5.2	12	3.4
Caribou Mine	10	1150	18	23	4.4	23	4.5	26	5.5	12	3.5
Colorado Creek	11	700	17	21	3.6	21	4.1	16	2.9	10	2.7
Granite Creek	12	1240	15	15	2.6	16	3.0	15	3.2	3	0.8
*Upper Chena	13	3000	16	27	6.3	29	6.8	34	7.8	30	8.1
Bonanza Creek	14	1150	15	20	3.4	20	3.8	20	4.2	13	3.2
Fort Greely	15	1500	16	15	2.6	17	3.0	16	3.3	4	0.9
Yak Pasture	17	600	23	19	3.2	20	3.8	21	4.1	5	1.6
Haystack Mountain	18	1950	13	27	5.3	28	5.7	31	6.2	26	6.6
Caribou Creek	19	1250	13	21	3.6	22	4.2	22	4.5	7	1.9
Caribou Snow Pillow	20	900	13	20	5.6	21	4.0	21	4.2	5	1.4
Monument Creek	21	1850	9	19	3.4	21	3.9	21	4.2	15	3.5
Teuchet Creek	22	1640	10	18	2.8	21	4.0	20	3.8	7	1.9
Lower Chena	25	2000	6	—	—	28	6.1	—	—	0	0
Little Chena Slope	26	1100	3	—	—	—	—	—	—	—	—
Little Chena Bottom	27	1460	5	—	—	—	—	—	—	—	—
Jack River	28	2450	—	—	—	—	—	—	—	—	—
Upper Chena Pillow	30	3400	2	—	—	—	—	—	—	—	—
Totchaket	31	350	3	—	—	—	—	—	—	—	—
Rhoads Creek	32	1225	2	—	—	—	—	—	—	—	—
Fairbanks	33	450	1	—	—	—	—	—	—	—	—
Lake Minchumina[3]	4E 02	—	16	—	—	20	3.8	21	4.3	—	—

* Affected to some degree by wind
1. Years of record may not be identical for all measurement dates at each site when different the longer period of record is shown.
2. Historical averages are not calculated until five years of data are recorded.
3. For snow survey inventory purposes this site is included in the Kuskokwim River Basin.

Source: "Snow Surveys and Water Supply Outlook in Alaska", U.S. Soil Conservation Service, 1982-3

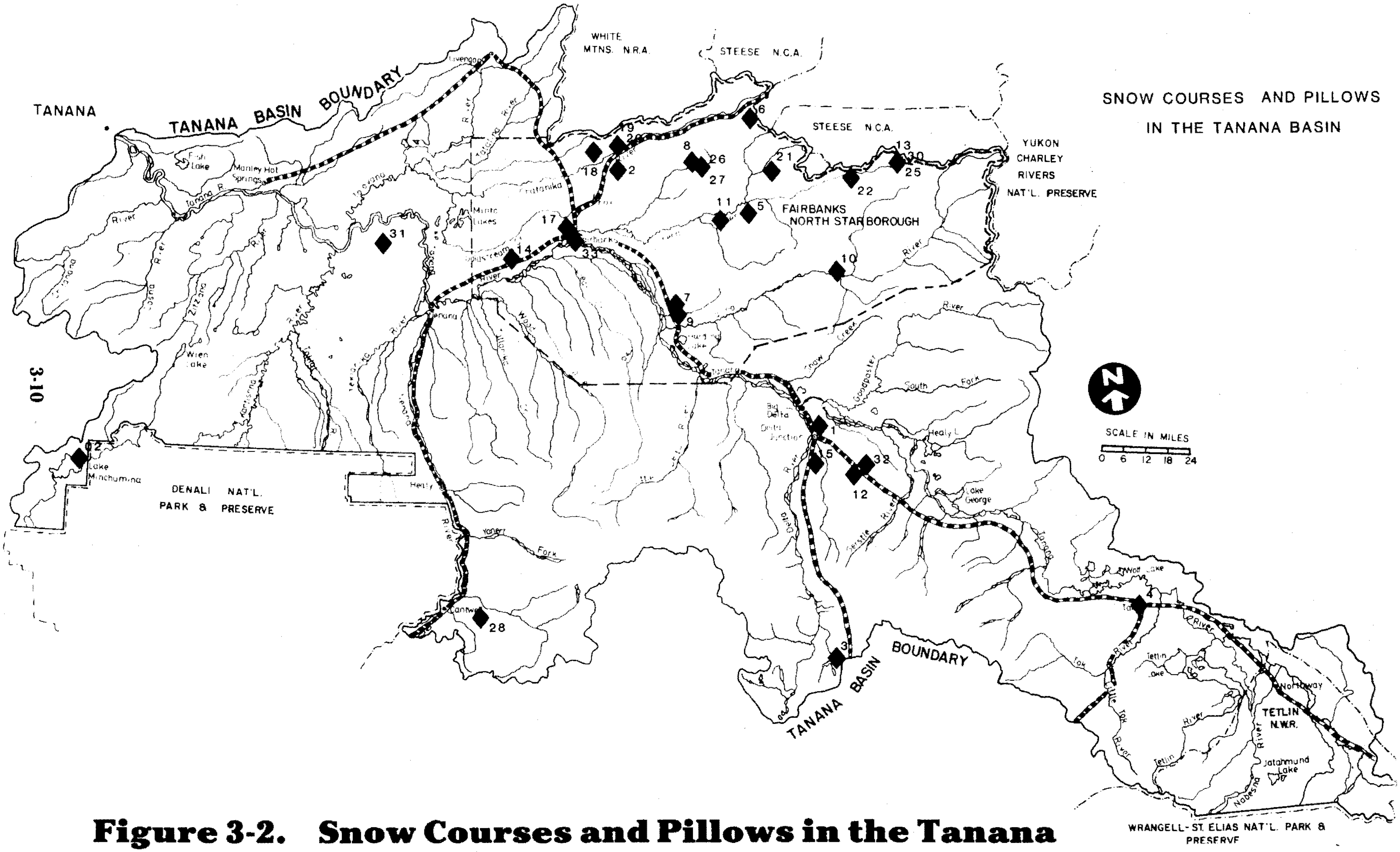


Figure 3-2. Snow Courses and Pillows in the Tanana Basin.

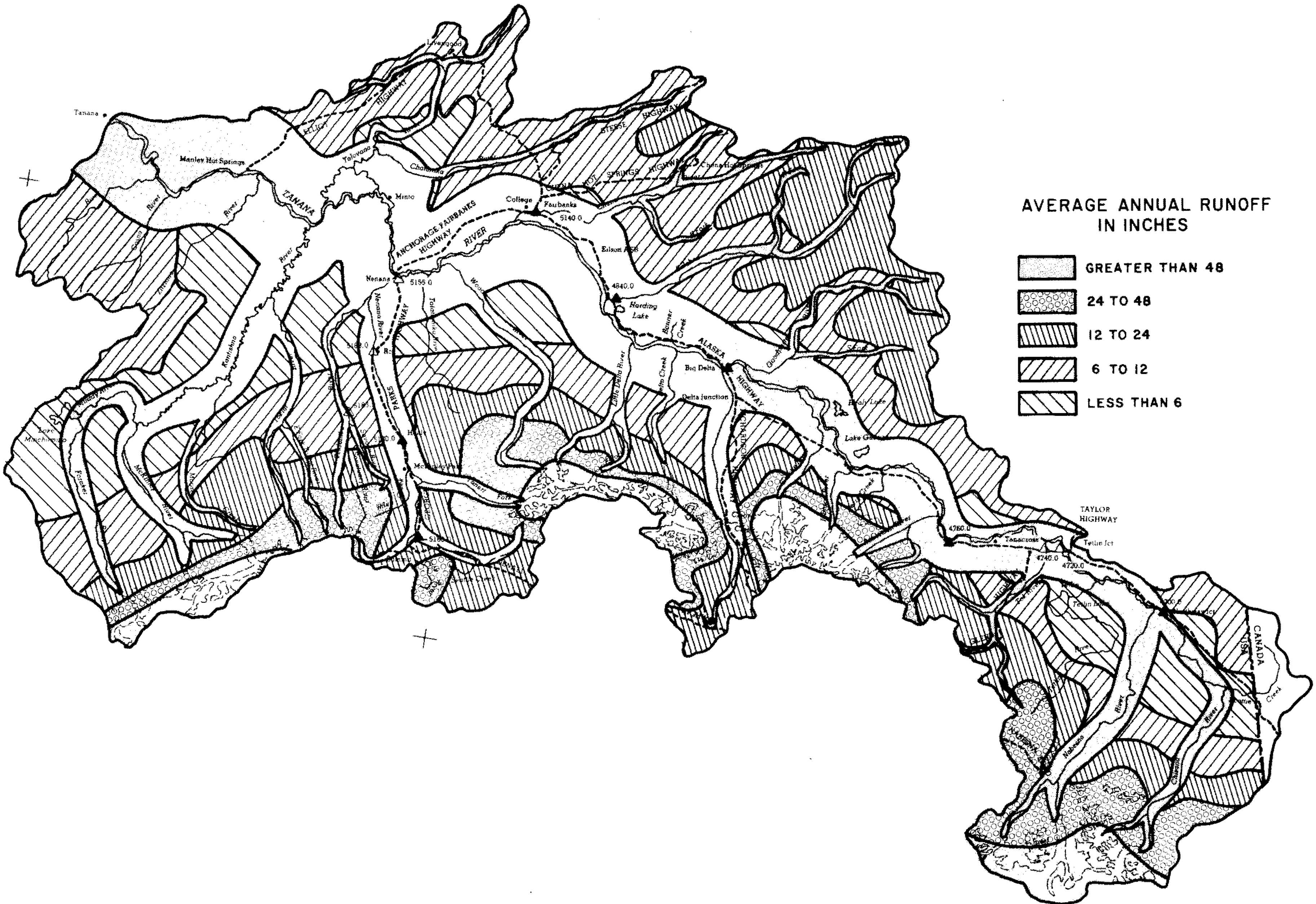


Figure 3-3. Average Annual Runoff in the Tanana Basin.

devices set into the ground which measure the weight of snow. Snow pillows can be connected to either a continuous recorder or telemetering device which reduce the need for on-site visits. Snowmelt provides much of base flow for many rivers in the Tanana Basin, thus snowpack data can provide a helpful forecast of water supply through the summer.

Figure 3-3 is a runoff map portraying average annual runoff by altitude zones and the average streamflow. Average runoff is expressed on the map in terms of inches per year. When expressed in inches, runoff represents average depth at place of origin. The longest streamflow records span 17 years and form the base period used. Where possible, shorter records were averaged to the longer time period. On ungaged basins, average streamflow has been estimated. (Anderson, 1970).

The runoff map was constructed by a trial-and-error process of apportioning measured streamflow and the estimated ground-water flow throughout the Basin, assuming that precipitation tends to increase and evapotranspiration tends to decrease with altitude. Other environmental factors such as geology, permafrost, vegatation, and lake or ice storage were introduced as variables related to evaluation distribution. Thus, area-altitude distribution provides an index to quantify altitude zones of assumed homogeneous runoff characteristics. A set of values was assumed to be satisfactory when estimated and measured runoff values were comparable at gaging stations. Altitude zones of assumed constant local runoff were drawn with the aid of altitude contours. The runoff values are real only in the sense that they satisfy an inferred hydrologic model and provide the best fit for apportioning the measured streamflow throughout the Basin. Thus, the map is useful in comparison of runoff with climatic or geologic characteristics of the area and in grossly delineating the geographic distribution of water in the basin. The map is not intended to provide a means for estimating the flow of any specific stream.

The greatest contribution of runoff to the Tanana River is from the Alaska Range from areas above 5,000 feet. This is a rather gross simplification of a complex process because some precipitation above 5,000 feet is transported in the solid state by wind or glaciers to lower altitudes before it melts and becomes runoff. Runoff from areas above 5,000 feet having perennial ice and snow is estimated to average 84 inches; runoff from subareas having minor amounts of perennial ice and snow may be as low as 24 inches. (Anderson, 1970)

In the 3,000 to 5,000 foot altitude (generally between tree line and snow line) average runoff approaches 100 percent of precipitation or 12 to 24 inches. From 3,000 feet to valley bottom, runoff is approximately 60 percent of precipitation or 8 to 12 inches (Anderson, 1970).

In the poorly drained low-relief areas of the valley bottoms, average annual runoff from direct precipitation is presumed to be 0 to 8 inches. Most of the runoff would be from snowmelt; little runoff results from rain. Lowest run-off is from the areas of lakes and swamps where evapotrans-piration is high.

A generalized water balance for the Tanana Basin is given in Table 3-5. The term water balance refers to the balance between the income of water from precipitation and snowmelt and the outflow of water by evapotranspiration, groundwater recharge, and streamflow.

The water balance has been used for computing season-al and geographical patterns of irrigation demand, the soil moisture stresses under which crops and natural vegetation can survive, the prediction of streamflow and water-table elevations and the flux of water to lakes. It is also use-ful for predicting some of the human impacts on the hydro-logic cycle. The hydrologic effects of weather modification or changes of vegetation cover can be quickly estimated at a very early stage in the planning. Although the predictions may be approximate, they are sufficiently accurate to indi-cate whether a scheme is hydrologically sound.

From Table 3-5 it is estimated that in the Tanana Basin, 32 percent of the annual precipitation is lost by evapotranspiration.

Year-to-year gains or losses in the lake, ground water, and permafrost or glacial ice of the hydrologic cycle are included in the values of the water-balance table; the proportions of their individual contributions are poorly defined. Data from the Gulkana Glacier has been from photo-graphs taken by the U.S. Geological Survey in 1910 and 1952. It is estimated that net loss of ice may contribute about 5 percent of the Tanana Basin yield. (Anderson, 1970). This estimate, which is quite crude, is based on the photographic record, on water budget studies of Gulkana Glacier, and the patterns of runoff. The water balance in this table is dynamic in the sense that it considers the net water volume moving through the hydrologic cycle. It does not include the large volume of water more or less perman-ently stored in lakes, groundwater, or ice within the Tanana Basin.

As discussed earlier, estimating flow rates for vary-ing return periods are made with little confidence in the Tanana Basin as well as in many other areas of Alaska. This is a particular problem in watersheds with little or no historical data.

Table 3-5.

WATER BALANCE IN THE TANANA BASIN

A generalized water balance for the Tanana basin is given in the table below.

Altitude Zone	Area: Square miles	Area: Percent basin area	Precipitation Acre-feet x 10^6	Evapotranspiration loss[1] Acre-feet x 10^6	Runoff: Acre-feet x 10^6	Runoff: Percent of total basin runoff
<1,000	12,000	27	8.0	6.3	1.7	5
1-3,000	20,000	46	14.9	7.7	7.2	24
3-5,000	8,000	18	7.7	0.4	7.3	24
>5,000	4,000	9	[2]14.2	Minor	14.2	47
Total	44,000	100	44.8	14.4	[3]30.4	100

[1]Calculated from precipitation minus runoff
[2]Includes an estimated 1.4 x 10^6 acre-feet long-term ice storage loss
[3]Includes an estimated 3.7 x 10^6 acre-feet of ground-water underflow

(Anderson 1970)

Dr. Doug L. Kane (Institute of Water Resources Fairbanks) is currently working on models and techniques that can readily use available data. His research should be available in April 1983.

Dr. John D. Fox (School of Agriculture and Resource Management, University of Alaska) is also working on a model at Spinach Creek, near Fairbanks. Studies on small watersheds have also been carried out on Caribou-Poker Creeks near Chatanika. (U.S. EPA, 1976).

2. Surface Water Storage

Lakes Water storage is seasonal and limited. Few on-stream lakes provide sufficient storage to sustain streamflow during winter or through dry summers. Table 3-6 lists lakes over 10 square miles in the Tanana Basin.

The snowpack retains most precipitation during winter, which causes the annual low flow. Glaciers provide some year-to-year storage that helps sustain streamflow during the dry years. Even though the Tanana Basin is widely underlain by permafrost, alluvial aquifiers near large rivers provide significant water storage that helps sustain streamflow (ARP 1974).

Wetlands The term "wetlands" describes several different kinds of land that may perform similar functions. They include swamps, bogs, fresh and salt marshes, wet tundra and other lands that are periodically or permanently covered by water or that support plants (such as sedges, alders, and black spruce) which often grow in wet areas (Dames and Moore, 1982). In the Tanana Basin wetlands occur along river systems and low-lying swamps, bogs and muskegs. Many wetlands in the Basin are associated with the presence of permafrost.

Providing habitat for fish, amimals, and birds is one important value of wetlands. Many species of fish and shellfish find breeding and rearing grounds in wetlands. Birds use them for resting, feeding, and nesting areas. Moose and caribou use them as feeding grounds or for migration routes.

Wetlands play other important roles. Some wetlands can absorb large amounts of water like a sponge and act as natural flood control systems for rivers. Wetlands may slow the rate of water flow over land (runoff) during periods of normal rainfall. This allows water that would otherwise quickly flow into rivers to be released slowly into the ground or river. Wetlands may serve as natural storm buffers protecting human life and property. They also prevent erosion along coastal lands. In some cases, pollutants are filtered out of the water by plants as the water flows through the wetland. Wetlands may also serve as important recreational areas for such activities as bird watching, berry-picking, and hunting.

Our coastal areas, rivers, streams, lakes, and wetlands are all important resources that must be used wisely. With good planning and design, most projects can be built in or along these areas and still protect their valuable characteristics.

Projects to be constructed in wetlands usually require permits from the Army Corps of Engineers and Alaska Department of Environmental Conservation per the requirments of the Clean Water Act. Section 10 covers any work such as construction of structures (pile or floating docks or pipelines), excavation (called dredging) or fill in "navigable water of the United States." These are waters that are affected by tides. They can also be fresh waters that have been, are, or may be used for interstate or foreign commerce. In general, if you can canoe on the waterbody, it usually is navigable water. Section 404 covers activities that involve placing dredged or fill material in waters of the United States. Dredged material is material that is excavated or dredged from these waters. Fill is material (usually rock and gravel) that is used to change a wet area into dry land or to change the bottom elevation of a waterbody. Water of the United States means not only "navigable water," but also includes all tributaries and streams, lakes, and adjacent wetlands on private, State, Federal, or native lands. Isolated water, such as some lakes and spruce bogs, may also be included in this definition and work in these areas may also require permits. The Corps is the final authority on whether or not a permit is required (Dames and Moore, 1982).

Most projects <u>do</u> receive permits. However, projects located in "wetlands" may experience more problems and these permits often take more time to process. This is because the law is designed to protect these valuable areas. A final decision to approve or deny a permit is made by the Corps in agreement with other government agencies.

Table 3-6

LAKES OVER 10 SQUARE MILES IN SURFACE AREA

Tanana Basin	Latitude Degrees North		Latitude Degrees West	
Harding	64`	25'	146`	50'
Birch	64	20	147	10
Quartz	64	13	145	49
Volkmer	64	07	145	11
Healy	64	00	144	45
Twelvemile	63	51	144	40
Black	63	48	144	41
George	63	47	144	32
Moosehead	63	45	144	32
Sand	63	45	144	15
Glaman	63	26	143	29
Mansfield	63	30	143	25
Fish	63	29	143	15
Wolf	63	27	143	10
Tetlin	63	05	142	45
Midway	63	13	142	17
Fish	62	57	141	50
Deadman	62	53	141	33
Island	62	42	141	07

Source: Alaska Regional Profiles, 1974

B. GROUND WATER

Abstract

Subunit boundaries delineate this management plan. The hydrogeologic framework of the Tanana Basin follows close parameters to general topography and drainage. Discontinuous permafrost, lithologic units and topography are indicators of aquifer characteristics being either unconfined or artesian. Of the 13 large subunits and associated smaller units, a broad overview concerning watersheds, soil types, depths of groundwater (when available), topography/elevations and probable availabilities are discussed.

Introduction

The hydrogeologic framework of the Tanana Basin, in a generalized sense follow closely with surficial topographic features of watersheds and associated drainage. That is to say, in most cases, groundwater flows are parallel to surface drainage (Anderson, 1970). According to Balding (1976) seepage from streams are the most important source of aquifer recharge. The scope of this summary is intended to provide a broad outline of groundwater availability data within the subunits of the Tanana Basin known as the Tanana Basin Area Plan (TBAP) (figure 3.).

The Tanana Basin lies totally within the discontinuous permafrost boundaries (Hopkins, 1955). Moisture content and thickness of permafrost is related to soil types, grain size, drainage, and topography (see figure 2.). Ground water availability ranges from good in the flood plain alluviums and fans with well sorted sands, gravels and silts, to poor in the alluvial (recent river deposits) silts, eolian (wind sorted) silts and bedrock where conditions of low permeability and limited saturated thicknesses occur (figure 3.). Of the lithological characteristics just mentioned above, yields ranging from 1,000-3,000 gpm (gallons per minute) are achievable in the alluvial sand and gravels from depths of ±200', to less than 50 gpm from wells 50'-550' in depth, located in bedrock fracture zones (Anderson, 1970).

This study shall consider the data available from 5 U.S. Geological survey base maps, Kantishna River, Fairbanks, Big Delta, Healy, and Hayes 1:250,00 and the associated "large" and "small" subunits as decreed through the TBAP project manager (Todd, 1982).

The following subunit ground-water delineation is based on available well log data supported by surficial geology basemaps and references where cited. Bear in mind however, many of the hydrologic descriptions can only be inferred due to the lack of data.

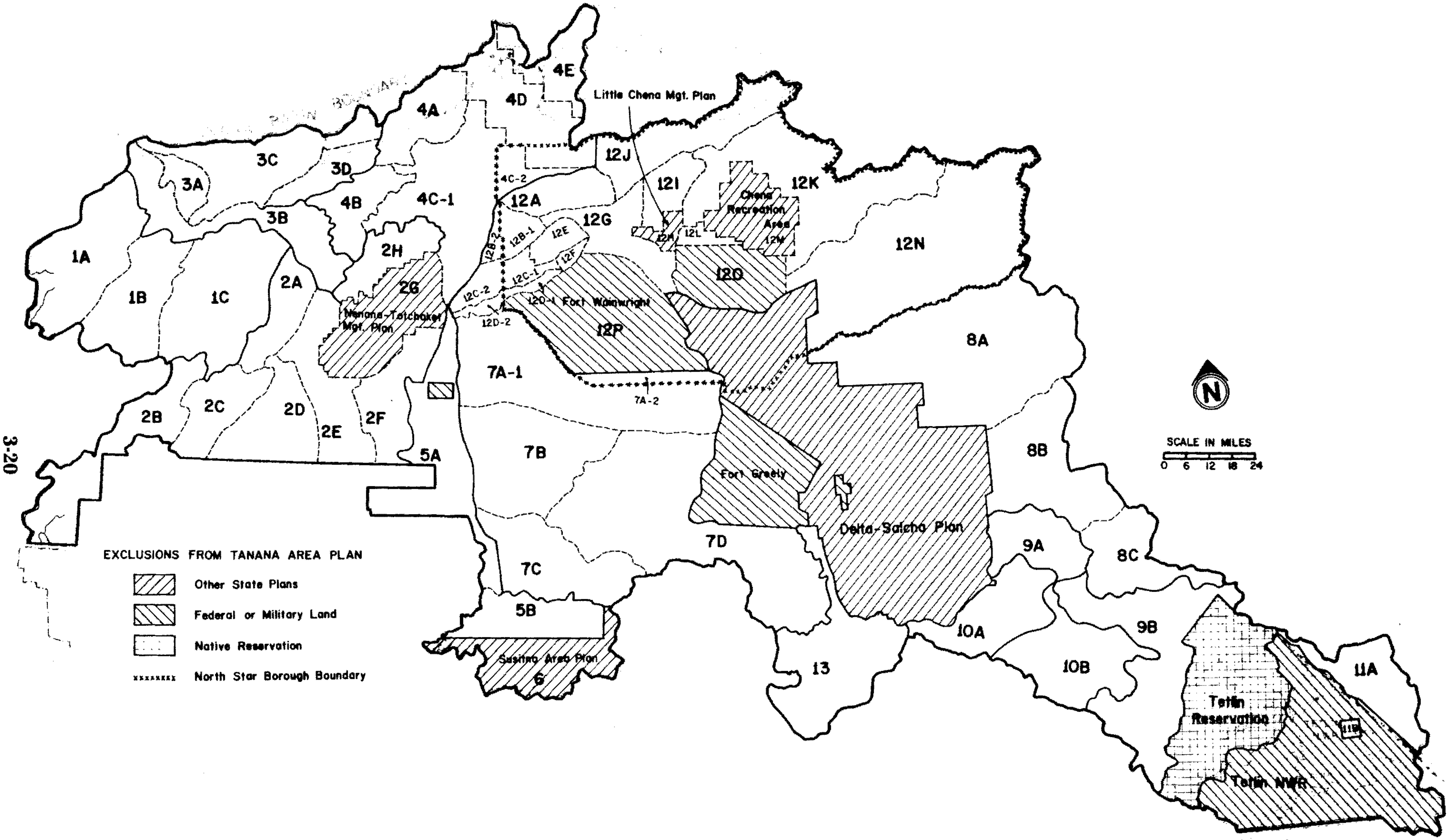
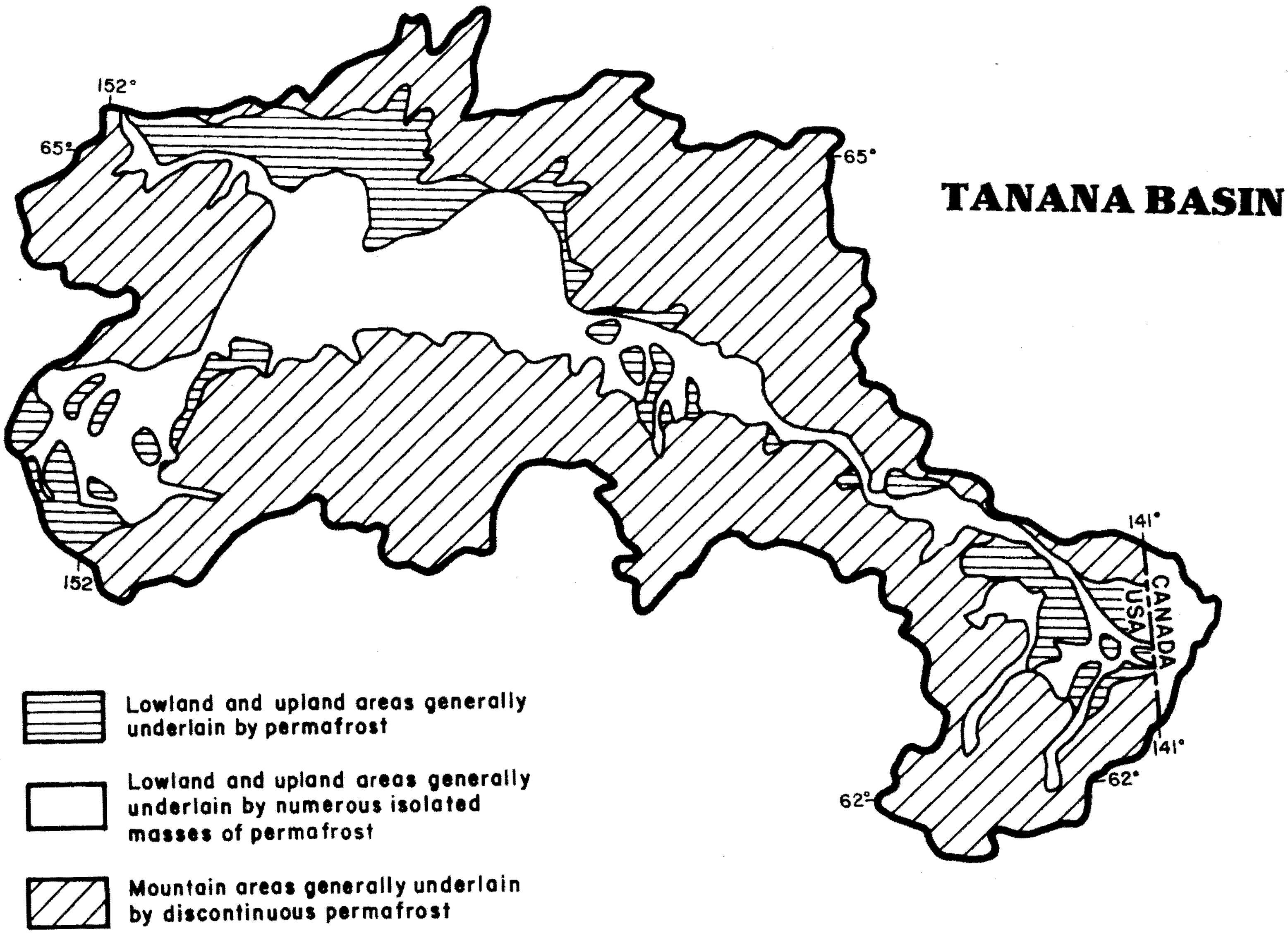


Figure 3-4. Management Units of the Tanana Basin Plan.



(After Ferrians, 1965)

Figure 3-5. Permafrost Areas in the Tanana Basin.

Large Unit 1

Large unit 1 includes the watersheds of the Chitinana River, Cosna River and Zitziana River and lies in the Kantishna River Quadrangle USGS 1:250,000. This area's topographic relief is generally dominated by low-lying swampy areas at approximatey +400 MSL (mean sea level) rising gently to +2000' MSL. The subsurface lithological description of this unit begins from the banks of the Kantishna River, west, toward the Zitziana. Dominant features here include dune fields and their associated eolian sand and silts. The approximate thickness of these dunes is estimated at 200' and assumed to be a poor to moderate ground-water source, generally free of permafrost. (Anderson, 1970).

From the Zitziana River, west, to the Cosna and Chitinana Rivers, surface and subsurface topography rises gently and is dominated by alluvium and colluvium (talus cliff debris) with high ice-content permafrost, low permeability and poor to moderate groundwater availability. Also, west of the Zitiana, sedimentary formations to +2000' are apparent. This rock unit, although associated with high surface runoff, low permeability and limited saturated thickness may be developed in areas with water-bearing fracture zones.

Large Unit 2

This unit's boundaries defined by the Tanana River to the north and the Nenana River to the east includes several small units, i.e., 2-A, 2-B, 2-C, etc. Following is a description of each "small" unit and its hydrogeologic scheme.

Small Unit 2-A

This area includes drainage to East Twin, West Twin and Kindanina Lakes. Although similar to areas described in large Unit I, close proximity to the Kantishna River flood plain alluvium and eolian deposits west would indicate that ground-water availability could vary and depths to which it can be reached may be significant. Overall availability is probably good.

Small Unit 2-B

The upper portions of the Kantishna River, including Wien Lake and Lake Minchumina depart only slightly from the above mentioned description. Here we see a more complex surficial geology. Some igneous and metamorphic features are apparent. Although poor in permeability, faulting and fracture zones may allow ground-water extraction. Topographic relief in this area range from ±500' MSL to approximately >2000' MSL.

Small Units 2-C, 2-D are quite similar in nature to the descriptions given for small unit 2-B.

Small Unit 2-E and 2-F

The Toklat River and the Teklanika River watersheds include a complex array of metamorphic, igneous and sedimentary bedrock. Also this area exhibits some glacial-morainal deposits. Ground-water extraction may be extremely difficult except near the alluvial flood plains. Elevations in this area range from ±400' to +2000' MSL.

Small Unit 2-H

North of the Nenana-Totchaket plan area includes eolian deposits and to a lesser degree colluvial and alluvial silt and sand. Generally low lying with a topographic relief of ±300' MSL to approximately ±600'. According to Anderson, (1970), ground-water availability within these map units are assumed to be poor.

Large Unit 3

This area encompasses the lower Tanana River drainage including Fish Lake in Small Unit 3-A and the lowland region south of the Tanana River in Small Unit 3-B. Small Unit 3-C includes the mining communities of Eureka and Tofty. According to Baldwin (1976), availability of ground-water ranges from less than 10 gpm to greater than 1000 gpm. Anderson, (1970) further details the area as having good flood plain alluvium, and sedimentary bedrock fracture zones. Elevations here range from a low of >600 MSL to 3000' above MSL.

Large Unit 4

Minto Flats and the Livengood area make up this unit. Small units include the Dugan Hills, Tolovana River, Tatalina River and Washington Creek watersheds. This area north of Minto is primarily alluvial silt and sand (Anderson, 1970) with its associated poor to moderate groundwater availability at depths less than 100'. These low terrace-type features grade to a more productive water-bearing alluvium near Minto. Further north, Livengood area is dominated by igneous, metamorphic and sedimentary bedrock units which allow ground-water extraction through fracture and fault zones. Poor to well-sorted silts, sand and peat with high ice content permafost is also present. Williams, (1970) indicates that water was produced from sand and fine gravel beneath 22-52' of frozen alluvium. This confined aquifer rose to within 12' of the land surface.

Large Unit 7

This unit includes the foothills and mountains of the Alaska Range. Basic rock type typify this area. Availability of water in gallons per minute is estimated to be approximately less than 10 in the higher elevations to 200 along the flatland (Balding, 1976).

Large Unit 8

The watersheds of the Goodpastor River, Healy River, George Creek, Sand Creek, Mansfield Creek, and Billy Creek have ground-water data available through their close proximity to the communities of Big Delta, and Delta Junction. This data can be obtained through the Northcentral District Office, Water Management Section and is not currently available for inclusion to this report. However, ground-water extraction from Big Delta and Delta Junction and along the Tanana River is indicated in Anderson, (1970) to be generally good. Subsurface conditions to the east, northeast of this area indicate poor water-bearing strata.

Large Unit 9

Areas here are near Tok and Tanacross. Again, along the flood-plain alluvium of the Tanana River, ground-water extraction is expected to be good. Undifferentiated alluvial, colluvial and/or eolian sand and silt (Anderson, 1970) is located near Tok Junction. Alluvial fans overburden the igneous and metamorphic bedrock further from the lowlands indicating poor to moderate ground-water sources. Records indicate that coarse to fine sandy gravel with lenses of silt and sand show that the water table in this area is between 53 to 70 feet below land surface (Williams, 1970).

Large Unit 10

This area delineates the Tok and Robertson watersheds. Good water bearing alluvial plains follow the rivers, igneous and metamorphic bedrocks should allow good surface drainage and recharge to these ground-water sources. (see figure 5).

Large Unit 11

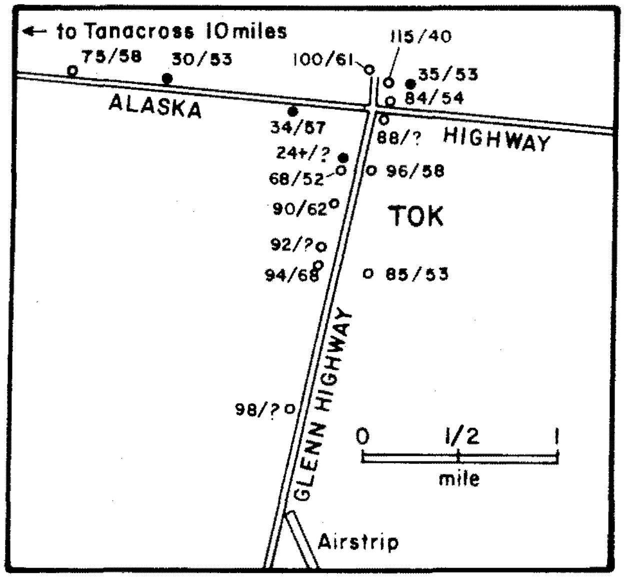
This area is a miscellaneous scattering of lands in the upper regions of the Basin.

Small Unit 11-A

Here we see a wide variety of lithology ranging from good water bearing alluvian in the floodplains to the less desirable formations offering poor capacities. Recharge to water-bearing formations due primarily to runoff's expected to be good.

Large Unit 12

This area is mostly the North Star Borough and is the most highly populated region in the Basin. In general, ground-water quantity and quality is a major concern here. Selected data indicate where availability is good, quality is poor. Wells developed in bedrock (schist) fracture zones offer moderate yields. Metamorphic domes in the area offer poor quality ground-water due to excessive mineral contents such as arsenic, iron, etc. This area has received much attention in recent years. The reader would be well advised to explore other sources of literature beyond the scope of this report.



WELL LOCATIONS IN THE TOK AREA, TANANA RIVER VALLEY

o 75/50 **Well in which frozen ground was not recorded**

Upper number is total depth; lower number is depth to water table if known, in feet.

• 40/50 **Well in which water occurs below the frozen layer**

Upper number is depth of base of frozen ground; lower number is depth to water table if known, in feet.

Figure 3-6.

Well Locations in the Tok Area, Tanana River Valley.

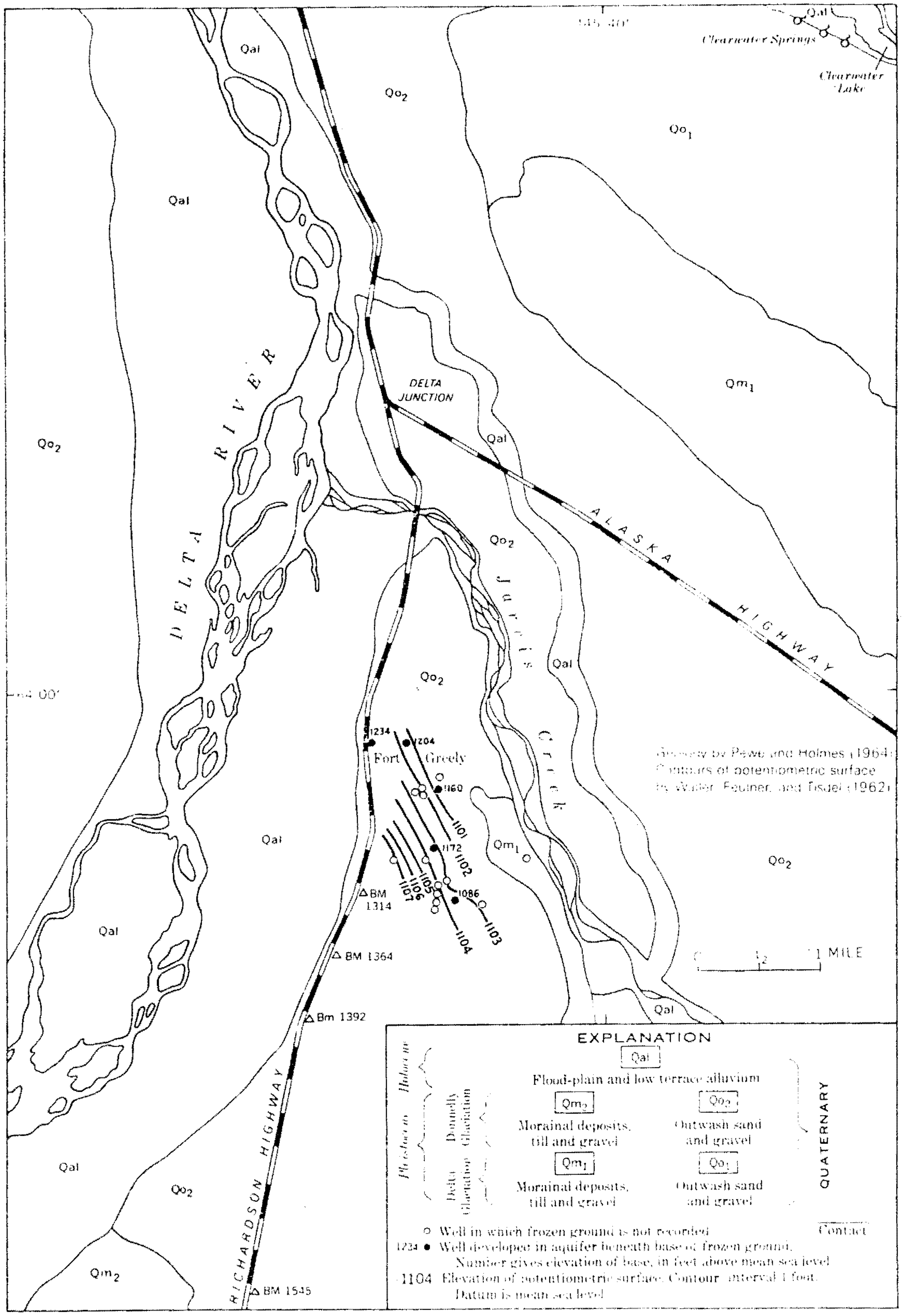


Figure 3-7.

Geology, slope of the potentiometric surface, and location of selected wells in the Fort Greely area.

Large Unit 13

This unit covers the Delta River watershed. Basically, this watershed is encompassed by three lithologic zones. At the confluence of the Delta-Tanana River are poor to well-sorted silts, sands and peat with high ice content and low ground-water yields (Anderson, 1970). Sedimentary bedrocks dominate the central portions of this watershed with permeability in fracture zones indicating poor to moderate yields giving way to well-consolidated igneous and metamorphics at the headwaters of the Delta River (see figures 3-6 & 3-9).

Conclusion

The Tanana Basin lies totally within the discontinuous permafrost regions of Alaska, in some cases this contributes to artesian and unconfined subsurface conditions (Hopkins, 1955) (Balding, 1970). Anderson (1970) mentions the general flow of ground-water as being parallel to surface flows, except where influent tributaries emerge from the Alaska Range, where we see water flowing away from the axis of the tributary. Ground-water is generally obtained in one of two circumstances, alluvial water bearing formations or bedrock aquifers (figure 3-8). Alluvial supplies may or may not occur either confined (artesian) by permafrost or silt/clay or unconfined in sands and gravels. Bedrock aquifers, where sufficient percolation occurs, yield poor to adequate supplies. A fracture trace mapping project is currently underway by the Institute of Water Resources, University of Alaska to determine possible ground-water trends in fracture zones. More detailed information from that organization should be forthcoming.

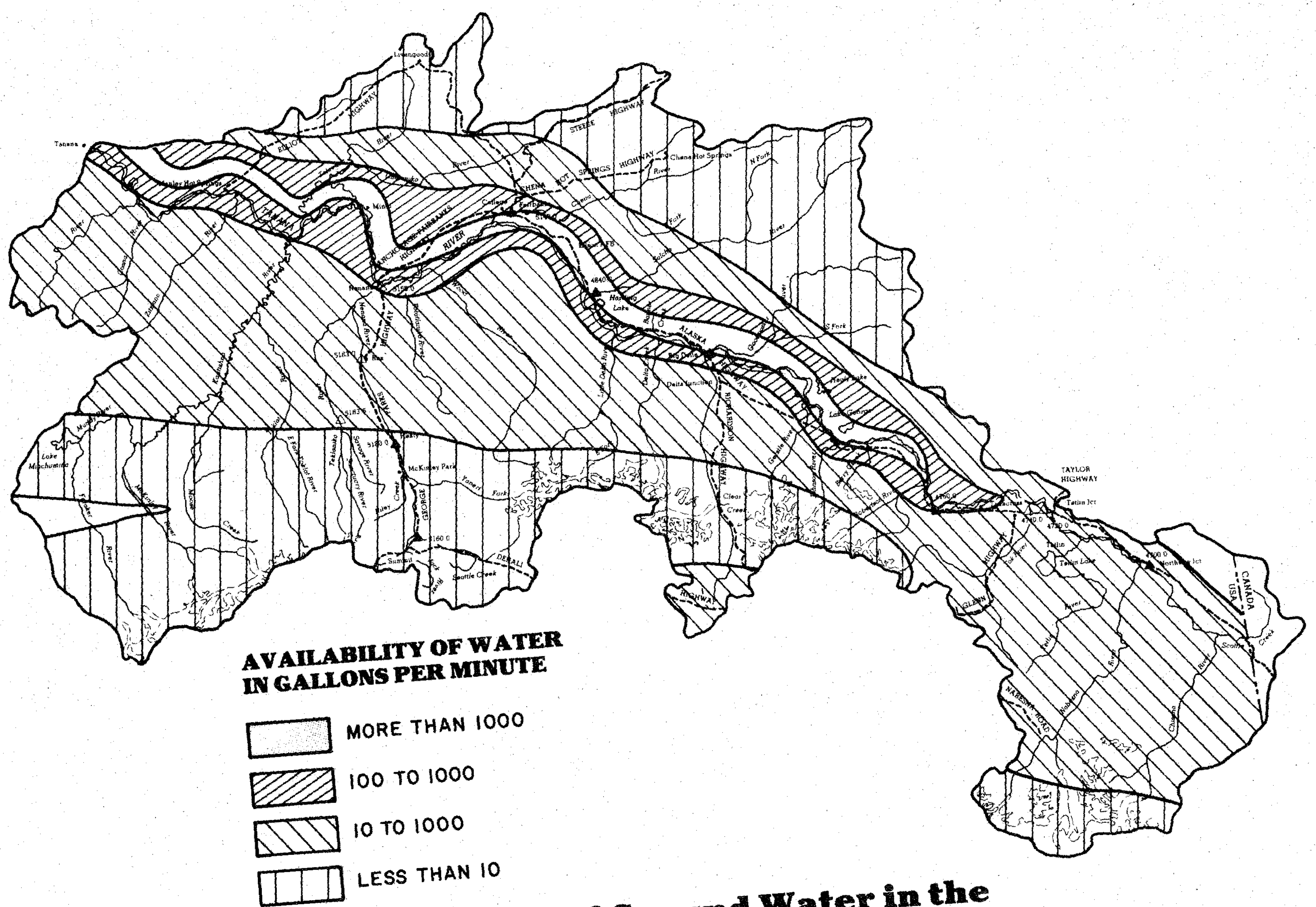


Figure 3-8. Availability of Ground Water in the Tanana Basin.

	ASSUMED WELL DEPTHS IN FEET TO IRRIGATE					
ELEVATION	40 acres	80 acres	120 acres	160 acres	240 acres	320 acres
1040 to 1090	50	75	75	100	125	150
1090 to 1140	75	75	100	100	125	150
1140 to 1190	100	100	125	125	150	175
1190 & Above	125	125	150	150	175	200

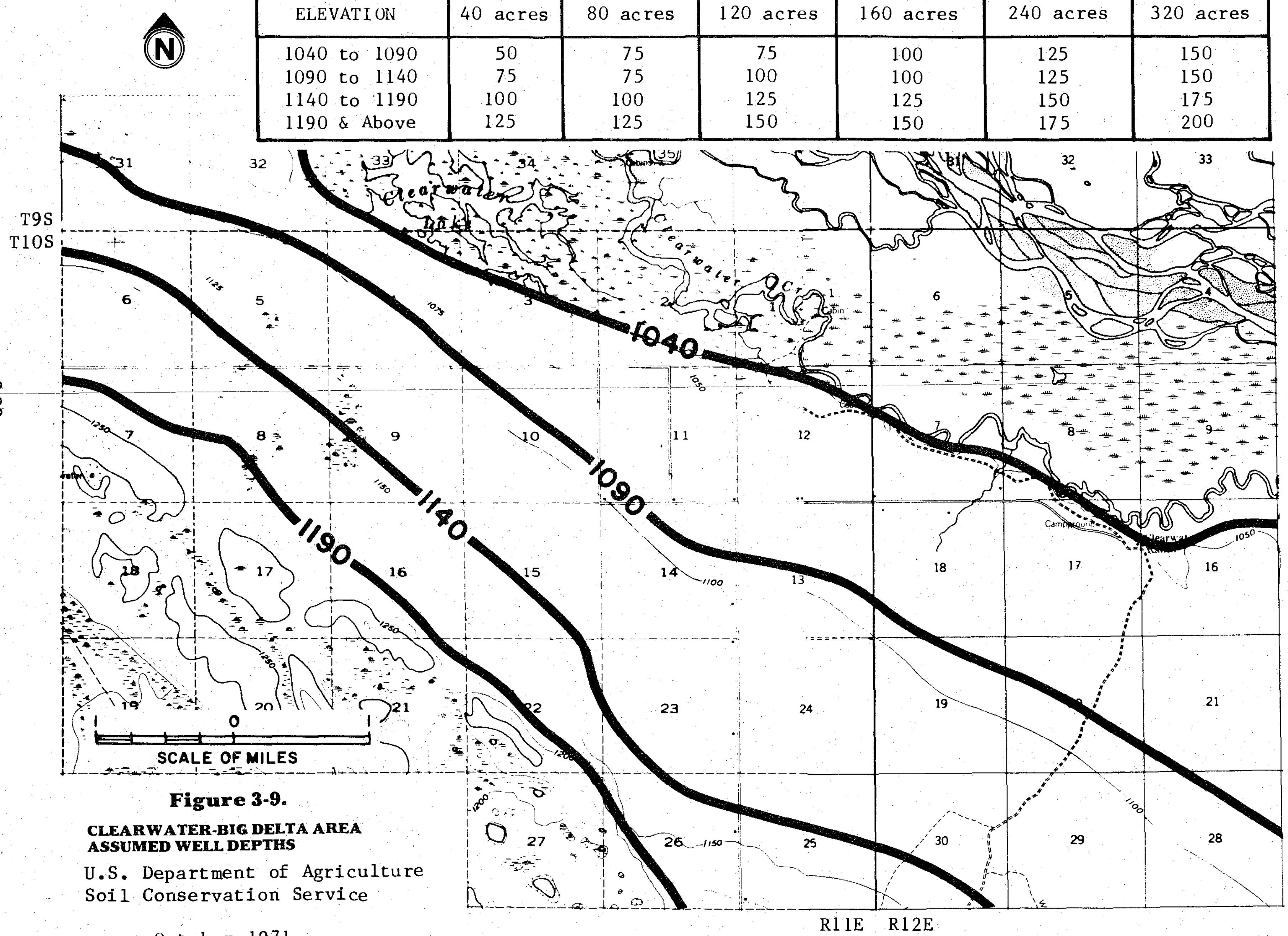


Figure 3-9.

CLEARWATER-BIG DELTA AREA ASSUMED WELL DEPTHS

U.S. Department of Agriculture
Soil Conservation Service

October 1971

C. WATER QUALITY

1. Surface Water Quality

Nearly all of the surface water tested in the Tanana River Basin is of acceptable chemical quality, ranging from 60 to 484 mg/l of dissolved solids with most less than 200 mg/l (AWSC, 1980). Principal constituents are calcium, magnesium and bicarbonate. Dissolved solids concentration is highest during periods of low flow from streams draining mineralized bedrock areas in the Alaska Range. Higher flows have lower dissolved solids concentration because the peak discharges are derived from rapid runoff or rain or snowmelt which is low in dissolved mineral matter, whereas the low flow has a high proportion of groundwater inflow.

Streams flowing from the Alaska Range are generally higher in sulfate and magnesium content than other streams, but none carry excessive amounts. Only iron has been found in undesirable amounts in surface waters and this was confined to two locations near the Canadian border. Hardness of lake water is generally less than that of streams. Water quality analysis of selected streams in the Tanana Basin is presented in Table 3-7. Table 3-8 shows the variability in water quality through the year at the Tanana River gaging station near Nenana.

Dissolved oxygen concentration in surface waters of the Tanana Basin has exhibited patterns common to most interior rivers. The dissolved oxygen concentration at any point is gradually depressed from near saturation in October to severe depletion in February or March. Also, the dissolved oxygen depletion usually becomes more severe when proceeding from the headwaters toward the mouth (Schallock & Lotspeich, 1974).

Sediment loads transported by streams have a direct effect on the cost and feasibility of water resources development. High sediment loads have to be considered in reservoir design. Treatment is necessary if the water is to be used for domestic supply. Sediment deposition in streams reduces channel capacity and increases the flood potential.

From just after breakup and throughout the short summer, meltwaters from glaciers add sediment load to the streams. Most of this suspended sediment from glacier-fed streams is "glacial flour", a very fine grayish particulate material. In glacier-fed streams such as the Nenana River bordering the entrance to Denali National Park and the Tanana River near Tanacross, sediment load is fairly well distributed throughout the summer. The Chena River receives sediment principally during the rainstorm runoff and spring snowmelt, which accounts for 50 percent of the annual load, and usually occurs in May. From limited data available, annual loads contributed to the Tanana River from non-glacial streams of the Yukon-Tanana Upland are inferred to be less than 150 tons per square mile. The streams draining the Alaska Range, of which the majority originate from glaciers, contribute loads ranging from 150 tons per square mile in the flat bottomland adjacent to the Tanana River to several thousand tons per square mile at the termini of the glaciers. Suspended sediment may be the least understood water quality characteristic and one of the most significant quality parameters from the standpoint of the overall quality of virgin fresh waters in the Tanana Basin.

The thermal aspects of water is an important consideration in the development of water supplies. The temperature of the water presents serious problems in the development, treatment, distribution, and use of water in the Basin.

Surface-water temperatures range from less than 32°F, to about 70°F during the year. Water temperatures below 32°F (supercooled) are common in surface water without ice cover and in some ground water in permafrost areas. The low temperature of ground and surface water requires a longer time for chemical reactions to reach equilibrium. In the design of water treatment systems, sufficient retention time must be allowed for the treatment process to reach completion. Also, use of surface water for waste disposal is adversely affected because the stream's natural ability for self-purification is reduced; many biological processes cease at temperatures near the freezing point. Records of river temperatures show rather uniform patterns of cooling by October to 32°F, or slightly below, remaining there until April, then warming to their seasonal highs in June and July.

Another water quality consideration peculiar to cold climate areas may be extended survival of pathogenic bacteria. In general, survival rate is higher at low temperature (winter conditions) than warm temperatures (summer conditions). Fecal coliform survival was 3 to 5 times greater than indicated by winter survival data from more temperate climates. Fecal coliform bacteria are used to indicate the possible presence of disease-causing bacteria originating from the human intestine, and are not in themselves harmful. However, pathogenic bacteria such as Salmonellae may survive longer than indicator bacteria at low temperatures. Implications here are for greater potential hazard to water users downstream of untreated sewage effluent, or for longer viability of pathogens in contaminated groundwater.

2. Ground Water Quality

Most ground water in the Tanana Basin can be characterized as calcium or magnesium bicarbonate. The quality of water ranges from very good to very poor with most municipal water requiring treatment, since iron content is often objectionable, and chloride and fluoride concentrations are low. Chemical quality of ground water reflects its geologic environment. Table 3-9 show water quality analyses for specific locations in the Tanana Basin. Hot springs in the Basin are probably connected with deep-seated sources that may account for high concentrations of sodium, chloride, bicarbonate, and magnesium. A few of the springs in the area have shallow groundwater sources and the type of water discharged from those springs is similar to most ground water in the area. (ARP, 1974)

Most wells in the uplands around Fairbanks yield water of suitable quality for drinking. However, wells that yield water polluted by arsenic and nitrate occur sporadically throughout the uplands. The high arsenic levels are a consequence of arsenic enrichment in the rocks of the area. Placer and lode-gold mining may increase the arsenic content of the waters by exposing arsenic-containing rocks to surface waters and by increasing the load of arsenic-rich sediments in the streams (Wilson and Hawkins, 1978).

Wells yielding water that contains objectionable odor are also not uncommon. No wells in the uplands are known to be polluted by bacteria from septic tank effluent. The considerable depth to the water table (30 to 300 feet, or more) and good filtering capacities of the silt and some types of decomposed bedrock cause the area to have low pollution susceptibility.

Water from most sources on the floodplain requires treatment to make it potable. Ground water may require treatment for bacteria, iron, manganese or odor. Some high quality ground water requiring no treatment may be available where the aquifer is oxygenated, generally near a source of recharge (Nelson, 1978).

Table 3-7 — WATER QUALITY OF SELECTED STREAMS IN THE TANANA BASIN [concentrations in milligrams per litre (mg/1) or micrograms per litre (ug/1)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific Conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved Solids	Total Hardness		
15470000 Chisana River at Northway																	
04-08-59 --	14	20(a)	10(a)	46	9.3	6.0	2.6	158	0	27	3.0	0.1	--	194	153	319	6.5
08-23-72 6,490	6.9	140(b)	0(b)	28	4.7	4.3	1.2	99	0	18	1.9	.0	0.02	114	89	197	7.1
15514000 Chena River at Fairbanks																	
08-06-69 10,200	6.4	2,700(a)	750(a)	12	2.3	1.1	2.1	30	0	10	.7	.1	.27	54	40	83	7.0
03-03-70 182	23	3,200(a)	820(a)	36	7.6	4.9	2.8	140	0	13	2.1	.2	.52	165	119	252	6.6
15515500 Tanana River at Nenana																	
01-25-74 4,740	19	--	--	54	10	4.8	2.9	173	0	33	2.4	.2	.30	212	180	310	7.5
05-23-74 34,300	7.4	--	--	24	5.0	2.7	1.9	72	0	34	2.5	.3	.10	113	81	155	7.2
15518000 Nenana River near Healy																	
02-16-59 497	8.2	0(a)	0(a)	36	10	5.6	2.6	102	0	51	5.0	.0	.11	169	131	282	7.0
05-24-68 8,750	4.0	550(a)	--	18	3.6	2.7	1.4	57	0	14	1.1	.2	.09	74	60	123	7.0

a Undifferentiated
b Dissolved

Table 3-8
SELECTED WATER QUALITY DATA, TANANA RIVER AT NENANA, WATER YEAR OCTOBER 1980 to SEPTEMBER 1981

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN DIS-SOLVED (MG/L)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREP TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARD-NESS (MG/L AS CACO3)	HARD-NESS NONCAR-BONATE (MG/L CACO3)
JAN											
21...	1510	6870	300	7.4	.0	1.3	8.3	<1	<1	150	27
MAR											
19...	1300	7590	325	6.8	.0	3.8	9.1	<1	<1	150	27
JUL											
15...	1400	77600	195	7.6	13.3	880	9.4	K49	<2	100	—
SEP											
17...	1300	24200	251	7.4	7.0	66	11.9	K18	K18	120	30

DATE	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGN-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE DIS-SOLVED (MG/L AS F)	SILICIA DIS-SOLVED (MG/L AS SIO2)	SOLIDS RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
JAN										
21...	44	9.0	5.0	2.1	150	32	1.2	.1	15	179
MAR										
19...	44	8.9	4.4	2.3	120	30	1.1	.1	15	175
JUL										
15...	30	6.1	2.0	2.3	—	43	.8	.1	6.7	125

Table 3-8 (cont'd)
SELECTED WATER QUALITY DATA, TANANA RIVER AT NENANA, WATER YEAR OCTOBER 1980 to SEPTEMBER 1981

DATE	NITRO-GEN, TOTAL (MG/L AS N)	CARBON ORGANIC TOTAL (MG/L AS C)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT DIS-CHARGE SUS-PENDED (T/DAY)
JAN				
21...	.62	4.9	15	278
MAR				
19...	.44	1.7	4	82
JUL				
15...	1.1	—	2770	580000
SEP				
17...	1.0	—	351	22900

DATE	TIME	ARSENIC TOTAL (UG/L AS AS)	BARIUM TOTAL RECOV-ERABLE (UG/L AS BA)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CHRO-MIUM TOTAL RECOV-ERABLE (UG/L AS CR)	IRON TOTAL RECOV-ERABLE (UG/L AS FE)	LEAD TOTAL RECOV-ERABLE (UG/L AS PB)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)
JUL								
15...	1400	35	600	1	70	69000	48	.3
SEP								
17...	1300	4	200	1	10	9600	150	.1

Table 3-9 — CHEMICAL ANALYSES OF GROUND WATER IN THE TANANA BASIN (concentrations in milligrams per litre (mg/1) or micrograms per litre (ug/1)

				mg/l	ug/l		mg/l													
Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved Solids	Total Hardness	Specific Conductance (umhos/cm at 25°C)	pH Units
WELLS																				
Manley Hot Springs	03-06-72	140	--	21	47,000(a)	960(a)	57	12	4.2	2.6	239	0	0.4	1.0	0.3	0.02	218	190	364	6.9
Minto	12----61	40	--	24	100(b)	1,200(b)	87	26	5.2	4.8	418	--	.0	1.0	.2	.07	355	325	599	7.3
McKinley	04-04-63	186	--	4.6	20(b)	0(b)	44	56	3.7	2.0	370	--	34	1.0	.1	.27	329	338	583	8.0
Minchumina	12-11-59	210	--	7.8	100(b)	460(b)	21	11	6.0	.7	106	0	20	2.0	.2	.05	121	98	207	7.0
Cantwell	07-02-68	--	3.0	6.0	1,200(b)	--	26	3.8	3.1	.5	52	0	43	3.0	.2	.02	110	80	191	7.6
Aurora	11-14-60	--	--	8.1	--	--	83	17	6.9	4.2	330	0	11	10	.3	.05	312	278	530	7.4
Fairbanks	12-15-70	--	--	23	40(a)	460(a)	43	12	4.6	3.1	194	0	11	.2	.4	.00	192	157	324	7.6
Delta Junction	07-21-65	150	--	6.1	20(b)	--	35	7.4	3.1	3.5	102	0	43	1.4	.1	.09	150	118	247	8.0
Tok	03-14-72	--	--	1.9	--	--	2.4	2.0	4.9	.2	20	0	9.2	.7	.0	.05	31	14	59	7.3
Tanacross	09-08-71	50	--	15	--	--	64	11	4.6	2.0	178	0	60	4.2	.2	.23	250	204	395	7.9
Tetlin	------69	--	--	31	--	--	42	8.7	7.2	2.2	194	0	.0	.0	.2	.00	188	141	286	7.4
Northway	09-02-71	95	--	28	1,800(a)	1,600(a)	49	11	30	2.3	223	0	.8	36	.5	.02	268	168	435	7.8
SPRINGS																				
Manley	01-14-70	--	--	54	--	--	8.2	.4	120	5.3	82	0	38	120	6.3	.11	393	22	623	7.8
Hutlinana	--	--	--	40	--	--	20	6.6	180	7.9	488	--	55	40	.8	--	--	--	--	7.7
Tolovana	--	--	--	75	--	--	82	1.2	321	23	49	--	40	615	.2	--	--	--	--	7.7
Chena	--	--	--	85	--	--	1.3	.1	110	3.3	115	--	68	29	19	--	--	--	--	9.1
Fox	09-30-66	--	36	11	--	--	40	23	6.5	3.7	200	0	41	.7	.2	.11	224	196	543	7.1

a Total
b Undifferentiated

Chapter 4

Water Use in the Tanana Basin

IV. WATER USE

A. Water Rights

Table 4-1 displays water rights on record as of December 1982 aggregated by Tanana Basin Plan small management unit and separated into water use categories: domestic, placer mining, agricultural livestock, agricultural irrigation and other. Domestic water use includes individual homes, community water supply, apartments, motels, hotels and other similar uses. Placer mining is limited to just that; it does not include lode mining. Agricultural livestock includes water use needed for production or maintenance of livestock. Agricultural irrigation is water use needed for the irrigation of crops and does not usually include garden use. Water uses in the other category included lode mining, small hydroelectric, commercial and industrial uses.

Different uses are characterized by different units of measurement because of the requirements of the particular water use. Placer mining generally requires a high continuous rate of flow through a sluicebox, thus cubic feet per second (cfs) is used. Gallons per minute (gpm) is also often used by practitioners. With agricultural irrigation the farmer will often have an estimate of the volume of water a crop will need over a season but will not need a rate of flow nor know exact times to irrigate in advance, thus acre feet (one acre of water one foot deep) per year is used. For smaller uses such as individual homes gallons per day is a convenient unit. For comparision purposes one cubic foot per second equals 448 gallons per minute which equals 724 acre feet per year which equals 646,000 gallons per day over the same time period. Placer mining and irrigation are seasonal uses,thus, for example, a miner using 1 cfs will need that only from June until September while a farmer irrigating with one acre foot per year will use all of his water during the growing season. Also, a miner using 1 cfs will need that rate of flow only during his hours of operation. If the hypothetical miner above was operating for 12 hours a day his daily water use would be 323,000 gallons.

Another consideration is consumptive use. Miners use a large rate of flow but most operations return almost all of that directly to the stream (although hopefully through a settling pond first). Irrigation consumptively uses water either by the plant in growth, transpiration by the plant, evaporation and percolation into the ground. Individual homes on wells return most water to the ground-water system through the septic system, although that takes time.

Water rights are acquired only through application to the Department of Natural Resources. Therefore those water uses that have not been applied for are not on record and do not appear in Table 4-1. Table 4-1 cannot be used to determine actual water use but is an indication of the relative use of water in the management units of the Tanana Basin.

Domestic Water Use. Not suprisingly, domestic water use on record closely follows the settlement pattern in the basin. The Fairbanks area has the most use and users. Actual domestic water use is under-represented by water rights. The national average of water use per person (in fully plumbed houses) is approximatley 90 gallons per day per capita for domestic use. If this figure is applied to the Tanana Basin 1980 population of 61,000 the domestic water use should be around 5.5 million gallons per day (MGD). Water rights on record for domestic use total only 709,000 gallons per day.

It is interesting to note that even at the larger amount, 5.5 MGD, domestic water use basin-wide is equivalent to 8.5 cfs. This is small compared to water availabilty (the Tanana River at Fairbanks average annual flow is 18,810 cfs) and less than placer mining water use on many individual streams. However, even though domestic use is relatively small compared to total basin-wide water availability, because many domestic supplies are wells tapping marginal aquifers. Domestic water supply, in rapidly developing upland areas, is one of the basin's major water problems.

Placer Mining. Placer mining is the largest out of stream uses of water in the basin. Table 4-1 shows that placer mining is well-distributed throughout the basin, although the greatest concentration is in the lower part of the basin. In terms of quantity placer mining is a nonconsumptive use of water, that is, most water is returned to the stream. This means that, for example, ten miners each using 2 cfs could conceivably be operating at the same time on a stream having a total flow of 5 cfs.

Agricultural Livestock and Irrigation. These water uses reflect settled areas and agricultural project lands. Unlike other water uses, irrigation water rights on record are greater than present actual use. The Delta Plan management unit which includes the Delta area agricultural project lands have water right requests of 28,464 acre feet per year yet that amount of water is not being used for irrigation currently. This amount is an indication of how much water may be used if irrigated agriculture becomes common on the agricultural lands in the basin. Estimates of water use for irrigation water use in interior Alaska range from 0.5 - 1.0 acre feet per year per acre of irrigated land.

Instream Flow. Table 4-1 only reflects water rights for out-of-stream uses. Until recently Alaska law only had provisions for water rights for out-of-stream uses of water. In 1980 that was changed to allow water rights for instream use for purposes of maintenance of fish and wildlife habitat, recreational use, water quality and navigation. Procedures for including those types of uses into the water rights system have not been adopted yet, thus no instream flow requests have been received or adjudicated. Water bodies that might be appropriate for instream flow reservations would be those with population of anadromous fish and other high quality sport fish populations, those water bodies heavily used for recreation and those where water quality is a concern.

Federal Reserved Water Rights. Federal reserved water rights are created when federal lands are withdrawn from entry (by Congress or other lawful means). Simultaneous with the land withdrawal, implicitly or explicitly, sufficient water is withdrawn to accomplish the intent of the land withdrawal. Federal reserved water rights may be created without a diversion or application to beneficial use, are not lost by nonuse, and priority dates from time of land withdrawal. No application nor notification to the state is necessary for creation. The measure of the right is the amount of water reasonably necessary to satisfy the purposes of the land withdrawal (Curran and Dwight, 1979).

Federal reserved water rights may only be quantified in a court-administered basin-wide adjudication pursuant to the McCarran Amendment (43 USCA 666(a)). This requirement plus the vague "reasonably necessary" definition for the amount of the reserved right make quantification difficult. No federal reserved water rights in Alaska have been quantified. Federal withdrawals in the Tanana Basin that might have federal reserved rights attached to them include Eielson Air Force Base, Forts Greely and Wainwright, Denali National Park and Preserve, Wrangell-Saint Elias National Park and Preserve, Tetlin National Wildlife Refuge and the wild and scenic river portion of the Delta River. Much of the land described above, while within the drainage basin of the Tanana River, are not included within the Tanana Basin Plan boundaries.

Table 4-1 WATER RIGHTS IN THE TANANA BASIN

Management Unit	Domestic # of Users	Domestic Amount	Placer Mining # of Users	Placer Mining Amount	Ag Livestock # of Users	Ag Livestock Amount	Ag Irrigation # of Users	Ag Irrigation Amount	Other # of Users	Other Amount
Chitanana, Cosna, Zitziana Rivers										
1A	–	–	–	–	–	–	–	–	–	–
1B	–	–	1	5.0 cfs	–	–	–	–	–	–
1C	–	–	1	0.14 cfs	–	–	–	–	–	–
Kantishna, Teklanika Rivers										
2B	1	436 GPD	–	–	–	–	1	2.0 AFY	–	–
2C	–	–	–	–	–	–	–	–	–	–
2D	–	–	–	–	–	–	–	–	–	–
2E	–	–	–	–	–	–	–	–	–	–
2F	–	–	–	–	–	–	–	–	–	–
2G	3	1010 GPD	–	–	–	–	–	–	3	194,300 GPD
2H	–	–	–	–	–	–	–	–	–	–
Lower Tanana River										
3A	–	–	–	–	–	–	–	–	–	–
3B	–	–	–	–	–	–	–	–	–	–
3C	6	1325 GPD	61	206.7 cfs	4	147 GPD	1	0 AFY	–	–
3D	2	5600 GPD	–	–	–	–	–	–	1	5,000 GPD

Management Unit	Domestic # of Users	Domestic Amount	Placer Mining # of Users	Placer Mining Amount	Ag Livestock # of Users	Ag Livestock Amount	Ag Irrigation # of Users	Ag Irrigation Amount	Other # of Users	Other Amount
Tolovana, Talalina Rivers										
4A	–	–	–	–	–	–	–	–	2	25,000 GPD
4B	–	–	–	–	–	–	–	–	–	–
Tolovana, Talalina Rivers										
4C-1	–	–	–	–	–	–	–	–	–	–
4C-2	–	–	–	–	–	–	–	–	–	–
4D	2	325 GPD	13	47.2 cfs	2	200 GPD	1	1 AFY	2	495,000 GPD
4E	–	–	6	15.1 cfs	–	–	–	–	–	–
Nenana River										
5A	33	22,645 GPD	7	31.9 cfs	7	130 GPD	9	12.7 AFY	8	1,160,500 GPD
5B	2	1250 GPD	–	–	1	0 GPD	2	500 GPD	5	12,660 GPD
5C	4	1600 GPD	2	9.1 cfs	1	0.0 GPD	3	1 AFY	4	6,300 GPD
Susitna River										
6	–	–	–	–	–	–	–	–	–	–
Tatlanika, Wood, Little Delta Rivers, Clear Creek										
7A-1	4	3100 GPD	–	–	1	0 given	4	1 AFY	–	–
7A-2	–	–	–	–	–	–	–	–	–	–
7B	–	–	30	69.0 cfs	–	–	–	–	–	–
7C	–	–	–	–	–	–	–	–	–	–
7D	1	450 GPD	5	0.33 cfs	–	–	–	–	–	–

Management Unit	Domestic # of Users	Domestic Amount	Placer Mining # of Users	Placer Mining Amount	Ag Livestock # of Users	Ag Livestock Amount	Ag Irrigation # of Users	Ag Irrigation Amount	Other # of Users	Other Amount
Shaw Creek, Goodpastor River										
8A	–	–	–	–	–	–	–	–	–	–
8B	–	–	–	–	–	–	–	–	–	–
8C	–	–	–	–	–	–	–	–	–	–
Upper Tanana River										
9A	2	575 GPD	1	6,000 GPD	1	175 GPD	1	1.0 AFY	2	6,000 GPD
9B	11	15,000 GPD	–	–	–	–	1	.01 AFY	16	2,035,700 GPD
Robertson, Tok Rivers										
10A	–	–	–	–	–	–	–	–	–	–
10B	–	–	–	–	–	–	–	–	–	–
11A	–	–	–	–	–	–	–	–	–	–
Fairbanks North Star Borough, Chena, Chatanika, Salcha Rivers, Goldstream Creek										
12A	11	22,777 GPD	10	20.0 cfs	1	15 GPD	–	–	–	–
12B-1	–	–	–	–	1	18 GPD	1	0.5 AFY	–	–
12C-1	–	–	–	–	–	–	1	30.0 AFY	1	1500 GPD
12C-2	2	700 GPD	–	–	–	–	1	10 AFY	–	–
12D-1	6	3,120 GPD	–	–	1	680 GPD	2	1 AFY	–	–
12D-2	–	–	–	–	–	–	–	–	–	–
12E	90	56,120 GPD	10	6.0 cfs	7	568 GPD	27	17.5 AFY	2	6,965 GPD

Management Unit	Domestic # of Users	Domestic Amount	Placer Mining # of Users	Placer Mining Amount	Ag Livestock # of Users	Ag Livestock Amount	Ag Irrigation # of Users	Ag Irrigation Amount	Other # of Users	Other Amount
Fairbanks North Star Borough, Chena, Chatanika, Salcha River, Goldstream Creek										
12F	–	–	–	–	–	–	–	–	–	–
12G	409	405,655 GPD	32	61.4 cfs	49	122,483 GPD	132	141.2 AFY	14	12,642 GPD
12H	31	17,710 GPD	3	6 cfs	13	4,692 GPD	13	12.3 AFY	–	–
12I	1	130 GPD	16	56.4 cfs	–	–	–	–	–	–
12J	5	31,500 GPD	45	118.9 cfs	–	–	2	unknown	4	4,300 GPD
12K	2	1,075 GPD	4	30.8 cfs	–	–	–	–	–	–
12L	17	8,090 GPD	–	–	14	4,581 GPD	10	63.7 AFY	8	15,890 GPD
12M	–	–	–	–	–	–	–	–	3	6,300 GPD
12N	–	–	5	14 cfs	–	–	–	–	–	–
12O	–	–	–	–	–	–	–	–	4	375 GPD
12P	8	5,580 GPD	–	–	3	296 GPD	6	31.8 AFY	–	–
Upper Delta River										
13	4	2,000 GPD	2	0.1 cfs	–	–	–	–	4	114,000 GPD
Tetlin	–	–	–	–	–	–	–	–	2	11,000 GPD
Tetlin NWR	1	500 GPD	–	–	–	–	–	–	3	12,000 GPD
Clear	–	–	–	–	–	–	–	–	4	12,600 GPD
Delta Plan	126	100,790 GPD	14	32.9 cfs	63	7,115,352 GPD	42	28,464 AFY	27	243,137 GPD
Susitna	–	–	1	2.5 cfs	–	–	–	–	1	775 GPD

B. Community Water Supplies

Most of the water used in the Tanana Basin for municipal, industrial, military and domestic supplies is ground water from wells. Water use for those uses in the basin is estimated at 11 to 12 million gallons per day (mgd). About 7.5 to eight mgd of this are used by military, two to three mgd are used by the City of Fairbanks and the remainder is used by smaller communities throughout the area (Alaska Regional Profiles, 1974).

Development of surface water for potable water supplies in the basin has been limited although extensive sources are available. Ground water is often high in iron and organic content and usually requires treatment. The procurement, treatment, and distribution of water supplies as well as the disposal of waste are hindered by low air, ground and water temperatures in the Tanana Basin.

Ground water is generally available in areas free of permafrost. Yields in excess of 50 gallons per minute (gpm) and in some areas more than 1000 gpm can be expected from unconsolidated materials. The largest reported yield is 5,000 gpm from a 130-foot well at Eielson Air Force Base (AWSC, 1980).

Water supplies and waste disposal systems in the Tanana Basin require engineering that considers the extremely low temperatures and the presence of permafrost. For example, the City of Fairbanks, completed a ground water supply and distribution system in 1953. Water having a temperture of 38°F is pumped from wells and is used to cool condensers at the city power plant, where it is warmed to 56°F or higher before being treated and fed into the distribution system (Alaska Water Study Committee, 1980). In addition, water is kept circulating in cold months through a "single main-loop system" which has no deadends.

There appears to be few limitations, to the quantity of available groundwater for municipal supply in Fairbanks (AWSC, 1980). Wells now in place (which were originally installed for power plant use) can draw ten times the volume of water that is needed for municipal supply. Daily use average for 1979 was 2.57 million gallons per day with higher use in the summer and lower use in the winter. The treatment plant capacity has been rated at 3.5 million gallons per day, but on occasion 4.5 million gallons per day have been processed with no problem (Alaska Water Study committee, 1980). Improvements to increase treatment capacity to 8 million gallons per day are being considered by the Fairbanks unility system (Shirley, 1983).

Table 4-2 is a summary of community water supply and treatment systems in the Tanana Basin.

Table 4-2 COMMUNITY WATER SUPPLY AND TREATMENT SYSTEMS IN THE TANANA BASIN

TOWN	POPULATION	NUMBER OF HOMES	WATER SUPPLY	ADEQUACY OF WATER SUPPLY	TYPE OF SEWAGE SYSTEM	PLANNED IMPROVEMENTS
Anderson	390	120	300 wells in village ranging in depth from 8' to 30'/Nenana River also used.	Untreated sources of supply/good drinking water/year Fe. 17 ppm/ Cl 1.3 ppm/TDS 179 ppm/ hardness 148 ppm.	Individual septic tanks/seepage pits.	None.
Delta Junction	945	348	Wells	No treatment.	Untreated to river.	------------
Dot Lake	83	16	PHS well/utilidor/ piped service to the homes/CL/FL/Homes heated off the same system/laundry and shower facilities in pumphouse.	Excellent quality and quantity—no iron removal needed/water obtained at pumphouse because of leakage in lines/CL/FL disconnected.	Individual septic tanks/drain fields.	None in the immediate future.
Fairbanks	22,645	8,145	Municipal	Ample quantity Cl, Fl, ph water softening.	Primary and secondary.	Pumping capacity may be increased to creased to facilitate water supply for fire fighting/ reservoir capacity may be expanded/out dated woodstave pipe in the down-town area will be replaced.
Healy	79	21	Haul from nearby lake/ 7 acre reservoir and earth dam/on stream/ water distribution system to all homes.	No treatment.	Collection system with concrete septic tank and outfall to Nenana River/serves entire community.	None.
Livengood	50	---	Hauled.	No treatment.	Privies, unknown.	------------

TOWN	POPULATION	NUMBER OF HOMES	ADEQUACY OF WATER SUPPLY	WATER SUPPLY	TYPE OF SEWAGE SYSTEM	PLANNED IMPROVEMENTS
Manley Hot Springs	77	27	4 individual wells/ most haul from watering point at hot springs.	Well water is highly highly mineralized/springs are of good quality and preferred by residents.	privies/septic tanks/cesspool/4 flush toilets.	None.
Minto	190	45	New PHS well/piped, insultated distribution system to all homes and institutions/FL.	Good quality drinking water/Fe .4 ppm/TDS 225 ppm/Hardness 272 ppm/ operates only as a watering point.	2 cell faculative lagoon discharges to marshy areas by seepage.	50 units of HUD housing proposed in 1982 PHS improvements to follow if funds available/ state funds available for feasibility study in 1982.
North Pole	724	249	Wells.	Good quality and quantity/Fe treatment necessary.	Primary and secondary.	---------------
Northway	143	20	Well/village corporation central facility/ bathing/restroom/laundry watering point.	Good quality drinking water/Fe 1.8 ppm/TDS 268 ppm/Hardness 168 ppm/Wells produce an abundant supply of water.	Honey buckets/ Privies/Drainfield/ Septic tank.	None.
Nenana	486	128	PHS well adjacent to River/Green sand filters/FL/CL/500,000 gal. storage tank/ Buried pipe service to homes.	After treatment: Fe .25 ppm/Hardness 200 ppm/well yield 55 gpm.	PHS rotating biological disc treatment plant/outfall to river/3 lift stations.	None.
Tanacross	90	28	PHS 50' well/24,000 gallon woodstave storage tank/recirculating system/buried pipe service to the homes/CL/FL/ Washerteria.	Good quality, good quantity drinking water/year round supply.	5-2,000 gallon community septic tanks and drain fields.	None.

TOWN	POPULATION	NUMBER OF HOMES	WATER SUPPLY	ADEQUACY OF WATER SUPPLY	TYPE OF SEWAGE SYSTEM	PLANNED IMPROVEMENTS
Tanana	447	76	VSW facility provides watering point/washer-teria/laundromat/source of supply is well/sub-division served by PHS well.	Good quality/water supply year round/low in Fe/ available at 2-3 wells located along banks of Yukon River/Quantity of water limited in winter.	Privies/few septic tanks/cesspools noted sewer line available for hookup to 15 homes/ VSW facility effluent to aerated lagoon/leak in outfall line needs repair short circuiting system.	None.
Tetlin	85	32	PHS central facility/ 56' well/watering point/CL/Laundry/Bath-ing/Hydropneumatic system.	Facility froze up/pre-sently using watering point only/CL not in use/ FE .1 ppm/TDS 184 ppm/ Hardness 214 ppm.	Pit toilets/seepage pits for sink wastes.	None.
Tok	709	270	250 individual wells in residences ranging in depth from 90' to 125'.	Generally good quality and quantity water but untreated sources of supply FE 0.2 ppm/Cl 1.3 ppm/Hardness 199 ppm/TDS 238 ppm.	Individual septic tanks/drain fields/ cesspools/privies.	None

Definitions:

1. CL - Chlorine treatment.
2. Fe - Iron treated.
3. Fl - Fluoride treatment.
4. Hydropneumatic system - Pressure tank system.
5. PHS well - A well installed by or meets standards established by the United States Public Health Service.
6. Primary Sewer System - Essentually a filtering, settling, and disinfecting process.
7. Privy - An outhouse.
8. Secondary Sewer System - Involves further settling and biological decompositon.
9. TDS - Total dissolved solids.
10. Tertiary Sewer System - Utilizes complex methods to remove dissovled nutrients which can result in a pure effuent.
11. Utilidor - A variety of passageways and storage areas to house water and sewer lines and similar facilities.
12. VSW Facility - A facility which meets the standards according to DEC similar to PHS).
13. Washerteria - A laundromat-type facility; some of which supply showers.
14. Woodstave pipe - Wood constructed sewer lines.

Sources: Alaska Department of Environmental Conservation (DEC), 1982
Alaska Water Study Committee, 1980
Alaska Department of Labor, 1981.

C. Hydroelectric Power

Electric power provided to Tanana Basin communities is presently generated, for the most part, by diesel and coal fired generators. The rising costs of fuel, especially diesel, environmental concerns, the idea of using a renewable resource and the idea of self sufficiency have tended to make the hydroelectric power alternative attractive as a source of power (Ebasco Services, Inc. (ESI), 1982, U.S. Department of Energy (DOE), 1979). Hydroelectric power facilities are generally broken down into three size categories: large, small, and micro. For this report the large category applies to facilities generating more than 5 megawatts; small, 5 megawatts to 100 kilowatts; micro, less than 100 kilowatts. Large hydropower facilities would provide electricity on a regional basis or to a large city, small hydropower would be for a small community and micro hydropower for individual home consumption.

Table 4-3 shows sites in the Tanana Basin that have been investigated in the past for large scale hydropower (ARP 1974). None of these sites are currently being seriously considered for construction.

Small hydropower feasibility in the Tanana Basin was examined as part of a study of small hydroelectric feasibility of 25 northeast Alaska villages (ESI 1982). Table 4-4 shows proven system information for the sites initially investigated in the Tanana Basin. Table 4-5 shows summary information for those sites warranting more detailed investigation. As can be seen from the last column, none of the detailed investigations showed a benefit-cost ratio greater than one. This means none of the sites were found to be economically feasible.

At least one operating hydropower facility at the micro hydropower scale exists in the Tanana Basin at Camp Denali in Denali National Park. Because of the availability of suitable terrain in much of the basin, the relative remoteness of settlement in the basin and the high cost of fuel for electrical power generation, micro hydropower might be the most feasible scale for the basin. The larger two scales need combination of population density, water source, location, and construction costs that haven't been demonstrated, whereas at the micro scale these factors exist throughout the basin for power generation, for at least part of the year.

Power generation is the product of flow rate and net head which is the net change in elevation which the water drops (DOE, 1979). The lower limits at which microhydropower is not feasible is ten feet of head and ten gallons per minute. However, ten gallons per minute at ten feet will not give any usable power. For an example of scale 10 gallons per minute at 100 feet of head or 100 gallons per minute at 10 feet of head will produce about 100 watts (DOE, 1979). An equation for theoretical power is QXH/5.3 = P where Q is flow rate in gallons per minute, H is net head in feet and P is power in watts (DOE, 1979). This equation determines theoretical power. Actual power will be less and will depend on the efficiency of the components of the system (DOE, 1979).

Table 4-3
Inventory of Large Hydroelectric Power Sites - Tanana Basin

Project Name	Stream	Drainage Area (sq. mi.)	Max. Reg. Water Surface Elev. (ft.)	Active Storage (1,000 A/F)
Junction Island	Tanana River	42,500	400	29,000
Bruskasna	Nenana River	650	2,300	840
Carlo	Nenana River	1,190	1,900	53
Healy (Slagle)	Nenana River	1,900	1,700	310
Big Delta	Tanana River	15,300	1,100	6,450
Gerstle	Tanana River	10,700	1,290	*
Johnson	Tanana River	10,450	1,470	5,300
Cathedral Bluffs	Tanana River	8,550	1,650	4,900

* Reservoir held essentially full for operation with upstream plants.

Table 4-4
EXISTING POWER SYSTEM DATA SUMMARY SMALL TANANA BASIN COMMUNITIES

Community Name	Longitude and Latitude	1981 Population	Method of Generation 1/	Utility Name 1/	Utility Ownership	Installed Capacity (kW) 1/	1981 Energy Use 2/ (kWh/year)	Cost of Diesel Fuel ($/gallon)	Cost of Residential 4/ Power ($/kWh)
Big Delta	145° 49'W 64° 09'N	30	Coal, Diesel, Oil	Golden Valley Electric	REA	225,000	133,091	0.920	.12
Chatanika	147° 28'W 65° 07'N	30	Coal, Diesel, Oil	Golden Valley Electric	REA	225,000	133,091	0.920	.12
Chena	147° 56'W 64° 48'N	35	Coal, Diesel Oil	Golden Valley Electric	REA	225,000	155,273	0.920	.12
Delta Junction	145° 44'W 64° 02'N	945	Coal, Diesel, Oil	Golden Valley Electric	REA	225,000	4,192,364	0.920	.12
Dot Lake	144° 04'W 63° 40'N	66	Diesel	Alaska Power and Telephone	Private	200 (temporary until transmission lines are in Operation) 2,275 (early 1982)	292,800	1.241	.25
Livengood	148° 33'W 65° 31'N	50	Diesel	None	Private	Individual generators	208,365	1.376	--
Tanacross	143° 21'W 62° 23'N	117	Diesel	Alaska Power and Telephone	Private	1,975	519,055	1.241	.25
Tok	142° 59'W 63° 19'N	750	Diesel	Alaska Power and Telephone	Private	2,275	3,260,728	1.241	.25

Table 4-5
TANANA BASIN SMALL HYDROPOWER SUMMARY TABLE RESULTS OF DETAILED RECONNAISSANCE INVESTIGATIONS

Community	Stream Name	Drainage Area (mi^2)	Transmission Distance (mi)	Net Head (ft)	Design Flow (cfs)	Minimum Flow (cfs)	Installed Capacity (kW)	Plant Factor (Percent)	Energy Cost $/kWh 1/	Benefit Cost Ratio
Dot Lake	Bear Creek	58.0	9.9	151.0	74.2	7.42	699	30	0.48	0.91
Tanacross	Yerrick Creek	29.0	1.5	237.0	18.6	1.86	299	31	0.69	0.63
Tok	Clearwater Creek	27.0	12.2	353	17.2	1.72	412	31	0.88	0.50
Big Delta - Delta Junction	Granite Creek	23.5	20.2	240	3.76	3.76	612	44	0.49	0.66

1/ 1981 $.

D. Navigability

When Alaska became a state in 1959, it also became the owner of lands beneath both tidal waters and the non-tidal, navigable water within the state. Although state ownership of these lands is an established right and is recognized as such by the federal government, only a small amount of the state's submerged acreage has been identified to the satisfaction of both the state and federal governments. Although in most instances identification of the actual location of state land underlying tidal waters awaits survey, the state and federal governments generally agree on how to identify these lands.

However, they do not agree on how to identify the beds of non-tidal, inland navigable waterbodies (i.e., lakes and rivers). The state and federal governments disagree over which characteristics and uses - or criteria - of Alaska's waterbodies satisfy the judicial test. This basic disagreement is a major obstacle to identfying this category of valuable state-owned submerged lands.

Both the State of Alaska and the United States government agree that the legal test of a waterbody's navigability - for the purpose of determining ownership of submerged lands - has five key elements.

From the viewpoint of the State of Alaska, the following constitute basic elements of navigability for the purpose of determining ownership of submerged lands in Alaska:

1. Waters must have been navigable at the time the state was admitted to the Union.
2. Waters must be navigable in their "natural and ordinary condition."
3. The waterbody must be useful as a means of transportation; that is as a "highway for commerce over which trade and travel may be conducted."
4. Navigation must be conducted in "customary modes of trade and travel on water."
5. Waterbodies which are susceptible of being used, although not yet actually used in the ways outlined above are, nevertheless, navigable."

Major Disputed Criteria

Consistent with the preceding considerations, the navigability criteria which the state supports, but the federal government does not, are the following:

a. Winter Use - travel on a waterbody, in its frozen condition, as an ice highway.

b. Airplane Use - use of a waterbody by floatplanes or, in the winter, by planes on wheels or equipped with skis.
c. Personal Use - travel on a waterbody by individuals in connection with activities not purely recreational in nature, such as hunting, fishing and trapping, or as a means of access to their homes or property.
d. Recreational Use - travel on a waterbody in connection with recreational activities, such as sightseeing and recreational fishing, by companies and guides involved in the tourism and recreational trades and by private individuals.
e. Susceptibility of Use - physical characteristics - such as length, depth, and width - of a waterbody which indicate the waterbody is susceptible of use in travel.
f. Isolated Lakes - travel and trade on isolated lakes and deadend sloughs are generally not criteria considered by the federal government since there is no "continuous" route of interconnected travel.
g. Obstructions to Navigation - the disagreement here is one of degree: At what point is a natural obstacle - such as rapids - so extensive that it becomes an "obstruction" rendering a waterbody, or a portion it, non-navigable?
h. Alternative Routes of Trade and Travel - the federal government often discounts use of a waterbody for travel if alternative overland trade or tavel routes, such as roads or trails, have developed on land.

Criteria Test Cases

In order to resolve these fundamental criteria disagreements regarding Alaska's inland waters, the State is filing test cases in federal court for legal identification of proper criteria for navigability determinations in Alaska. By filing lawsuits the state seeks to obtain judicial navigability determinations for selected waterbodies presently considered non-navigable by the federal government but considered navigable by the State. With each test case, the State aims to clarify aspects of its positon on navigability criteria.

The following waterbodies within the Tanana Basin promise to be the subject of litigation in the near future in the state's effort to obtain judicial guidelines concerning correct navigability criteria of waterbodies in Alaska.

Nenana River - This river is being investigated in the vicinity of Denali National Park and Preserve and Healy. The stretch of river under investigation was chosen by the state primarily to test the obstruction-to-navigability criterion. The federal government has declared this stretch of river through the lengthy rapids alongside the Parks Highway non-navigable, although it has in fact been extensively used, including present use by commerical river-rafting companies appealing to the tourist trade. Hydrological, historical, and contempoary use research and reports are scheduled for completion in January 1983, at which time the state can begin legal action.

Northway Lakes - Several lakes in the vicinity of Northway provide significant value for a criteria test case. These lakes were determined non-navigable by the federal government. The lakes - and the streams and sloughs connecting them - receive local use by small boats for activities such as personal use hunting, fishing, trapping, and travel to homesites. A few of the lakes also experience substantial recreational use. Some of the lakes are not connected by streams but still receive boat traffic by portages between the lakes. Aspects of the isolated-lake, personal-use, recreational-use and susceptibility-of-use criteria which are not presented in other cases filed by the state are presented by these lakes. Historical and contemporary use reports have been completed. A hydrological report is scheduled for completion by December 1982, at which time the State can begin legal action.

Minto Flats - This area may be used as a criteria case because of the reported use of its waterbodies as a transportation network primarily for winter-use activities, such as hunting and trapping related mainly to personal consumptive use of resources in this rural area. Contempory use and historical research is scheduled for Spring 1983. At that time, the state will decide the need for this area as a criteria case.

E. Floodplain Management

Floodplain management, in a comprehensive sense, has not been widely recognized as a responsibility of state government in Alaska. The federal government has assumed primary responsibility for projects to control flood waters such as dams and channel improvements, as well as minimum floodplain standards required by the National Flood Insurance Program. To date, the state government in Alaska has played a relatively minor role in floodplain management (Department of Community and Regional Affairs (DCRA), 1982).

In interior Alaska, cold winter freezing followed by rapid warming in spring causes rapid snowmelt which overflows frozen or ice jammed channels and often results in spectacular spring breakup floods. Moreover, the presence of permafrost prevents rainfall from infiltrating, so a large percentage of rainfall during heavy storms becomes flood runoff.

Some of the most extensive floods in the state have occurred in the Tanana River system (ARP, 1974). The relatively short summers concentrate the major portion of the annual runoff into less than five months. High flows occur from May through September; low flows from October through April. Beginning in late September, freezing weather at the heads of tributaries rapidly advances downstream, and by April, flow is gradually reduced to only the infiltration of groundwater in the stream bed. In May, ice in the rivers is broken up by higher flows swollen by the runoff from snowmelt. Most peak discharges in the region occur following the breakup of ice. Smaller peaks sometimes occur in late summer from heavy precipitation, particularly where permafrost is near the surface and prevents infiltration.

The flood potential in the Tanana depends on the water level in its tributaries. Streams originating in the Wrangell Mountains and the Alaska Range are fed by glaciers; the others obtain water from snowmelt at lower elevations. This results in heavy streamflow all summer with peak flows in July and August. Flooding is most likely to occur when rainfall follows a period of warm weather during which the snowmelt rate increases rapidly (ARP, 1974).

The State of Alaska currently has very little statutory authority to plan for and manage the floodplain areas of the state. What statutory provisions do exist relate primarily to state participation in floodplain projects and to state liability in post-flood situations (DCRA, 1982).

Settlement in interior Alaska, including the Tanana Basin, has traditionally included village development within the floodplain in order to facilitate a subsistence lifestyle based on use of the river system for transportation and a source of food. Several villages in the Tanana Basin are located in areas rated by the United States Corps of Engineers as having flood hazards of average to high. Two villages, Minto and Tanacross, have actually been moved to alternate sites in recent years due to extensive flooding. The U.S. Soil Conservation Service is currently developing maps of flood prone areas in the Tanana Basin. These maps should be available in the summer of 1983.

Fairbanks, developed unplanned on a poor site, is apparently typical of old northern settlements (AWSC, 1980). Located in a flat lowland area, Fairbanks has been flooded by the Chena River six times since 1902 when the settlement was founded: 1905, 1911, 1930, 1937, 1948 and 1967. The 1967 flood killed six people and caused damages exceeding $85 million dollars (DCRA, 1982).

Fairbanks exemplifies a community that cooperatively developed a floodplain management program following the devastating 1967 flood. Fairbanks has one of the most comprehensive floodplain management programs in Alaska, combining flood insurance, regulation, recreation enhancement and structural flood control (the Chena River Dam and Floodway and the Tanana River levee) to mitigate their flood hazard. It should also be noted that this program was achieved at a sizeable cost to the public. The Chena River project is estimated to have cost $243 million in state and federal funds. Operation and maintenance costs are estimated at $763,000 annually (DCRA, 1982). The final stage of this project, however, is still incomplete and quite controversial. It appears that a potential land-use conflict is halting completion. The Army Corps of Engineer's plan of extending the levee into the Tanana River near the International Airport has been criticized as causing unpredictable results, including a southward shift in the Tanana River bed with a consequent drop in the water level and loss of navigability of the Chena River (AWSC, 1980). Another potential land-use conflict is in the construction of a drainage channel from the Tanana River into the Chena by way of the Borough landfill. Such a route could have serious threat to ground water quality by the landfill leachate (DEC, 1982). Alternative routes and plans are being considered and a final solution will undoubtedly be forthcoming.

The National Flood Insurance Program (NFIP) offers property owners in participating communities flood insurance at initially low, federally-subsidized premium rates. To participate in the program, the city or borough must adopt and administer building and subdivision ordinances which will minimize flood damage within flood hazard areas. (DCRA, 1982).

According to federal regulations a community is flood prone for purposes of participation in the NFIP if it contains one or more "special flood hazard areas." These areas are defined as portions of a floodplain subject to flooding during a "100-year flood", the size flood which has a one percent chance of being equalled or exceeded every year. Many communities in Alaska may experience flood problems, thus may be considered flood prone, but lack sufficient historical and hydrological data to map the floodplain estimated to be covered by the 100-year flood event. Statistical analysis of available streamflow analysis of rainfall and runoff characteristics of the watershed, or storm characteristics are used to determine the extent and depth of the 100-year flood. Fairbanks is one community where sufficient past data collected at stream gaging stations existed to classify the flood events in the magnitude of a 100-year flood or greater.

A community joins the NFIP in two phases: 1) The Emergency Program phase and 2) the Regular Program phase. Any municipality may join the Emergency Program. However, as previously noted, certain requirements must be met at the time the application is made. Generally, there is less technical data available and the insurance and regulatory aspects are adjusted according to available data in this phase (DCRA, 1982).

A community enters the regular Program phase on the effective date of the final Flood Insurance Rate Map (FIRM). FIRM is based on preliminary studies during the Emergency Program phase.

Federal flood insurance is no longer available to nonparticipants in the NFIP. An example of the impact of this is that an owner trying to sell an uninsured residence will not be able to do so if the buyer needs to obtain a mortgage or loan from a federally insured or regulated lending institution. No federal grants or loans for building (including repair or improvement loans) may be made in indentified flood hazard areas. If flooding occurs, it is possible that the local governments could be held liable by residents and/or businesses who could not get flood insurance because of the decision not to participate in the National Flood Insurance Program.

There are other effects too. For further information regarding the National Flood Insurance Program, refer to the "Floodplain Management Guide for Alaskan Communities" (1982) published by the Department of Community and Regional Affairs, Division of Community Planning.

F. Placer Mining and Water Quality

If there were only one placer miner operating in Alaska, there would be little, if any, concern for its impact on the environment. There are, however, an estimated 150 placer mining operations in the Tanana Basin (Miller, 1983). These operations have the potential to cause adverse effects on water quality and generate other pollution problems. The conventional operating procedures involved in placer mining include:

1. Stripping of overburden material to expose the mineral-bearing materials;
2. Thawing of permafrost;
3. Ditching or stream diversion to obtain water;
4. Transporting mineral-bearing material to the sluice-box;
5. Recovering minerals from the mineral-bearing materials;
6. Constructin of tailings ponds or other control structures; and
7. Disposal of tailings.

These practices can result in the removal of vegetative cover, changes to topography at the mine site, modification of the stream channel, and introduction of material into the stream system. (Madison, 1981). The major water pollution concerns with these changes are with sedimentation and water quality.

The effects of sedimentation from mining is similar to that of other land-disturbance activities. Reseachers have concluded that the following impacts are possible:

1. Physical effects which include increased turbidity and alteration of channels and changes in stream bottom material.
2. Effects on aquatic plant life including reduction in photosynthetic activity and consequent reduction in growth of algae and macrophytes, smothering of plant life inhabiting the stream bottom, and increase in the mobility of the substrate.
3. Effects on benthic invertebrates including reduction in the abundance and diversity of benthos and changes in community composition from clean-water species to species more adaptable to higher sediment levels but possibly less suitable as fish-food organisms.
4. Effects on fish life which include loss of available food supply due to reductions in production at the lower trophic levels (plant life and benthic invertebrates), interference with the sight-dependent feeding habits of salmonids, obliteration of hiding or living areas in gravel, temporary or permanent destruction or

modification of spawning beds, short-term exposure to very large concentrations of suspended sediment that can cause fish mortality through damage to the gill structure, and avoidance of normal spawning areas (even relatively low turbidity) and preference for cleaner tributaries or other sections of a stream (Madison, 1981).

5. Effects on drinking water: aesthetic, increased total metals particularly arsenic, interference with disinfection, interference with microbe analyses, source of nutrients for microbes, increase loads on treatment.

Possible water quality impacts include:

1. An increase in organic loading in the stream system from the introduction of overburden sediments or innundation of organic-rich topsoils.
2. An increase in the minor-element content of water or sediments as the result of exposure and oxidation of metal-bearing materials, the leaching of tailing deposits, or chemical treatment of the ores.
3. Acid mine drainage.
4. Effects of the above water-quality changes in the form of toxicity to fish and other aquatic biota (Madison, 1981).

The above mentioned effects are not present in every mining operation. The use of settling ponds, recycling of water, classification of material, proper sizing of equipment and a good mining plan are common practices and techniques that will help a placer mining operation reduce adverse impacts on water resource.

As mentioned above in Section IIC all waters in the State of Alaska with the exception of the Chena River must meet drinking water standards. With respect to placer mining, the standards of most concern are settleable solids (0.2 ml/l), turbidity (5 NTU's above background) and heavy metals.

In light of the increased mining activity, increased environmental degradation will and has occurred. To best achieve compliance from miners in wastewater treatment the state DEC worked closely with other involved agencies and sponsored an active field program during 1982 (Reeves, 1982).

It has been demonstrated that it is extremely difficult if not impossible to maintain a multiple water use program through cooperation between user groups without an active field compliance program. The amount of effort put forth by miners to upgrade wastewater quality depends on their ability to realistically attain compliance. The few miners creating conflicts between water user groups will be required to use well-designed and maintained settling ponds. Additional treatment in order to eliminate the conflicts might be one solution to this problem; however the economics of such action should be analyzed prior to formulation of additional requirements. Technical assistance is provided to miners in the field. They are advised of proper methods of settling pond construction and told how to best achieve compliance, obtain permits, etc. (Reeves, 1982).

Samples were taken in the field in 1982 and will be again in 1983. The purpose of this sampling program is to determine settling pond efficiency and whether or not the operation is in compliance. It is the Department of Environmental Conservation's intention to focus field monitoring activities in the Tanana Basin during 1983 on those high priority streams such as the Chatanika and Chena Rivers where multiple use conflicts exist (Reeves, 1982).

On streams where there is heavy mining impact, it is DEC's goal to encourage properly built and maintained settling ponds or other techniques to settle out solids. It is felt that all operators can meet the EPA settleable solids limit of 0.2 ml/L. if they maximize the use of settling ponds. The State turbidity standards are the most difficult water quality parameter to meet and on-going research will shed needed light on what environmental effects these suspended solids actually have.

Field compliance to water quality requlations is recognized by DEC to be difficult at times and some sites may require a tailored approach to meeting standards. In many situations economics and practicability play a role in determining best sediment control methods. As long as the miner demonstrates a willingness to comply and engages in coorperative efforts to meet standards the State will pursue every avenue available in achieving its own mandate to offer technical assistance and allowing a reasonable amount of time to solve the problems associated with water quality as effected by placer mining. In the meantime, regulatory agencies, miners, recreational users and the general public should display a willingness to understand each others views and problems so that a meaningful and well-balanced program of environmental quality and economic growth can be effectively constructed and maintained (Reeves, 1982).

G. Forestry

Poor forestry practices can lead to changes in watersheds and stream ecosystems. The following summary of potential adverse effects is taken from a personal cummunication (Mark Oswood, 1983). Loss of stream bank vegetation can result in increases in soil mass movement, increased erosion, loss of riparian cover for fish, changes in nutrient input into waterways changes in input of terrestrial insects as fish food, and decrease of terrestrial interception and evapotranspiration of water with subsequent increases in stream flow.

Sediment input into streams can negatively affect developing fish eggs by physically damaging them, by decreasing the flow of intragravel water and thereby decreasing oxygen uptake and waste removal (smothering the eggs). Increased sediment on the stream bed can change the composition of aquatic algae and invertebrates, disrupting the food chain important to commercial and sport fish in the stream. Sediment input can also destroy habitat space utilized by small fish and/or overwintering fish.

Loss of canopy can result in decreasing leaf litter and woody debris input into the waterway, and increased solar radiation causing higher maximum diurnal and summer temperatures, and decreased winter minimum temperatures.

Input of large debris can be potentially beneficial to fish by providing cover, but also can cause potential problems with Biochemical Oxygen Demand (BOD), creating barriers to fish movement, and causing possible channel changes.

Road building and other logging activities can adversely affect waterways by becoming sources of sediment and toxic materials (such as oil and grease). Heavy equipment and yarding across waterways may cause erosion of the lower banks and culverts may impede fish passage.

Channel changes, gradient changes, discharge and velocity changes can negatively affect the fishery population by changing the pool habitat to riffle habitat ratio. Many adult and juvenile fish typically rest in areas of reduced water velocities (pools), but feed on benthic invertebrates derived from the riffle areas.

Dr. Oswood notes that there is a lack of published, quantitative information in many Tanana Basin areas of logging/stream interactions.

The Alaska Forest Resources and Practices Act (January, 1979) and the Regulations (February, 1981) attempt to assure continuous growth and harvest of timber and to protect Alaska's forest, wildlife, soil and water resources. A Forest Practices Field Manual for each forestry region of Alaska lists the Best Management Practices (BMP's) for each type of activity. These BMP's constitute the state-of-the-art methods that may be used to achieve the Standards contained in the Forest Practices Regulations. They are not mandatory, but serve as guidelines for forest operators to assist them in meeting the intent of the Act and the Regulations.

On a state agency level, a cooperative agreement exists between the Alaska Departments' of Fish and Game, Natural Resources and Environmental Conservation (April, 1982). This agreement delineates the responsibilities and activities of each agency and the relationship between them in protecting the renewable forest resources and the environment. In essence, the Department of Natural Resources is responsible for the renewable forest resources. The Department of Environmental Conservation has the lead responsibility to protect and maintain water quality -- including control of nonpoint source pollution. The Department of Fish and Game is responsible to protect and conserve fish, game and other natural resources, and is vested with the authority to require written approval of activities in waters important for the spawning, rearing, and migration of anadromous fish under Title 16 of the Alaska Statutes. Coordination among these agencies includes joint forest practices training programs, joint inspections, enforcement and monitoring activities whenever possible, and cooperative review of the BMP's and logging activities of the Tanana Basin region.

H. Agricultural Development

Agricultural development projects in the Tanana Basin are resulting in the clearing of large amounts of virgin forested land and subsequent development into treeless, cultivated lands with necessary roads and homesteads. Because often large parts of small watersheds are involved in a development plan these changes have significant effects on the water resources of the affected watersheds. These effects can be categorized as effects on the hydrologic system and on water quality.

1. Hydrologic System

Effects on the hydrologic system are changes in volume of direct runoff and changes in lag which effect peak rate of runoff (Soil Conservation Service (SCS), 1972). The major contributions to change in volume are changes in infiltration rates and changes in surface storage of water. Lag is also affected by infiltration rate and by changing the timing of surface flow by changing the distance and/or velocity of flow (SCS, 1972).

Forested land has high infiltration rates, high storage and usually reduces flow velocity. Clearing of forested land should result in larger volume of surface water runoff and higher peaks occurring more rapidly during periods of flooding and lower discharges during periods of low flow. These effects can be mitigated by land use and treatment measures. Forested greenbelts, permanent meadows, contouring and furrowing measures and use of grass-lined ditches and outlets are examples of mitigation measures that might be useful in the Tanana Basin.

The effects of mitigation measures may be different with respect to snowmelt runoff than with rainfall runoff. With snowmelt runoff, because of seasonal weathering and frost action, contouring, terracing and crop rotation may not be effective measures while permanent meadows and woodlands would remain effective (SCS, 1972).

Roads in project lands may also impact the hydrologic system. Improperly located roads can act as dams or conduits for overland flow. Improperly sized and/or located culverts can also impede drainage.

2. Water Quality

Agriculture - a potential nonpoint source of water pollution - has not traditionally been a source of serious water pollution in the state. However, rapid large scale development of undisturbed lands has increased dramatically in recent years, and has introduced the possibility of significant deterioration of water quality in local environments. Potential threats to water quality that are related to agricultural development arise as a result of two major classes of activities: land development and ensuing agricultural operations.

Land development includes surveying, construction of access roads, bridges, and utilities, and land clearing. Primary water quality effects that can result from such activities are increases in sedimentation, suspended load, and concentration of plant nutrients; decreases in light transmission; and changes in temperature.

Agricultural operations include fertilizing, irrigation, seedbed preparation, chemical treatment of seeds, application of fungicides, insecticides, and herbicides, and so on. Primary water quality effects that can result from these activities are similar to those that result from land development, but in addition include introduction of fungicides, insecticides, and herbicides, and decreased concentration of dissolved oxygen.

Large scale agricultural development in Alaska began in 1978 with the launch of the Delta I Agricultural Project. This farm community has not been unaware of the potential for development of water quality problems. During early stages of the Delta Project, a poll of the twenty-four member 1980 Delta Citizen Council indicated unanimous support for allocating state funds for "air and water quality monitoring within the immediate area of the Delta agricultural community," and for assessing "the effect of large scale agriculture on the ecosystem."

Several baseline water quality studies have been carried out in the vicinity of the first agricultural development site, Delta I. These studies include a geohydrologic report by U.S.G.S., a water quality study by the Agricultural Experiment Station, a water quality and benthos investigation by the Institute of Water Resources, a pesticide residue sampling report by the U.S. Fish and Wildlife. None of the studies produced evidence of significant water quality problems. Most of the studies, however, were completed prior to extensive development in the area. Most of the investigators stressed the importance of continuous long term water quality monitoring in order to determine the effects, if any, of agricultural development on the region's surface and ground water. Unfortunately only two followup studies, one of nitrogen fertilizer fate, and other on pesticide residues, were initiated in 1982, and final results of these studies will probably not be available before 1985. Neither of these studies is specifically intended to monitor water quality.

In 1983 the Alaska Department of Environmental Conservation, Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service will commence a monitoring program on Delta Clearwater Creek which will compare new information with data from past studies. Additionally, the Alaska Department of Natural Resource's baseline studies will commence in the Delta Creek area, which is being proposed as an extension of the Delta I Agricultural Project. This study will include a study of meteorological conditions, surficial geology, forest cover evaluation, surface and ground water hydrology and water quality.

The Department of Environmental Conservation is responsible for protecting Alaska's waters from pollution from either point or nonpoint sources. The Department intends to carry out monitoring programs in areas of large scale agriculture as funding permits and will continue to enforce Alaska Water Quality Standards. Additionally, the Department has developed Best Management Practices (BMP's) appropriate for Alaska. These BMP's describe general agricultural operations conducted so as to minimize adverse water quality effects, or practices designed to protect water quality directly. A Memorandum of Agreement between ADEC and the Alaska Soil Conservation District spells out terms of cooperation between the two organizations with respect to implementation and evaluation of BMP's to prevent or mitigate water quality problems. A Memorandum of Understanding between ADNR and ADEC accomplishes similar goals.

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