Water-Supply and Irrigation Paper No. 196 Series M, General Hydrographic Investigations, 21

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

WATER SUPPLY

OF

NOME REGION, SEWARD PENINSULA, ALASKA

1906

BY

JOHN C. HOYT AND FRED F. HENSHAW

WASHINGTON
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WATER SUPPLY OF NOME REGION, SEWARD PENINSULA, ALASKA, 1906.

By JOHN C. HOYT and FRED F. HENSHAW.

INTRODUCTION.

The successful operation of a placer deposit depends primarily upon the water supply. Data in regard to this supply are essential to its economical development, and lack of such information in regard to the flow of streams has often caused financial failure in mining as well as in other enterprises which depend on water.

For a number of years the United States Geological Survey has made in the United States systematic measurements and studies of the water supply as one of the great resources of the country. These data are now available for all of the more important streams, and are extensively used by engineers and others in problems involving water power, city water supply, irrigation, and manufacturing.

During the season of 1906 the Survey extended these investigations to Alaska in order that information in regard to water supply may be available for the economical development of the placer mines and water power of that territory. The field work was carried on from June 11 to October 3. The work necessary for the preparation of this report was done under the direction of the water-resources branch, but the expenses were paid from the appropriation for the investigation of the mineral resources of Alaska.

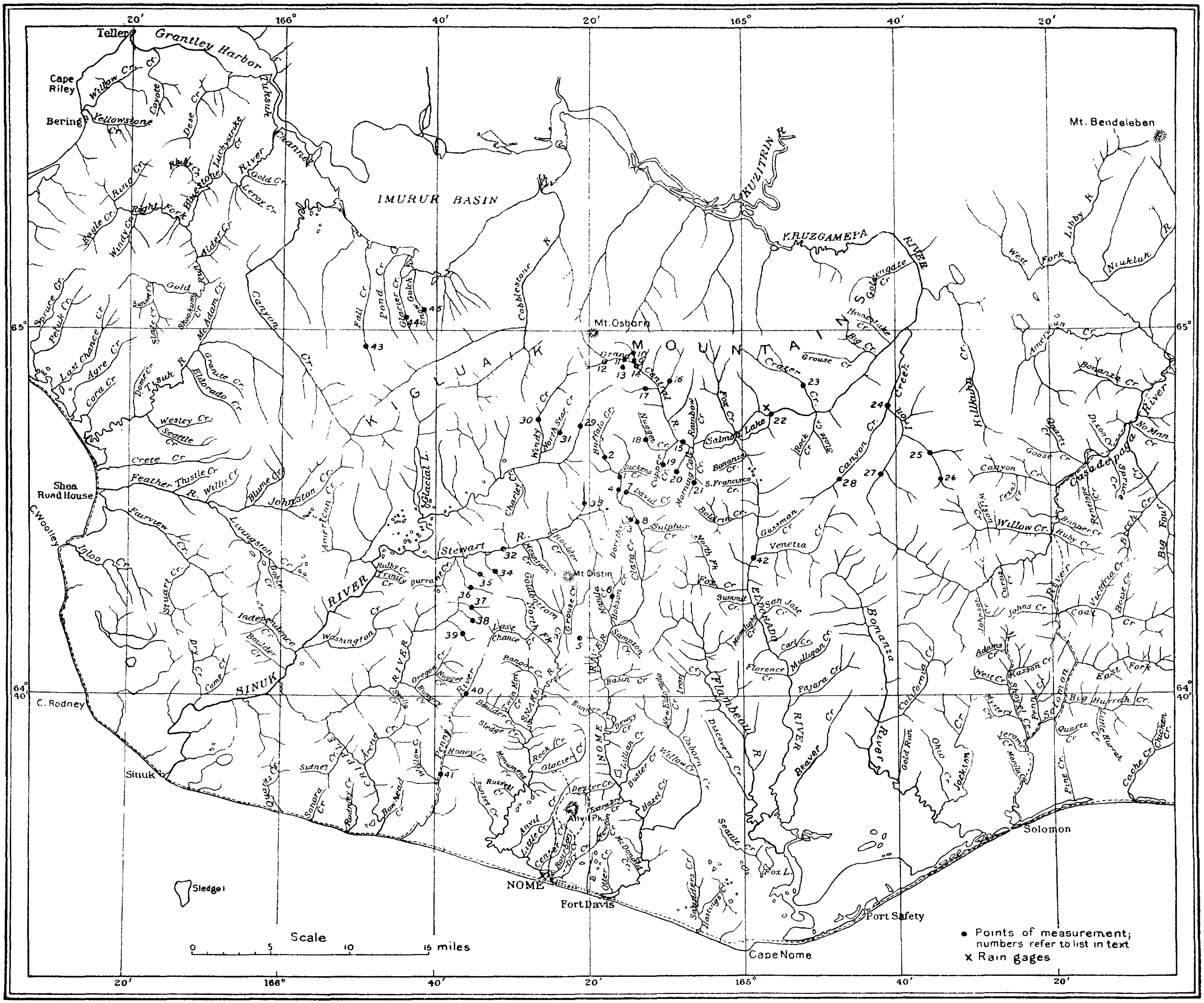
The limited funds available made it necessary to restrict the investigations to a comparatively limited area. Owing to the rich placers and extensive mining in the vicinity of Nome the work was confined to streams of that section, special attention being given to the more important of those that supply water for working the rich deposits back of Nome. The gaging stations were so located (see Pl. I and the following list) that the measurements should show the water available in this important area. The additional supply below the points of measurement may in many cases have a local value, as has also the water of many of the smaller streams, but it was impossible to measure them on account of the limited funds. The data obtained, however, give a fair idea of the conditions of flow that may be expected at points in the vicinity where measurements were made (see pp. 44–47) and are also of value in determining the flow that may be expected in other parts of this region.

List of gaging stations.[a]

1. Nome River above Miocene intake.
2. Buffalo Creek.
3. Dorothy Creek.
4. Miocene ditch at Black Point.
5. Miocene ditch at flume.
6. Hobson Creek at Miocene ditch crossing.
7. David Creek ditch intake.
8. Seward ditch intake.
9. Grand Central River (north fork) at elevation 750 feet.
10. Grand Central River (north fork) at elevation 1,030 feet.
11. Grand Central River (west fork) at elevation 860 feet.
12. Grand Central River (west fork) at elevation 1,010 feet.
13. Crater Lake outlet.
14. Grand Central River below forks.
15. Grand Central River below Nugget Creek.
16. Gold Run.
17. Thompson Creek.
18. Nugget Creek.
19. Copper Creek.
20. Jett Creek.
21. Morning Call Creek.
22. Kruzgamepa River at outlet of Salmon Lake.
23. Crater Creek.
24. Iron Creek below mouth of Canyon Creek.
25. Iron (Dome) Creek.
26. Eldorado Creek.
27. Discovery Creek.
28. Canyon Creek.
29. Sinuk River.
30. Windy Creek.
31. North Star Creek.
32. Stewart River.
33. Slate Creek.
34. Josie Creek.
35. Irene Creek.
36. Jessie Creek.
37. Upper Oregon Creek.
38. Slate Creek.
39. Aurora Creek.
40. Penny River at elevation 420 feet.
41. Penny River at elevation 120 feet.
42. Eldorado River.
43. Fall Creek.
44. Glacier Creek.
45. Snow Gulch.

The hearty cooperation of the mining and other interests in the vicinity of Nome greatly facilitated the work. In this connection special acknowledgment is made to the officers and employees of the Miocene Ditch Company, Wild Goose Mining and Trading Company,

[a] Number refers to Pl. I.



MAP SHOWING LOCATION OF MEASURING STATIONS.

Cedric Ditch Company, Pioneer Mining Company, Gold Beach Development Company, and the United Ditch Company; to W. L. Leland, of the Three Friends Mining Company; to J. E. Styers, superintendent of the National Wood Pipe Company; and to Arthur Gibson, George Ashley, William E. Morris, J. Potter Whittren, and George M. Ashford, civil and mining engineers, Nome.

GENERAL DESCRIPTION OF AREA.

The region covered by this investigation is, in a general way, 15 to 20 miles wide and stretches 40 miles inland from the town of Nome, which is situated on the southern coast of the Seward Peninsula. While most of the measurements were made about 20 to 25 miles from the coast, at points where the altitude is sufficiently high to make the water available for mining high-level placers, some trips were also made into the adjacent regions to the east and west.

The region embraces three types of topography, which, from south to north, are (1) a coastal plain, (2) an upland, and (3) a mountain mass.

Bordering the coast line between Cape Nome and Cape Rodney is an area of low relief, which stretches back to the foothills with a width of from 2 to 5 miles. This lowland, known as the Nome tundra, is made up in general of wet moss-covered ground, rising with a gentle slope to an elevation of between 200 and 300 feet at the southern margin of the upland.

The ridges that constitute the upland trend in a general way north and south, rising from about 700 feet near the coast to 2,000 feet 30 miles inland. These ridges are separated by the broad U-shaped valleys of the larger drainage courses. Thirty miles from the coast the ridges are united by an east-west ridge, which presents a steep escarpment toward a broad depression to the north. This depression separates the upland from the Kigluaik Mountains.

The east-west ridge is broken by broad low gaps, a feature of great importance to the engineer who contemplates tapping the water resources of the Kigluaik Mountains. North of the depression the Kigluaik Mountains, locally known as the Sawtooth Range, rise abruptly, constituting a rugged east-west mass, sharply dissected, with serrated crest line. As these mountains have been the center of local glaciation in recent times, their valleys are characterized by cirques, which form important sources of water for the district.

Most of the area here considered drains southward to Bering Sea through Nome and Snake rivers, whose sources lie close to the ridge which forms the northern boundary of the upland. Besides these, a part of the waters of the upland also flow southward to Bering Sea through Eldorado, Flambeau, Cripple, and Penny rivers. The valleys of all of these are of about the same type—broad and deep in the upland, with gentle slopes for 300 to 600 feet, then steeper walled to crest lines, which vary from 800 to 1,500 feet in altitude. Their floors are usually covered with gravels. Some of the smaller tributaries occupy sharply incised trenches and have but a thin coating of gravel on their rock floors.

The east and west depression which separates the upland from the mountains to the north is drained in part by streams flowing west to Sinuk River, which empties into Bering Sea, and in part by streams flowing east to Kruzgamepa River, which discharges into Imuruk Basin. The streams draining the southern slope of the Kigluaik Mountains are all tributary to one or the other of the two systems. Many of them head in glacial cirques and flow through steep-walled rock-bound valleys, and all have torrential courses.

The general character of all the drainage areas is the same (see Pl. II). The streams have little slope, except in their extreme upper portions, and spread over wide gravelly beds, in which they often divide into several channels or disappear in the gravel. The channels are also subject to considerable shifting during floods. For from 1,000 to 3,000 feet on either side of this gravelly bed extend level or gentle-sloping bottom lands, from which the hills rise quite abruptly. The drainage basins are from 4 to 12 miles wide. The tributary streams are in most cases short and flow in narrow ravines having steep sides. Their slope is great, and in many cases they are made up of a series of rapids, waterfalls, and pools.

Practically the whole country to an elevation of 1,000 feet is covered with a thick turf, commonly known as "tundra" (see Pl. III, *A*). On this in the summer there is a rank growth of grass dotted with wild flowers of many varieties, and in some areas there is considerable moss. There are no trees with the exception of occasional patches of scrub willow and alder, which in the absence of better fuel can be used for firewood. Much of the ground within 2 feet of the surface remains frozen throughout the year. The soil in the lowlands is mostly gravel, overlain with muck, and often contains a large per cent of water, which, when it thaws out in the summer time, makes the muck very soft. Some considerable areas are underlain by clear ice. The hills are composed largely of schist and limestone rock, mantled with loose slide and gravel. Thawing often causes serious slides.

CONDITIONS AFFECTING WATER SUPPLY.

Three sources of water supply contribute to the run-off of the Seward Peninsula: (1) Summer rains; (2) melting of accumulated snow; (3) ground water originating mostly from melting ice.

Of the rainfall there is but little direct data, as few rainfall records were kept in this section until the present year, when four rainfall stations were established in connection with the hydrographic studies.

TYPICAL TOPOGRAPHY OF SEWARD PENINSULA.

The present year was one of drought; therefore the records can not be taken as a mean.

The four rain gages were located at Nome, at Salmon Lake, at Claim No. 15 Ophir Creek, and at Deering. The gage at Nome was read by Mr. Arthur Gibson. It was located on the roof of a house, about 20 feet above the ground and about 40 feet above sea level. The gage at Salmon Lake was placed on the ground at an elevation of about 450 feet above sea level and was read by Mr. John P. Samuelson. The location of the gage at No. 15 Ophir is not known. No records were obtained from Deering.

During the month of June there was only a trace of rain on one day at Nome, and on three days at Salmon Lake. During the present season it was also noted that the country is subject to local showers.

The only previous record known to have been kept at Nome was made in 1900, when the precipitation was 0.60 of an inch from August 13 to 31 and 7 inches in September.

The following data, compiled from observations by members of the Geological Survey and from other sources, throw some light on the general weather conditions of Seward Peninsula for the last eight years:

1899. July, 4 rainy days; August, 14 rainy days; September, 14 rainy days; recorded at Teller.

1900. June to July, inclusive, warm and dry, tundra fires common; August to end of September, rain.

1901. June to August, inclusive, cold and foggy with some rain; September to October, inclusive, usually clear and cold with one or two hard rains of few days' duration.

1902. June, dry; July, 10 rainy days; August, 6 rainy days; September, 3 rainy days; recorded at Teller.

1903. Summer warm; little rain, but considerable fog.

1904. June, dry; rainy days as follows: 10 in July, 10 in August, 10 in September; temperature moderate.

1905. Very wet and cold the whole season.

1906. Very warm and dry; tundra fires common; temperature reached as high as 85°.

The following tables give the mean monthly and the daily precipitation at the various stations during 1906:

Monthly rainfall, in inches, in Nome region, June to September, 1906.

Station.	June.	July.	August.	September.	Total, June to August.	Total, June to September.
Nome	Trace.	2.38	2.50	1.02	4.88	5.90
Salmon Lake	Trace.	4.92	3.33	3.26	8.25	11.51
Ophir	Trace.	3.57	1.91	(a)	5.48	....

[a] No record.

Daily rainfall, in inches, at stations near Nome, 1906.

	July.			August.			September.	
	Nome.	Salmon Lake.	Ophir.	Nome.	Salmon Lake.	Ophir.	Nome.	Salmon Lake.
1								0.14
2						Trace.	0.04	
3		0.12						
4		.35			0.17	0.01		
5		.35		0.07	.07	.05		
6		.10	0.02		.23	.03		
7	[a] 0.52	.17	.23	[b] .41	.28			
8	.37	2.32	1.30					.01
9	.92	.31	.19	Trace.	.29	.08		
10	.14	.25				.12		
11			.85			.01		
12	.04		.01		.10			
13			.02				.12	
14		.35	.01				.01	.03
15			.02					
16			.02					
17					.10		.14	.01
18			.01				.16	.28
19						.31	.23	1.06
20					.57	.31	.28	.99
21		.25	.01	.80			.04	.55
22			.01					.16
23	.08		.60	.22	.50	.22		.03
24	.27	.35	.25					
25	.04		.01	.04	.01	.05		
26				.37	.78	.40		
27			.01	.30	.23	.32		
28				.14				
29				.15				
30								
31								
Total	2.38	4.92	3.57	2.50	3.33	1.91	1.02	3.26

[a] Total, July 1-7.

[b] Total, Aug. 6-7.

NOTE.—During June there was no measurable precipitation at any of the stations.

No data as to actual quantity of snowfall are available, but from conversation with residents it is believed that the annual snowfall is not great, seldom exceeding from 2 to 3 feet. With the exception of the drifts which form in the gulches and the ice banks along the beds of the rivers practically all snow in the drainage studied melted before the first of June; therefore, excepting the streams whose sources are in the protected gulches, the snow storage has but little effect upon the run-off.

The ground water comes from the melting of the frozen ground, which carries a large per cent of water. Its quantity depends, therefore, on the temperature and surface covering and action of rain. The thawing of the ground is slow and never reaches any great depth, so the rain does not have an opportunity to be taken up as ground storage, except late in the season. Early frosts, however, interfere with this storage, so that it can be said that practically all the ground water comes from melting ice.

With the exception of Sinuk and Nome rivers, which have their sources in the Kigluaik, a short distance apart, the streams flowing into Bering Sea rise in the low foothills south of the Kigluaik Range. Their drainage areas have a direct southern exposure and practically

A. TUNDRA BETWEEN BEACH AND FOOTHILLS.

B. MIOCENE DITCH, GLACIER CREEK.

all the snow on them is melted by the first of June. They are therefore limited for their water supply to the summer rains and the ground water from the melting ground.

The gulches in the Kigluaik are more protected and hold their snow much later in the season. There are also occasional summer snows in these mountains, so that the streams which rise in them have a much better sustained flow.

Owing to the steep slopes, lack of other vegetation than grass, and nearness of the frozen ground to the surface, the water from rainfall and thawing finds its way into the streams in a very short time. Flood flow comes immediately after showers and extreme warm

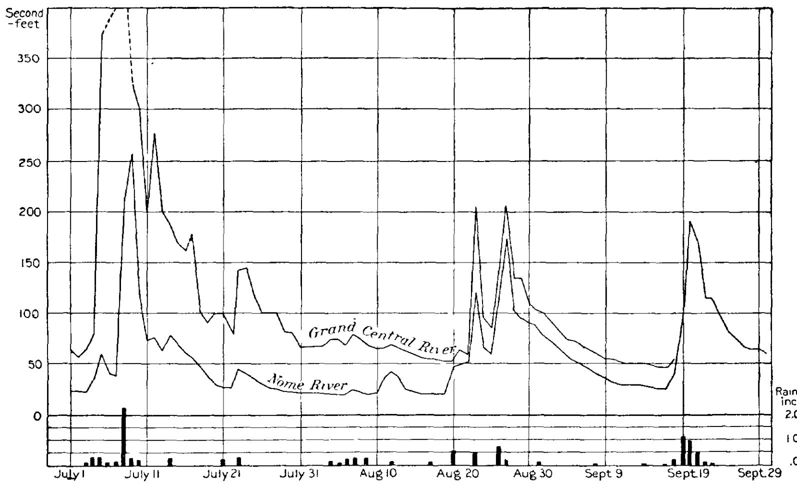


FIG. 1—Diagram showing flow of Nome River above Miocene intake and of Grand Central River below the forks.

spells and is usually of short duration, as there is no way in which the excess water can be taken up by the ground and stored (see fig. 1). In going along the Miocene ditch during the heavy storm of July 8, 1906, it was noted that although all supply gates were closed and the waste gates were open, the ditch was running full from the rain water coming in from the drainage above. Owing to this lack of ground storage, which is one of the important factors of maintaining a well-sustained stream flow in warmer climates, the streams depend on the rainfall and melting ice and respond very quickly to an increase in either of these two factors. Therefore, when the rainfall is slight, as in the past year and in 1900, the stream flow will be small.

MEASUREMENTS OF FLOW.

EXPLANATION OF DATA AND METHODS OF WORK.

The methods of carrying on the work and collecting the data were substantially the same as those previously used for similar work and described in Water-Supply Papers Nos. 94, 95, and 167. They may be briefly outlined as follows:

In the consideration of industrial or mining enterprises which use the water of streams, it is essential to know the total amount of the water flowing in the stream, the daily distribution of the flow, and facts in regard to the conditions affecting the flow. Several terms are used, such as second-foot, miner's inch, gallons per minute, etc., to describe the quantity of water flowing in a stream, the one selected depending on the use to be made of the data.

"Second-foot" is in most general use for all classes of work, and from it the quantity expressed in other terms may be obtained.[a] It is an abbreviation of cubic foot per second and may be defined as the quantity of water flowing in a stream 1 foot wide and 1 foot deep at the rate of 1 foot per second. It should be noted that it is a rate of flow, and to obtain the actual quantity of water it is necessary to multiply it by the time.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly, as regards both time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage problems.

The "miner's inch," the unit used in connection with placer mining, also expresses a rate of flow, and is the quantity of water flowing through an orifice of a given size, with a given head. The head and size of the orifice used in different localities vary, thus making it a most indefinite and unsatisfactory unit. Owing to the confusion arising from its use, it has been defined by law in several States. The California miner's inch is in most common use and was defined by an act approved March 23, 1901, as follows: "The standard miner's inch of water shall be equivalent or equal to 1½ cubic feet of water per minute, measured through any aperture or orifice."

The determination of the quantity of water flowing past a certain section of a stream at a given time is called a "discharge measurement," and points where regular measurements are made are called "gaging stations." Hydrographic field work consists in measuring

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[a] The miner's inch is generally regarded as one-fortieth or one-fiftieth of a second-foot; therefore, to reduce second-feet to miner's inches it is necessary to multiply by either 40 or 50.

the area of the cross section of a stream and the velocity of its current. The product of these two factors gives the discharge.

In making a measurement a tapeline is stretched across the stream (see Pl. IV, *B*), and depth and velocity are measured at regular intervals (varying from 1 to 5 feet apart, depending on the size of the stream). The depths from which the area of the cross section is computed are taken by sounding with a graduated rod. The velocities are measured by a current meter (see Pl. IV, *A*). As the velocity varies with the depth, observations are taken near the surface, at middepth, and near the bottom. The mean of the velocities at these points gives the mean velocity for that vertical section.

One of the general laws of the flow of streams with permanent cross sections is that the discharge varies directly with the stage, or gage height, and that it will be the same whenever the stage or gage height of the stream is the same. Therefore, in order to determine the daily discharge of a stream, a gage on which the fluctuations of the surface of the stream may be noted is installed and read daily. As the discharge regularly increases with the stage, it is possible with a few discharge measurements taken at various stages to construct a rating curve which will give the discharge at all stages. The beds of most of the streams measured changed but little during the season and it was therefore possible to obtain the daily flow as just stated.

Water to be of use for mining purposes must be available under considerable pressure, or when diversion is necessary it must be taken at an elevation high enough to allow it to be carried over the divides. The gaging stations, therefore, were so established as to obtain measurements at points whose elevations were sufficient to permit the stream to be diverted for use in mining on the ground already prospected. Such stations were established on all the important streams in the area. At some of the locations it was impossible to secure gage readers to take the daily observations of river height, and for these stations it is only possible, therefore, to give the flow at the time of the actual discharge measurements. The following pages give the results of measurements on the various streams:

NOME RIVER DRAINAGE BASIN.

GENERAL DESCRIPTION.

Nome River is formed by the junction of Buffalo and Deep Canyon creeks, which have their sources in the Kigluaik Range. It has a drainage area of 150 square miles and flows in a general southerly direction through a valley having a length of about 40 miles and a width varying from 4 to 6 miles. The elevation at the headwaters is between 3,000 and 4,000 feet, while the altitude of the ridges that bound the valley on the east and west averages 1,000 feet. The principal tributaries are David, Sulphur, Darling, Buster, and Osborn creeks from the east and Divide, Dorothy, Clara, and Hobson creeks from the west.

Nome River is the most important source of water for use in hydraulicking the rich placer deposits on the old beach lines back of Nome. Four ditches have been built to divert water for mining purposes. These systems, with the elevations of their intakes, are the Campion, 610 feet; Miocene, 572 feet; Seward, 407 feet; and Pioneer, 340 feet.

Any additional water supply that may be obtained in other high-level streams can best be brought to the mines by way of the valley of Nome River. During the season of 1906 the waters of Nugget, Copper, and Jett creeks were diverted over the Nugget divide by branches of the Miocene system.

Discharge measurements made in this drainage are given in the following pages:

NOME RIVER ABOVE MIOCENE INTAKE.

This station, elevation about 575 feet, is located between the junction of Buffalo and Deep Canyon creeks and the intake of Miocene ditch. At low water the river at this point has a width of about 30 feet, a depth of 1½ feet, and a mean velocity of 1 foot per second. The gage was read twice daily by employees of the Miocene Ditch Company.

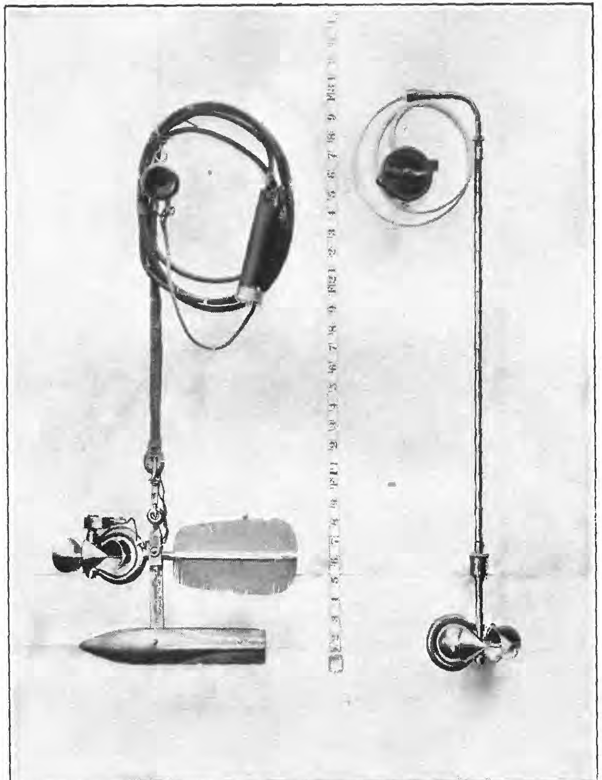
The flow at this station is affected by four ditches: Campion ditch, which diverts water from above the station, and Jett Creek, David Creek, and Grand Central ditches, which bring in water above the station from outside the area. In order to obtain the natural flow of the river, the mean flow of Campion ditch has been added to the flow at the gaging station and the flow of the other three ditches subtracted.

Discharge measurements of Nome River above Miocene intake in 1906.

[Elevation, 575 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
June 17 [a]	....	39	July 14	.82	117
June 28	0.15	28	August 3	−.01	21.4
July 3	.00	21	August 23	.87	121
July 5	.45	54.7	August 23	.70	87
July 14	.40	50.5			

[a] One-half mile above Dorothy Creek.



A. PRICE CURRENT METERS.

B. MEASURING GRAND CENTRAL RIVER.

Mean daily gage height and discharge of Nome River at Miocene intake, 1906.

[Drainage area. 15 square miles.]

Day.	July.		August.		September.	
	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.
	Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1	....	23	0.02	22	0.61	78
2	....	23	.0	21	.57	72
3	0.00	21	−.01	21	.52	65
4	.25	35	−.02	20	.46	57
5	.48	59	−.04	20	.42	52
6	.31	40	−.04	20	.40	49
7	.28	37	+.09	25	.36	45
8	1.31	214	+.04	23	.36	39
9	1.5	260	−.02	20	.27	37
10	.85	119	.0	21	.21	32
11	.58	73	+.26	36	.18	30
12	.6	76	.34	43	.18	30
13	.5	62	.28	37	.18	30
14	.61	78	.10	25	.15	28
15	.56	70	.04	23	.12	26
16	.49	61	.03	22	.10	25
17	.45	56	.02	22	.10	25
18	.38	47	.0	21	.32	41
19	.26	36	.0	21	.70	92
20	.16	29	+.38	47	1.22	194
21	.14	27	.41	50	1.12	172
22	.13	27	.42	52	.83	115
23	.36	45	.87	123	.82	114
24	.31	40	.53	66	.74	99
25	.26	36	.48	59	.65	84
26	.18	30	.80	110	.6	76
27	.12	26	1.14	176	.54	68
28	.09	25	.78	106	.52	65
29	.06	23	.72	96	.52	65
30	.04	23	.70	92	.5	62
31	.02	22	.62	79	....	....
Mean at gaging station	....	56.2	....	49.0	....	65.6
Mean of Campion ditch	....	5.2	....	14.4	....	15.8
Total	....	61.4	....	63.4	....	81.4
David Creek ditch	....	a 6	....	6	....	a 7
Jett Creek ditch	....	a 1	....	a 3	....	a 5
Grand Central ditch (Nugget Creek)	....	a 3	....	a 4	....	a 5
Total	....	10	....	13	....	17
Natural flow of Nome River	....	51.4	....	50.4	....	64.4
Run-off per square mile	....	3.43	....	3.36	....	4.29
Run-off, depth in inches	....	3.95	....	3.87		4.79

a Approximate.

BUFFALO CREEK.

Buffalo Creek rises in a deep canyon on the south side of the Kigluaik Mountains. From this canyon it joins Deep Canyon Creek and forms Nome River. Measurements were made as follows:

Discharge measurements on Buffalo Creek in 1906.

[Elevation, 800 feet; drainage area, 4.4 square miles.]

Date.	Discharge.
	Sec.-feet.
June 28	18.1
July 6	23.3
August 3	9.1

DOROTHY CREEK.

Dorothy Creek, which enters Nome River from the southwest, is a short, precipitous stream. It receives water from Campion ditch, as noted on page 21. The following discharge measurements were made above the outlet of the ditch:

Discharge measurements on Dorothy Creek in 1906.

[Elevation, 500 feet; drainage area, 2.7 square miles.]

Date.	Discharge.
	Sec.-feet.
June 16	5.1
July 29	3.0
August 18	2.9

THE MIOCENE DITCH SYSTEM.

GENERAL DESCRIPTION.

The Miocene ditch system includes 31 miles of main ditch and 31 miles of lateral feeders and distributing ditches, 8 miles of which are under construction (see Pl. III, *B*, and Pl. V). This ditch diverts water from upper Glacier Creek, upper Snake River, Nome River and its tributaries, and from the Grand Central River drainage for use on claims along lower Glacier, Dexter, and Anvil creeks.

The first section of this system was built in 1901, from upper Glacier Creek to Snow Gulch, this being the first ditch in Seward Peninsula. In 1902 an extension was made from Ex to Hobson Creek, and in 1903 it was extended to the head of Nome River, these three sections constituting the main line of the system, with a length of 31 miles. The elevation of the intake is 572 feet and that of the lower end 420, giving a fall of 152 feet. This fall varies along the ditch from 3.37 to 7 feet per mile. There are two siphons, one at Dorothy Creek, 24 inches by 300 feet, which carries about 40 second-feet, and one at Manila Creek, 40 inches by 1,000 feet. Below Willow Creek there is a 1,100-foot flume. The main ditch has an average width of 8 feet above and 10 feet below Hobson and a capacity of 60 second-feet. The mean flow is about 40 second-feet.

The water is delivered from the end of the ditch on claims along Glacier Creek; on Anvil Creek by a tunnel 1,800 feet long and 4 by 6 feet in cross section, built in 1903 and 1904; and on Dexter Creek by a ditch from Ex around the south side of King Mountain.

The lateral feeders, in order up the ditch, are: (1) From upper Glacier to Ex (this was the upper portion of the first section of the main ditch); (2) Grouse and Cold creeks to flume; (3) Upper New Eldorado to Sparkle Creek (this section is to be connected to the main ditch by a siphon across Nome River); (4) David Creek ditch, which empties into Nome River above the intake; (5) Jett Creek ditch, which runs along the south side of the Nugget divide into Deep Canyon and takes water from Jett and Copper creeks; (6) Grand Central

ROCK CUT AROUND CAPE HORN ON MIOCENE DITCH.

ditch, which is under construction (this ditch diverts water from Nugget Creek and will tap the headwaters of Grand Central River).

As a rule water can not be turned into ditches in this region before July 1, as there is too much frost in the ground. In 1906 the water of Hobson Creek was turned into the ditch about June 20 and of Nome River about June 26, but before July 1 was turned out frequently to permit of repairs. The ditch was also out of use on account of a break from July 8 to 11, inclusive, after which date the water ran almost continually.

The following pages give the results of measurements on ditches in this system.

MIOCENE DITCH AT BLACK POINT.

Measurements of flow were made at this point, about 1 mile below the intake, to determine the amount of water diverted from Nome River by the Miocene ditch. The gage was read by employees of the Miocene Ditch Company.

Discharge measurements of Miocene ditch at Black Point in 1906.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
July 7	0.80	31.8	August 2	0.39	18.1
July 13	.89	34.1	August 11	1.20	44.7
July 21	.71	27.5	August 23	1.30	48.3
July 27	.68	25.7	September 11	.85	30.7
July 29	.46	20.6	September 25	1.10	38.2

Mean daily gage height and discharge of Miocene ditch at Black Point, 1906.

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.7	27	0.4	18.8	1.2	43.5
2	.7	27	.38	18.5	1.2	43.5
3	.6	24	.35	18	1.2	43.5
4	.85	31.5	.34	17.8	1.2	43.5
5	.95	34.8	.33	17.7	1.2	43.5
6	.88	32.4	.34	17.8	1.2	43.5
7	.85	31.5	.52	21.6	1.17	42.4
8		0	.48	20.6	1.04	37.9
9		0	.37	18.3	1.0	36.5
10		0	.40	18.8	.98	35.8
11	.5	21	.81	30.3	.82	30.6
12	1.0	36.5	.82	30.6	.8	30
13	1.0	36.5	.96	35.1	.8	30
14	1.0	36.5	.6	24	.76	28.8
15	1.2	43.5	.5	21	.72	27.6
16	1.1	40	.5	21	.66	25.8
17	1.1	40	.45	19.9	.64	25.2
18	1.1	40	.39	18.6	.78	29.4
19	.92	33.7	.46	20.1	.80	30
20	.7	27	.86	31.8	.58	23.4
21	.7	27	1.12	40.7	.69	26.7
22	.62	24.6	1.03	37.6	.92	33.7
23	.85	31.5	1.17	42.4	1.0	36.5
24	.95	34.8	1.19	43.2	.96	35.1
25	.92	33.7	1.2	43.5	1.05	38.2
26	.75	28.5	1.17	42.4	1.06	38.6
27	.62	24.6	1.16	42.1	1.22	44.2
28	.54	22.2	1.2	43.5	1.2	43.5
29	.5	21	1.2	43.5	1.2	43.5
30	.45	19.9	1.2	43.5	1.2	43.5
31	.42	19.2	1.2	43.5		
Mean		27.4		29.2		35.9

MIOCENE DITCH AT THE FLUME.

This station was established to determine the amount of water entering the ditch between the intake at Black Point and the flume. This water includes seepage from the bank and the flow of several small creeks—10 to 15 second-feet at low water from Hobson Creek and a small amount from the branch ditch to Grouse Creek. The flume has a grade of 7 feet to the mile, a width of 8 feet, and a height of 28 inches. On September 25 a measurement was made to determine its capacity with the water 2 feet deep, when the flow proved to be nearly 60 second-feet. This exceeds the safe capacity of the ditch in the vicinity of the flume. The gage was read by employees of the Miocene Ditch Company.

Discharge measurements of Miocene ditch at flume in 1906.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
July 4	0.95	29.8	September 11	1.50	43.9
July 27	1.08	36.5	September 25	1.85	58.2
August 2	.81	28.3	September 26	1.65	48.5

Mean daily gage height and discharge of Miocene ditch at flume, 1906.

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Ft.	*Sec.-ft.*	*Ft.*	*Sec.-ft.*	*Ft.*	*Sec.-ft.*
1	0.98	31.6	0.82	27.2	1.71	51.5
2	.95	30.8	.81	27	1.71	51.5
3	.92	29.9	.84	27.8	1.7	51.2
4	1.0	32.1	.89	29.1	1.7	51.2
5	1.08	34.3	.9	29.4	1.7	51.2
6	1.09	34.5	.91	29.7	1.69	50.9
7	1.12	35.3	.93	30.2	1.66	50.1
8	(a)	0	.98	31.6	1.68	50.6
9	(a)	0	.9	29.4	1.63	49.2
10	(a)	0	.88	28.9	1.54	46.7
11	.79	26.4	1.01	32.4	1.49	45.3
12	1.1	34.8	1.13	35.6	1.46	44.5
13	1.26	39.1	1.23	38.3	1.45	44.2
14	1.29	39.9	1.02	32.6	1.41	43.2
15	1.28	39.7	.94	30.5	1.4	42.9
16	1.39	42.6	.92	29.9	1.34	41.3
17	1.35	41.6	.91	29.7	1.31	40.5
18	1.35	41.6	.87	28.6	1.47	44.8
19	1.28	39.7	.86	28.3	1.48	45.1
20	1.19	37.2	1.1	34.8	1.52	46.2
21	1.16	36.4	1.29	39.9	1.58	47.8
22	1.11	35.1	1.28	39.7	1.65	49.8
23	1.19	37.2	1.32	40.7	1.61	48.7
24	1.09	34.5	1.4	42.9	1.6	48.4
25	1.26	39.1	1.44	44	1.71	51.5
26	1.17	36.7	1.55	47	1.63	49.2
27	1.07	34	1.34	41.3	1.75	52.6
28	.98	31.6	1.46	44.5	1.76	52.9
29	.95	30.8	1.51	45.9	1.79	53.7
30	.91	29.7	1.56	47.3	1.8	54
31	.88	28.9	1.5	45.6		
Mean		[b] 31.8		35.2		48.4

[a] Ditch broken by heavy rains.

[b] For 28 days, 35.2 second-feet.

JETT CREEK DITCH.

Jett Creek ditch was constructed during 1906 to divert water from Jett and Copper creeks over the Nugget divide. The water was turned in from Copper Creek on July 20 and from Jett Creek on August 18, and was turned out on September 25. The ditch carries the total flow of these creeks above the intake up to a maximum of about 10 second-feet.

Discharge measurements on Jett Creek ditch at outlet in 1906.

Date.	Discharge.	Date.	Discharge.
	Sec.-ft.		*Sec.-ft.*
July 21	2.4	September 2	9.2
August 11	.8	September 7	7.2
August 29	4.6	September 10	5.3
August 31	7.3	September 14	3.9

GRAND CENTRAL DITCH.

The completed portion of the Grand Central ditch diverted water from Nugget Creek at an elevation of 785 feet between June 27 and September 29. For measurements of the flow in the ditch see p. 33.

DAVID CREEK DITCH.

David Creek flows into Nome River a short distance below the intake of Miocene ditch. It has a well-sustained flow, which is diverted at an elevation of 590 feet by a ditch leading to and emptying into Nome River just above the Miocene intake. This ditch carries all the flow of David Creek up to 14 second-feet. Its width is 4 feet on the bottom, 6 feet on the top, and when full it has a depth of 1½ feet and a mean velocity of about 1¾ feet per second. The water was running in this ditch before gagings were made on Nome River and was turned out only during extreme high water.

Discharge measurements of David Creek ditch in 1906.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
July 3		3.5	August 29	0.49	7.6
July 29		6.4	Do	.63	10.1
August 3		4.4	Do	.78	13.7
August 23	0.51	7.9	Do	.81	13.7
August 29	.41	5.4	Do	.68	11.4

Mean daily gage height and discharge of David Creek ditch, 1906.

[Drainage area at point of diversion, 4.3 square miles.]

Day.	August. Gage height.	August. Discharge.	Day.	August. Gage height.	August. Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
1			18	.31	3.7
2			19	.29	3.3
3			20	.40	5.4
4	0.35	4.4	21	.38	5.0
5	.35	4.4	22	.50	7.5
6	.35	4.4	23	.52	7.9
7	.42	5.8	24	.48	7.1
8	.38	5.0	25	.54	8.3
9	.37	4.8	26	.77	13.2
10	.37	4.8	27	.34	4.3
11	.38	5.0	28	.4	5.4
12	.4	5.4	29	.41	5.6
13	.38	5.0	30	.78	13.4
14	.35	4.4	31	.80	13.8
15	.34	4.3			
16	.33	4.1	Mean		6.1
17	0.39	5.2			

SEEPAGE MEASUREMENTS ON MIOCENE DITCH.

Measurements were made at different times at several points along the main ditch and also on the Jett Creek branch to determine the loss by seepage from the different sections of the ditch. The discharge of the branches and principal feeders was found by measuring the flow in the ditch above and below them. The results obtained for the section between measurements were therefore the resultant of the gain from creeks too small to measure and the loss by seepage and leakage. The measurements of July 3 to 4 and on July 27 were made at periods of extreme low water, and show a much larger loss than those of September 11 to 12, when there was much more water entering. On the latter date the ditch was gaining along much of its course. These measurements are of value to ditch builders in showing the losses which may be expected in ditches in frozen countries.

Seepage measurements of Miocene ditch, 1906.

MAIN DITCH FROM NOME RIVER TO GLACIER CREEK.

Date.	Point of measurement.	Discharge.	Gain.	Loss.
		Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*
July 3	Nome River intake	21		
Do	Above Hobson	15.8		5.2
July 4	do	20.5		
Do	Below Hobson	31.0	10.5	
Do	Above flume	28.1		2.9
Do	Below flume	29.8	1.7	
Do	Above Ex	27.9		1.9
Do	Above tunnel	28.8	.9	
July 27	Nome River intake	28		
Do	Black Point	25.7		2.3
Do	Above Dorothy	26.2	.5	
Do	Below Dorothy	26.0		.2
Do	Above Hobson	23.7		2.3
Do	Below Hobson	38.0	14.3	
Do	Grouse Creek branch	1.7		
	Total above flume	39.7		

Seepage measurements of Miocene ditch, 1906—Continued.

MAIN DITCH FROM NOME RIVER TO GLACIER CREEK—Continued.

Date.	Point of measurement.	Discharge.	Gain.	Loss.
		Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*
July 27	Below flume	36.5		3.2
August 2	do	28.3		
Do	Glacier branch	13.0		
Do	Dexter branch	13.3		
	Total	26.3		2.0
September 11	Nome River at intake	29.8		
Do	Black Point	30.7	.9	
Do	Above Dorothy	30.3		.4
Do	Above Hobson	30		.3
Do	Below Hobson	44.4	14.4	
Do	Grouse Creek branch	2.4		
	Total above flume	46.8		
Do	Below flume	43.9		2.9
September 12	do	a 43		
Do	Glacier Fork at Ex	30.3		
Do	Dexter Fork at Ex	15.3		
	Total at Ex	45.6	2.6	
September 13	Glacier Fork at Ex	a 29.6		
Do	Above tunnel	29.4		.2
July 29	Intake, David Creek branch	6.9		
Do	Outlet, David Creek branch	6.4		.5

JETT CREEK BRANCH.

September 10	Copper Creek ditch, intake	2.5		
Do	Copper Creek ditch, outlet into Jett Creek ditch	1.8		0.7
Do	Jett Creek ditch, intake	4.2		
	Total	6 0		
Do	Jett Creek ditch, below junction with Copper Creek ditch	5.7		.3
Do	Outlet over Nugget divide	5.3		.4

a Estimated.

CAMPION DITCH AT BLACK POINT.

This ditch diverts water from Buffalo Creek at an elevation of 610 feet. Its lower end terminates in Dorothy Creek, into which it discharges. The ditch has a width of 6 feet on bottom and 9 feet on top, is 2 feet deep, and has a mean velocity of 2 feet per second when running full. The water was turned in at 1 p. m. on July 6. The ditch broke near its outlet at 7 a. m. on July 8. It was repaired and water turned in again on the 19th. All water was turned out from 9.30 p. m. August 12 to 2.30 p. m. August 13.

Measurements were taken on the ditch in order to determine the natural flow of Nome River below the junction of Buffalo and Deep Canyon creeks.

Discharge measurements of Campion ditch at Black Point in 1906.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*		*Feet.*	*Sec.-feet.*
July 7	0.80	11.9	August 11	1.36	27.5
July 20	.60	8.9	August 18	.76	12.0
July 21	.70	10.2	August 23	1.10	19.6
August 2	.67	9.7	August 31	1.00	16.8

Mean daily gage height and discharge of Campion ditch, 1906.

[Drainage area at point of diversion, 8.2 square miles.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1			.69	10.1	0.98	16.5
2			.68	10	.9	14.5
3			.65	9.5	1.02	17.5
4			.62	9	1.04	18
5			.56	8.2	1.0	17
6			.61	8.9	1.02	17.5
7	0.88	14.1	.69	10.1	.96	16
8			.7	10.3	.96	16
9			.73	10.9	1.0	17
10			.77	11.7	1.08	19
11			1.13	20.4	1.07	18.8
12			1.05	18.2	1.02	17.5
13			1.09	19.2	1.06	18.5
14			1.02	17.5	1.02	17.5
15			.92	15	.98	16.5
16			.8	12.3	.93	15.2
17			.8	12.3	.92	15
18			.78	11.9	.9	14.5
19			.75	11.3	1.1	19.5
20			.8	12.3	.98	16.5
21			.76	11.5	.5	7.5
22			1.01	17.2	.6	8.7
23			1.16	21.3	.75	11.3
24			.99	16.8	.72	10.7
25	.92	15	.93	15.2	.91	14.8
26	.78	11.9	1.15	21	.96	16
27	.75	11.3	1.16	21.3	1.02	17.5
28	.82	12.7	1.14	20.7	.98	16.5
29	.78	11.9	1.09	19.2	.95	15.8
30	.76	11.5	1.0	17	.94	15.5
31	.72	10.7	.99	16.8		
Mean		12.4		14.4		15.8

SEWARD DITCH.

Seward ditch was built in 1905-6 to take water from Nome River just below Dorothy Creek, at an elevation of 407 feet, and convey it to Saturday Creek for use along the ancient beach line. Its total length is 38 miles. The water is conducted across Hobson and Clara creeks by 42-inch continuous stave-pipe siphons having lengths of 1,050 and 800 feet, respectively.

Measurements to determine the flow and also the seepage of this ditch were made as follows:

Seepage measurements of Seward aitch in 1906.

Date.	Point of measurement.	Discharge.	Gain.	Loss.
		Sec.-feet.	*Sec.-feet.*	*Sec.-feet.*
July 29	Intake	19.7		
Do	Above Clara Creek	20.6	0.9	
Do	Hobson branch	4.0		
		24.6		
Do	Above Trout Creek	22.0		2.6

Other measurements were made at the intake as follows:

Discharge measurements of Seward ditch at intake in 1906.

Date.	Discharge.
	Sec.-feet.
August 18	25
August 30	26
September 13	[a] 32

[a] Estimated.

GRAND CENTRAL RIVER DRAINAGE BASIN.

GENERAL DESCRIPTION.

On account of its elevation and well-sustained flow, Grand Central River offers one of the most valuable unused water supplies of Seward Peninsula. The drainage area of this stream, which is about 12 miles long and 2 miles wide, is almost surrounded by ridges of the Sawtooth Range (Kigluaik Mountains), having elevations of from 1,500 to 4,000 feet (see Pl. VI, *A* and *B*).

The river is formed near the foot of Mount Osborn, at an elevation of about 700 feet, by the junction of North and West forks, and flows in a southerly direction into Salmon Lake.

From the forks to Salmon Lake the river has a fall of about 300 feet, and at high stages spreads over a wide gravelly bed, on either side of which there is a little bottom land, from which the mountains rise abruptly.

The principal tributaries of Grand Central River below the forks are Gold Run and Rainbow creeks from the east, and Thompson, Thumit, Nugget, Jett, and Morning Call creeks from the west. These tributary streams, with the exception of Nugget Creek, drain short, steep-sided gulches. They have considerable fall and are fed from melting snow.

In order to use the water from the drainage at Nome it has to be diverted over the Nugget divide, which has an elevation of 785 feet. One such diversion has been made from Jett Creek and Copper Creek, from which water is taken by the Jett Creek ditch into the Miocene ditch.

The Miocene Ditch Company is building a ditch which will tap West Fork above the mouth of the Crater Lake outlet, and North Fork at an elevation of about 850 feet. This ditch will follow down the west side of the valley, crossing and tapping Thompson and Thumit creeks, and will pass over the Nugget divide, where it will be taken up by the main Miocene ditch and carried to Glacier and Anvil creeks.

The Wild Goose Mining and Trading Company has started from Crater Lake a 42-inch continuous wood-pipe line, which will extend along the south side of the valley over the Nugget divide and down Nome valley to Anvil Mountain. The company plans to dam and use Crater Lake as a storage reservoir, into which the waters from North and West forks will be diverted by lateral pipes. Other laterals will carry the water of Gold Run and Thompson Creek into the main pipe line. Measurements made in this drainage are shown on the following pages.

GRAND CENTRAL RIVER (NORTH FORK).

North Fork of Grand Central River rises in a cirque at the base of Mount Osborn, which is surrounded by almost perpendicular mountains rising from 1,000 to 3,000 feet above the bed of the stream. This cirque contains the remnant of a small glacier, the melting of which maintains a very steady flow. The flow is added to by a large spring at an elevation of about 860 feet.

Discharge measurements on this stream were made at elevations of about 750 feet and 1,030 feet, which points give the flow at the ditch and pipe intakes, respectively. The bed is very rough and it is difficult to obtain satisfactory measuring sections. Gage heights were read at the time of the measurements by measuring down from reference points on rocks.

A. UPPER GRAND CENTRAL RIVER DRAINAGE.

B. MOUNT OSBORN.

Mean daily gage height and discharge of Grand Central River (North Fork), 1906.

[Elevation, 750 feet; drainage area, 5.4 square miles.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1		23		30		44
2		(23)		30	0.92	[b] 44
3		(23)		30		38
4		(25)		32		38
5				32		40
6				29		37
7			0.81	[b] 32		33
8				33		31
9				31	.76	[b] 27
10				33		28
11	1.10	[a] 67		32		27
12				27		(26)
13				27		26
14				28		27
15				28		26
16			.76	[a] 27		25
17			.74	[b] 25		25
18				27		27
19				25		
20		40		27		
21		(45)		(32)		
22	.85	[a] 38		(36)	1.5	[bc] 120
23		42		(60)		
24		61	.85	[b] 37		
25	.95	[a] 47		40		
26	.9	[b] 42		(40)		
27		45		(67)		
28		50		67		
29		38		71		
30		42		54		
31		28		48		
Mean		[d] 39.9		36.7		[e] 31.6
Run-off per square mile		7.39		6.80		5.85
Run-off depth in inches		4.67		7.84		3.92

[a] Measurements.
[b] Estimates based on gage readings.
[c] Not included in mean.
[d] 17 days.
[e] 18 days.

NOTE.—These estimates are made by subtracting the sum of the discharges at the West Fork and Crater Lake station from the flow below the forks. For the days for which this method does not give consistent results the estimates are based on the West Fork flow and are in parenthesis. From July 5 to 19 the flow did not fall below 40 second-feet. The flow on June 26 was 43 second-feet.

Mean daily discharge in second-feet of Grand Central River (North Fork), 1906.

[Elevation, 1,030 feet; drainage area, 2.3 square miles.]

Day.	July.	August.	September.	Day.	July.	August.	September
1	21	22	31	20	31	20	
2	21	22	[a] 31	21	35	24	
3	21	22	27	22	30	27	
4	22	24	27	23	33	45	
5		24	28	24	48	[a] 28	
6		21	26	25	37	30	
7		[a] 23	23	26	[a] 33	30	
8		25	22	27	34	50	
9		23	[a] 19	28	38	50	
10		25	20	29	28	53	
11		24	19	30	32	40	
12		20	17	31	21	36	
13		20	18				
14		21	19	Mean	[b] 30.3	27.4	[c] 22.2
15		21	18	Run-off per square mile	13.2	11.9	9.65
16		20	18				
17		[a] 19	17	Run-off, depth in inches	7.86	13.7	6.46
18		20	19				
19		19					

[a] Measurements. Other discharges are obtained by taking about the same percentage of the flow at elevation 750 feet as was found on the dates of measurements. This varied from 70 to 90 per cent. Gagings on June 20 gave 30 second-feet, and on June 26, 43 second-feet. The flow from July 5 to 19 probably exceeded 35 second-feet. [b] 16 days. [c] 18 days.

GRAND CENTRAL RIVER (WEST FORK).

West Fork of Grand Central River has its source in Mount Osborn, and flows between Mount Osborn and the high ridges which separate the Grand Central drainage from the Sinuk drainage. It is fed from snow storage for a greater part of the season, and by Crater Lake, which lies at an elevation of 973 feet and has an area of about 106 acres. West Fork did not have as well-sustained flow as North Fork, as much of the snow disappeared during the rain of July 4–12, and thereby reduced the yield from the higher levels for the rest of the summer.

There is considerable glacial drift in the lower part of the area, containing several depressions, one having an area of nearly 5 acres. These fill with water during a rain and gradually drain off through the gravel.

Two gaging stations were established on the fork at elevations of 1,010 feet and 860 feet. The latter is just above the outlet to Crater Lake, and shows the flow at the proposed ditch intake. The conditions for measuring in this section were especially good, and a well-defined rating was obtained. At low water the width of the fork is 17 feet, depth 2 feet, and mean velocity 1.2 feet per second.

The other station was established to obtain the flow at the proposed pipe intake by comparison with the flow at the lower station. The flow was about 70 per cent of that at the lower station during the earlier part of the season. As the snow above the pipe intake melted away and the flow of the springs between the intakes increased, this percentage became about 35 for low water and 50 for higher stages. The cold weather in September checked the flow at high levels and reduced the percentage to 32.

Discharge measurements of Grand Central River (West Fork) in 1906.

[Elevation, 860 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*		*Feet.*	*Sec.-feet.*
June 19		40.4	July 22	1.20	38.1
June 26		38	July 24	1.41	58
July 1		28.6	July 25	1.34	50
July 10	1.65	115	August 6	1.12	30.9
July 11	1.53	86	August 16	1.01	23

Mean daily gage height and discharge of Grand Central River (West Fork), 1906.

Elevation, 860 feet; drainage area, 54 square miles.]

Day.	July.		August.		September.	
	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.
	Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1		29	1.12	30	1.27	44
2	1.1	28		30	1.24	40
3	1.0	22		30	1.2	36
4	1.1	28		34	1.12	30
5	1.8	162		34	1.08	27
6			1.12	30	1.05	25
7			1.15	32	1.05	25
8			1.11	29	1.02	23
9				26	1.01	23
10	1.65	116	1.02	23	1.0	22
11	1.53	86	1.05	25	1.0	22
12	1.75	144	1.1	28	1.0	22
13	1.6	103	1.08	27	.98	21
14	1.55	90	1.05	25	.95	20
15	1.45	70		24	.92	19
16	1.4	61	1.01	23	.92	19
17	1.45	70	1.0	22	.92	19
18	1.4	61	1.0	22	1.0	22
19	1.3	47	1.0	22		
20	1.3	47	.98	21		
21	1.35	54	1.12	30		
22	1.2	36	1.2	36	1.6	a103
23	1.52	83	1.39	60		
24	1.41	63	1.21	37		
25	1.33	51	1.16	33		
26	1.25	42	1.22	38		
27	1.25	42	1.35	54		
28		39	1.3	47		
29	1.2	36	1.3	47		
30	1.15	32	1.27	44		
31	1.14	31		44		
Mean		b59.8		32.5		c25.5
Run-off per square mile		11.07		6.02		4.72
Run-off, depth in inches		11.12		6.94		3.16

a Not included in mean. b 27 days. c 18 days.

Mean daily discharge, in second-feet, of Grand Central River (West Fork), 1906.

[Elevation, 1,010 feet; drainage area, 2.8 square miles.]

Day.	July.	August.	September.	Day.	July	August.	September.
1	a19	12	22	20	20	7	
2	18	12	19	21	23	12	
3	15	12	16	22	a15	16	
4	18	14	12	23	44	30	
5		14	9	24	32	a18.5	
6		a12	9	25	a25	15	
7		12	8	26	19	19	
8		10	8	27	19	27	
9		9	a7.3	28	16	24	
10		8	7	29	14	24	
11	a45	9	7	30	13	22	
12	72	11	7	31	12	22	
13	52	10	7				
14	45	9	6	Mean	b27.0	13.9	c9.4
15	32	8	6	Run-off per square mile	9.64	4.96	3.36
16	27	8	6				
17	32	a7.6	6	Run-off, depth in inches	8.96	5.72	2.25
18	27	8	7				
19	20	8					

a Measurements. Other discharges are obtained by taking about the same percentage of the flow at elevation 860 feet as was found on the dates of measurements. Gagings on June 19 gave 28 second-feet, and on June 26, 26 second-feet.
b 25 days.
c 18 days.

CRATER LAKE OUTLET.

Crater Lake discharges into West Fork of Grand Central River just below the lower point of measurement on that stream. The lake, which lies in a depression of glacial origin, has an elevation of 973 feet and an area of 106 acres. Its basin adjoins those of Sinuk River and Thompson Creek.

A gaging station was located on the outlet about midway between the lake and West Fork. The stream bed is composed of large angular rocks and has a fall of nearly 300 feet to the mile. It is hard to make measurements on account of the swiftness of the current, and the one at high water is only approximate. Gage heights were taken by employees of the Wild Goose Mining and Trading Company.

Discharge measurements of Crater Lake outlet in 1906.

[Elevation, 925 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*		*Feet.*	*Sec.-feet.*
June 19		14.2	July 24	1.10	21.5
June 26		23.7	August 6	.90	7.1
July 1		13.6	August 8	.98	13.0
July 10	1.55	59	August 16	.80	5.6
July 22	.96	12.0	September 9	.73	4.3

Mean daily gage height and discharge of Crater Lake outlet, 1906.

[Drainage area, 1.8 square miles.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Feet.	*Sec.-feet*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1		14	0.85	7	0.98	13
2	1.0	14		7	.94	10
3	1.0	14		8	.9	9
4	1.15	25		8	.82	6
5	1.65	69		9	.78	5
6			.9	9	.78	5
7			.95	11	.78	5
8			.96	12	.75	4.5
9				10	.73	4.3
10	1.55	59	.9	9	.71	4.1
11	1.25	33	.9	9	.69	3.9
12	1.45	50	1.0	14	.68	3.8
13	1.3	37	.95	11	.65	3.5
14	1.15	25	.9	9	.65	3.5
15	1.1	21		7	.61	3.1
16	1.15	25	.8	5.5	.61	3.1
17	1.1	21	.8	5.5	.61	3.1
18	1.05	17	.79	5.5	.75	4.5
19	1.0	14	.8	5.5		
20	1.0	14	.78	5		
21	1.05	17	1.01	15		
22	.96	12	1.01	15	1.4	[a]46
23	1.06	18	1.22	31		
24	1.1	21	1.02	15		
25	1.05	17	1.0	14		
26	1.02	15	1.1	21		
27	1.0	14	1.12	23		
28		12	1.1	21		
29	.9	9	1.05	17		
30	.88	8	1.0	14		
31	.88	8		13		
Mean		[b]22.3		11.8		[c]5.2
Run-off per square mile		12.4		6.56		2.89
Run-off, depth in inches		12.4		7.56		1.93

[a] Not included in mean. [b] 27 days. [c] 18 days.

GRAND CENTRAL RIVER BELOW THE FORKS.

This station was established to obtain the total flow from the headwaters of Grand Central River and also to ascertain the amount that can be diverted over the Nugget divide, as there is but little water coming into the stream between the measuring section and the proposed pipe and ditch intakes. At ordinary stages the river at the measuring point is 50 feet wide, 2 feet deep, and has a mean velocity of 1.2 second-feet. Gage readings were taken by employees of the Wild Goose Mining and Trading Company.

Discharge measurements of Grand Central River below the forks in 1906.

[Elevation, 680 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. feet.*		*Feet.*	*Sec. feet.*
July 1	0.95	63	July 26	1.10	101
July 11	1.40	180	August 7	.89	66
July 24	1.29	140	August 17	.79	54.4
July 24	1.22	129			

Mean daily gage height and discharge of Grand Central River below the forks, 1906.

[Drainage area, 14.6 square miles.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1	0.95	63	0.9	67	1.1	100
2	.9	56	.9	67	1.05	91
3	.95	63	.9	67	1.0	82
4	1.05	80	.95	74	.95	74
5	1.87	370		74	.93	72
6			.9	67		67
7			.98	79		63
8			.94	73		59
9	1.75	325	.9	67	.8	55
10	1.7	300		65		54
11	1.45	198		66	.78	53
12		280		68	.75	50
13	1.45	198		65	.75	50
14	1.42	187		62	.75	50
15		168		59	.72	48
16		160	.81	56	.71	47
17	1.4	180	.79	54		47
18	1.1	100		54		54
19	1.05	91		53		
20	1.1	100	.78	53		
21	1.1	100		65		
22	1.0	82		59	1.72	a 310
23	1.28	143		210		
24	1.29	145	1.08	96		
25	1.18	118	1.02	86		
26	1.1	100		140		
27		100		210		
28	1.1	100	1.25	135		
29	1.0	82	1.25	135		
30	1.0	82	1.15	111		
31	.9	67	1.12	104		
Mean		b 144		85.2		c 62.0
Run-off per square mile		9.86		5.84		4.25
Run-off, depth in inches		10.27		6.73		2.84

a Not included in mean. b 28 days. c 18 days.

NOTE.—The interpolated discharge of Aug. 21–23 and 26–27 are 40 to 45 per cent of the flow at the station below Nugget Creek. This is about the proportion that holds for higher water. Other interpolations are made by comparison with the West Fork and Crater Lake outlet stations.

GRAND CENTRAL RIVER BELOW NUGGET CREEK.

This station was established on June 30, but it was not possible to obtain regular gage readings until August 12, after which date the gage was read once each day by A. W. Peterson. At low water the river at this point is about 50 feet wide, 1 to 2 feet deep, and has a mean velocity of about 2 feet per second. It is impossible to obtain measurements above gage height 1.2 feet by wading. The estimates at this station give practically the total flow of Grand Central River into Salmon Lake.

Discharge measurements of Grand Central River below Nugget Creek, 1906.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*		*Feet.*	*Sec.-feet.*
June 24	....	313	August 28	1. 10	324
June 30	0. 57	148	September 9	. 46	121
July 7	. 98	286	September 14	. 36	101
August 4	. 46	123			

Mean daily gage height and discharge of Grand Central River below Nugget Creek, 1906.

[Drainage area, 39 square miles.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1	0. 5	132			0. 8	220
2	. 45	120			. 75	204
3					. 65	172
4					. 6	157
5					. 6	157
6					. 55	144
7					. 5	132
8					. 5	132
9					. 45	120
10	1. 9	750			. 42	114
11					. 4	109
12	1. 55	545	0. 5	132	. 4	109
13			. 5	132	. 38	105
14			. 5	132	. 35	100
15			. 4	109	. 35	100
16			. 42	114	. 3	90
17			. 45	120	. 3	90
18			. 4	109	. 4	109
19			. 35	100	1. 2	375
20			. 5	132	2. 6	1,230
21	. 6	157	. 55	144	2. 2	950
22			. 5	132	1. 6	570
23			1. 5	520	1. 6	570
24			. 8	220	1. 35	445
25			. 7	187	1. 15	352
26	5	132	1. 05	310		
27			1. 5	520		
28			1. 1	330		
29			. 95	272		
30			. 9	255		
31			. 8	220		
Mean				a 210		b 274
Run-off per square mile				5. 38		7. 03
Run-off, depth in inches				4. 00		6. 54

a 20 days. b 25 days.

GOLD RUN.

Gold Run enters Grand Central River from the east 2 miles below the forks. It drains a deep gulch, has a very steep grade, and terminates in a large gravel fan, where its flow sinks and disappears.

In order to determine the quantity of water from this stream available for diversion across the Nugget divide a station was established at an elevation of about 800 feet.

Mean daily gage height and discharge of Gold Run, 1906.

[Elevation, 800 feet.]

Day.	July.		August.		September.	
	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.
	Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1		14		18		30
2		a 13		18	0.95	b 26
3		13		18		23
4		20		20		20
5				24		17
6				30		16
7			1.03	b 34		15
8			.90	b 22		14
9			.89	b 21		13
10				20	.71	a 12
11		52		20		12
12	1.21	a 69		24		12
13		55		22		11
14		45		20		11
15		40		18		11
16		38	.81	b 17		10
17		42	.8	b 16.5		10
18		24		16		12
19		20		16		
20		22		15		
21		23		28		
22	.84	a 18.5		34		
23	1.0	b 30		50		
24		30		34		
25	1.00	a 30	.99	b 29		
26	.93	b 24		44		
27		24		68		
28		21	1.13	a 51		
29		20		40		
30		19		36		
31		18		32		
Mean		c 29.0		27.6		d 15.3

a Measurements.
b Estimates based on gage heights. Other estimates were made by plotting a hydrograph passing through the known points and following the rise and fall of the other streams in the vicinity. Gagings made on June 20 gave 22 second-feet and on June 25, 24 second-feet.
c 25 days.
d 18 days.

THOMPSON CREEK.

Thompson Creek enters Grand Central River from the west about 2 miles below the forks. It drains a small glacial cirque almost wholly surrounded by very steep walls ranging from 1,000 to 2,000 feet high. Measurements were made at a point with an elevation of 720 feet, which gives the amount of water available for diversion over the Nugget divide.

Daily gage height and discharge of Thompson Creek, 1906.

[Elevation, 720 feet, drainage area, 2.5 square miles.]

Day.	July.		August.		September.	
	Gage. Height.	Dis-charge.	Gage Height.	Dis-charge.	Gage Height.	Dis-charge.
	Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1		11		9		19
2		[a] 11		9		14
3		11		10		12
4		16		10		8
5				11		7
6				15		7
7			1. 39	[b] 22. 5		7
8			1. 22	[b] 14		6
9			1. 19	[a] 12. 5	1. 0	[b] 6. 2
10				11	1. 00	[a] 6. 2
11		36		11		6
12		[a] 52		17		6
13		40		14		6
14		30		12		5
15		24		11		5
16		28	1. 11	[b] 9. 6		5
17		23	1. 12	[b] 10		5
18		19		10		6
19		16		10		
20		16		9		
21		18		20		
22	1. 2	[b] 13		20		
23		21		40		
24	1. 42	[a] 25	1. 4	[b] 23		
25	1. 41	[a] 23		21		
26	1. 29	[b] 17. 5		28		
27		16		30		
28		14		28		
29		11	1. 44	[b] 25. 4		
30		11		22		
31		10		20		
Mean		[c] 20. 5		16. 6		[d] 7. 6
Run-off per square mile		8. 20		6. 64		3. 04
Run-off, depth in inches		7. 62		7. 66		2. 10

[a] Measurements.
[b] Estimates based on gage heights. Other estimates were made by plotting a hydrograph passing through the known points and following the rise and fall of Crater Lake outlet, whose basin adjoins that of Thompson Creek and is of a similar character. A measurement on June 25 gave 42 second-feet.
[c] 25 days.
[d] 18 days.

NUGGET AND COPPER CREEKS.

Nugget Creek rises in the divide between Nome River and Grand Central River and empties its waters and those of its tributary, Copper Creek, into Grand Central River about 2 miles above Salmon Lake.

The headwaters of both Nugget and Copper creeks are quite precipitous and are said to be fed by springs in limestone. Measurements were made on Nugget Creek at an elevation of 785 feet at the point of the diversion of its waters over the Nugget divide by the Grand Central ditch.

The flow of Copper Creek is also tapped by a branch of the Jett Creek ditch at an elevation of about 800 feet.

Discharge measurements of Nugget and Copper creeks in 1906.

NUGGET CREEK.

[Elevation, 785 feet.]

Date.	Elevation of point of measurement.	Discharge.	Date.	Elevation of point of measurement.	Discharge.
	Feet.	*Sec.-feet.*		*Feet.*	*Sec.-feet.*
June 18		1.8	August 11		3.0
June 19		1.6	August 29		8.6
June 21		4.4	September 2		6.8
June 28		.96	September 7		6.1
July 12		6.8	September 14		4.4

COPPER CREEK.

Date.	Elevation of point of measurement.	Discharge.	Date.	Elevation of point of measurement.	Discharge.
June 18	700	3.8	July 21	800	2.4
June 19	800	8.7	August 11	800	.8
June 21	700	11.6	August 31	800	6.6
July 12	700	11.3	September 10	800	2.4

JETT CREEK.

Jett Creek enters Grand Central River from the south. It has a short drainage and is made up of a series of falls and rapids. Water is diverted over the Nugget divide into Nome River by the Jett Creek ditch (see p. 19 for measurements on Jett Creek ditch).

Measurements were made to show the amount of water available at the diversion.

Discharge measurements of Jett Creek in 1906.

[Elevation, 800 feet.]

Date.	Discharge.	Date.	Discharge.
	Sec.-feet.		*Sec.-feet.*
June 19	14.9	July 21	5.8
July 2	4 4	August 31	8.3
July 12	14.3	September 10	4.2

MORNING CALL CREEK.

Morning Call Creek enters Grand Central River from the south near Salmon Lake. The hills to the south are lower and more exposed than in the case of Copper and Jett creeks, and the snow melts earlier in the spring. At low water all the flow disappears in the previous limestone above the point where a ditch intended to cross the Nugget divide would have its intake. The water appears again near the contact with the schist, at an elevation of about 750 feet.

Discharge measurements of Morning Call Creek in 1906.

Date.	Elevation of point of measurement.	Discharge.	Date.	Elevation of point of measurement.	Discharge.
	Feet.	*Sec.-feet.*		*Feet.*	*Sec.-feet.*
June 20	700	36	July 2	700	10.0
June 20	900	24.6	July 12	700	20.8
June 24	500	27.3	August 9	900	0.0

SALMON LAKE.

Salmon Lake lies at the foot of the Kigluaik Mountains at an elevation of about 442 feet. It has a water surface area of 1,800 acres and a drainage area of 81 square miles. Its principal supply comes from Grand Central River, which enters it at its western end. A number of small streams also enter the lake from both the north and the south, but with the exception of Fox Creek and Jasper Creek these are of minor importance. The outlet of the lake is through Kruzgamepa River.

This lake offers an excellent opportunity for a storage reservoir for power purposes and mining along Kruzgamepa River. The use of its water in the vicinity of Nome is practically prohibited owing to its low elevation and the long tunnel which would be necessary to bring the water through the Nugget divide into the Nome River basin. By raising the water of the lake to an elvation of 500 feet the shortest tunnel line would be between 5 and 6 miles long; and if any allowance be made for drawing on the storage, water could not be brought through to the Nome Valley at an elevation greater than about 450 feet. The mouth of the tunnel would be near Dorothy Creek, and the loss in grade between there and Nome would bring the water so low that it could not be used to any extent for hydraulicking. Even if the water could be brought to the vicinity of Nome under a sufficient head for hydraulicking, the great cost and difficulty of building so long a tunnel would make the feasibility of the plan very doubtful.

Measurement of flow in and out of Salmon Lake in 1906.

Date.	Stream.	Discharge.
		Sec.-feet.
June 22	Rainbow Creek	3.4
Do	Fox Creek	99
Do	8 small streams from north	[a] 6
June 24	Jasper Creek	11.6
Do	Morning Call Creek	27
Do	Jett Creek	[a] 10
Do	6 small streams from south	[a] 4
Do	Grand Central River below Nugget Creek	313
	Total	474
June 23	Kruzgamepa River, at outlet of Salmon Lake	425

[a] Estimated.

NOTE.—The stage of Salmon Lake remained practically constant June 22-24, inclusive.

A measurement on Fox Creek on August 16 gave a discharge of 17.3 second-feet.

KRUZGAMEPA RIVER DRAINAGE BASIN BELOW SALMON LAKE.

GENERAL DESCRIPTION.

Kruzgamepa, or Pilgrim, River, the outlet of Salmon Lake, has a larger discharge than any other stream in this section. For about 12 miles it follows a valley ranging from 6 to 12 miles in width, and then enters the lowlands north of the Kigluaik Range, and finally discharges into Imuruk Basin. The principal tributaries are Crater, Grouse, and Homestake creeks from the north and Iron Creek from the south.

As it leaves Salmon Lake the river flows through a narrow outlet having a width of 150 feet at the bottom and 500 feet at the top, offering an excellent dam site and location for a hydro-electric power plant. Plans for the construction of such a plant have been perfected by the Salmon Lake Power Company, which plans to develop 3,000 horsepower, to be used on dredges at Nome and Council and on Solomon River.

Salmon Lake, at its present level, 442 feet, covers 1,800 acres; if raised to a level of 475 feet it would cover 3,600 acres; and at 500 feet, 4,600 acres. The reservoirs thus formed may be used for the storage of the water of the floods caused by the melting snow in the spring and the occasional heavy rains in the summer. The water thus retained will give a large minimum flow not only in summer but also during the winter months, when the natural run-off becomes small.

Kruzgamepa River seldom freezes over before the first of January, and it is probable that with proper installation power could be developed throughout the year.

KRUZGAMEPA RIVER AT OUTLET OF SALMON LAKE.

A gaging station was established at Leland's camp, about 100 yards below the lake. During the spring flood a temporary gage had been set by Mr. John P. Samuelson and read twice a day. Float measurements were also made, which gave a discharge considerably smaller than the open-water flow, showing a backwater effect caused by snow banks in the channel below. This effect became less as the water fell and the snow banks melted.

A new gage was set June 23, with its datum 3 feet below that of the temporary gage. The old gage heights were reduced to the datum of the new gage by adding 3 feet. A tagged wire stretched across the river gave distances from the initial point. Measurements were made by wading at low water and up to a gage height of 1.5 feet. At higher stages it was impossible to reach the middle of the stream, because of the depth and velocity of the water, and float measurements were resorted to.

The gage was read twice daily by Mr. John P. Samuelson. The natural storage in the lake regulated the flow, making the rise and fall very gradual, and the gage readings give the mean height of the lake very closely.

A change in channel occurred during the high water of July 8 to 9, the soundings showing a scour in the middle of the gaging section of about 0.2 foot, and the increase in velocity indicating an even greater scour below. No low-water measurements could be obtained after the high water of September 21 to 23, but it is believed that no change occurred.

Discharge measurements of Kruzgamepa River at outlet of Salmon Lake in 1906.

	Area of section.	Mean velocity.	Gage height.	Discharge.
	Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 23	183	2.32	1.22	425
June 29	170	2.08	1.00	353
June 30	157	2.01	.93	315
July 9	431	5.43	3.18	2,340
Do	412	5.09	3.02	2,094
July 10	372	4.73	2.68	1,760
August 4	117	1.81	.38	212
August 15	116	1.80	.37	209
August 25	148	2.11	.70	312
August 26	159	2.33	.80	371
August 28	184	2.49	1.02	458
September 1	164	2.27	.85	373
September 7	127	1.95	.52	248
September 17	108	1.62	.27	175
September 21	336	4.61	2.38	1,546
September 23	299	3.76	2.06	1,124
September 24	269	3.44	1.80	925

Mean daily gage height and discharge of Kruzgamepa River at Salmon Lake.

[Drainage area, 81 square miles.]

	May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			3.05	1,780	0.82	272	0.48	239	.86	387
2			3.75	2,270	.72	241	.42	221	.81	364
3			3.9	2,350	.7	235	.38	209	.74	336
4			4.2	2,520	.7	235	.36	203	.69	316
5			3.75	2,270	.8	265	.38	209	.65	300
6			3.2	1,920	1.1	380	.38	209	.6	280
7			2.45	1,220	1.1	380	.4	215	.53	256
8					1.92	1,030	.4	215	.49	242
9					3.05	2,130	.4	215	.46	233
10					2.6	1,640	.36	203	.41	218
11					2.2	1,275	.35	200	.39	212
12					1.95	1,065	.35	200	.37	206
13					1.85	985	.36	203	.34	197
14					1.55	768	.34	197	.31	188
15					1.45	702	.36	202	.3	185
16					1.25	582	.35	200	.28	180
17					1.12	511	.32	197	.26	175
18					1.08	490	.3	185	.27	178
19					.98	441	.26	175	.52	252
20					.9	405	.32	191	1.34	634
21					.82	369	.39	212	2.35	1,410
22					.85	382	.42	221	2.4	1,455
23			1.2	420	.82	369	.66	304	2.11	1,198
24			1.25	442	.85	382	.71	324	1.78	930
25			1.2	420	.82	369	.7	320	1.58	787
26			1.12	388	.8	360	.76	344	1.38	658
27			1.1	380	.72	328	.9	405	1.22	566
28	5.45	3,270	1.05	360	.7	320	1.02	460	1.08	490
29	5.0	3,000	1.02	348	.62	288	1.05	475	.98	441
30	4.05	2,430	.92	308	.55	262	.99	446	.88	396
31	3.6	2,180			.5	245	.94	423		
Mean		2,720	[a]2,050	[b]383		571		259		456
Run-off per square mile		33.6	25.3	4.73		7.05		3.20		5.63
Run-off, depth in inches		5.00	6.59	1.41		8.13		3.69		6.28
Run-off in acre-feet		21,600	28,500	6,040		35,100		15,900		27,100

[a] June 1 to 7.

[b] June 23 to 30.

CRATER CREEK.

Crater Creek is the first large tributary entering Kruzgamepa River from the north. It rises in mountains that reach an elevation of nearly 4,000 feet. The topography and general character of its basin closely resemble those of the Grand Central River. (See page 23.) It drains many small lakes, but none of any considerable size. This stream has good possibilities for water-power development. Measurements were made at an elevation of about 550 feet.

Discharge measurements of Crater Creek in 1906.

[Elevation 550 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-feet.*		*Feet.*	*Sec.-feet.*
August 5		67	September 1	0.71	110
August 15	0.45	57	September 8	.45	55
August 27	1.30	290	September 16	.35	39

IRON CREEK.

Iron Creek rises in an area of limestone and schist hills of no great elevation lying between Salmon Lake and the headwaters of Casadepaga and Eldorado rivers. It is formed by the junction of Eldorado and Telegram creeks. Its principal tributaries are Discovery and Canyon creeks, both from the southwest. The portion of the stream above Discovery Creek is sometimes called Dome Creek. Iron Creek empties into Kruzgamepa River about 12 miles below Salmon Lake.

Several mines are being worked successfully on this stream and its tributaries. During 1906 the Gold Beach Development Company built a ditch 13 miles long, which diverts water from Eldorado, Discovery, and Canyon creeks, for use on Discovery No. 1 and No. 2 claims on Iron Creek.

Measurements of Iron Creek and tributaries in 1906.

Date.	Stream.	Elevation.	Discharge.
		Feet.	*Sec.-feet.*
August 14	Iron Creek	450	[a] 17.1
September 15	do	425	[a] 26.1
August 14	Iron (Dome) Creek	630	6.0
September 15	do	630	5.0
August 13	Eldorado Creek	750	4.5
September 15	do	750	5.6
August 13	Discovery Creek	740	1.25
September 15	do	740	2.3
August 13	Canyon Creek	760	1.3
September 15	do	760	1.1

[a] Below Canyon Creek.

IMURUK BASIN DRAINAGE.

The following measurements were made on streams tributary to Imuruk basin to determine their availability and value for water-power development. They rise on the northerly slope of the northernmost ridge of the Kigluaik Range and are fed by large banks of perpetual snow.

Measurements on streams tributary to Imuruk basin in 1906.

Date.	Stream.	Elevation.	Drainage area.	Discharge.
		Feet.	*Sq. miles.*	*Sec.-feet.*
September 5	Fall Creek	1,208	5	34
Do	Glacier Creek	1,212	3	10
Do	Snow Gulch	1,212	2	9.7

SINUK RIVER DRAINAGE BASIN.

GENERAL DESCRIPTION.

Sinuk River has its headwaters on the southern slope of the Kigluaik Range, adjacent to those of Grand Central River and Thompson and Buffalo creeks. It flows in a southwest direction, entering Bering Sea near Cape Rodney. The upper portion of its drainage basin is mountainous, the greater part of it having an elevation of over 1,000 feet. The upper valley contains a large amount of glacial débris and rock slide. Below the mouth of Stewart River, which is the principal tributary, the valley widens out and is almost flat. The principal tributaries to the upper stream are Windy Creek and the outlet of Glacial Lake from the north and Stewart River from the south.

Owing to inability to secure a gage reader it was only possible to make occasional measurements of streams in this drainage. A sufficient number, however, were made to obtain a fair estimate of the flow. These estimates are given on page 45.

ADDITIONAL WATER SUPPLY FOR NOME.

Owing to the mountainous character of the drainage basin, which insures a well-sustained flow, the upper Sinuk River, with its tributaries, North Star and Windy creeks, offers an attractive additional high-level water supply for Nome.

This water can be brought into the Nome River drainage for use near Nome in four ways: (1) By high-line ditches. These would run either across the Buffalo divide, which has an elevation of 1,012 feet, into Hudson Creek; or over the Slate Creek divide, elevation 989 feet, down to Stewart River, and hence over the Divide Creek divide, elevation 722 feet, to Nome River; or over the Silver Creek divide, elevation 910 feet, into Stewart River, and hence over the Divide Creek divide to Nome River. The feasibility of such high-level ditches is questionable, as it would be necessary to tap the streams near their sources, where the water supply is much less than lower down, and ditching for such a plan would be very difficult and expensive on account of the large amount of loose rock that would be encountered.

(2) By pipe line, ditch, and tunnel over Divide Creek divide. This is the most attractive plan. The most feasible route would start from Windy Creek, at an elevation of about 820 feet, just below the upper lake, and carry the water by pipe line around the rocky point to near North Star Creek, then by ditch across North Star Creek to Sinuk River, at an elevation of 770 feet. Taking the water from Sinuk River just below the upper lake, the ditch would continue down the valley, reaching Silver Creek divide at an elevation of 753 feet. At this elevation a tunnel about 5,800 feet long would carry the water through the divide to Stewart River, where it could be taken by ditch over Divide Creek into Nome River.

(3) By pipe line, ditch, and tunnel by Goldbottom Creek. This line is the same as in plan (2), as far as the outlet of the tunnel through Silver Creek divide. From this point the water would be taken by ditch around the head of Stewart River down to Goldbottom Creek, and thence over the divide to Miocene flume.

(4) By ditch and siphon. The ditch would follow the north side of the ridge between Sinuk and Stewart rivers to its west end. then along its south side to near Francisco Creek; thence by siphon across Stewart River, and by ditch over the divide into Goldbottom Creek, to a point near Miocene flume.

The table below gives the length of ditch, pipe, and tunnel for the sections of the three latter routes, together with the elevation of the beginning and ending of each section. This was prepared from the Grand Central special topographic sheet, published by the United States Geological Survey as part of the topographic atlas of the United States.

Length of ditch, pipe, and tunnel necessary to carry water from Sinuk River to Miocene flume.

BY TUNNEL AND DIVIDE CREEK.

Section.	Kind of construction.	Length.	Fall per mile.	Total fall.	Elevation above sea level. Intake.	Outlet.
		Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Windy Creek to Sinuk River	Pipe	1.8	15	27	820	793
	Ditch	[a] 4.1	4.5	18	793	775
Sinuk River to tunnel	do	4.2	4	17	770	753
Sinuk River through to Silver Creek	Tunnel	1.1	6	7	753	746
Silver Creek to Divide Creek	Ditch	6.5	4	26	746	720
Divide Creek to flume	do	14.3	3-7	86	562	476
Total	Ditch	29.1				
	Pipe	1.8				
	Tunnel	1.1				

[a] 2.1 mile of ditch may be avoided by carrying the water of Windy Creek in a siphon 3,500 feet long across Sinuk River.

Length of ditch, pipe, and tunnel necessary to carry water from Sinuk River to Miocene flume—Continued.

BY TUNNEL AND GOLDBOTTOM CREEK.

Section.	Kind of construction.	Length.	Fall per mile.	Total fall.	Elevation above sea level.	
					Intake.	Outlet.
		Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Windy Creek to Sinuk River	Pipe	1.8	15	27	820	793
	Ditch	a 4.1	4.5	18	793	775
Sinuk River to tunnel	..do	4.2	4	17	770	753
Sinuk River through to Silver Creek	Tunnel	1.1	6	7	753	746
Silver Creek to Goldbottom Creek	Ditch	b 12.4	4	51	705	654
Goldbottom Creek to flume	....do	9.2	4	37	513	476
Total	Ditch	29.9				
	Pipe	1.8				
	Tunnel	1.1				

BY DITCH AND SIPHONS ACROSS STEWART RIVER AND GOLDBOTTOM CREEK.

Section.	Kind of construction.	Length.	Fall per mile.	Total fall.	Intake.	Outlet.
Windy Creek to Sinuk River	Pipe	1.8	15	27	820	793
	Ditch	a 4.1	4.5	18	793	775
Sinuk River to Siphon	....do	20.0	4	80	770	690
Near Francisco Creek to below Mountain Creek.	Pipe	1.5	35	52	690	638
Siphon to Goldbottom divide	Ditch	2.0	4	8	638	630
Goldbottom Creek to flume	....do	9.2	4	37	513	476
Total	Ditch	35.3				
	Pipe	3.3				

a 2.1 miles of ditch may be avoided by carrying the water of Windy Creek in a siphon 3,500 feet long across Sinuk River.
b 6.1 miles of ditch may be replaced by 1.2 miles of siphon across Stewart River.

UPPER SINUK RIVER.

The gagings on the upper Sinuk were made at an elevation of 770 feet, and show the probable water supply which could be diverted from this stream for any of the plans just described.

Discharge measurements of upper Sinuk River in 1906.

[Elevation, 770 feet; drainage area, 6.2 square miles.]

Date.	Discharge.	Date.	Discharge.
	Sec.-feet.		*Sec.-feet.*
June 27	33	August 3	20
July 6	37	August 10	23.5
July 20	36		

WINDY CREEK.

Windy Creek, the first large tributary of Sinuk River, lies between the main ridge of the Kigluaik Mountains and the headwaters of the Sinuk. It adjoins the west fork of Grand Central River, from which it may be reached by crossing a high divide. The topography is very rough, the creek being entirely lost in some places in the large bowlders which form its bed.

Discharge measurements of Windy Creek in 1906.

Date.	Elevation at point of measurement.	Discharge.	Date.	Elevation at point of measurement.	Discharge.
		Sec.-feet.			*Sec.-feet.*
June 21	1,100	49	August 3	650	32
June 27	1,100	17	August 10	650	[b] 35
July 13	[a] 650	114	September 6	650	[b] 32
July 20	650	48			

[a] Drainage area, 12 square miles. [b] Estimated.

NORTH STAR CREEK.

North Star Creek lies between Sinuk River and Windy Creek, and is a tributary to the latter near its mouth. It is a small stream with a steep slope.

Discharge measurements of North Star Creek in 1906.

[Elevation, 900 feet; drainage area, 2.3 square miles.]

Date.	Discharge.	Date.	Discharge.
	Sec.-feet.		*Sec.-feet.*
June 27	9.8	July 20	3.9
July 6	18.1	August 3	3.0
July 13	16.4	August 10	2.9

STEWART RIVER.

Stewart River lies south of upper Sinuk River, to which it is tributary. It drains an area of limestone and schist hills. The flow is small and the stream of minor importance.

Discharge measurements of Stewart River in 1906.

[Elevation, 400 feet.]

Date.	Discharge.	Date.	Discharge.
	Sec.-feet.		*Sec.-feet.*
July 15	72	July 30	[a] 26
July 17	49	August 19	11.4

[a] Estimated.

SLATE CREEK.

Slate Creek is the second tributary to Stewart River from the north. The following gives approximate measurements of the flow that can be diverted into Nome River over Divide Creek:

Discharge measurements of Slate Creek in 1906.

[Elevation, 700 feet; drainage area, 2.1 square miles.]

Date.	Discharge.	Date.	Discharge.
	Sec.-feet.		*Sec.-feet.*
July 15	6.7	July 30	2.8
July 17	4.4	August 19	2.2

OTHER SINUK RIVER DRAINAGE.

For measurements on Josie, Irene, and Jessie creeks, which are small tributaries of Stewart River, see below.

CRIPPLE RIVER DRAINAGE BASIN.

GENERAL DESCRIPTION.

Cripple River enters Bering Sea about 12 miles west of Nome, after draining an area of about 88 square miles.

As yet but little mining has been done in this section, except in the vicinity of Oregon and Hungry creeks. Some small ditches have been constructed at the headwaters of Cripple River, the principal one being the Cedric, which diverts water from the Stewart River drainage.

CEDRIC DITCH.

The Cedric ditch was built in 1905 to divert water from Josie and Jessie creeks (tributary to the Stewart River) over the divide to the Cripple River basin for use on Oregon, Hungry, Trilby, and Nugget creeks. After passing the divide it picks up water from upper Oregon (2 forks), Slate, and Aurora creeks, which are its principal feeders, and from Daisy Swift Creek, Snowshoe Gulch, and three other small gulches. It has a total length of about 19 miles and a width of from 4 to 8 feet. The elevation of the head is about 870 feet and of the outlet 790 feet. The capacity of the lower half is about 25 second-feet. Water is carried across Oregon Creek near the outlet by a siphon 2,970 feet long, of 30-inch riveted steel pipe. There are about 6 miles of distributing ditches at the lower end.

The following measurements were made to determine the amount of water available for the ditch:

Water available for Cedric ditch in 1906.

Stream.	July 15-17.	July 30-31.	August 19.
	Sec.-feet.	*Sec.-feet.*	*Sec.-feet.*
Josie Creek	3.0	1.5	1.1
Irene Creek	1.0	[a] .8	[a] .4
Jessie Creek	[b] 3.2	2.6	.6
Upper Oregon Creek	[b] 6.8	2.6	
Slate Creek	4.0	2.0	
Aurora Creek	4.8	2.1	
Daisy Swift Creek	.5		
Total available for ditch	18.3	11.6	

[a] Estimated.
[b] Measured below ditch level; only about half this amount is available for the ditch.

Seepage measurements on Cedric ditch.

Date.	Point of measurement.	Discharge.	Loss.	Distance.	Loss per mile.
		Sec.-feet.	*Sec.-feet.*	*Miles.*	*Sec.-feet.*
July 30	Below upper Oregon Creek	2.6			
Do	Above Slate Creek	1.9	0.7	2.3	0.3
Do	Below Slate Creek	3.9			
July 31	Above Aurora Creek	3.1	.8	1.8	.4
Do	Below Aurora Creek	5.2			
Do	Above Daisy Swift Creek	4.7	.5	2.0	.25
Do	Below Daisy Swift Creek	4.5	.2	.6	.3
Do	At penstock	2.5	2.0	3.7	.5
	Total		4.2	10.4	.4

PENNY RIVER DRAINAGE BASIN.

Penny River enters Bering Sea a little east of the mouth of Cripple River, and has a drainage area of 36 square miles. Its waters are being used by the United Mining Company on the tundra near the old beach, and are diverted by means of two ditches.

The following measurements were made in the Penny River drainage:

Date.	Point of measurement.	Elevation.	Discharge.
		Feet.	*Sec.-feet.*
August 1	Below intake of high-line ditch	420	7.8
Do	Sutton ditch at intake	120	30.0
Do	Penny River below Sutton ditch intake	120	6.2

SNAKE RIVER DRAINAGE BASIN.

Snake River empties into Bering Sea at Nome. It has a drainage area of 110 square miles, which contains some of the richest mining ground in the Seward Peninsula, notably the claims on Glacier, Anvil, and Little creeks. Owing to the slight fall its use for mining purposes is limited to ground sluicing. All the available water from both the main stream and its tributaries is being used, and water is diverted into this area by the Miocene ditch, the Seward ditch, and the Nome River ditch of the Pioneer Mining Company.

FLAMBEAU AND ELDORADO RIVER DRAINAGE BASINS.

These streams rise near Salmon Lake and flow in a southerly direction to Bering Sea near Cape Nome. Because of their minor importance, but one measurement was made upon them. The flow of Eldorado River was measured August 14 below the mouth of Venetia Creek and found to be 44 second-feet.

AVAILABLE WATER SUPPLY DURING 1906.

In order to determine the amount of water that could have been used during 1906 for hydraulicking the placers near Nome, the mean flow of the streams in each drainage basin has been tabulated by weekly periods in the table on page 45. In using this table the following points should be noted:

The "high-level flow of Nome River" represents the total amount of water in that river above Miocene ditch, including the flow of Campion ditch, David Creek, and Hobson Creek. The flow of the springs on the latter creek has been taken as 14 second-feet, except for the first week in July, when it did not exceed 10 second-feet.

"Low-level flow, Nome River," includes all additional water down to the Pioneer ditch. This has been estimated on basis of drainage area as equal to 90 per cent of the naural flow at Miocene intake, plus about 3 second-feet at Hobson Creek.

"Grand Central River" includes the station below the forks and those on Thompson Creek and Gold Run, and gives the amount that can be brought over the Nugget divide.

The mean flow of "Nugget, Copper, and Jett creeks" gives the amount that can be brought over the Nugget divide, and was estimated from the few measurements obtained.

The flow of "Sinuk River and its tributaries, Windy and North Star creeks," has been estimated for an elevation of 800 feet, which is as low as the water can be taken over the divide into Nome River (see p. 39).

The amount of this flow was obtained by taking 70 per cent of the flow of Grand Central River below the forks, this percentage being determined as follows:

Comparison of flow of Grand Central River below forks with that of Sinuk River and its tributaries at elevation 800 feet.

Date.	Sinuk River.	Windy Creek.	North Star Creek.	Total.	Grand Central below forks.	Sinuk, Windy, and North Star in per cent of Grand Central.
	Sec.-feet.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	
June 26, 27	33	22	10	65	105	62
July 6	37	(35)	18	90	....	....
July 13	(75)	86	16	177	198	89
July 20	36	36	4	76	100	76
August 3	20	24	3	47	67	70
August 10	23.5	26	3	52.5	65	81
September 6	(20)	24	(3)	47	67	70

The drainage areas of Grand Central River, Sinuk River, and Windy and North Star creeks lie adjacent to each other on the north and the south side, respectively, of Kigluaik Mountains. On the days when measurements of flow were made of the streams on both sides of the mountain it was found, as shown in the preceding table, that the flow on the south side was from 62 to 89 per cent of the flow on the north side. It is, therefore, conservative to say that the average combined flow of Sinuk River and Windy and North Star creeks will be 70 per cent of the flow of Grand Central River below the forks.

The following table should not be taken as indicating the water that can be used. This will, of course, be limited by the capacity of ditches that can be built economically. In the ecnomical construction of a ditch the size will depend largely upon the duration of the low-water flow. This will probably limit the size in most cases to twice the minimum, except for short ditches.

Mean weekly water supply, in second-feet, available for use back of Nome, 1906.

Dates.	Available for use at elevation 250 to 275 feet.	Available for use at elevation 400 to 450 feet.				
	Nome River low level.	Nome River high level.	Upper Grand Central, Thompson, and Gold Run.	Nugget, Copper, and Jett creeks.	Sinuk River, Windy and North Star creeks.	Total.
July 1-7	31	45	153	7	88	324
July 8-14	110	144	343	26	173	796
July 15-21	36	58	179	15	90	378
July 22-28	29	49	156	12	79	325
July 29-August 4	22	42	101	8	50	223
August 5-11	26	45	108	8	49	236
August 12-18	34	53	91	8	42	228
August 19-25	58	84	138	10	62	352
August 26-September 1	94	128	202	22	94	540
September 2-9	48	73	101	14	51	287
September 9-18	33	53	68	9	36	199
September 18-30	86	118	250	20	125	599
Mean	51	74	158	13	78	375
Maximum	110	144	343	26	173	796
Minimum	22	42	68	7	36	199

WATER SUPPLY AVAILABLE FOR OTHER YEARS AND LOCALITIES.

But little definite information in regard to climatic and other conditions at Nome prior to 1900 is known. The climatic conditions of that year are described by the old residents as very similar to those for 1906, both being dry and warm seasons. The years 1901, 1902, 1904, and 1905 are described as being wet and cold; 1903 was dry in the eastern portion of the peninsula. There were, therefore, two years of drought out of a total of seven, and it is probable that similar low-water periods will occur every few years.

Notwithstanding the fact that the flow for 1906 was as a whole below the normal, there were weeks when it probably reached an absolute summer maximum; for instance, the second week in July. The rain storm of July 8 was one of the severest which had been known in that section, and owing to the frozen condition of the ground practically all this rain ran off within a few days and gave a maximum high-water flow to nearly all the streams (see fig. 1). In the weeks beginning August 16 and September 18 there was also considerable rain, and these weeks were probably typical of high water. The week beginning July 29 probably showed as small a flow as may be expected before the cold weather lessens the yield of high levels.

The above-described conditions are due to the fact that the principal source of water supply of this country is the rainfall, which appears almost immediately in the streams. Therefore a very severe storm, even in a dry season, will give the same conditions of flow as a similar storm during a wet season. The above table of weekly flow, therefore, can be used as a general criterion for hydraulic development in this section.

In order to predict what the flow would be in other areas similar to Seward Peninsula the following tables have been prepared, showing the absolute daily minimum and the mean monthly flow, in second-feet per square mile, for the various streams.

These streams have been grouped into two classes: (1) those rising in foothills, having southern exposures and but few gulches in which snow can be stored; (2) streams rising in mountainous areas with northern exposures and many gulches in which snow is stored and held during the whole summer.

The minimum and mean flow can be obtained, approximately, by multiplying the drainage area of a stream by the flow per square mile given in the tables for a stream of similar character.

Minimum daily flow of streams in Seward Peninsula during 1906.

STREAMS RISING IN FOOTHILLS.

Stream.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum run-off per sq. mi.
	Feet.		*Sec.-feet.*	*Sq. miles.*	*Sec.-feet.*
Iron Creek below mouth of Canyon Creek	450	Aug. 14	17.1	37	0.46
Eldorado River below mouth of Venetia Creek	400	....do...	44	51	.86
Jett Creek	800	Sept. 10	[a] 4.2	1.4	3
Copper Creek	800	Aug. 11	.8	.85	.94
Nugget Creek	785	June 28	[b] .96	2.1	.46
David Creek	590	Aug. 19	3.3	4.3	.77
Dorothy Creek	500	Aug. 18	2.9	2.7	1.1
Hobson Creek	500	July 4	10.5	2.6	[c] 4
Slate Creek (tributary of Stewart)	700	Aug. 19	2.2	2.1	1.05
Stewart River	400	....do...	11.4	36	.32
Penny River	120	Aug. 1	[a] 36	19	1.9

[a] Lowest measurements obtained. The flow was less on certain dates.
[b] The lowest flow later in the season was 3.0 second-feet, or 1.4 second-feet per square mile, on August 11.
[c] The flow of Hobson Creek is from large limestone springs whose catchment area may not coincide with the surface watershed.

Minimum daily flow of streams in Seward Peninsula during 1906—Continued.

STREAMS RISING IN KIGLUAIK MOUNTAINS.

Stream.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum run-off per sq. mi.
	Feet.		*Sec.-feet.*	*Sq. miles.*	*Sec.-feet.*
Grand Central River (North Fork)	750	July 1	23	5.4	4.3
Grand Central River (West Fork)	850	Sept. 15 to Sept. 17	19	5.4	3.5
Grand Central River below the forks	690	Sept. 16 to Sept. 17	47	14.6	3.1
Grand Central River below Nugget Creek	455	....do...	90	39	2.3
Between station below the forks and station at Nugget Creek		....do...	43	24.4	1.76
Crater Lake outlet	925	Sept. 15 to Sept. 17	3.1	1.8	1.7
Thompson Creek	720	Sept. 16 to Sept. 17	5	2.5	2.0
Windy Creek	650	Aug. 3	32	12	2.7
North Star Creek	900	Aug. 10	2.9	2.3	1.26
Sinuk River	770	Aug. 3	20	6.2	3.2
Buffalo Creek	800	....do...	9.1	4.4	2.1
Nome River	575	Aug. 5	20	15	1.3
Fox Creek	550	Aug. 16	17.3	11	1.6
Crater Creek	550	Sept. 16 to Sept. 17	39	....	....
Kruzgamepa River	442	Aug. 19 to Sept. 17	175	81	2.16

Mean run-off, in second-feet per square mile, at gaging stations.

Station.	Drainage area.	July 1-31.	July 1-4 and 11-31	Aug. 1-31.	Sept. 1-30.	Sept. 1-18
	Sq. mi.					
Grand Central River (North Fork), elevation 750 feet	5.4	....	[a] 7.53	6.80	....	5.85
Grand Central River (North Fork), elevation 1,030 feet	2.3	....	....	11.9	....	9.65
Grand Central River (West Fork), elevation 860 feet	5.4	....	10.3	6.02	....	4.72
Grand Central River (West Fork), elevation 1,010 feet	2.8	....	9.64	4.96	....	3.36
Crater Lake outlet	1.8	....	10.8	6.56	....	2.89
Thompson Creek	2.5	....	8.20	6.64	....	3.04
Grand Central River below the forks	14.6	....	8.36	5.84	....	4.25
Grand Central River below Nugget Creek	39	....	....	[a] 4.42	....	3.36
Kruzgamepa River at outlet Salmon Lake	81	7.05	....	3.20	5.63	3.05
Between Grand Central River below the forks and Kruzgamepa River stations	66	....	....	2.62	....	2.79
Nome River at Miocene intake	15	3.43	2.71	3.36	4.29	....

[a] Approximate.

DITCH AND PIPE LINES.

In order to bring the water to the gold-producing ground between Capes Nome and Rodney at sufficient elevation to be used for hydraulicking and sluicing, nearly 300 miles of ditch and pipe line have been constructed and several extensive additional systems are now under construction or consideration. The first ditch in this section was built in 1901, by W. L. Leland and J. M. Davidson, from upper

Glacier Creek to Snow Gulch. This ditch demonstrated the practicability of ditch systems in this country and was the beginning of the Miocene system.

Ditches are usually built following the approximate contour with grades limiting the velocity to about 2 feet per second, which is as high as the material in this section will stand without scour. The ditches therefore are for the most part on slopes, and are constructed by making a cut from 12 to 18 inches deep to grade at the lower bank. This bank is then built up by material from the excavation. The slopes of the banks are from 1 to 1 to $1\frac{1}{2}$ to 1, depending on the material.

The work of constructing a ditch is usually divided into three classes: (1) Team work; (2) pick and shovel work; and (3) rock work.

Teams may be used in handling dry soil that contains only medium sized rock. This is the fastest method, and the compacting of the lower banks by the horses and scrapers makes it much tighter than when the dirt is thrown in loose.

Pick and shovel are used in loose rock, in wet soil, and in frozen ground from which the top is removed as it thaws from the surface.

Rock must be blasted, unless it is fissured limestone, which may be loosened with the crowbar, or decomposed schist which yields to the pick. In building through solid rock, a shelf is blasted out about 1 foot below grade and wide enough to carry the ditch and the lower bank, which is built of rocks. The bottom and both sides are lined with sod about 1 foot thick, and are puddled with clay.

In rock slide the method is similar. A good example of this kind of construction was seen on the Grand Central branch of the Miocene system. The ditch was built through a pile of large bowlders, unmixed with any soil or gravel. A trench was made 1 foot deeper and 2 feet wider than the finished ditch. The sides of the trench were lined with a slope wall, laid 1 to 1, to a height of 4 or 5 feet. The outer slope of the lower bank was also rock wall, laid somewhat flatter. The ditch will be lined with sod and will be tight and permanent.

The use of sod is very common and economical, and saves much piping and fluming that would otherwise be necessary. This sod in a short while settles and knits together, and thus becomes a very serviceable bank. It will not cut or wear out, and the older it gets the better it becomes. When, however, it becomes evident that the bottom of the ditch is cutting and wearing away, sodding must be resorted to, and by lining the bottom of the ditch with sod the trouble may soon be overcome. In this way a ditch can be made over perpetually frozen ground, where otherwise it would be impossible. Much ditch has to be constructed over loose stones with little or no sediment between them. In this case the ditch must be lined with sod and all holes must be filled by tamping sod into them as far as possible. This being done, it will be found that the water traveling through the ditch will deposit sediment over the sod and that after a little while it will ' ecome tight.

Canvas is also used as a lining to secure water-tightness. Willows with the tops left out, so that they may grow, are utilized in embankments with success.

In construction over "glacier," which is the term used for frozen muck mixed with ground ice, the ditch is either built wholly on top of the sod covering or an excavation is made and lined with sod. Ditches over this material are expensive to maintain, owing to the thawing of ice by running water.

One of the most interesting pieces of construction over glacier is the flume on the Miocene ditch. This flume is 1,100 feet long, and has a width of 8 feet and a depth of 28 inches. It was constructed in 1901, and is now in practically perfect alignment, both horizontal and vertical, and no repairs have been necessary on it. In putting in the foundation, trenches were dug 3 or 4 feet deep in the frozen ground, which was practically all ice. The excavated material was covered to protect it from thawing. A sill was laid in the bottom of the trench and the uprights fastened to this sill. The excavated material was then replaced in the trenches and froze again into the original condition. Sod was carefully placed over the trench. The uprights were then sawed off to grade and the flume constructed on them.

Inverted siphons are built across deep ravines where their use will save expense and reduce loss by seepage. Most of these are of riveted steel pipe. Joints are made by lapping the ends from 4 to 6 inches. Siphons must be weighted down and protected by rock to prevent injury by frost and snow slides. During 1906 two siphons were built on the Seward ditch, across Clara and Hobson creeks, using continuous wood-stave pipes with steel bands.

On account of the rapid surface run-off during hard rains, it is necessary to have frequent waste gates. The most common waste gates consist either of a flume as deep as the bottom of the ditch, in which the height of the water is regulated by flashboards, or of a long weir, laid on the ground surface, which will spill the water when it reaches a certain level.

Intakes of ditch consist of a dam or barrier across the stream, containing one or more waste gates, and head-gates for regulating the flow into the ditch. In order to divert the entire flow of a stream, a bed-rock dam must be built to stop the ground flow through the gravelly beds. These are made by cutting a trench across the stream bed, extending down to an impervious stratum, and filling it with sod, which is carefully laid and tamped. The dam should be protected from erosion with large flat rocks or riprap.

Frozen ground, inadequate facilities for transportation, and high cost of help[a] and supplies make ditching very expensive. To the first cost of a ditch should be added the cost of maintenance for the first three years, during which time extensive repairs are necessary. These in many cases equal the first cost of construction. At the end of three years ditches are, as a rule, in fairly permanent condition, and the cost of maintenance is greatly reduced. Such information as could be obtained shows that the cost of a ditch carrying from 1,000 to 2,000 inches, including the first three years' maintenance, is from $5,000 to $8,000 per mile. Owing to dangers from washouts and landslides, it is necessary to have the ditch constantly patrolled.

Owing to the frozen condition of the ground, it is not practicable to use ditches much before the 1st of July, as the surface does not become fully thawed until that time, and during the thawing period the ground becomes very soft and there is great danger of damage by washouts.

The following table gives a list of the principal ditches in this section. The data given are in some cases only approximate, as it was necessary to obtain them by inquiry.

Ditches between Cape Nome and Cape Rodney, Seward Peninsula.

Name.	Extends		Length.	Completed.	Bottom width.	Fall per mile.	Capacity.	Elevation.	
	From—	To—						Head	Outlet.
Miocene Ditch Co.:			*Miles.*		*Feet.*	*Feet.*	*Sec.-feet.*		
Main ditch...	Nome River...	Hobson Creek.	13	1903	8	4.5	40	572	500
	Hobson Creek.	The Ex........	14	1902	10	3.37	55	500	445
	The Ex........	Snow Gulch ...	4	1901	8	6.5	55	445	420
Feeding laterals.	Upper Glacier Creek.	The Ex........	2	1901	......	......	6	......	445
	Grouse Creek..	Flume.........	4	......	......	......	4	......	478
	Upper New Eldorado Creek.	Sparkle Creek..	7	1906	......	......	6	742	......
	David Creek...	Nome River above main intake.	1.8	......	4	......	14	590	......
	Jett Creek.....	Nugget Divide.	3.5	1906	3.5	6	10	806	785
	Grand Central River.	....do.........	8	([b])	8–10	5–6	80	850	785
Distributing laterals.	The Ex........	Grass Gulch...	4	......	6	3.3	16	445	432
Tunnel.......	Kanoma Gulch. Glacier Creek.	New Year Gulch, Anvil Creek.	[c] 1,800	1904	[d] 4x7	......	......	......	......
Wild Goose Mining and Trading Co.:									
Seward......	Nome River below Dorothy Creek.	Saturday Creek.	38	1906	10	3.18	32	408	274
Pipe line.....	Crater Lake...	Nugget Divide.	8	([b])	[e] 42	15	60	963	......
	Nugget Divide.	Anvil Mountain.	35	([b])	[e] 48	10	70	......	......
	Pumping plant.	....do.........	7	......	[e] 18	......	6	......	......
	No. 3, below Little Creek.	Pumping plant.	3	1902	4	5.3	6	......	......

[a] Laborers receive $5 per day and board; blacksmiths, cooks, etc., $6.
[b] Under construction.
[c] Feet.
[d] Cross section.
[e] Diameter in inches.

Ditches between Cape Nome and Cape Rodney, Seward Peninsula—Continued.

Name.	Extends From—	Extends To—	Length.	Completed.	Bottom width.	Fall per mile.	Capacity.	Elevation. Head	Elevation. Outlet.
			Miles.		*Feet.*	*Feet.*	*Sec.-feet.*		
Pioneer Mining Co.:									
South bank..	No. 2, above Anvil Creek.	No. 1, below Anvil Creek.	0.75	1902	5	7	4-6	......	......
North Bank..	No. 4, above Anvil Creek.	Moonlight Reservoir.	1.25	1903	6	....	10-12	......	......
	Nome River, above Clara Creek.	Little Creek...	38	1906	8	3	40	......	......
United Ditch Co.:									
Sutton.......	Penny River...	Beach.........	6	1905	20-15	3.12	100	120	90
Highline.....	....do.........	.....do........	....	*a* 1904	7	4.22	......	420	......
Miscellaneous:									
Cedric........	Josie Creek....	Hungry Creek.	19	1905	4-8	4	25	870	790
Campion.....	Buffalo........	Dorothy Creek.	4	1903	6	7.5	28	610	580
Northwestern Ditch Co.	Osborn Creek..	Hastings Beachline.	18	....	....	....	20	......	......
Northland Mining Co.	Goldbottom Creek.	Balto Creek...	12	(*a*)	....	....	20	390	......
Hot Air......	Divining......	Glacier Creek opposite Snow Gulch.	6	1902	....	....	10	......	......
Price and Tremper.	Glacier Creek..	Opposite Snow Gulch.	2.5	....	....	....	5	175	......
Golden Dawn	Twin Mountain Creek.	Alpha Creek...	10	(*a*)	....	....	20	500	......
Corson Mining Co.	Last Chance Creek.	Pioneer Gulch..	4	1903	....	....	18	460	......
Plein.........	No. 7, Otter Creek.	Mouth.........	1	1904	....	....	3	......	......
Flambeau Hastings.	Head of Flambeau River.	Hastings Creek	29	1906	....	....	20	......	......
Capt. Peterson.	No. 3, below Anvil.	Little Creek...	2.5	....	....	....	16	......	......
Cripple River Hydraulic Mining Co.	West bank Cripple River.	....	10	....	....	....	......	......	......
Jourden-Cummings.	Buffalo Creek..	Boer Creek....	4	1906	4	6	20	1,000	......

a Under construction.

WATER-POWER POSSIBILITIES.

Owing to the great value of water in this section of the country for use in the auriferous gravels, but little attention has been given to power development. There are, however, a large number of excellent power sites on various portions of the peninsula whose development is feasible, both from an engineering and a financial standpoint.

The scarcity of fuel makes steam power very expensive, and it is probable that much of the future mining, especially along the tundra back of Nome and along the larger streams, will be carried on by dredging or by some form of elevating in which power will play an important part. With this in view the attention of mining men should be directed to the consideration of power possibilities. Among those which were observed are the Salmon Lake development, which has been started; the development at Nugget Divide, by bringing over the water from Grand Central River; the developments at Divide Creek and Gold Bottom Creek, possible in connection with the diversion of the Sinuk water; the Glacier Lake power, and many other powers in the streams of the Kigluaik Mountains, notably on the glacier-fed torrents on their northerly slope. (See p. 38.)

NOTES FOR INVESTORS.

Present information shows that the total water supply available for use in the vicinity of Nome, and probably in other parts of Alaska, is limited. Caution, therefore, should be used in extensive hydraulic developments.

There is a great tendency in that country to push forward construction and the installation of expensive machinery before making a preliminary investigation to determine the feasibility of the project from an engineering and from a financial standpoint. A large portion of the ditch and other hydraulic work already constructed in this section has been a failure from the first, both on account of insufficient water supply and the lack of mineral ground on which to use the supply if it were available, and also in many cases from inefficient construction.

Furthermore, there is a great tendency for individuals and companies to undertake the construction and installation of expensive plants without employing the services of an engineer. This has resulted in total or partial failure, due both to the excessive cost and the inefficiency of the plant, where a successful development should have been made.

The cost of useless machinery, ditches, etc., which are to be seen almost everywhere in this section of the country, amounts to hundreds of thousands of dollars. This condition and the tendency for immature development should be noted by all who are looking toward this region for investment, and investments should be preceded by a thorough investigation by competent engineers.

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[Water-Supply Paper No. 196.]

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Most of the above publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except classes 2, 7, and 8), on application.
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3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost.
4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they can be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This paper is the twenty-first in Series M, the complete list of which follows (WS=Water-Supply Paper):

SERIES M—GENERAL HYDROGRAPHIC INVESTIGATIONS.

WS 56. Methods of stream measurement. 1901. 51 pp., 12 pls.
WS 64. Accuracy of stream measurements, by E. C. Murphy. 1902. 99 pp., 4 pls.
WS 76. Observations on the flow of rivers in the vicinity of New York City, by H. A. Pressey. 1902. 108 pp., 13 pls.
WS 80. The relation of rainfall to run-off, by G. W. Rafter. 1903. 104 pp.
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WS 91. Natural features and economic development of the Sandusky, Maumee, Muskingum, and Miami drainage areas in Ohio, by B. H. Flynn and M. S. Flynn. 1904. 130 pp.
WS 92. The Passaic flood of 1903, by M. O. Leighton. 1904. 48 pp., 7 pls.
WS 94. Hydrographic manual of the United States Geological Survey, prepared by E. C. Murphy, J. C. Hoyt, and G. B. Hollister. 1904. 76 pp., 3 pls.
WS 95. Accuracy of stream measurements (second edition), by E. C. Murphy. 1904. 169 pp., 6 pls.
WS 96. Destructive floods in the United States in 1903, by E. C. Murphy. 1904. 81 pp., 13 pls.
WS 106. Water resources of the Philadelphia district, by Florence Bascom. 1904. 75 pp., 4 pls.
WS 109. Hydrography of the Susquehanna River drainage basin, by J. C. Hoyt and R. H. Anderson. 1904. 215 pp., 28 pls.

WS 116. Water resources near Santa Barbara, California, by J. B. Lippincott. 1904. 99 pp., 8 pls.

WS 147. Destructive floods in the United States in 1904, by E. C. Murphy and others. 1905. 206 pp., 18 pls.

WS 150. Weir experiments, coefficients, and formulas, by R. E. Horton. 1906. 189 pp., 38 pls. (Out of stock.)

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WS 187. Determination of stream flow during the frozen season, by H. K. Barrows and Robert E. Horton. 1907. 93 pp., 1 pl.

WS 192. The Potomac River basin: Geographic history—rainfall and stream flow—pollution, typhoid fever, and character of water—relation of soils and forest cover to quality and quantity of surface water—effect of industrial wastes on fishes, by H. N. Parker, Bailey Willis, R. H. Bolster, W. W. Ashe, and M. C. March. 1907. — pp., 10 pls.

WS 196. Water supply of Nome region, Seward Peninsula, Alaska, 1906, by J. C. Hoyt and F. F. Henshaw. 1907. 52 pp., 6 pls.

Correspondence should be addressed to

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UNITED STATES GEOLOGICAL SURVEY,

WASHINGTON, D. C.

MARCH, 1907.

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1891.

RUSSELL, I. C. Account of an expedition to the Yukon Valley in 1889. In Eleventh Ann. Rept., pt. 1, 1891, pp. 57-58. Extract from Professor Russell's complete report in Bull. Geol. Soc. America, vol. 1, 1890, pp. 99-162. (Out of stock.)

——— Account of an expedition to the vicinity of Mount St. Elias in 1890. In Twelfth Ann. Rept., pt. 1, 1891, pp. 59-61. A full report of this expedition was published in Nat. Geog. Mag., vol. 3, 1892, pp. 53-203. (Out of stock.)

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Casadepaga Special, Seward Peninsula; scale, 1:62500. T. G. Gerdine.
Fortymile quadrangle; scale, 1:250000. E. C. Barnard.
Grand Central Special, Seward Peninsula; scale, 1:62500. T. G. Gerdine.
Juneau Special quadrangle; scale, 1:62500. W. J. Peters.
Nome Special. Seward Peninsula; scale, 1:62500. T. G. Gerdine.
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