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DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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Report of Investigations 84-16

STREAM-ICING ZONES IN ALASKA

By
K.G. Dean

STATE OF ALASKA
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(other plates available upon request (fig. 1);
cost $2 each).

STREAM-ICING ZONES IN ALASKA

By
K.G. Dean[1]

INTRODUCTION

Large stream-icing zones in Alaska were mapped at a scale of 1:250,000 by interpretation of multidate Landsat imagery (fig. 1). These features include late-winter overflows and residual ice sheets that range from 20 to 100,000 acres (6 to 40,500 ha) in areal extent; braided streams that are susceptible to icings were also mapped (fig. 2).

Almost all icings occur in or near upland or mountainous terrain in the Brooks Range and northeastern Alaska. Icings are scant in northwestern Alaska, and the number and size of icings generally decrease southward. In interior Alaska, occurrences are numerous but small and are restricted to tributary stream channels or flood plains. Many icings occur in the Alaska Range, especially along the north flank.

Stream icings (also called aufeis or naleds) are seasonal flood phenomena in high latitudes and alpine regions. When water repeatedly overflows its ice cover during subfreezing air temperatures, thick sheets of surface ice form beyond the stream channel. Icings occur when hydrostatic water pressure in aquifers or streams is sufficiently large to force water through cracks in the ice cover. The increased hydrostatic pressure generally results from restricted water flow and from the hydraulic gradient in stream channels and aquifers (Carey, 1973; Harden and others, 1977). Climate, hydrology, geology, permafrost, and topography influence occurrences of icing and fluctuations in their activity (Carey, 1973).

Historically, three types of icings have been described: river, spring, and ground (Carey, 1973). In this investigation, stream icings encompass all three categories. Areas affected by icings range from a few square yards to thousands of acres. Typically, ground icings are much less extensive than river and spring icings (Carey, 1973). Because only icings larger than 20 acres (6 ha) were mapped during this study, most represent river or spring icings.

Areas susceptible to icings present difficult engineering problems for construction of buildings, highways, and other structures (Carey, 1973). Icing zones also target ground-water seeps, springs, or streams with perennially flowing water (Childers and others, 1977).

PREVIOUS INVESTIGATIONS

Many investigators have mapped or studied surface-icing conditions in Alaska. The occurrence, control, and prevention of icings were summarized by Carey (1973). Large icings in northeast Alaska were mapped by Leffingwell

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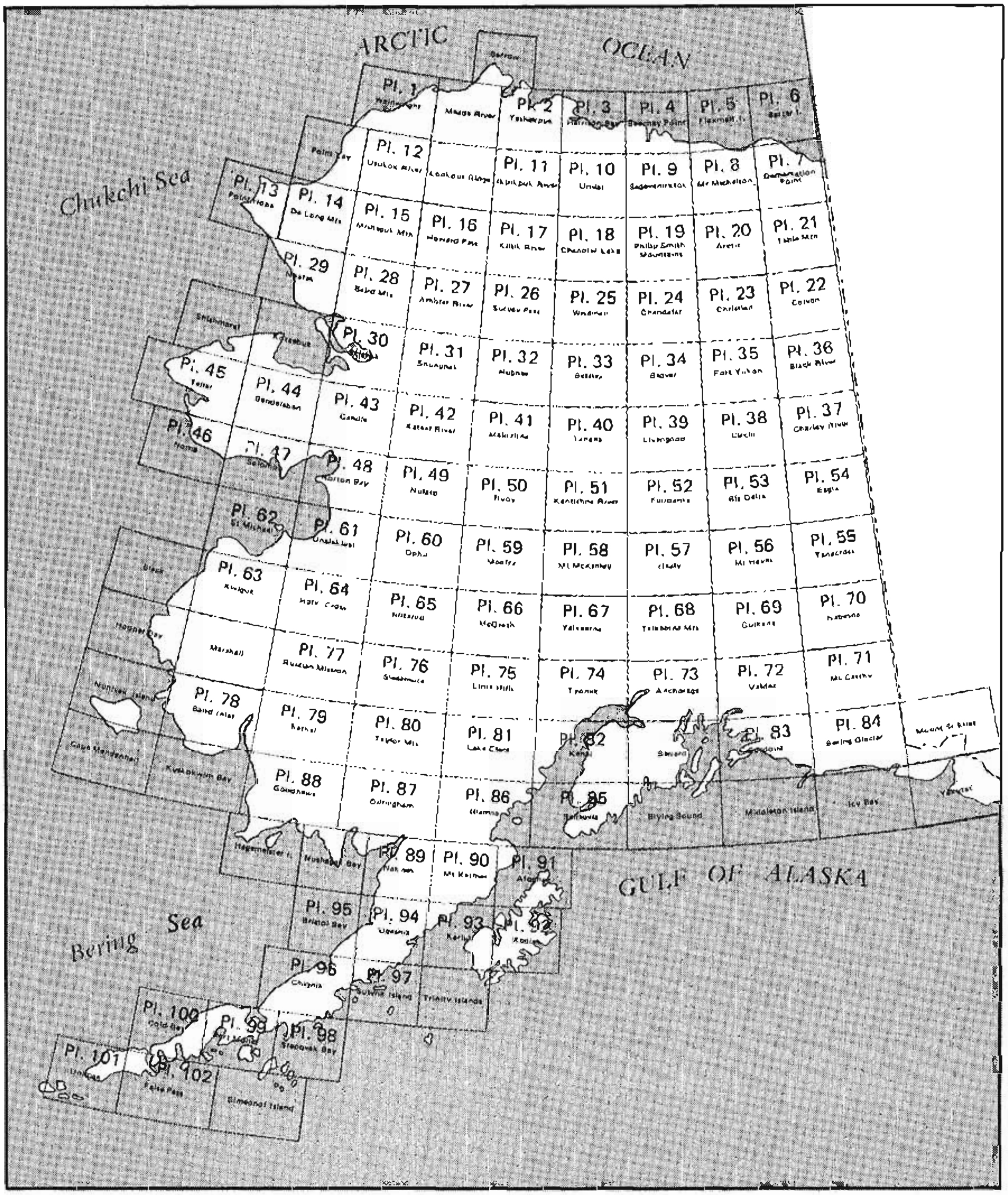

Figure 1. Map of Alaska showing plate locations. Plate 20 is included in report; other plates are available upon request (cost $2 each).

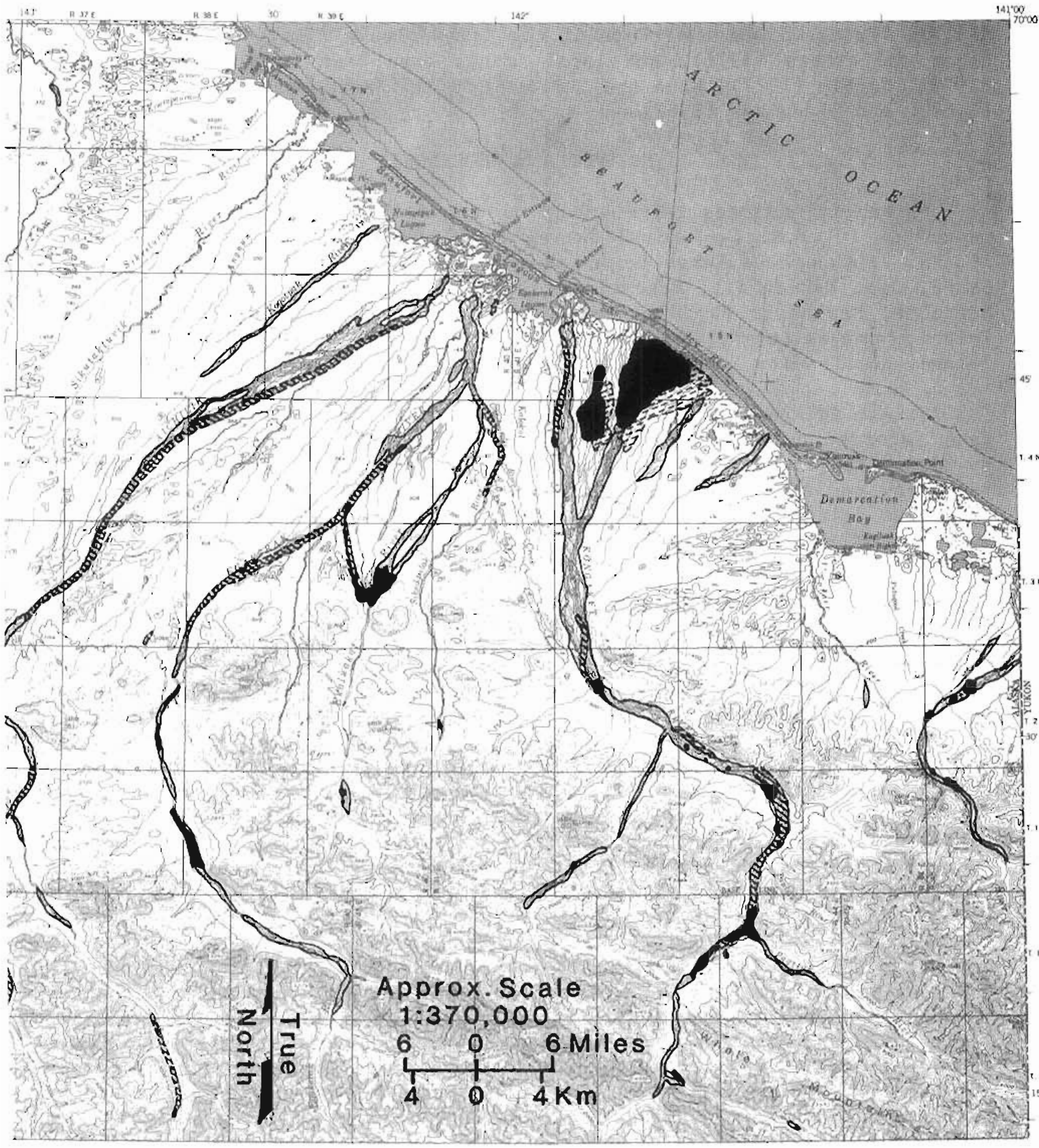

Figure 2. Stream icings near Demarcation Bay (interpreted from 1972-1982 Landsat imagery). Solid areas indicate residual ice sheets, hatched areas indicate overflows, and open areas indicate braided streams that may be subject to stream icings.

(1919), Hall (1976; 1980), Childers and others (1977), and Harden and others (1977). Icings along the route of the Trans-Alaska Pipeline were mapped by Sloan and others (1976), and local icings have been studied by Carlson (1979), Corbin (1977), Kane and Carlson (1977), Kane and others (1973), Péwé (1982), and Slaughter (1982).

METHODS AND PROCEDURES

Stream-icing zones large enough to be visible on Landsat imagery were mapped on 101 U.S. Geological Survey 1:250,000-scale topographic maps of Alaska. Although no large icings were observed in the Barrow, Black, Blying Sound, Cape Mendenhall, Hagemeister Island, Hooper Bay, Icy Bay, Kaguyak, Kotzebue, Kuskokwim Bay, Lookout Ridge, Marshall, Meade River, Middleton Island, Nunivak Island, Nushagak Bay, Point Lay, Seward, Shishmaref, Simeonof Island, and Trinity Island Quadrangles, small icings are undoubtedly present.

Stream icings were interpreted from Landsat MSS (Multispectral scanner) data recorded during the 1972 to 1982 late-winter, spring, and summer seasons. The location and maximum extent of icings were mapped regardless of frequency and timing of occurrences. Images with minimum cloud cover and extensive icings were enlarged to 1:250,000 scale and used as primary data sources for each plate. Landsat images at 1:1,000,000-scale provided additional information (see appendix) that was not recorded on the 1:250,000-scale images.

Visible-wavelength (band 5) data were used to map residual ice after spring thaw (fig. 3). These ice sheets appear white on band 5 images due to their high reflectance compared with surrounding vegetation, soil, or rock. Occasionally, the ice had a higher reflectance than nearby snow cover.

Landsat images recorded in near-infrared wavelengths (band 7) were used to map late-winter overflows (fig. 4). Overflows appear dark gray to black due to absorption of these wavelengths by water. The dark signature in the infrared wavelengths contrasts markedly with the highly reflective snow and ice. Correlation between the location of overflows and residual ice sheets, coupled with a few field observations, support the validity of my interpretations.

Very limited field observations were made during this investigation. Crosschecking of features observed on images with different dates and wavelengths and discussions with individuals familiar with specific areas helped limit misinterpretations. In some areas, cloud cover restricted the number of images available for interpretation. At a few locations, aerial photographs were used to verify occurrences. Large icings previously mapped by Childers and others (1975), Hall (1976; 1980), Sloan and others (1976), and Harden and others (1977), compare favorably with those mapped in this investigation.

The presence of confusing spectral signatures in some areas may have resulted in some misinterpretations; these areas are queried on the maps. Surface features that may be confused with or mask residual ice sheets include snow cover (usually at higher elevations), snow drifts along flood

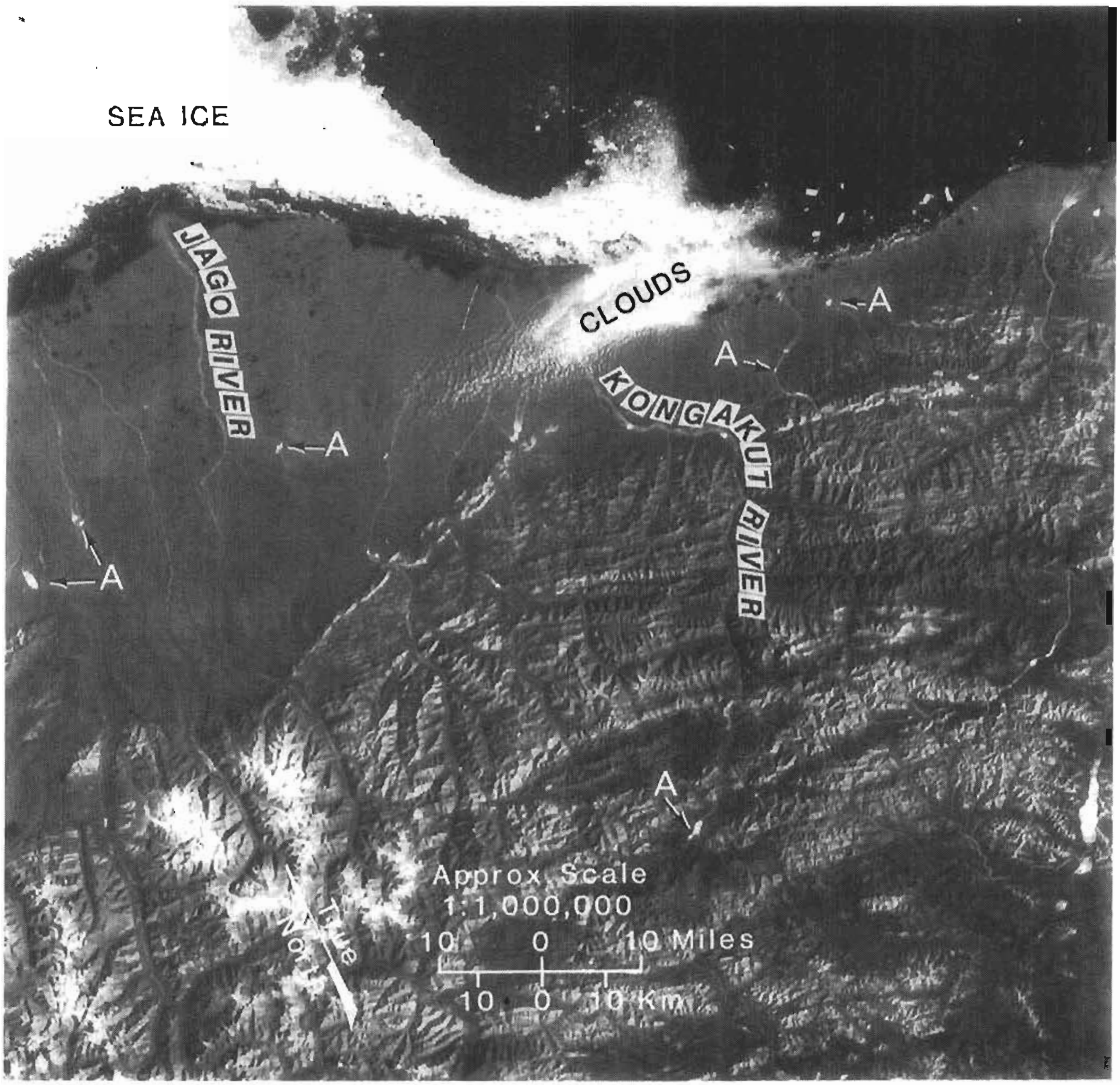

Figure 3. Summer Landsat image (band 5) of the Demarcation Bay area. Residual ice sheets (A) are bright and coincide with overflows shown on figure 4. Numerous unlabeled ice sheets are also present. Image 5828-19272, July 25, 1977.

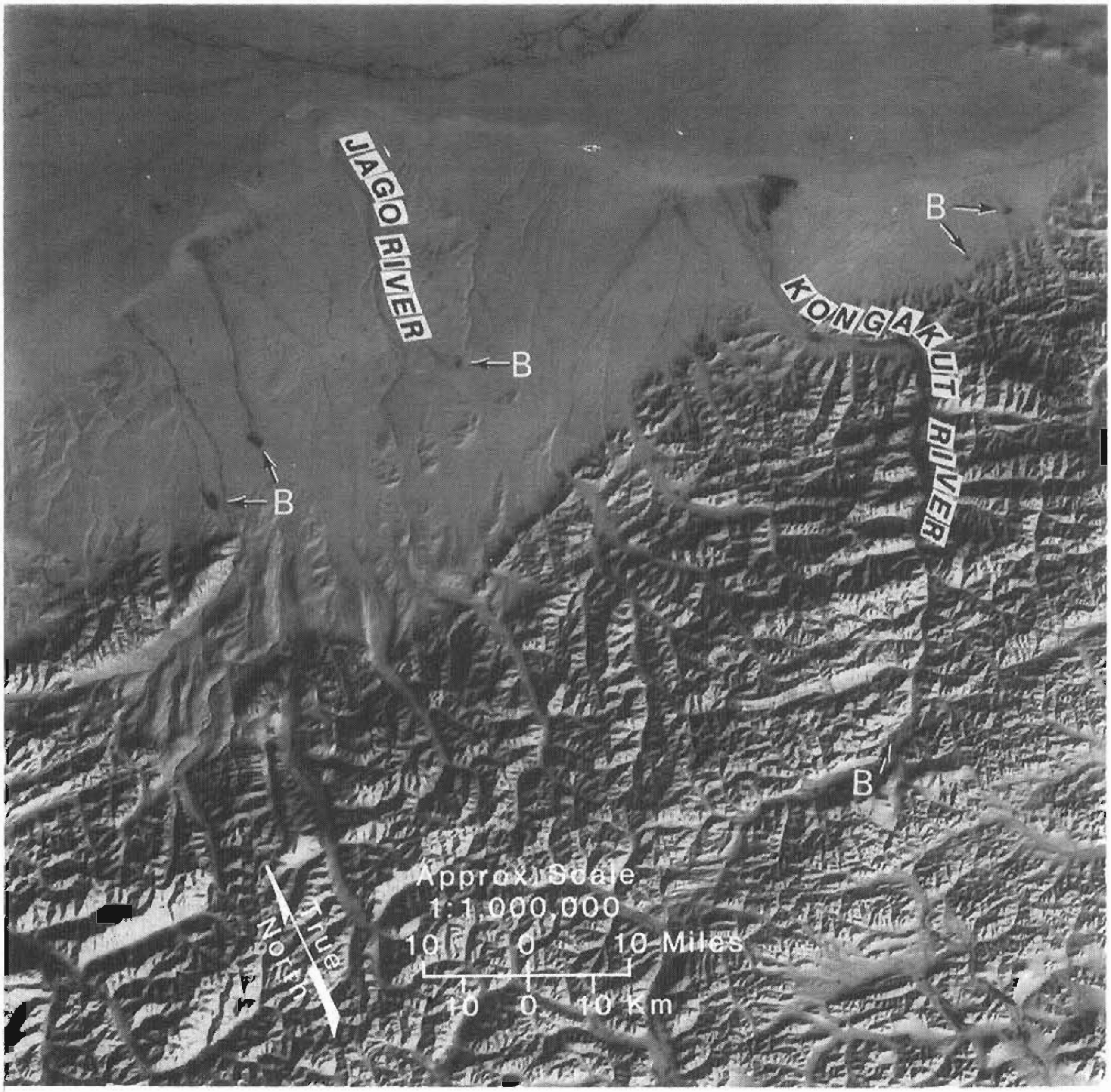

Figure 4. Late-winter Landsat image (band 7) of the Demarcation Bay area. Stream overflows (B) are dark and coincide with ice sheets shown on figure 3. Several unlabeled overflows are also present. Image 1608-20493, March 23, 1974.

plains, river ice, gravel, and vegetation. Features that may be confused with late-winter overflows include dense spruce forests; dense, leafless brush along streams; unfrozen stream channels; and exposed clear ice.

Overflows were usually observed on late-winter images in areas where large residual ice sheets were mapped. Typically, almost all overflows are located in stream valleys (river or spring icings) and their extent is larger than the residual ice sheets. The smallest mapped overflow is about 20 acres (6 ha) in area.

Icings are often associated with braided streams (Carey, 1973) and may result in braided-stream patterns (Harden and others, 1977). Boundaries of flood plains thought to be susceptible to icings were delineated by braided patterns on topographic maps and Landsat images and by proximity to icing zones. Typically, streams that are susceptible to icings are finely rather than coarsely braided, and invariably, meandering streams in mountainous regions with relatively short, braided segments are affected by icings in the braided reach. If springs are also present, icings are probably responsible for the braided patterns. In mountainous regions, bifurcated channels were also observed in icing areas.

REGIONAL DISTRIBUTION OF ICINGS

The regional distribution of icings is related to physiography, as shown by similar distribution patterns and size in various physiographic regions (figs. 5 and 6).

Arctic Coastal Plain Region

Icings in the Arctic coastal plain region are numerous in the east and decrease to few occurrences in the west. Most icings occur east of the Sagavanirktok River, where many icings coincide with known springs (Childers and others, 1975). Calcium carbonate deposits on some icings indicate that water has flowed through calcareous bedrock in some areas of the eastern coastal plain (Hall, 1980). The absence of icings in the west probably results from a difference in geological and hydrological factors rather than climatological factors because the Arctic coastal plain region is located in a single climatic regime (Joint Federal and State Land Use Planning Commission for Alaska, 1973).

Arctic Foothills Region

The distribution of icings in the northern foothills of the Brooks Range is similar to that in the Arctic coastal plain region. Numerous residual ice sheets, overflows, and icings were observed on unvegetated flood plains of braided streams east of the Sagavanirktok River. Few occurrences were observed to the west. The same conditions that restrict the development of icings in the western Arctic coastal plain region are probably in effect in the western foothills.

Figure 5. Regional distribution of icings in Alaska. Physiographic regions include icings with a similar distribution pattern and size range.

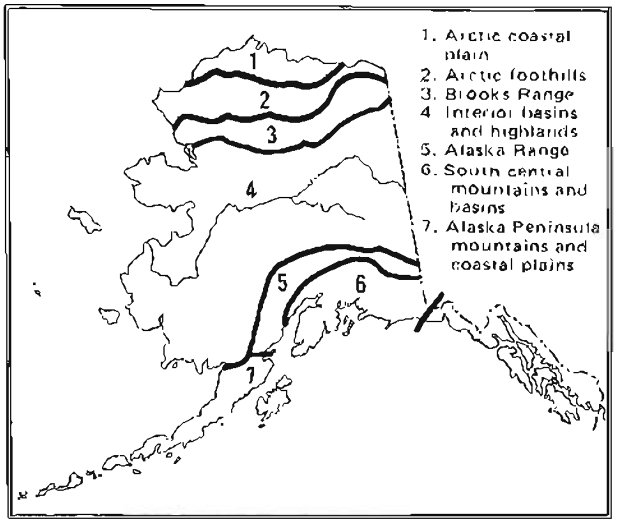

Figure 6. Location of physiographic regions with similar icing patterns and distribution.

Brooks Range Region

The Brooks Range region has the greatest density and most numerous icings. Although icings occur on both the north and south flanks of the range, they are slightly larger and more frequent on the north flank.

Interior Basins and Highlands Region

Most mapped icings in interior Alaska are residual ice sheets and icings on braided-stream flood plains. Few overflows were observed on the images, except on the Seward Peninsula. Most icings are restricted to hilly and mountainous terrains and are confined to small tributary stream valleys (Sloan and others, 1976).

Alaska Range Region

Although many residual ice sheets, overflow zones, and braided streams were mapped in the Alaska Range region, icings are not as numerous or as large as in the Brooks Range region. Icings are larger and more numerous on the north (rather than south) flank of the Alaska Range. Overflows were observed in some areas where residual ice was not present, and icings occur on many finely braided flood plains.

South-central Mountains and Basins Region

Most icing zones in this region occur as residual ice-sheets on braided streams. Few large ice deposits and overflow zones are present, and most icings are limited to streams or flood plains in or near uplands or mountains. Few occurrences were observed along the coast. In some areas, poor Landsat coverage (due to cloud cover) limited the number of images available for interpretation.

Alaska Peninsula Mountains and Coastal Plains Region

The majority of mapped, icing-related features in this region consists of braided streams that may be susceptible to icings. Cloud cover restricted the number of images available for interpretation.

CONCLUSIONS

Stream icings are common throughout Alaska and usually recur near the same locality annually. Their areal extent is variable. The highest frequency and greatest density of large icings occur in the Brooks Range region, the eastern Arctic coastal plain region, and the eastern Arctic foothills region; few icings occur in the western coastal plain and foothills region. Generally, the number and size of icings steadily decrease southward, except in the Alaska Range, where there are numerous stream icings. In interior Alaska, icings are numerous but relatively small and are restricted to tributary stream valleys.

Almost all large icings occur within or near upland or mountainous regions and often along finely braided streams. Larger and more numerous icings occur on the north (rather than south) flank of the Alaska Range.

ACKNOWLEDGMENTS

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APPENDIX
List of small-scale Landsat images

Landsat 1, 2, and 3 images were used as supplemental data sources to help identify and locate stream icings. These 1:1,000,000-scale images are listed by the standard Landsat Path/Row World Reference System (fig. 7) and by date.

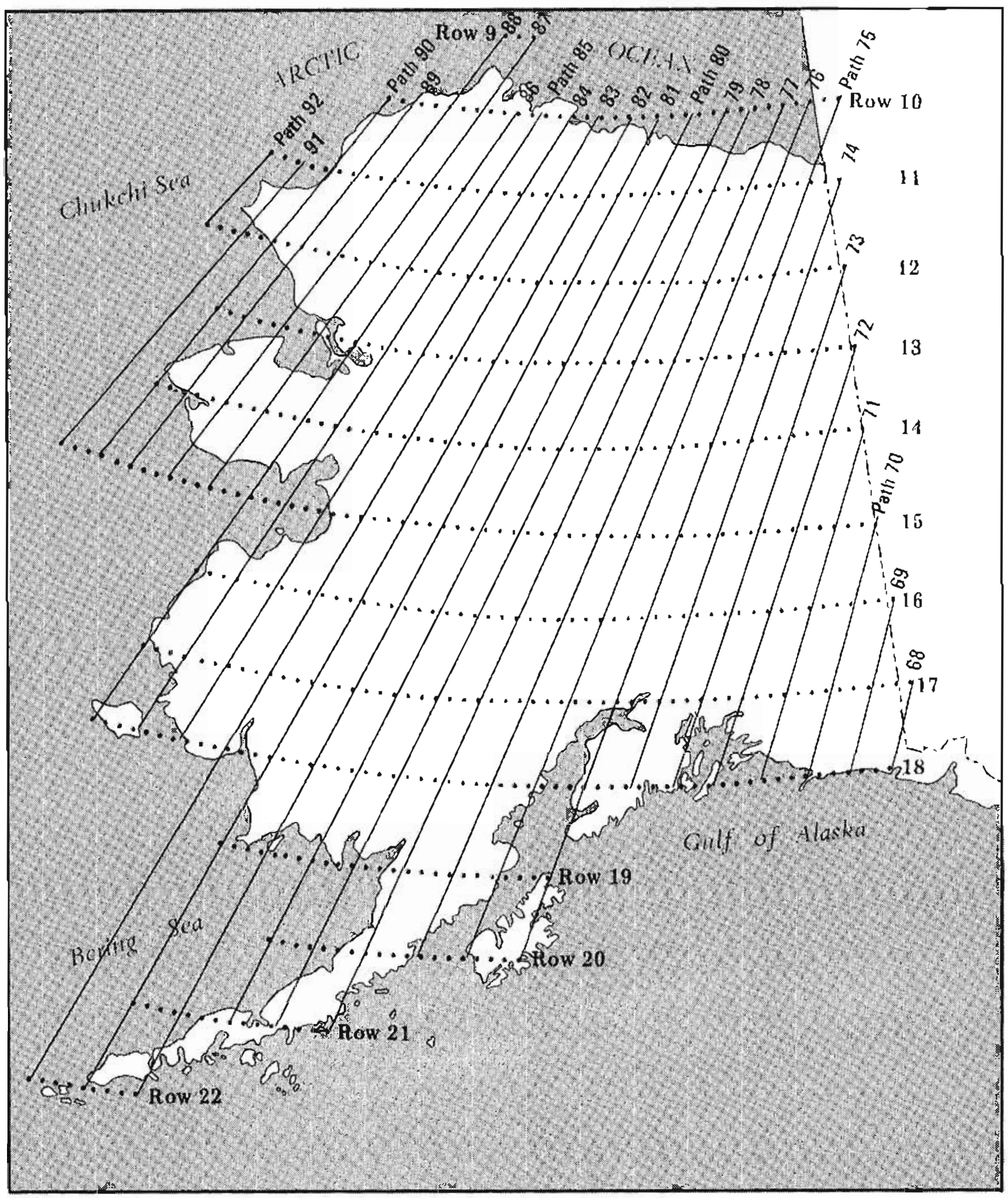

Figure 7. World Reference System in Alaska that designates Path-Row numbers for Landsat 1, 2, and 3 images.

Path/row	Date	Path/row	Date	Path/row	Date
79/10	6-7-79	79/11	9-20-76	82/11	2-27-78
	7-13-79	(con.)	5-12-77	(con.)	5-28-78
	4-14-79		6-17-77		8-8-78
			4-30-77		2-22-79
82/10	7-2-73		7-29-77		3-30-79
	7-8-77		4-19-78		7-16-79
	3-12-79		5-7-78		3-1-81
	2-27-78		6-7-79		4-6-81
	3-30-79		7-13-79		4-24-81
			2-26-81		5-12-81
85/10	7-10-79		4-21-81		4-13-78
	6-4-79		5-27-81		3-21-79
	4-30-77		5-16-78		5-14-79
	4-2-79				6-1-79
		76/11	4-15-73		2-26-80
88/10	7-2-77		7-14-73		5-26-80
	7-14-77		8-1-73		
	7-18-77		4-28-74	85/11	6-17-73
	9-5-72		6-21-74		4-1-74
	5-2-79		2-28-75		3-9-75
	5-28-74		4-5-75		7-4-75
			5-20-75		3-30-76
90/10	5-31-79		2-14-76		6-28-76
	3-17-76		3-21-76		7-16-76
	4-9-78		7-25-76		7-16-77
			4-23-75		3-2-78
79/11	8-27-72		7-25-77		2-25-79
	3-31-73		6-11-81		4-2-79
	4-18-73		3-13-81		7-10-79
	5-24-73		6-4-79		3-29-78
	6-29-73		3-20-78		6-4-79
	8-4-73		3-11-78		2-29-80
	3-8-74		4-7-78		3-23-80
	3-26-74		4-25-78	88/11	
	4-13-74		5-31-78		3-17-74
	4-17-75		7-6-78		4-8-75
	5-5-75		3-15-79		5-14-75
	7-16-75		7-1-79		3-28-75
	8-21-75				6-26-77
	2-17-76	82/11	4-21-73		7-14-77
	3-6-76		7-2-73		8-1-77
	4-11-76		7-13-76		7-2-77
	6-4-76		7-8-77		7-19-77
					4-1-78

Path/row	Date
88/11 (con.)	4-19-78
90/11	6-17-74
	5-16-75
	6-15-76
	5-23-77
	3-2-79
	5-31-79
	3-27-81
	4-14-81
	4-21-78
	6-14-78
	2-21-79
	3-29-79
73/12	8-21-72
	4-12-73
	5-18-73
	6-5-73
	6-23-73
	7-29-73
	4-25-74
	3-20-74
	7-22-76
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	8-4-77
	7-30-78
	6-1-79
	7-25-79
	8-12-79
	8-24-80
76/12	9-11-72
	4-15-73
	5-3-73
	6-8-73
	4-10-74
	9-1-74
	3-18-75
	4-5-75
	5-20-75
	4-23-75
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	7-22-80
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	7-6-78
	8-24-79
	3-31-81
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	3-16-73
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	4-6-74
	6-17-74
	4-10-75
	5-16-75
	6-3-75
	6-15-76
	8-8-76
	5-23-77
	6-10-77

Path/row	Date	Path/row	Date	Path/row	Date
90/12	6-28-77	82/13	5-14-79	88/13	4-1-78
(con.)	5-18-78	(con.)	6-1-79	(con.)	2-19-79
	5-2-79				
	5-31-79	85/13	5-30-73	89/13	7-9-73
	4-14-81		6-17-73		5-29-74
	6-7-81		4-1-74		3-16-76
	5-9-78		5-7-74		4-22-77
	6-14-78		6-30-74		7-15-77
	6-16-77		3-9-75		
	7-3-77		4-23-75	71/14	5-15-75
			5-11-75		5-15-75
73/13	4-25-74		5-29-75		
	2-22-79		7-4-75	73/13	6-1-79
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			3-30-76		
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79/13	3-13-73		5-13-78		
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	5-23-75		6-2-81		5-27-79
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	5-9-81		5-22-78	79/14	5-24-73
	8-14-78		6-4-79		6-29-73
	3-18-79		2-29-80		3-16-74
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82/13	2-26-73		4-22-74		5-9-81
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	2-21-74		2-26-76		2-25-73
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	2-22-79		4-12-81		4-7-79
	4-24-81		5-18-81		5-31-79

Path/row	Date
81/14 (con.)	3-14-80
83/14	4-4-73
	4-22-73
	7-21-73
	3-30-74
	5-5-74
	5-23-74
	5-6-79
	3-20-81
	5-13-81
	5-31-81
85/14	3-19-73
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	2-29-80
87/14	2-13-73
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	3-16-74
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	7-2-74
	6-18-75
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	5-7-76
87/14 (con.)	6-12-76
	3-27-77
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89/14	4-5-74
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	7-15-77
	6-15-77
	7-21-77
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	2-18-81
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71/15	3-23-73
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	5-1-81
73/15	3-7-73
	4-12-73
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	6-5-73
73/15 (con.)	4-7-74
	4-25-74
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	8-4-77
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	7-19-80
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75/15	3-27-73
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77/15	3-11-73
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79/15	3-31-73
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81/15	2-25-73
	4-20-73
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	4-7-79

Path/row	Date	Path/row	Date	Path/row	Date
81/15	5-31-79	71/16	7-10-78	85/16	2-23-76
(con.)	8-23-80	(con.)	4-13-81	(con.)	5-23-76
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83/15	2-27-73		7-20-76		4-29-79
	5-10-73				5-15-81
	7-3-73	73/16	4-30-73		3-22-81
	2-22-74		4-25-74		2-16-79
	3-12-74		3-15-75		
	4-17-74		3-28-81	69/17	2-26-74
	5-5-74		4-15-81		3-16-74
	2-21-76		2-22-79		4-3-74
	3-28-76		2-17-80		4-21-74
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	4-10-77				6-18-75
	4-28-77	75/16	3-27-73		4-11-81
	2-23-79		5-2-73		5-1-79
	2-12-81		5-31-76		2-13-80
	3-20-81		7-6-76		
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	3-27-78		7-21-80		6-9-77
	5-2-78		3-30-81		7-10-77
	2-27-80		4-17-81		4-5-74
					6-14-76
85/15	2-24-74	77/16	5-4-73		2-11-79
	3-14-74		5-22-73		2-15-80
	4-1-74		2-16-74		4-24-79
	5-7-74		5-15-76		4-20-78
	5-25-74		7-9-77		
	3-9-75		5-7-81	73/17	3-7-73
	7-4-75		3-16-79		4-7-74
	5-23-76				4-25-74
	5-24-77	79/16	3-31-73		4-5-76
	6-29-77		5-24-73		4-23-76
	3-11-78		3-8-74		3-28-81
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69/16	3-21-73		2-28-79		
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	3-16-74				5-21-78
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	6-24-79				2-24-79
		83/16	5-5-74		
71/16	4-10-73		4-25-81	77/17	3-11-73
	6-3-73		2-27-80		4-16-73
	6-21-73				5-22-73
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	6-14-76		5-7-74		5-15-76

Path/row	Date	Path/row	Date	Path/row	Date
77/17	6-28-78	67/18	3-14-74	83/18	4-7-81
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	5-7-81		6-7-80		2-23-79
	2-8-79		3-4-81		
	5-27-79			85/18	3-4-81
		69/18	2-26-74		2-16-79
79/17	3-25-81		3-16-74		
	5-29-79		3-27-77	75/19	3-23-79
	3-18-79		6-15-79		7-1-77
	5-27-81		4-11-81		7-19-77
	4-21-81				2-6-79
	5-1-74	71/18	8-14-73		
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	3-31-73		3-18-74		6-26-75
	3-26-74		3-28-79		1-29-74
	3-8-74				3-6-74
		73/18	3-28-81		3-19-75
81/17	7-29-78		4-15-81		2-27-77
	3-2-79		9-8-79		12-14-80
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	3-28-74		2-25-77		2-8-79
	3-10-74		5-21-78		5-27-79
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	2-25-73		8-26-80		2-18-74
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83/17	5-10-73	77/18	3-17-77		3-26-74
	7-21-73		5-28-77		3-24-76
	2-22-74		5-7-81		3-1-77
	3-12-74		3-21-78		4-6-77
	5-5-74				5-12-77
	3-10-76	79/18	2-18-74		2-6-78
	2-12-81		3-8-74		4-14-79
			5-1-74		1-23-79
85/17	8-9-75		2-19-79		2-10-79
	5-25-74		4-14-79		
	3-2-78		4-21-81	81/19	3-10-74
	2-7-79		2-10-79		3-28-74
	2-25-79				5-21-74
	3-4-81	81/18	2-25-73		8-5-75
	3-22-81		4-2-73		6-1-77
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68/18	5-13-73		3-10-74		1-25-79
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	4-10-81		3-25-78	75/20	2-25-77
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			4-19-80		9-3-72
			2-1-76		

Path/row	Date	Path/row	Date	Path/row	Date
77/20	1-29-74	79/21	3-31-73	81/22	4-2-73
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	5-7-81		3-24-76		4-26-77
	3-21-78		1-21-81		
	5-27-79		1-23-79		
	7-28-79		2-10-79		
79/20	3-31-73	81/21	3-25-78		
	8-15-73		3-10-74		
	2-18-74		4-13-76		
	3-8-74		4-26-77		
	3-24-76				
	2-10-79				