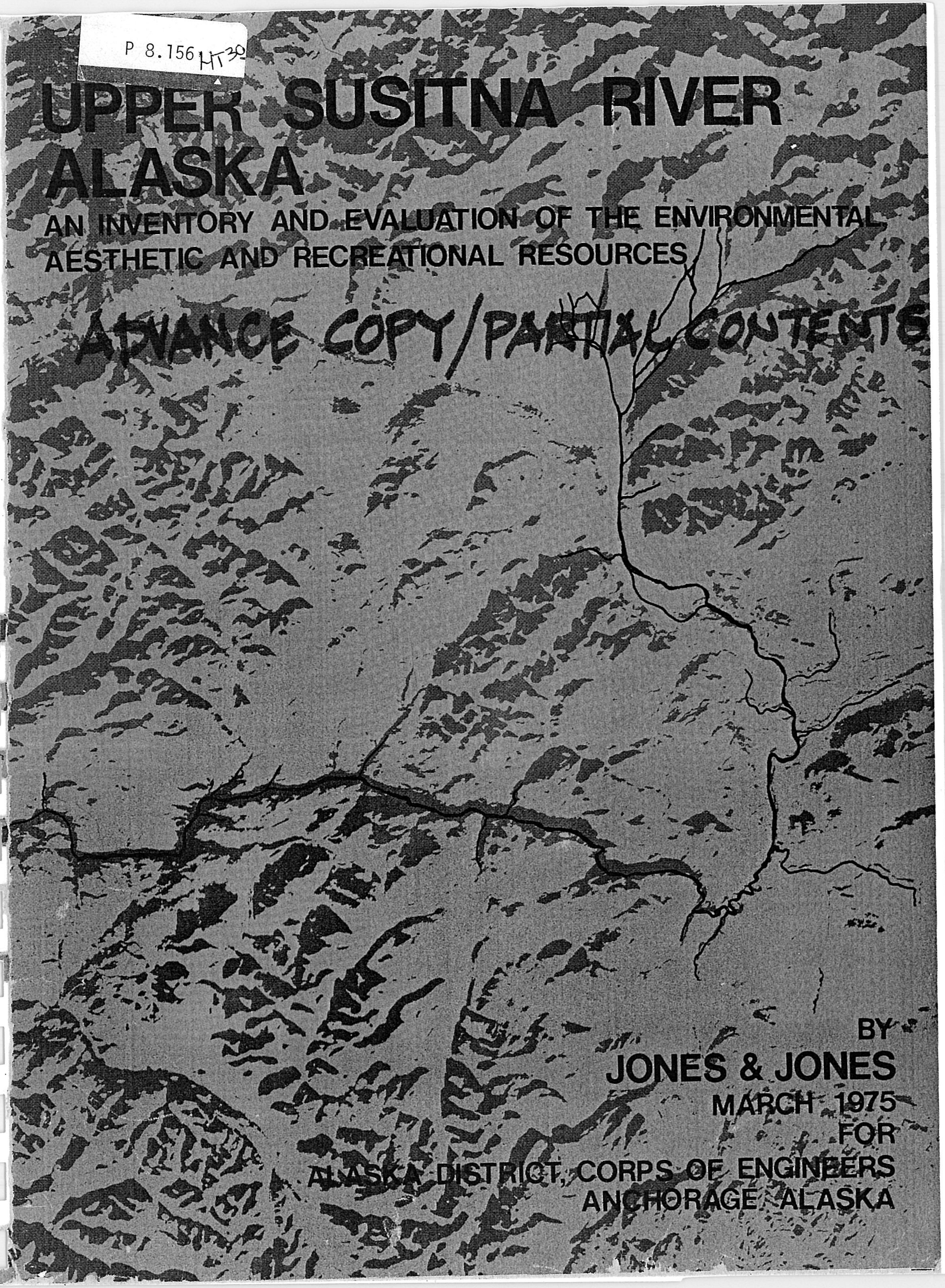
UPPER SUSITNA RIVER
ALASKA

AN INVENTORY AND EVALUATION OF THE ENVIRONMENTAL AESTHETIC AND RECREATIONAL RESOURCES

ADVANCE COPY/PARTIAL CONTENTS



BY
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MARCH 1975
FOR
ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA

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14 March 1975

Col. Charles A. Debelius, District Engineer
Department of the Army
Alaska District, Corps of Engineers
P.O. Box 7002
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SUBJECT: Inventory and Evaluation of the Environmental, Aesthetic and Recreational Resources of the Upper Susitna River, Alaska
Contract No. DACW85-74-C-0057

ATT: Mr. Duane Petersen, Acting Chief
Environmental Section

Gentlemen:

We are very pleased to present the camera-ready original and three photocopies of our final report on the environmental, aesthetic, and recreational resources of the Upper Susitna River and how these will be affected by the construction of the presently proposed hydroelectric system comprising four dams and their reservoirs. We have greatly enjoyed the cooperation of your staff over the past months, and especially that of Bill Gabriel (former Chief of the Environmental Section) during the formulation and initial stages of this study. Since his departure, the project has been very ably managed by Duane Petersen with the assistance of Bob Wienhold and Marion Varela, under the direction of Weldon Opp, Chief of the Planning Branch.

This report, which embodies a summary of our findings, we trust will be a useful and major element for the comprehensive

LANDSCAPE ARCHITECTURE ENVIRONMENTAL PLANNING URBAN DESIGN ARCHITECTURE
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assessment of the Upper Susitna Hydroelectric Project and serve as a data base for further studies and alternatives.

Respectfully submitted,

Grant R Jones

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GRJ:ds

Encl.

ABSTRACT

The Upper Susitna River, midway between Anchorage and Fairbanks, possesses significant hydroelectric resources which have figured prominently in mid- and long-range planning for provision of electrical power to Alaska's rapidly growing Railbelt. Presently proposed hydropower development of the Upper Susitna would be initiated by a power dam in lower Devil Canyon near Gold Creek, followed by the construction of a regulating dam near the present Denali Highway bridge. Eventual full development would then add dams at Vee Canyon and the Watana site, downstream from Deadman Creek. The consultants were retained by the Army Corps of Engineers, Alaska District, to inventory the existing environmental, aesthetic and recreational resources of the river, and to evaluate the effects of the proposed four dams and their reservoirs upon these resources.

The river corridor was classified into discrete segments to spatially locate resources and effects, and to facilitate site-specific recommendations. This classification was generated from a nested set of patterns defined by physiography and geology as well as characteristics of the river, notably channel type and major tributaries. Existing natural, cultural and aesthetic resources were quantitatively inventoried in each segment; however, river segments could not be directly compared on the basis of resource magnitude because fundamentally different landscape types were represented. Instead, building on previous work by the consultants and others, comparability was achieved without reliance on paradigm landscapes by devising component measures of resource importance. In combination, these measures quantified

the extent to which natural processes characteristic of each landscape type were operative (Natural Value) and visually expressed (Aesthetic Value), before and after the dams. Together, these two measures were taken to indicate relative Environmental Quality, considered in terms of landscape health and integrity. Effects on recreational values (Recreation Suitability) were then assessed, before and after, in terms of environmental constraints on recreation activities grouped by relative impact. While its performance was outside the scope of this study, projection of recreation use is discussed. It will require a conceptual recreation plan, and a regional analysis of competing recreational opportunities.

Major adverse effects on Aesthetic Value were identified, particularly for the Devil Canyon and Vee dams. Earlier studies finding the Upper Susitna Project to have fewer adverse effects on fish and wildlife than other hydroelectric alternatives were in general confirmed, although high relative impacts within the study area and potentially severe effects upon the regionally significant Nelchina caribou herd were found. Mitigation may be possible in both cases, dependent upon suggested further design studies. Areas where lack of information requires additional field studies were also identified. The methodology of the study is thoroughly explained in the text and appendices, and an extensive bibliography is intended to support further environmental studies of this and similar Alaskan projects.

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II. SUSITNA BASIN DESCRIPTION

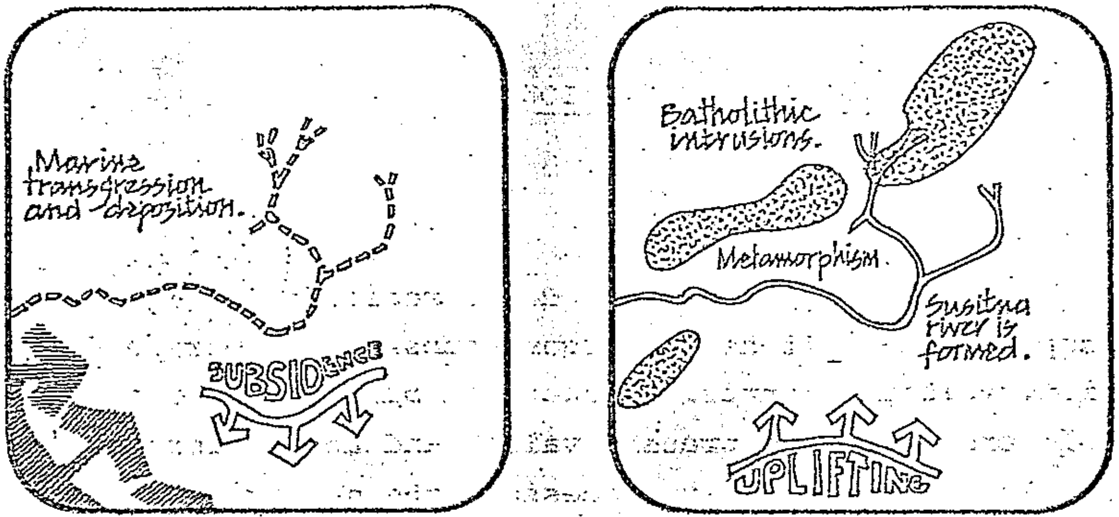
GEOLOGY

The Upper Susitna River region is a geologically complex area. It has undergone subsidence, marine deposition, volcanic intrusion, mountain building, and considerable erosion. The present valley and upland form is the result of many complex processes; the geomorphological features are, in large part, the resultant expression of structural controls, most notably block faulting.

Since much of the Upper Susitna River occupies a deep, entirely stream cut valley, it is a geologically unique feature in an area of the world dominated by glacially carved, broad U-shaped valleys.

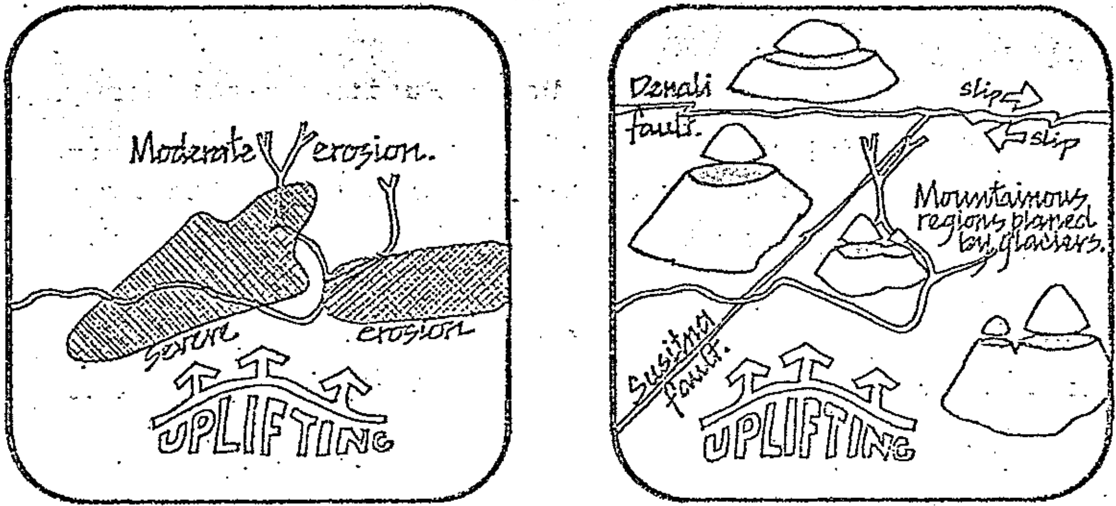
A brief summary of the geology of the Upper Susitna basin is provided here, while a more complete description is included in the appendices.

The oldest rocks known in the area are paleozoic volcanics, which form the base strata or "terrane" which later strata overlie. Following the establishment of these base strata, deposition of sandstones and shales (clastics) interbedded with submarine lava flows indicates that the study area was below sea level during the Triassic and early Jurassic periods (fig. 1a). Massive intrusions of granitic rock, beginning in the latter period, warped and lifted the region. The uplifting continued during the Cretaceous period and the Susitna River drainage became established (fig. 1b). During the early Tertiary, uplifting continued and erosion was severe, evidenced by the exposed Paleozoic rocks in



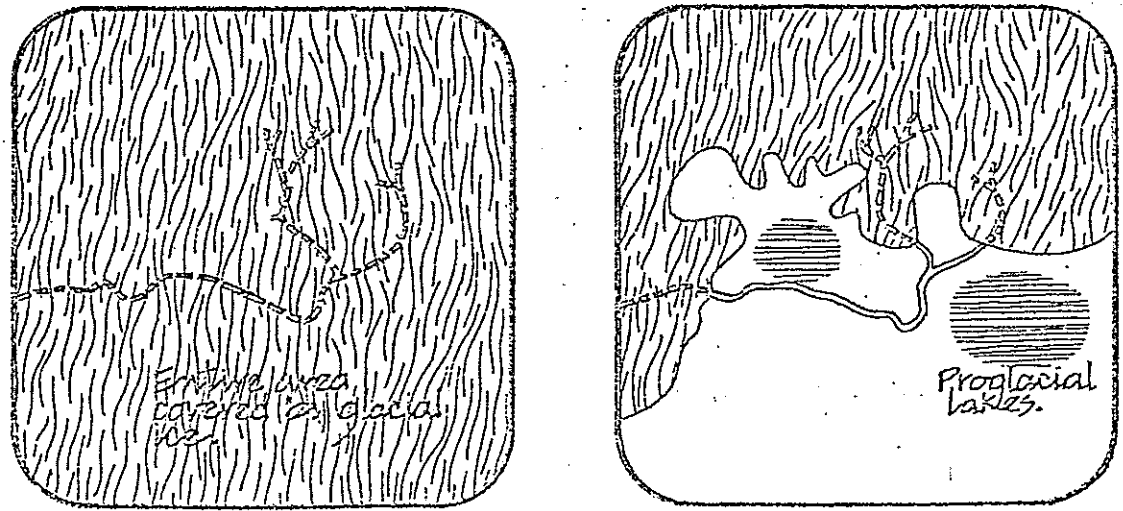
a Mid-Triassic to early Jurassic.

b Mid-Jurassic to Paleocene



c Tertiary

d Post-pliocene to Quaternary



e Middle Pleistocene

f Late Pleistocene

FIGURE 1. INFERRED HISTORIC GEOLOGY

the mid-section of the Upper Susitna (fig. 1c and fig. 3). The east-west portion of the river may well have changed its direction of flow several times during this period of warping and block faulting, as suggested by several "barbed" tributaries entering at more than a 90 degree angle.

From the late Tertiary (post-Pliocene) to the early Quaternary periods, vigorous mountain-building took place, attended by severe faulting. Several extensive southwest-trending faults, including the major Susitna Fault, were in turn truncated by the arcuate Denali Fault during this time span (fig. 1d and fig. 2). Evidence of faulting can be read directly in a number of striking river offsets on the Upper Susitna.

Extensive glaciation also occurred in this period, planing the mountaintops to a relatively even elevation. During the Pleistocene epoch (fig. 1e) the entire area was covered with ice, while the less extensive recent glaciations allowed the central and eastern portions of the study area to be filled by an enormous proglacial lake (fig. 1f). The moraine north of this lakebed encloses a second area of glaciolacustrine deposits from a body of water once backed up behind the terminal moraine (fig. 3). The Denali Dam would restore this smaller lake for part of the year by plugging the passage breached by the Susitna.

The streamcut portions of the river valley downriver from the major lakebed area are characterized by strongly defined terraces alternating with rock-bound walls, of which the most prominent are those of the Devil Canyon gorge.

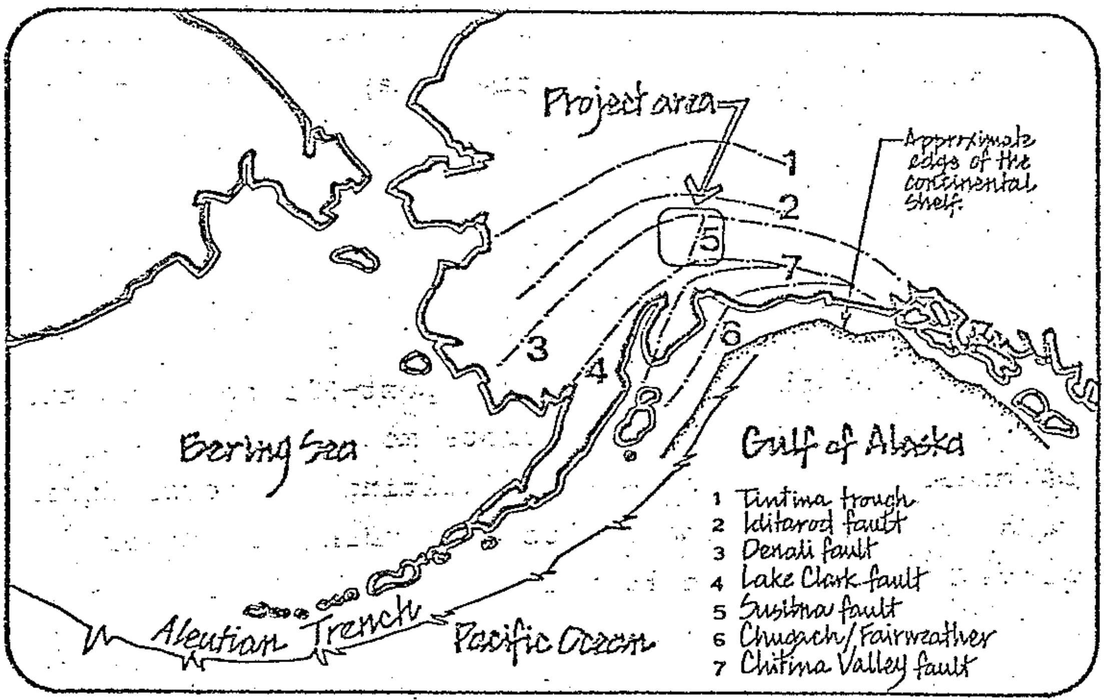


FIGURE 2. PERTINENT ALASKAN FAULTS (A.E.I.D.C., SOUTHCENTRAL REGION, 1974)

GEOLOGY LEGEND

A = ALLUVIUM
G = GLACIOFLUVIAL
Gc= GLACIOLACUSTRINE
M = MORAINE
I = INTRUSIVES
Mc= METAMORPHOSED CLASTICS
S = SANDSTONES, SHALES & INTERBEDDED VOLCANICS
P = PALEOZOIC CONTINENTAL TERRANE

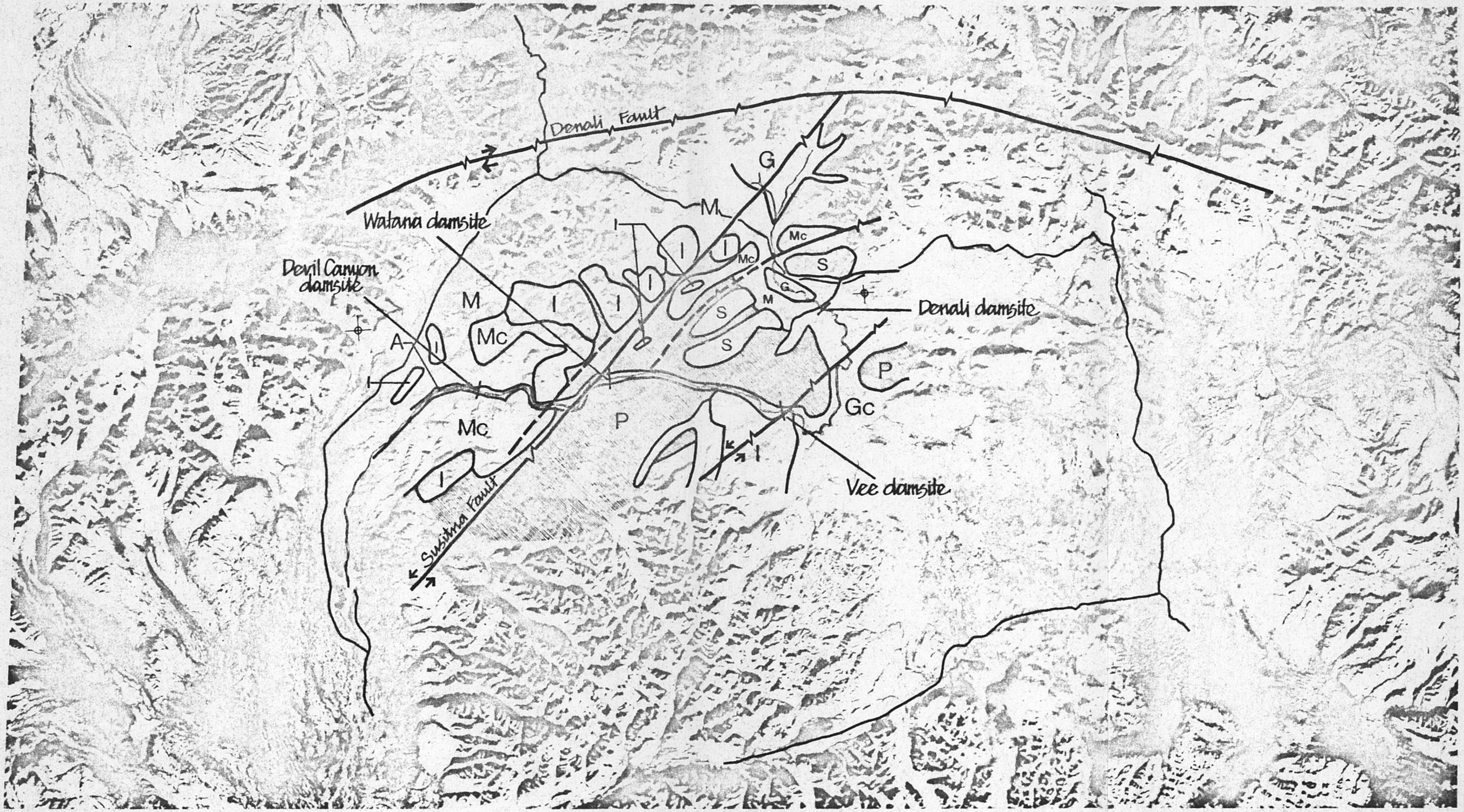


FIGURE 3 GEOLOGY OF THE UPPER SUSITNA RIVER

CLIMATE

Few systematic records of climate are available for the Upper Susitna basin itself, but the region is bracketed by the stations at Talkeetna, Summit, Paxson and Gulkana. The climate of the area is Transitional, being sometimes under the influence of ocean-moderated, moist Maritime Zone weather, and at other periods subject to the temperature extremes of the dry Continental Zone climate. Temperature extremes are generally somewhat less than in the Continental Zone, and average maximums and minimums show considerably less range than Continental averages. Nevertheless, the climate is severe and freeze-thaw (periglacial) processes play a major role in mass wasting, accentuated by solar aspect, elevation, and proximity to the Alaska Range.

HYDROLOGY

The study area lies within the Southcentral Region, the fifth of six hydrologic regions defined in Alaska on the basis of drainage and climate. In this case the climate is a mixture of Maritime and Transitional, and the divide runs up the crest of the Wrangells, along the Alaska Range, and down the Alaska Peninsula. The three major drainages within this region are Kodiak Island and the narrow strip of land along the eastern edge of the Peninsula, the Susitna and the Copper Rivers.

The Upper Susitna River itself drains an area of some 5930 square miles between the headwater divides and the Gold Creek bridge. Counting the three tributary forks separately, there are approximately 200 linear miles of river in this area. The river is swift and silt-laden, but most of its tributaries are clear, except for the turbid Maclaren and the Oshetna. The streams below the Tyone drop down to the Susitna from its ancient terraces, carrying masses of cobbles and small boulders with them. Above, at terrace level, many of these streams are quite flat and even meandering. This lower portion of the watershed is predominantly well-drained soils or rocky uplands; permafrost is therefore discontinuous and little groundwater is available. In the lakebed and moraine deposits beginning above Vee Canyon, permafrost is continuous and groundwater supplies are also relatively low, although surface water is everywhere in evidence.

Soils are young and little developed, dominated by drainage, slope and parent material. In the flat lakebed up-river areas, drainage is poor due both to the fineness of the parent material and to permafrost, and extensive peaty, wet areas occur. These areas could pose problems for road and recreation facility construction.

VEGETATION

The pattern of study area vegetation simplifies both with altitude and with distance up-river. At Gold Creek, the bottomland (Major Ecosystems of Alaska) forest of white spruce and black cottonwood is very much in evidence on well-drained banks. All of the major association types, with the exception of the coastal hemlock-spruce forest, occur in large or small areas along gradients of drainage or altitude. Ascending the river, black cottonwooddrops out to be replaced by balsam poplar around Fog and Tsusena Creeks. Then hardwoods and white spruce become less and less in evidence, but still occur in small stands on well-drained river bars and tributary fans until Butte Creek. Past this tributary only black spruce stands occur, up to the glaciers themselves. The lower hill-sides are covered in low brush with moist tundra in low areas. The periodically flooded river flats are in willow and sedges - high brush and wet tundra. Since so much of the drainage basin is uplands, alpine tundra is one of the most prominent vegetation types.

FAUNA

Perhaps the most significant wildlife resource in the study area is the Nelchina caribou herd, a population defined by its common calving ground on the south side of the Susitna in the uplands above the Kosina Creek confluence. This herd, a major recreational resource in the Southcentral Region, declined in ten years from a population high of around 71,000 in 1962 (Bos, 1972) to between 6500 (McIlroy, 1974) and 8100 (Bos, 1974). This spectacular decline is traced to a number of factors; initial outmigration may have started the process (Bos,1972). Bad weather and overhunting appear to have been the major factors in the acceleration of the decline. Access to the back country improved dramatically with the introduction of the snowmobile and hunters were able to increase and stabilize their kill in the face of a rapidly declining population. Finally, drastically reduced hunting seasons were imposed which effectively preclude use of snowmobiles. Bag limits were also reduced to one animal and some areas of the game management unit closed to hunting entirely on an emergency basis. An increasing number of hunters use all-terrain vehicles to get in and out of the back-country, frequently traveling several days to reach their intended hunting area; eventually, this mode of access may have to be controlled as well (the Clearwater Mountains are already closed to hunters depending on motorized transport).

Moose are prominent in the watershed, but too have declined sharply from previous population highs. Weather, wolf predation, and unbalanced age-sex ratios have all been blamed for the decline.

Several small populations of Dall sheep cling to localized habitats in the area while mountain goats apparently do not occur at all within the watershed. Grizzlies are fairly numerous despite the absence of salmon, and wolves, wolverine, black bears, etc. are known to exist within the watershed, although little detailed information is available. The smaller furbearers are also present.

The east-west stretch of the Susitna is used as a flyway by waterfowl, but the major waterfowl nesting areas are on the lakes of the Copper River Lowland (lakebed) region and in the drained ponds and lakes of the flat Goose Island area just above the terminal moraine where the Denali dam is now proposed. A broad variety of waterfowl use this area, probably including some trumpeter swans.

Raptors occur throughout the study area, but in decreasing numbers in the lower stretches of the river (these stretches are less productive of wildlife in general). A survey of cliff-nesting raptors determined that population densities of these birds are low and that no peregrine falcons appear to nest along the Upper Susitna.

Salmon spawn in numbers in Indian River and Portage Creek but cannot traverse Devil Canyon. While some freshwater fish apparently inhabit the mainstem of the Susitna above this point, its tributaries are too steep for significant fish populations until the Tyone is reached, where the Susitna is only shallowly entrenched. Some of the upper sections of these tributaries however, such as Deadman Creek, support very fine grayling populations. Lake trout are also prominent in many of the terrace and upland lakes and drained ponds. Lake Louise, which drains into the Susitna via Susitna Lake and the Tyone River, is especially noted for its lake trout and burbot populations. All of the rivers and streams from the Tyone to Windy Creek support fish populations; several minor unnamed streams with flat gradients in the headwaters area contain quite suprising numbers of grayling.

HISTORY

The Upper Susitna has a long but only partially known prehistory. Extensive archeological remains have been found in the Tangle Lakes area on the Maclaren, and the area has been entered on the National Historic Register. The remains are apparently associated with the large proglacial lake that existed during and after the last glaciation and accordingly date back some 10 to 12,000 years. It is reasonable to expect further remains to be found around the lakebed margins when investigations are eventually made.

In the period just before contact with Europeans, the Upper Susitna was apparently a meeting ground or marginal area between three groups of Athapaskan peoples - the Tanaina, Upper Tanana, and Ahtna. While all three groups undoubtedly hunted caribou throughout the area, as did the first residents, they did not inhabit the area permanently. The Tanaina were the most sedentary of all Athapaskan peoples, having adopted many of the cultural patterns of the riverine Eskimos who were their neighbors on Cook Inlet (Osgood). They gained much of their sustenance from the sea and another large portion from the salmon of the Susitna and Matanuska. The Upper Tanana and Ahtna were apparently "restricted wanderers" (Vanstone) who traveled over their territory in a more or less fixed seasonal round. While caribou were an important part of their diet, salmon figured as even more important. Accordingly the Upper Susitna was visited only for relatively short periods.

The Russian discovery of Alaska fundamentally but indirectly changed the lives of these peoples. The Ahtna along the Copper and the Tanaina on the Susitna forcibly resisted Russian settlement in their areas. But they did accept Russian trade goods and gradually gave up their material culture for European utensils, clothing, and to a certain extent, food. They obtained these goods by shifting from subsistence hunting of food animals to the trapping of furbearers, many species of which were relatively valueless for food. They also settled permanently near trading posts and utilized distant portions of their territory less frequently.

The American purchase of Alaska did not change the pattern of this "stabilized fur trade and mission period;" in fact it did not end until after World War II (Vanstone) when the fur market finally collapsed. However, gradually at first and then with a rush, Americans moved into the lands of the Tanaina and Upper Tanana.

The Russians had never fully explored the headwaters of the Copper and Susitna, and American Army expeditions finally opened up these regions to general knowledge, beginning with Allen's expedition up the Copper in 1885. The prospectors followed and substantial amounts of gold were discovered at Valdez Creek in 1903, where the town of Denali was established. Gold was also mined on the southern edge of the Oshetna drainage near Nelchina and at Gold Creek. Economic conditions gradually closed the workings in the 30's before the gold ran out, and renewed activity is now taking place.

In 1920 the Alaska Railroad was completed, giving general access to Mount McKinley Park, created in 1917, in the process. Highways followed in the 40's and 50's and the primary use of the area became recreational, the road approach to McKinley being along the gravel Denali Highway until the recent completion of the Anchorage-Fairbanks Highway.

CURRENT LAND USE AND LAND STATUS

The uses made of the study area now are predominantly recreational and are highly seasonal. No significant year-round habitation is known to exist in the watershed above Gold Creek. Several lodges are scattered along the shores of Lake Louise and that area has been opened to recreational development. Susitna Lodge and Gracious House are sited at the Denali Susitna river crossing; these cater primarily to hunters, fishermen and geological parties since the Mt. McKinley traffic has fallen off.

However, considerable changes in land use may occur soon, spurred by the Alaska Native Claims Settlement Act of 1971. The land along the Anchorage-Fairbanks Highway has been selected by the State and has been designated as the New Capital corridor (fig. 4). Three site clusters have been identified, at Palmer, Talkeetna and Nenana. An Anchorage-Fairbanks power intertie, together with the Capital Relocation, will undoubtedly spur development in this corridor and intensify recreational and other use pressures in the Upper Susitna basin.

The land around the Denali crossing may well be available for use, since it is in d-1 status and will be classified and managed by the B.L.M. However, the use of the land along the river corridor between the Denali Highway downstream almost to Gold Creek is problematical, for this land is now eligible for native selection, much of it by the relatively land-short Cook Inlet Native Association, Inc. (fig. 5). If hydroelectric development takes place, jurisdictional questions will have to be resolved, preferably in cooperation with new private owners. Development of recreation opportunities may take quite opposite directions, depending on the final jurisdictional disposition of

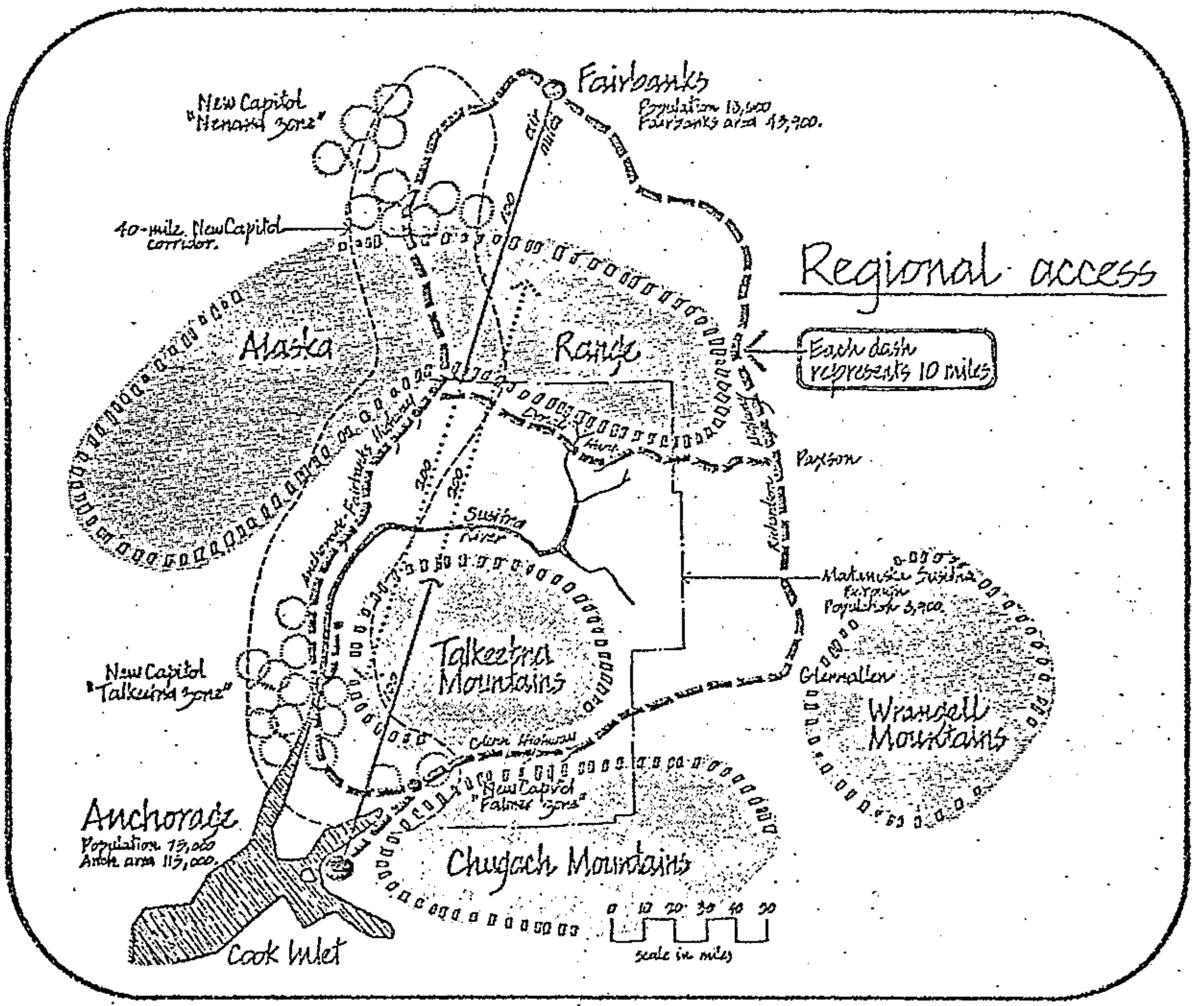


FIGURE 4. REGIONAL ACCESS

these lands. The river corridor could become a focus of relatively high-intensity recreational development ringed by mountain chains preserved in wilderness condition. Or the river corridor might be maintained in a state of semi-wilderness, managed by access restrictions.

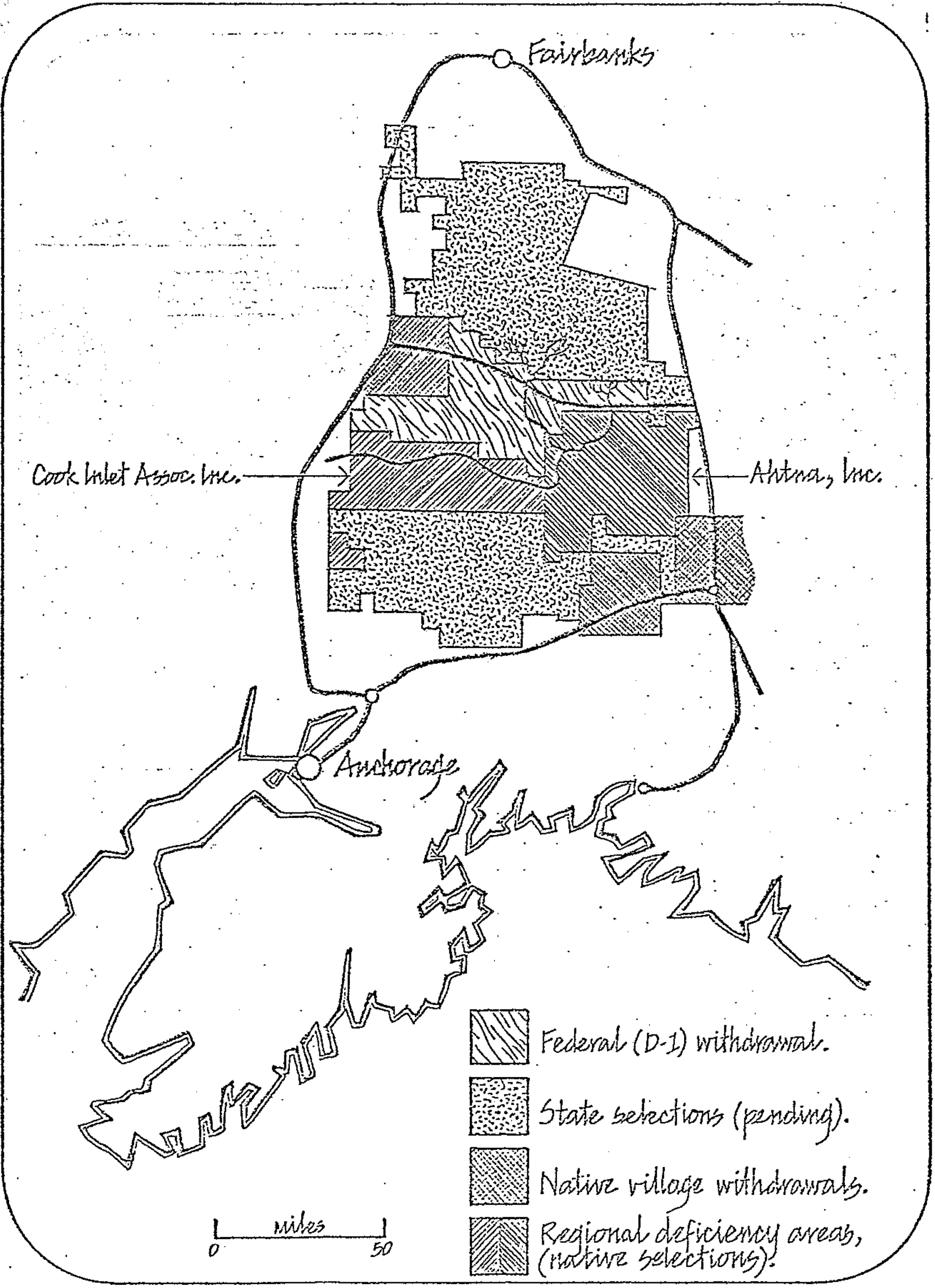


FIGURE 5. 1974 LAND OWNERSHIP STATUS

III. METHODOLOGY

The methodology of this study, the series of steps by which its conclusions have been reached, is diagrammed in figure 6. The discussion of methodology in this chapter follows this outline. There were, of course, feedback loops between many of the steps which are omitted in the diagram for clarity. While the methodology did develop and evolve during the study as specific steps were carried out, the outline and order of the steps is accurate.

STUDY AREA

This assessment deals with the resources of the upper Susitna River, from its headwaters at the mouths of three glaciers in the Alaska Range to the Gold Creek railroad bridge, some 200 river miles downstream. The recreational and aesthetic impacts of the proposed hydroelectric dams and their reservoirs are confined to this portion of the river, as are most of the environmental effects. There may be environmental impacts associated with changes in river flow regime below the Devil Canyon dam, both within the study area and further downstream; however, these are excluded from this assessment, as are the effects of the power transmission system which would branch off from Gold Creek toward Anchorage and Fairbanks (see the section Future Conditions Assessed).

Within this length of the Susitna, the resources of lands influencing or influenced by the river are

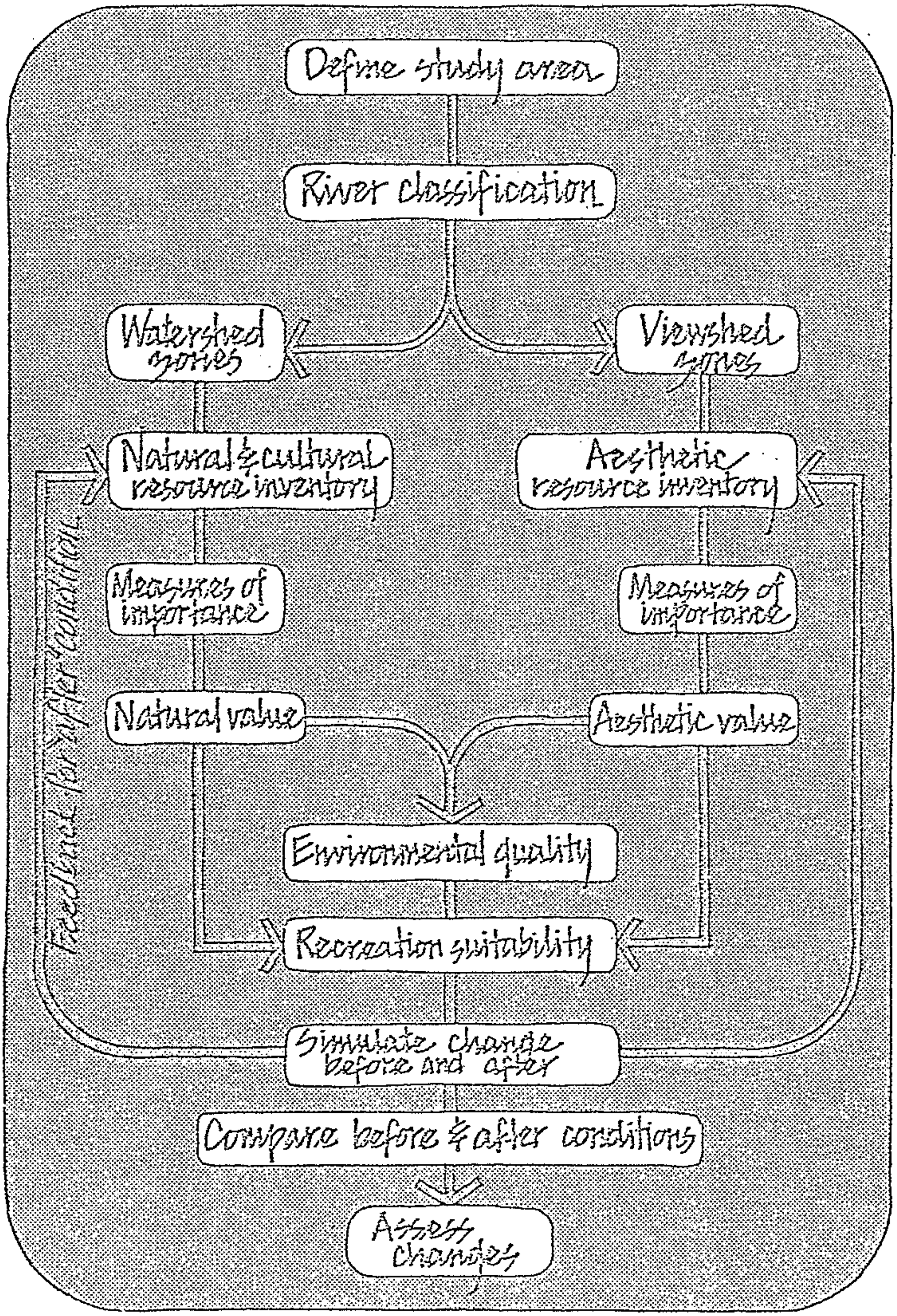


FIGURE 6. STUDY METHODOLOGY

evaluated. Physically, this includes all lands draining into the upper Susitna: its watershed. However, in order to include all terrain which contributes to river experience, we must look beyond the physical territory of the watershed to the visual domain of the river as well. This visual domain we will term the viewshed. Both the watershed and the viewshed can be mapped spatially, and the two together define the outer limits of the study area.

RIVER CLASSIFICATION

To provide a framework for assessment, the river has been subdivided and classified into segments. This framework makes it possible to spatially locate resources and values before and after consideration of the dams; this in turn is necessary to compare the effects of the low dams and to begin to suggest locations for the ancillary facilities that must eventually be planned for the project.

The classification of river segments is organized into four hierarchical levels, and is based on the characteristics of the river itself and the landscape which it drains and through which it passes. The first and highest level is that of the realm of the entire upper Susitna, considered as a whole. At the second level, the river has been divided into regions, based on the physiography of the surrounding terrain. Here we have followed Wahrhaftig, who has divided Alaska into 12 physiographic provinces with 60 physiographic sections. The Susitna lies within the Coastal Trough Province and portions of 6 sections fall within the watershed of the upper river (see figure 7). These sections are set apart by characteristic topography and land forms, inferring a degree of uniformity in the lithology and geologic history within each unit (the correlation between physiography and geology can be noted by comparing figures 7 and 3). Each river region has been given the name of the physiographic section through which it flows.

The reach is the third level of river classification and is defined by the interaction between physiography and river channel pattern. An understanding of the four basic recognized channel patterns or zones (Leopold,et al, 1964) is fundamental to any classification of river environments. Each distinct channel pattern is based on the relationship between the cohesiveness of the material through which the channel is cut, and the stream's discharge. Every river in the world may not exhibit each of the four channel pattern zones and the zones are not always in the same sequence: the fixed channel zone may not appear in a mature river flowing across a plain; a braided channel zone may flow into a fixed channel zone at a waterfall, or a looped meander channel zone may become a steeper braided channel zone downstream; the branched channel zone may not occur at all in young rivers tumbling directly into seas or lakes. Further, each channel zone contains its own characteristic resources and cannot be directly compared with another zone. Some of the typical attributes of the four zones are:

Fixed Channel Zone

series of nearly straight, non-meandering channel paths

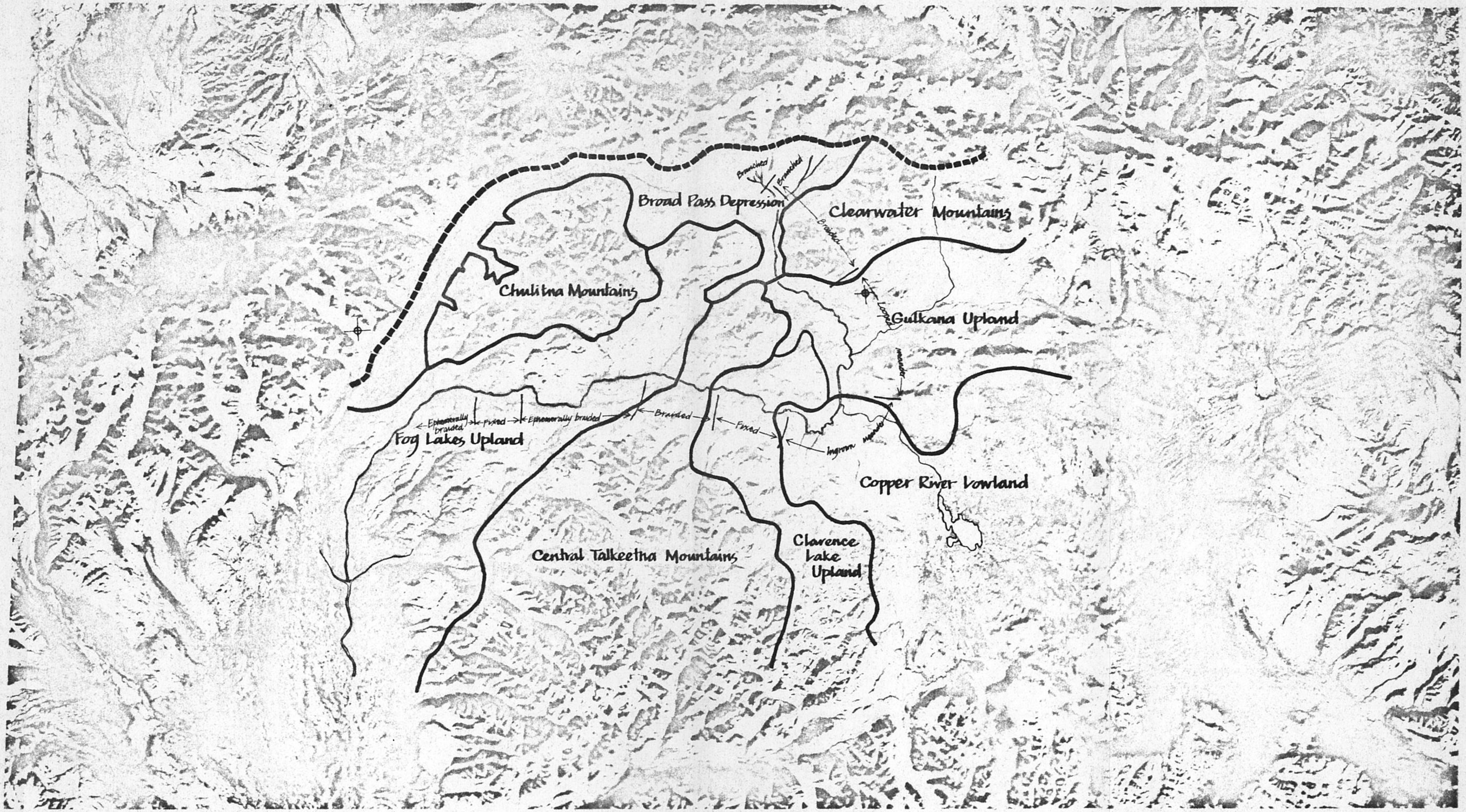


FIGURE 7 PHYSIOGRAPHIC SECTIONS AND RIVER CHANNEL TYPES

islands very rare

narrow valley floor, little or no floodplain

cobbles and boulders prevalent

turbulent, noisy streamflow, rapids and waterfalls, moving boulders and cobbles of considerable size

frequently very enclosed landscape of high contrasts

often steep, scenic headwaters in mountainous area

Braided Channel Zone

braided channels and small meanders

many islands

valley floor widens from Fixed Zone, floodplain develops

moderate stream gradient

sands, gravel and cobbles prevalent, banks erodible

pools and riffles, infrequent rapids, material in suspension, transportation

expansive views across wide streamway

beaches and bars ideal for recreation, canoeing and boating

Looped Meander Channel Zone

Sinuous meandering single channel, may have short straight portions

occasional islands

wide floodplain valley

moderate to low stream gradient

silt and sand deposition

smooth, quiet river current

open views

paths, bike trails and picnic spots possible along river's edge

Branched Channel Zone

several distributing tidal channels

many water courses

wide floodplain and tidal flats, often estuarine marshes

nearly flat stream gradient

mud flats and silts, infrequently sands

current may change directions, backflowing with rising tides, final deposition of load

wide open views across flat wetlands

waterfowl, fish, and other wildlife; highly productive natural area

On the upper Susitna (figure 7) there are several departures from the classic sequence of fixed-braided-looped meander-branched channel zones. These apparent anomalies reflect the river's own individualized character. They are also clues, as previously discussed, to the geologic history of the landscape through which the Susitna passes and which it has helped to form.

In brief, the river rises in a proglacial channel (inverted fan) zone, visually analogous to the branched channel zone. This is a departure not unusual among Alaskan rivers emerging from glaciers. The gradients in this zone of headwater collector channels are among the steepest on the river, the exact opposite of those typical of estuarine distributaries at river mouths; however, the gradients are very even and this zone looks very broad and flat to the eye. The Susitna then passes through braided and meandered zones, but becomes ingrown in the lakebed sediments of the Copper River Lowland, hinting at relatively recent uplift in this region. The river flows in a fixed channel zone through Vee Canyon, where it is subject to structural control, and then braids ephemerally in its deep V-shaped valley where it may be aggrading its bed. In periods of low water the river is somewhat undersized for its streamway and flows in several shifting channels. The gradient then steepens again and the Susitna rushes forward into Devil Canyon, a textbook example of a fixed channel. The river resumes its ephemeral braiding upon emerging from the Canyon and finally takes up the conventional channel zone sequence from here to the sea.

Fourteen river reaches have been identified by superimposing this sequence of channel zones on top of the river regions defined by physiography.

The fourth and most fine-grained level of river classification is the run. The identification of runs is based on an analysis of tributary stream orders, further refined by consideration of the orientation of the river corridor and its spatial character. Wherever, in a reach, the "sense-of-place" becomes distinctly different, an individual run has been identified. It is notable that the differentiation between runs within a reach is usually traceable to either a geologic feature (for example, a valley fault) or the entrance of a major tributary. The Upper Susitna has been classified into 28 runs (see table 1).

TABLE 1

SUSITNA RIVER CLASSIFICATION

Region/Reach	Run	Length (mi)	Gradient (ft/mi)
FOG LAKES UPLAND			
GOLD CREEK	INDIAN RIVER	8.00	15.0
	PORTAGE CREEK	5.25	17.1
DEVIL CANYON	LOWER DEVIL	6.25	20.8
	UPPER DEVIL	4.50	15.6
STEPHAN	LAST CHANCE	4.50	31.1
	STEPHAN LAKE	8.50	14.1
	TSUSENA/FOG CRKS.	6.30	12.7
FOG LAKES	DEADMAN CREEK	4.70	12.8
	WATANA CREEK	7.50	9.3
CENTRAL TALKEETNA MTNS.			
WATANA	MT. WATANA	5.50	10.9
	KOSINA CREEK	6.00	10.0
CLARENCE LAKE UPLAND			
CLARENCE	JAY CREEK	7.50	13.3
	VEE CANYON	9.50	16.8
COPPER RIVER LOWLAND			
TYONE	OSHETNA RIVER	10.60	18.9
	TYONE RIVER	9.80	9.2
GULKANA UPLAND			
MACLAREN	MACLAREN RIVER	11.50	7.0
	CLEARWATER CRK.	6.50	6.2
GOOSE ISLAND	DOGSLED	8.75	4.6
	RAFT CREEK	9.00	3.3

SUSITNA RIVER CLASSIFICATION (Continued)

Region/Reach	Run	Length (mi)	Gradient (ft/mi)
BROAD PASS DEPRESSION			
DENALI	WINDY/BUTTE CRKS.	4.24	4.7
	VALDEZ CREEK	7.25	5.5
CLEARWATER MTNS.	RUSTY HILL	10.50	5.7
	BOULDER CREEK	3.75	5.3
MIDDLE FORK	SUSITNA GLACIER	8.50	15.3
EAST FORK	LOWER E. FORK	7.25	20.7
	UPPER E. FORK	5.25	34.3
WEST FORK	LOWER W. FORK	6.50	12.3
	UPPER W. FORK	5.50	41.8
6 / 14	28	199.85 mi	10.5 ft/mi

The lands along the river also had to be demarcated into zones to transform this linear river segmentation into a spatial framework for analysis. Two overlapping spatial frameworks were actually developed, one for the material inventory of natural and cultural resources, and one for the perceptual inventory of aesthetic resources. As suggested earlier, the bases for these two inventories were the watershed and the viewshed.

The latter was defined as the visual domain of the river. More specifically, it includes all lands which can be seen from the river viewing corridor.

These lands lie in several discrete zones (figure 8). Included in the coterminous viewshed zone are all visible lands which are contiguous, i.e., the landscape extending from the river to the first topographic sightline interruption or crest on each side of the river. Within this zone, those lands visible from the river were termed the primary viewshed. Given the prominence of terraces on the Upper Susitna, the importance of the wildlife and other resources of these terraces to the visual experience of the river, and the prevalence of light aircraft in Alaskan transportation, the definition of the viewing corridor was expanded to include the airspace within the river valley from the river to an elevation just above the rim of the first terrace. The additional coterminous terrace landscape not visible from the surface of the river itself is called the supporting viewshed (much of this sub-zone would become part of the primary viewshed from the proposed reservoirs). The visual resources of the coterminous zone, comprising these two subzones, are allocated to the river run to which the lands are adjacent.

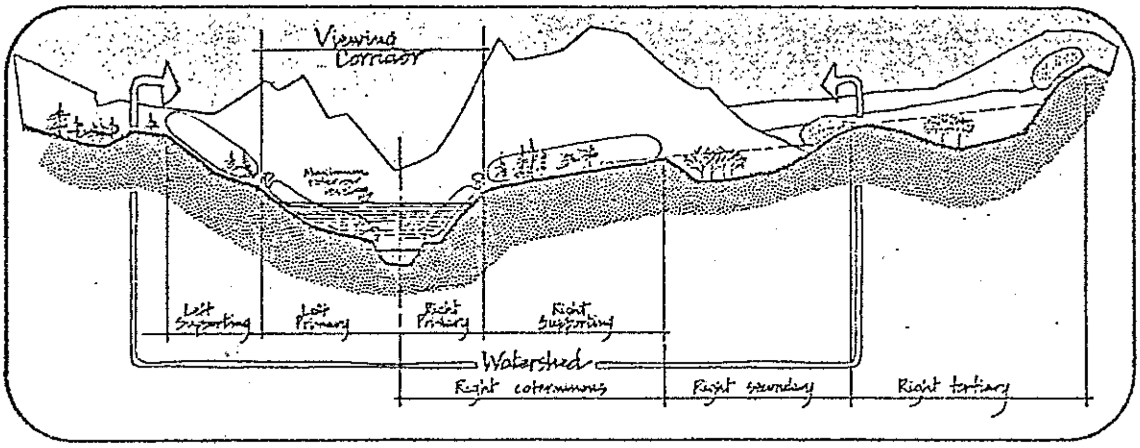


FIGURE 8. VIEWSHED STRUCTURE

The secondary viewshed zone includes all the non-contiguous lands visible from the viewing corridor which are within the study area watershed; from a given run, it also includes the visible portions of the coterminous zones of adjacent runs. The tertiary viewshed is defined similarly for visible lands outside the watershed of the Upper Susitna.

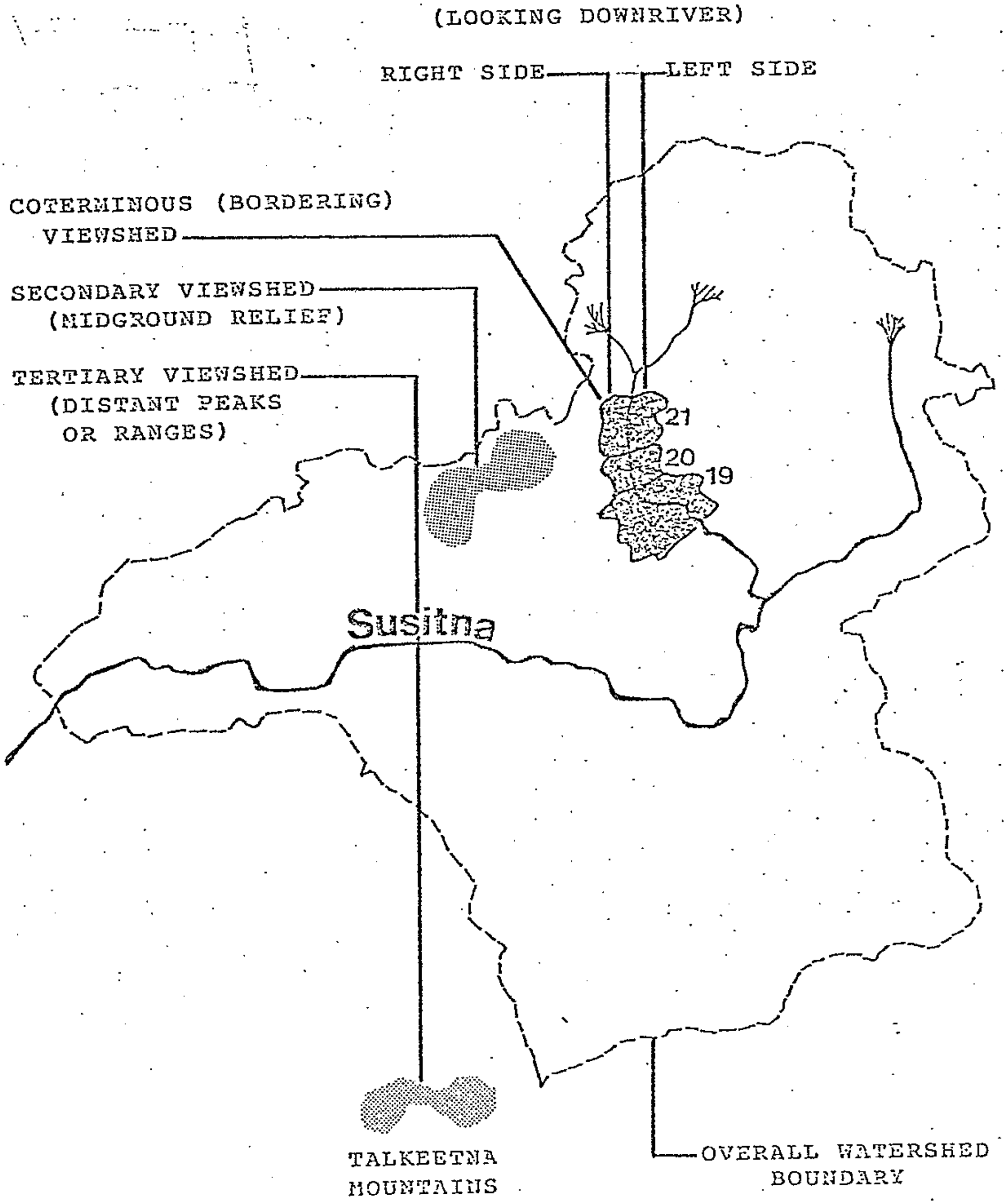
Viewshed zones have been further differentiated by the side of the river on which they occur, looking downstream.

Neither the secondary nor tertiary zones have been allocated to individual river runs, although this can be done by mapping the viewshed of each run separately. This was unnecessary for this study because the visual effects of the dams and reservoirs will be confined to the river corridor. However, it would be advisable to make the additional differentiation when assessing the visual effects of alternative access road or transmission line corridors.

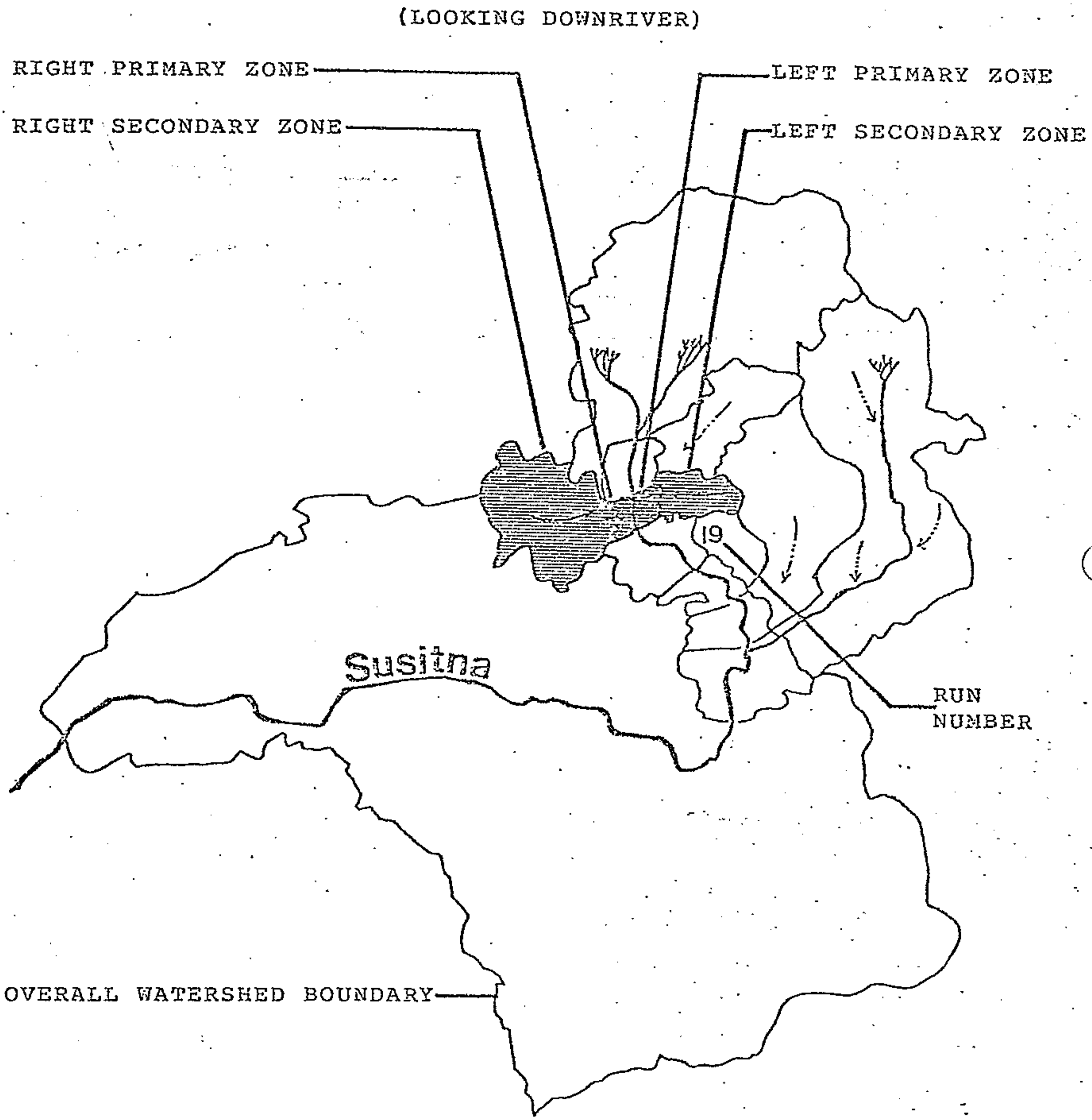
The viewshed classification of the Upper Susitna has been mapped in figure 9. The inner boundary line is that of the coterminous viewshed and its contiguity is evident. Some apparently contiguous lands are not visible from the run adjacent and are therefore not included within the coterminous zone. Dashed lines indicate an indefinite boundary, and outward pointing arrows indicate the expansiveness of certain coterminous viewsheds, delimited only by very slight topography. The outer watershed boundary is indicated, differentiating the secondary and tertiary viewsheds. The left side of the river is on the north and west.

The watershed classification is mapped in figure 10. This classification, also left and right-sided, was derived by mapping the watershed of each river run along the Upper Susitna. The watersheds of the 28 runs were further differentiated into primary and secondary watershed zones, based on their relative influence on the river and vice versa. The primary watershed zone was defined as that portion of the watershed overlapped by the coterminous viewshed of that run. Thus, considering left and right sides, there are 28 x 2 = 56 primary watershed zones in the classification. Of these, 14 zones are entirely contained within the coterminous viewshed, so there are 42 secondary watershed zones.

River viewshed · legend



River watershed · legend



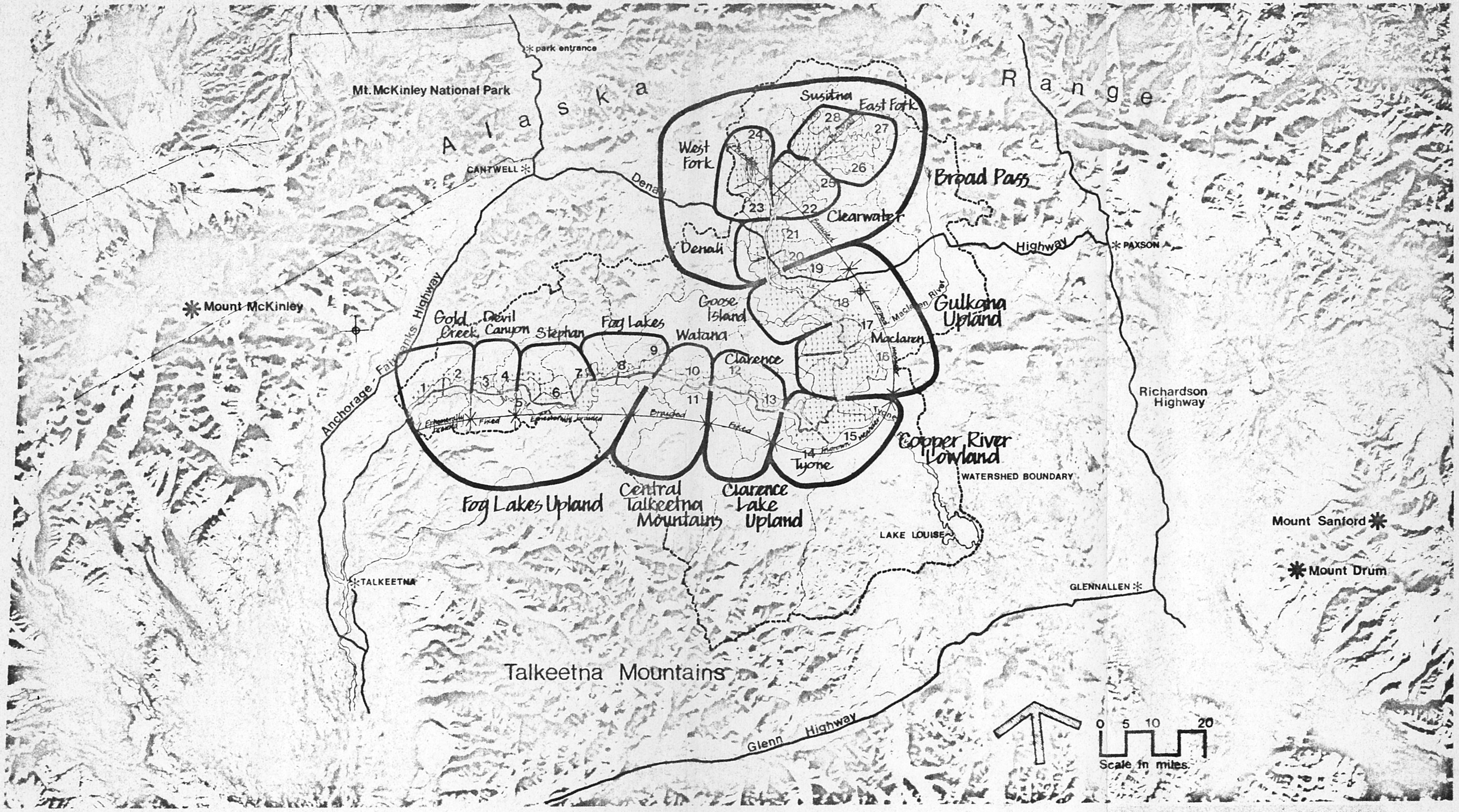


FIGURE 9 RIVER VIEWSHED CLASSIFICATION

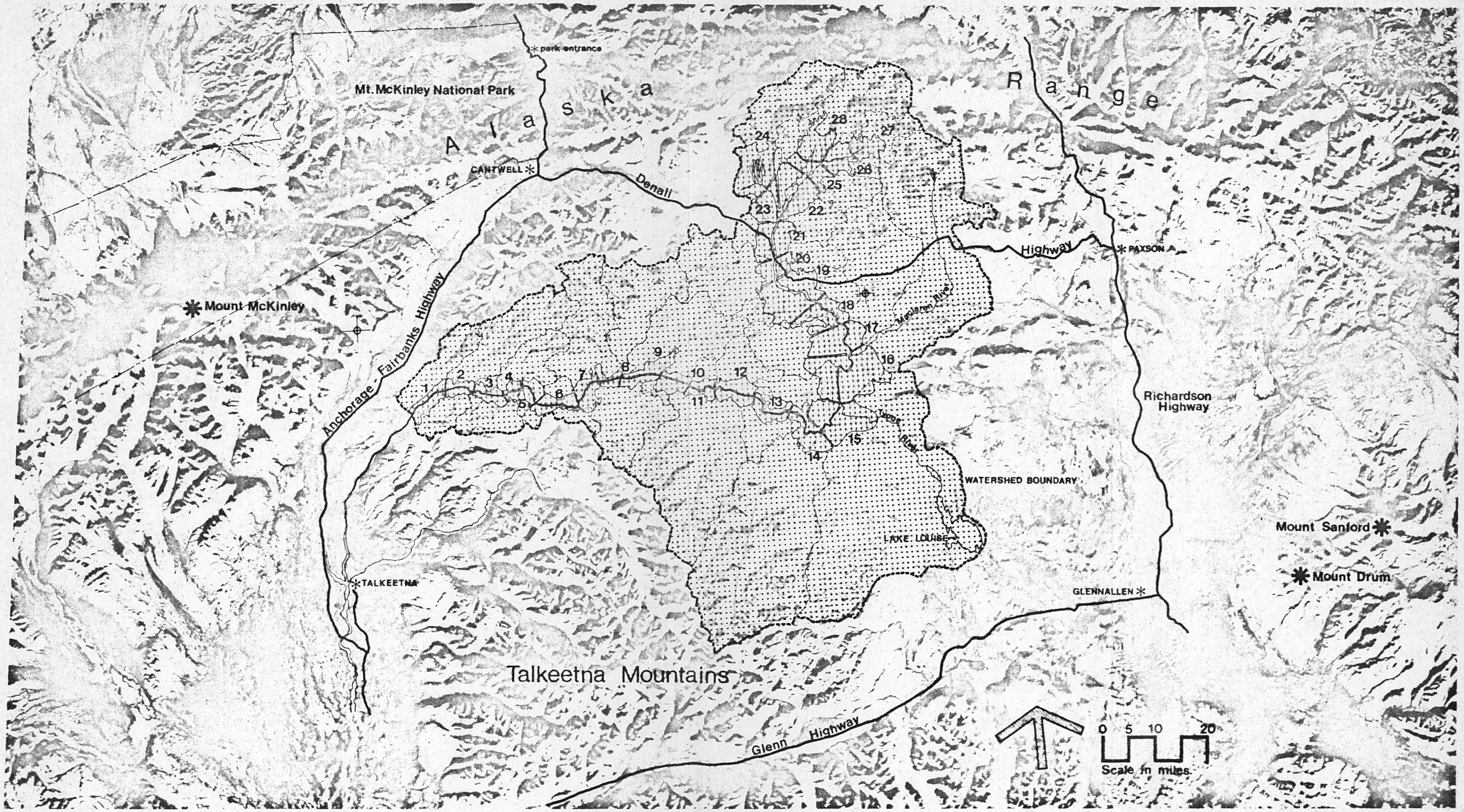


FIGURE 10 RIVER WATERSHED CLASSIFICATION

DATA BASE

Natural/Cultural Resources and Visual Resources.

Having developed a hierarchy of river segments, it was possible to proceed effectively with the inventory of Upper Susitna resources. These were divided at the outset of the inventory into two groups: visual resources and natural/cultural resources. Information on the first group, the data base for the aesthetic assessment, had to be gathered primarily in the field and from an extensive slide record of the field reconnaissance. Data on the second group of resources, the base for determining natural and cultural value, were acquired in large degree from published material and interviews. The organization of each data base is very similar, deriving from the conceptual data structure displayed in figure 11. The general organization of the data bases for the natural/cultural resources and visual resources is shown in figures 12 and 13.

Figure 11 CONCEPTUAL DATA STRUCTURE

<table>
<tr><td colspan="8">LANDSCAPE</td></tr>
<tr><td>TERRAIN</td><td colspan="7">COVER</td></tr>
<tr><td colspan="3">Physical</td><td colspan="3">Biological</td><td colspan="2">Cultural</td></tr>
<tr><td>geologic</td><td>climatic</td><td>hydrologic</td><td>edaphic</td><td>botanic</td><td>zoologic</td><td>structural</td><td>social</td></tr>
</table>

Figure 12 NATURAL / CULTURAL RESOURCES DATA BASE

<table>
<tr><td colspan="3">Physical</td><td colspan="3">Biological</td><td>Cultural</td></tr>
<tr><td>geologic</td><td>climatic</td><td>hydrologic</td><td>edaphic</td><td>botanic</td><td>zoologic</td><td>human use</td></tr>
</table>

Figure 13 VISUAL RESOURCES DATA BASE

<table>
<tr><td>TERRAIN</td><td colspan="5">COVER</td></tr>
<tr><td colspan="5">Natural</td><td>Cultural</td></tr>
<tr><td>landform</td><td>skyform</td><td>waterform</td><td>vegetation</td><td>wildlife</td><td>structures</td></tr>
</table>

Resources were inventoried at four ordinal levels of magnitude, and this information was recorded, again, in two matrices. The data variables for each were organized according to the structures displayed in figures 12 and 13; 112 individual variables were included in the natural/cultural resource inventory and 27 in the aesthetic resource inventory.

The vertical axis of both matrices was the river run, but the actual data unit was the watershed or viewshed zone. In the matrices, these were arranged about a vertical centerline for each data variable and this centerline may be thought of as the river. For example, in the natural/cultural resource matrix, the zones,reading across, are the left secondary (LS), left primary (LP), right primary (RP) and right secondary (RS). The record of each individual data variable is thus organized as a diagrammatic strip map of the river. The complete matrices can be examined in Appendix C, at the end of this report.

The inventory of resources sought to be as comprehensive in detail as possible within the time constraints of the study. The resource data characteristics and the magnitude rating scales used in the inventory are found in tables 2 and 3 . Further information on methods used to rate resource magnitude are included in Appendix C . As mentioned, the natural/cultural resources were to be acquired primarily from available literature, and several areas of sparse information soon revealed themselves. Many of these data gaps were filled by discussions with knowledgeable state and federal agency staff as well as several Alaskan private citizens. Consultants were also retained to fill in certain areas. However, the information coverage still remains thin in some respects, notably for certain types of wildlife.

A brief outline of the principal sources and scales of information inventoried under "natural and cultural resources" follows:

a. Geology; the generally available published material is scanty, so a consultant was retained.

b. Climate; observations within the study area were unavailable, and data were generalized from available records in accordance with generally accepted climatological principles.

c. Hydrology; A.P.A. and Corps data, U.S.G.S. maps, and field reconnaissance were the sources used except for the whitewater classification. Mr. and Mrs. Jules Tileston of the Knik Canoe Club advised on the I.A.C. whitewater ratings assigned to the river runs.

d. Soils (edaphic units); the L.U.P.C. 1/250,000 soil maps and Alaska Regional Profiles: Southcentral Region were the sources employed.

e. Botany; since the L.U.P.C. maps are not yet complete for the study area, a consultant was retained to identify vegetation association types from air photography and slides, supplemented by ground verifications made during field reconnaissance.

f. Zoology; heavy reliance was placed on Alaska's Wildlife and Habitat, supplemented by numerous A.D.F. & G. reports and Skoog's Ecology of the Caribou, for the ungulates and large carnivores. However, much work remains to be done in this area and distributional data is almost entirely lacking for small mammals and several of the large carnivores. Bird distributions and populations are also little known in the study area, although some generalized waterfowl information is available and an on-site investigation of raptors was commissioned in the river corridor by the U.S. Fish and Wildlife Service. Fish populations in the study area are also under continuing investigation by that agency and the Alaska Department of Fish and Game. Past reports were supplemented by the fortunate opportunity to observe field investigations and to discuss this on-going work with some of the biologists involved.

g. Human use; U.S.G.S. maps, the Southcentral Profile, field reconnaissance, and discussion with the operators of a lodge on the river served to identify much, but not all, of the land use in the study area. The secondary watershed zones on the left side of the river may therefore contain some low-intensity uses in addition to those inventoried. Numerous federal, state and local agency reports were studied for clues to the future use and ownership of the area and its potential for recreational use. The archeology of the study area - its past use - is only partially known; published material and discussions with an archeologist attached to the Alaska Division of Parks provided the information recorded in the inventory.

TABLE 2

MAGNITUDE OF EXPRESSION RATING SCALES, NATRUAL AND CULTURAL RESOURCES*

I. PHYSICAL	High	Moderate	Low	Absent
A. GEOLOGIC				
1. FAULTING - TECTONICS				
a. Bedrock				
1. Linear Valleys	Prominent example	Moderate example	Minor example	Absent
2. Alpine Regions -	"	"	"	"
Basins - Faults	"	"	"	"
b. Fluvio - Glacial				
1. Hanging Valleys	"	"	"	"
c. Glacial				
1. Offest Glaciers	"	"	"	"
2. SOLIFLUCTION				
a. Fluvio - Proglacial				
1. Patterned Ground	"	"	"	"
Ground Creep	"	"	"	"
b. Fluvio - Glacial				
1. Asymmetric Valleys	"	"	"	"

*Note: See Appendix C for details of magnitude rating methods.

I. PHYSICAL	High	Moderate	Low	Absent
3. PERIGLACIAL				
a. Bedrock	Prominent example	Moderate example	Minor example	Absent
1. Vallons de Gelivation				
Talus Accumulations	"	"	"	"
Rock Glaciers	"	"	"	"
2. Asymmetric Valleys	"	"	"	"
b. Fluvio - Proglacial				
1. Patterned Ground	"	"	"	"
c. Glacial				
1. Patterned Ground	"	"	"	"
4. GLACIAL				
a. Bedrock				
1. U-shaped Valleys	"	"	"	"
2. Cirques-Hanging Val.	"	"	"	"
Roches Moutonees	"	"	"	"
b. Fluvio - Proglacial				
1. Drift Mantle	"	"	"	"
c. Glacial				
1. Drumlins-Moraines	"	"	"	"
Ice-cored Moraines	"	"	"	"
5. FLUVIAL				
a. Bedrock				
1. V-shaped Valleys	"	"	"	"
2. Canyons	"	"	"	"
3. Gorges	"	"	"	"
4. Terraces-Rill Channels	"	"	"	"

I. PHYSICAL (Continued)	High	Moderate	Low	Absent
b. Fluvio - Proglacial				
1. Meander Scars	Prominent example	Moderate example	Minor example	Absent
c. Glacial				
1. Eskers-Kames	"	"	"	"
B. CLIMATIC				
1. SURFACE HEATING	High	Moderate	Low	N/A
2. LOCAL CLIMATIC STRESS	HH	MM-LMH	LL	N/A
C. HYDROLOGIC				
1. MAINSTEM				
a. Hydrology				
1. I.A.C. Class	V, VI	III, IV	I, II	Slack water
2. Volume	Over 6300 cfs	6300-2700 cfs	Under 2700 cfs	N/A
3. Average Gradient	Over 25 ft/mi	25-15 ft/mi	15-2.5 ft/mi	2.5-0 ft/m
4. Offset Stream	Prom. example	Mod. example	Minor example	Absent
5. Streamform Incision	a.Entrenched loop/meander b.Incised fixed	a.Braided b.Looped meander	a.Fixed or branched b.Ephemerally braided	Slack wate
b. Channel Features				
1. Drops-Whirlpools	Prom. example	Mod. example	Minor example	Slack wate
2. Rapids	"	"	"	"
3. Cutbanks-Outcrops	"	"	"	Absent
4. Pools-Riffles	"	"	"	Slack wate
5. Islands (Vegetated)	2/3,3/2,3/3	2/1,2/2,3/1	1/1,1/2	Absent
6. River Bars (Unvegetated)	"	"	"	"
7. Point Bars-Beaches	Prom. example	Mod. example	Minor example	"

I. PHYSICAL (continued)	High	Moderate	Low	Absent
2. MAJOR TRIBUTARIES				
a. Hydrology				
1. Stream Order	Fourth	Third	Second	First or zero
2. Maximum Gradient (Primary Zone)	Over 25 ft/mi	25-15 ft/mi	15-2.5 ft/mi	2.5-0 ft/mi
3. Turbidity	Clear	Sl. turbid	Mod. turbid	Very turbid
4. Watershed Area	1000-100 sq mi	100-10 sq mi	10-1 sq mi	N/A
b. Channel Features				
1. Number of Major Tributaries	Three or more	Two	One	None
2. Waterfalls	"	"	"	"
3. Rapids	Prom. example	Mod. example	Minor example	Absent
4. Pools-Riffles	"	"	"	"
5. Cutbanks-Outcrops	"	"	"	"
6. Islands (Vegetated)	2/3,3/2,3/3	2/1,2/2,3/1	1/1,1/2	"
7. River Bars (Unvegetated)	"	"	"	"
8. Point Bars-Beaches	Prom. example	Mod. example	Minor example	"
9. Confluence Delta(s)	Several Chan.	Two Channels	One Channel	"
3. WATERSHED FEATURES				
a. Lakes	2/3,3/2,3/3	2/1,2/2,3/1	1/1,1/2	"
b. Ponds (Drained)	Three or more	Two	One	"
c. Ponds (Undrained)	"	"	"	"
d. Oxbow Lakes	"	"	"	"
e. Sloughs	"	"	"	"

II. BIOLOGIC	High	Moderate	Low	Absent
A. EDAPHIC				
1. WELL DRAINED	More than 75%	75-25%	25%-trace	Absent
2. WELL DRAINED WITH PERMAFROST	"	"	"	"
3. POORLY DRAINED	"	"	"	"
4. STEEP-ROCKY/ICELANDS	"	"	"	"
B. BOTANIC				
1. BOTTOMLAND SPRUCE-POPLAR	More than 25%	25-12.5%	12.5%-trace	Absent
2. UPLAND SPRUCE-HARDWOOD	"	"	"	"
3. UPLAND HARDWOOD-SPRUCE	"	"	"	"
4. HIGH BRUSH	"	"	"	"
5. LOWLAND SPRUCE-HARDWOOD	"	"	"	"
6. LOWLAND SPRUCE BOG	"	"	"	"
7. LOW BRUSH	"	"	"	"
8. MUSKEG	"	"	"	"
9. MOIST TUNDRA	"	"	"	"
10. WET TUNDRA	"	"	"	"
11. ALPINE TUNDRA	"	"	"	"

II. **BIOLOGIC** (Continued)	High	Moderate	Low	Absent
C. ZOOLOGIC				
1. MAMMALS				
a. Ungulates				
1. Dall Sheep	100%	99-50%	50%-trace	0%
2. Mountain Goat	"	"	"	"
3. Moose (presence)	N/A	N/A	Presence	N/A
4. Moose (winter)	100%	99-50%	50%-trace	0%
5. Moose (spring)	"	"	"	"
6. Moose (summer)	"	"	"	"
7. Moose (fall)	"	"	"	"
8. Caribou (presence)	N/A	N/A	Presence	N/A
9. Caribou (winter)	100%	99-50%	50%-trace	0%
10. Caribou (spring)	"	"	"	"
11. Caribou (summer)	"	"	"	"
12. Caribou (fall)	"	"	"	"
13. Caribou (migration routes)	Mapped routes	Inferred routes	N/A	Absent
b. Carnivores				
1. Wolf	N/A	N/A	Presence	N/A
2. Wolverine	"	"	"	"
3. Black Bear	"	"	"	"
4. Grizzly Bear Presence	"	"	"	"
5. Grizzly Bear Denning	Extensive sites	2 or more small dens	1 small den	Absent
6. Grizzly Bear Fishing	More than 0.5 mi	0.5-0.25 mi	0.25-trace mi	"
c. Small Mammals	N/A	N/A	Presence	N/A

II. BIOLOGIC (Continued)	High	Moderate	Low	Absent
2. BIRDS				
a. Raptors	Mapped sightings	N/A	Presence	N/A
b. Waterfowl	Nesting & moulting	Mod. Concentrations	Low Concentrations	Absent
3. FISH				
a. Anadromous	Spawning	Present	Possible	Absent
b. Freshwater	Spawning & wintering	"	"	"
III. CULTURAL				
A. HUMAN USE				
1. SETTLEMENT				
a. Archeological Sites	Surveyed	Known	Possible	Prob. absent
b. Campsites	3 or more known	2 known	1 known	Unknown
c. Cabins-Cottages	"	"	"	"
d. Resorts-Lodges	Major	Moderate	Primitive	Absent
e. Towns-Villages	N/A	N/A	Small	Absent
2. ACCESSIBILITY				
a. Facility Dependent				
1. Rail	100-66%	66-33%	33%-trace	Absent
2. Auto	All-weather highway	Unimproved highway	N/A	"

III. CULTURAL (Continued)	High	Moderate	Low	Absent
3. Air	Airfield	Airstrip	N/A	Absent
b. Facility Independent				
1. Air	Low limits	Mod. limits	High limits	Very dang
2. Boat	Power	Raft	Kayak	Impossibl
3. A.T.V.	Low limits	Mod. limits	High limits	"
4. Sled	"	"	"	"
5. Foot	"	"	"	"
3. UTILITIES				
a. Major	Very prominent	Mod. prominent	Minor	Absent
b. Secondary	Undetermined	Undetermined	Undetermined	"
c. Overhead	Major	Intermediate	Minor	"
d. Underground	100-66%	66-33%	33%-trace	"
4. EXTRACTION				
a. Surface	Major workings	Several mod.	1 or 2 minor	Absent/un
b. Subsurface	"	"	"	"
5. OWNERSHIP				
a. Federal Withdrawals	100-66%	66-33%	33%-trace	Absent
b. State Selections	"	"	"	"
c. Native Withdrawals	"	"	"	"

TABLE 3

MAGNITUDE OF EXPRESSION RATING SCALES, AESTHETIC RESOURCES

I. LANDFORM	High	Moderate	Low	Absent
A. SPATIAL DEFINITION				
1. EXPANSIVENESS, in:				
a. Coterminous viewshed	Pronounced	Moderate	Slight	Absent
b. Secondary viewshed	"	"	"	"
c. Tertiary viewshed	"	"	"	"
2. ENCLOSURE, in:				
a. Coterminous viewshed				
1. primary zone	Pronounced	Moderate	Slight	Absent
2. supporting zone	"	"	"	"
b. Secondary viewshed	"	"	"	"
B. SURFACE PATTERN/EDGE DEFINITION				
1. SURFACE DEFINITION OR DISSECTION	Pronounced	Moderate	Slight	Absent
2. OVERLAPPING LANDFORMS OR PLANAR ZONES	"	"	"	"
3. SKYLINE AND BASAL BOUDARY DEFINITION	"	"	"	"

TABLE 3

MAGNITUDE OF EXPRESSION RATING SCALES, AESTHETIC RESOURCES

I. LANDFORM	High	Moderate	Low	Absent
A. SPATIAL DEFINITION				
1. EXPANSIVENESS, in:				
a. Coterminous viewshed	Pronounced	Moderate	Slight	Absent
b. Secondary viewshed	"	"	"	"
c. Tertiary viewshed	"	"	"	"
2. ENCLOSURE, in:				
a. Coterminous viewshed				
1. primary zone	Pronounced	Moderate	Slight	Absent
2. supporting zone	"	"	"	"
b. Secondary viewshed	"	"	"	"
B. SURFACE PATTERN/EDGE DEFINITION				
1. SURFACE DEFINITION OR DISSECTION	Pronounced	Moderate	Slight	Absent
2. OVERLAPPING LANDFORMS OR PLANAR ZONES	"	"	"	"
3. SKYLINE AND BASAL BOUDARY DEFINITION	"	"	"	"

I. LANDFORM (Continued)	High	Moderate	Low	Absent
C. RELIEF				
1. MAXIMUM, in:				
a. Coterminous viewshed	+2000'	1000-2000'	1-1000'	0'
b. Secondary viewshed	+6000'	3000-6000'	1-3000'	0'
2. TYPICAL, in:				
a. Coterminous viewshed	+1000'	500-1000'	1-500'	0'
b. Secondary viewshed	+3000'	1500-3000'	1-1500'	0'
D. LANDMARKS				
1. COTERMINOUS VIEWSHED	Highly Prominent	Moderately Prominent	Least Prominent	Absent
2. SECONDARY VIEWSHED	"	"	"	"
3. TERTIARY VIEWSHED	"	"	"	"

A = Mt. McKinley
B = Mt. Hayes
C = Mt. Hess
D = Mt. Deborah
E = Clearwater Mountains
F = Rusty Hill
G = Butte Mountain
H = Mt. Watana
I = Central Talkeetna Mountains
J = Tsusena Butte
K = Mt. Sanford/Mt. Drum

I. LANDFORM (Continued)	High	Moderate	Low	Absent
E. SEQUENCE				
1. DIRECTIONAL SEQUENCE	High Complexity	Moderate Complexity	Low Complexity	No Complexity
2. SPATIAL SEQUENCE	"	"	"	"
3. END CLOSURE OF RUN	"	"	"	"
II. SKYFORM				
A. CHARACTERISTIC CLOUDFORM	Overcast	Broken	Scattered	Clear
B. EXPANSIVENESS	Pronounced	Moderate	Slight	Absent
III. WATERFORM				
A. RIVER MAINSTEM				
1. Water edge definition	Steep	Moderate	Gentle	Absent
2. Waterform pattern	High Complexity	Moderate Complexity	Low Complexity	No Complexity
3. Waterform texture	"	"	"	"
B. MAJOR TRIBUTARIES				
1. Water edge definition	Steep	Moderate	Gentle	Absent
2. Waterform pattern	High Complexity	Moderate Complexity	Low Complexity	No Complexity
3. Waterform texture	"	"	"	"
4. Confluence visibility	High	Moderate	Low	Absent

III. WATERFORM (Continued)	High	Moderate	Low	Absent
C. WATERSHED FEATURES	Highly Prominent	Moderately Prominent	Least Prominent	Absent
IV. VEGETATION FORM				
A. ENCLOSURE	High	Moderate	Low	Absent
B. PATTERN	High Complexity	Moderate Complexity	Low Complexity	Absent
C. PROFILE	High Irregularity	Moderate Irregularity	Low Irregularity	Absent
D. CONTRAST BETWEEN VEGETATION TYPES	High	Moderate	Low	Absent
V. WILDLIFE FORM				
A. NUMBERS: PRESENCE OF SEASONAL CONCENTRATIONS	High Probability	Moderate Probability	Low Probability	Unlikely
B. VARIETY OF SPECIES ATTRACTING VISUAL INTEREST	"	"	"	"
VI. MAN-MADE FORM				
A. STRUCTURES	Highly Prominent	Moderately Prominent	Least Prominent	Absent

RECREATION RESOURCES

The recreation resources inherent within the study area are subsumed within the visual and natural/cultural resource data bases just described. These include resources that attract recreational use, resources that make use possible, and resources that constrain use. Constraints and usability factors are in general endogenous to a study area, while attractions must be considered within a regional context. Further, attractiveness for recreation is not only based on the supply of site resources valued in a wider region, but also on the provision of man-made facilities. Therefore, any resource analysis of recreation attractiveness must be developed concurrently with a recreation plan which considers competing resources off-site, regional recreation patterns, and proposed site facilities.

This assessment, which does not include a recreation plan, is primarily concerned with the constraint and usability aspects of study area recreation resources, i.e., recreation suitability, although the data base also inventories those resources which attract recreation use now and those which will attract it in the future, if the proposed hydroelectric system is built.

NATURAL AND CULTURAL MEASURES OF IMPORTANCE AND THE DETERMINATION OF NATURAL VALUE

Measures of Importance and Natural Value

The individual natural and cultural resources of comparably scaled river units cannot be directly compared, even on the basis of a thorough inventory of the occurrence and magnitude of these river and riverscape characteristics. This is the case because the characteristic resource base differs for each physiographic section (region) and each river channel pattern (reach); in general, no common base of comparability exists at the level of the quantitative data inventory, since the very segmentation of the river is based on distinctive complexes of resources.

In order to compare units, we must evaluate the quality of the natural and cultural resources defining each river unit. The chosen scale of evaluation is that of the smallest distinctive unit identified in this study, the river run, and its primary and secondary zones. The basis for comparision is the degree to which characteristic natural processes are operative in these zones, as evidenced by characteristic forms: that is, how strongly the river and its landscape express themselves. To the degree that the characteristic processes have not been obstructed or obscured, we may speak of landscape health and integrity.

The measure of landscape integrity and health can be taken by considering three dimensions of the resource base: fragility (F), diversity (D) and natural intactness (NI). When adjusted by the natural uniqueness (NU) of each resource complex, a culturally important factor, we obtain a quantification, or model, of the natural value (NV) of each river run in terms of the strength and integrity of its characteristic natural processes:

$$NV = \frac{F + D + NI}{3} \div NU$$

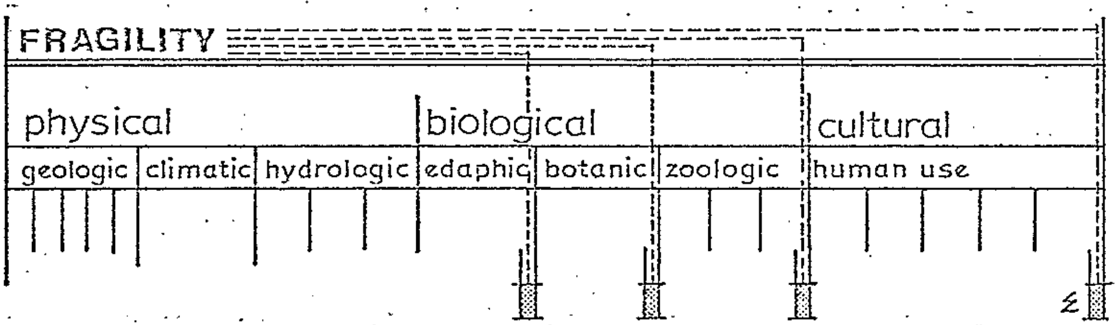
River runs can now be compared along this qualitative baseline.

The definitions of fragility, diversity, natural intactness and natural uniqueness, and the simple models with which each was measured from the resource base follow in the next section. Two additional measures, seasonal availability and accessibility, are also defined and described; these are measures of the resource base relating to its usability for human purposes, and their utility in determining recreation suitability is explained in the section dealing with that analysis.

Fragility

Fragility is defined here as a measure of the sensitivity of biologic resources to change and the ability to survive environmental stress. Generally, as an area is progressively impacted, its natural systems become less and less fragile as they become more coarse; e.g., a parking lot is less fragile than an alpine meadow. The presence of intolerant species suggests minimal interference with natural systems, and high fragility is therefore considered evidence of landscape integrity.

Fragility was measured on a seven-level interval scale over the biological portion of the natural and cultural resources data base:



There were four steps in the process:

a. Rate individual biological resource fragility.

b. Tabulate levels of fragility within the three biological resource categories in each watershed zone.

c. Determine category fragility

d. Determine overall biological fragility (indicated by the summation sign in the diagram above).

Resource fragility was rated High, Moderate or Low, based on the inherent sensitivity of the resource and its powers of survival. Typical examples of rating in each of the three biological resource categories at High (H), Moderate (M), or Low (L) magnitudes of individual resource variables are:

	Low Fragility	Mod. Fragility	High Fragility
Edaphic	well-drained soils (HML)	poorly drained soils (L)	poorly drained soils (HM)
Botanic	upland spruce (HML)	moist tundra (HML)	alpine tundra (HML)
Zoologic	waterfowl (L)	caribou wintering (HML)	waterfowl (H)

The fragility of each biological category was determined by use of a stepped matrix based in each instance on the range of existing occurrences of fragile resources on the river. The highest level attained in this matrix predominated. The matrix for zoologic fragility in the primary zone is reproduced here as an example:

Resource	Zoologic Fragility						
Fragility	VH	H	MH	M	ML	L	VL
High	3	2	1				
Mod.			5,4	3	2,1		
Low					3	2	1

Here it is seen that zoologic fragility is measured on a seven-level scale, ranging from Very High (VH) to Very Low (VL). The numbers in this matrix refer to number of times resources at a given fragility level occur within the left or right primary watershed zone of each run.

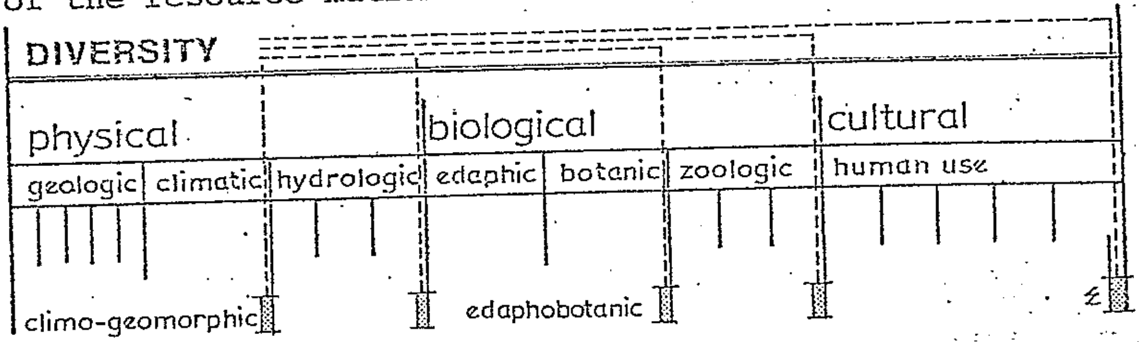
Overall biological fragility was determined by tabulating the level of edaphic, botanic and zoologic fragility in each zone of each run and referring to the following matrix, again with the highest level attained predominating:

Category	Overall Biological Fragility						
Fragility	VH	H	MH	M	ML	L	VL
VH	3,2	1					
H		3,2	1				
MH			3,2	1			
M				3,2	1		
ML					3,2	1	
L						3,2	1
VL							3

Diversity

A key indicator of the health of a given environment, diversity accounts for the adaptability, resilience, and richness of natural systems. It relates to the abundance, variety, and complexity of the resources of the river and the riverscape. Diversity helps to maintain stability within ecosystems and also has a cultural utility value: it promotes mental well-being in people by providing different kinds of opportunities and surroundings for self-expression and creativity.

Diversity was measured separately in the primary and secondary zones, across all natural resources, i.e., the physical and biological portions of the resource matrix:



The five steps in the process were:

a. Tabulate and sum resource occurrence, at any level of magnitude, in the four resource categories.

b. Normalize the sums into seven levels, corresponding to the range Very High to Very Low.

c. Rank each watershed zone for each of the four categories.

d. Add the four ranks in each zone.

e. Determine total diversity of each zone.

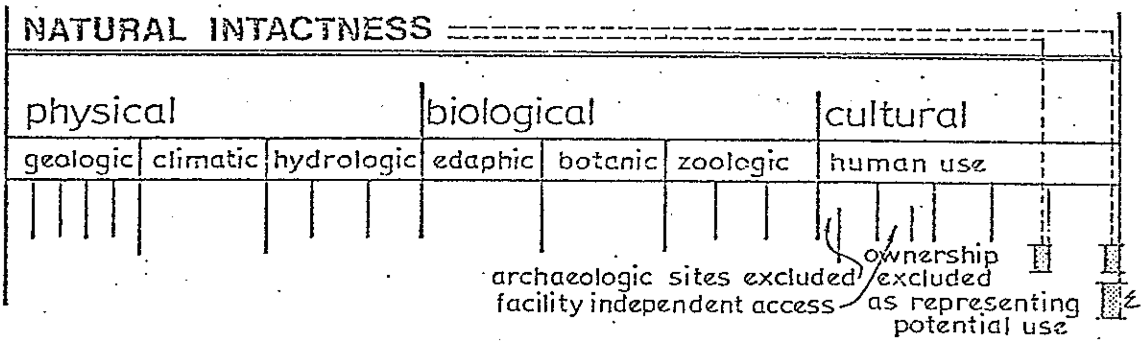
The total natural diversity of each zone was determined by reference to this table:

Sum of Ranks	Total Natural Diversity
4.0-7.3	VH = Very High
7.4-10.8	H = High
10.9-14.2	MH = Mod. High
14.3-17.6	M = Moderate
17.7-21.0	ML = Mod. Low
21.1-24.5	L = Low
24.6-28.0	VL = Very Low

Natural Intactness

Resource intactness is a measure of the extent to which natural processes are not obscured or obstructed, and therefore is a measure of landscape integrity. Its inverse is encroachment, the degree of intrusion upon the landscape resource base.

Natural intactness was inferred by measuring the level of human use, found in the cultural portion of the resource matrix:



The steps in measurement were:

a. Rate human uses for encroachment.

b. Tabulate number of uses occurring in each watershed zone at each level of encroachment.

c. Determine natural intactness.

Certain categories of cultural data were not considered encroaching at all, because they represent past use or potential use. These include archeological sites and the categories of facility independent access and ownership. Examples of uses considered encroaching are:

	Low Encroachment	Moderate Encroachment	High Encroachment
Settlement	cabins (L)	cabins (HM)	towns (HML)
Utilities	underground (L)	underground (HM)	overhead (HM)

The level of natural intactness was taken from the following matrix, with the most encroaching uses determining the level for any given zone:

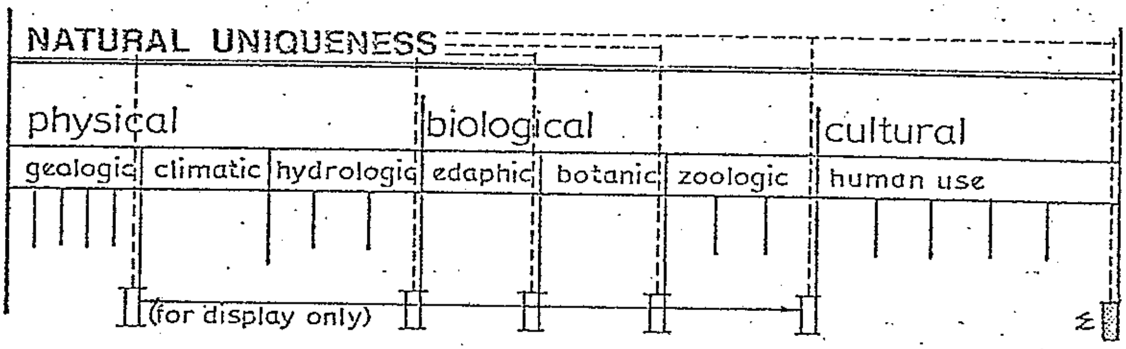
Encroachment by Human Use	Natural Intactness						
	VH	H	MH	M	ML	L	VL
High					1-3	4-6	7-9
Mod.			1-4	5-7	8-10		
Low	0-1	2	3-4				

The range of intactness encompassed by this matrix is defined by the maximum possible future encroachment on the one hand, and complete absence of encroachment on the other.

Natural Uniqueness

The relative availability or rarity of physical and biological resources, measured by the frequency with which scarce resources are found at moderate to high levels of expression in any river run, is termed <u>natural uniqueness</u>. This is treated as a weighting factor, since the perceived value of a landscape resource usually rises as it becomes more scarce, while other measures of natural importance may remain static or even decline. Relative uniqueness provides an excellent means of assigning land use priorities among otherwise equal landscapes.

This dimension of landscape value was measured across the physical and biological portions of the resource matrix, plus archeological sites from the cultural section:



The steps in arriving at the natural uniqueness of each river run were:

a. Determine relative scarcity of each resource, in primary and secondary zones.

b. Tabulate occurrence of unique resources, by level of relative scarcity, in each watershed zone.

c. Determine natural uniqueness of each watershed zone.

The determination of the relative scarcity of resources was based on a tally of the number of occurrences of each within the study area at moderate or high magnitude. Occurrences within the primary and secondary zones were tallied separately. All resources that occurred at these magnitudes in less than one-third (33%) of the study area watershed zones were deemed to be scarce; relative scarcity was further differentiated into three levels:

Occurrence	Relative Scarcity
23-33%	Low
12-22%	Moderate
1-11%	High

After the number of occurrences at each level of relative scarcity were totaled for each watershed zone, natural uniqueness within the study area was determined with the aid of a stepped matrix based on the actual ranges of occurrence across the entire resource base considered, within the three levels of relative scarcity. Separate matrices resulted for the primary and secondary zones, which were considered not strictly comparable in terms of data structure; the matrix for primary zone uniqueness:

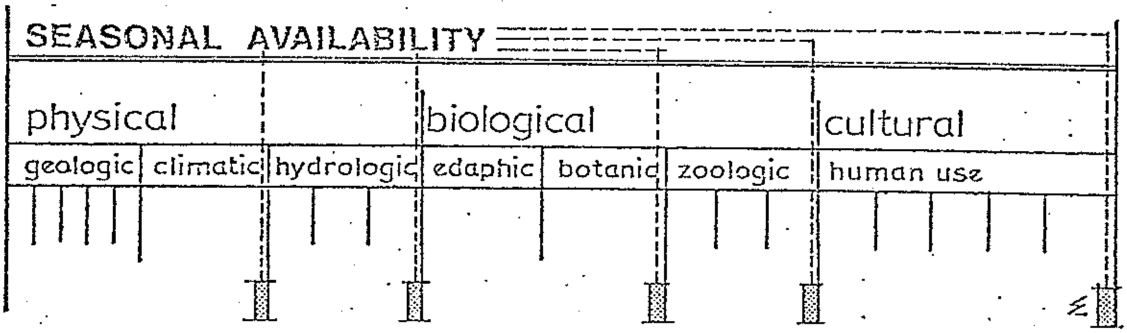
Relative Scarcity	Natural Uniqueness						
	VH	H	MH	H	ML	L	VL
High	5,4	3	2,1				
Mod.			8-6	5,4	3-1		
Low					8-6	5-3	2-0

In addition, the relative uniqueness of each zone was determined in major physical and biological resource categories for display in the full resource matrix as an aid in locating the class of resources in which an individual river run's uniqueness resides.

Seasonal Availability

This factor is a dimension of resource utility for human purposes, here primarily recreation. It is a measure of potential opportunity and/or supply, interpreted in terms of the relative length of time the various resources in the various runs are available for human use, including appreciation.

Seasonal availablity was assessed for the resources in the landscape cover; for the purpose of recreation use, edaphic resources were considered a part of the terrain rather than its cover:



The measurement process was:

a. Rate the seasonal availability of resources on a simple numeric scale.

b. Sum for each watershed zone, within the four resource categories.

c. Normalize the sums into seven levels.

d. Rank each watershed zone for seasonal availability by category.

e. Add the ranks.

f. Determine total seasonal availability for each zone.

Seasonal availability of resources was rated High (=2), Moderate (=4), Low (=6), Absent (=7), or Non Applicable (=0) based on the relative availability of each resource to principal recreational uses. Examples of typical ratings are:

	Absent S.A.	Low S.A.	Mod. S.A.	High S.A.
Climatic	–	solar heating (L)	solar heating (M)	solar heating (H)
Hydrologic	lakes (0)	lakes (L)	lakes (M)	lakes (H)
Botanic	bottomland-spruce (0)	alpine tundra (HML)	lowland-spruce (HML)	bottomland-spruce (HML)
Zoologic	moose conc. (fall) (0)	moose conc. (fall) (L)	moose conc. (fall) (M)	moose conc. (fall) (H)

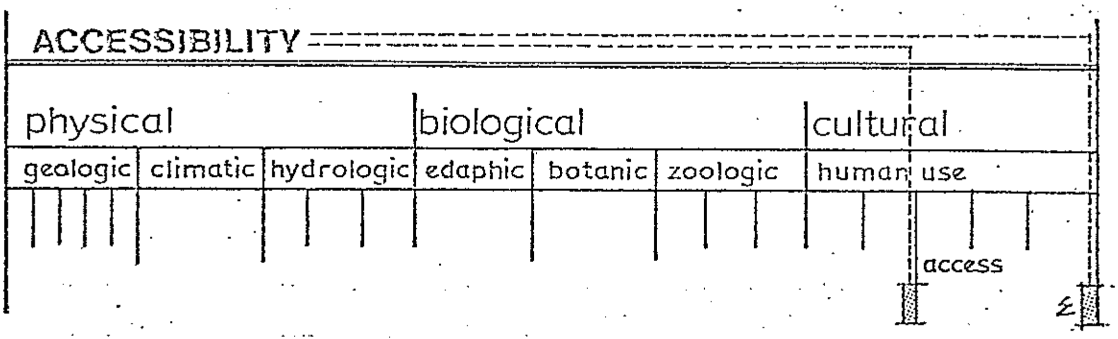
Total seasonal availability was determined with this table (also used for diversity):

Sum of Ranks	Total Seasonal Availability
4.0-7.3	VH = Very High
7.4-10.8	H = High
10.9-14.2	MH = Mod. High
14.3-17.6	M = Moderate
17.7-21.0	ML = Mod. Low
21.1-24.5	L = Low
24.6-28.0	VL = Very Low

Accessibility

Another dimension of resource utility, this is a measure of the seasonality of human access to each watershed zone, in terms of the relative time each is available to the access modes inventoried.

Accessibility was extracted from the access inventory section of the cultural portion of the resource matrix:



The measurement process was similar to that used for seasonal availability:

a. Rate the relative length of access season for each of the access modes.

b. Sum for each watershed zone.

c. Normalize the sums into seven levels.

d. Rank each watershed zone.

The ratings for relative seasonality of the access modes were slightly elaborated over those used for seasonal availability. The additions are Moderately High (=3), Moderately Low (=5). Examples are:

Facility Dependent: Rail	Length of Season
Absent	Absent (=7)
Low	Mod. (=4)
Moderate	High (=2)
High	High (=2)
Facility Independent: Air	
Absent	Absent (=7)
Low	Mod. Low (=5)
Moderate	Mod. High (=3)
High	Mod. High (=3)

In normalizing the sums, the same range was used for primary and secondary zones because the data bases were comparable. Watershed zones were ranked from Very High to Very Low on the strength of this normalization.

Natural Value

A holistic measure of landscape integrity, health, and distinctiveness may be obtained from considering the fragility, diversity, natural intactness, and natural uniqueness models described above. This measure is termed natural value, and was defined above for each watershed zone by the equation:

$$NV = \frac{F + D + NI}{3} \div NU$$

The input values for fragility, diversity and natural intactness are derived from equating the Very High - Very Low ratings to a 1-7 numeric scale. The average of these three values is displayed in the resource matrix as "unadjusted natural value." For purposes of comparison and scaling, this value was converted to a 1 to 100 scale (cf. Burnham et al., 1974; Hendrickson et al., 1974), with low scores equated to high value. The unadjusted average was then weighted for natural uniqueness, which has been converted to a coefficient:

Natural Uniqueness

Rating	Coefficient
VH	1.6
H	1.5
MH	1.4
M	1.3
ML	1.2
L	1.1
VL	1.0

The maximum weighting thus would improve the natural value score of the lowest possible value area by 40%, from 100 to 62.5. The weighting effect tapers off, with very high unadjusted natural values being increased slightly, if at all. The 1 to 100 scale for adjusted natural value is the base for computation of change described below. For graphic display in the resources matrix and for summary discussion, it has been converted back to the Very High - Very Low seven-level scale.

AESTHETIC MEASURES OF IMPORTANCE AND AESTHETIC VALUE

Like the natural and cultural resources, the aesthetic resources of one reach cannot be directly compared with those of another reach; even within one reach, one run may have so distinctive a character as not to be truly comparable with its neighbor. Comparisons of visual character must also rest on qualitative evaluations of the visual resources of each unit.

These qualitative evaluations of the visual resources of different landscape units must be based on inherent capacity to evoke perceptual response rather than on the subjective preferences of the investigator, or even of the public at large. Preferences are culturally and historically conditioned, and as such are transitory: "the mountain scenery, for instance, which many people now admire above all other, was once detested as dreary wastes" (Fairbrother, 1974, p.4). Preference testing is highly appropriate when used to prioritize the results of a resource-based landscape assessment. The resource-based assessment itself can attain a high degree of objectivity by breaking visual character into component elements, performing qualitative evaluations on these, and then re-combining the results into an overall measure of character or value. A considerable degree of consistency in qualitative judgements between groups with markedly different preferences has been achieved with this method, which may be interpreted as an empirical demonstration of success (Burnham, et al., 1974; Hendrickson, et al., 1974).

The elements of aesthetic value that have been identified in these and other studies were used in the assessment of the aesthetic resources of the

Susitna River. These elements are vividness (V), visual intactness (VI), and unity (U). A fourth element, visual uniqueness (VU), is used as a modifier, and aesthetic value (AV) is defined by this equation:

$$AV = \frac{V + VI + U}{3} \div VU$$

This definition of aesthetic value will be seen to meet the criteria of comparability and objectivity, in the sense that river runs, the smallest units of distinctive character identified on the river, are compared in terms of the unique capacity of each to evoke aesthetic response, rather than in terms of their approximation to an idealized landscape type.

Vividness

Vividness is defined as the strength of the visual impression, or the "memorability" of the visual experience offered by a landscape or its elements. Thirteen factors are considered here as they contribute to the vividness of the landscapes within the study area:

TERRAIN	Landform spatial definition: expansiveness
	Landform spatial definition: enclosure
	Landform surface pattern and edge definition
	Landform relief
	Landform landmarks
	Landform sequence
COVER	Skyform
	Waterform of the run analyzed
	Waterform of the major tributaries to the run
	Watershed features

Vegetation
Wildlife
Structures (man-made form)

Each run is assessed on a seven-level scale for each of these factors.

Overall vividness of each unit is a final qualitative assessment that takes into account the vividness of all contributing visual resources (both natural and man-made) as they interact in concert to form a memorable visual impression of the place. Overall vividness is measured on the following scale (as are all the above vividness categories):

Numeric Value	Vividness
1	Very High
2	High
3	Mod. High
4	Moderate
5	Mod. Low
6	Low
7	Very Low

Visual Intactness

Visual intactness is defined as the relative degree of apparent natural condition of the landscape or its elements. To determine the level of intactness of a landscape, one must consider two factors: its level of development and the presence or absence of disturbing visual encroachment. As both have been found to diminish landscape quality (Zube, March, 1973), both are evaluated as elements of intactness.

Visual encroachment is the presence or absence of visually disturbing foreign landscape elements, such as junk yards or distracting billboards, as well as the apparent level of man's physical alteration or scarring of natural landforms or vegetation, such as road cuts and fills, gravel pits, or clearcutting. The degree of encroachment is a global assessment for the entire "natural" portion of the aesthetic resources matrix:

Intactness	Degree of Visual Encroachment
VH	Pristine landscape.
H	Very minor visual disturbance/physical alteration.
MH	Minor visual disturbance/physical alteration.
M	Moderate visual disturbance/physical alteration.
ML	Moderately substantial visual disturbance/physical alteration.
L	Substantial visual disturbance/physical alteration.
VL	Highly visually/physically altered.

The level of development is an assessment of the "cultural" portion of the aesthetic resources matrix. It represents the apparent degree of natural condition or level of presence of man-made development in the landscape:

Intactness	Level of Development
VH	Wilderness, no apparent man-made development.
H	Highly natural, few signs of man-made development.
MH	Moderately highly natural, few signs of man-made development.
M	Moderately natural, scattered low-density development.
ML	Moderately high degree of man-made development.
L	Not very natural, high degree of man-made development.
VL	Man-made development dominates landscape.

Both assessments were carried out separately for the left and right sides of the coterminous viewshed of each run. The summary value for visual intactness entered in the resources matrix represents an average of these two component measures.

Unity

Unity is a measure of the degree to which the visual resources of a landscape join together to form a single, coherent, harmonious visual unit. Unity refers to the compositional harmony or intercompatability of the visual resources comprised in each river run. Unity does not necessarily demand that all interacting visual resources be similar or bland, but may rather depend upon the presence of an organized balance between dominant and subordinate visual resources. Unity is measured in two components.

First, the degree of unity between man-made and natural visual resources is rated in the "cultural" portion of the resources matrix. This evaluation of unity differs from the evaluations of intactness and the vividness of man-made elements; it is not concerned with the abundance of man-made elements (as in intactness) nor with their level of distinction or visual contrast (as in vividness). This component of unity is only concerned with the level of visual integration of man-made elements with the natural setting, or the degree to which they contribute to or detract from the visual composition. The degree of unity between man-made and natural elements is measured on the following scale:

Unity	Man-made Elements
VH	Very highly unified with natural (or absent).
H	Highly unified with natural.
MH	Moderately highly unified with natural.
M	Moderately unified with natural.
ML	Moderately low unity with natural.
L	Low unity with natural.
VL	Very low unity with natural.

Second, the unity of the overall landscape is rated on a similar seven-level scale.

Both assessments again are carried out separately for the two sides of each run. The two are then averaged to obtain the final evaluation of landscape unity.

Visual Uniqueness

Visual uniqueness of distinct landscape elements which may be scarce enough to warrant higher than normal consideration is identified here. The level of uniqueness of each landscape element depends upon the number of times it occurs in each run in relation to the number of times it occurs within the study area (Leopold and Marchand). As with natural uniqueness, this is a culturally significant weighting factor, and its value for each side of each coterminous viewshed zone is determined by the method described in the discussion of natural uniqueness. One variation, however, is that only characteristics occurring at a high magnitude of expression are considered in evaluating the relative scarcity of individual resources. Another is that the matrix used to determine the visual uniqueness of each run after the occurrences of scarce resources have been tallied is slightly different, because the ranges of occurrence at each level are different for the visual resources:

Relative	Visual Uniqueness						
Scarcity	VH	H	MH	M	ML	L	VL
High	3	2	1				
Mod.			3	2	1		
Low					7,6	5-3	2-0

Parallel to natural uniqueness, the relative uniqueness of viewshed resources in major categories is displayed in the full aesthetic resource matrix: terrain and cover.

Aesthetic Value

Aesthetic value was defined above by the equation:

$$AV = \frac{V + VI + U}{3} \div VU$$

The input values for vividness, visual intactness and unity are derived in the same way as those for natural value and the resulting average again converted to a 1 to 100 scale. The visual uniqueness evaluation also was converted to a coefficient similar to natural uniqueness, and the adjusted aesthetic value is also the basis for the computation of change. Again, for graphic display in the matrices, aesthetic value was converted back to a Very High - Very Low scale.

ENVIRONMENTAL QUALITY

The discussions of aesthetic and natural values have been parallel in several respects; in particular, both definitions of value have been couched in terms of strength or vigor, and in terms of integrity. In a river run with high natural value, the characteristic natural processes and systems are both pronounced and unimpaired; similarly, in a run with high aesthetic value, the visual impression is both strong and whole. A landscape that is healthy and is also seen to be healthy - that is the working definition of environmental quality advanced here:

$$\frac{AV + NV}{2} = EQ$$

There are other dimensions of environmental quality that must be considered in more developed areas - for example, air quality and ambient sound or noise levels. In this study, however, the level of existing development and the type of proposed development make it reasonable to assume that these qualities are so high that they may be taken as constants and dropped from the analysis. Water quality, another frequent dimension encountered, is included under "natural value" in this definition of environmental quality.

RECREATION SUITABILITY

Projection of Recreational Use.

The U.S. Army Corps of Engineers has a well defined method for estimating the recreational use of a proposed reservoir (D.A. Crane, 1974). This method utilizes time-distance analysis, examination of alternative recreational opportunities, and an analysis of the projected reservoir's recreational possibilities. However, the method's application hinges on the use of a "similar project" analog (i.e., analysis of per capita recreational use based on an existing analogous reservoir and region) and, therefore, is of doubtful value in the Alaskan context, where situations similar to the proposed Devil Canyon and Denali reservoirs are unavailable.

Nonetheless, the Corps' experience with over 50 reservoirs nationwide within the lower 48 states has led to some valuable general conclusions:

a. About 50% of reservoir use can be explained purely in terms of distance in relation to population centers.
b. Each reservoir's unique recreational opportunities will help determine the range of use.
c. The degree of development is not a strong indicator of use.
d. Alternatives (competition) will often affect recreational use.
e. Socio-economic factors are of limited value.
f. Soil and water quality affect use only where they are quite unsuitable.

Nationwide analysis of reservoirs has come up with useful indicators for day use and camping use:

a. A reservoir's "market area" radius for day-use

(80% of all visitation) is predominantly under 75 miles. A practical day-use limit is about 100 miles.

b. A reservoir's camping (weekend use) market area radius is predominantly from 100 to 200 miles.

The importance of accessibility is further noted in the typical one-way distances traveled for certain types of outdoor recreation in the continental United States. (Clawson and Knetsch, p.98)

a.	After work, for adults seeking special opportunities.	Up to 5 miles.
b.	One-day outings.	20-50 miles (farther if traffic is light and attractive areas are unavailable nearer).
c.	Weekend outing.	100 to 150 miles.
d.	Short vacation (two weeks or less).	400 to 600 miles.
e.	Longer vacation (more than two weeks).	1000 miles or more.

The Anchorage area (population 115,000 - 1974 Milepost) is by far the greatest source of recreational use in the Railbelt area. The project area (east of the Anchorage/Fairbanks Highway and south of the Denali Highway) is from 150 to 200 miles from both Fairbanks and Anchorage. Thus the upper Susitna Valley currently lacks a nearby (day-use) recreational "market" (figure 4).

For the Denali Reservoir, this is unlikely to substantially change in the future: none of the three potential New Capital zones will exert close-in (100 miles) pressure. The Devil Canyon Reservoir could present another picture. The New Capital (representing a population of under 20,000 by 2000 A.D.) may very well be sited in the Talkeetna Zone. If this is the case, the Devil Canyon Reservoir will be in its day-use range.

For both reservoirs, the camping and weekend use market area will contain about 170,000 people (Fairbanks, Anchorage, and Matanuska Susitna Borough). Per capita use relative to the reservoirs has yet to be determined, and will require much further study.

Some additional considerations in projecting potential day-use and weekend-use pressures at Devil Canyon include: the inherent difficulty of utilizing narrow steep-sided reservoirs for recreation; the competition of Denali State Park, Chugach State Park, the expanded Mount McKinley National Park; the splendid Kenai Peninsula (south of Anchorage), other regional attractions; and the degree of access developed to the reservoir (i.e., gravelled roads vs paved, steep vs gentle road grades, the presence or absence of boat launches and moorages, or the development of fishing accesses and trails). The operation and maintenance of Devil Canyon facilities will be another factor:

the Corps has, in other states, turned over various completed reservoir parks for management as state park units. If this were the case, Devil Canyon facilities might be managed as a remote unit of Denali State Park. (The more isolated Denali Reservoir would require a separate recreational management program, possibly based on hunting, fishing, boating, and nature conservancy).

Management of recreation facilities by the Alaska Division of Parks would provide a basis for one projection of recreation use. However, the eventual ownership of lands adjoining the reservoirs might preclude state sponsorship of facilities and instead open the possibility of sponsorship by a native corporation with quite different policies, generating alternative projections of recreation use.

The actual projection of recreation use is outside the scope of this study; nevertheless, this assessment is intended to be of use in that projection. To that end the focus of the recreational assessment will be to identify the inherent suitability of each river run for specific levels of recreation use, in terms of the run's capacity to accept recreation impacts.

Recreational Carrying Capacity

The simplest meaning of this concept is the ability of an area to absorb outside influence and still retain its essence. When <u>carrying capacity</u> is exceeded, that essence is lost. The origins of carrying capacity theory and application are found in the fields of wildlife, range management, agriculture and forestry. To a certain degree, this same theory can be applied to recreational carrying capacity because "as in the case of grazing and forestry, there is some limit beyond which use cannot increase without serious deterioration in the quality of the recreational experience - and frequently, serious physical deterioration of an area as well." (Clawson and Knetsch, p.176).

For a definition of recreation carrying capacity to be useful and complete, it must cover all aspects of capacity - physical, ecological, psychological, and social, which the following seems to do: "the recreational carrying capacity is the character of use that can be supported over a specified time by an area developed at a certain level without causing excessive damage to either the physical environment or experience of the visitor." (Stankey and Lime, p.175). How much use can an area support without detracting from or destroying the very environmental resources and qualities that initially attracted recreation use?

Recreational carrying capacity is composed of two basic factors: 1) physical/ecological capacity, and 2) social/psychological capacity.

1. The physical/ecological capacity of a recreation area pertains to the amount and character of use beyond which the physical resource will be unacceptably altered. Generally, the physical and ecological carrying capacity of a recreation area is concerned with the change in the natural environment brought about by both natural processes and human impacts.

Impacts associated with recreational use have tangible effects on the environment. For example, camping can have the following effects in varying degrees:

Resource	Effect
Soil:	Soil compaction, erosion, loss of organic layers, changes in soil acidity.
Vegetation:	Loss of vegetation through trampling, fire, removal, root compaction, or disease; changes in vegetation types.
Animal Life:	Loss or disruption of resident and migratory species through habitat loss, fire, disease or destruction; changes in species types.
Water:	Impaired water quality (increased sedimentation, eutrophication, or petrochemical contamination); increased runoff through soil compaction or paving.
Air:	Impaired air quality (smoke, dust, auto emissions); increased noise levels.

The *intensity* of use is often far more important than the *type* of use, although certain uses are intrinsically more detrimental than others (e.g., horseback riding impacts on trail or meadow are more severe than foot traffic).

The gross magnitude of impact is dependent on the number and frequency of users more than any other determinant. The number and frequency of users is determined by site qualities, access, population pressure, and development.

Particular areas of concern relative to specific recreational uses are tabulated in figure 14.

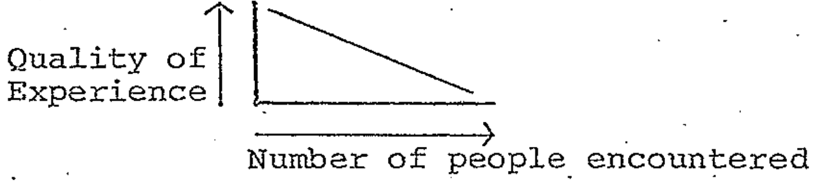
effect	land			water				air			animals					veg.
resource concerns relating to recreational use. cause	compaction	displacement	rutting	bottom disturb.	siltation	chem. pollution	eutrophication	dust	chem. pollution	noise	ground birds	waterfowl	rodents	large animals	game fish	degradation
horseback riding	2	③	③	2	2		2	③		1	2					③
trail biking	③	2	③	2	2	2		③	2	④	③					③
heavy A.T.V.	④	④	④	④	③	2		③	2	④	③	③				③
hiking	1	1			1			1		1	1					2
pleasure driving						2			③	④				③		
camping, picnicking	③	1			2	2		2	③	2	2			③		③
rifle hunting	1	1								④				④		1
bow hunting	1	1												③		1
game bird hunting	1	1		2						④	④	④				1
canoe/kayak/raft				1								1			1	
light power boating				③		③				③		③			2	
heavy power boating				④		④				④		④			④	
fishing				2								2			④	
amphibious vehicles				④		2			2	③		③			2	
amphibious aircraft				2		1				④		④			1	
ski-touring													1			1
snowmobile			2						2	④			2	④		③
snow tractor			③						2	④			③	③		③
ice boating									2	④					2	
ice fishing															③	
land-based aircraft	2	2	③					③	1	④						2

Concerns are recorded in a range of 1 to 4. Numbers 3 and 4 show areas of "significant concern"; that is, adverse effects which should be anticipated and investigated if the "cause" (a particular recreational use) is introduced or magnified.

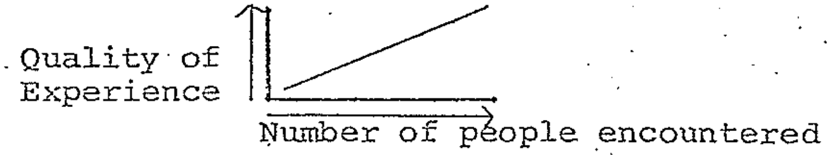
FIGURE 14. RECREATIONAL USE AND RESOURCE CONCERNS

2. The social/psychological capacity of a recreation area involves the quality of the recreational experience as perceived by the user and relates to the effect of such factors as overcrowding and the condition of physical resources on user satisfaction. Sociological consideration also relate to the effects of people on people as well as those of the natural environment on people.

These impacts are manifested in adverse effects of different types of recreational activities upon each other. Levels of tolerance for other people's recreational activities vary. At one extreme is the person for whom the sight or even the knowledge of other persons in the vicinity detracts from the quality of experience.



At the other extreme are those whose primary delight in recreational experience comes from their association with companions ("socialization") or their recreational equipment ("artifactualism") rather than the natural resource itself.



Conflicts are both psychological (e.g., the noise of motorized equipment effectively negating a sensitive user's wildland experience) and physical (e.g., motor boating creating hazardous conditions for canoeing). Conflicts may arise due to use-intensity conflicts, or may occur within a given intensity level (e.g., low-intensity trailbiking conflicting with low-intensity hiking or camping); however, compatible activities generally occur within a similar range of intensity.

Seasonal availability adds another dimension to conflict: the short late-summer-to-fall use season is pressured by a variety of incompatible uses such as hunting, camping, or off-road vehicle use. A seasonality chart (figure 15) presents seasonal variations and recreation-use overlaps. "Peaking is the time factor that causes most management problems. Nearly all outdoor recreation activities are subject to extreme peaks of use at certain times and to very low level of use at other times. One consequence of this extreme peaking of demand is that natural resources, capital investments, and to a large extent, management and other personnel, are inefficiently utilized." (Clawson and Knetsch, p.170).

Interaction between Physical and Social Carrying Capacity.

In considering the physical and social carrying capacity, it becomes evident that each recreation site or river unit can withstand only so much use and abuse, and that the user can tolerate only so much congestion. All these factors are interdependent, and it is the interaction of these variables that makes the understanding and quantification of recreational carrying capacity difficult.

Where physical and social carrying capacities are of different values, which should govern? For most recreational resources, the physical capacity is the absolute capacity, and under no circumstances should recreational use be permitted to exceed it. Although in some cases, damage to the natural resource will not affect the user's satisfaction (i.e., ATV activities), normally the physical capacity should be considered as the upper limit in planning for recreation areas. (Alldredge, p.22).

However, it is also entirely possible that the social capacity can be exceeded with no serious physical damage resulting to the natural resources of an area. In such situations the controlling or limiting capacity should be that capacity which has the lowest tolerance. (Alldredge, p.22). In other words, "if the level of use at which visitor satisfaction is excessively diminished is reached before unacceptable physical damage occurs, social carrying capacity is controlling." (Treib, p.3).

Usually, the different factors which affect recreational quality are not so easily isolated and examined as they are in theoretical discussions. Often, it is a combination of different capacities, in varying degrees, that establishes the recreational carrying capacity of an area.

Recreational Carrying Capacity Levels

Three levels of carrying capacity were developed in an attempt to deal with High, Moderate, and Low use intensities. The primary zones of each run are rated as being suitable for one of these carrying capacity levels.

1. High carrying capacity areas are appropriate to generally high impact uses and are characterized by some of the following:
    a. Large numbers of users.
    b. High density of users.
    c. High extent of required mitigation (e.g., regular maintenance, control, or resource rehabilitation). The need for high accessibility and tolerance.
    d. The need for formal support facilities.
    Examples: Highly accessible developed public parks (camping, picnicking, boat launching, field games), high volume power boating, high volume hiking, horseback, or trailbike trails.
2. Moderate carrying capacity areas represent a balance between high and low impact uses:
    a. Smaller groups of users.
    b. Moderate density.
    c. Less need for mitigation.
    d. Less need for accessibility and tolerance.
    e. Low-key facilities
    Examples: Small-scale campgrounds or picnic areas, moderate volume trail uses, low density power boating.
3. Low carrying capacity areas relate to the most sensitive river units and low impact uses such as the following:
    a. Small number of users.
    b. Low density, dispersed users.
    c. Little or no need for mitigation (maintenance, control or repair).
    d. Least accessible, less tolerant areas.
    e. Virtually no support facilities
    Examples: Low density, long-range trails of

all types, individual or small-group remote campsites, wildlife preserves, ecological study areas.

The general carrying capacity level of each river run should be used as a guide for future recreational planning with further adjustments based on the compatibility of potential uses with each other.

Usability

An element of suitability for recreation is resource usability. This measure, developed for each side of the primary watershed zones, is based on the relative abundance and length of season for recreation resources; it also captures the relative physical availability of the resources. It is the product of seasonal availability and accessibility, both evaluative measures derived from the natural and cultural resources inventory and described above. These measures were expressed in a seven-point numeric scale (1=VH), multiplied, and the actual range of their product stratified into three levels of usability:

(S.A.) x (Access)	Usability
2 - 11.3	High
11.4-20.7	Moderate
20.8-30	Low

This measure reflects the utility of resources for recreation in terms of the human user, and therefore is a measure of the potential human pressure on resources. It does not necessarily correlate with carrying capacity levels.

Recreation Resource Levels

In determining landscape suitability for recreational uses, it is necessary to assume as a starting point that at least some areas are suitable for each level of use identified. This assumption can then be modified by environmental constraints and use considerations. The starting point in this study was a simple stratification of the river runs (right and left sides kept separate) into three preliminary recreation resource levels corresponding to the three recreational carrying capacity levels. This was done by normalizing the range of existing environmental quality scores into three levels:

Recreation Resource Levels	Preliminary Recreational Carrying Capacity
High	Low
Moderate	Moderate
Low	High

The same breakpoints were used to distribute the environmental quality scores re-calculated for after-construction conditions. The basic assumption is that high impact uses, requiring high recreational carrying capacity, are least suited to areas of high environmental quality.

Recreation Suitability

The preliminary identification of recreation value above does not respond to the evaluative parameters measured for each run. The determination of recreation suitability requires this response and is diagrammed in its entirety in figure 16 .

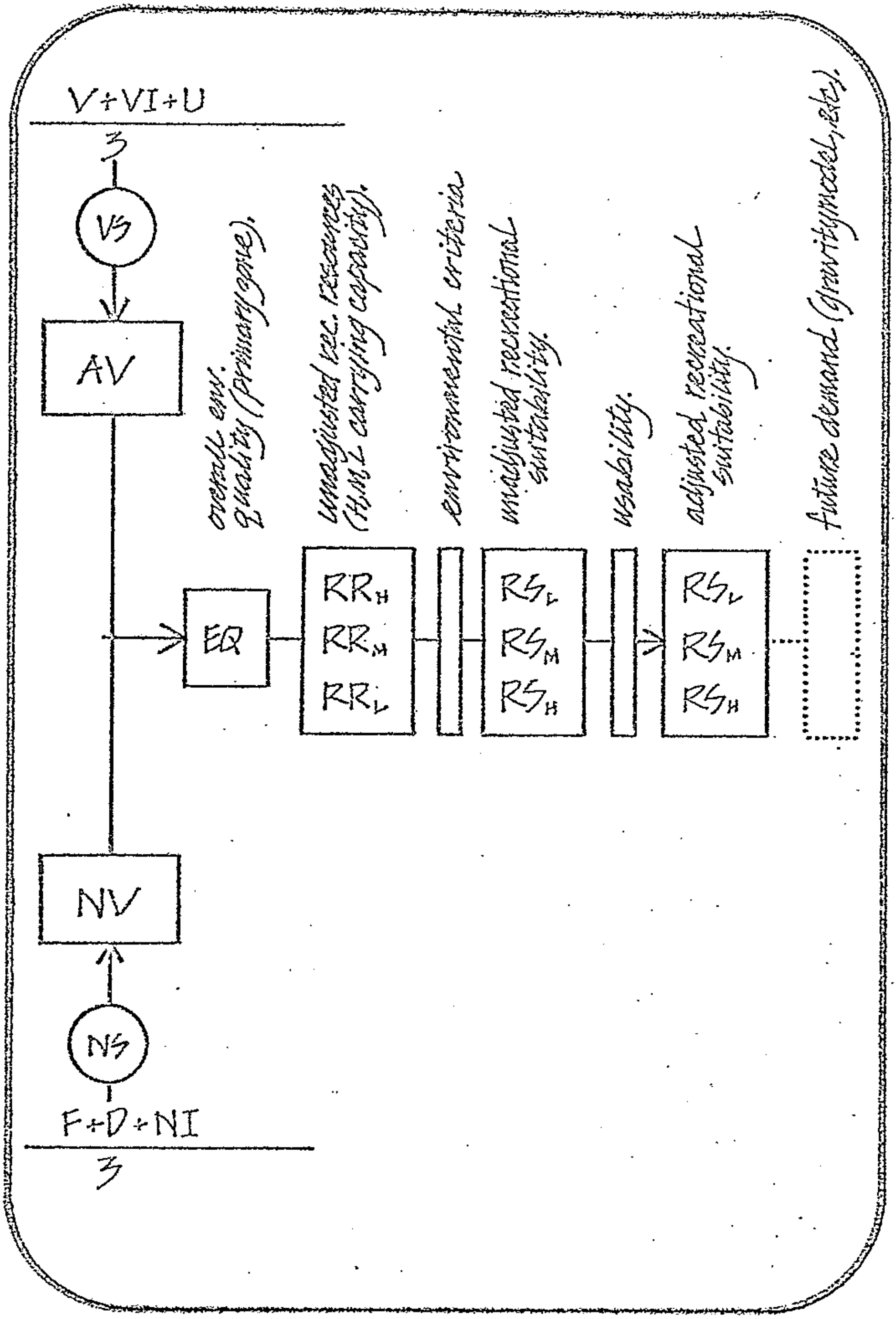


FIGURE 16. SUMMATION OF NATURAL, AESTHETIC, ENVIRONMENTAL & RECREATION VALUES

As the diagram displays, there were two steps between the determinations of recreation value and recreation suitability. The first consisted of checking the zones in each preliminary recreation resource level against a set of environmental criteria for the corresponding recreational carrying capacity level. These three sets of criteria are:

Environmental	Recreational Carrying Capacity Level		
Criteria	Low	Moderate	High
Fragility	HM	M	L
N. Intactness	H	HM	HML
Aesth. Value	HM	HM	HML

The results of this check are displayed as unadjusted recreation suitability in the summary matrix.

The second step checked this unadjusted suitability against usability, considered as a measure of pressure. Areas marginally suited for a given recreation level were shifted into a lower impact capacity class by high pressure, and into a higher impact class by low pressure (usability). Specifically, the following marginal suitabilities were shifted:

Environmental	Recreational Carrying Capacity			
Criteria	Low	Moderate		High
Fragility	HM	H	L(M)	L
N. Intactness	H	H	HM	HML
Aesth. Value	M	H	HM	HML
Usability	L ⟶	⟵ H	L ⟶	⟵ H

It is stressed again that this determination of recreation suitability does not necessarily mean that an area is attractive to a given recreation type; this analysis is intended, instead, to identify areas able to tolerate high-impact recreation types. Further, the analysis assumes minimal recreation facilities and management. Provision of facilities and management would have a mitigating effect and could increase the carrying capacity of the areas affected. Nonetheless, the suitability levels derived here are based on constraints inherent to the recreation resource base and should discipline any future recreation planning.

EVALUATION OF CHANGE

Resource Magnitude

The evaluation of changes in study area conditions after construction of the four dams begins with changes in the data base (see the section "Future Conditions Assessed"). The dams were located on the 1/250,000 and 1/63,360 base maps used in the study and inundated areas delineated. The roads and power lines for which corridors have been delineated were also mapped (see the section "Future Conditions Assessed"). Then every resource data characteristic in the matrices was re-examined and all changes in magnitude entered. Resource increases (e.g., lakes) were noted, as well as decreases. Only resource changes directly relating to dam construction or reservoir inundation were recorded. Therefore, changes were generally not entered in the secondary watershed zones; the exception was Lower Devil Canyon, where the new road and power lines are slated to cross the left secondary zone.

The up-dates tend to be conservative, in that not all changes in the resource base were great enough to be picked up in the magnitude ratings. Several potentially significant changes could not be quantified or spatially located, and these were not entered in the updated inventories at all: most notably, potential adverse effect on wildlife, and particularly caribou and moose. Both species range widely and habitat losses due to inundation are relatively insignificant in terms of total ranges. The concerns over the future of these animals center on critical winter range and barriers to migration. These issues could only be raised for discussion and consideration, as no solid data were available to resolve these questions.

Resource Value

All measures of importance were reassessed (aesthetic value) or re-calculated (natural value) from the updated magnitude of resource supply matrices. Then aesthetic value, natural value, environmental quality and recreation suitability were re-computed and re-mapped.

Numeric Change

The numerical difference between aesthetic value before and aesthetic value after is a direct way of expressing the magnitude of change. This difference was tabulated for natural value and environmental quality as well. For graphic display, the range of difference in each value or quality was normalized into seven levels, and the various zones of each run ranked accordingly. This is both displayed in the "after" matrices and mapped. Recreation suitability was slightly different in that it was determined at only three levels. While the analysis would have allowed change in either direction, the actual changes in recreation value were all toward suitability for more intense, higher impact use. These were ranked and graphically displayed as follows:

Recreation Suitability		Relative	Gray
Before	After	Change	Scale
L	H	H	Dark
M	H	M	Medium
L	M	L	Light
HML	no change	VL	V.Light

Proportional Change

The numerical change in value does not convey the degree of change relative to original value. For example, there is no indication whether a 16-point reduction in aesthetic value affects a run the value of which was extremely high or fairly low to begin with. However, a ratio which expressed the change in value relative to the run's original aesthetic value will convey the significance of the change or impact. This ratio, termed <u>proportional change</u> (PC) is here demonstrated for existing aesthetic value (AV_E) and aesthetic value after dam construction (AV_A):

$$PC = \frac{AV_E - AV_A}{AV_E} \text{, or } \frac{NC}{AV_E}$$

The value of PC will vary according to the relative severity of change in aesthetic value. If there is no change PC will equal zero. Three examples of varying severity of change are:

$$PC = \frac{26 - 10}{10} = 1.60$$

Pristine Landscape, 16-poin
loss in AV

$$PC = \frac{36 - 20}{22} = 0.72$$

Semi-developed landscape,
16-point loss in AV

$$PC = \frac{56 - 40}{40} = 0.36$$

Intensively developed landsca
16-point loss in AV

The use of proportional change here implies the view that a given loss in aesthetic value is most severe at a pristine site, and reflects the widely held belief that high quality visual resources should be preserved.

Proportional change has been calculated for aesthetic value, natural value, and environmental quality (the concept is not applicable to the recreation suitability determinations). These ratios have been displayed and mapped graphically, based on a seven-level logarithmic ranking of proportional change.

VI. RESOURCES OF REGIONAL SIGNIFICANCE

GEOLOGY

Several geologic features of the Upper Susitna are unique and significant in the regional context.

Within the framework of the global tectonic theory, the study area occupies a middle ground between the older pre-Cambrian to Devonian rocks north of the Denali Fault and younger intrusives and eugeosynclinal sedimentary rocks south of the Susitna River region. This middle ground has been translated 400 km right laterally along the Denali Fault, suggesting that original deposition of the basement terrane rocks may have occurred in the Kluane Lake area. This middle ground must represent the depositional transition zone between the continental terrane and the oceanic crust and may someday yield clues essential to a more precise understanding of Southcentral Alaska geologic history. Ultimately, this area may provide information vital to the furthering of global tectonic theory.

A large portion of the area is now covered by proglacial lake deposits. These sediments were deposited during Late Pleistocene time (figure 1f). Only three significant proglacial lakes are recorded in Alaska: A small lake occupied an area of western Kodiak Island; Cook Inlet was inundated by water during part of the Pleistocene; the southeast third of the Upper Susitna River region and portions of the Copper River Basin were flooded during the Knik and Naptowne glaciations (Alaska Glacial Map Committee, 1965).

The lower portion of the Upper Susitna valley appears to be entirely stream cut; an anomalous feature in a region dominated by glacially carved U-shaped valleys. Numerous underfit streams attest to the predominance of glacial scouring in the tributary valleys, but the valley of the east-west portion of the Upper Susitna displays a V-shaped profile substantially unmodified by glacial action.

WHITEWATER

Not only does much of the Upper Susitna River occupy a stream-cut valley, but the rapids in Devil Canyon are so exceptionally violent and spectacular as to constitute a nearly unique aesthetic and recreational resource. Most Alaskan rivers occupy broad glacially scoured valleys, and whitewater beyond class III is rare (conversations with members of the U.S.D.I. Alaska Task Force responsible for recommendations on additions to the National Wild and Scenic Rivers System, 1974). Only three major whitewater rivers are known in Alaska: the Susitna and the Bremner in the Southcentral Region, and the Alsek in the Southeast. All are class VI rivers (I.A.C. rating), at the limit of navigability, and cannot be attempted without risk of life. All three are glacial rivers; the near-freezing water and its opacity further add to the danger posed by the turbulence of their rapids. The Susitna and Alsek were recently both successfully kayaked by Dr. Walt Blackadar for the first time. It is not known if anyone has yet attempted the Bremner, a tributary of the Copper. According to whitewater boaters, the characteristics of the three are quite different, although equally violent. The Bremner is a small, steep river in an exceptionally narrow slot-like gorge; the Alsek is a short, very steep, turbulent river; the Susitna has a relatively flat gradient and owes its violence to its great volume, the constriction of its channel in Devil Canyon, and the rocky obstructions in its bed. Blackadar has described Devil Canyon as much more difficult than the Grand Canyon and as the "Mount Everest" of kayaking (Anchorage Daily Times, March 28, 1973).

FAUNA

The Upper Susitna project may be seen as having attained its present priority through a series of comparisons of its wildlife effects with those of other hydroelectric projects. Most notable of these was the Rampart Project, which would have entailed great wildlife losses; the Susitna project was singled out as an alternative "with no significant fish and wildlife problems" (U.S.D.I., Alaska Natural Resources and The Rampart Project, 1967, p.29). While an analysis of the relative effects of inundation of Upper Susitna River runs displays differential effects ranging from very low to very high, a regional overview does tend to bear this earlier conclusion out in some respects - but not all.

Mammals

Caribou are the principal potential exception to the conclusion reached above. The Nelchina Herd is defined by its habitual calving grounds centering on the secondary watershed zone of Kosina Creek and occupies the most favorable portion, or "center of habitation," of the caribou region comprising south central Alaska

(Skoog, p.212). This herd is the most accessible of the major Alaskan herds and is a major recreation resource, although it is presently in a much reduced state from its population high in the early 1960's. The effects of the dams and reservoirs on the herd could not be quantified for this study, but it is known that adverse effects are possible (Villmo 1972, Klein 1973 and 1971). While the danger posed to the calving migration by ice-moated reservoirs may be mitigated (see "reduction of conflicts" in the next chapter), there may well be a long-term depression of caribou population levels through the "compartmentalization" of the Nelchina herd's range. Subarctic ecosystems are characterized by extreme oscillation and large geographic scale appears to have a survival function in averaging out local oscillations (Dunbar, 1973). Thus, the great mobility of the caribou appears to be an adaptation allowing the herd to flourish, independent of locally adverse weather and range conditions (Skoog, p. 125). Should road and transmission line construction inhibit caribou movement as they have the movement of feral reindeer in Scandinavia, smaller average populations appear the inevitable result in the study area and throughout developing Alaska.

Unlike caribou range, the best moose range appears to be the early successional vegetation types. Moose may therefore be said to be inhabitants of "disturbed landscapes" and are fairly tolerant of man's activity and its consequences, even, to a degree, including fire. While moose populations in the study area may be reduced (the extent of the possible reduction has yet to be established), the long-term prognosis for moose in Alaska appears to be good. In the Southcentral Region, however, because of hunting pressure, any reduction may be viewed with concern.

Dall sheep are much less numerous than the above two species; the populations in the study area are relatively small, heavily hunted, and therefore vulnerable.

Grizzly bear, black bear, and wolf populations inhabit the study area, but no special significance or vulnerability is known for any of these. Mountain goats apparently do not inhabit the study area at all.

Birds

According to the survey commissioned by the Fish and Wildlife Service, no significant raptor populations inhabit the impoundment areas. Numerous waterfowl nest in the Denali impoundment area, but in regional terms (Alaska Regional Profiles: Southcentral Region, 1974, p.158) this is a small portion of a medium-density range extending throughout the Copper River Lowland. This range is in turn overshadowed by high density and very high density ranges in the lower Susitna and Copper rivers. A significant part of the latter would be inundated by the Wood Canyon dam, a hydropower alternative to the Upper Susitna project.

Fish

A principal reason for attention to the Upper Susitna as a hydropower resource appears to be the absence of salmon runs beyond the hydraulic block at Devil Canyon. Current studies appear to suggest that earlier reports may have been too optimistic in discounting effects on downstream spawning, but the Upper Susitna project still appears to have the least effect on salmon of any mid-range or long-range hydropower alternative. The tributaries upstream of Devil Canyon are also too swift for significant freshwater fish habitat until the Tyone is reached. Grayling populations from here up to the Lower West Fork would be impacted by the reservoirs and altered river flows. The regional significance of these populations is not known, although the Tyone does have some reputation as a fishing stream.

RECREATION

The recreational use of Alaska's 365 million acres is limited only by the state's enormous travel distances, scant road system, its climate and biotic limitations. Most of Alaska's recreational development serves predominantly either the two prime urban centers (Anchorage, 75,000; Fairbanks, 18,600) or the north-south highway system which connects them. These two centers engross the majority of Alaska's population and will probably continue to do so, with the addition of the new capital somewhere along the rail/highway link between them.

The upper Susitna River Valley is overwhelmingly characterized by low volume uses associated with hunting, fishing, rockhounding and the like. Rafting or kayaking on the Susitna (especially on the Devil Canyon Rapids) requires hardiness and a degree of skill possessed by few. The upper Susitna is surrounded by potent recreational attractions: the coastal Chugach Mountains and the Kenai Peninsula to the south, the Lake Louise area to the east, Mount McKinley National Park close by to the northwest, the new Denali State Park immediately to the west in the lower Susitna Valley, and Nancy Lake State Recreation Area. The map on the following page illustrates the regions's primary recreational features (figure 34). The primary orientation of these is toward low-impact wilderness-experience recreation. It could be argued that a place for higher intensity recreation should be defined in the the Nelchina basin, surrounded as it is by mountainous areas held (or proposed) as parklands.

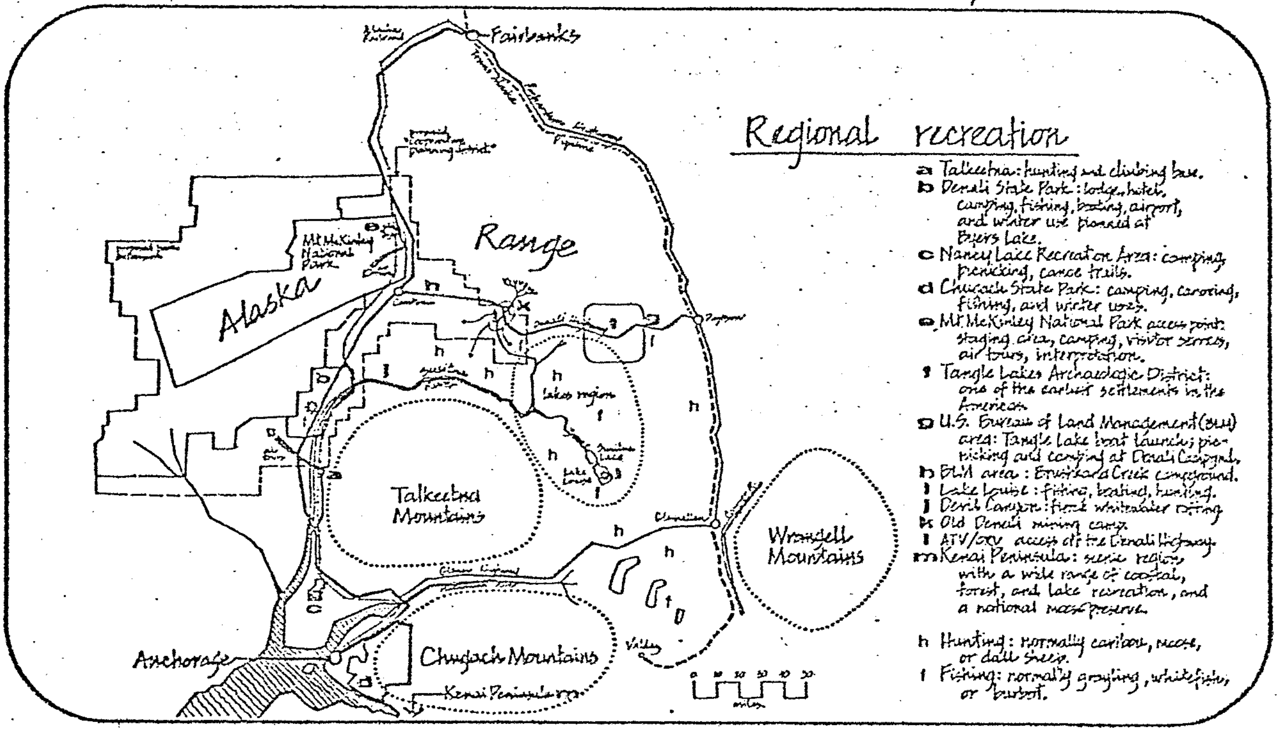


FIGURE 34. REGIONAL RECREATION

Mount McKinley National Park is the largest recreational attraction in the vicinity, and would be doubled in size by current proposals. The vehicular access point on the Anchorage-Fairbanks Highway (opposite McKinley Station on the Alaska Railroad) has core facilities such as a main transportation staging point, camping, visitor services, air tours, interpretation, and trailheads.

Chugach State Park, within 10 miles of Anchorage, is a 495,000 acre park with camping (91 units), canoeing, fishing, hiking and winter uses.

Denali State Park is a 282,000 acre area approximately 130 miles north of Anchorage which is planned for a wide range of intensity levels. The forecast at Byers Lake is for a commercial hotel complex and lodge, camping (initially 200 sites), boat launching, winter sports, and an airport.

Nancy Lake State Recreation Area is a 23,000 acre area in the Susitna Valley, about 70 road miles north of Anchorage. Nancy Lake provides camping (over 100 units), picnicking, and a 12 mile interlake canoe trail with portages.

Lake Louise (with adjoining Susitna Lake) is a major fishing, hunting and boating center mostly in private ownership; it is the source of the Tyone River, a Susitna tributary. Lake Louise is approached from the south via the Glenn Highway.

Kenai Peninsula Region. About 100 road miles south of Anchorage, the world famous Kenai Peninsula is available for the widest possible range of Alaskan recreation: superior fishing, big-game hunting, scenic driving, skiing, lake and saltwater recreation are all available. Features include the Kenai National Moose Range, Kachemak Bay State Park and Wilderness Park (accessible by air or boat only), and numerous private lodges.

Tangle Lakes Archaeologic District. In recent years over 220 archaeologic sites have been found adjacent to the Denali Highway east of the Susitna River crossing; Tangle Lakes Archaeologic District was thus recorded in the National Register in late 1971. Within the Tangle Lakes Complex are more archaeological sites than in any other known area of comparable size in the America subarctic. Evidence of occupation reaches back some 12 to 15,000 years; thus Tangle Lakes is a likely candidate for the earliest occupations in the American hemisphere, showing affinity with Central Siberian occupations. The intact "Landmark Gap Chert Quarry" appears to be one of the only chert quarries and tool workshops known in Alaska. Some of the earliest inhabitants ("Denali Complex," Late Paleolithic) occupied the shore of a large proglacial lake; they disappeared with its sudden drainage (perhaps coupled with other catastrophic changes), leaving no trace of their culture among succeeding occupants.

Fearing vandalism, archaeologists are keeping the area relatively unpublicized. Eventually, interpretive programs and open air in-situ displays (particularly the chert workshop) may become possible.

Talkeetna is a "recreation town," a center for air tours, hunting expeditions, and climbing parties. Talkeetna could become a gateway to the expanded national park's southern areas as well as a service center for the Denali park complex and any recreational features arising from the Devil Canyon Dam.

The Bureau of Land Management maintains small campgrounds, boat launches, and picnic areas along the Denali and other highways. Since the completion of the Anchorage-Fairbanks Highway in 1972, these areas are principally used by sportsmen.

Hunting and Fishing are perhaps the most dominant uses of the region between the Alaska Range and the Talkeetna Mountains. Caribou and other game are commonly taken adjacent to the Denali Highway; further access requires the use of aircraft, snow vehicle, or off-road vehicle. Waterfowl hunting and fishing for trout, grayling, and burbot centers on the glacial outwash region near the upper river reaches, south of the Denali Highway. Many larger lakes (e.g., Susitna Lake and Lake Louise) and hundreds of smaller lakes and ponds provide nesting grounds for migratory waterfowl.

Eleven de facto wild and scenic rivers lie within 200 miles of Anchorage; sixteen are also within the same distance from Fairbanks (table 5).

Among the eleven accessible from Anchorage, however, only the Bremner River is similar to the Susitna; it also offers a narrow canyon experience with a similar whitewater character.

Four scenic and wild rivers lie within 100 miles of Anchorage: the Swanson River, the Kenai River, the Russian River, and the Susitna.

These are among the 40 rivers recommended for detailed study as possible additions to the National Wild and Scenic Rivers System in 1973. The quality of river experience meets the standards of the System on all of these, but for a variety of reasons, many based on land use and ownership considerations, only 20 of the 40 rivers were actually recommended for inclusion in the System by the Secretary of the Interior in 1974 (figure 35).

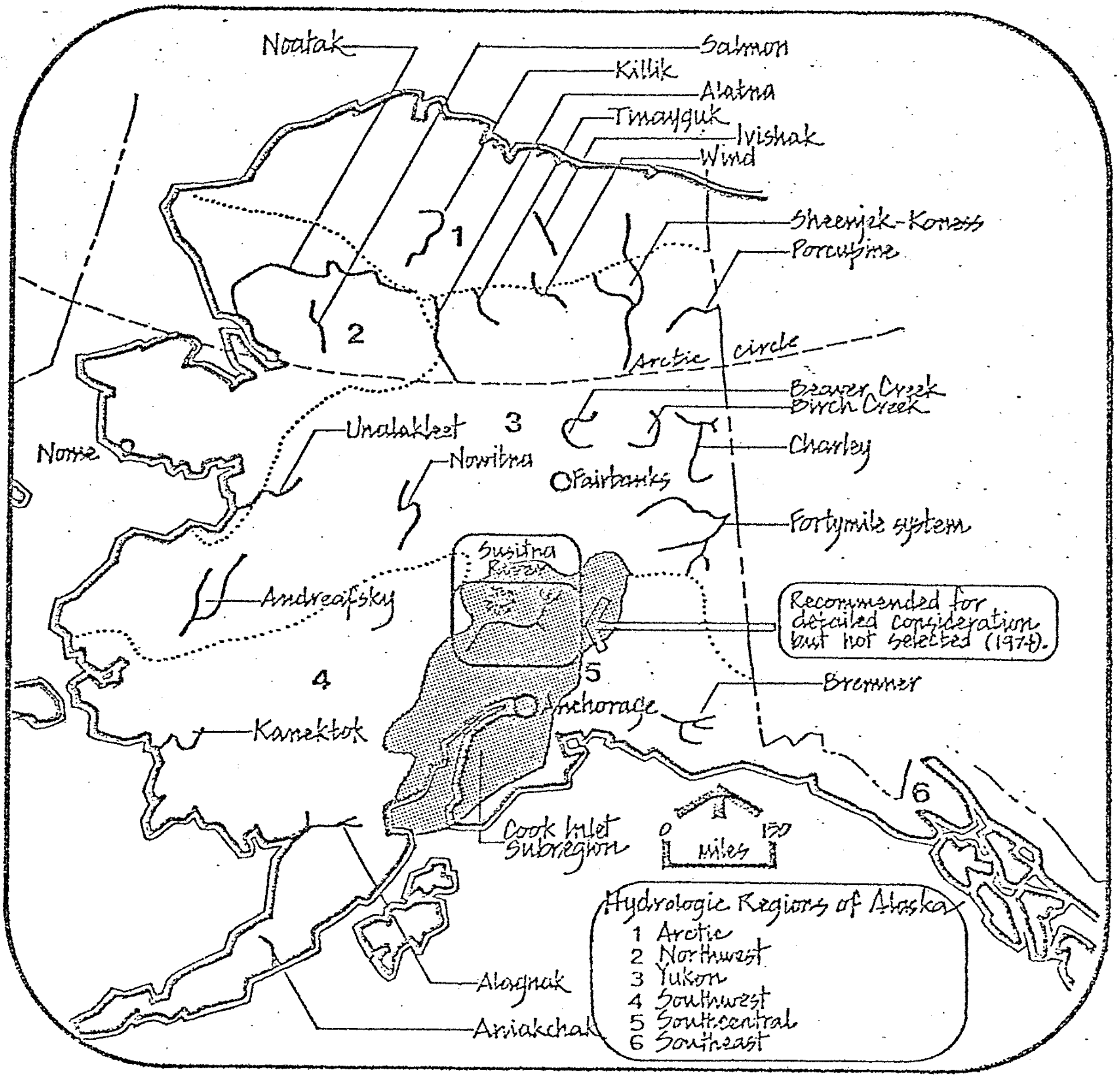


FIGURE 35. ALASKAN RIVERS SELECTED FOR INCLUSION IN THE NATIONAL WILD AND SCENIC RIVERS SYSTEM

TABLE 5

SCENIC AND WILD RIVERS NEAR MAJOR POPULATION CENTERS

Air [illegible] Mileage	Anchorage	Talkeetna	Fairbanks
50 mi.	Swanson R.	Susitna R.	Chatanika R.
	Kenai R.		Beaver Cr.+
	(2)	(1)	(2)
100 mi.	Susitna R.	0	Birch Cr.+
	Russian R.		
	(2)	(0)	(1)
200 mi.	Delta R.	Nowitna R.+	Nowitna R.+
	Gulkana R.	Chatanika R.	Alatna R.+
	Copper R.	Delta R.	Wild R.
	Chitina R.+	Gulkana R.	Tinayguk R.+
	Bremner R.+*	Copper R.	Sheenjek R.+
	Iliamna R.	Chitina R.+	Kandik R.
	Hoholitna R.	Swanson R.	Upper Yukon R.+
		Kenai R.	Charley R.+
		Russian R.	Forty Mile R.+
		Hoholitna R.	Delta R.
			Gulkana R.
			Copper R.
			Susitna R.
	(7)	(10)	(13)
TOTAL	11	11	16

+Recommended for inclusion in the National Wild and Scenic Rivers System.
*Similar canyon to Susitna.

APPENDIX C: NATURAL/CULTURAL RESOURCE DATA CODING

GEOLOGY

The geologic characteristics of the river runs were organized at two levels, first by grouping processes (faulting/tectonics; solifluction; periglacial; glacial; fluvial) and then by grouping the materials affected (bedrock; fluvio-proglacial; fluvial; glacial). The magnitude of expression of these characteristics was then rated by a geologist as Absent, Low (a minor example), Moderate (a moderate example), or High (a prominent example).

The primary zones of the Kosina Creek Run contain examples of five of the 30 geologic characteristics (figure A-1). The minor Vallon de Gelivation and the asymmetric valley wall on the right side of the river were produced by periglacial (frost) action on bedrock. The prominence of neither will be affected by the new water level.

The Susitna has cut a moderately prominent V-shaped valley in the run. The damming will cause some loss of prominence of this characteristic, particularly in the right primary zone. The rating there drops from Moderate to Absent, while the left primary falls only from Moderate to Low.

All of the meander scars (abandoned river channels) will be covered by the high water, completely eliminating even the prominent example in the left primary zone.

Rill channels are very minor (considered absent) in this run, but terraces (indicating former river levels) are moderately to prominently displayed. The projected Watana Reservoir would cover all but minor evidence of this characteristic.

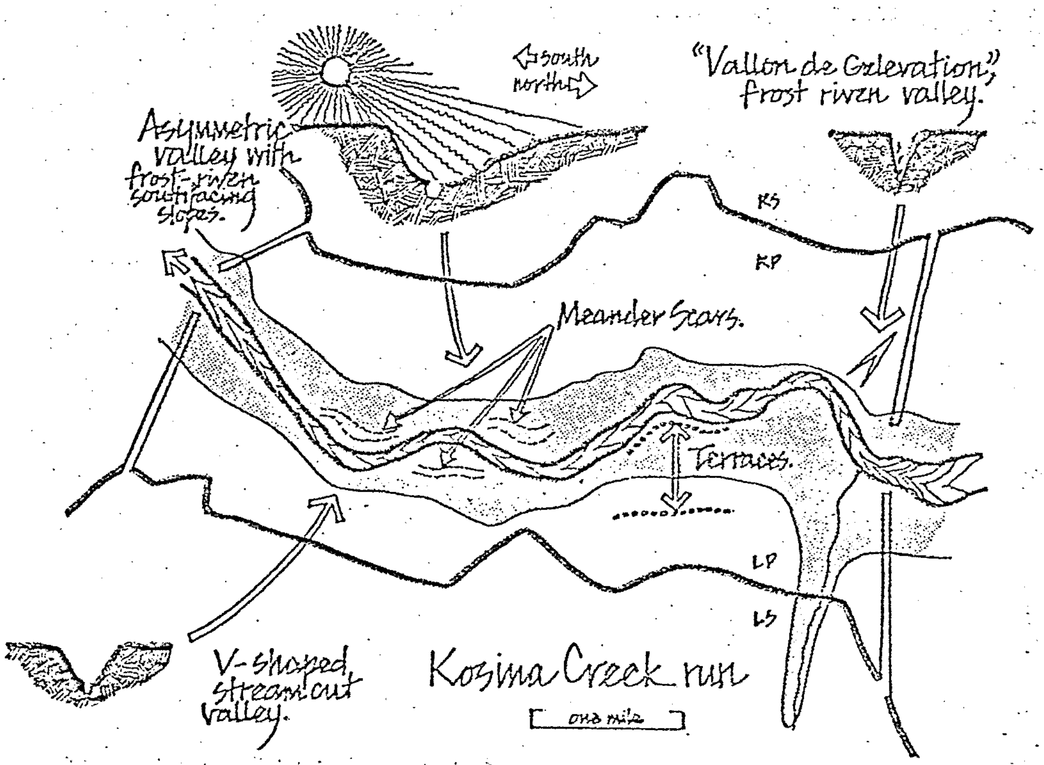


FIGURE A-1. GEOLOGY

CLIMATE

The major climate variables were grouped into two characteristics for evaluation in the study. Solar heating, the first characteristic, encompasses the effect of diurnal and seasonal changes in sun track on slope angle and aspect. At the scale these were mapped, slope angle dropped out of consideration as an important factor, even though it is of considerable importance at useful biometeorologic scales.

The second characteristic, local climatic stress, is a composite of three major variables: temperature, precipitation, and air movement (wind). Extremes were used, rather than ranges. Since there are no weather stations in the study area, regional data from the Southcentral Region profile and other sources was weighed with basic meteorological principles to produce working maps of the three variables for the entire study area. Figure A-2 illustrates these variables for the Valdez Creek run.

Temperature was mapped as a function of lapse rate (locally, about 3.4° F/1000 ft.), times elevation. The topographic range within the study area was divided into three roughly equal zones to which the values High (H), Moderate (M), and Low (L) were assigned.

Wind was considered to be prevailingly from the N.E. in the study area, with considerable local topographic modification. Wind stress was mapped on the basis of prevailing wind as modified by localized topographic channeling or sheltering.

Precipitation extremes occur when storms drive in from the S.W. The orographic effect of elevated landforms creates a distribution of precipitation known popularly as the "rain shadow." The form of precipitation is an additional function of elevation and the lapse rate, since lower temperatures produce snow. Ratings are distributed non-uniformly from S.W. to N.E., based on elevation and rain-shadowing.

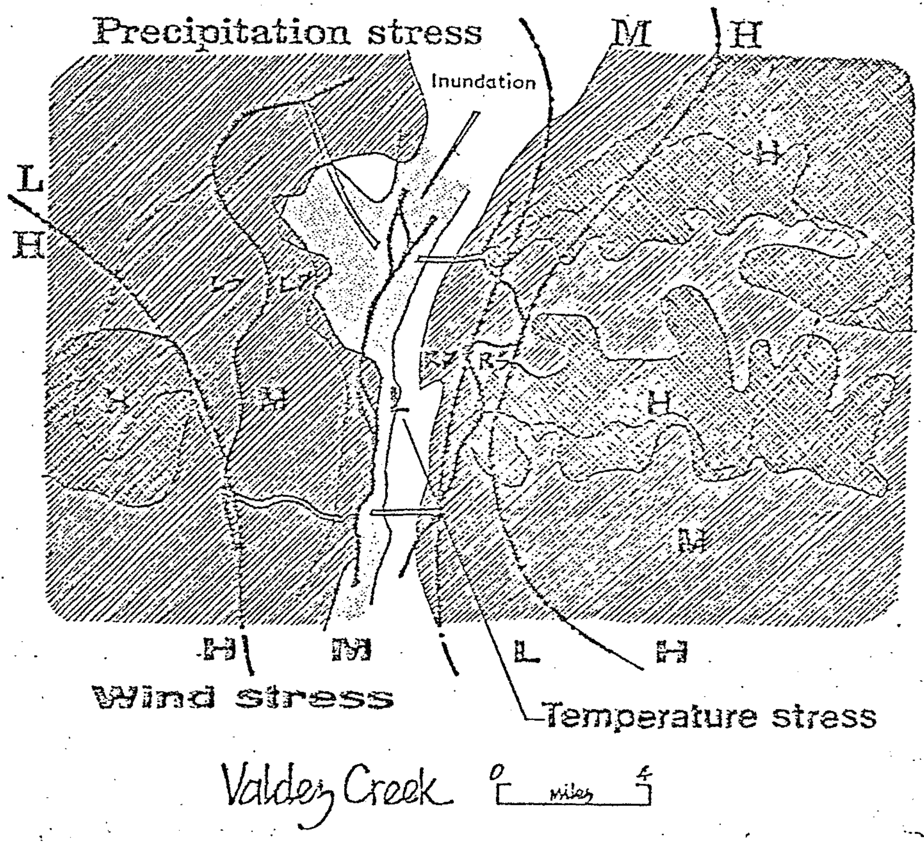


FIGURE A-2. LOCAL CLIMATIC STRESS

The Valdez Creek Run illustrates how the final composite magnitude of climatic stress was obtained. By definition, there cannot be an absence of climate. With three levels (H, M, L) of three variables (temperature, precipitation, and wind) there are ten possible combinations of factors (order immaterial).

A zone was considered subject to high climatic stress if it had two H's, low climatic stress if it had two L's, and moderate climatic stress if it received either two M's or the combination LMH.

A given level of any variable must cover more than half of a zone to be considered dominant. Hence, in the left secondary zone of the Valdez Creek Run precipitation received an H, wind an H and temperature an H. The composite occurrence rating that appears in the matrix (for two H's) is High. The left primary zone was given an L for temperature, M for wind and L for precipitation. The final rating (for two L's) is Low. Ratings of Moderate were the result for both right primary and secondary zones.

Although both solar heating and local climatic stress will change after construction of the dams and the filling of the reservoirs, these changes could not be captured at the scale of this study.

HYDROLOGY

The hydrologic portion of the Natural and Cultural Resources Matrix is divided into three major sections: the mainstem; major tributaries (if any) and other watershed features. Both the mainstem and major tributary sections were divided into hydrologic characteristics of the waterflow itself and channel features. The rating measures used for the former are self-explanatory as listed in the data legend (Table 2).

Information sources for the thirty characteristics included under hydrology are discussed in the body of this report, but several characteristics are used here in the Kosina Creek Run to illustrate the resource magnitude ratings (figure A-3). This discussion will touch on the rating of eight characteristics: four from the mainstem, three from the tributaries and one from watershed features.

Cutbanks represent the erosion wall of the actively working river, while outcrops are prominent, more resistant portions of bedrock, not necessarily in a predictable location. Ratings were based on the relative magnitude of expression on the entire river within the study area.

In the Kosina Creek Run, cutbanks on the mainstem were considered Moderate examples and were rated as such. One is illustrated. The new water level completely covers the evidence of active stream erosion, and the rating falls to Absent.

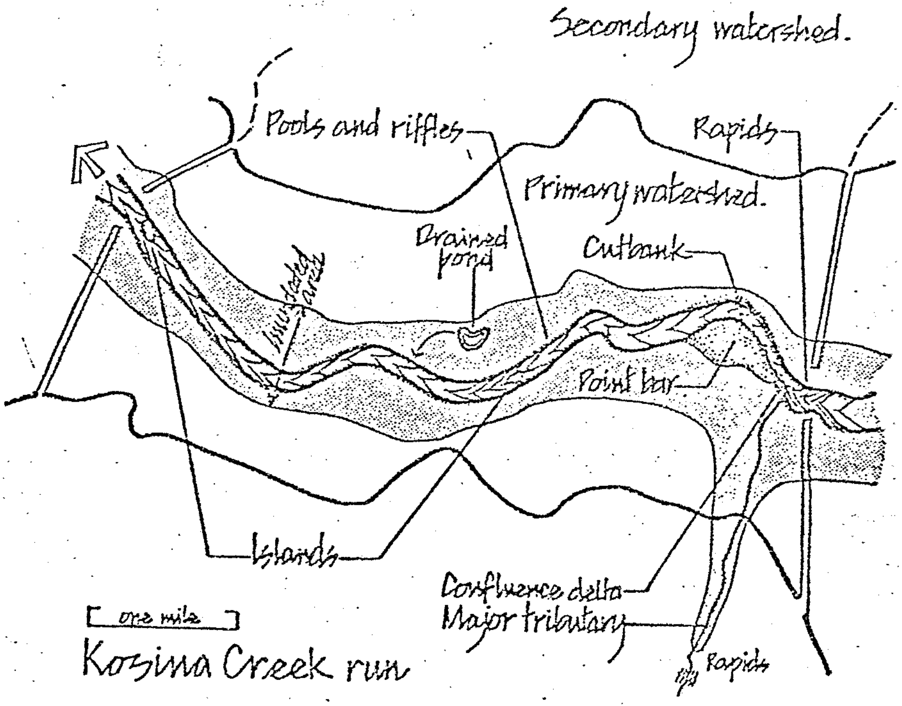


FIGURE A-3. HYDROLOGY

Pools and riffles are regularly alternating shallow bars (riffles) and deeper "holes" or pools. The rating was also based on magnitude of expression. Here the mainstem is only rated Low for pools and riffles, and will of course lose them entirely when inundated.

Islands are rated using a system developed in <u>The Nooksack River Study</u> (Jones & Jones, 1973). A composite number (A/B) is employed, the first part recording size relative to the whole river (1=small, 2=medium, 3=large), and the second, the frequency of occurrence. Words of fairly general character were used (Low, Moderate, High) to avoid an island-by-island inventory. The composite numbers were grouped to provide the magnitude rating recorded in the matrix:

Absent = 0/0
Low = 1/1; 1/2
Moderate = 3/1, 2/1, 2/2
High = 2/3, 3/2, 3/3

Kosina Creek Run was determined to have two small islands and was given the composite score of 1/2. Its rating for islands thus was Low. This would fall to Absent after construction of Watana Dam.

Point bars and beaches are similar in many respects, since they are both depositional features, produced by the active river. Beaches, however, tend to be transient or seasonal expressions on such a river, while point bars are quite stable, changing size as water levels rise and recede, but generally staying in one location for many years.

The Kosina Creek Run has one quite dominant point bar in the left bank of the mainstem. On the relative magnitude of expression scale that particular bar brought a High rating to the left primary zone. After the advent of the reservoir, the bar would be covered, dropping the score to Absent.

While all units had several minor drainages entering them on both sides, 17 of the 28 river runs were judged to have a major tributary. Of these, only 5 runs have two major tributaries, and only the Oshetna River Run has both on one side. Ratings were based on number of tributaries only for this characteristic, since relating tributary magnitude was covered by the watershed area rating. The number of tributaries would, of course, not be changed by raising the water level.

There are many physical causes for rapids, but two are common on the Susitna River and its tributaries. Rapids in the tributary itself are normally the typical "boulder zone" rapids found in young actively cutting mountain streams. When such a stream enters a larger water body, it drops its bed load of boulders, causing rapids in the mainstem. Spring floods sweep away these blockages, only to have them replaced. Ratings were based, again, on relative magnitude of expression within the river both types are illustrated here. The rapids on the tributary would not be affected by the new water levels, but those in the mainstem would become Absent. For the Kosina Creek Run, the mainstem rapids were rated Moderate before the dams, as were the rapids on Kosina Creek itself. Magnitude ratings of High were of course given to the rapids within the two Devil Canyon runs, for example. These rapids are due to the constriction of the river channel and to the fractured blocks of bedrock through which the mainstem is actively cutting in that area of steepened gradient.

The only characteristic from the watershed features section to be illustrated will be ponds (drained). These were rated by quantity, and thus the single such pond in the right primary zone received a Low rating. Two would have been given a Moderate and three or more, a High. After the dams, this pond would be covered and the resulting "after" rating was Absent.

SOILS (EDAPHIC)

The L.U.P.C. 1/250,000 soil type maps were examined, and four soil classes were aggregated for the Natural and Cultural Resource Matrix: (1) well drained, (2) well drained with some permafrost, (3) poorly drained, and (4) steep slopes/rocky land/icelands.

Ratings were based on the percentage of a zone covered by each soil class. Those classes covering from a trace up to 25% of the zone received a Low occurence rating. Twenty-five to seventy-five percent coverage was rated Moderate, and over seventy-five percent, High. Complete absence of a soil class was represented as such.

Vee Canyon Run is used as an example of the ratings (figure A-4). There are no steep/rocky/icelands in the run, so this class was rated Absent in all four zones (left secondary, left primary, right primary, right secondary). Well drained soil groups appear in two locations in the left secondary zone - but only there - covering about 40% of the area, so this class was rated Moderate in that zone. Poorly drained soils are found in small areas of both primary zones, and so are rated Low. Well drained soil containing some permafrost is found extensively in all four zones, so all were rated High for this class, except the left secondary which was less than 75%, therefore Moderate.

Maximum new high water levels would not totally eliminate any soil class, nor reduce any to a lower area coverage rating, so no magnitude of occurrence changes were recorded for Vee Canyon soils in the "after" matrix.

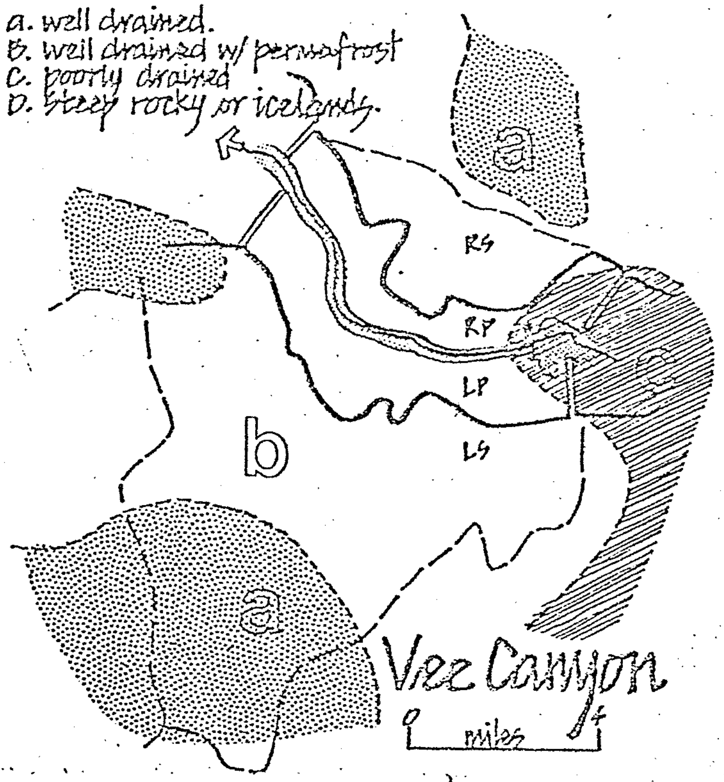


FIGURE A-4. SOILS

BOTANY

The vegetation typology follows that employed in Major Ecosystems of Alaska, which in turn is based on Viereck and Little. However, the typology was slightly expanded to differentiate between "upland" forests dominated by white spruce and those dominated by hardwoods. Also, black spruce bogs have been differentiated from the black spruce-hardwood type within "lowland" forests.

The L.U.P.C. 1/250,000 vegetation maps were incomplete for the study area, and in part mapped with a different typology from that of Major Ecosystems, so an Alaskan ecologist/forester was retained to map the vegetation types at 1/63,360 from oblique 35mm slides and commercial aerial photography, which was available for most of the primary zone from Indian River up to Jay Creek. Type identification was verified during field reconnaissance. Because of the heavy reliance on oblique photography, vegetation boundaries are to be considered proportionally or relatively (rather than precisely) accurate. Some associations were mosaiced too finely to separate at this scale, and are mapped as concurrent.

An association received an Absent rating only if it was not found in a zone at all. The other magnitude ratings were based on area coverage. A type found in more than 25% of the area was rated High. Between 12.5% and 25%, the magnitude given was Moderate. An association covering less than 12.5% of a zone was considered to have a Low magnitude of occurrence.

The Kosina Creek Run was selected to illustrate the botanic rating process in the primary zones (figure A-5). Seven of the eleven associations received Low or higher, and several of these will be affected by the high water level after the dam.

The lowland spruce-hardwood association and the low brush association are most prominent, rating High. One small lowland spruce bog in the left primary zone received a Low. Bottomland spruce-poplar and upland spruce-hardwood do not cover over 12.5% of either side of the primary zone and were rated Low, as was high brush. Upland hardwood-spruce is extensive enough to have been rated Moderate on both sides.

The new high water level will affect neither the lowland spruce-hardwood association nor the low brush type. However, much of the lowland hardwood-spruce association will be flooded, reducing its area coverage to Low on both sides. All of the other associations (bottomland spruce-poplar, upland spruce-hardwood, high brush and spruce bog) will be inundated and, therefore, were rated Absent in the "after" matrix.

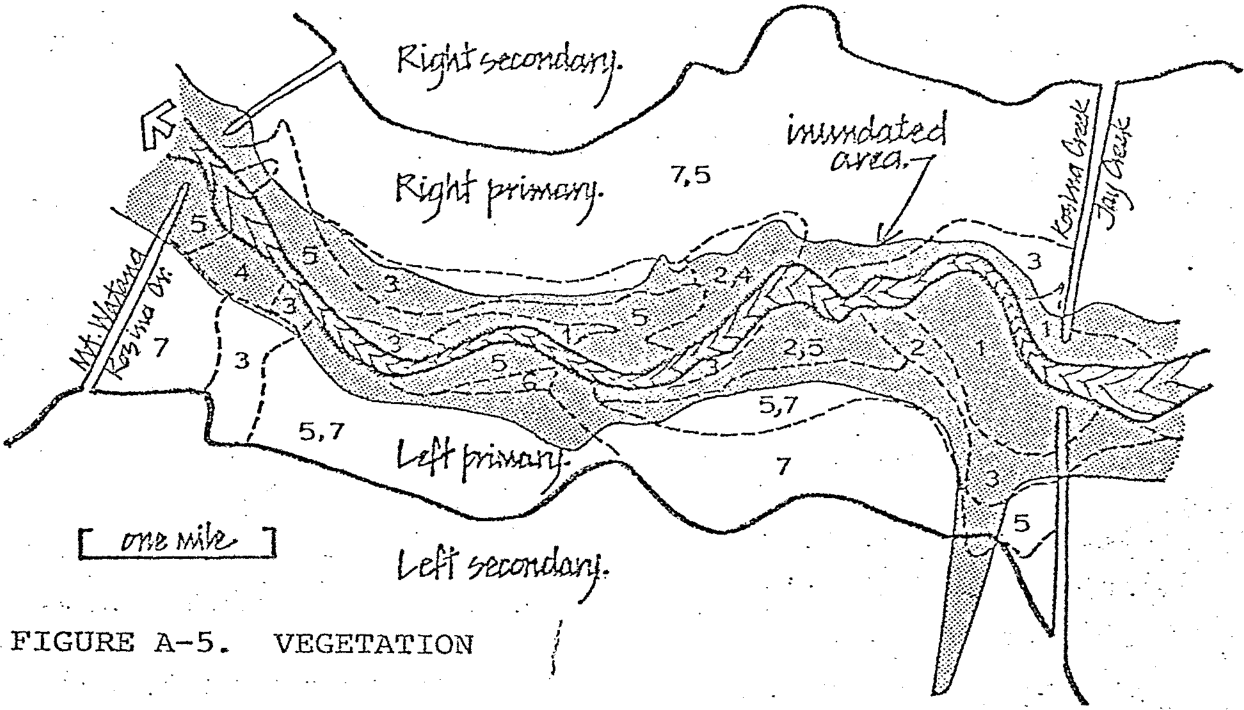


FIGURE A-5. VEGETATION

Mammals

Mammals were divided into three major groups: ungulates, carnivores and small mammals. No distinctive data for any of the small mammals (beaver, fox, etc.) was found, but the group was included in the inventory with a Low rating in all zones, simply to record the presence of small mammals throughout the study area.

Several species of carnivores were mapped in Alaska's Wildlife and Habitat (the principal inventory source of distributional data) as present throughout the study area, without special habit delimitations. Given the mobility of these species - wolf, wolverine, and black bear - it was also decided to indicate their presence with a Low rating in all zones. Grizzly bear are also likely to be found anywhere in the study area and therefore received at least a Low rating in all zones. The wildlife atlas does map some of the denning and fishing sites used by this species, and these known sites (others undoubtedly exist) were rated for magnitude as described in the data legend included earlier in the text.

Within the ungulate group, highly area-specific range maps were available for Dall sheep, which have stringent habitat requirements. Ratings were based on how much of a discrete sheep range was contained in a given zone, or vice versa. The Raft Creek Run, used here for illustration (figure A-6), contains a portion of a rather isolated Dall sheep range bounded by the Watana-Butte Creeks fault valley and the Jay-Coal Creeks valley. Only part of the range is contained in either the right primary or right secondary, and both were rated Low in magnitude. Since no range occurs on the left bank at all, sheep in both left zones were rated Absent. A magnitude rating of Moderate would have been assigned if the range were found largely in one zone, and High if it were either contained completely in the zone or the zone contained completely in it. The existence of a known mineral lick in a zone also earned it a High magnitude rating.

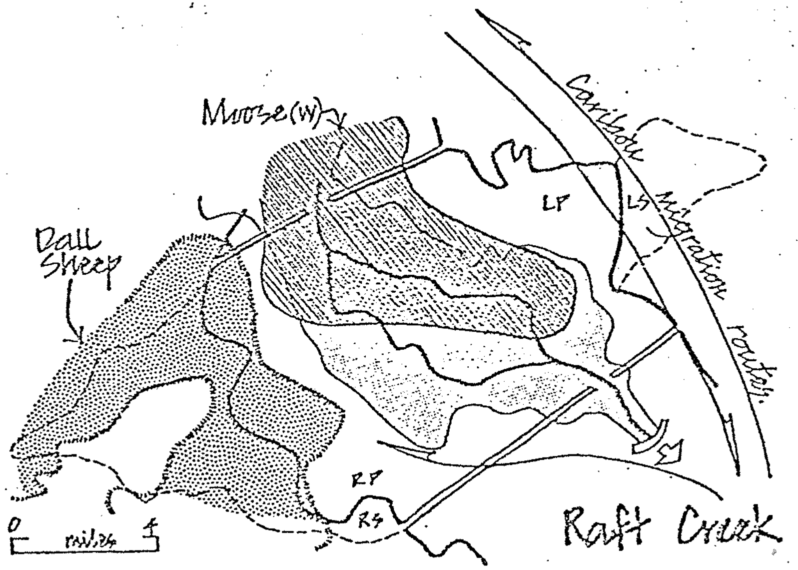


FIGURE A-6. MAMMALS

The mountain goat was initially included as an important game species which appeared to have possible habitat in the study area. However, no published data was found to document its presence in the upper Susitna watershed, although it occurs in the Talkeetnas not far south of Stephan Lake.

It is possible to find both caribou and moose in any zone of any run of the study area, and this ubiquity at a Low level of magnitude was noted. Specific locational data is available for seasonal concentrations, and this was recorded by zone. If a zone was completely confined in a seasonal range, the animal was considered to have a High likelihood of being present there in numbers during the season. If more than half of a zone overlapped the range, the likelihood was rated Moderate, and a Low rating was used for all overlaps less than one half.

Raft Creek contains moose winter and fall range, and caribou winter and spring range. Only moose winter range is illustrated, for clarity. The left and right primary zones were rated Moderate and Low for this seasonal range.

Data on caribou migration routes was drawn from several sources in addition to the wildlife atlas, notably Skoog and Hemming. All migration routes mapped in these sources were rated as having a High probability of use, and the inference was drawn that the remaining intervening primary zones also had a Moderate probability of use. The illustration of Raft Creek Run shows two known routes, one used during the spring and one during the fall migration.

It was not possible to quantify the effects of the dams on wildlife populations except where known habitat was flooded. In this example, virtually all moose winter range in the left primary zone will be flooded, dropping the "after" rating from Moderate to

Low, while the right primary rating was reduced to Absent.

Waterfowl

Birds were grouped into two classes for inclusion in the Natural and Cultural Resources Matrix: raptors and waterfowl. Data was lacking on the distribution of upland species, so these were not included although they are known to occur in the study area.

Raptor populations are relatively sparse in this area (White, 1974), and apparently will be little affected by the dams. Cliff height helicopter flights in the primary zone brought several positive sightings, rated as High, and the rest of the primary zones were rated Low to reflect the general presence of this group despite its sparse distribution. No data was available for secondary zones, so these columns in the matrix have been left blank as "unsurveyed".

Mapped waterfowl distribution data was taken primarily from Alaska's Wildlife and Habitat and Alaska Regional Profiles: Southcentral Region. Low and moderate concentrations were simply rated as Low and Moderate, respectively. High ratings were registered for those areas used for nesting and moulting.

Waterfowl were frequently found in both primary and secondary zones. In the Raft Creek Run, however, used here as an illustration (figure A-7), waterfowl are absent in both secondary zones. Raft Creek's primary zones are predominantly nesting/moulting areas, and so were rated as High. The Denali Reservoir, rising each summer, would virtually eliminate this type of use, but moderate concentrations of waterfowl could be expected to use the open water during migration, resulting in an "after" rating of Moderate for magnitude of occurence of waterfowl.

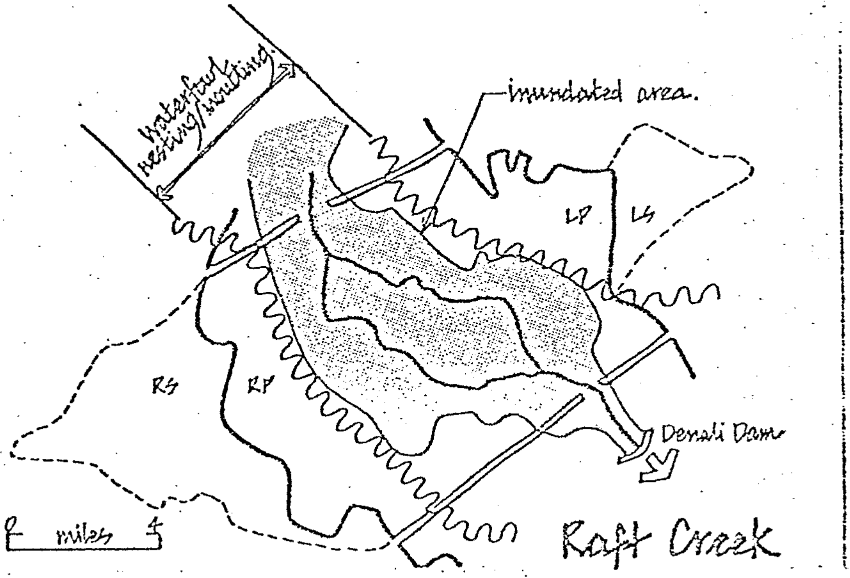


FIGURE A-7. WATERFOWL

HYDROLOGIC

MAINSTEM: I A C CLASS, VOLUME, AVE GRADIENT, OFFSET STREAM, STRMFORM INCIS, DROPS WHIRLPOO, RAPIDS, CUTBNK OUTCROP, POOLS RIFFLES, ISLANDS VEG, RIV BARS UNVEG, PT BARS BEACH

MAJOR TRIBUTARIES: STREAM ORDER, MAX GRAD PRIM, TURBIDITY, WATERSHED AREA, NR TRIBUTARIES, WATERFALLS, RAPIDS, POOLS RIFFLES, CUTBNK OUTCROP, ISLANDS VEG, RIV BARS UNVEG, PT BARS BEACH, CONFLUENCE DEL

WATERSHED FEATURES: LAKES, PONDS DRAINED, PONDS UNDRAIN, OXBOW LAKES, SLOUGHS

HYD SEAS AVAIL

HYDR DIVERSITY

HYDR UNIQUENES

L S / L P / R P / R S

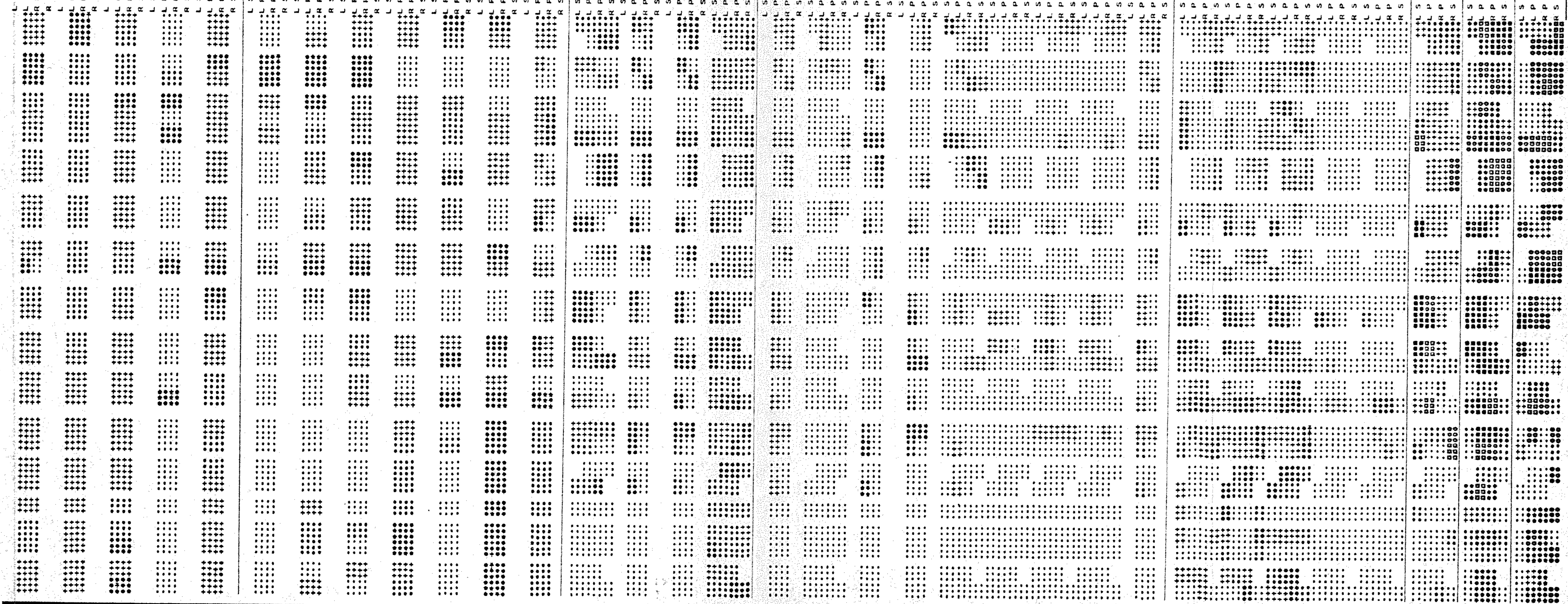
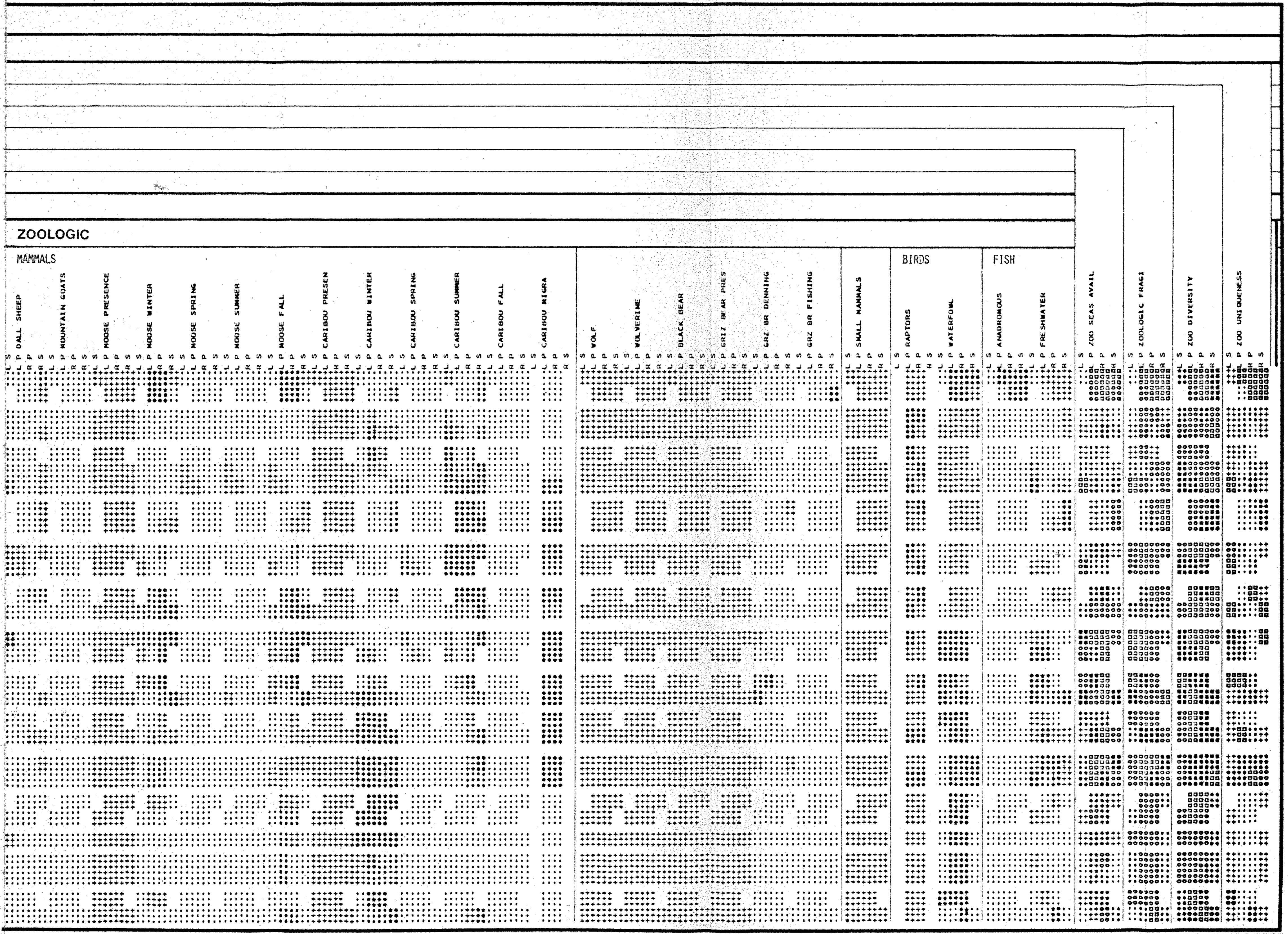


TABLE A-1 (Continued)



ZOOLOGIC

MAMMALS

DALL SHEEP

MOUNTAIN GOATS

MOOSE PRESENCE

MOOSE WINTER

MOOSE SPRING

MOOSE SUMMER

MOOSE FALL

CARIBOU PRESEN

CARIBOU WINTER

CARIBOU SPRING

CARIBOU SUMMER

CARIBOU FALL

CARIBOU MIGRA

WOLF

WOLVERINE

BLACK BEAR

GRIZ BEAR PRES

GRZ BR DENNING

GRZ BR FISHING

SMALL MAMMALS

BIRDS

RAPTORS

WATERFOWL

FISH

ANADROMOUS

FRESHWATER

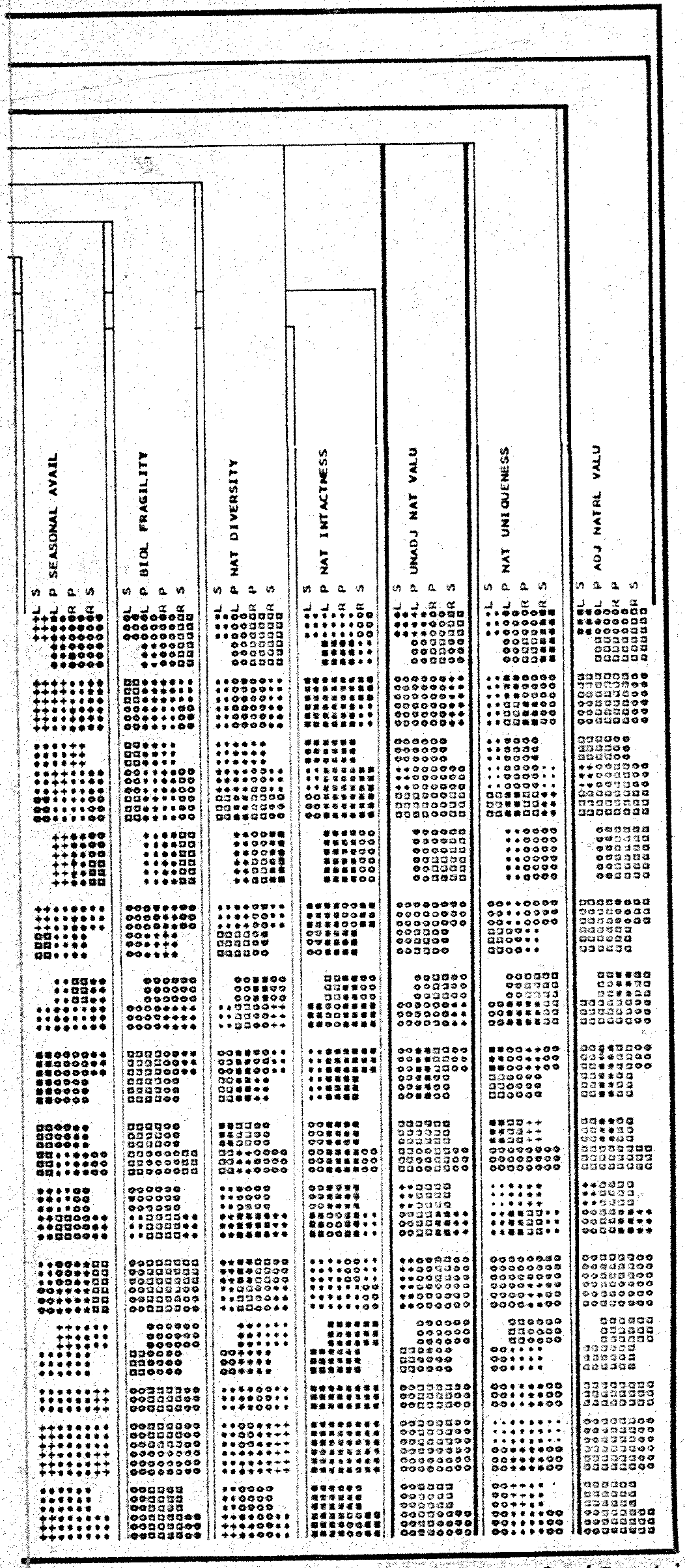
ZOO SEAS AVAIL

ZOOLOGIC FRAGI

ZOO DIVERSITY

ZOO UNIQUENESS

TABLE A-2 (Continued)



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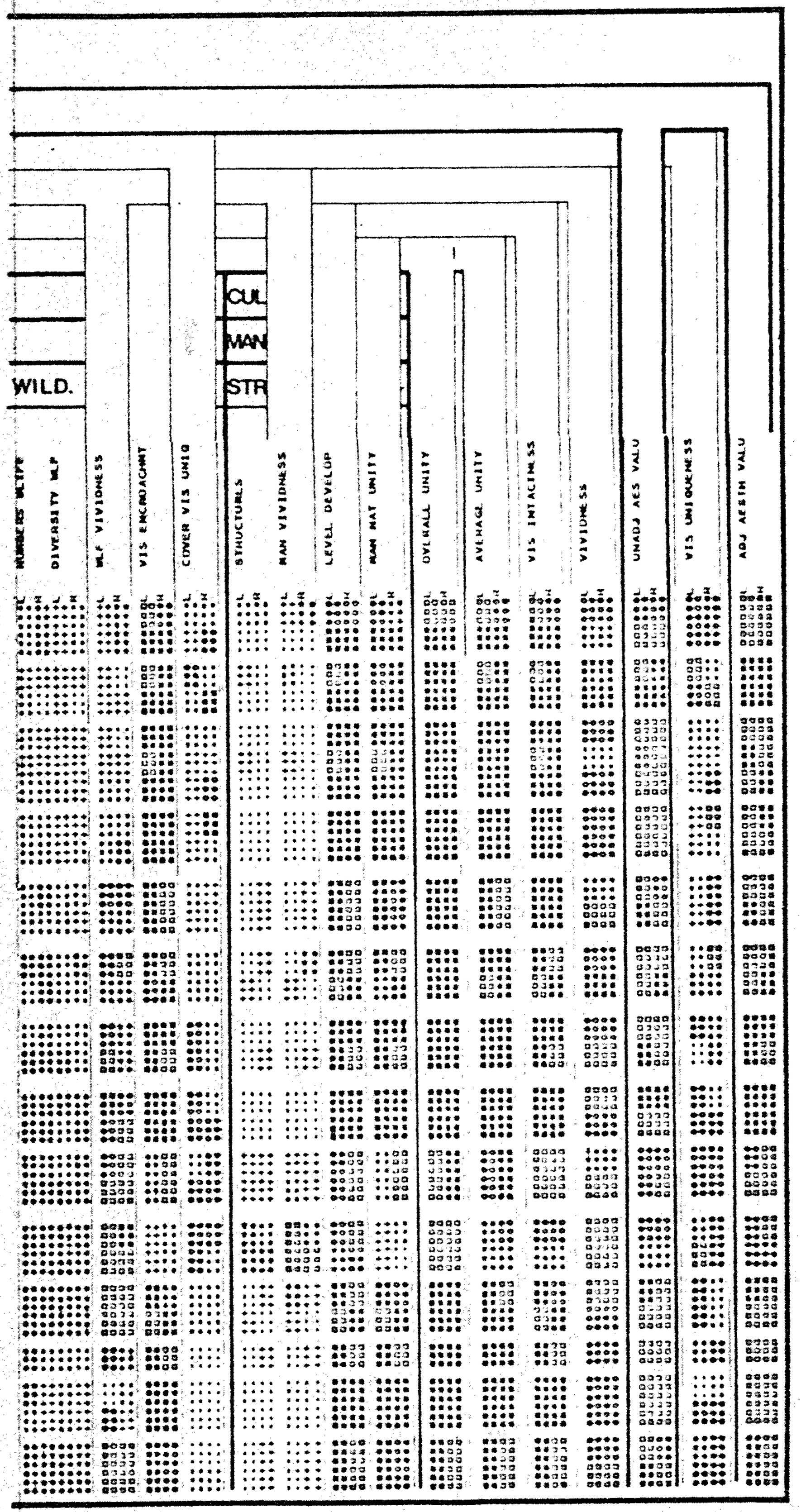
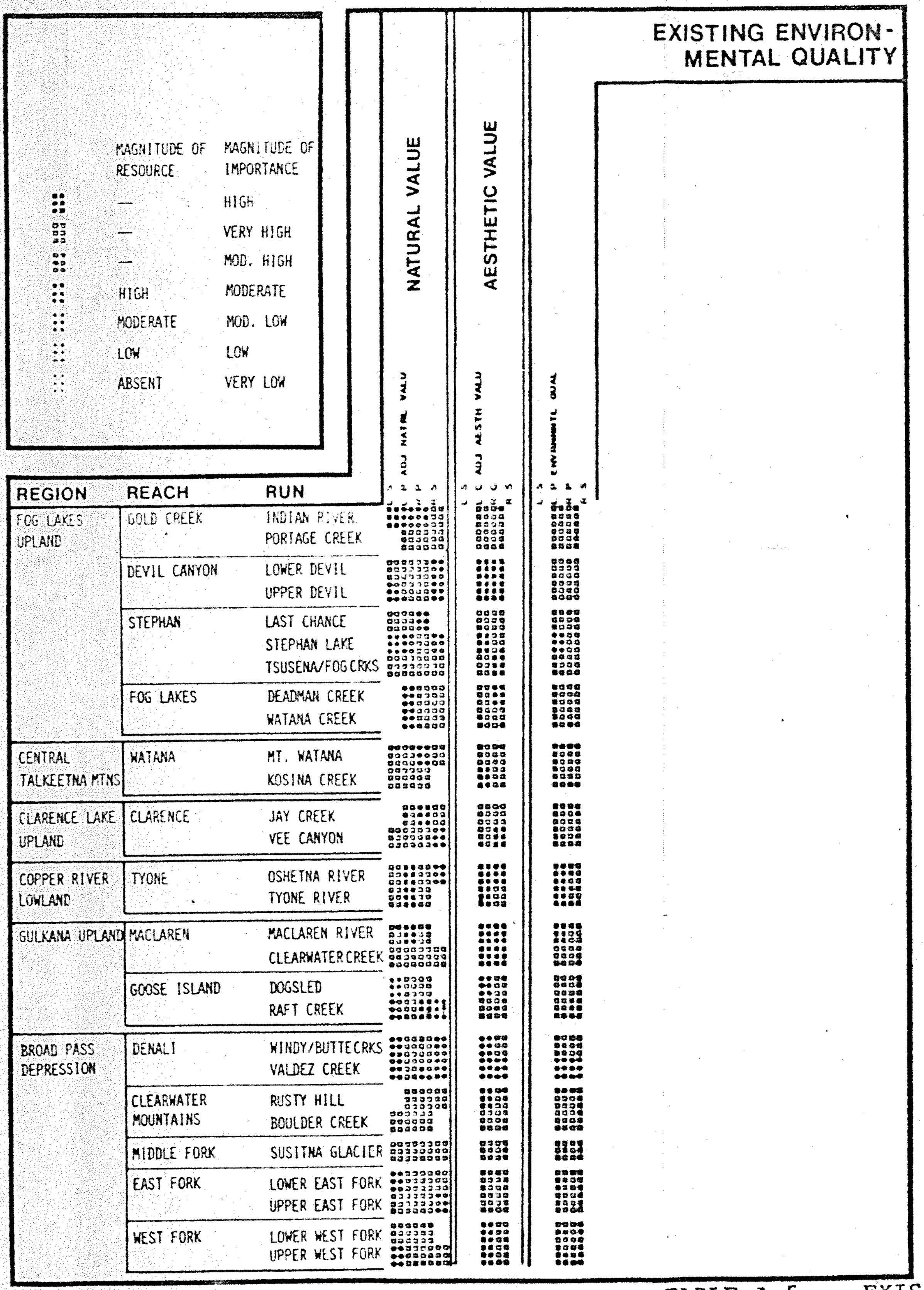




EXISTING ENVIRONMENTAL QUALITY

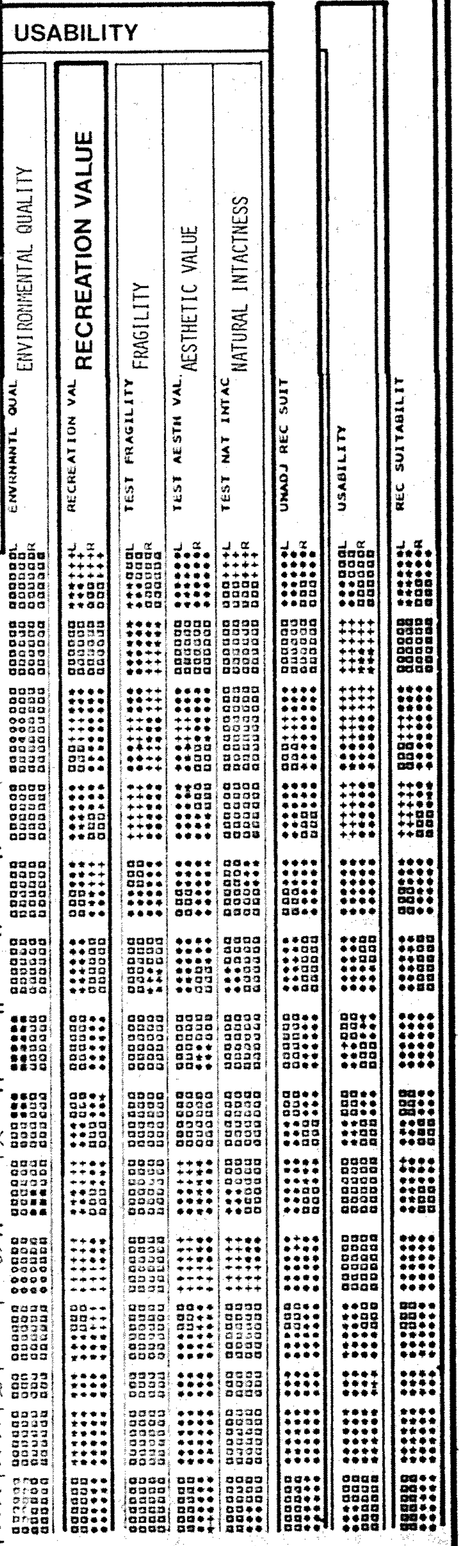
MAGNITUDE OF RESOURCE	MAGNITUDE OF IMPORTANCE
—	HIGH
—	VERY HIGH
—	MOD. HIGH
HIGH	MODERATE
MODERATE	MOD. LOW
LOW	LOW
ABSENT	VERY LOW

REGION	REACH	RUN
FOG LAKES UPLAND	GOLD CREEK	INDIAN RIVER PORTAGE CREEK
	DEVIL CANYON	LOWER DEVIL UPPER DEVIL
	STEPHAN	LAST CHANCE STEPHAN LAKE TSUSENA/FOG CRKS
	FOG LAKES	DEADMAN CREEK WATANA CREEK
CENTRAL TALKEETNA MTNS	WATANA	MT. WATANA KOSINA CREEK
CLARENCE LAKE UPLAND	CLARENCE	JAY CREEK VEE CANYON
COPPER RIVER LOWLAND	TYONE	OSHETNA RIVER TYONE RIVER
GULKANA UPLAND	MACLAREN	MACLAREN RIVER CLEARWATER CREEK
	GOOSE ISLAND	DOGSLED RAFT CREEK
BROAD PASS DEPRESSION	DENALI	WINDY/BUTTE CRKS VALDEZ CREEK
	CLEARWATER MOUNTAINS	RUSTY HILL BOULDER CREEK
	MIDDLE FORK	SUSITNA GLACIER
	EAST FORK	LOWER EAST FORK UPPER EAST FORK
	WEST FORK	LOWER WEST FORK UPPER WEST FORK

TABLE A-5 EXISTING ENVIRONMENTAL QUALITY

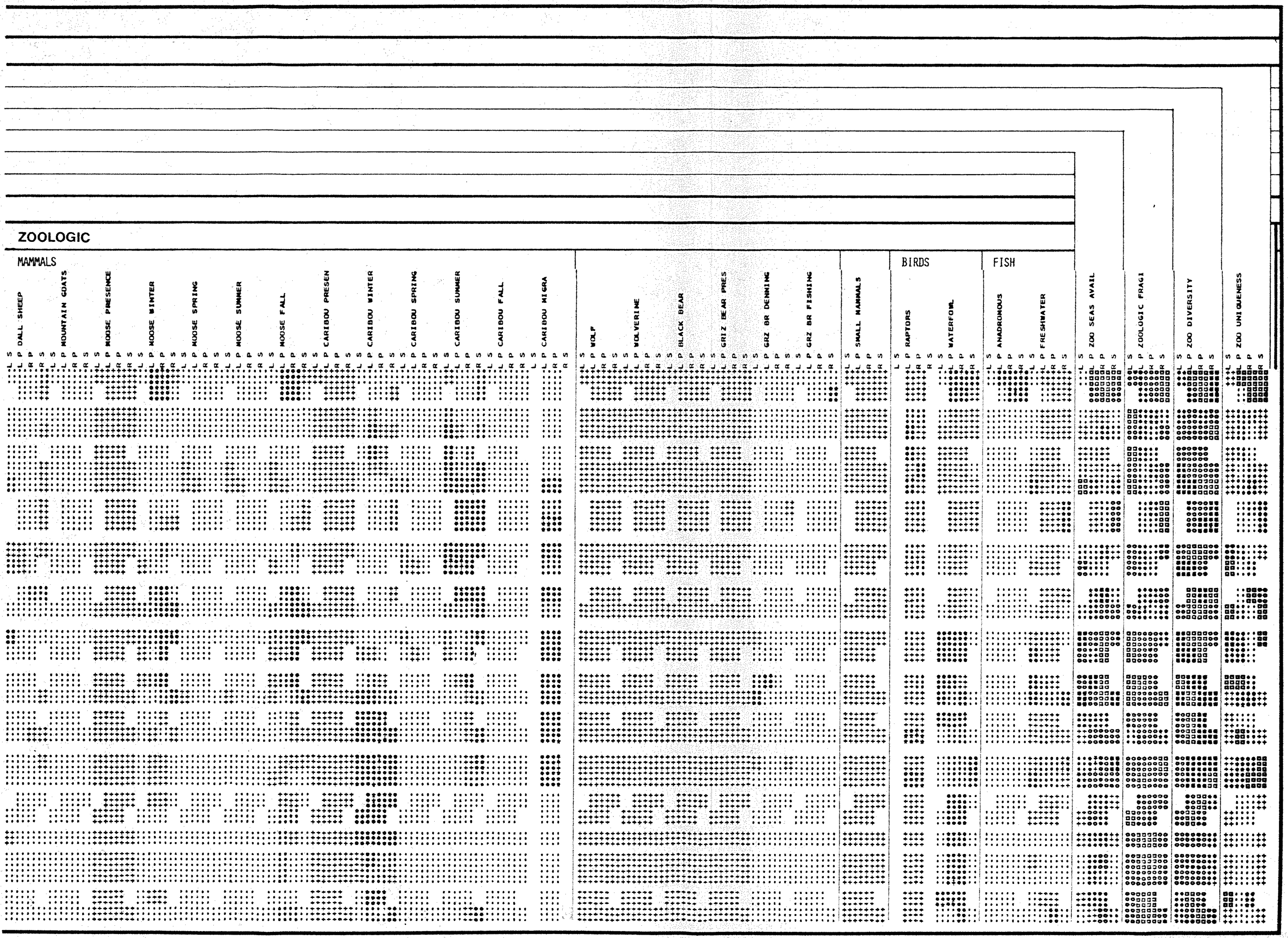
	ENVIRONMENTAL VALUES & QUALITY	RECREATIONAL IMPACT SUITABILITY
□	HIGH	LOW
●	MODERATE	MODERATE
+	LOW	HIGH

EXISTING RECREATION SUITABILITY



REGION	REACH	RUN
FOG LAKES UPLAND	GOLD CREEK	INDIAN RIVER PORTAGE CREEK
	DEVIL CANYON	LOWER DEVIL UPPER DEVIL
	STEPHAN	LAST CHANCE STEPHAN LAKE TSUSENA/FOG CRKS
	FOG LAKES	DEADMAN CREEK WATANA CREEK
CENTRAL TALKEETNA MTNS	WATANA	MT. WATANA KOSINA CREEK
CLARENCE LAKE UPLAND	CLARENCE	JAY CREEK VEE CANYON
COPPER RIVER LOWLAND	TYONE	OSHETNA RIVER TYONE RIVER
GULKANA UPLAND	MACLAREN	MACLAREN RIVER CLEARWATER CREEK
	GOOSE ISLAND	DOGSLED RAFT CREEK
BROAD PASS DEPRESSION	DENALI	WINDY/BUTTE CRKS VALDEZ CREEK
	CLEARWATER MOUNTAINS	RUSTY HILL BOULDER CREEK
	MIDDLE FORK	SUSITNA GLACIER
	EAST FORK	LOWER EAST FORK UPPER EAST FORK
	WEST FORK	LOWER WEST FORK UPPER WEST FORK

TABLE A-6 EXISTING RECREATION SUITABILITY



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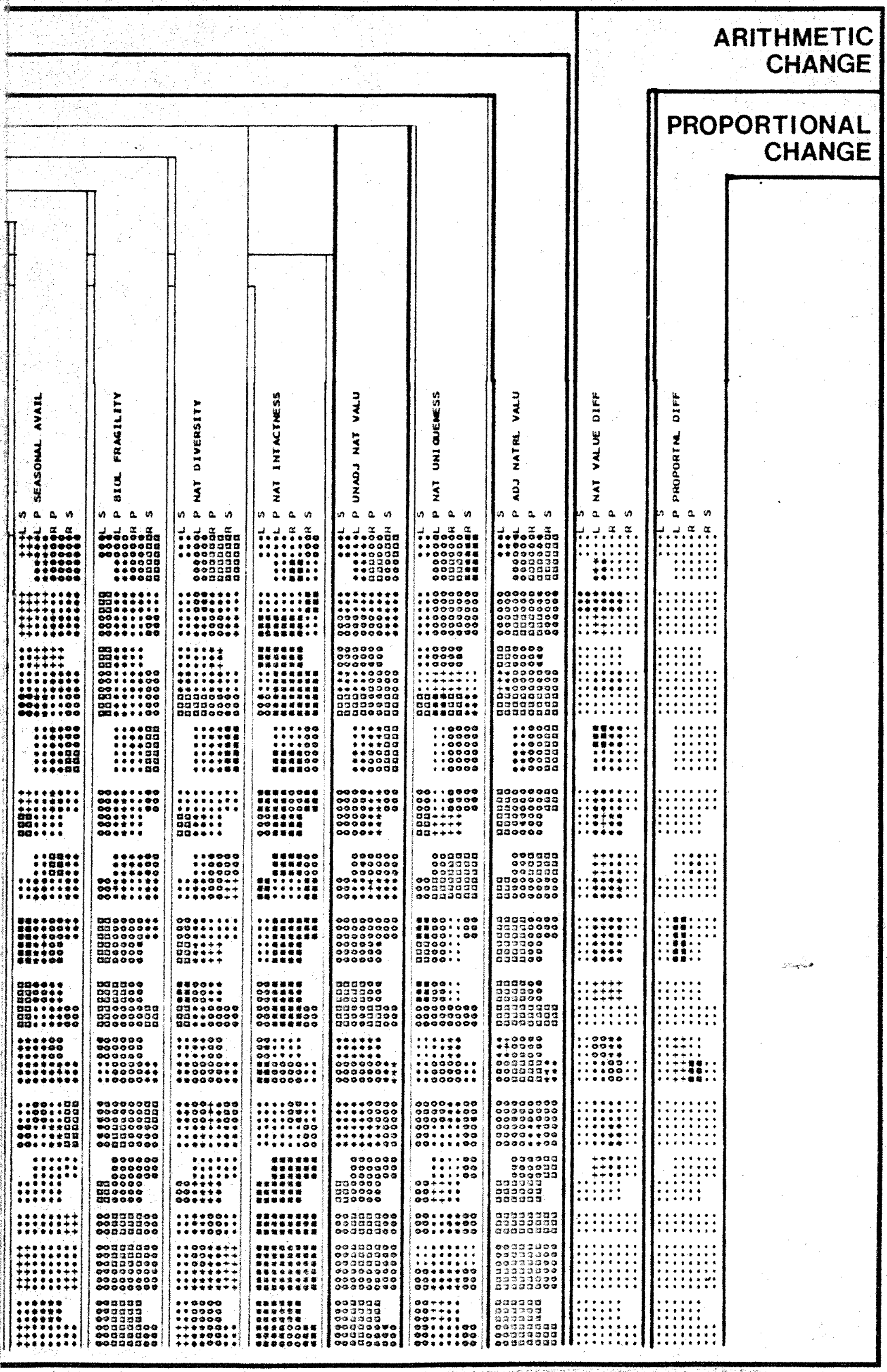

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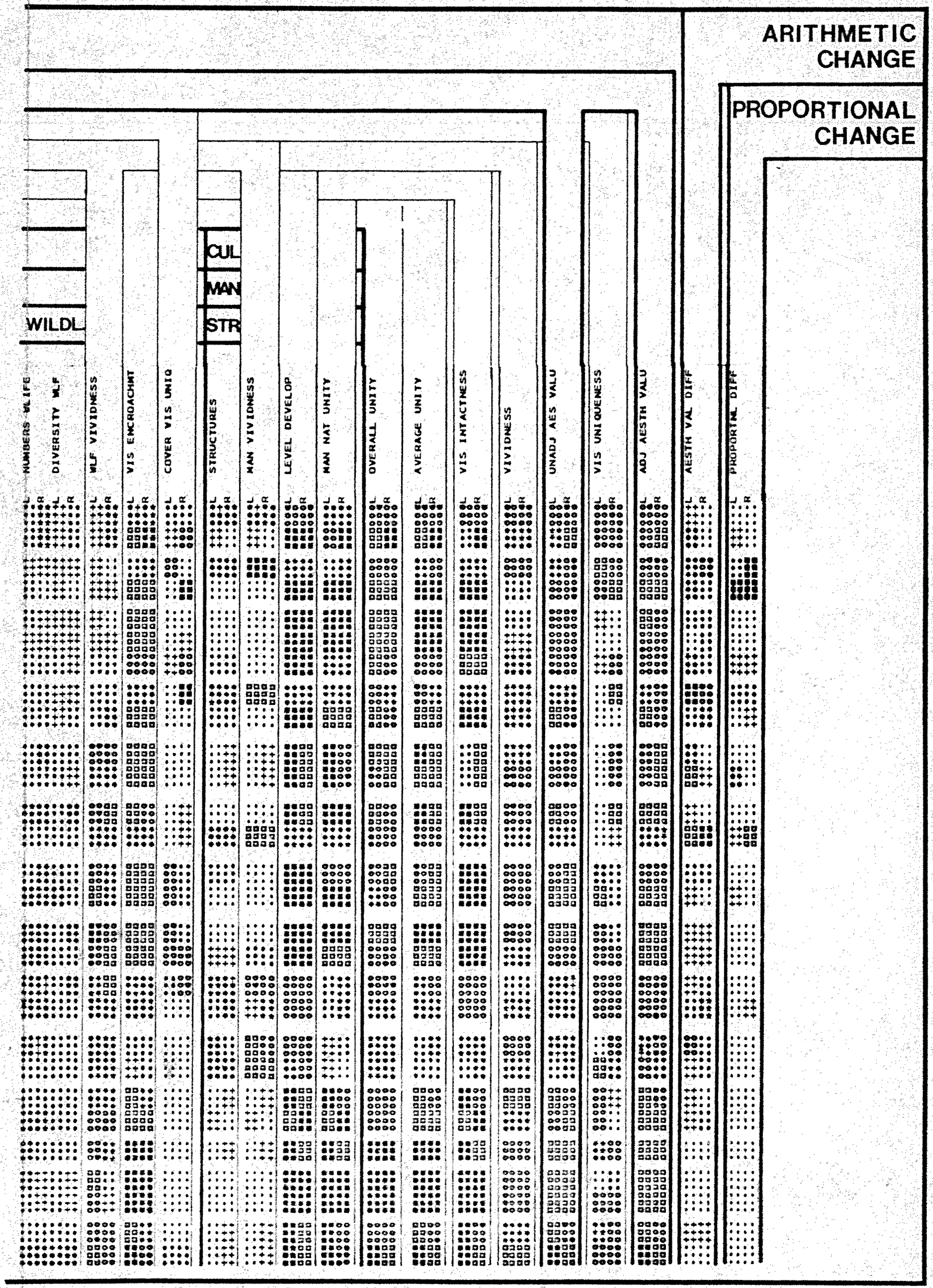


	MAGNITUDE OF RESOURCE	MAGNITUDE OF IMPORTANCE
■	—	HIGH
□	—	VERY HIGH
○	—	MOD. HIGH
●	HIGH	MODERATE
◆	MODERATE	MOD. LOW
+	LOW	LOW
·	ABSENT	VERY LOW

REGION	REACH	RUN
FOG LAKES UPLAND	GOLD CREEK	INDIAN RIVER PORTAGE CREEK
	DEVIL CANYON	LOWER DEVIL UPPER DEVIL
	STEPHAN	LAST CHANCE STEPHAN LAKE TSUSENA/FOG CRKS
	FOG LAKES	DEADMAN CREEK WATANA CREEK
CENTRAL TALKEETNA MTNS	WATANA	MT. WATANA KOSINA CREEK
CLARENCE LAKE UPLAND	CLARENCE	JAY CREEK VEE CANYON
COPPER RIVER LOWLAND	TYONE	OSHETNA RIVER TYONE RIVER
GULKANA UPLAND	MACLAREN	MACLAREN RIVER CLEARWATER CREEK
	GOOSE ISLAND	DOGSLED RAFT CREEK
BROAD PASS DEPRESSION	DENALI	WINDY/BUTTE CRKS VALDEZ CREEK
	CLEARWATER MOUNTAINS	RUSTY HILL BOULDER CREEK
	MIDDLE FORK	SUSITNA GLACIER
	EAST FORK	LOWER EAST FORK UPPER EAST FORK
	WEST FORK	LOWER WEST FORK UPPER WEST FORK

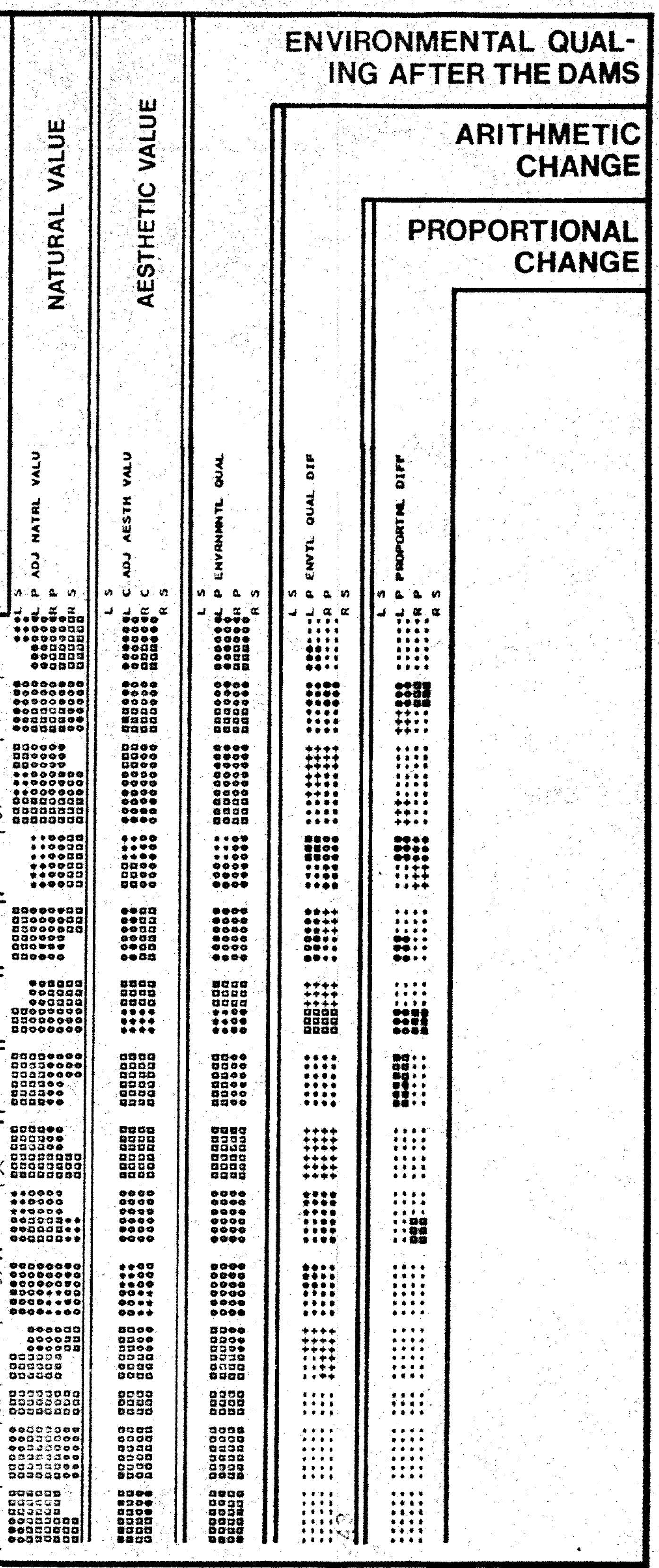
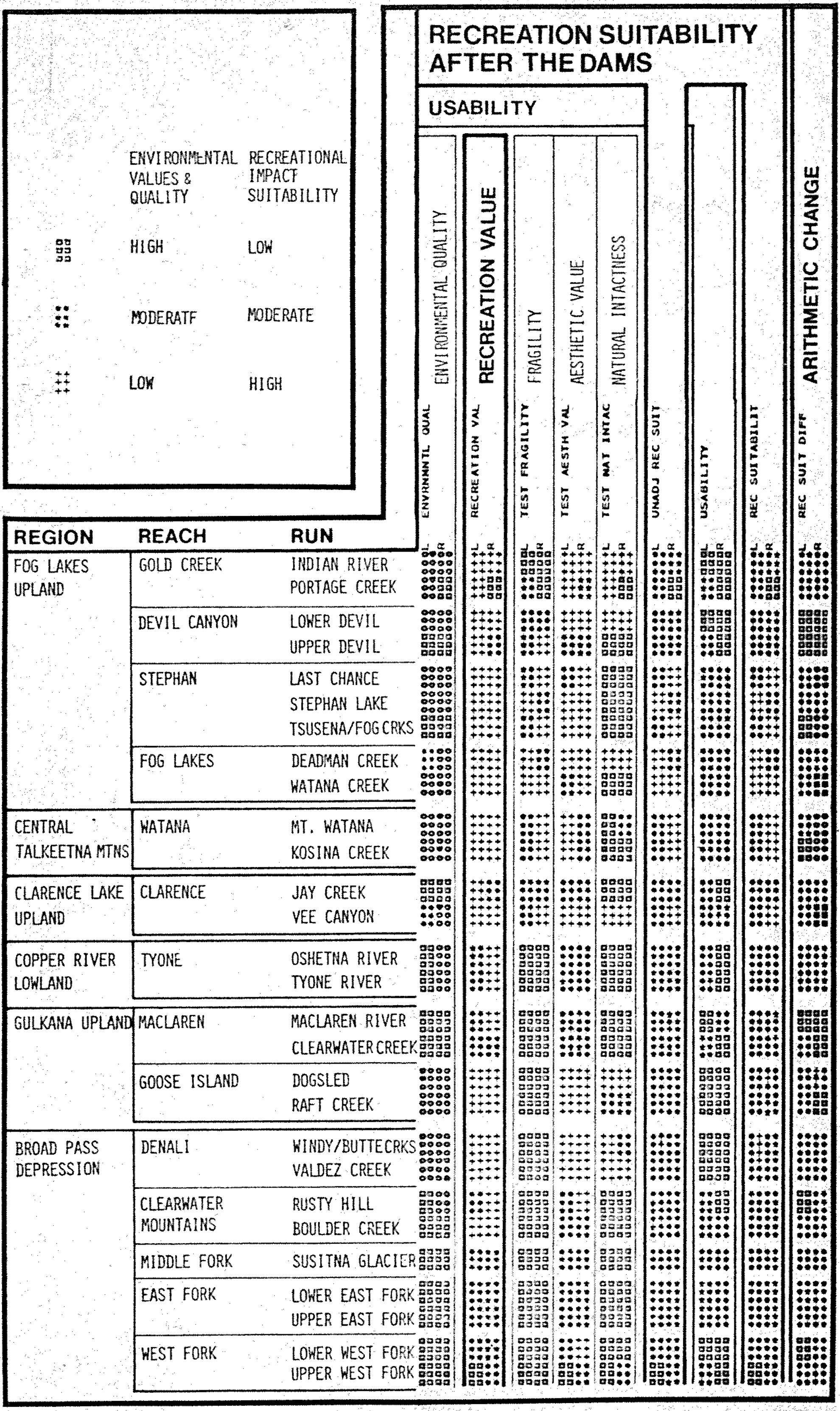


TABLE A-11 ENVIRONMENTAL QUALITY AFTER DAM CONSTRUCTION



	ENVIRONMENTAL VALUES & QUALITY	RECREATIONAL IMPACT SUITABILITY
▫	HIGH	LOW
•	MODERATF	MODERATE
+	LOW	HIGH

RECREATION SUITABILITY AFTER THE DAMS

USABILITY

ENVIRONMENTAL QUALITY — ENVRNMNTL QUAL (L R)

RECREATION VALUE — RECREATION VAL (L R)

FRAGILITY — TEST FRAGILITY (L R)

AESTHETIC VALUE — TEST AESTH VAL (L R)

NATURAL INTACTNESS — TEST NAT INTAC (L R)

UNADJ REC SUIT (L R)

USABILITY (L R)

REC SUITABILIT (L R)

ARITHMETIC CHANGE — REC SUIT DIFF (L R)

REGION	REACH	RUN
FOG LAKES UPLAND	GOLD CREEK	INDIAN RIVER PORTAGE CREEK
	DEVIL CANYON	LOWER DEVIL UPPER DEVIL
	STEPHAN	LAST CHANCE STEPHAN LAKE TSUSENA/FOG CRKS
	FOG LAKES	DEADMAN CREEK WATANA CREEK
CENTRAL TALKEETNA MTNS	WATANA	MT. WATANA KOSINA CREEK
CLARENCE LAKE UPLAND	CLARENCE	JAY CREEK VEE CANYON
COPPER RIVER LOWLAND	TYONE	OSHETNA RIVER TYONE RIVER
GULKANA UPLAND	MACLAREN	MACLAREN RIVER CLEARWATER CREEK
	GOOSE ISLAND	DOGSLED RAFT CREEK
BROAD PASS DEPRESSION	DENALI	WINDY/BUTTE CRKS VALDEZ CREEK
	CLEARWATER MOUNTAINS	RUSTY HILL BOULDER CREEK
	MIDDLE FORK	SUSITNA GLACIER
	EAST FORK	LOWER EAST FORK UPPER EAST FORK
	WEST FORK	LOWER WEST FORK UPPER WEST FORK

TABLE A-12 RECREATION SUITABILITY AFTER DAM CONSTRUCTION

HUMAN USE

Settlement

The five characteristics inventoried under Settlement were intended to capture the range of human dwelling patterns in the study area before and after construction of the dams.

The rating for archeological sites was based on the degree of certainty with which the sites and their resources are known. Sites already at least partially investigated and studied, i.e., the Tangle Lakes sites, were given a prominence rating of High. From discussion with the staff archeologist of the Alaska Division of Parks, Karen Workman, several sites were identified where remains had been found, but no formal investigation has yet been carried out to define the extent or importance of these remains. These sites were considered Moderate in prominence. The Tangle Lakes sites have been associated by their investigator with the shores of the proglacial lake that existed in the Copper River Lowland region during the last glaciation, and with caribou hunting. Therefore, other zones along the edges of this ancient lake were considered possible locations of archeological sites, along with the Broad Pass Depression region, a likely migration route for both caribou and prehistoric man. Skoog records instances of systematized native caribou hunts at Clarence Lake, and it and Stephan Lake were also considered potential archeological sites. In general, sites were considered to be on drier, high ground and not subject to inundation by the projected reservoirs.

Campsite locations were based on observation during fly-overs, and discussion with local lodge operator. On this basis information is lacking for the lower left secondary zones. A single known camp received a Low magnidute rating. Two known camps in a zone rated a Moderate, and three or more, a High. "Campsites" here means tent platforms or other improved campsites with repeated and regular use.

Cabins and cottages were inventoried similarly, from U.S.G.S. maps and the above sources.

Resorts and lodges were to receive a Low magnitude rating if a "primitive" facility, intended to be reached only by foot or sled. They were rated Moderate when a small or moderate sized facility with facilities for mechanized access. Major resort complexes were to be rated High. All resorts and lodges in the study area are in the Moderate class.

Existing towns and villages in the watershed are all small. Distinctions "before" seemed to be unnecessary, and all received Low magnitude ratings.

Since secondary land use projections were not a part of this assessment, the ratings for none of the above four classes of settlement were increased after construction of the dams, and decreases were registered only where a facility would be inundated.

Accessibility (Facility Dependent)

The magnitude of rail access within the study area was rated on the approximate proportion of a zone made accessible by the track system. Rail access received a Low rating if one-third of the zone (or less) was made accessible. Moderate accessibility was assessed for up to fifty percent of the zone. To receive a High rating, virtually all the zone had to be accessible by rail. There will be no changes after the dams.

Air access was rated on the permanence of the ground facility. Airstrips received Moderate scores, while airfields (with hangers, etc.) were rated High. No aircraft ground facilities were rated Low if they occurred at all, since Alaskan bush pilots land on a wide variety of unprepared surfaces. The proposed reservoir of water levels will not affect any existing aircraft facilities.

Auto accessibility also received no Low ratings if roads were persent, since 4-wheel drive vehicles can and do travel in roadless areas. Moderate ratings were attached to unimproved highways, such as the Denali Highway, while all weather highways, did any exist in the study area, would have received High scores.

The Lower Devil Run is used to illustrate this type of rating (figure A-8). Devil Canyon Dam will require an unimproved access road to be built from the Anchorage-Fairbanks Highway to the dam site, so facility-dependent auto access ratings for both the left secondary and primary zones change from Absent to Moderate.

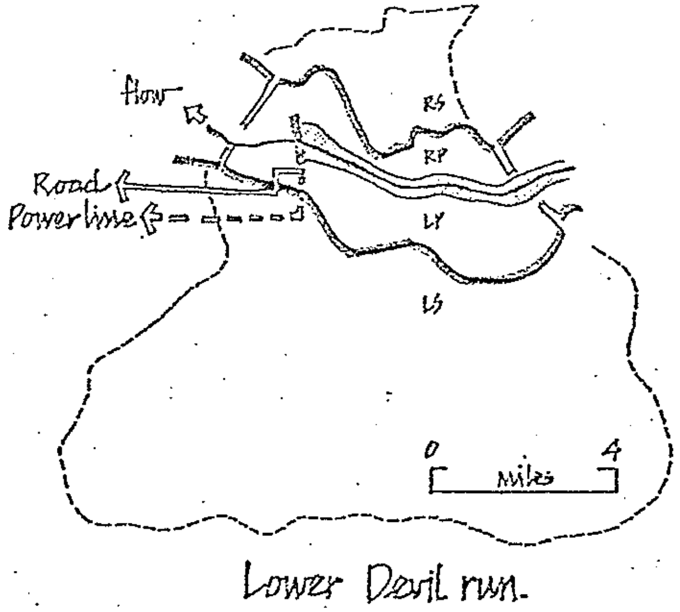


FIGURE A-8. FACILITY-DEPENDENT ACCESS AND UTILITIES

Accessibility (Facility Independent)

In the Alaskan backcountry, great reliance is placed on transportation modes that do not require prepared ground surfaces. Each zone was rated for accessibility in terms of the degree to which its terrain imposes limitations on five different facility-independent transportation modes. For each mode, accessibility levels were mapped for the entire study area; watershed zones were then assigned the highest rating occurring within their boundaries.

When rating accessibility by air, helicopters were not considered for several reasons: 1) accessibility was an element of the recreation analysis and helicopters are little used for recreation because of their expense in comparison to fixed-wing aircraft; 2) they are illegal for transportation of hunting gear and game, a principal recreational use of aircraft; 3) there are few non-weather limitations to their use. Accessibility via fixed-wing aircraft was rated during the ice-free months, although skis were assumed to be available for summer glacier landings.

Accessibility was rated Absent if landings were judged impossible or very risky. A Low rating was given to zones with high limitations, e.g., only one lake, few usable stretches of river or terrain requiring specialized techniques or equipment (tundra tires, glacier landings, etc.). Zones with several poorly distributed lakes, or other landing sites were rated Moderate. A High rating was assigned to any zone having several well distributed lakes, or very good river access with gravel bars showing recent use.

The presence of impoundments would raise many primary zone ratings to High, since the reservoirs would provide excellent float plane access. No changes in air accessibility were projected for the secondary zones.

Boat access would also be rated High on the new reservoirs after dam construction. Ratings for existing conditions ran from Absent (not enough water to navigate, i.e. Upper West Fork Run) to High, for zones where power craft might reasonably be expected to pass class III rapids. Moderate ratings were assigned to those zones passable by raft (class IV rapids), while the fact that several experienced - and lucky - kayakers have run Devil Canyon successfully caused class VI rapids to be assigned a Low accessibility rating, rather than an Absent.

Accessibility to all-terrain vehicles, or ATV's, was rated by the limitations posed to traversability by load-carrying wheeled or tracked vehicles before freeze-up. Recreational use of ATV's in the study area is presently ancillary to hunting and seems likely to remain so in the future because of trailering distances to major population centers. Access in steep, broken or boggy areas (impassable to the types of ATV presently available for recreational use) was rated Absent. Low ratings were given to potentially traversable areas closed by law to the use of motorized hunting transport. Moderate ratings were given to lands appearing traversable but requiring more than a day or two of travel-time from the nearest highway trailering point (e.g., the rolling terrain south and east of the Susitna River). High accessibility ratings were assigned to zones with known ATV routes or inferred extensions of such routes within a day or two of highway access. Information on existing routes was obtained from the owner/operator of Susitna Lodge and from field reconnaissance.

Rating changes after the dams were predicated on distance from the additional roads presently proposed for Denali and Devil Canyon dams. Since no firm road proposals have yet been made for the middle section of the river, no changes in ATV access were projected here. Thus, these ratings will require adjustment for any road extensions eventually planned for Vee and Watana dams.

Since sled accessibility ratings were based on winter conditions, snowmobile access was included in this class. Only steep slopes, broken terrain, or bare rock are inaccessible to these modes of transport, and the river becomes a mainline.

High ratings were given to gentle terrain which appeared likely to have consistent snow cover. Moderate ratings were used for steeper terrain and mountain pass areas subject to occasional dangerous conditions. Terrain of reasonable slope, but subject to loss of snow cover was given a score of Low.

The Lower Devil Run (figure A-9) illustrates a portion of the rating map developed for this characteristic. The left secondary zone is rated Low while the other three zones have some highly accessible areas and so are rated High.

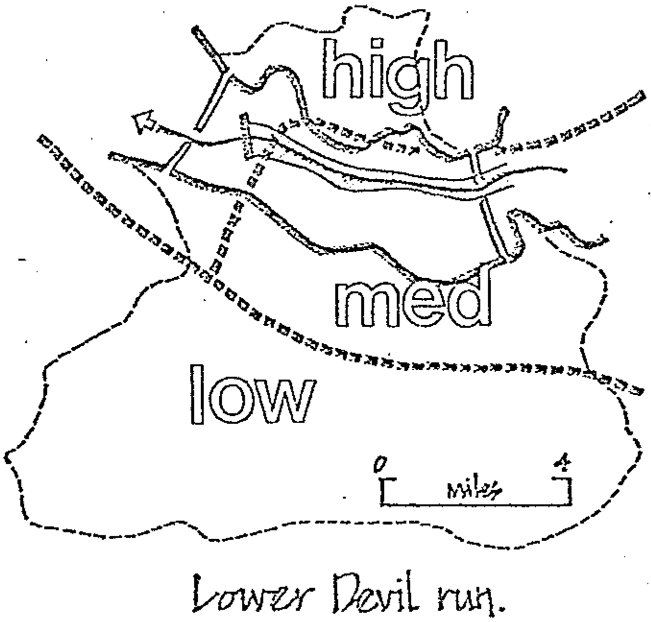


FIGURE A-9. FACILITY-INDEPENDENT ACCESS

Access by foot was examined with the assumption that most hunters and hikers do not walk more than ten miles from a road, equal to a maximum dayhike of twenty miles round trip. No trail construction was assumed. The Absent rating was used for very wet areas considered impassable on foot. Low ratings were given to all traversable terrain more than ten miles from roads or rails. Moderate was assigned to difficult land (i.e., wet or mountainous) within ten miles of a railraod or highway. High scores were reserved for easy terrain (e.g., alpine tundra) within the ten mile zone.

All zones of Lower Devil Run were rated Low before the dams. Afterwards, the presence of the access road would raise the primary zone ratings to Moderate and both secondary zone scores to High.

Utilities

Utility characteristics could potentially figure very strongly in the evaluation of aesthetic and environmental impacts of the Upper Susitna hydroelectric project considered as a complete system, but most of the necessary ancillary facilities to the dams and reservoirs were excluded from the scope of this assessment.

Underground utilities were rated in a similar manner to rail access. There are no existing underground utilities in the study area, and no data on such facilities "after," so all ratings were Absent. Secondary facilities (such things as substations, storage depots, etc.) are indeterminate at this time, but would figure in any impact analysis of ancillary facilities and functions. For this reason, the category was retained, but was rated Absent in all zones for this study.

The Lower Devil Run illustrates the occurrence of both major facilities and overhead facilities (figure A-8). The former are considered to be dams - the principal generator of secondary facilities. All four dams being evaluated were rated High as major utilities. Moderate or Low ratings would go to re-regulating dams or small dams on tributaries.

Overhead utilities presently exist only in the Indian River Run, where the present telegraph line received a Low rating. The Lower Devil Run shows the path of the planned 230 KV power transmission line assumed to run parallel to the new access road. This was rated High in both the left primary and left secondary zones. Any overhead utility of intermediate size and R.O.W. requirements would be considered Moderate in magnitude.

Extraction

Examples of surface extraction include placer mining for gold, gravel extraction, quarrying and strip mining of coal. Subsurface extraction refers to underground mining of metallic or non-metallic minerals such as gold, copper, and coal. The primary objective of historic and existing extracting activity in the study area has been gold, both placer and lode, although claims for other minerals have been recorded, and prospecting activity continues in the area. There has also been a recent re-activation of gold workings, as yet at a small scale, notably in the Denali Reach.

The magnitude of this activity was judged by the relative number of deposits mapped by Cobb (1972) and Clark and Cobb (1972). One or two reported deposits in a zone received a Moderate rating, while more than that received a High magnitude score. These sources identify known deposits only and do not differentiate between active and inactive workings; claim activity may be several times higher. Placer deposits were considered to be surface workings, and lode deposits subsurface.

There has also been a moderate amount of sand and gravel extraction, again in the Denali Reach, for the Denali Highway. These materials have been taken from eskers and other fluvio-glacial deposits and several moderate-sized pits are located in the vicinity of the bridge crossing.

Although gravel extraction may be a major impact during construction of the dams and ancillary facilities, including access roads, its location and extent cannot yet be assessed. No decreases in existing extractions are anticipated due to high water, although the worked-out gravel pits will be flooded, nor are any increases yet projected, for the reason just given.

Ownership

The March 1974 revision of the Bureau of Land Management's Map of Alaskan Land Status was the primary source of land ownership data. Land status or ownership was considered in three major classes within the study area: federal withdrawals, state selections, and lands withdrawn for native selection. The subgroups within each class were not identified separately in the matrix inventory; see the earlier discussion of land ownership in the body of this report for details.

When one-third or less of a zone was covered by a particular ownership class, that class was rated Low. One-third to two-thirds coverage was considered Moderate, and over two-thirds, High.

The Indian River Run (figure A-10) illustrates a Low rating for federal ownership (d-1 withdrawals) in the right secondary zone. Lands eligible for native selection received Low coverage ratings for the two primary zones, a High for the left secondary, and a Moderate for the right secondary. State lands were rated Low for the left secondary, Moderate for the right secondary, and High for both primaries.

Inundation does not affect the proportional coverage of any zone in the study area, so no changes are registered after construction of the dams in this section of the matrix.

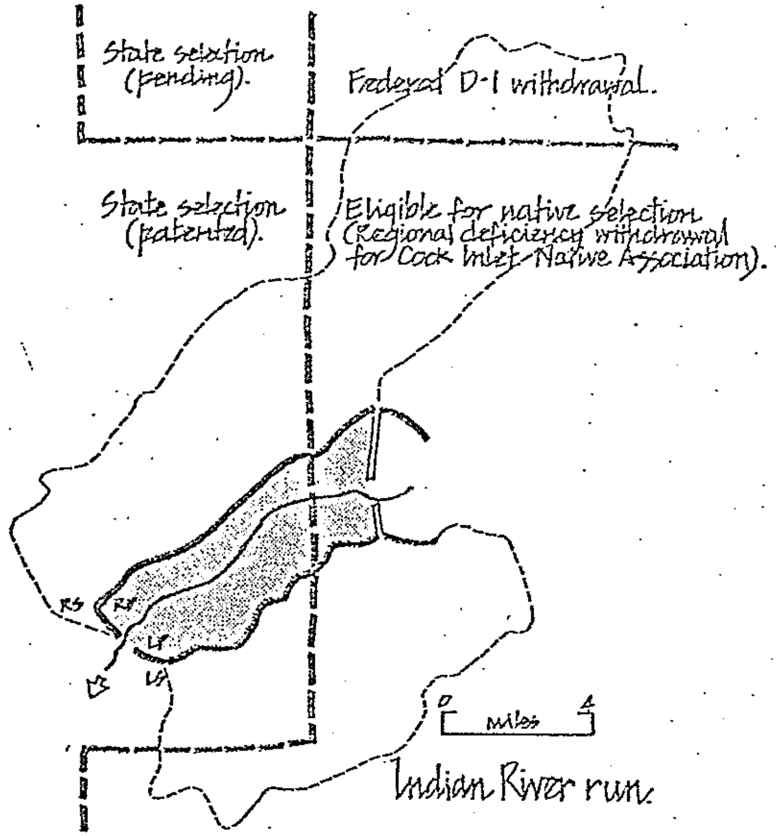


FIGURE A-10. LAND STATUS

APPENDIX D: GEOLOGY

INFERRED GEOLOGIC HISTORY

The Upper Susitna River lies in a middle ground between older rocks (pre-Cambrian to Devonian) north of the Denali Fault and younger rocks (Jurassic and Cretaceous) south of the Susitna. The oldest known rocks of this area are Pennsylvanian(?) and Permian volcanics and volcaniclastics. These are the basement terrane or strata upon which the regional sequences have been built.

The area received marine deposition, probably in a transitional shelf/trench environment, through the Middle and Late Triassic and continuing through the Early Jurassic (figure 1a). This event is contemporaneous with the massive outpouring of subareal lavas in the Eastern Alaska Range, resulting in a subsidence of the region (Richter and Jones, 1973). These marine sediments or clastics are evident today as sandstones and shales interbedded with volcanic flows and sediments.

Batholithic intrusions beginning in the Middle Jurassic are probably responsible for much of the regional uplifting and deformation. This uplifting and metamorphism of the clastics continued through the end of the Cretaceous and into Tertiary time (figure 1b). These metamorphosed clastics, predominantly phyllite, are well exposed in the canyon walls at Devils Canyon and along the slopes of Valdez Creek.

Sometime during the Cretaceous the Susitna River must have begun to form. The Late Cretaceous and Tertiary periods are marked by severe erosion which must have required a developed drainage system. Block faulting, differential uplift, and batholithic intrusive forces make it entirely possible that the Upper Susitna River, particularly the apparently more youthful east-west segment, has changed its course and direction of flow many times since Cretaceous time. Paleozoic rocks exposed at the surface in the central Upper Susitna region reflect the significant degree of erosion which has taken place. This area may also represent a locally high block which was subsequently subjected to greater erosion.

The Tertiary period was primarily dominated by continuing uplift and erosion while deposition was limited to localized non-marine sedimentation in fault block basins (figure 1c). Both intrusive and extrusive volcanics have been noted during this period. The post-Pliocene epoch was a period of great orogenic activity, involving tremendous uplift and faulting (Payne, 1955). Many of the faults in the Upper Susitna region are probably related to the post-Pliocene orogeny though a positive date is unknown (figure 1d). The Susitna Fault is truncated by the Late Tertiary and Quaternary activity of the Denali Fault and must predate the Denali Fault.

During the Caribou Hills/Mt. Susitna and Eklutna glaciations of the Pleistocene epoch the entire area was covered with ice (figure 1e). Subsequent glaciations (Knik and Naptowne) were not as extensive as the earlier ones and only the northern and western portions were subjected to glacial scouring and carving, leaving the central and eastern portions to be occupied by a tremendous proglacial lake (Alaska Glacial Map Committee, 1965; figure 1f). Proglacial lake deposits cover a large portion of the area today.

LITHOLOGY AND STRUCTURE

The Gold Creek, Devil Canyon, and lower half of the Stephan reaches are dominated by medium to dark gray metamorphosed fine grained clastics of Middle Jurassic to Late Cretaceous age. These phyllites are generally massive and contain numerous quartz stringers. Incipient fractures common to the phyllite have been filled by calcite.

The northern portion of the Gold Creek and Devil Canyon reaches has been mantled with glacial till and ground moraine. Localized glaciofluvial deposits can be found in terrace channels along the south slope.

Within these lower reaches bedding is relatively uniform, approximately striking east-west and dipping 50 - 60° south. Several joint sets have been noted in the area. The most well developed of these sets strikes N. 25° W. and dips 80° east. Several lesser developed sets have been noted, striking parallel or sub-parallel to the bedding but generally dipping north rather than south. Shear zones have also been noted in the bedrock walls. They are well developed, spaced from 50 to 800 feet apart, and trend similar to the master joint system (Kachadoorian, 1974).

The Stephan reach is bisected by an inferred right lateral strikeslip fault. In addition, the Susitna Fault crosses near the east end of the reach causing a southerly shift in the river course. The Susitna Fault is a 180 km left lateral fault showing at least 11 km of displacement. It is truncated by the Denali Fault near the terminus of the Susitna Glacier and offset from its northerly section at Kluane Lake, Yukon, N.W. Territory by 400 km of right lateral displacement along the Denali Fault (Richter, oral communication; figure 2).

The upper Stephan, Fog Lakes, Watana, and Clarence reaches are dominated by Paleozoic basement terrane rocks. These are the oldest known rocks in the area and are the terrane upon which later formations are deposited and intruded. The southern flank of the Clarence reach is intrusive rock.

Near the Clarence/Tyone reach border, at Vee Canyon, a major fault intersects the river valley. On the basis of apparent offset of the river it appears to be a left lateral strike-slip fault. The fault is terminated at the Denali Fault on the north and trends N. 30° E. to a point south of Lake Iliamna in western Alaska, approximately 1000 km southwest (Lathram, 1973). Offset along the fault is unknown, but it is expected to be substantial. This fault intersects the river again at the confluence of the Maclaren River.

All of the reaches from the Tyone north are dominated by deposits related to the glaciers which occupied this area during Pleistocene time. Glaciolacustrine deposits, sediments deposited in proglacial lakes, cover the Tyone, Maclaren, and lower Goose Island reaches. These are the same deposits which cover the majority of the Copper River Basin. The remainder of the Goose Island reach is covered by glaciofluvial deposits and a small morainal belt. The Denali reach is predominantly mantled by moraine of past glaciers. The remainder of the reaches are located in glaciofluvial deposits and an intrusive body near the upper East Fork reach.

Two faults cross the Denali reach: The first, a right lateral strike-flip fault, bisects the reach. This fault is inferred to continue in a southwesterly direction, again intersecting the river in the eastern portion of the Fog Lakes reach. The other intersects the river at the northern boundary of the reach (figure 3).

TOPOGRAPHY

The lower reaches of the Upper Susitna River are characteristically an upland region planed to a relatively smooth surface by glaciers which invaded the area during the Pleistocene epoch. The area is dotted with numerous lakes and hillocks and is cut by the westward trending Susitna River valley.

The valley is predominantly asymmetrical through the lower reaches; though neither the north nor south-facing slopes are consistently steeper, the south-facing slopes are steeper in aggregate, if all cross-sections are compared. Numerous occurences of hillslope shortening were noted in sample cross-sections. Due to the acute angle of the sun with the horizon and its wide arcuate track at this latitude, the upper hillslopes receive a significantly greater degree of light and radiant heat and are subjected to an earlier thaw and subsequently greater degree of erosion. This solifluction action is thought to be responsible for the predominance of asymmetrical valleys; a similar conclusion was reached by D.F. Currey (1964), studying asymmetric valleys in western Alaska (Embleton and King, 1968). Although the Coriolis effect, manifested in a right lateral shift in the axis of the stream, could create an asymmetrical stream channel, it is doubtful that such an effect could sculpt the valley forms seen here.

Devil Canyon is entirely stream carved and the walls still stand at greater than the natural angle of repose, making it an unusual feature in an area of the world dominated by glacially carved U-shaped valleys.

Many terraces can be seen at higher valley levels. They are the result of earlier stages of river cutting combined with glacial stream drainages of the Pleistocene epoch.

At the upper reaches of the river the valley opens out into a broad nearly level lowland region. Here the river is braided and meandered and appears to be in a more mature state and at a greater approximation to equilibrium.

One of the most unusual and unique features of the area is the obtuse angle at which many of the tributaries enter the Susitna River. Devil Creek is the most notable example. It is entirely possible that at one time the east-west trending portion of the river flowed in an easterly direction and joined the southerly flowing portion at a confluence in the Tyone/Oshetna River area and drained out through the Copper River drainage system. A subsequent local uplift in the Copper River basin would have reversed the flow creating the drainage pattern we see today.

The extreme upper reaches of the river, particularly the West Fork reach, are typical of areas experiencing extreme amounts of glaciofluvial deposition. The West Fork reach is comparable to the Lower Matanuska River area - a broad silt flat with braided fluvial patterns.

Reconnaissance photos show a patterned ground suggestive of intense periglacial activity in these extreme upper reaches.

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