THE STATE ELECTRICITY AUTHORITY

HESTVATN HYDRO-ELECTRIC PROJECT

HYDROLOGICAL REPORT

by

SIGURJÓN RIST

Reykjavík, July 1961

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2.1 DRAINAGE AREA

Fig. 2-1 shows the drainage area. The inset shows its geographical position within Iceland. Its size above the site of the proposed diversion dam at Århraun is 4360 km^2. Its elevation ranges between 48 m at the damsite and 1765 on the Hofsjökull ice cap. The hypsometric curve in Fig. 2-2 shows for each elevation the percentage of the total area lying above that elevation.

No long-term meterological observations are available from within the Hvítá drainage area above the damsite. The monthly mean temperature and precipitation at the meteorological observation post Hæll lying close to the eastern water divide at el. 140 m are as follows (30 year means 1901-1930).

Month	Precipitation millimetres	Temperature degrees Centigrade
September	115	7.1
October	110	3.4
November	90	0.3
December	95	-0.9
January	75	-1.8
February	75	-1.2
March	75	-0.8
April	65	1.4
May	60	5.5
June	65	9.5
July	70	11.4
August	60	9.9
Year	955	3.7

About 690 km^2 or 16% of the drainage area above the damsite is glaciated. The glacier melt contribution to the flow is usually confined to the three summer months June, July and August, its maximum usually in July or August. The two tributaries Brúará and Tungufljót are both mainly spring-fed rivers with a very constant flow, and contribute greatly to the winter flow at the damsite. Other tributaries carry mainly surface run-off or snow melt and their flow, therefore, tends to be high in spring and normally wet summers but low, sometimes negligible, in sustained frost periods in the winter, and summer draughts.

Lakes cover an area of 51 km^2 or 1,3% of the drainage area. The principal lake is Lake Hvítárvatn at the southeastern margin of the Langjökull ice cap, 28 km^2 in size. Lake Hvítárvatn has a great natural regulating effect upon the discharge of Hvítá River, principally by storing the meltwater from the ice cap for release during the winter. The drainage area above the outlet of Lake Hvítárvatn plus those of the two spring fed rivers Brúará and Tungufljót amount to 2000 km^2 or 46% of the total. It is from these three sources that River Hvítá derives most of its base flow.

2.2 STREAM FLOW

2.2.0 Flow Data Available

No water gauge has been installed at the damsite, but the stream flow there has been computed from data furnished by water gauges Nos 2 and 64 (see Fig. 2-1), where records are available for 20 and 10 years, respectively. Therefore, stream-flow data are available for 10 years (1950/60) at the damsite. The mean discharge (MQ) for this period is 270 kl/s, corresponding to a mean annual yield ($M\sum aQ$) of 8492 Gl and a mean specific discharge of 62 l/s pr. km^2 of drainage area.

The tables in Figs 2 - 4 and 2 - 5 show monthly means of discharge (kl/s) and monthly yields (Gl) for the whole period of records (1950/60). Figs 2-6 and 2-7 show weekly averages of discharge for the water years 1950/58, and Fig. 2 - 8 shows a flow duration curve and flow utilization curve for the same period (50/58). The latter curve shows for each discharge the area below the flow duration curve up to that discharge, expressed as a percentage of the total area below the curve. Fig. 2-9 shows flow regulation curves for each of the water years 50/57 to 57/58, and, finally, fig. 2 - 10 shows cumulative storage curves, based on the regulation curves. These curves show the amount of storage, expressed as a percentage of mean annual yield ($M\sum aQ$, vertical scale) required to ensure in a given percentage of years (horizontal scale) a uniform discharge equal to any given percentage of the mean discharge (curve parameter).

2.2.1 Floods

The greatest floods in Hvítá River at the damsite observed so far are 2500 - 3000 kl/s (in 1930 and 1948); 2000 kl/s (Febr. ´60) and 1100 kl/s (Jan. ´61). All these floods occurred in winter and were of the so-called winter flood type. Such floods are caused by a sudden inrush of humid and warm air masses from the Atlantic into the snow-covered basin, causing intense snow melt to coincide with heavy rainfall. As the frozen ground is highly impermeable, the result is a fairly sharp flood peak.

There are also other types of floods, such as those caused by snow melt in the spring or by rainstorms, but they are usually of a smaller magnitude than the winter floods. Finally, there are the so-called glacier bursts, which may be due to either the failure of an ice dam holding up a lake, or to subglacial volcanism. There are no evidences of glacial bursts caused by volcanism within the Hvítá drainage area nor any records thereof in historical times although Icelandic annals frequently mention glacier bursts in other, sometimes more remote, parts of the country. A burst caused by release of water from an ice-dammed lake, on the other hand, occurred on Sept. 16 1929, when ab. 55 Gl of water flowed from Lake Hagavatn through Lake Sandvatn to Tungufljót and Sanda Rivers in ab. 24 hours.

Flood data are still too meagre to base frequency studies upon them. However, from the observed floods on the one hand and

on the other hand from the absence of glacial bursts due to subglacial volcanism, the order of magnitude of which is known from observations elsewhere in the country, a reasonable estimate appears to be ab. 3500 kl/s for 100 years floods
and ab. 4500 kl/s for 1000 years floods
at the damsite.

Fig. 2 - 11 shows the observed water surface profile of River Hvítá from a point approximately 1 km downstream from the damsite to Iða, a narrow to the north of Vördufell, near the confluence of Stóra-Laxá. The level surface of the lower part of this reach at high discharges is due to flooding of the plain on the left side of the river, and of the low ground separating Hvítá River and Lake Hestvatn. The lower part of the figure shows the water stage at different discharges at the tailwater of the proposed plant.

In a 1000 years flood, the water levels will probably be some 0. 5 - 0. 7 m above the highest stages shown in the figure.

2. 2. 2 Low Flow

Owing to snow melt water from the glaciers and from mountains in the uppermost parts of the basin, the flow at the damsite is generally lower in frost periods in the winter than in dry summers. Rainstorms are frequent in the autumn. Through groundwater storage, their effect on the discharge may extend some time into the winter. The lowest flows occur when a dry summer is followed by a cold winter without any intervening rain period. That is what happened in 1950/51, the driest water year of record in the Hvítá basin (At the Ljósafoss power station on the Sog, a tributary entering River Hvítá some distance downstream of the Århraun damsite, where stream-flow data are available since 1940, 1950/51 is also the driest year of record).

As shown in Fig. 2 - 3 (table), the lowest recorded daily mean discharge at the damsite is 70 kl/s (April 13 1951).

The Q_{95} is ab. 150 kl/s (Fig. 2 - 8), and the lowest recorded monthly mean is 155 kl/s (March ´51, see Fig. 2 - 4).

2. 3 ICE CONDITIONS

2. 3. 1 Diversion Area

Apart from a relatively narrow channel kept open by the water from Brúará River (temp. 0. 2 - 5 °C depending on the weather), an ice cover is formed in every winter over Hvítá River in the reach between the outlet from Lake Hestvatn and the mouth of the proposed diversion canal. The width of the channel is variable and it is sometimes jammed by sludge which may couse a rise in stage of some 2 metres. This jam usually is formed at river km 4 - 5 upstream from cross section V18 (see fig. 2 - 11), i.e. at Útverkatunga. The rise is limited by the following four factors, acting alone or in combinations.

1. The water flows over the ice dam.
2. The river cuts a new irregular channel through the sludge.
3. Scouring of the sandy river bottom.
4. The flow of the Hestvatn outlet river is reversed and the water starts flowing into the lake and into the plain on the left bank. This causes the level of Lake Hestvatn to rise. At a certain rise the water flows from the lake back to the river along the route of the proposed diversion canal.

2.3.2 Lake Hestvatn

An ice cover is formed over the inlets from the lake early in the winter, with the central area remaining open until later. After the diversion is completed, this sequence will be reversed.

2.3.3 Tailwater Area

Ice jams are sometimes formed at the sharp bend in Hvítá River a short distance downstream from the powerhouse site, causing a rise in stage of 2 - 3 metres at the mouth of the proposed tailrace canal.

2.4 FORECAST OF ICE AND SEDIMENT CONDITIONS AFTER COMPLETION OF THE DEVELOPMENT

2.4.1 Introduction

In the following an attempt will be made to predict the effect of the development structures upon the ice and sedimentation regime of Hvítá River at the site. The forecast is based upon the design of the various structures as proposed by Mr. Thoroddsen in his Report. A drawdown of Lake Hestvatn for pondage purposes of 1.3 m from a normal operating level at el. 49.5 is assumed.

2.4.2 Back-water Effects

The back-water effect of the diversion dam will presumably extend somewhat beyond river km 8 (see fig. 2 - 11). The proposed rock-fill groin from the left river bank will divide the impounded water into two parts, upper and lower, which will be connected by a 500 m wide channel from the end of the groin over to the right canal bank. The volume of the water stored in the upper part will be 0.6 Gl approximately. The groin will cause additional back-water rise in the area above it. The amount of this rise will vary with the river discharge. Since the threshold between Lake Hestvatn and River Hvítá at the site of the proposed powerhouse is never overtopped under natural conditions, the construction of the power plant will cause no back-water rise. On the other hand, the drawdown of the reservoir and the head loss in the headrace canal will create a water level at the intake which is lower than the present natural lake level.

2.4.3 Ice Conditions After Completion of the Development

2.4.3.1 Hvítá River Above Diversion Canal

As will be mentioned below, when discussing the sediment behaviour of the river after development, the 0.6 Gl space above the rock groin will presumably be silted up in a relatively very short time. Before this silting-up has taken place, however, an ice cover will be formed over the river, with occasional thaw-outs at places in the upper parts caused by the warm Brúará water. Rise in water level caused by ice will be negligible.

After the silting-up, the ice conditions will be similar to those prevailing at present. Normal rise in stage due to ice will be ab. 60 cm, but occasionally considerably more (see fig. 2-15a and Section 2.3). The rock-fill groin will probably be buried under ice every winter. It will be exposed to both wave action and the impact of ice floes. At certain ice conditions on the river, except for a small part flowing in the outlet channel of Lake Hestvatn, all the river water will flow over the groin. All this will greatly endanger its stability. Part of the groin will probably be buried in sand and only a slight settlement will result in a continuous overtopping of it by the river.

2.4.3.2 Diversion Canal

A normal flow velocity of 0.6 m/s, as proposed in Thoroddsen's design of the canal is too high for an ice cover to form. A partial ice cover will be formed at both banks, with an open channel in the middle. While the river upstream of the canal is freezing over, sludge will be carried into the canal from the river. This sludge will flow under the ice cover along both banks or is carried into the lake. Only if the velocity falls below 0.5 m/s will the canal freeze over. Such a reduction in the flow may occur for two reasons, viz.

1. At times of low load on the plant, with the reservoir in Lake Hestvatn nearly full.
2. Restriction in the area available to the flow may be caused by accumulated ice, e.g. near the entrance to the lake, with a resulting back-water effect extending up through the canal.

As long as the canal retains its original shape, only a small back-water rise is needed to reduce the velocity considerably or even to stop the flow altogether. The canal will then freeze over. As soon as the reservoir is drawn down, the velocity will increase again to 0.6 m/s and may in most cases reach a considerably higher value, 1.5 - 2 m/s. For an ice cover to remain on the canal at 0.6 m/s, the water temperature must be very close to zero Centigrade. An air temperature of ab. ÷ 20°C, plus a rather strong wind is required for the temperature of Hvítá River where it flows from under the ice cover upstream of the canal entrance to remain below 0.02 °C. According to Norwegian investigations (O. Devik), an open channel is sustained in a river flowing with 0.6 m/s velocity even if the water temperature is + 0.02 °C only. At a higher flow velocity of course, the chances that an ice cover can remain on the canal are less still.

The water level fluctuations of Lake Hestvatn, caused by its use for daily flow regulation through the power plant will entail variations in the flow velocity in the diversion canal. This, in turn, will cause more unstable ice conditions in the canal and greater back-water effects due to ice than would have been the case if a constant velocity was maintained throughout the day.

2.4.3.3 Lake Hestvatn

The proposed diversion of Hvítá River into Lake Hestvatn will materially alter the ice conditions of the Lake. At present an ice cover is formed on the inlets in the autumn, while the main central part remains open until later in the winter. The volume of the Lake, up to el. 49.5 is 161 Gl. A normal flow of Hvítá River at the damsite at the time when the lake is freezing over is 140-180 kl/s, corresponding to a complete renewal of the whole water body in 12 days. After the diversion, an ice cover will presumably be formed on the central area in early winter, with parts of the inlets open until later.

This applies to an ice cover formation in calm weather. In periods of snow-storms from the NE, the process would be different. If, initially, the lake and Hvítá River are completely ice free, the sequence of events would be roughly as follows: The river and subsequently the lake will be cooled down to 0 °C; the formation of ice crystals starfs at the lake´s surface, and frazil ice is carried into it from the river. The waves prevent the lake from freezing over, and, instead, the ice is driven by the wind towards the entrance of the headrace canal at the south-western end of the lake.

2.4.3.4 Headrace Canal

In Thoroddsen´s design, a skimmer wall is contemplated across the canal entrance to prevent drifting ice from flowing into the canal. The skimmer wall should probably lie in a direction oblique to the flow direction, which could be done by placing the western anchor farther south than the eastern one. A V-shaped inlet would thus be formed between the skimmer wall and the western shore, open against north-east. In that way, the shore would take up a part of the ice pressure, which would considerably increase the efficiency of the skimmer wall in preventing drift ice from entering the canal. Probably, two skimmer walls should be constructed. The outer one would then act as a breakwater.

In discussing the ice conditions likely to be encountered in the headrace canal, two cases may be distinguished between,

1) the lake is frozen over and 2) the lake is essentially ice-free and a moderate to strong wind is blowing from the north-east. In the former case, the water entering the canal from under the ice cover will have a temperature of about 0.5°C. A simple calculation will show that, even at a reduced output of the plant, sufficient heat is carried from under the ice cover to prevent the canal from freezing over. Some frazil ice and sludge may, of course, be carried through the canal, but it would be so little that no operating troubles are likely to result.

The latter case is by far the most critical one. Under these conditions, the temperature of the water entering the canal may be very close to 0° C. Ice formation will probably take place in the headrace canal. The rate of ice formation may be considerable for short periods and the thrash racks may get clogged unless measurers are provided for to heat them. On the other hand, heating of the thrash-racks will be ineffective to melt sludge and broken-up ice floes entering the canal from the lake. The skimmer wall must be relied upon for preventing such ice from getting into the canal.

2.4.4 The Sediment Problem

2.4.4.1 General

The size of the sediment load of Hvítá River at the point of diversion is not known with any accuracy. The order of magnitude of the suspended sediment, however, may be estimated from observations at Gullfoss. Fig. 2-43 shows a sediment duration curve, based on the flow duration curve plus a relationsship between discharge and suspended sediment, established by analysis of 43 samples from the river at different flow. According to the figure, the average annual suspended sediment load at Gullfoss is ab. 0.38 Gl or 380,000 m^3. Assuming a 30% increase in this figure to account for sediment brought to Hvítá River by tributaries between the damsite and Gullfoss, above all the Stóra-Laxá, an average annual sediment load at the damsite of ab. 500,000 m^3 is obtained. Comparing this to the 0.6 Gl of water impounded above the groin, that space will probably be silted up in the first year or two after completion of the dam.

2.4.4.2 The Channel of Hvítá River

As stated above, there will be a channel, 500 m wide and with a cross section area of 200 m^2 approximately between the end of the rock groin and the mouth of the diversion canal. A discharge of 260 kl/s, flowing at right angles to the above cross section would render a flow velocity of 1.3 m/s. Since, actually, the water flows in a direction oblique to the cross section, the velocity will be somewhat higher than this. Therefore, even if the rock groin is constructed after the dam is completed, it will cause an additional backwater effect, as pointed out previously. This latter backwater rise will result in a scour of the river bottom in this section, whereby the backwater rise will be partly eliminated.

The material scoured from the river bottom is partly carried past the canal entrance and deposited in the wtill water downstream of the groin, and partly carried into the diversion canal. Material is transported past the canal only when water is spilling over the dam. A delta will be formed in the area downstream of the rock groin, with sand-tongues extending in direction to Hestfjall. The front edge of the delta will be rather steep. The scour process will be especially effective at discharges somewhat above the normal, sufficiently high to increase the back-water effect of the groin, but too low for any substantial backwater rise to take place below the groin when the dam is fully open.

The position of the groin is at river km 5, fig. 2-11. From that figure it is apparent that the water level at the groin end will be at elevation 49.3 m or thereabout at the discharges that will render the maximum scouring above the groin i.e. only about 20 cm below the normal operating water level. At such discharges, therefore, very little scouring of the delta below the groin takes place.

If the dam could be kept open at discharges well below rated plant discharge, some scouring of the front edge of this delta will take place, but since the silt transporting capacity is small at such discharges, no great quantities of silt will be passed through the damgates.

When a flood is approaching the damgates will be fully opened. Under such conditions,, some outwash of silt from the mouth of the narrows north of the dam will take place. To the north of the narrows the backwater rise will cause deposition of silt, and still farther north, scouring will occur until the back-water rise has reached that far, when, of course, it will stop.

From this it is apparent that a normal operating level of the reservoir at el. 49.5 m does not permit any effective removal of the deposited silt by washing it through the damgates. For such a process to be effective, the elevation of the delta must be considerably higher than it can possibly become if the reservoir is normally kept at el. 49.5 m.

In the general diversion area, deposition of sediment takes place now, under the natural conditions, at or around a flood peak, but the suspended sediment load is greatest during the ascending limb of the flood hydrograph and is also considerable although possibly somewhat less, during the descending limb.

2.4.4.3 The Diversion Canal

As previously stated, a drawdown of Lake Hestvatn of 1.3 m for regulating purposes is assumed. A corresponding lowering of the water level at the canal entrance may be ab. 1.2 m. That means that the water level there will be at el. 48.3 m, i.e. 0.6 m below the natural water level there at a discharge of 260 kl/s and ab. 1.1 m below the present level of the sand banks. Consequently, under such conditions, and assuming a flow of 260 kl/s through the canal, scouring of the sand banks will inevitably take place and the material be carried into the canal and partly through it into Lake Hestvatn, where a delta will be formed.

Scour channels, 0.5 to 1.1 m deep will be formed in the sand banks. Gradually, due to deposition of silt in the diversion canal, its hydraulic capacity will be reduced so that a higher head is required to drive the 260 kl/s through it. Consequently, as time goes on, a constant difference in elevation between the canal ends of some 0.4 - 0.6 m will develop. To a normal level of the pond above the dam of 49.5 m will then correspond a lake level of 49.0 m.

2.4.5 Combined Effects of Ice and Silt Deposits

Presently, a rise in stage of some 2 m due to ice jamming in the reach just upstream of the proposed diversion has been observed. After diversion and when the pond above the rock groin has been silted up, a similar rise may be expected again. Some ice jamming may take place in the canal too. As just mentioned the silt deposited in the canal may cause a head of some 0.5 m between the canal ends. The combined effect of both ice jamming and silt may result in a difference in water level between the northern end of Lake Hestvatn and Hvítá River above the groin that will frequently amount to 1 m and occasionally to some 3 m. Some flooding of the river banks will occur under such conditions.

The above is based on the assumption that, once completed, the canal is left to itself and no control structures built into it. Presumably, such a control would materially improve the canal performance, both as regards ice troubles and silting. If, on the other hand, no such control is provided, the above 3 m difference will inevitably occur and then has to be taken into account in the planning of the development.

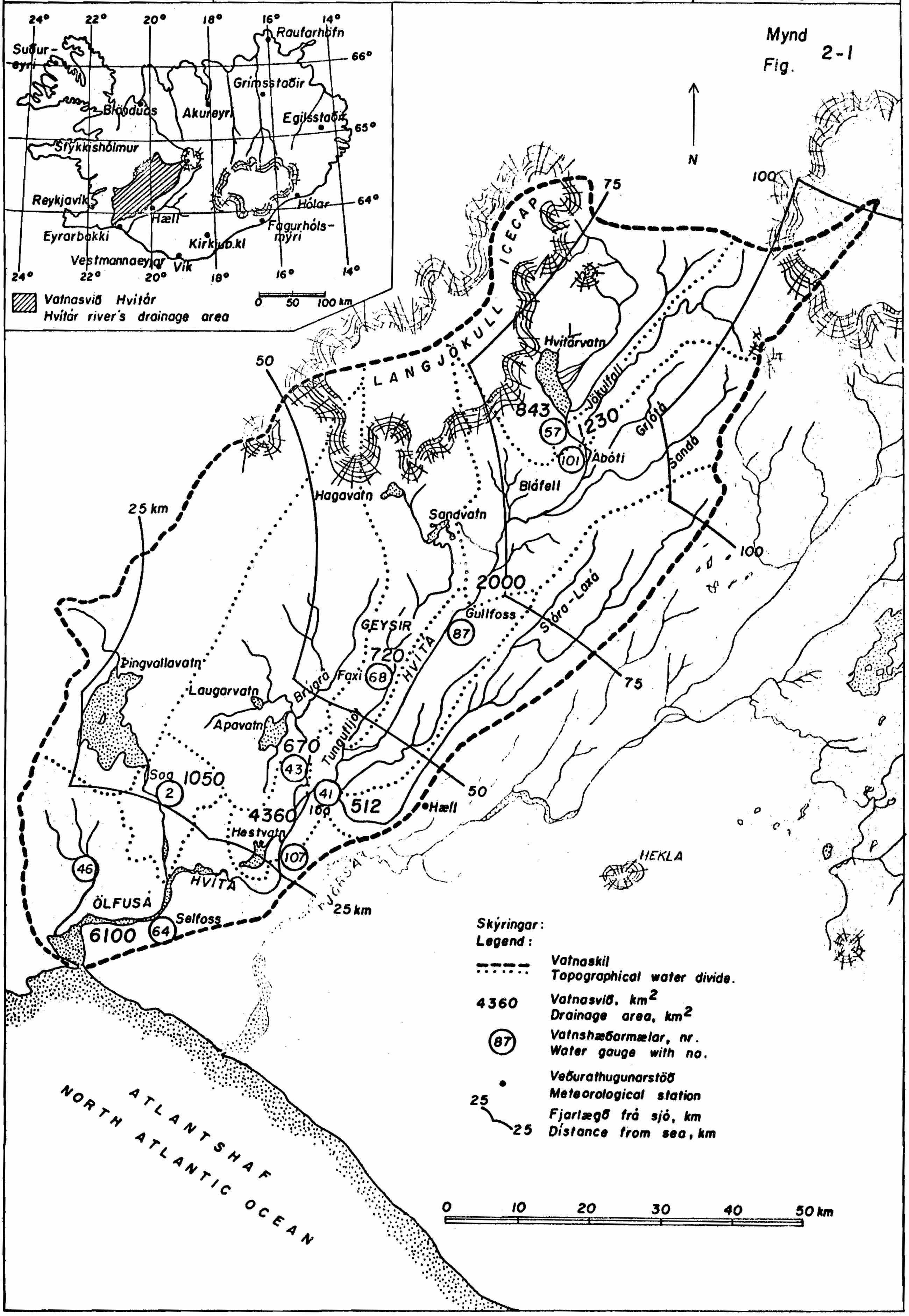
DRAWINGS

RAFORKUMÁLASTJÓRI
Vatnamælingar

Vatnasvið Hvítár
Drainage Area of Hvítá River, km^2

23.1.1960 S.Rist/O.H.
B-274 / TNR. 240
Vhm 107 / TNR. 19
FNR. 5295

Mynd
Fig. 2-1



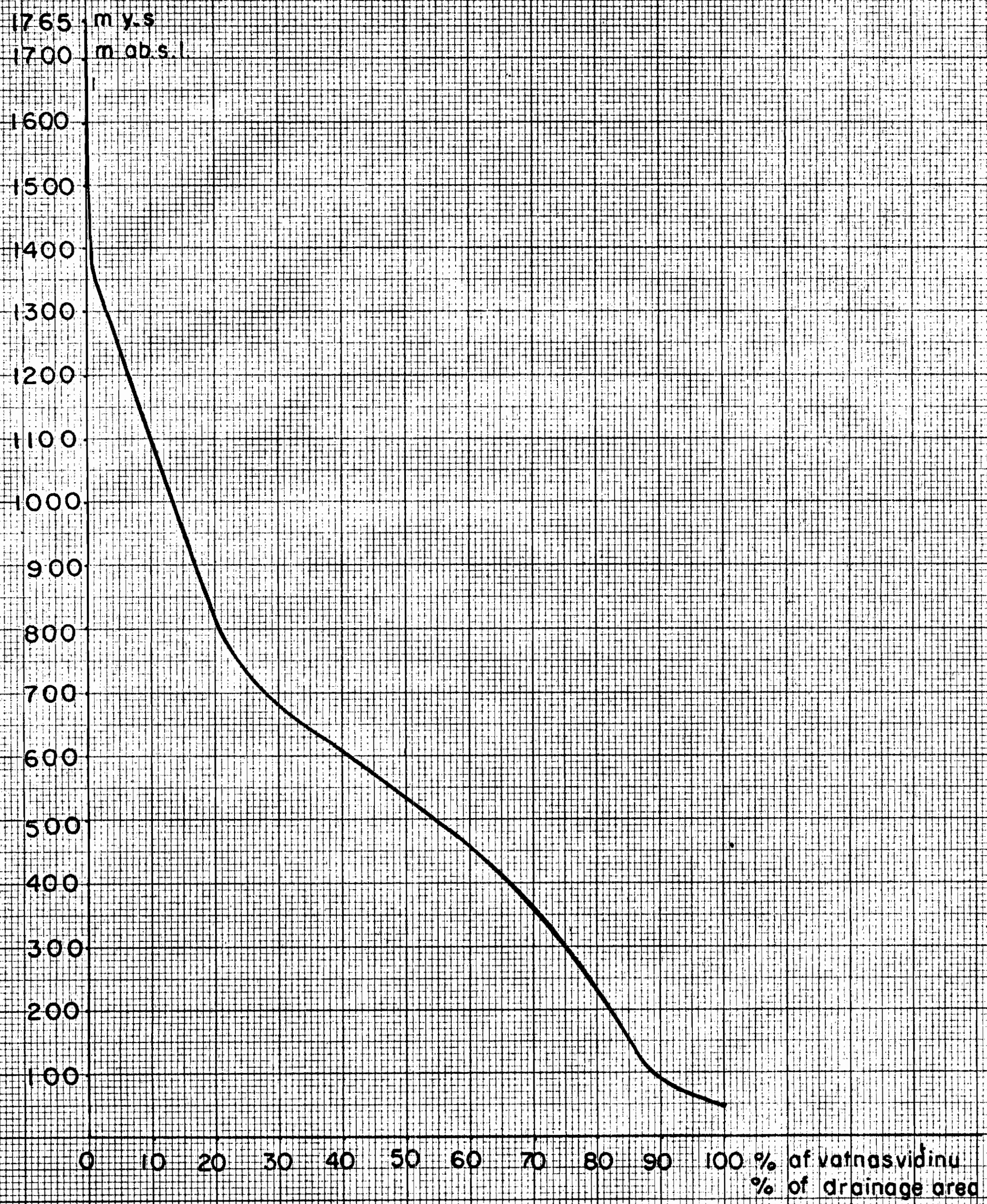
RAFORKUMÁLASTJÓRI HVÍTÁ ÁRHRAUN Hypsografisk lína Hypsometric curve.	1.2.61. S.RIST/PJ TNR. 254 B— 274 Vhm 107/29 FNR. 5320

VATNASVIÐ 4360 km²

DRAINAGE AREA 4360 km²

MYND 2-2

FIG 2-2



Raforkumálastjóri
Vatnamælingar
The State Electricity Authority
Hydrological Survey

Mynd
Fig. 2 - 3

EINKENNISRENNSLI HVERS VATNSÁRS

CHARACTERISTIC RUN-OFFS FOR EACH WATER YEAR OF RECORD

Vhm nr. Water Gauge No Vatnsfall Water-course Mælistaður Location Vatnasvið Drainage Areas	Vatnsár (1/9 - 31/8) Water year	HaMdQ		MaQ		Qa50	Qa75	Qa95	LaMdQ		Maq
		kl/s	P.u. MQ	kl/s	P.u. MQ	kl/s	kl/s	kl/s	kl/s	P.u. MQ	1/s km^2
1	2	3	4	5	6	7	8	9	10	11	12
87	50/51	316,3	2,67	84	0,71	74,0	49,0	34,1	31,9	0,27	42
Hvítá	51/52	578,7	4,89	116	0,98	97,1	61,8	36,0	31,9	0,27	58
Gullfoss	52/53	1150,0	9,71	140	1,18	95,0	74,0	64,8	49,0	0,41	70
2000 km^2 MQ=118,4 kl/s	53/54	495,0	4,18	156	1,32	136,1	97,1	69,3	48,9	0,41	78
MΣ aQ=3737 Gl/a	54/55	770,1	6,50	119	1,01	91,0	63,9	40,0	30,0	0,25	60
	55/56	180,2	6,84	114	0,96	99,0	84,0	67,0	56,0	0,47	57
	56/57	341,0	2,88	118	1,00	114,0	86,0	62,0	47,0	0,40	59
	57/58	377,0	3,18	97	0,82	90,0	65,0	53,0	44,0	0,37	49
68	51/52	116,0	2,48	43	0,92	40,5	36,7	35,8	35,5	0,76	60
Tungufljót	52/53	173,6	3,72	45	0,96	42,8	37,4	36,1	35,5	0,76	62
Faxi	53/54	111,8	2,39	51	1,09	49,8	47,3	41,6	37,4	0,80	71
720 km^2 MQ=46,7 kl/s	54/55	125,0	2,68	48	1,02	45,1	40,2	36,1	35,5	0,76	67
MΣ aQ=1473 Gl/a	55/56	96,1	2.06	49	1,05	48,2	45,1	38,8	36,1	0,77	68
	56/57	114,0	2,44	48	1,02	45,7	43,4	37,8	36,4	0,78	67
	57/58	93,5	2,00	43	0,93	40,6	37,80	35,0	33,8	0,72	60
43	48/49	154,9	2,36	70	1,07	66,3	61,9	56,8	51,0	0,77	104
Brúará	49/50	143,9	2,19	65	0,99	61,5	55,6	53,4	50,1	0,76	97
Dynjandi	50/51	129,6	1,98	58	0,88	54,4	51,9	49,5	49,2	0,75	87
670 km^2 MQ=65,6 kl/s	51/52	139,9	2,13	63	0,96	57,6	54,1	49,2	48,4	0,74	94
MΣ aQ=2069 Gl/a	52/53	193,9	2,96	65	0,99	56,4	52,8	51,9	48,8	0,74	97
	53/54	181,2	2,76	75	1,14	67,8	59,5	55,0	52,5	0,80	112
	54/55	130,0	1,98	65	0,99	59,1	54,7	52,5	52,3	0,78	97
	55/56	118,1	1,80	69	1,05	65,9	59,5	52,2	49,2	0,75	103
	56/57	174,8	2,66	66	1,01	61,5	54,4	51,3	50,1	0,76	98
	57/58	114,6	1,75	59	0,90	55,3	51,0	48,1	41,6	0,63	88

1	2	3	4	5	6	7	8	9	10	11	12
107	50/51	580	2,21	195	0,74	177	155	111	70	0,27	45
Hvítá	51/52	853	3,25	274	1,04	228	193	162	117	0,45	63
Hestfjall	52/53	1519	5,79	268	1,02	213	183	156	106	0,40	61
4360 km^2 MQ=262 kl/s	53/54	996	3,80	307	1,17	272	240	206	174	0,66	70
$M\Sigma aQ$=8284 Gl/a	54/55	1018	3,88	273	1,04	238	179	147	135	0,51	63
	55/56	618	2,36	277	1,06	257	213	178	107	0,41	64
	56/57	733	2,79	279	1,06	245	224	166	153	0,58	64
	57/58	690	2,63	226	0,86	211	178	149	136	0,52	52
2	40/41	130,4	1,17	106	0,95	105,9	99,5	91,7	83,1	0,74	101
Sog	41/42	150,2	1,35	116	1,04	117,1	107,1	99,1	85,9	0,77	110
Ljósafoss	42/43	127,8	1,15	107	0,96	107,4	102,0	95,4	84,6	0,76	102
1050 km^2 MQ=111,6 kl/s	43/44	145,9	1,31	118	1,05	119,9	109,1	99,9	91,8	0,82	112
$M\Sigma aQ$=3519 Gl/a	44/45	144,8	1,30	118	1,05	115,9	109,5	102,2	98,3	0,88	112
	45/46	142,6	1,28	120	1,08	118,6	112,3	104,4	97,7	0,88	114
	46/47	161,5	1,45	118	1,05	116,2	111,6	100,5	96,9	0,87	112
	47/48	174,5	1,56	122	1,09	119,6	112,4	105,9	102,4	0,92	116
	48/49	142,1	1,27	117	1,04	116,2	110,4	104,3	95,7	0,86	111
	49/50	140,4	1,26	110	0,99	109,7	103,4	96,2	89,7	0,80	105
	50/51	122,3	1,10	92	0,82	91,2	87,4	80,4	78,4	0,70	88
	51/52	116,1	1,04	96	0,86	96,8	90,4	82,2	78,8	0,71	91
	52/53	144,9	1,30	101	0,91	99,8	88,4	83,6	81,4	0,73	96
	53/54	167,1	1,50	124	1,11	122,8	109,8	104,4	91,3	0,82	118
	54/55	128,5	1,15	105	0,94	103,8	99,3	92,9	85,8	0,77	100
	55/56	133,0	1,19	113	1,01	111,9	105,2	99,0	95,4	0,85	108
	56/57	152,7	1,37	117	1,04	117,1	104,7	95,9	93,6	0,84	111
	57/58	120,3	1,08	102	0,91	100,1	95,7	85,3	82,6	0,74	97
64	50/51	706	1,83	302	0,78	285	257	248	164	0,42	52
Ölfusá	51/52	967	2,50	386	1,00	346	302	163	213	0,55	67
Selfoss	52/53	1684	4,36	386	1,00	333	289	257	205	0,53	67
5760 km^2 MQ=386 kl/s	53/54	1188	3,07	452	1,17	416	372	336	302	0,78	78
$M\Sigma aQ$=12198 Gl/a	54/55	1159	3,00	296	1,02	364	295	263	254	0,66	69
	55/56	732	1,89	409	1,06	393	333	295	230	0,60	71
	56/57	890	2,30	415	1,07	382	350	292	263	0,68	72
	57/58	923	2,12	344	0,89	329	292	266	263	0,68	60

Framh.
Cont.
Mynd
Fig. 2-3

RAFORKUMÁLASTJÓRI
Vatnamælingar

Hvítá, Árhraun

(Meðalrennsli mánaða, kl/s)
MmQ. kl/s (Mean discharge, kl/s)

Mynd
Fig. 2-4

W.y. / Month — Vatnsár / Mán.	Sept.	Okt.	Nóv.	Des.	Jan.	Febr.	Marz	Apr.	Maí	Júní	Júlí	Ág.	Vatnsár Water year
Meðaltöl ...1... ára 50/51....	174	183	167	194	197	162	155	168	334	204	211	188	195
51/52	184	265	179	231	353	535	244	274	335	222	242	224	274
52/53	183	187	185	178	183	287	705	230	296	265	263	252	268
53/54	280	346	328	490	360	257	274	310	291	262	253	228	307
54/55	198	195	242	185	235	229	250	404	227	262	409	442	273
55/56	358	271	232	202	388	340	262	296	280	275	229	191	277
Meðaltöl ...6... ára 50/51-55/56	229	241	222	247	286	302	315	280	294	248	268	254	266
56/57	192	310	469	300	296	222	177	307	327	271	238	234	279
57/58	200	272	292	282	161	184	170	296	179	243	238	194	226
58/59	237	275	504	267	289	401	366	233	354	274	257	273	314
59/60	395	344	281	213	269	370	254	267	269	251	260	219	283
60/61													
Meðaltöl ..10.. ára 50/51-59/60	240	265	288	254	273	299	286	279	289	253	260	244	270
Meðaltöl ..10.. ára 50/51-59/60	199	272	262	222	279	272	252	285	294	262	248	226	276

Almanaksár Calender year Ár	MmQ. kl/s.
1951	206
1952	264
1953	327
1954	254
1955	294
	224
1956	296
1957	260
1958	246
1959	307
1960	

Athugasemdir:
Remarks
← {Meðaltöl
Mean Values
← {Miðgildi
Median Values

RAFORKUMÁLASTJÓRI
Vatnamælingar

Hvítá, Árhraun

Σm Q Gl (Vatnsmagn mánaða, Gl)
(Total run-off, Gl)

Mynd
Fig. 2-5

Mán. / Vatnsár (Month / W.y.)	Sept.	Okt.	Nóv.	Des.	Jan.	Febr.	Marz	Apr.	Maí	Júní	Júlí	Ág.	Vatnsár Water year
Meðaltöl 1 ára 50/51	451	490	434	519	527	391	415	435	893	528	564	503	6150
51/52	476	711	464	617	947	1341	652	710	898	575	648	599	8638
52/53	475	502	480	479	489	695	1889	596	792	688	704	676	8465
53/54	726	926	850	1311	965	621	735	804	780	679	678	611	9686
54/55	513	521	628	497	630	553	671	1048	608	679	1094	1185	8627
55/56	929	726	600	541	1040	851	701	766	751	713	612	512	8742
Meðaltöl 6 ára 50/51-55/56	595	646	576	660	767	742	843	727	786	644	717	682	8385
56/57	498	831	1215	804	792	537	474	796	875	703	638	627	8790
57/58	518	727	758	755	431	444	455	768	479	629	636	518	7118
58/59	613	737	1305	717	774	978	980	604	949	710	689	733	9789
59/60	1024	923	729	571	722	925	680	693	720	649	698	588	8922
60/61													
Meðaltöl 10 ára 50/51-59/60	622	709	746	681	732	734	765	722	774	655	696	655	8492
Meðaltöl 10 ára 50/51-59/60	516	726	678	594	748	658	676	738	786	679	663	605	8690

Almanaksár
Calender year

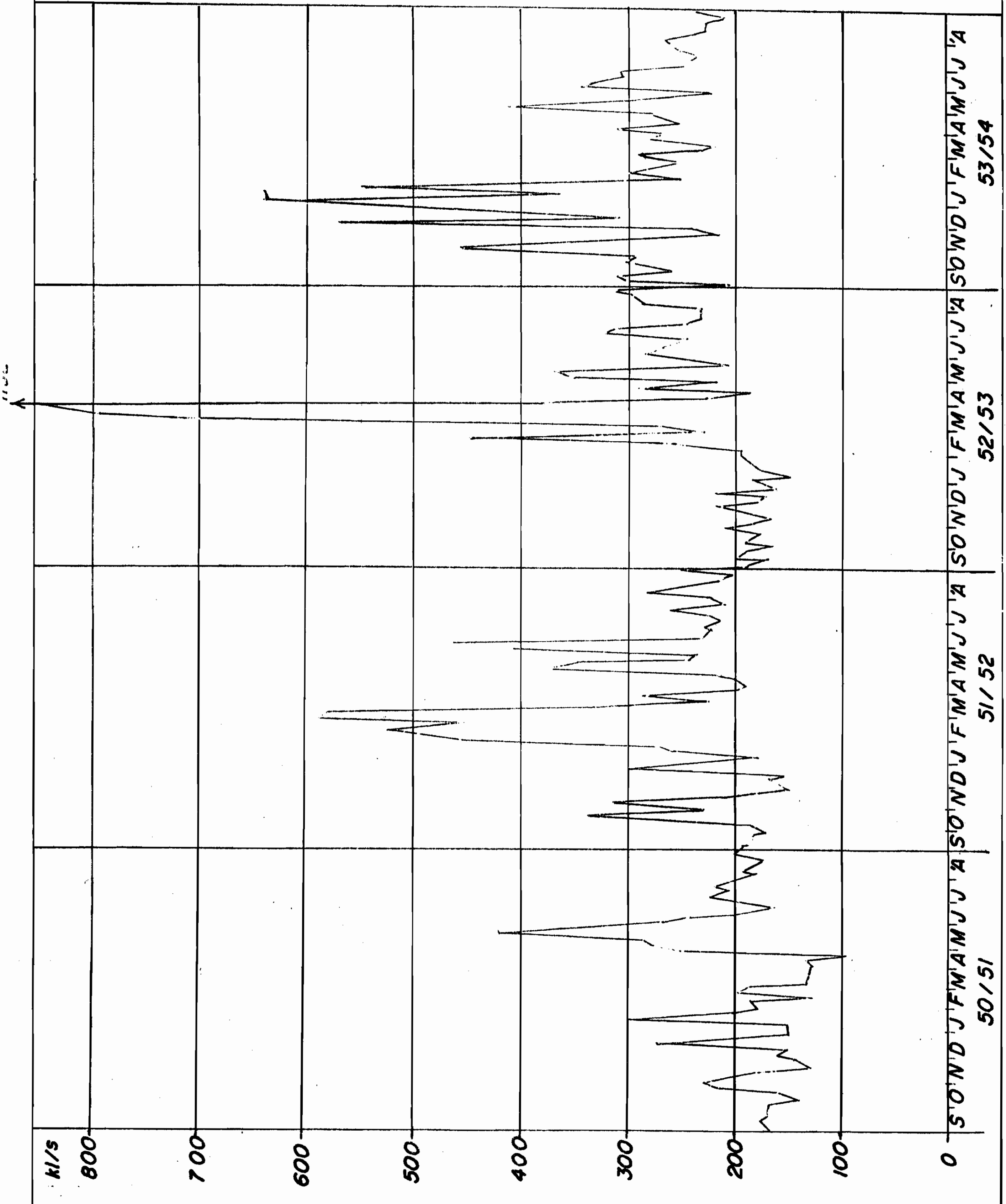
Ár	Σa.Q.Gl.
1951	6524
1952	8306
1953	10342
1954	8032
1955	9264
1956	9294
1957	8200
1958	7732
1959	9664
1960	

Athugasemdir:
Remarks:
Meðaltöl Mean Values
Miðgildi Median Values

RAFORKUMÁLASTJÓRI
Vatnamælingar
HVÍTÁ, HESTFJALL. Árhraun.
Vikumeðalrennsli.

Mynd
Fig. 2-6

Weekly Averages of Discharge for the Water Years 1950/54



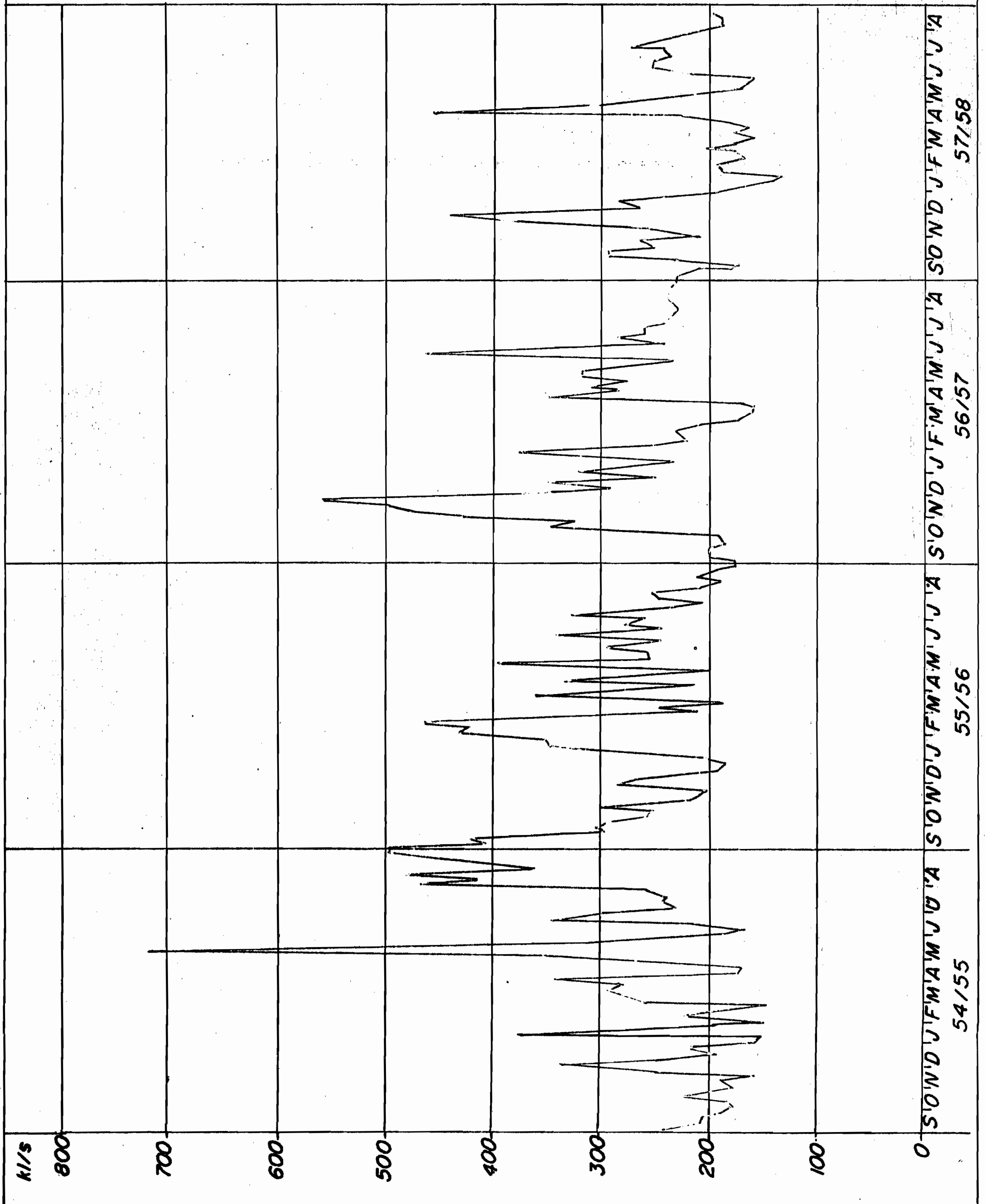
RAFORKUMÁLASTJÓRI
Vatnamælingar

HVÍTÁ, HESTFJALL, Árhraun.

Vikumeðalrennsli

Mynd
Fig. 2-7

Weekly Averages of Discharge for the Water Years 1954/58

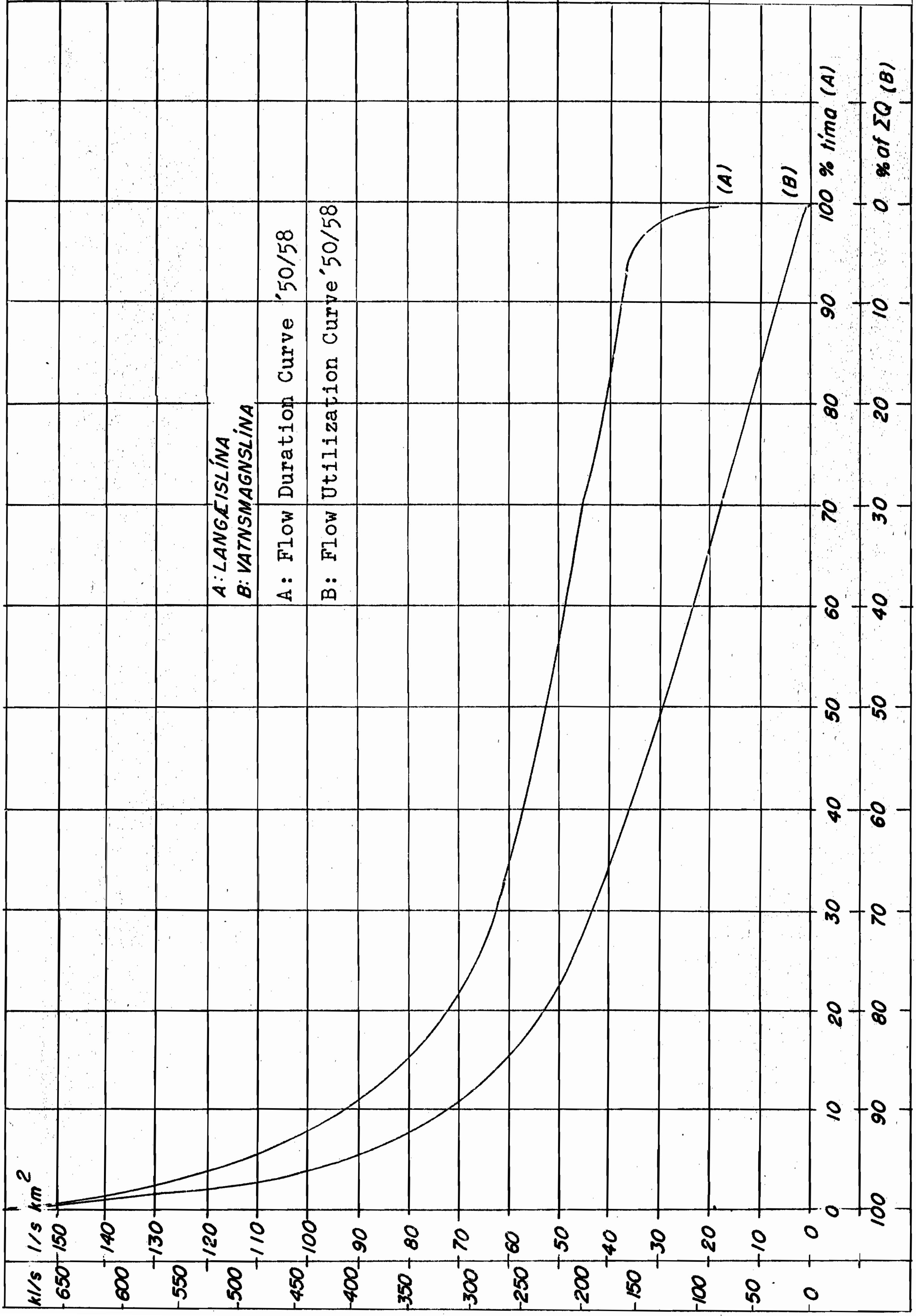


Vatnasvið
Drainage Area
4,360 km²

RAFORKUMÁLASTJÓRI
Vatnamælingar

HVITÁ, HESTFJALL, ÁRHRAUN
LANGÆISLÍNA, 8 ÁRA 1950/58

Mynd
Fig. 2-8



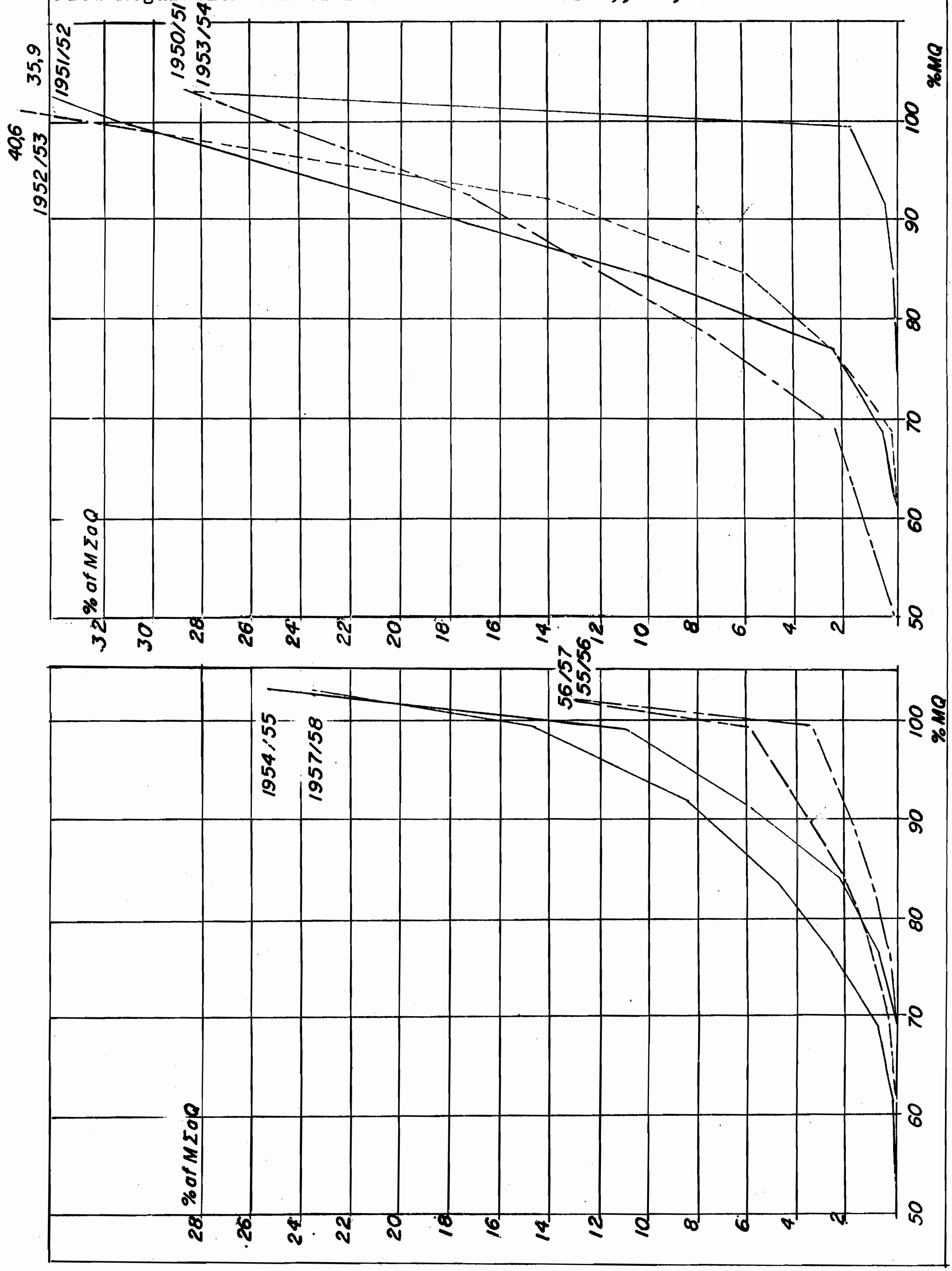
RAFORKUMÁLASTJÓRI
Vatnamælingar

HVÍTA, HESTFJALL, ÁHRAUN

Jöfnunarlina 8 ára 1950-58

Mynd
Fig. 2-9

Flow Regulation Curves for the Water Years 1950-'58.

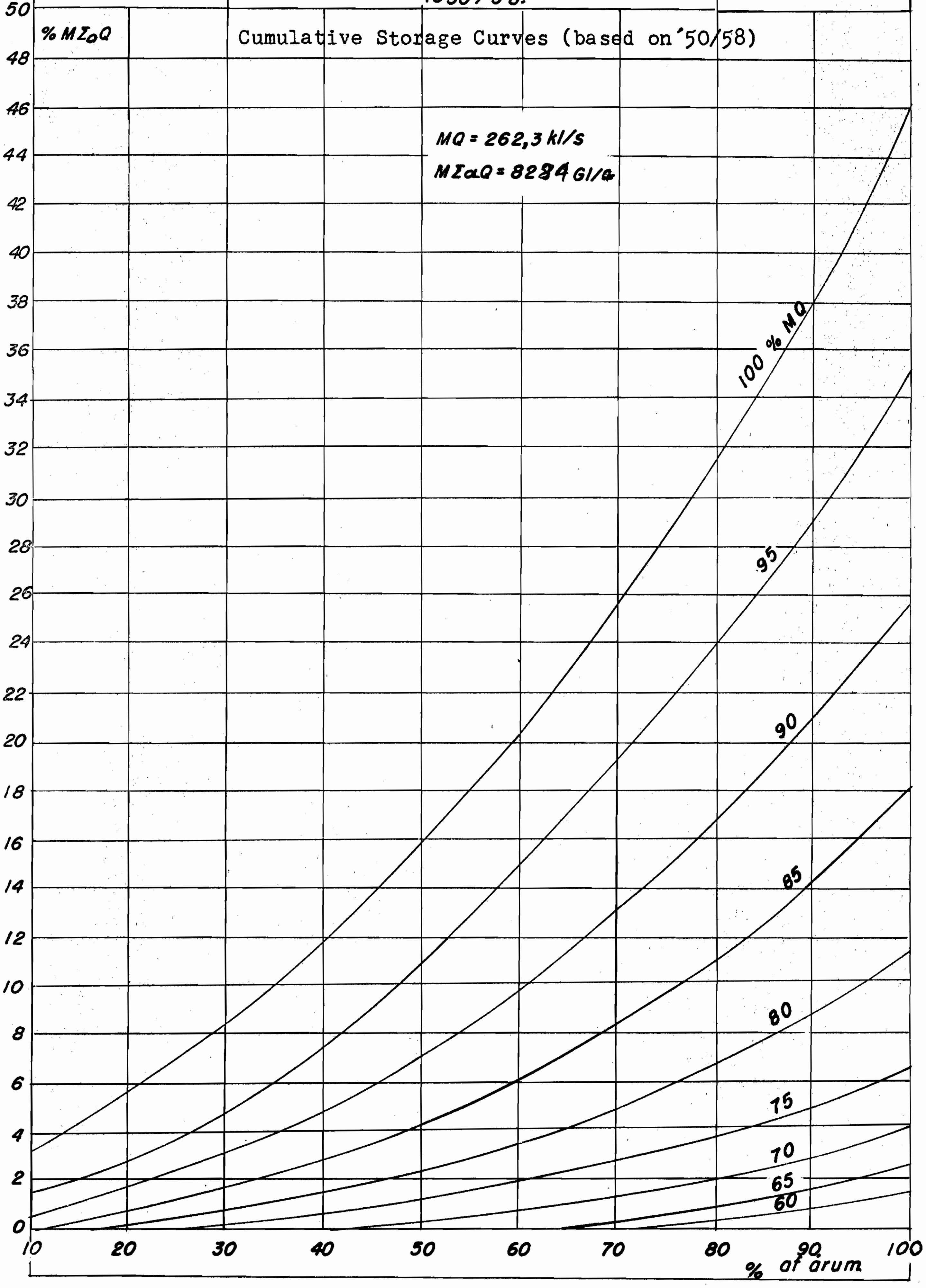


RAFORKUMÁLASTJÓRI
Vatnamælingar.

HVÍTÁ OFAN SOGS, HESTFJALL, ÁRHRAUN
MIÐLUNARLÍNUR 8 ÁRA
1950/58.

Mynd
Fig. 2-10

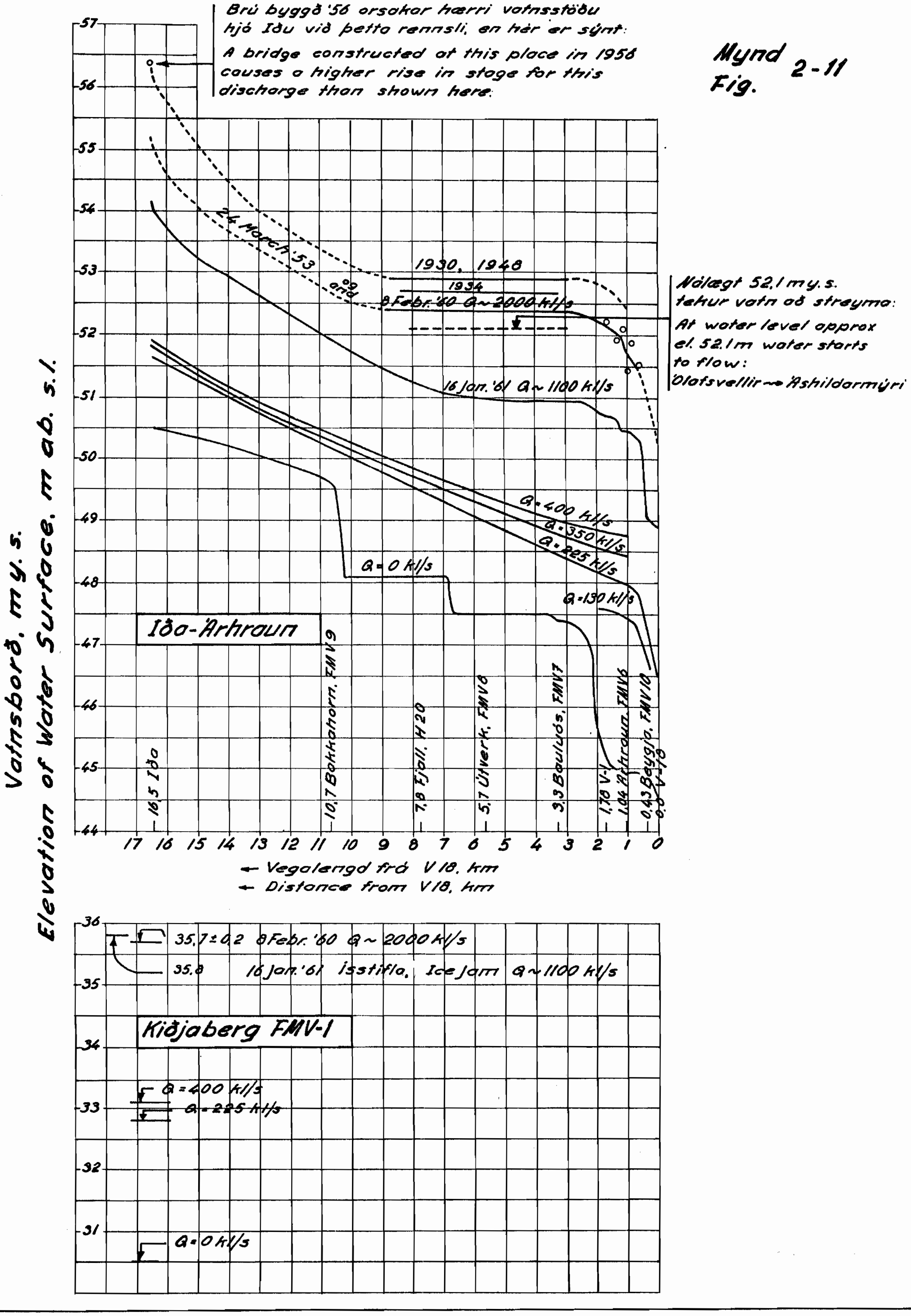
Cumulative Storage Curves (based on '50/58)



RAFORKUMÁLASTJÓRI
Hvítá, Iða - Árhraun og/and Kiðjaberg
Samsvarandi vatnshæðir
Corresponding Water Levels

17 Jan. '61 S.Rist/GA
Vhm 107 T 30
B. 274 Tnr. 225
Tnr. 5326

Mynd
Fig. 2-11



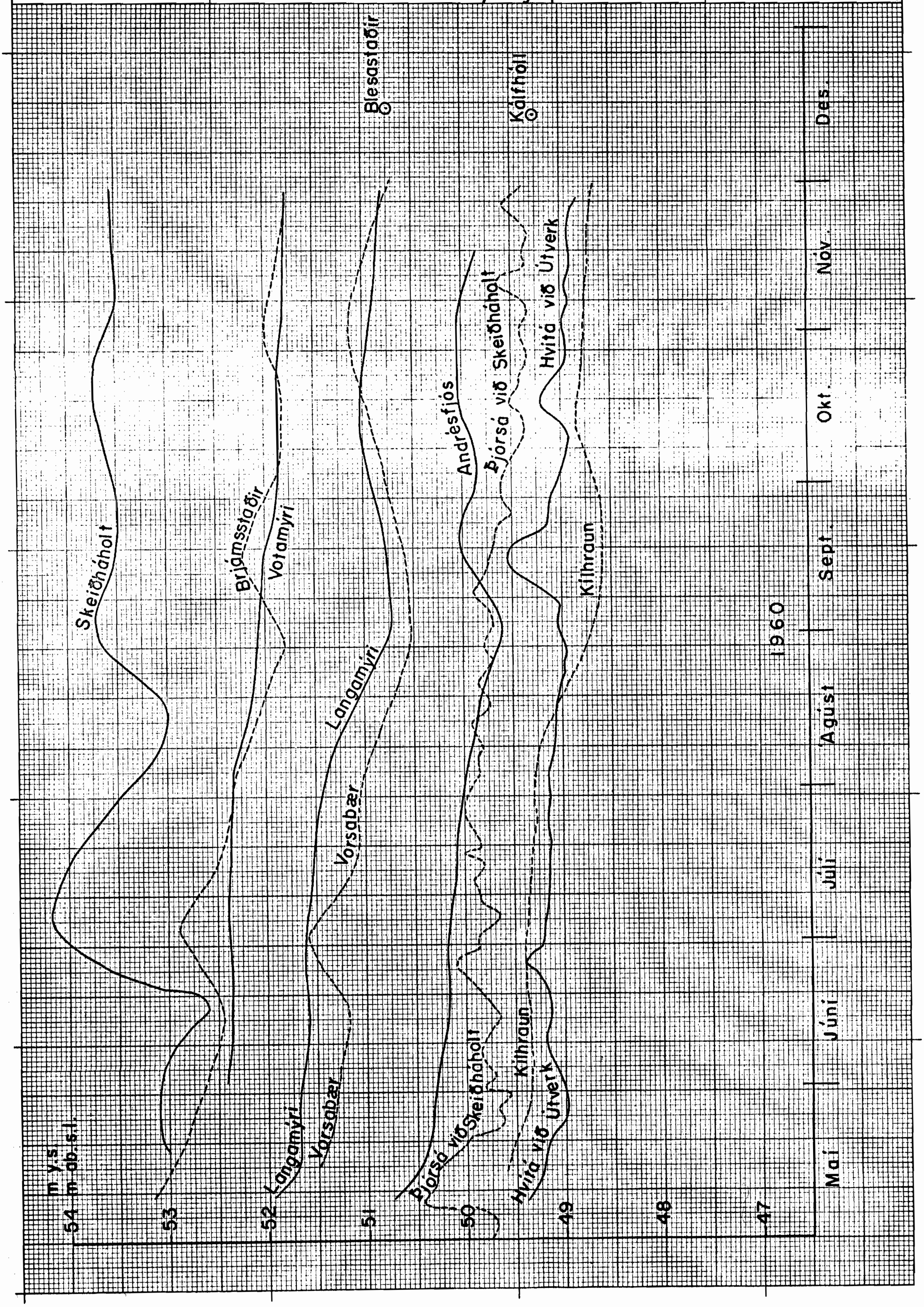
Brú byggð '56 orsakar hærri vatnsstöðu hjá Iðu við þetta rennsli, en hér er sýnt:
A bridge constructed at this place in 1956 causes a higher rise in stage for this discharge than shown here.

Nálægt 52,1 m y.s. tekur vatn að streyma:
At water level approx el. 52.1 m water starts to flow:
Ólafsvellir → Áshildarmýri

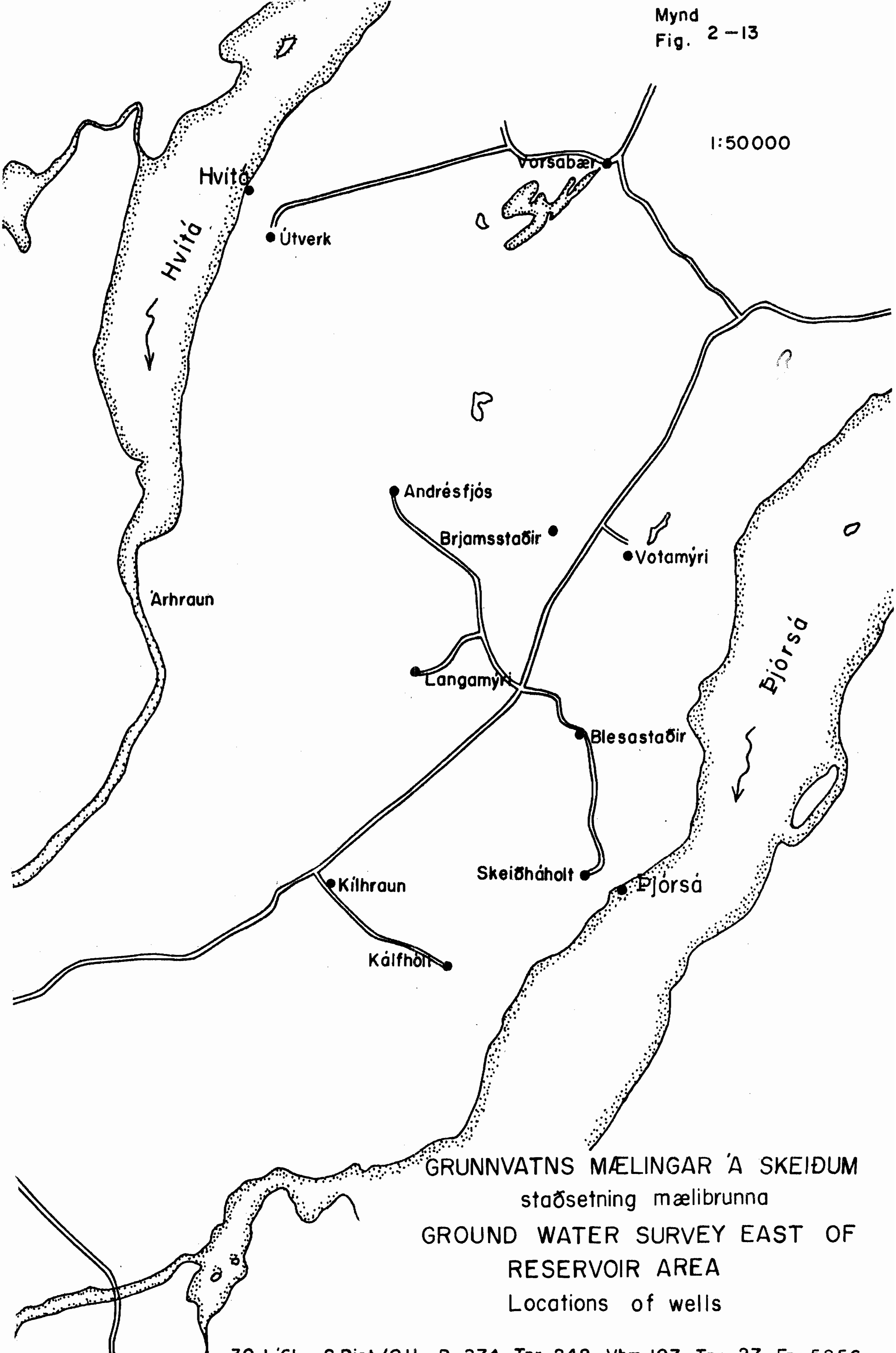
Mynd 2-12
Fig.

RAFORKUMÁLASTJÓRI

GRUNNVATN Á SKEIÐUM
GROUND WATER SURVEY EAST OF RESERVOIR AREA. Hydrographs



Mynd
Fig. 2-13



GRUNNVATNS MÆLINGAR Á SKEIÐUM
staðsetning mælibrunna
GROUND WATER SURVEY EAST OF
RESERVOIR AREA
Locations of wells

30.1.'61. S.Rist/O.H. B-274 Tnr. 248 Vhm. 107 Tnr. 27 Fnr. 5256

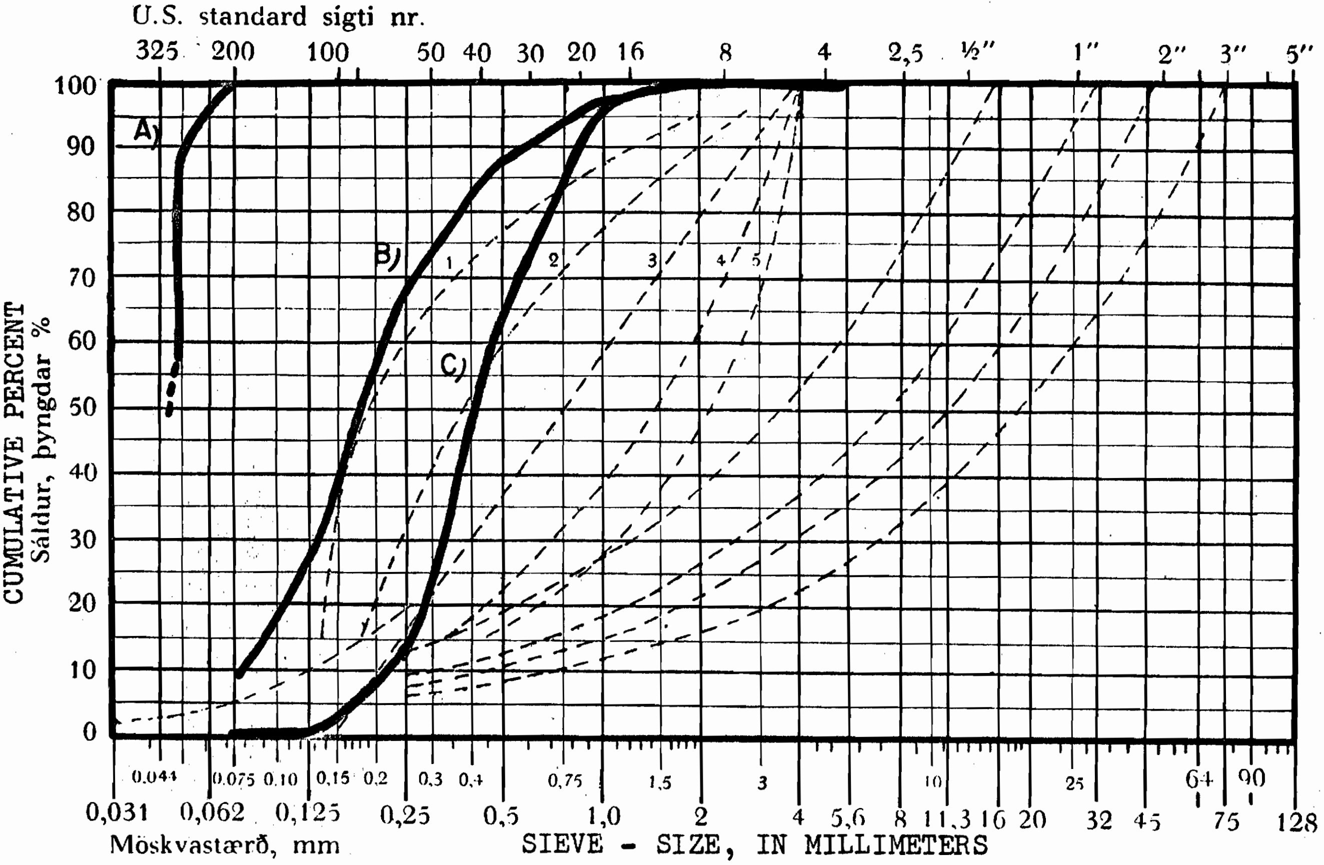
Mynd
Fig. 2-14

Rannsókn á kornastærðum.

Graphs showing particle-size distribution

Humusgráða

Slam %



HVÍTÁ, ÁRHRAUN 1. SEPT. 1960

A) Sýnishorn af útfellingu í kyrrstæðu vatni, tekið úr botni viksins við vinstri bakkann milli V-1 og V-2.
A sample of deposit taken from the bottom of still water in the creek into the left bank between V-1 and V-2.

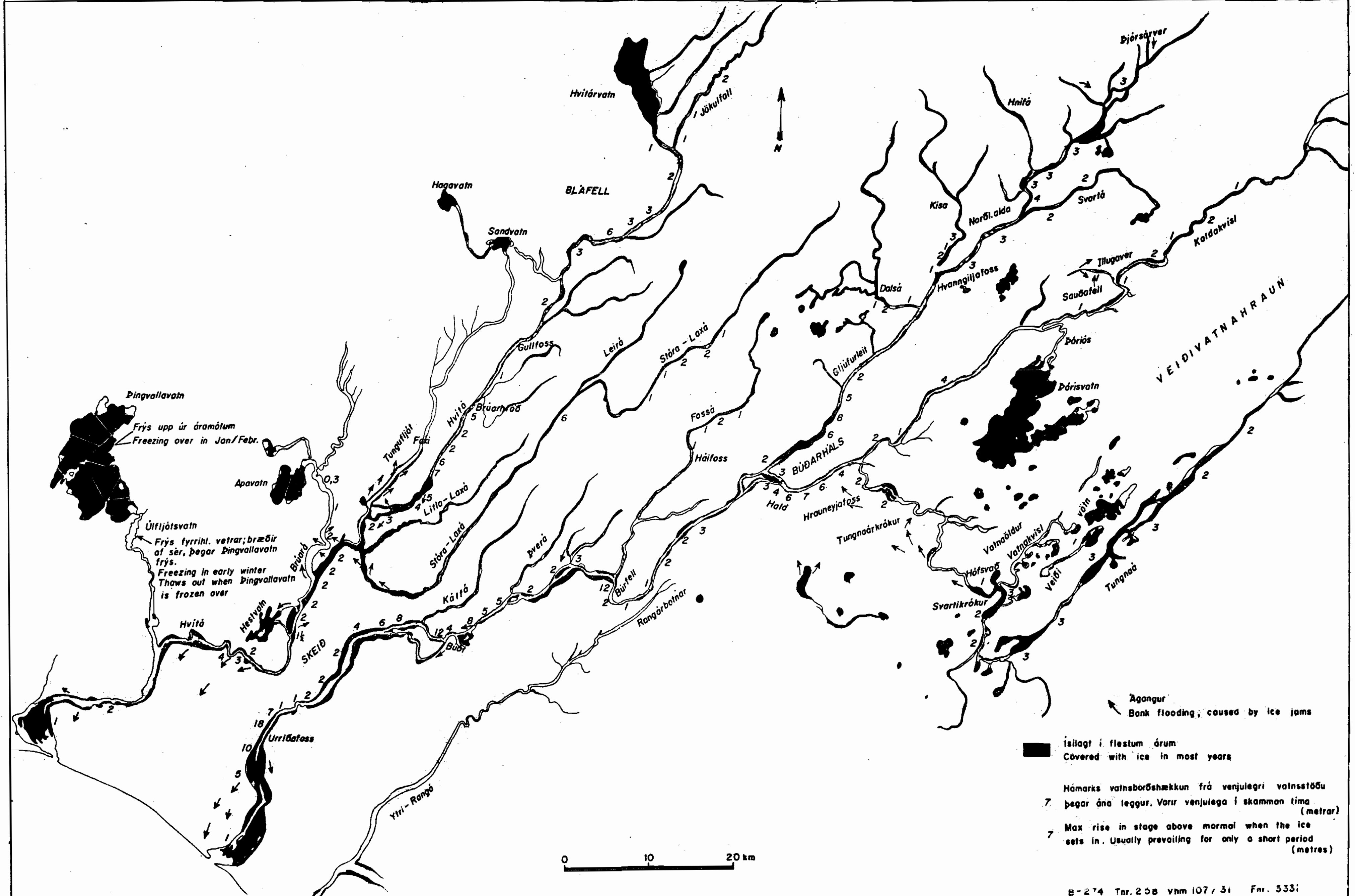
B) Sýnishorn úr botni þversniðs V-1 150 m frá V-1.
Sample from the bottom of cross section V-1 150 m from the bench mark V-1.

C) Sýnishorn úr sandeyri nál. miðri Hvítá undan Bauluósi.
Sample from a sandbank in the middle of River Hvítá near Bauluós.

RAFORKUMÁLASTJÓRI
Vatnamælingar

MYND
FIGURE 2-15 a

ÍSALÖG HVÍTÁR OG ÞJÓRSÁR UM MIÐJAN VETUR
ICE CONDITION USUALLY PREVAILING IN THE ÞJÓRSÁ AND HVÍTÁ RIVER SYSTEMS IN THE MIDDLE OF THE WINTER

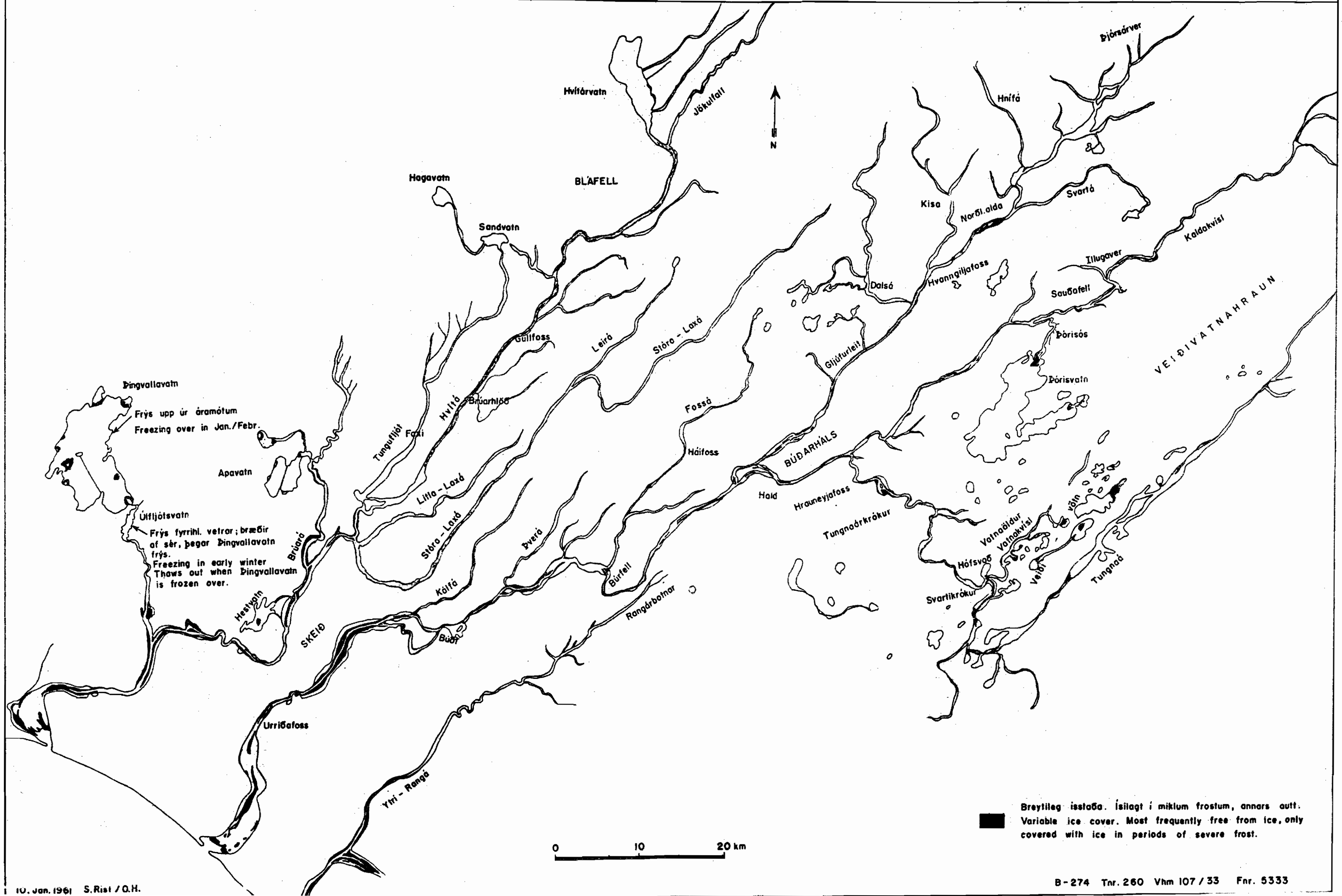


B-274 Tnr. 258 Vhm 107/31 Fnr. 5331

RAFORKUMÁLASTJÓRI
Vatnamælingar

ÍSALÖG HVÍTÁR OG ÞJÓRSÁR UM MIÐJAN VETUR
ICE CONDITION USUALLY PREVAILING IN THE ÞJÓRSÁ AND HVÍTÁ RIVER SYSTEMS IN THE MIDDLE OF THE WINTER

MYND
FIGURE 2–15 b



Frýs upp úr áramótum
Freezing over in Jan./Febr.

Frýs fyrrihl. vetrar; bræðir af sér, þegar Þingvallavatn frýs.
Freezing in early winter
Thaws out when Þingvallavatn is frozen over.

■ Breytileg ísstaða. Ísilagt í miklum frostum, annars autt.
Variable ice cover. Most frequently free from ice, only covered with ice in periods of severe frost.

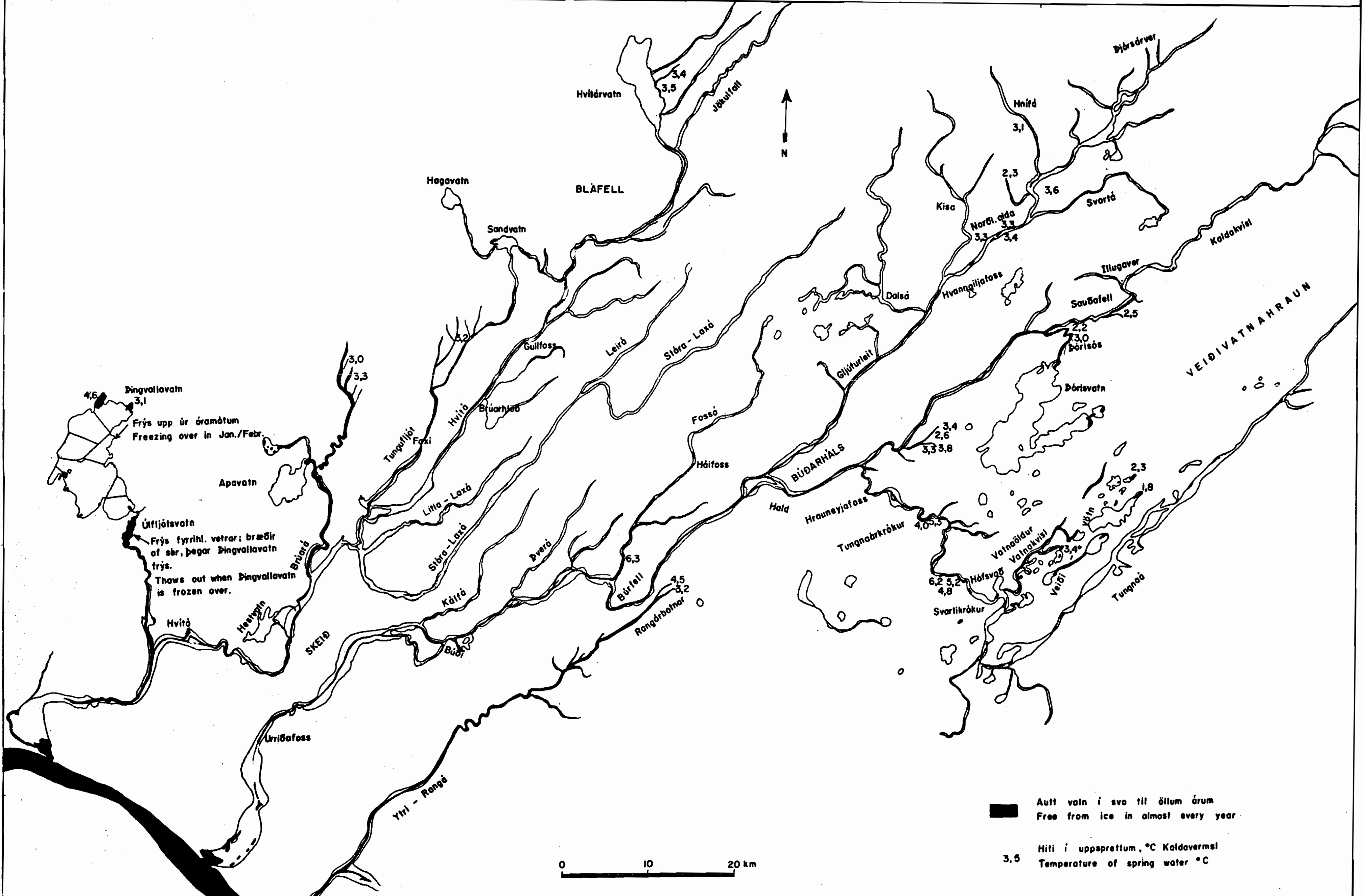
10. Jan. 1961 S.Rist / O.H.

B-274 Tnr. 260 Vhm 107/33 Fnr. 5333

RAFORKUMÁLASTJÓRI
Vatnamælingar

ÍSALÖG HVÍTÁR OG ÞJÓRSÁR UM MIÐJAN VETUR
ICE CONDITION USUALLY PREVAILING IN THE ÞJÓRSÁ AND HVÍTÁ RIVER SYSTEMS IN THE MIDDLE OF THE WINTER

MYND
FIGURE 2-15c

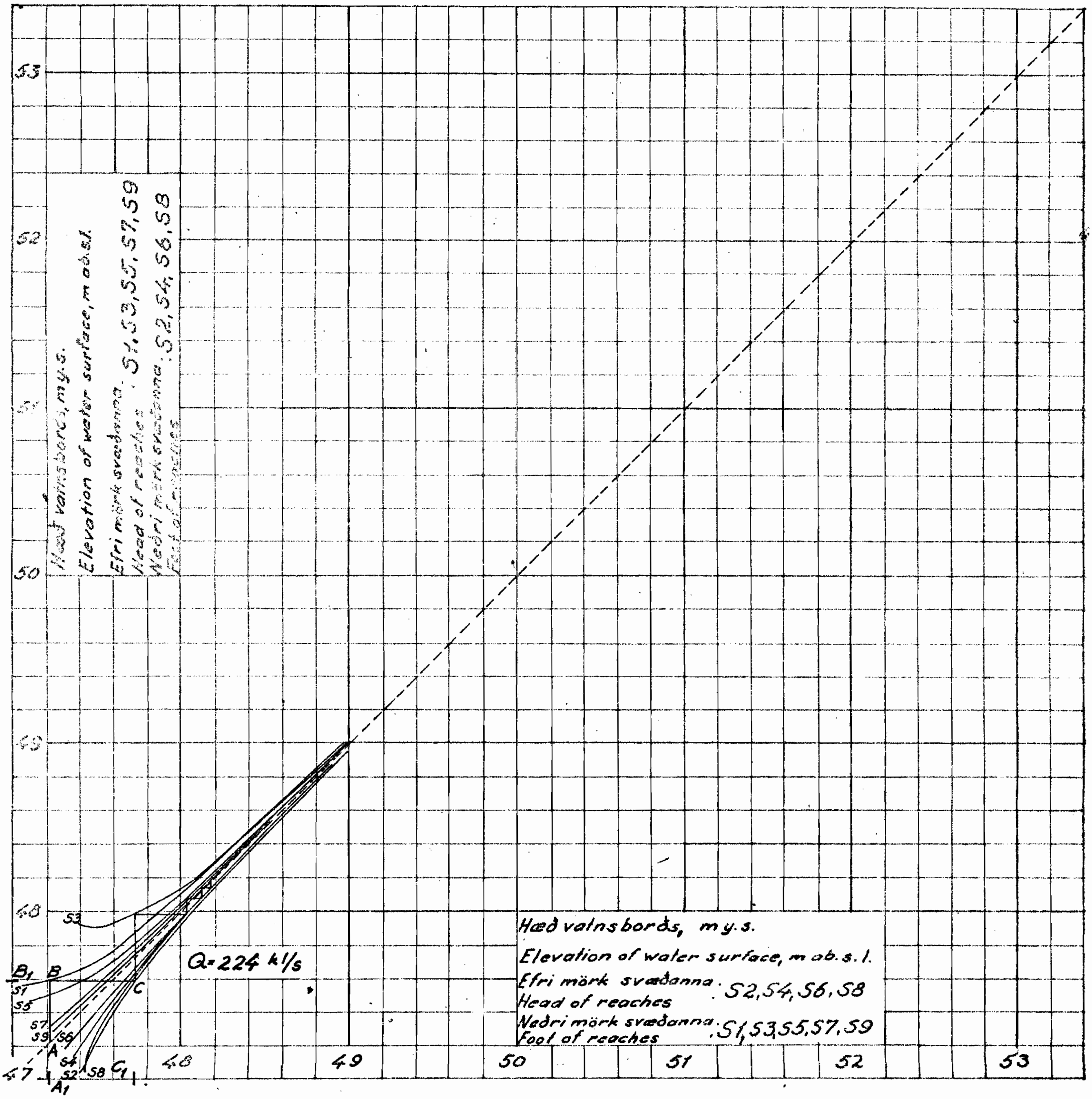


10 Jan. 1961 S. Rist / O.H.

B-274 Tnr. 259 Vhm 107 / 32 Fnr. 5332

Raforkumálastjóri Vatnamælingar	[illegible] Bakvatnslinur Backwater curves Q=224 kl/s	[illegible] Tnr. 21 Tnr. 242 Fnr. 5297

Mynd
Fig. 2-16



Dæmi:

Ef hæð neðri marka S1 er A (lesið á lárétta ásinn við A1) er hæð efri marka S1 B (lesið á lóðrétta ásinn við B1). Efri mörk S2 eru við C (lesið á lóðrétta ásinn við C1) o.s.frv.

Example:

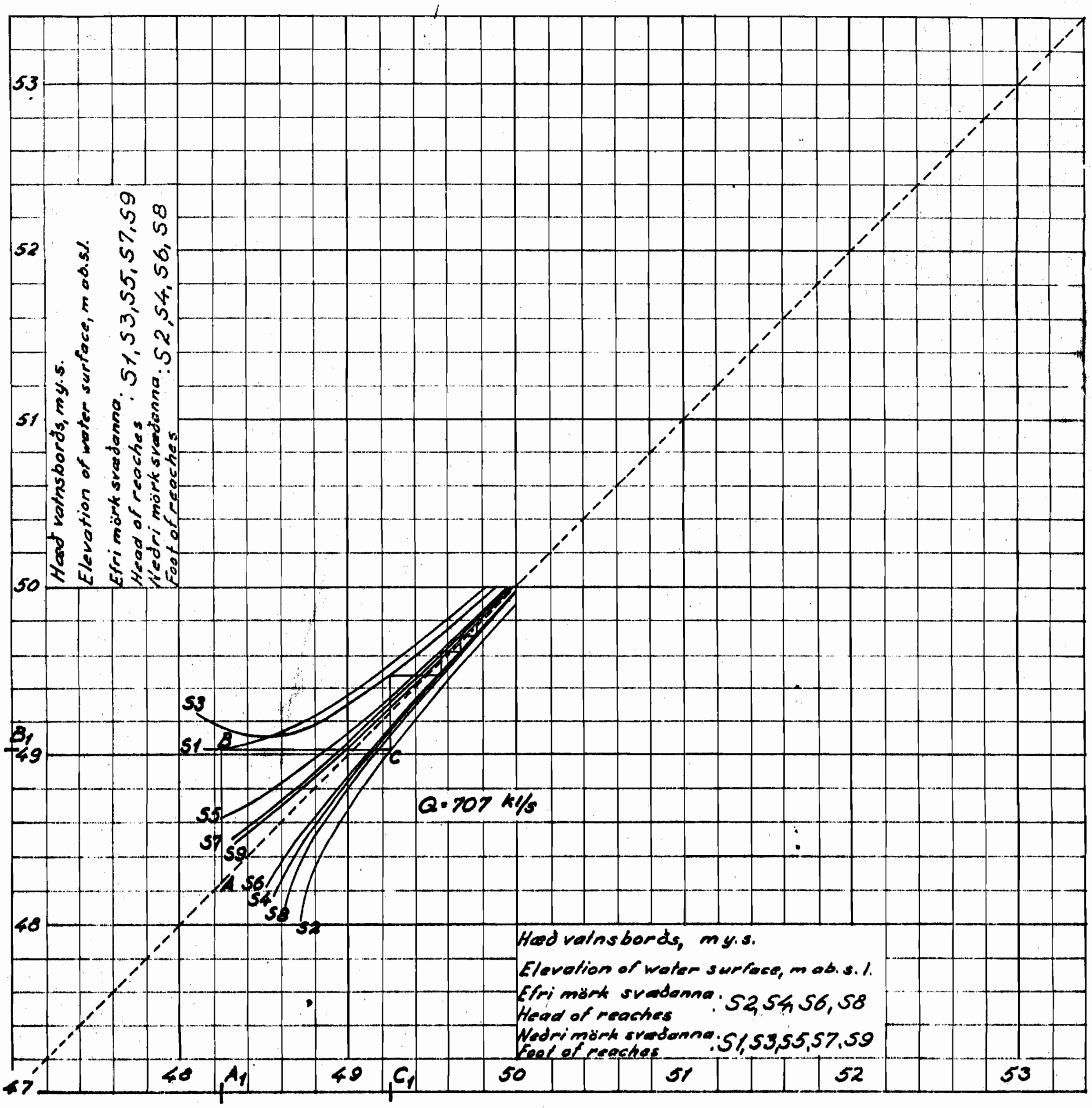
Let the foot elevation of reach S1 be A (on the horizontal scale). Then the head elevation of reach S1 is B (on the vertical scale), which is also the foot elevation of reach S2, whose head elevation is then at C (horizontal scale) etc.

Raforkumálastjóri
Vatnamælingar

Hvítá, Árhraun
Bokvatnslinur
Backwater curves
$Q = 707\ kl/s$

Teikn. S.Kist/AS/JB
Vnm. 137 Tnr. 22
B. 274 Tnr. 243
Fnr. 5298

Mynd
Fig. 2-17



Dæmi:

Ef hæð neðri marka S1 er A (lesið á lárétta ásinn við A_1) er hæð efri marka S1 B (lesið á lóðrétta ásinn við B_1). Efri mörk S2 eru við C (lesið á lóðrétta ásinn við C_1) o.s.frv.

Example:

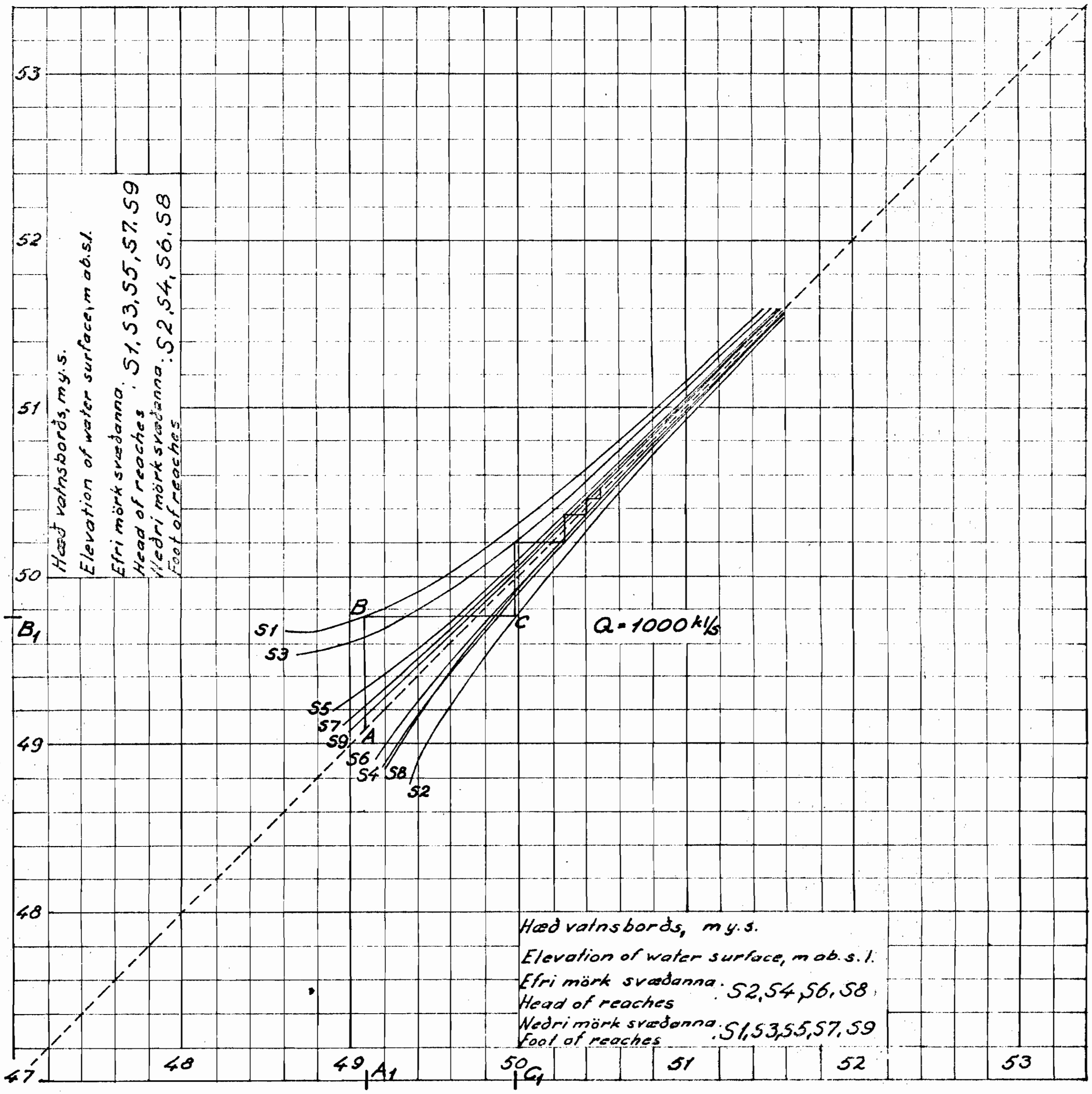
Let the foot elevation of reach S1 be A (on the horizontal scale). Then the head elevation of reach S1 is B (on the vertical scale), which is also the foot elevation of reach S2, whose head elevation is then at C (horizontal scale) etc.

Raforkumálastjóri
Vatnamælingar

Hvítá, Árhraun
Bakvatnslinur Q = 1000 kl/s
Backwater curves

T.29/1 '61 [illegible]
Vhm. 101 Tnr. 23
B. 274 Tnr. 244
Fnr. 5299

Mynd
Fig. 2-18



Dæmi:

Ef hæð neðri marka S1 er A (lesið á lárétta ásinn við A1) er hæð efri marka S1 B (lesið á lóðrétta ásinn við B1). Efri mörk S2 eru við C (lesið á lóðrétta ásinn við C1) o.s.frv.

Example:

Let the foot elevation of reach S1 be A (on the horizontal scale). Then the head elevation of reach S1 is B (on the vertical scale), which is also the foot elevation of reach S2, whose head elevation is then at C (horizontal scale) etc.

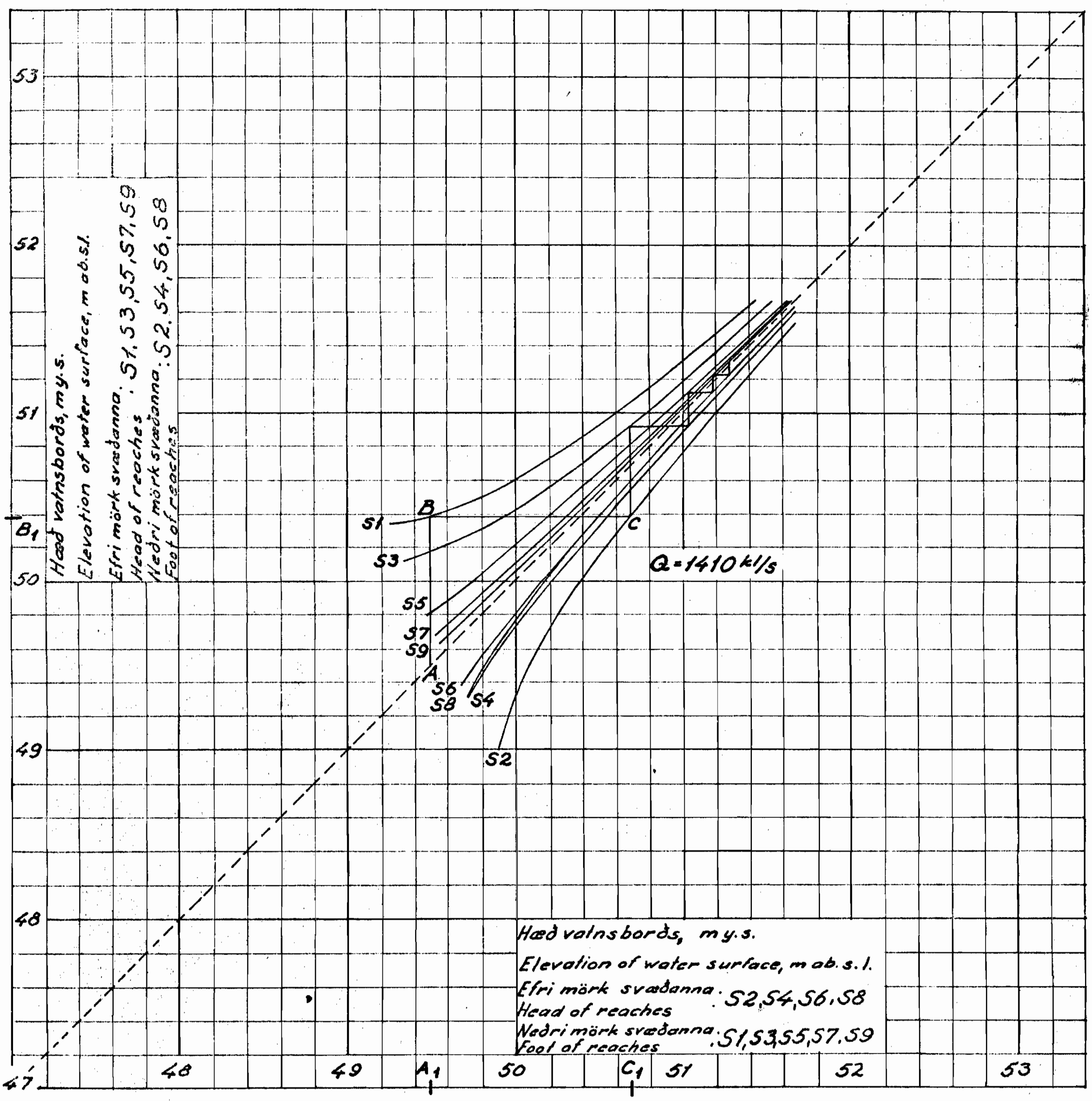
Raforkumálastjóri
Vatnamælingar

Hvítá, Árhraun
Bakvatnslinur
Backwater curves

Q=1410 kl/s

[illegible] S.Rist/RS./DB
Vhm. 107 Tnr. 24
B. 274 Tnr. 245
Fnr. 5300

Mynd
Fig. 2-19



Dæmi:

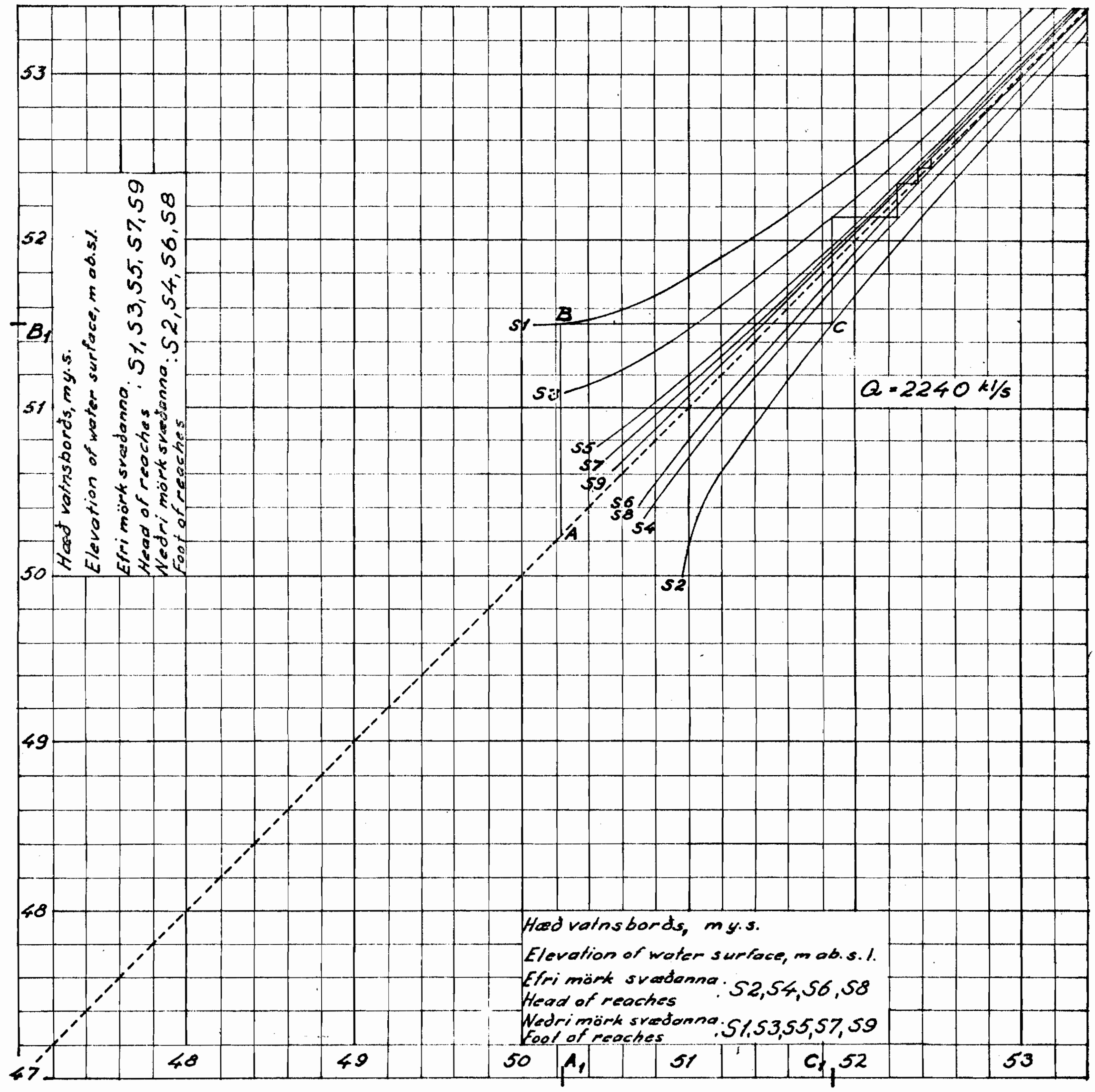
Ef hæð neðri marka S1 er A (lesið á lárétta ásinn við A1) er hæð efri marka S1 B (lesið á lóðrétta ásinn við B1). Efri mörk S2 eru við C (lesið á lóðrétta ásinn við C1) o.s.frv.

Example:

Let the foot elevation of reach S1 be A (on the horizontal scale). Then the head elevation of reach S1 is B (on the vertical scale), which is also the foot elevation of reach S2, whose head elevation is then at C (horizontal scale) etc.

[illegible] Vatnamælingar	[illegible] Bakvatnslínur Backwater curves Q = 2240 kl/s	[illegible] Vhm. 10. Tnr. 25 B. 274 Tnr. 246 Fnr. 5301

Mynd
Fig. 2-20



Dæmi:

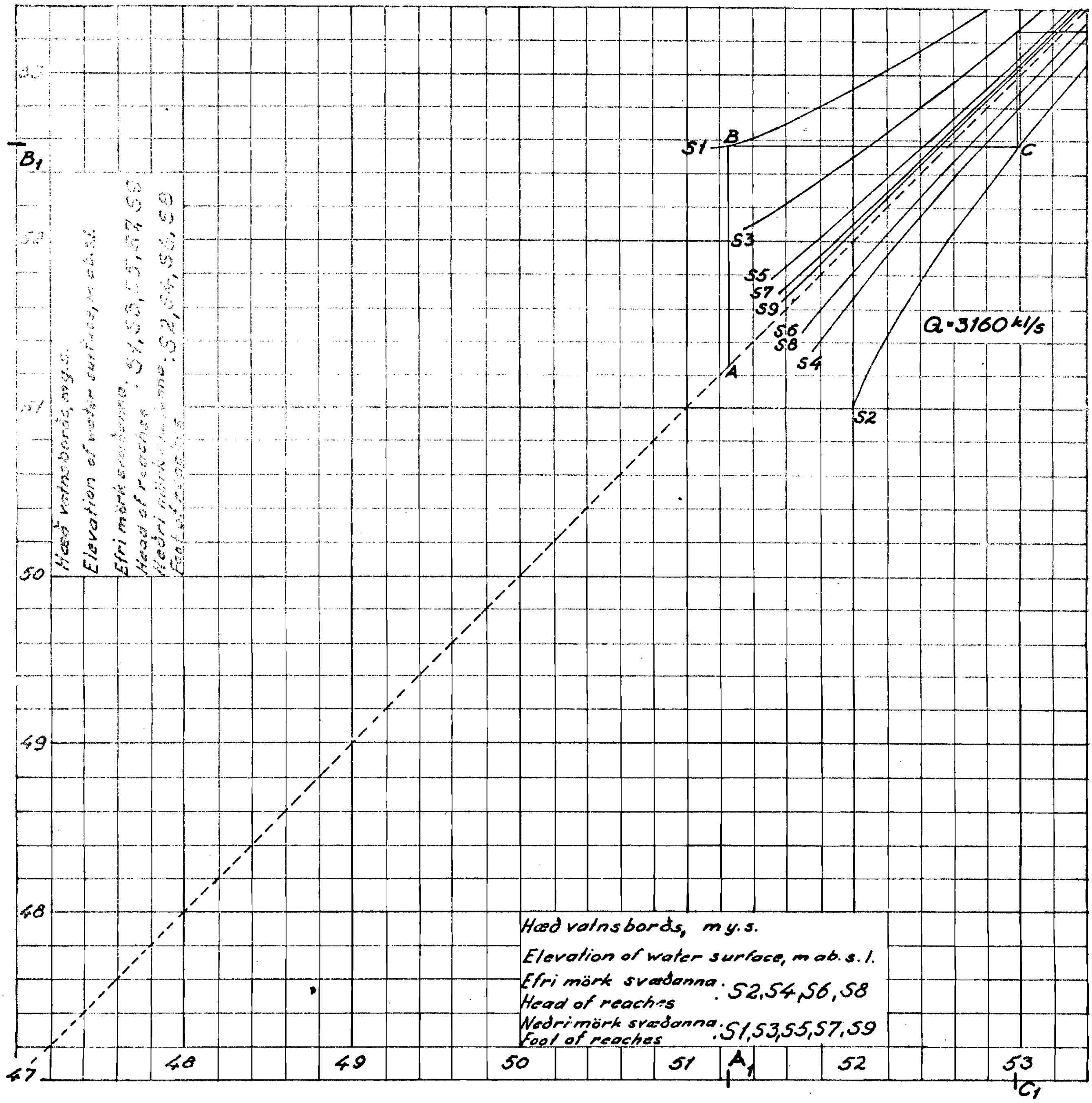
Ef hæð neðri marka S1 er A (lesið á lárétta ásinn við A1) er hæð efri marka S1 B (lesið á lóðrétta ásinn við B1). Efri mörk S2 eru við C (lesið á lóðrétta ásinn við C1) o.s.frv.

Example:

Let the foot elevation of reach S1 be A (on the horizontal scale). Then the head elevation of reach S1 is B (on the vertical scale), which is also the foot elevation of reach S2, whose head elevation is then at C (horizontal scale) etc.

[illegible] Vatnamælingar	Hvítá, Árbraun Bakvatnslínur Backwater curves Q=3160 kl/s	[illegible] Vhm. 107 Tnr. 26 D. 274 Tnr. 247 Fnr. 5302

Mynd
Fig 2-21



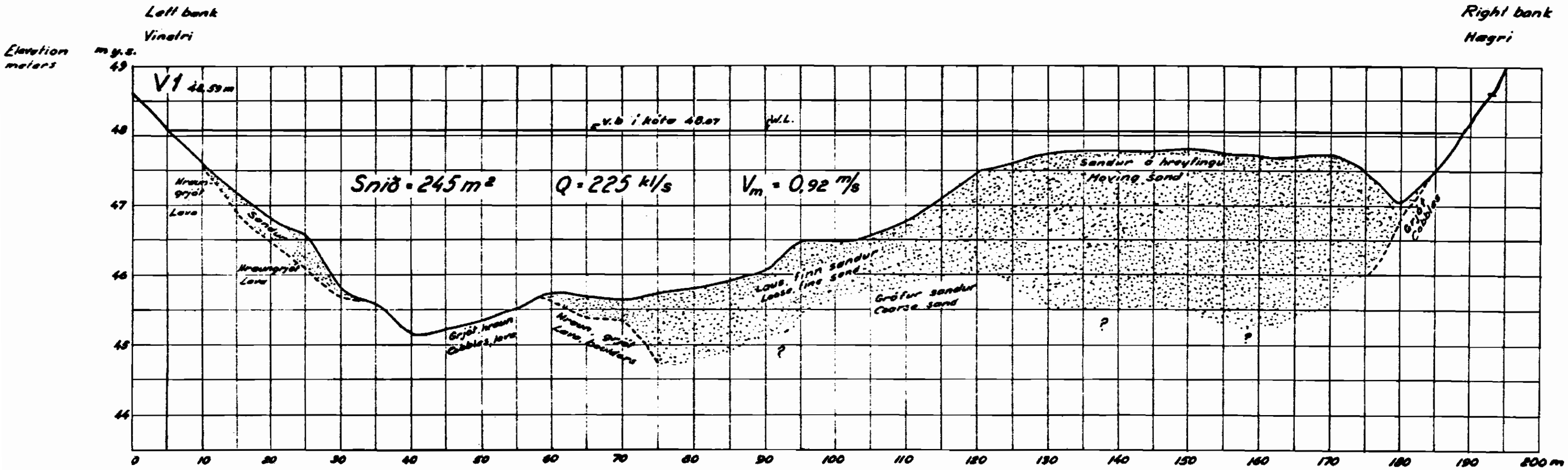
Dæmi:

Ef hæð neðri marka S1 er A (lesið á lárétta ásinn við A₁) er hæð efri marka S1 B (lesið á lóðrétta ásinn við B₁). Efri mörk S2 eru við C (lesið á lóðrétta ásinn við C₁) o.s.frv.

Example:

Let the foot elevation of reach S1 be A (on the horizontal scale). Then the head elevation of reach S1 is B (on the vertical scale), which is also the foot elevation of reach S2, whose head elevation is then at C (horizontal scale) etc.

Mynd
Fig. 2-22



RAFORKUMÁLASTJÓRI

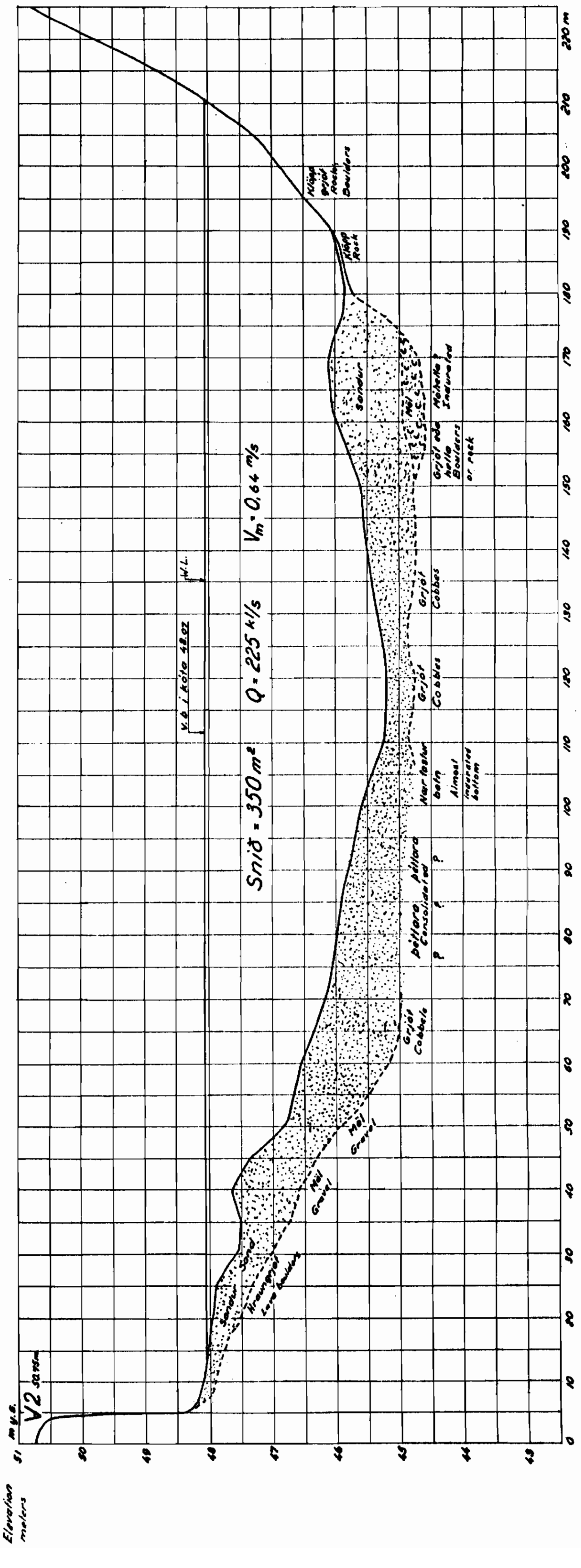
Hvítá, Árhraun
Þversnið V1
Cross section V1

H = 1:50
L = 1:500

19/12 '60 S.Ris1/38
Vhm. 107
Ð.274 T.206

Fnr. 5234

Mynd
Fig. 2-23



RAFORKUMÁLASTJÓRI

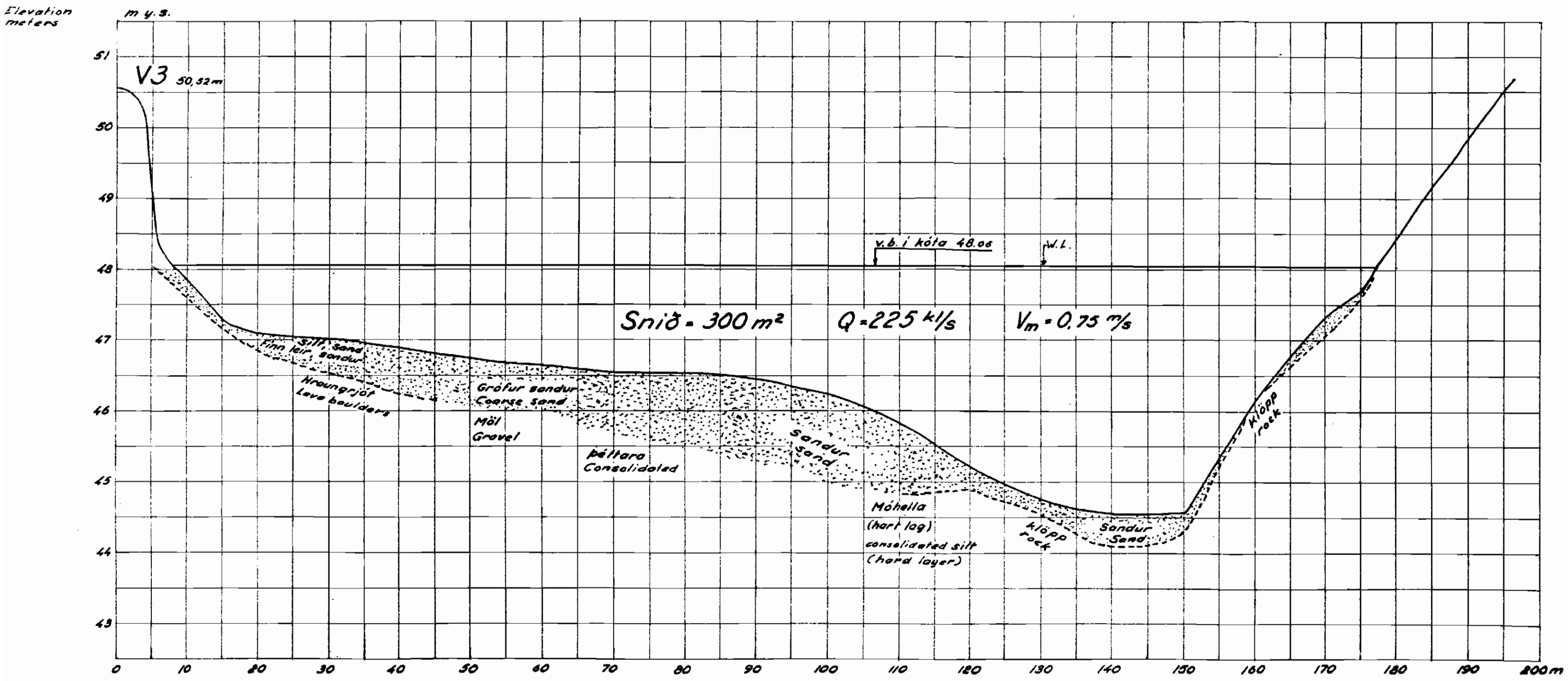
Hvítá. Árhraun
Þversnið V2.
Cross section V2

H = 1:50
L = 1:500

Teikn. S.R. 3/10
Vhm. 107
B 274 T. 209

Fnr. 5235

Mynd
Fig. 2-24



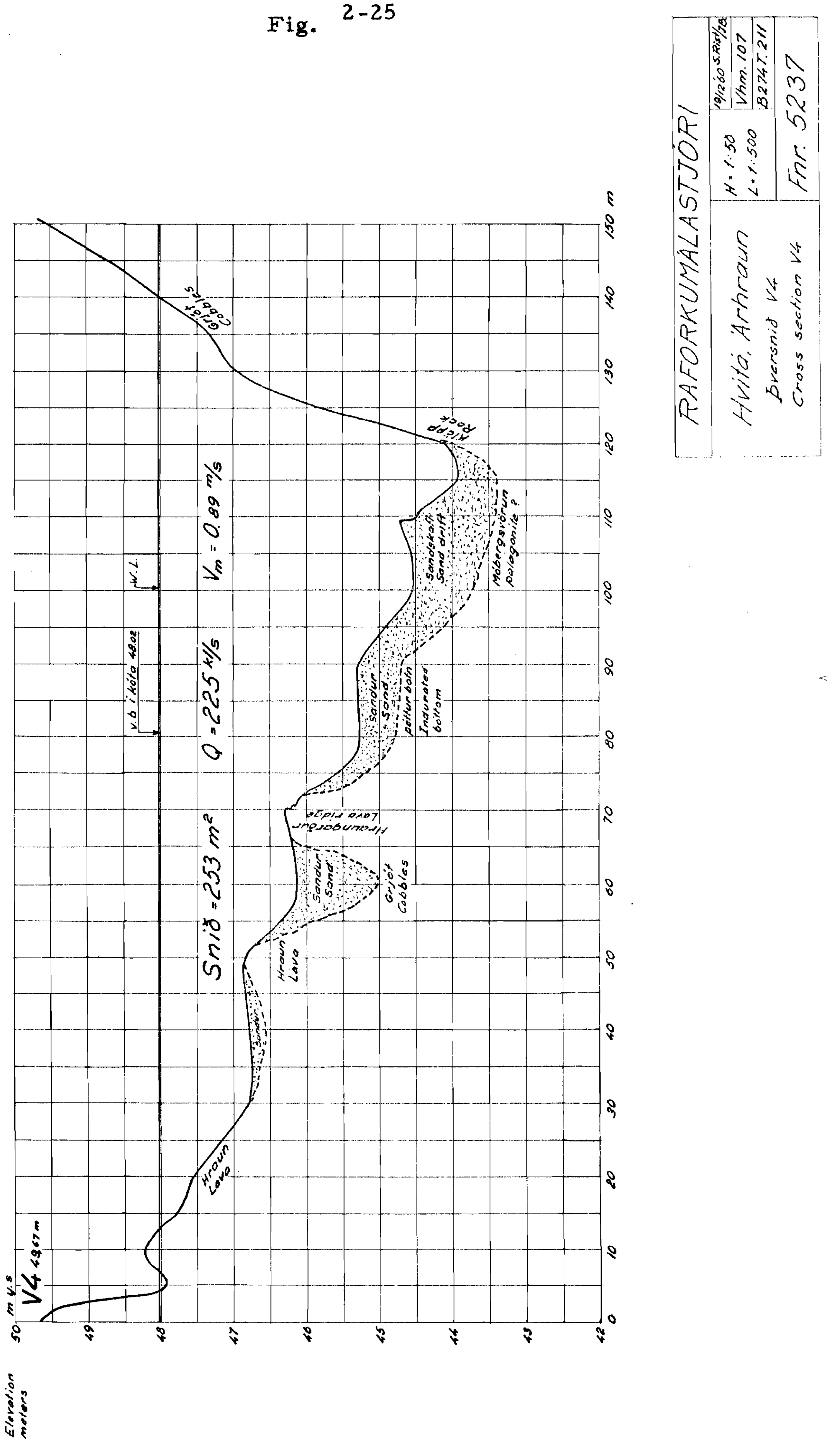
RAFORKUMÁLASTJÓRI

Hvítá, Árhraun

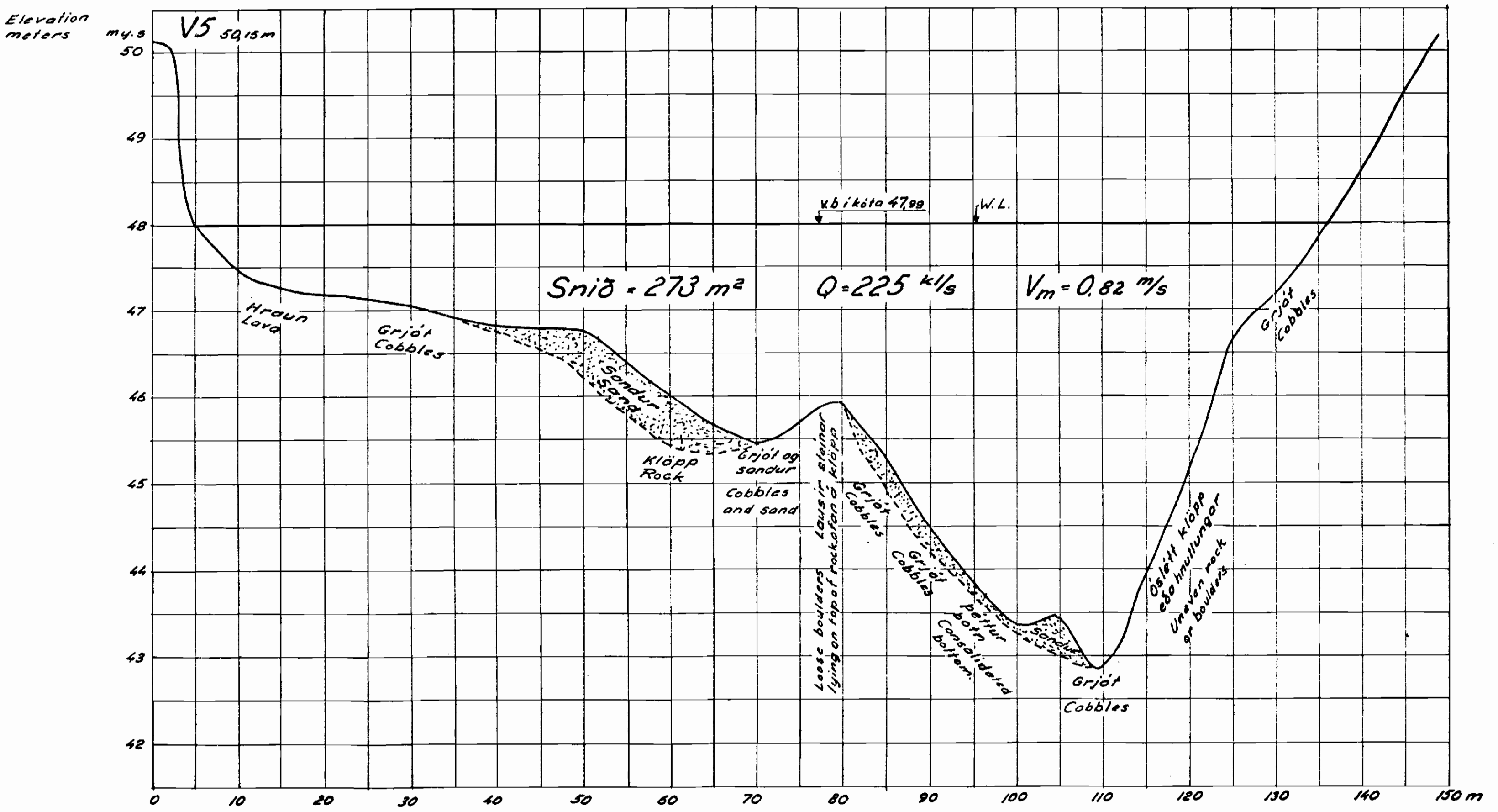
Þversnið V3
Cross section V3

H = 1:50 L = 1:500	19/12 '60 S. Rist/J.B. Vhm. 107 B274 T. 210
Fnr. 5236	

Mynd
Fig. 2-25


RAFORKUMÁLASTJÓRI
19/12'60 S.Rist/JB
Vhm. 107
B274T.211
H = 1:50
L = 1:500
Hvítá, Árhraun
Þversnið V4
Cross section V4
Fnr. 5237
m y.s
V4 49.67 m
Elevation meters
50
49
48
47
46
45
44
43
42
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150 m
v.b í kóta 48.02
W.L.
Snið = 253 m²
Q = 225 kl/s
Vm = 0.89 m/s
Hraun Lava
Sandur
Hraun Lava
Sandur Sand
Grjót Cobbles
Hraungarður Lava ridge
Sandur Sand
þéttur botn
Indurated bottom
Sandskafl Sand drift
Móbergsvörun Palagonite ?
Klöpp Rock
Grjót Cobbles

Mynd
Fig. 2-26



RAFORKUMÁLASTJÓRI

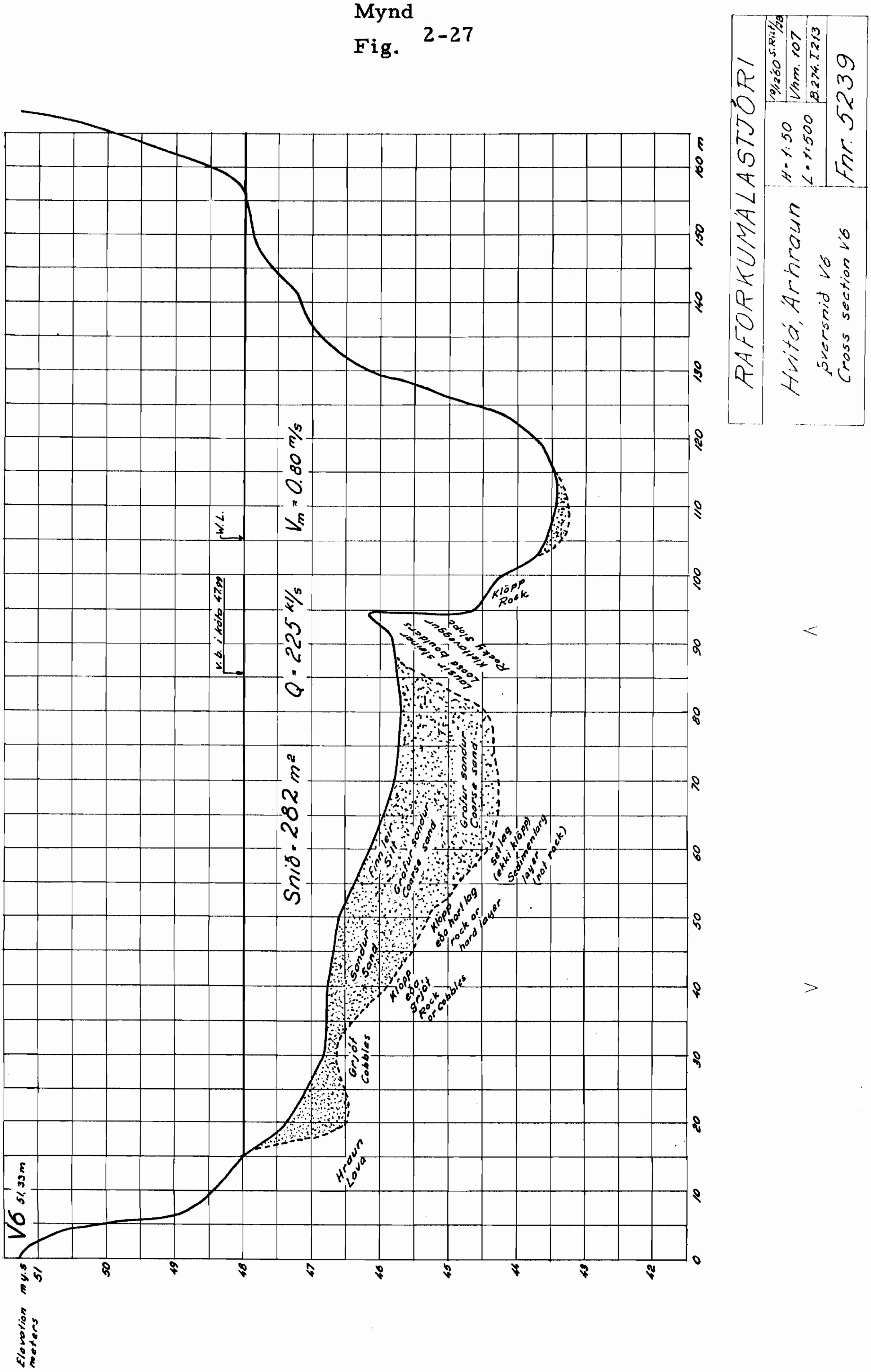
Hvítá, Árhraun
Þversnið V5
Cross section V5

H = 1:50
L = 1:500

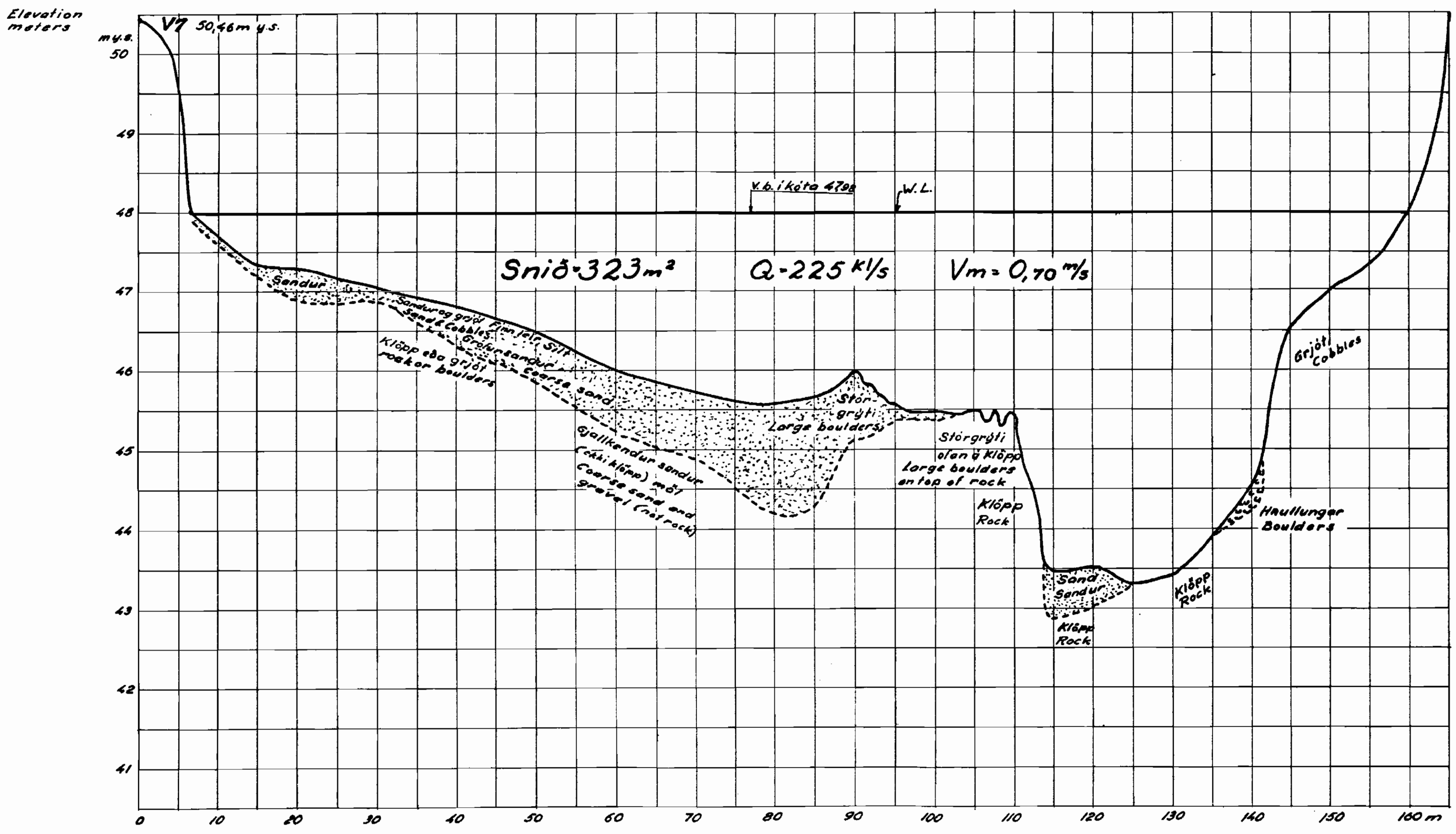
10/12'60 S.Ris.1/38
Vhm 107
B274 T212

Fnr. 5238

Mynd
Fig. 2-27


RAFORKUMÁLASTJÓRI
19/12 '60 S.Rist/TB
Vhm. 107
B.274. T.213
Hvítá, Árhraun
H = 1:50
L = 1:500
Þversnið V6
Cross section V6
Fnr. 5239
V6 51.33 m
Elevation m.y.s. meters
51
50
49
48
47
46
45
44
43
42
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160 m
v.b. í kóta 47.99
W.L.
Snið = 282 m²
Q = 225 kl/s
Vm = 0.80 m/s
Hraun
Lava
Grjót
Cobbles
Sandur
Sand
Klöpp
eða
grjót
Rock
or cobbles
Finn leir
Silt
Grófur sandur
Coarse sand
Klöpp
eða harl lag
rock or
hard layer
Grófur sandur
Coarse sand
Setlag
(ekki klöpp)
Sedimentary
layer
(not rock)
Lausir steinar
Loose boulders
Klettaveggur
Rocky slope
Klöpp
Rock

Mynd
Fig. 2-28



RAFORKUMÁLASTJÓRI

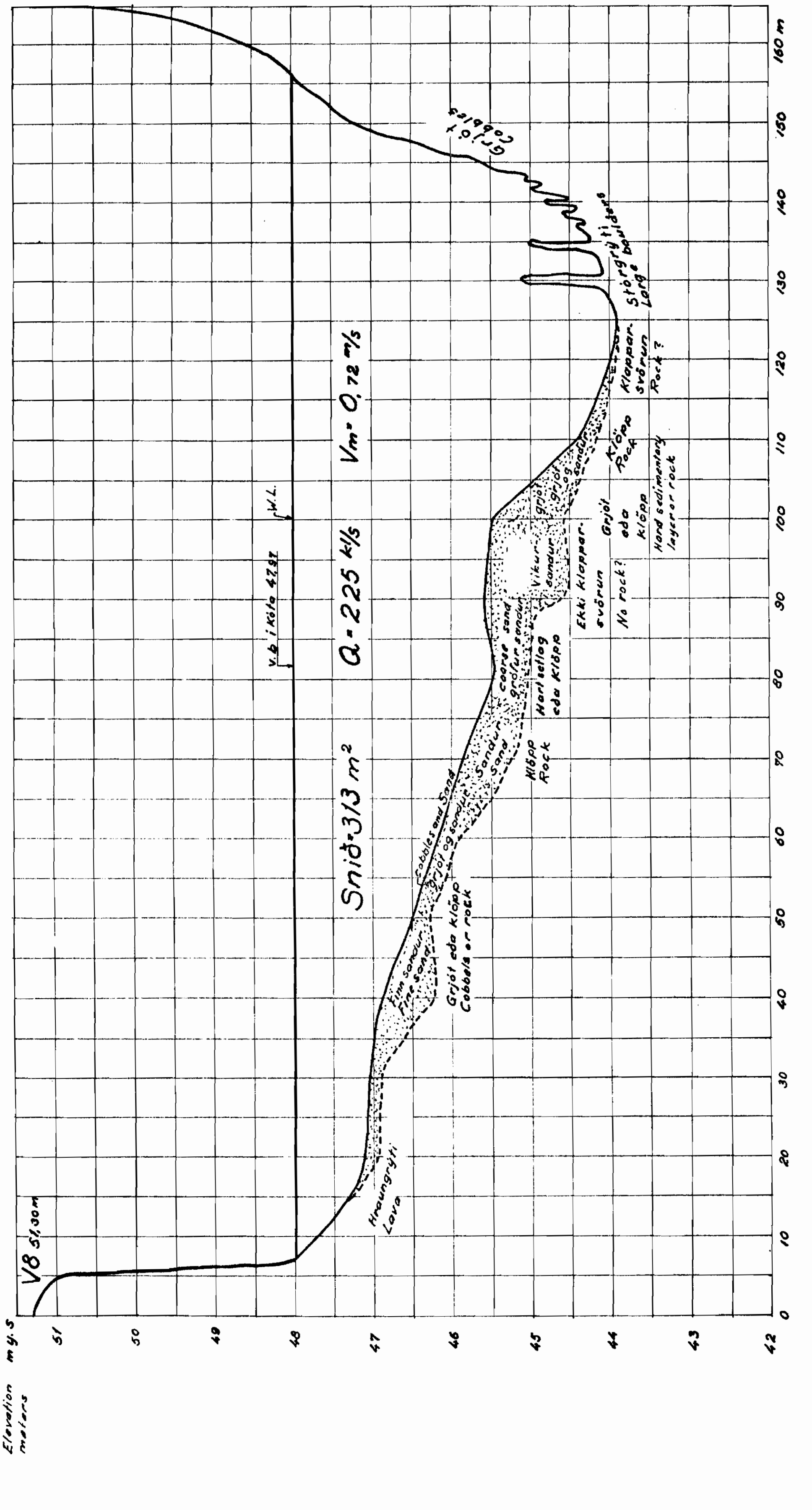
Hvítá, Árhraun
Þversnið V7
Cross section V7

H-1:50
L-1:500

19/12 60 S.Rist/JB
Vhm. 107
B274 T.214

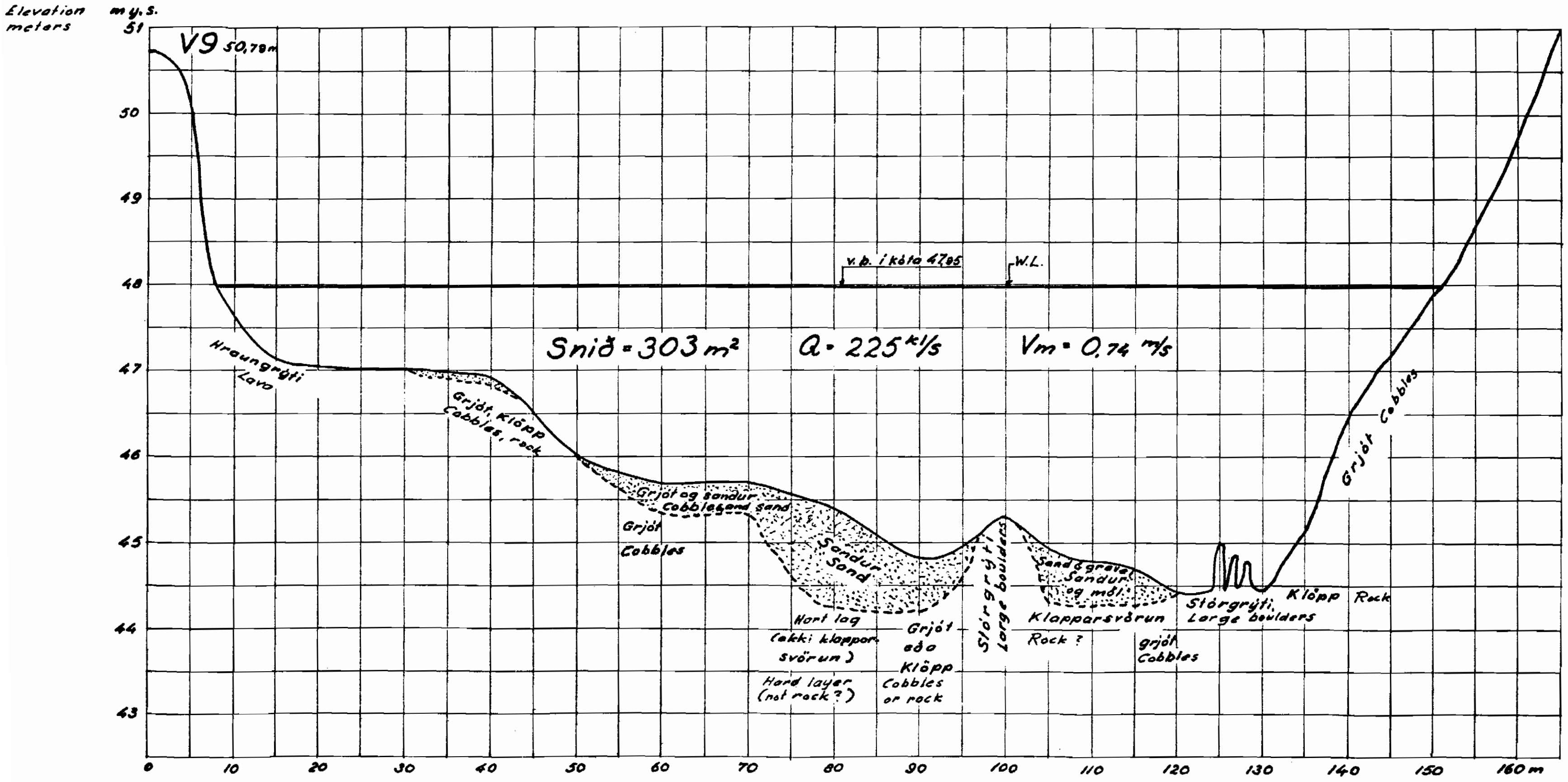
Fnr. 5240

Mynd
Fig. 2-29



RAFORKUMÁLASTJÓRI
19/12 60 S.Rist/JB
Vhm. 107
B. 274 T.215
H = 1:50
L = 1:500
Hvítá, Árhraun
Þversnið V8
Cross section V8
Fnr. 5241

Mynd
Fig. 2-30



RAFORKUMÁLASTJÓRI

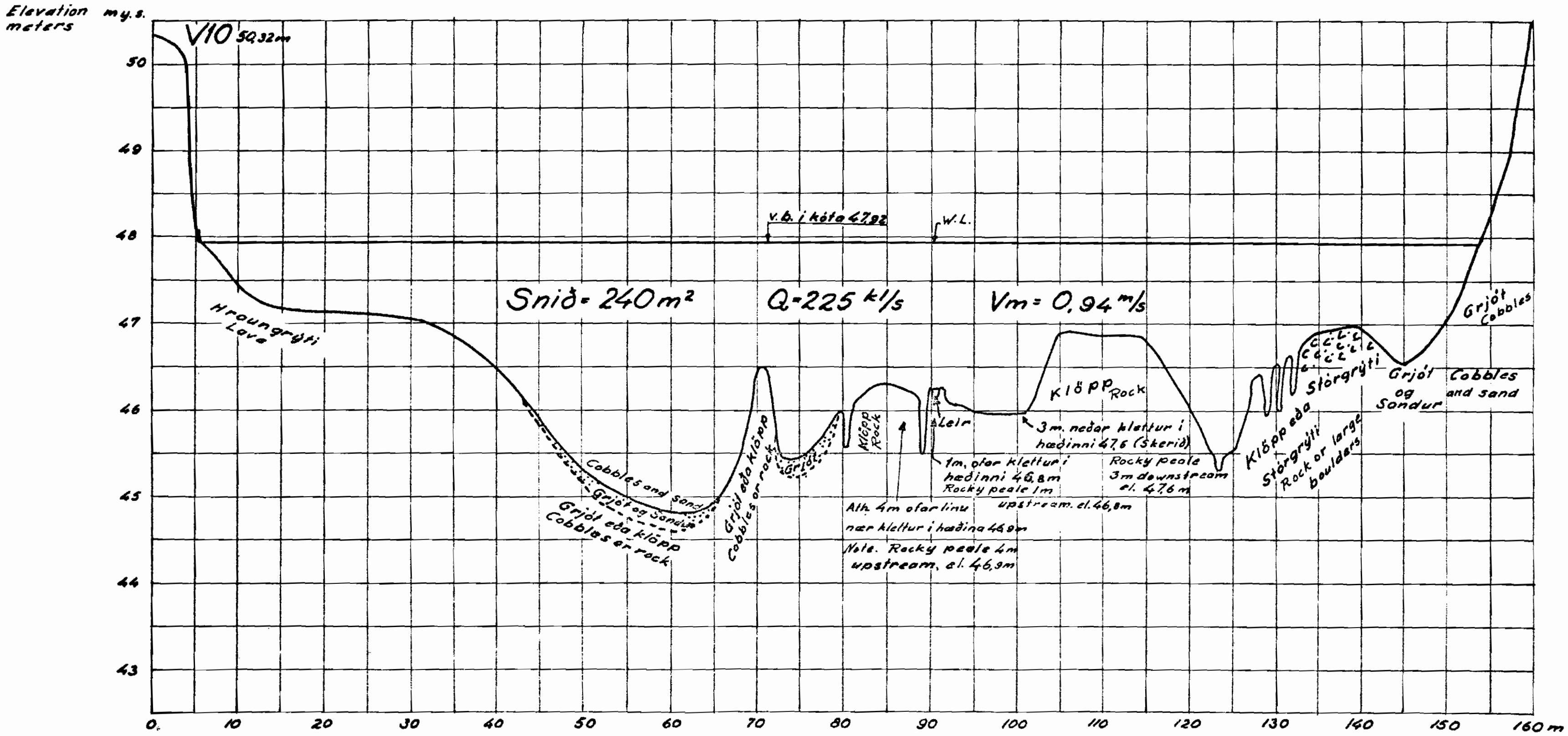
Hvítá, Árhraun
Þversnið. V9
Cross section V9

H = 1:50
L = 1:500

19/12'60 S. Rið/JB
Vhm. 107
B.274 T.216

Fnr. 5242

Mynd
Fig. 2-31



RAFORKUMÁLASTJÓRI

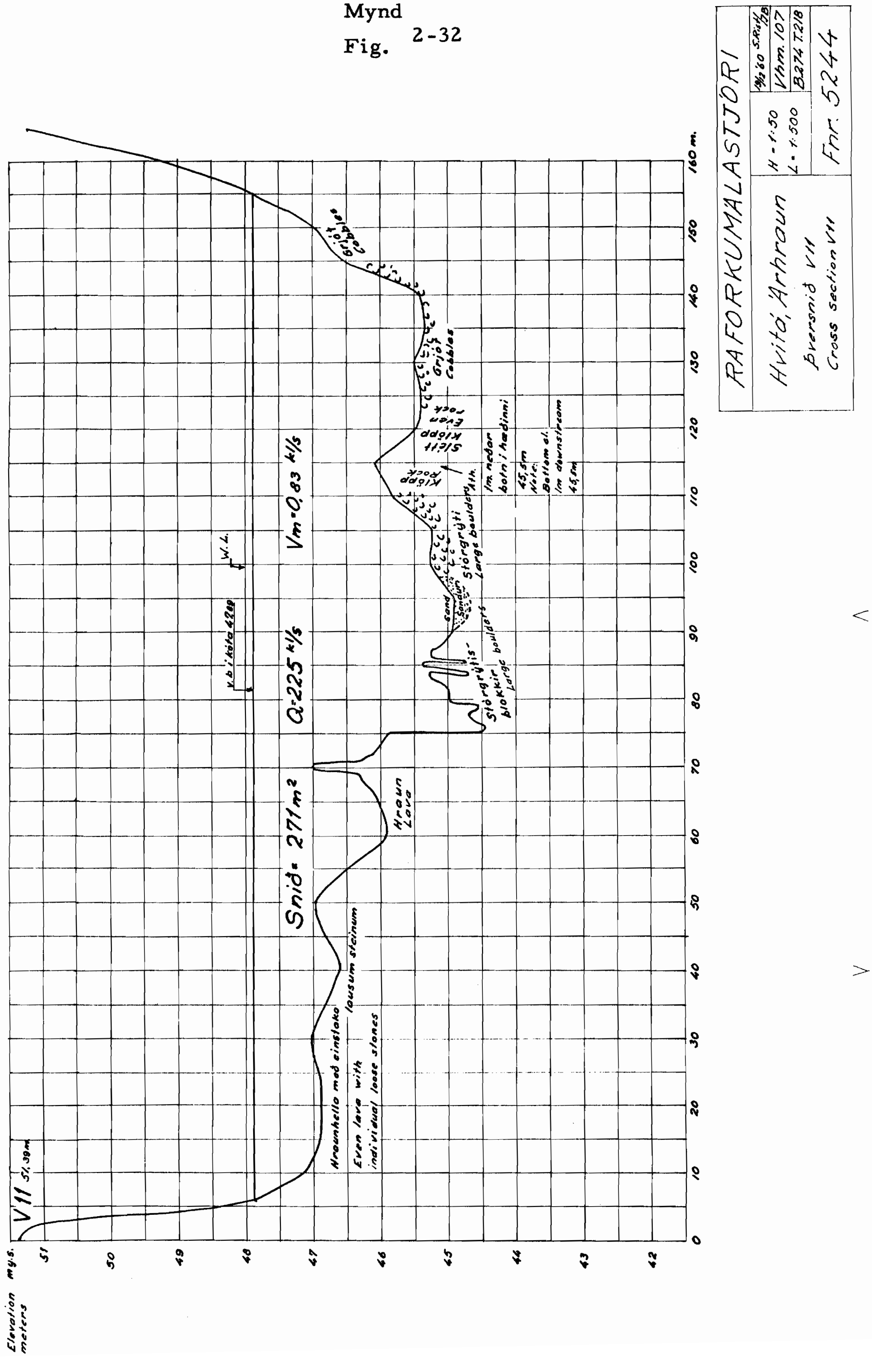
Hvítá, Árhraun
Þversnið V10
Cross section V10

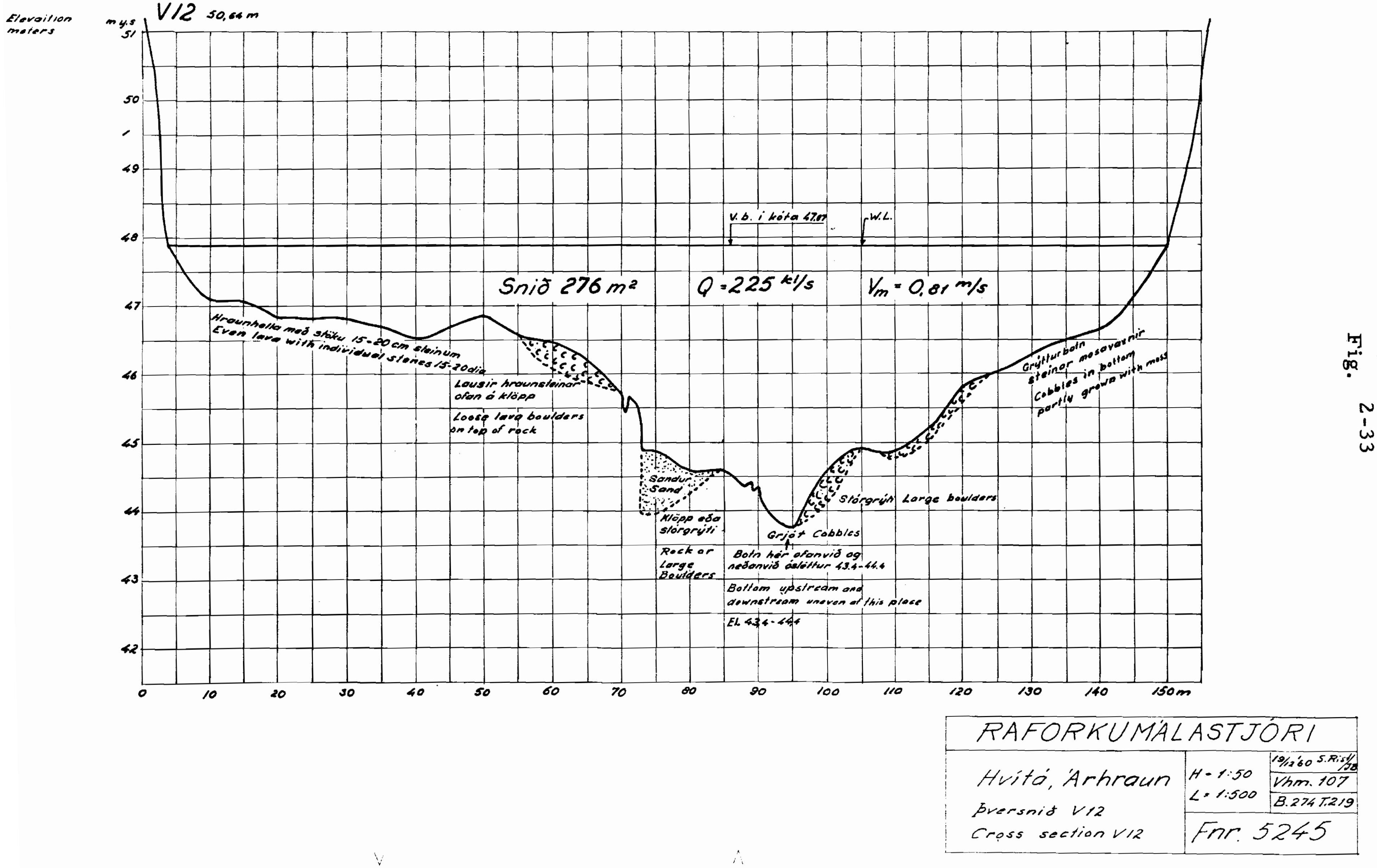
H = 1:50
L = 1:500

19/12'60 S.Rist/120
Vhm. 107
B274 T.217

Fnr. 5243

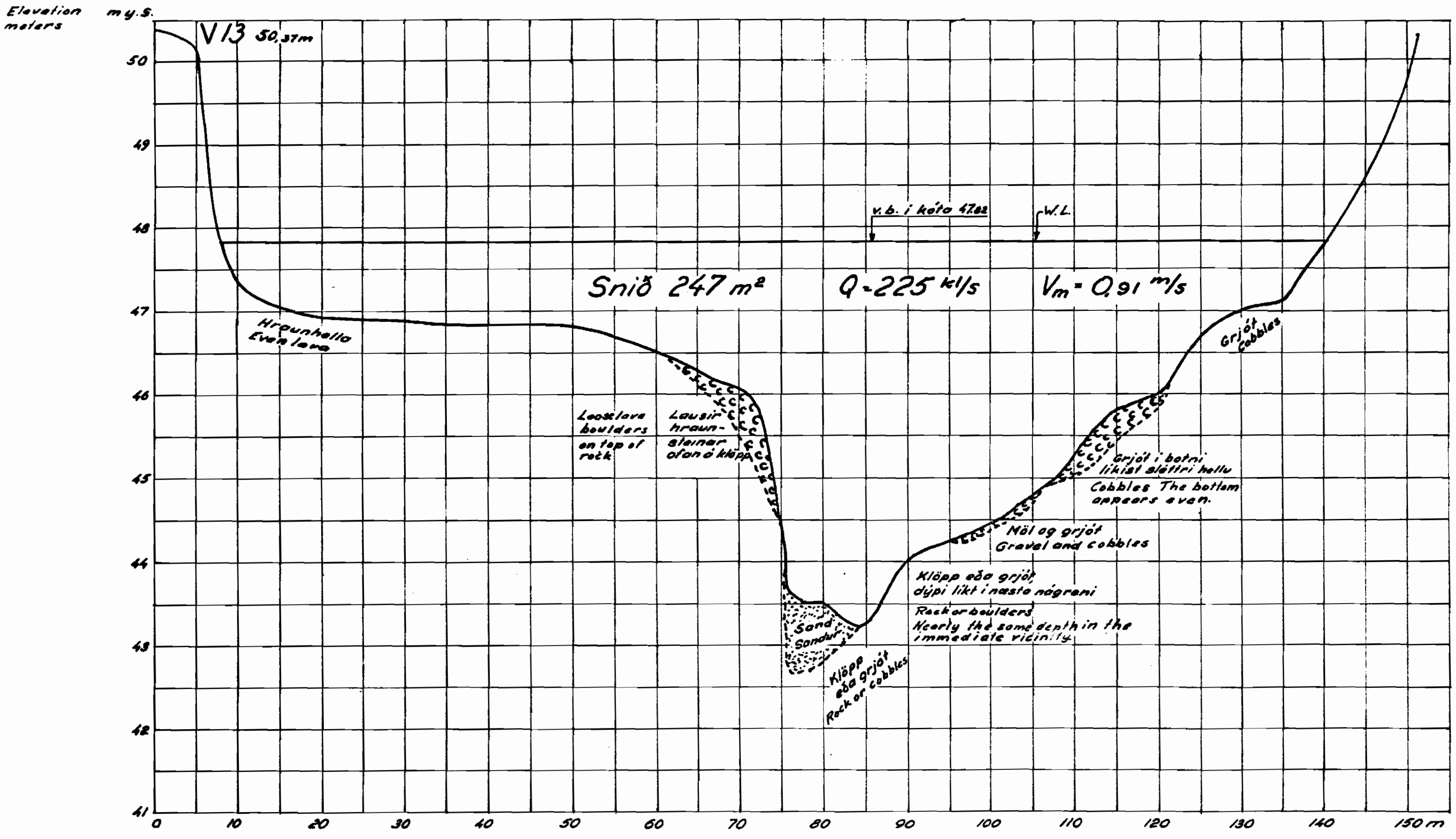
Mynd
Fig. 2-32


RAFORKUMÁLASTJÓRI
Hvítá, Árhraun
Þversnið VII
Cross section VII
H = 1:50
L = 1:500
19/12 '60 S.Rist / JB
Vhm. 107
B.274 T.218
Fnr. 5244
VII 51,39 m
Snið = 271 m²
Q = 225 kl/s
Vm = 0,83 kl/s
V.b. í kóta 42,89
W.L.
Hraunhella með einstaka lausum steinum
Even lava with individual loose stones
Hraun
Lava
Stórgrýtis-blokkir
Large boulders
Sand
Sandur
Stórgrýti
Large boulders
Klöpp
Rock
Slétt klöpp
Even rock
Grjót
Cobbles
Grjót
Cobbles
Ath. 1m neðar botn í hæðinni 45,5m
Note: Bottom el. 1m downstream 45,5m
Elevation meters
m.y.s.
51
50
49
48
47
46
45
44
43
42
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160 m.


Elevation meters
m y.s
51
50
49
48
47
46
45
44
43
42
V12 50,64 m
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150m
V.b. í kóta 47.87
W.L.
Snið 276 m²
Q = 225 kl/s
V_m = 0,81 m/s
Hraunhella með stöku 15-20 cm steinum
Even lava with individual stones 15-20 dia
Lausir hraunsteinar ofan á klöpp
Loose lava boulders on top of rock
Sandur Sand
Klöpp eða stórgrýti
Rock or Large Boulders
Grjót Cobbles
Stórgrýti Large boulders
Botn hér ofanvið og neðanvið ósléttur 43.4-44.4
Bottom upstream and downstream uneven at this place
El. 43.4-44.4
Grýttur botn steinar mosavaxnir
Cobbles in bottom partly grown with moss
RAFORKUMÁLASTJÓRI
Hvítá, Árhraun
Þversnið V12
Cross section V12
H = 1:50
L = 1:500
19/12'60 S.Ris 1/78
Vhm. 107
B.274 T.219
Fnr. 5245

Mynd
Fig. 2-33

Mynd
Fig. 2-34



RAFORKUMÁLASTJÓRI

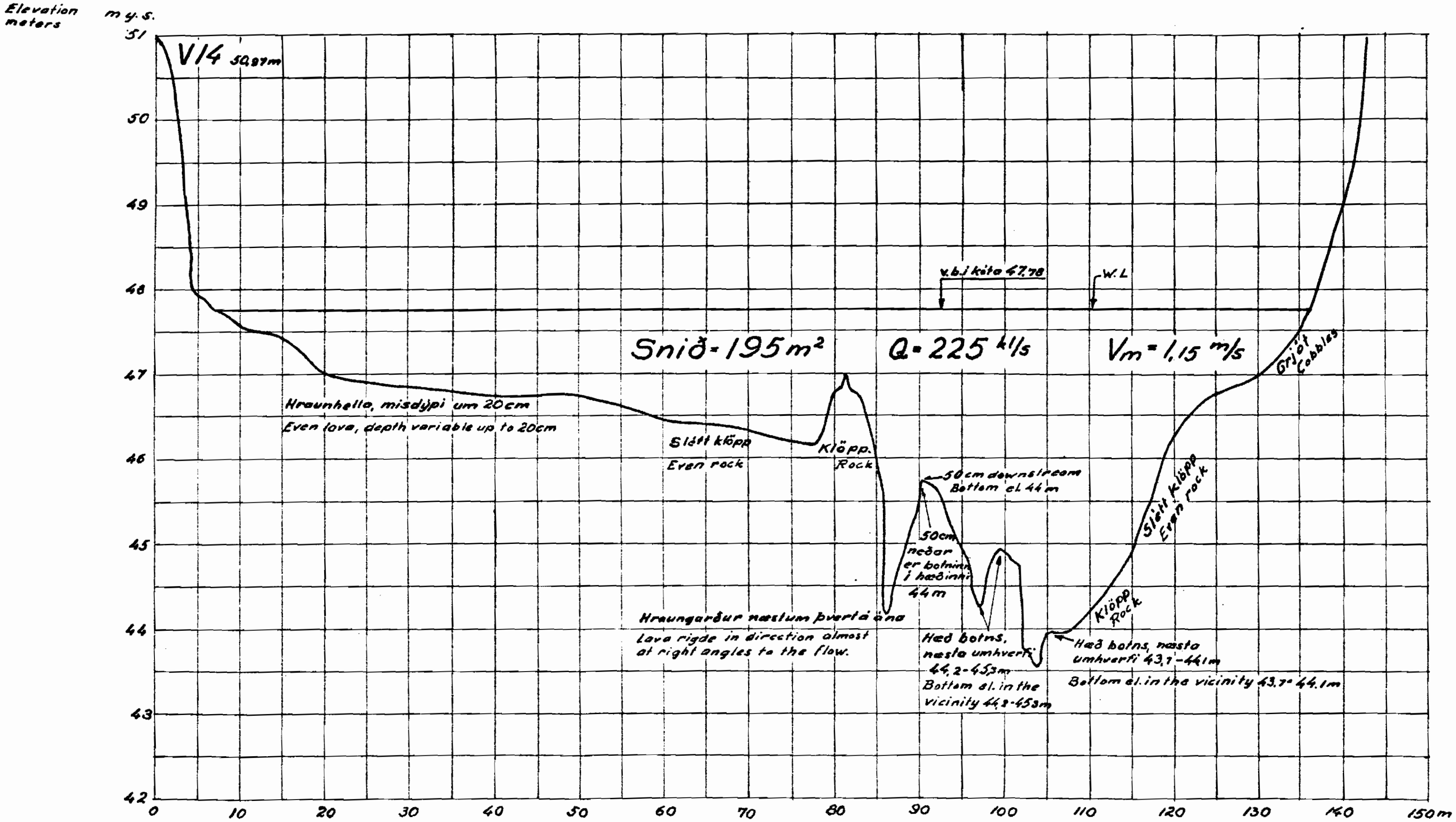
Hvítá, Árhraun
Þversnið V13
Cross sectin V13

H=1:50
L=1:500

19/12'60 S.Rist/JB
Vhm. 107
B274.T.220

Fnr. 5246

Mynd
Fig. 2-35



RAFORKUMÁLASTJÓRI

Hvítá, Árhraun

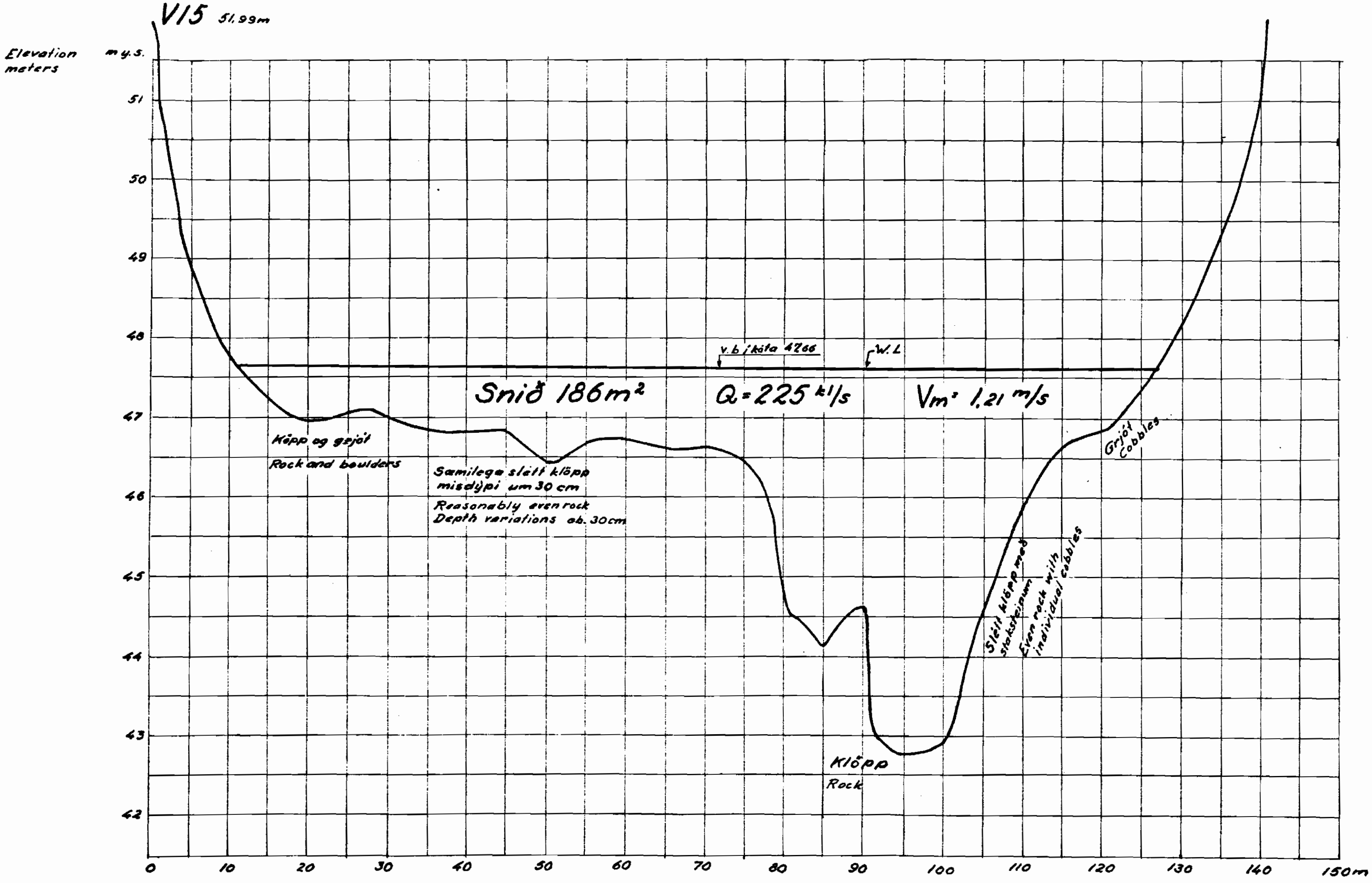
Þversnið V14
Cross section V14

H = 1:50
H = 1:500

19/12'60 S. Rist/JB
Vhm. 107
B274 T. 221

Fnr. 5247

Mynd
Fig. 2-36



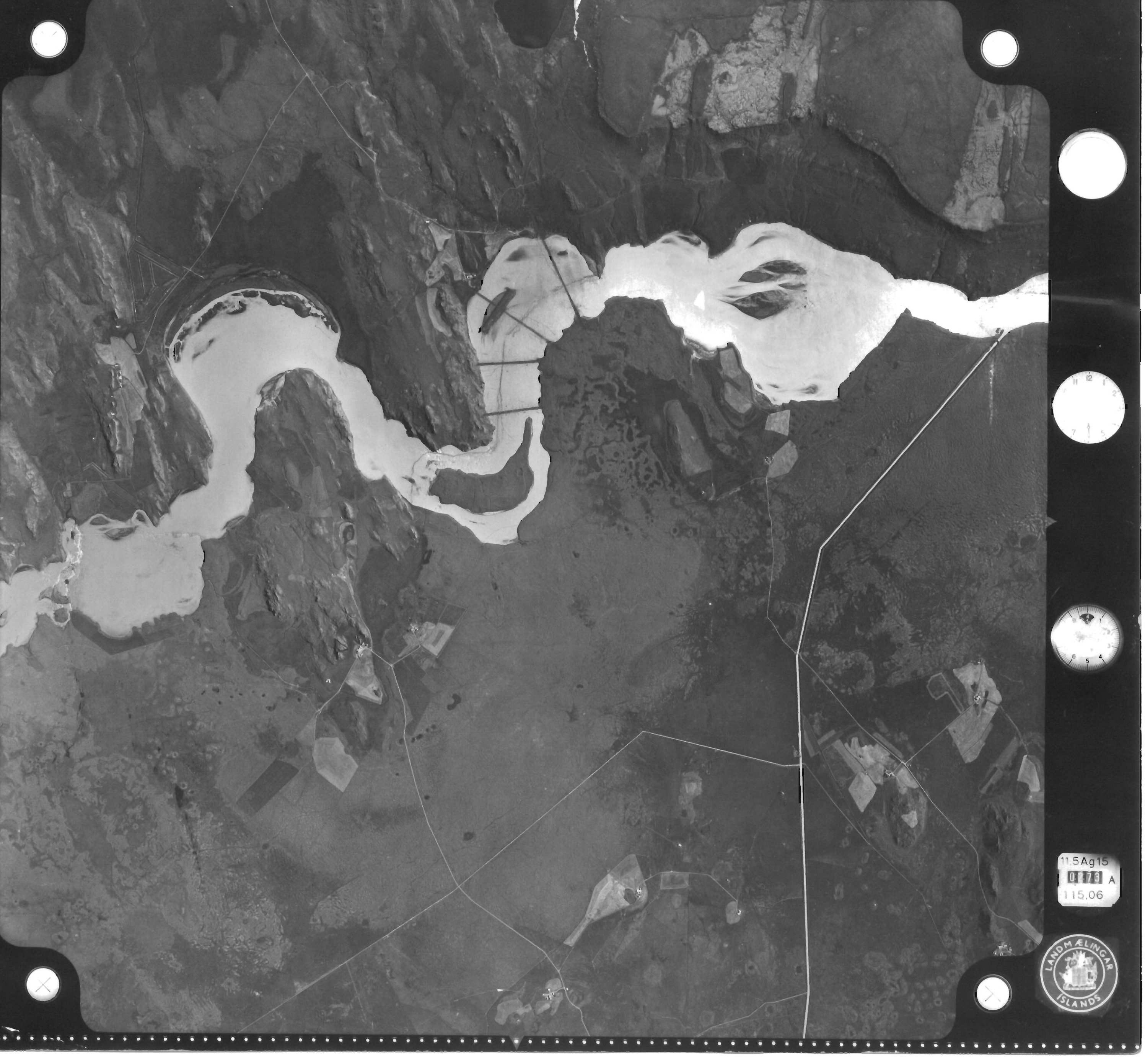
RAFORKUMÁLASTJÓRI

Hvítá, Árhraun
Þversnið V15
Cross section V15

H = 1:50
L = 1:500

19/12 '60 S.Risl/JB
Vhm. 107
B274 T.222

Fnr. 5248



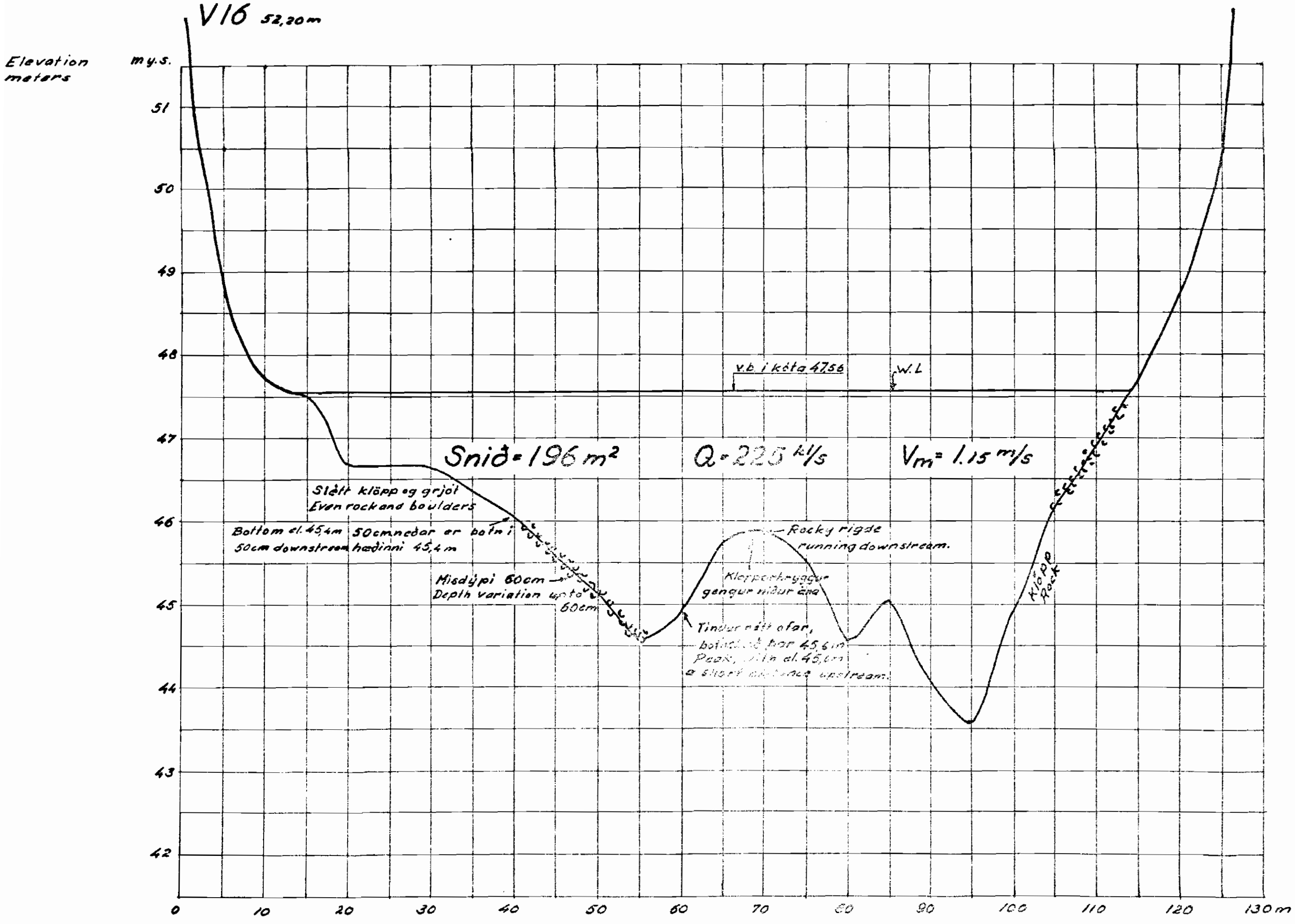
11.5Ag15

0273 A

115.06

LANDMÆLINGAR ÍSLANDS

Mynd
Fig. 2-37



RAFORKUMÁLASTJÓRI

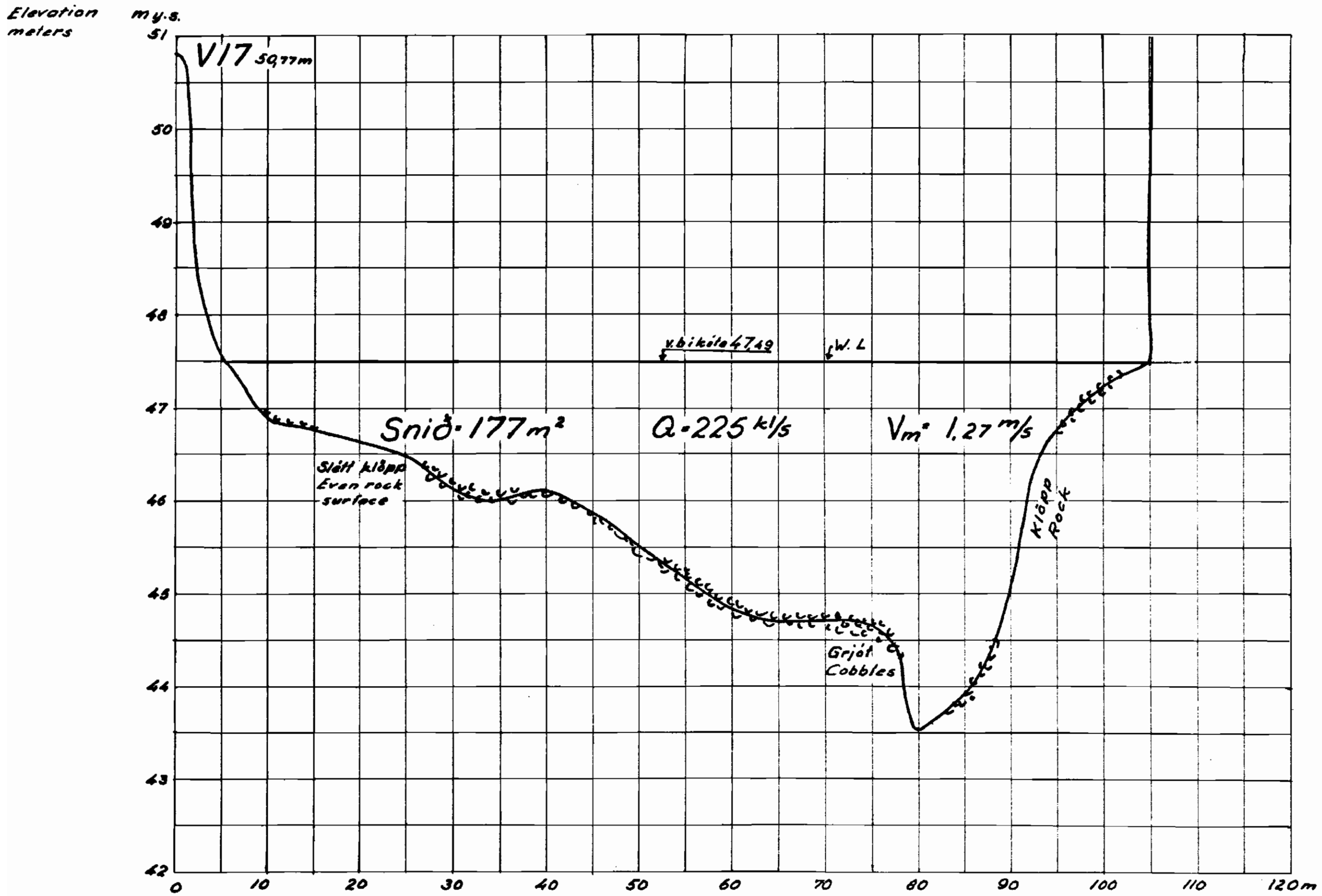
Hvítá, Árhraun
Þversnið V16
Cross section V16

H = 1:50
L = 1:500

19/2 '60 S.Rist/JB
Vhm. 107
B274. T223

Fnr. 5249

Mynd
Fig. 2-38



RAFORKUMÁLASTJÓRI

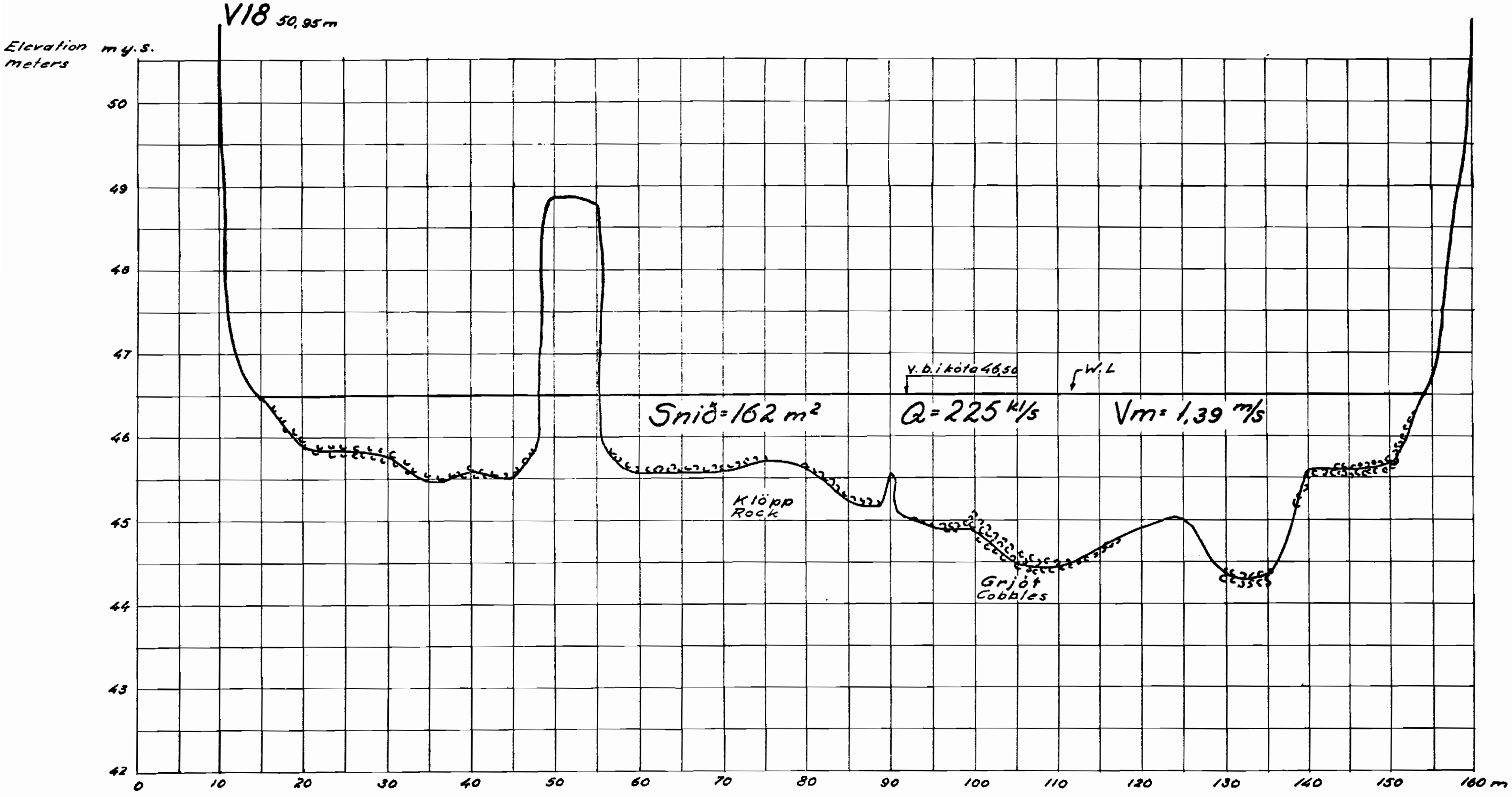
Hvítá, Árhraun.
Þversnið V17
Cross section V17

H = 1:50
L = 1:500

19/2'60 S.Rist/JB
Vhm. 107
B274 T.224

Fnr 5250

Mynd
Fig. 2-39



RAFORKUMÁLASTJÓRI

Hvítá, Árhraun
Þversnið V18
Cross section V18

H=1:50
L=1:500

19/12'60 S.Rist/JB
Vhm. 107
B274 T.225

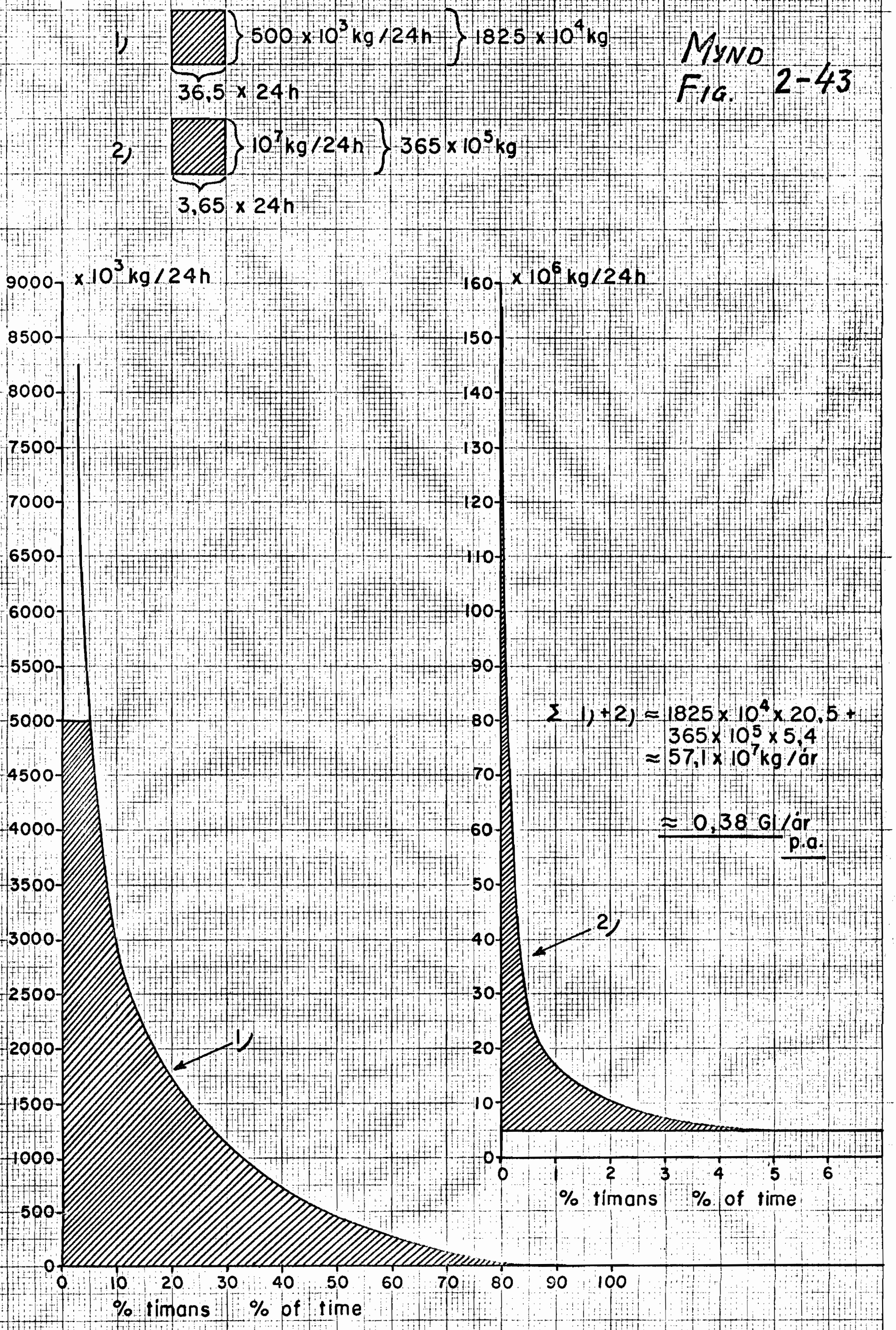
Fnr. 5251

Grundvallað á 43
vatnssýnishornum.
Based on 43
Water Samples
24. Feb.'56 - 24. Jun.'60

RAFORKUMÁLASTJÓRI
Vatnamælingar

HVÍTÁ GULLFOSS
Aurburður, upphrærður
Suspended Sediment

20.2.'61 Þ.S./E.E./O.H.
Tnr. 262 Tnr. 16
B-274 Vhm 87
Fnr. 5351



$$\Sigma\ 1)+2) \approx 1825 \times 10^4 \times 20{,}5 + 365 \times 10^5 \times 5{,}4 \approx 57{,}1 \times 10^7\ \text{kg/ár}$$

$\approx$ 0,38 Gl/ár
p.a.

MYND
FIG. 2-43