CLASS A.
No. 32.

REPORT ON THE CHONG KUMDUN DAM AND THE SHYOK FLOOD OF 1929.

BY

J. P. GUNN,

Executive Engineer.

Price: Rs. 3-12-0 or 5s. 8d.

CONTENTS.

	Page.
Chapter I	1
Chapter II	6
Chapter III	14
Appendix A—Skardu gauge	22
Appendix B—Flood warnings	23
Appendix C—1929 Flood rises ..	25
Appendix D—Flood levels at Attock ..	26
Appendix E—Calculations	27
Sketch Map of Route ..	Plate I
Map of Upper Shyok Glaciers ..	At end

REPORT

ON

THE CHONG KUMDUN DAM

AND

SHYOK FLOOD OF 1929.

CHAPTER I.

The danger of flooding in the Attock district was brought into prominence in the summer of 1928 and the Government of the Punjab decided that the matter required further investigation ; accordingly arrangements were made to carry out certain surveys in the Attock neighbourhood and to despatch an expedition to investigate the glaciers of the Upper Shyok.

As matters stood in the autumn of 1928 the Chong Kumdun glacier was blocking the Shyok near its source and it was anticipated that the dam might burst and do considerable damage. The floods of 1841 and 1858 had shown that the region around Attock was liable to be heavily damaged by floods, and,though it has been definitely shown that these two floods had no connection whatever with the Shyok, a sudden rise at Attock of twenty feet in two and a half hours in October 1926 was definitely traced to the bursting of the glacier dam.

The objects of the expedition to the dam were first of all to make arrangements whereby a warning would be conveyed to the Punjab Government if an abnormal flood occurred due to the bursting of the dam, and secondly to carry out such investigations as might be necessary to estimate what would be the effect at Attock of the bursting of the dam and generally to get some information about the conditions in the region of the dam.

The party which went to the dam consisted of Mr. Ludlow, two Indian Subordinates, B. Mohammad Abdullah and B. Abdul Rahim, and the writer.

Mr. Ludlow has lived in Thibet and is well acquainted with the conditions of climate etc. found in Central Asia. He had already visited the lake and dam in 1928, and was consequently able to give valuable information on the state of the Shyok Glaciers and the lake last year. In addition to this not only his advice on matters of transport and details of equipment but his first hand knowledge of the whole region traversed rendered him an invaluable acquisition to the party. I would take this opportunity of acknowledging gratefully the help he gave me on the expedition.

The observations in the neighbourhood of Attock were in charge of B. Raghbir Singh, Assistant Engineer, and the surveys were mostly done by Mohammad Qasim, Overseer.

A preliminary visit was paid to Calcutta where I obtained the latest maps and much useful information and advice from Major Kenneth Mason of the Survey of India. I was also able to select suitable instruments from the Mathematical Instrument Office and obtained two steel boats each made in two sections for use on the lake. I also visited Srinagar where I met the Political officers concerned and made certain preliminary arrangements.

The party arrived in Srinagar on 10th May where Mr. Ludlow joined us. The time for preparations had been relatively short and much remained to be done in strengthening the light crates in which the boat sections were carried, making up our equipment into loads suitable for transport and such like tasks.

Diary.

Arrangements were also made, through the Political officers, for the Kashmir State officials to help us in obtaining transport at the various stages on the road.

A sketch map is given in Plate I showing the places beyond Leh mentioned in the report.

These preliminaries occupied a considerable time, and it was not till the 22nd May that the party left Srinagar for Leh. The road over the Zoji-La had been declared open a few days before the party reached there and the whole journey to Leh was accomplished without difficulty, Leh being reached on the 6th June.

At Leh considerable difficulty was experienced regarding transport. The Khardung pass was still under heavy snow and as the majority of the local yaks and zhos had died of an epidemic during the winter the only course open was to fall back on coolies. All the coolies from the neighbouring villages had already been called out to take the Visser party over the pass, and arrangements had to be made to collect coolies form the more distant villages. To enable the necessary arrangements to be made the 19th was fixed for crossing the pass. This allowed the civil authorities sufficient time to warn the coolies and let them in turn arrange for their food.

On the 12th, however, the weather broke, rain fell in Leh in small amounts and a good deal of fresh snow fell on the Khardung. This snow continued at intervals during the 13th and 14th and, eventually, I decided to postpone our departure for two days. Had the coolies been allowed to collect on the day fixed and then a postponement been found necessary, all would have had to return for more rations and the resulting delay might have been considerable.

The interval was fully occupied however, by sorting out kit not needed till the party left Panamik, and dumping this to follow when the pass was open, and in splitting up our 80 lb. loads, made up in Srinagar for animal transport, into 60 lb. loads for coolie transport. By dumping the kit not immediately required we were able to get it across the pass at a very much less cost than would have been the case if it had gone on with the party. The boat sections in any case had to be left as it would have been next to impossible to get them over in the heavy snow.

On the 20th June the party left Leh and camped at the Khardung Polu, about 2,500 feet below the summit of the pass. An early start was made on the 21st and the last of the baggage got down the steep snow slopes on the northern side before the snow got really soft.

The Shyok Valley was reached on the 22nd June and camp was pitched at Khalsar. All along the valley traces of the flood of 1926 were visible and the level of the flood could be readily determined from the line of drift-wood left behind in many places. Lines of levels were run along the flood marks and cross sections taken at selected places and a gauge was set up from which a warning could be sent in the event of a flood.

By July 3rd all work that could be done from Khalsar as a base was completed and the whole camp moved to Diskit, a distance of 11 miles, on the 4th July. Working from Diskit surveys of the river were done along the left bank up to a short distance below the Shyok-Nubra confluence. While these surveys were in progress Mr. Ludlow and I proceeded down the Shyok to a point about three miles downstream of the Pachatang Nala, with the object of ascertaining if the gorge on the Shyok below this point had any appreciable effect on the flood levels upstream. The pony road had been washed away below this point and we were not able to take a camp down, but as there were no indications that the gorge affected the flow of the river in flood we did not attempt to proceed farther but returned to Diskit which we reached again on the 11th July.

By this time all the surveys on the left bank were completed, with the exception of a small portion at the upstream end connecting on to the previous work, and on the 12th July the main camp moved to Teggur direct, fording the Shyok which was rising gradually but had not become impassable, while the surveyors took a light camp up to Thirit completing the connection between the two surveys and working down the right bank of the Shyok.

The surveys of the flood levels were completed by the 17th when the party moved to Panamik. Here a halt was made to await the arrival of the heavy baggage from Leh. This baggage was due on the 15th July but more snow had fallen on the Khardung pass after we left and the baggage party took three days to get across the pass as all the ponies had to be unloaded and taken across the pass light and the loads manhandled over.

Transport is scarce in those regions and ponies had to be collected from all over the Shyok and Nubra valleys. Owing to the time lost on the Khardung pass by the baggage party we could give no definite date by which we would start, and as grazing is very scarce the ponies could not be detained indefinitely at Panamik without causing much extra expense to the pony-men for hire of grazing, but transport was collected and the party left on the 23rd July after dumping all surplus kit.

The Sasir pass was crossed on the 25th July without any great difficulty and camp was pitched about a mile upstream of Sasir Brangsa. We had taken supplies with us to last a month but we decided that the best course was to push up at once to the dam with a light camp and see what the conditions were. Accordingly on the 26th Mr. Ludlow and I took our camp up past the snouts of the Aktash and Kichik Kumdun glaciers to about a mile below the Chong Kumdun. The route was not passable for ponies but some of the pony men acted as porters.

Investigations to see whether it would be possible to take the whole camp across the glacier and up the lake showed that the banks of the lake were not passable for a camp. We accordingly returned to Sasir Brangsa and took the whole camp along the Central Asian Trade Route up to the Chip Chak river. Here we turned downstream along the route used when the glaciers are not blocking the Shyok, till we arrived at the lake which we reached on the 5th August.

The first camp at the lake was pitched on the north shore about a mile west of the Chip Chak stream, and surveys and soundings of the lake were put in hand. While this work was in progress Mr. Ludlow took a light camp down along the eastern shore to see if it was possible to reach the dam on foot. This proved to be impossible, and after completing the work at the northern end of the lake the rest of the camp moved down on the 10th August to join Mr. Ludlow and carry out surveys at the southern end of the lake.

This camp was situated five miles north of the dam as it proved to be the nearest site, suitable for a large camp. On the 12th August we went by boat down to the dam and inspected the conditions there, and from the boat it appeared that several nalas were impassible except perhaps to a party fully equipped for climbing and carrying no loads.

By the 13th only a few observations remained to be taken and on the 14th the party set up some marks, cached the boats, and left the lake on the return journey ; camp was pitched about seven miles from the lake.

The next day the trade route over the Dipsang plateau was rejoined, Mr. Ludlow proceeded on his way to Kashgar while the rest of the party turned south and reached Sasir Brangsa about noon on the 17th.

The Shyok was found to be in flood when we reached Sasir Brangsa and from the quantities of ice scattered about the river bed it was obvious that the dam had burst.

The Zak (a raft made of inflated skins) which we had taken with us for crossing streams that could not be forded had not been in use for some time and it was not possible to use it till the skins had been properly soaked but it was ready by the night of the 18th. Early on the 19th I had a light camp ferried across, as the left bank was not passable, and set off up the right bank to re-visit the dam and see what the conditions were up there.

The animals had been made to swim the river the night before as there was no grazing on the left bank and after my camp had been ferried over the remainder of the baggage was taken across the river.

The route to the glacier was much more tedious and difficult than had been the case on our first visit as the Aktash had been damaged by the flood and the river was flowing along the foot of the ice and also the streams issuing from the Kichik Kumdun were almost twice the size they had been previously. Also owing to the water in the river above the Kichik Kumdun it was not possible to cut across the river bed.

Owing to the delay in ferrying the camp across the river and to having to cross the Aktash glacier, instead of walking past the snout, it was not possible to take the camp past the left lateral moraine of the Kichik Kumdun. The next day a road had to be found along some steeply sloping cliffs for a mile before it was possible to get down to the river bed and approach the Chong Kumdun, and it was not till late that night that I got back to my camp at Sasir Brangsa after having inspected the dam.

Some observations of flood marks were made at Sasir Brangsa and the party returned to Panamik arriving there on the 23rd August.

After halting here a day to pay off the pony-men and settle various charges for labour and supplies the march was continued, Thirit being reached on the 26th.

Some observations were taken to compare this year's flood levels with those of 1926 along the reach between Teggur and Khalsar, which was reached on the 27th August. After collecting information about the flood the march was resumed and Leh was reached on the 30th August after meeting some unpleasant weather on the Khardung pass. After two days at Leh, settling up various things there, the return journey was begun on September 2nd and Srinagar reached on 14th September.

CHAPTER II.

Shyok Valley above Diskit.

The Valley of the Shyok as can be seen from the photograph, Fig. 1, is of the U type with a width of about a mile between the hills on each side of the bottom. The general shape suggests that formerly the glaciers extended downstream to below the Shyok-Nubra confluence. Large conical deposits of shingle are found where the tributary nalas join the main river ; these spread out like fans across the river bed for distances depending on the magnitude and slope of the tributary. In some cases these fans have a radius of about three miles and may be as much as 400 feet above the river where the nala leaves the hills. In general, these fans are far enough apart for the river to be able to run round the foot but occasionally the stream cuts into one.

The rocks and boulders are mainly granite and the sand is large grained particles of decomposed granite. With the exception of a few plants the only places where vegetation is found are the fans of the side nalas and there alone is habitation possible.

In normal supplies the river runs round the foot of the fans but during the last two big floods the water came some distance up the fans and destroyed many of the shrubs on them. Figs. Nos. 2 and 3, taken from the same spot, show the fan of the Khardung stream before and after this year's floods, and give some idea of the force of the stream. Fig. 4 of the Shyok below Khalsar was taken from the flood mark on the left bank looking across the river and a distinct line can be seen where the flood of 1926 reached on the right bank. At this point the width is about $1\frac{1}{2}$ miles ; the river is in its low stage and only about two feet deep.

The Shyok has a slope of eighteen feet per mile in the reach from Khalsar to the confluence with the Nubra but this is far from uniform over any great length of river.

The bed is of large shingle and small boulders but is not stable owing to the steep slope. Rapids of considerable length alternate with regions of smooth flow, but the position of these is constantly charging.

Above Sasir Brangsa the slope is much steeper and more variable, while the average slope is forty-one feet per mile ; the maximum observed was a fall of fifty feet in a length of half a mile.

The flood of this year had the effect of altering the channel at almost every point and eroding a much more efficient hydraulic channel past the gauge at Khalsar lowering the bed there by approximately nine and a half feet. Fig. 5 shows the Shyok-Nubra confluence with the Shyok running in one channel, this photograph was taken after the flood.

I have inspected over forty miles of the river in the region of human habitation where it would be possible to set up a gauge and communicate speedily with the Punjab, but I have not seen any place

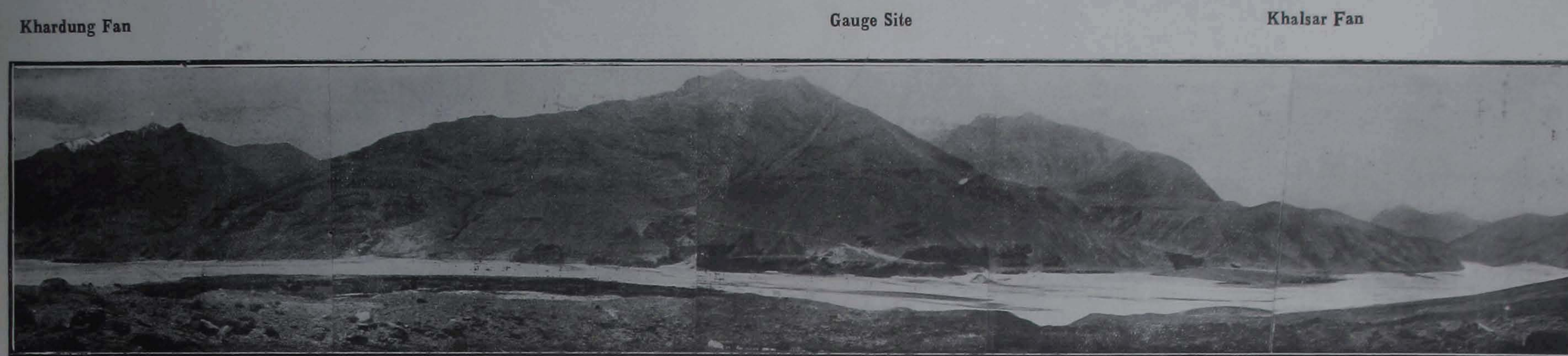
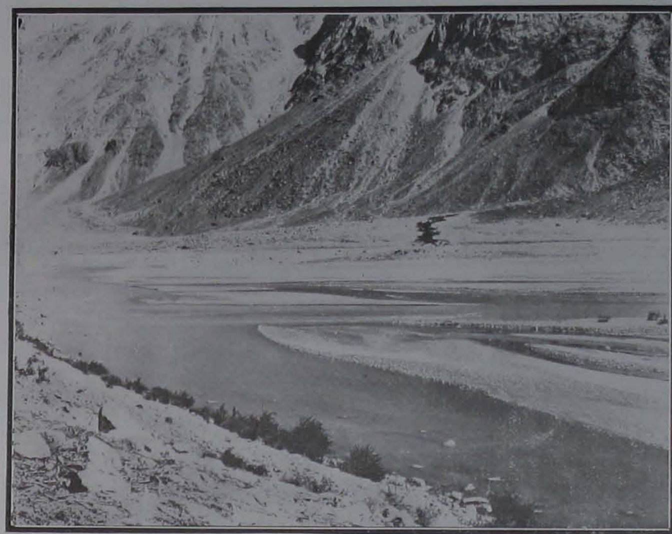


Fig. 1. Panorama of Shyok from Sati.

Fig. 2. Khardung fan before flood.

Fig. 3. Khardung fan after flood.



Flood Mark.

Fig. 4. Shyok below Khalsar shewing 1926 flood mark.

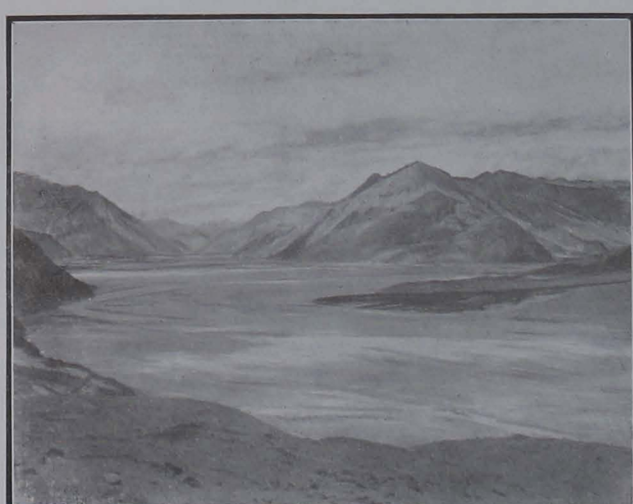


Fig. 5. Shyok-Nubra confluence looking down the Shyok valley ; Nubra valley on right.

Fig. 6. Shyok from Diskit shewing Thirit fan on right and channels through bushes cut by 1926 flood.

Fig. 7. Nubra Valley looking towards the Shyok from Teggur.

Fig. 8. Nubra Valley looking north from Teggur.

where the river is in the least stable, the bed is all of the same composition and the shingle bars are all gradually changing their position and the main stream splitting up into small channels.

From the gradual changes that occur in periods of normal supply, to say nothing of the sudden ones effected by the occasional floods, it can easily be seen that the variations are such as to render the permanent calibration of any gauge impossible. I attempted to make an estimate of the flood discharge of 1926 when I arrived at Khalsar first, but after seeing the effects of this flood I do not consider that it is possible to make any theoretical approximation to the discharge.

Opposite Thirit the Shyok Valley opens out and the river runs along sidelong ground cut up by nalas. Cross sections show that depressions exist along the foot of the hills on both sides of the river bed and that it is the flood water spilling into these that causes the damage at Diskit and Liekzun. Fig. 6 taken from above Diskit looking up the Shyok shows the spill channels torn through the shrubs by the 1926 flood and shows the way in which the water that damaged Diskit reached the village.

After the junction of the two rivers the bed resumes its normal type, running round the foot of the fans where the curvature is suitable and cutting into them when it is not. This type of bed continues down to a gorge about thirty-five miles below the confluence, and lends itself to most uneven flow in floods, as each fan helps to check the velocity and lowers the intensity of discharge.

Nubra Valley.

The valley of the Nubra shown in Figs. 7 and 8 is of much the same nature as that of the Shyok. The slope however is about twelve feet per mile and it has not been subjected to the same disastrous floods. A small flood occurred about 1914, apparently caused by a small transverse type glacier effecting a junction with the main Siachen glacier and holding up some water, in much the same way as the Chong Kumdun glacier blocks the Shyok, but the local people said it was a small affair and did no damage to speak of.

Nearly all the nalas feeding the Nubra are of a considerable size and there is much cultivation in the valley, also there is much jungle in the river bed.

The effect of the Nubra Valley in diminishing the intensity of the Shyok floods has been much over-estimated previously both by myself and others. The surveys showed that the 1926 flood did not reach Burma village and submerged an area of about 3,500 acres and the depth of water opposite Teggur was three feet. This year's flood gave 17 feet of water at the same place submerging about 5,000 acres and destroying Burma village. The reservoir effect of such comparatively small areas can only be very slight.

While at Khalsar the final instructions were issued for conveying warning to Leh of a disastrous flood. I had arranged with the Tehsildar, Leh, for six dak-runners. Two were stationed at the Khardung Polu, ten miles from Leh, two more at Khardung village fifteen miles further on and two at Khalsar, twelve miles from Khardung.

Shyok Valley above Sasir Brangsa.

Above Sasir Brangsa the valley of the Shyok presents the same general appearance but as the elevation is 15,000 feet roughly against 10,000 feet at the confluence certain changes are to be expected. Instead of long side nalas coming down a considerable distance from the snow the glaciers are much nearer and the larger ones come right down to the river.

When no glaciers block the river the Central Asian Trade Route follows the course of the Shyok and Chip Chak up to Daulat Beg Oldi but at present it takes a long detour by the Murgo ravine and the Dipsang plateau. In the first number of the *Himalayan Journal* Major Kenneth Mason has written an article on the glaciers of the Upper Shyok and has collected information about their state of advance or retreat, in some cases from statements by those who passed there, but in many cases he has inferred that the glaciers were blocking the river from the fact that the Dipsang detour was used. Much valuable information about these glaciers during the last 150 years is to be found in that paper.

Aktash Glacier.

Going upstream from Sasir Brangsa the first glacier of any magnitude is the Aktash. From time to time this glacier has blocked the trade route, and even obstructed the river but there is no record of any disastrous flood having been caused by it. The hills from which this glacier debouches are some little distance from the cliffs on the left bank of the river, and I do not think that it is big enough ever to build up a high obstruction and impound any great quantity of water.

Kichick Kumdun Glacier.

The Kichick Kumdun glacier is the next one to the Aktash, and is roughly twice the size at the snout. It has often blocked the road but apparently never blocked the river. In any case the configuration of the country is such that even if it did impound a four hundred foot depth the volume of water would only be about one-third of the volume retained by the same depth at the Chong Kumdun.

A view, Fig. 9, looking downstream from near the Kichick Kumdun gives some idea of the nature of the valley while Fig. 10 taken from a slightly higher viewpoint shows the river after the flood with the river bed covered with blocks of ice and the eroded snout of the Aktash in the distance.

Chong Kumdun Glacier.

The glacier which actually blocked the river is the Chong Kumdun, a photograph taken from a distance of about two miles is shown in Fig. 11. It issues from a side valley of considerable width at a place where the hills on both sides of the river approach much nearer than is the case at the Aktash or Kichick Kumdun. The valley above the dam continues narrow for about four miles and then widens out considerably, with the result that the top hundred foot depth of water in the lake this year had a volume over twice that of the lower portion, the total depth at the dam being in the region of four hundred feet.

This glacier has blocked the valley before and is, in my opinion, probably responsible for all the previous Shyok floods, as it is the largest of the three glaciers and has a shorter length outside its rocky

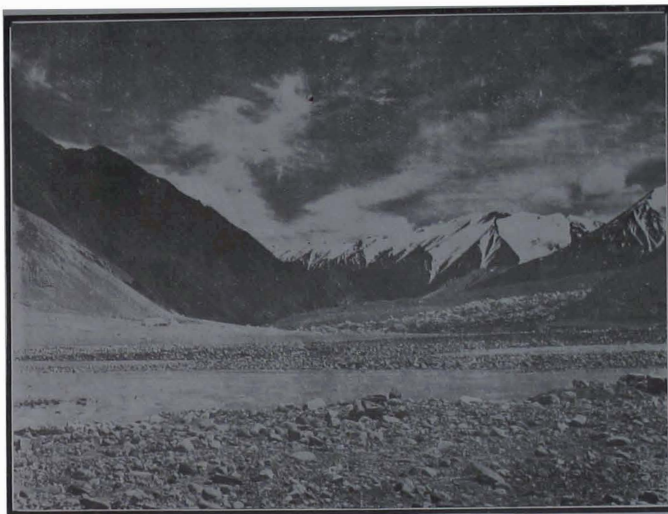


Fig. 9. Shyok Valley from near the Kichik Kumdun before flood.

Fig. 10. Shyok Valley from near Kichik Kumdun after flood shewing the eroded snout of the Aktash Glacier.

Fig. 11. Distant view of Chong Kumdun Glacier.

Fig. 12. Index Photograph shewing stations from which photos were taken.

Fig. 13. Chong Kumdun snout before burst.

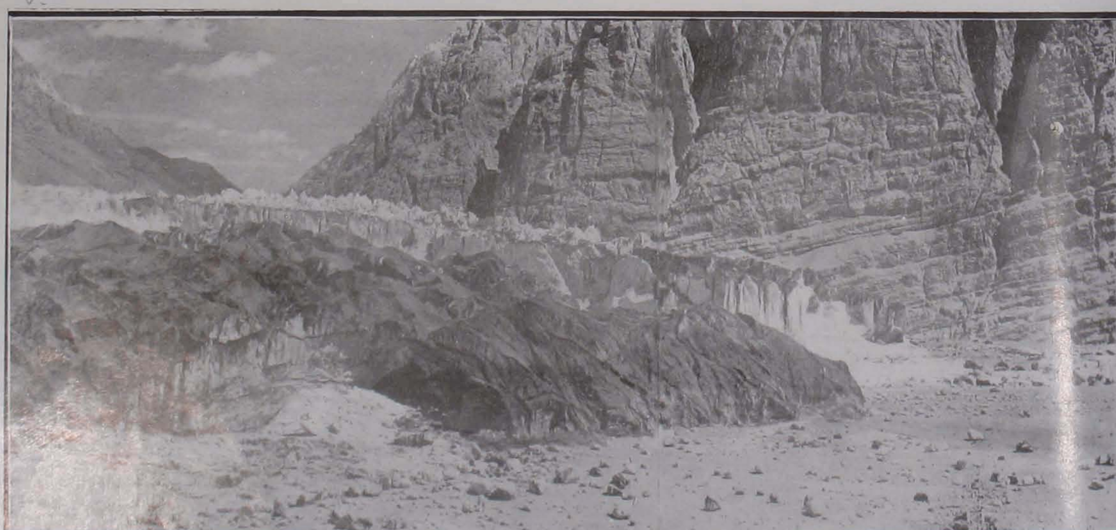


Fig. 14. Chong Kumdun snout after burst.

Fig. 15. Gapshan lake from point " U " with Chong Kumdun Glacier in foreground.

Fig. 16. Detail of snout of Chong Kumdun Glacier.

Fig. 17. General view of snout of Chong Kumdun.

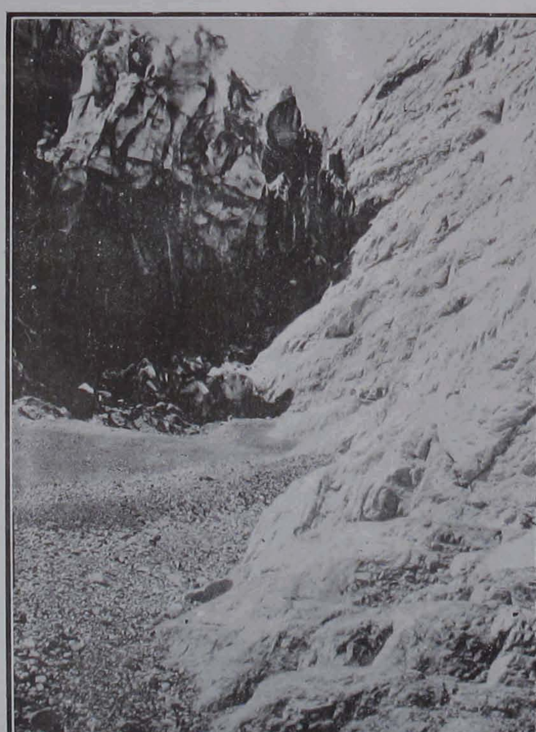


Fig. 18. Detail of Gully.

valley to traverse before it reaches the cliffs on the left bank of the river.

An inset on the map shows the general shape of the ice dam and also indicates the position and direction from which the various photographs were taken. The width of the ice across the river bed is about 4,000 feet and the height excluding the pinnacles was of the order of 500 feet while the lower edge was about two hundred and fifty feet.

In order to enable the position of the snout to be determined at various times a point was selected about 300 feet above the river bed and a photograph taken transverse to the axis of the river. The position from which this photograph was taken was in front of one of a group of boulders indicated in the index photograph Fig. 12 by the lower of the two circles. The boulder itself was marked by a T about 9" high cut in the face of the boulder towards the river and painted white while a small cairn of stones about 3 feet high was erected on the top of the boulder itself. The site is between two small water-falls and about twenty feet from the left bank of a small nala. The site is conspicuous and should be readily recognised.

From the same point also another photograph was taken looking directly across the glacier in the direction of the river axis upstream. These two photographs were repeated after the flood and from them the two composite views Figs. 13 and 14 were prepared.

Another view taken from the point " U " about 1,000 feet above the river bed is shown in Fig. 15. This point is indicated by the upper circle in the index photograph Fig. 12 and is a flat ridge of rock about 15 feet square projecting from the hillside and is marked by a cairn of stones about five feet high.

From an inspection of the dam it appeared that the body of ice in the river bed was approximately square in plan, while the snout, which pressed up against the cliffs on the left bank of the river, was considerably lower than the main body of the dam. A detail view of the debris-covered snout is shown in Fig. 16 ; a distant view showing the dip is shown in Fig. 17, while a closer view of the miniature valley in Fig. 18 shows the black ice pressed up against the red marble cliffs.

Up to the time we reached Sasir Brangsa we had no information whether the lake was still in existence or whether it had quietly leaked away during the early spring as several of this type of lake have been known to do. At Sasir Brangsa however the river was much smaller than it had been at the time of Mr. Ludlow's visit last year, indicating that the dam was still in existence. This was amply confirmed when we found the river bed absolutely dry above the Kichick Kumdun, but it was not till we reached the upper of the two points from which photographs were taken and we could examine the lake with a telescope that I realised the full size of the lake. Mr. Ludlow was able to tell me that it had risen much since last year.

It also appeared probable that the heat reflected by the cliffs at the snout might have caused the gully to deepen itself, and as the water did not appear to be far off the bottom of the gully it was decided to push on with the surveys of the lake.

A triangulation station of the de Fillipi expedition marked 16,545 on the map was used as the origin for the survey of the lake and as it was desired to get an approximate idea of the total volume of the lake a 4" to a mile scale was used, so that the contour lines might be well spaced, though time did not permit the full detail to be surveyed that the scale allows. The panorama in Fig. 21 was taken from a point 150 feet south of the origin.

Gapshan Lake.

A working bench mark was set up on one of a pair of large conspicuous boulders about a mile from the Chip Chak stream and the height derived from the origin. On the last day at the lake a series of small cairns were built the bottom of each being respectively 10, 20, 30, 40, 50 and 60 feet above the level of the lake, these cairns are marked 10, 20, etc., and their position is shown on the inset of the lake as "gauge." The inset map shows the position of the gauge and bench mark as well as the place where the boats are cached.

The lake was visited by Mr. Ludlow and by Captain Sinclair last year and both mentioned the existence of several marks along the shores of the lake indicating previous lake levels, but this year all these marks except one were submerged ; this mark was at a level twenty-five feet above the highest level in the lake this year.

The nearest site at which a large camp could be pitched was five miles above the dam, and the nearest point it is possible to reach without hard climbing, on the left bank, is two miles off the dam. In these last two miles at least three nalas render the approach difficult, if not actually impassable. The Ladakhis say the route is impassable and it certainly appears so. The right bank is no better : the first impassable nala is four miles off the dam and there are others between it and the dam.

The time at our disposal was short and only one day was devoted to the inspection of the dam, the general appearance of which can be seen from Fig. 19. As far as could be seen from a boat the gully along the cliffs was approximately sixty feet above the water level, this gully can be seen in Fig. 20.

At the time of our visit large ice floes were breaking off the dam and, after vanishing beneath the surface, reappearing on the surface some considerable distance off. These floes rendered it inadvisable to approach too close or to attempt a landing in the gully while the rocks were difficult of passage and we could not afford the time to approach that way.

All the time we were at the dam there were loud creaks and groans lasting some time whenever an ice floe was detached, which were not audible when inspecting the glacier from below a fortnight before. While I considered that the dam was too large to fail, in any way except by being overtopped, these noises seemed to promise a rapid breakdown and a large flood when the dam did burst.

I also paid a visit to the Rimo Glacier, the largest in this region, and the main source of the Shyok River. I hoped that some information might be derived from the state of its snout. A panorama taken from a point about 400 yards south of point 16,932 is shown in Fig. 22

Rimo Glacier.

Fig. 19. Dam from above with lake in foreground.

Fig. 20. Dam from Boat shewing gully along cliffs.

Fig. 23. Terminal pinnacles of Aktash Glacier before flood.

Fig. 24. Aktash from right lateral moraine after flood shewing erosion of terminal pinnacles.

On the return journey the boats were carried up about a hundred feet above the level of the Chip Chak to a level patch of ground between two nalas on the left bank and buried under stones, a cairn was put up to mark the spot. The oars were left with the Kashmir State P. W. D. Subordinate at Leh. The actual site where the boats were cached is opposite the place where the trade route leaves the plateau and enters the river bed.

Shyok after flood.

On emerging from the Murgo Ravine on the return journey the Shyok River presented a remarkable sight. The whole of the river bed was strewn with ice blocks and berms of white ice could be seen at different levels where the water level had remained stationary for some time.

As soon as possible I proceeded to inspect the remains of the dam, but was unable to get closer than three miles off the dam that night. From a distance it was not possible to detect much change in the appearance of the glacier and it was only when I got close that I was able to see what had happened.

Investigation showed that the lake had emptied itself through a gully that began near the right bank of the river on the upstream side and after a curved course came out near the left bank on the down-stream side. I estimate that the gully is about four hundred feet wide and has almost vertical sides. A comparatively small portion of the water made its way out towards the right bank of the river through a hole which can be clearly seen in the foreground in Fig. 14.

Taking into consideration the huge mass of water liberated by the bursting of the dam remarkably little damage was done. Most of the damage occurred in the reach between Thirit and Skardu. On the whole river forty-eight villages were affected, and the damage is estimated at under three lakhs of rupees in the Skardu tehsil.

Future of dam.

The question now remains whether it is likely that the Chong Kumdun will again block the Shyok next year. An indication of the probability of this occurrence may be obtainable from a consideration of the state of the other glaciers in the neighbourhood. If these are advancing it is my opinion that the dam will certainly reform, while even if the glacier was in a condition of stability, with the snout against the cliffs, I am inclined to think, that it might possibly close up the gap. The form of the channel lends itself to easy closure and only requires about four hundred feet advance to effect a complete stoppage. If the glacier is in retreat then the river bed will rapidly become clear, for the large mass of dead ice separated from the main glacier will melt in the due course.

With a view to ascertaining the general state of the glaciers in this region I took a number of photographs of their snouts. The only ways which I know of by which it can be told by a single inspection that a glacier is in retreat is by noting the presence of a terminal moraine or of detached dead pinnacles.

The photograph of the Aktash terminal pinnacles, Fig. 23, was taken from a mound of moraine material while the figure of the man standing on another mound of moraine material shows the position of the snout in 1928. The flood of 1926 must have cleared away any terminal deposit of gravel and boulders that might have existed previously as the river course keeps the stream up against the snout of the Aktash in high supplies. The effect of this year's flood in removing the two mounds of terminal moraine and much of the terminal ice can be seen from Fig. 24, taken from the right lateral moraine, which shows a clear river bed about a hundred feet below the level of the foot of the ice pinnacles.

From the conditions at the Aktash I infer that the glacier has been in retreat since 1927. It is the smallest of the glaciers examined and is probably the most sensitive to variations of snowfall.

With regard to the Kichik Kumdun I could see no distinct traces of a double terminal moraine as at the Aktash, but Figs. 25, 26, 27 give some idea of the state of the terminal pinnacles from the river side and Fig. 28 taken from a hill to the south about 2,000 feet above the ice, shows their scattered nature. This last photograph shows the river bed at the foot of the cliffs which was dry on July 28th when the photograph was taken. Last year Major Kenneth Mason pronounced the glacier to be in retreat on the evidence of certain Mr. Ludlow's photographs. The gravel deposit in the foreground of Figs. 25, 26 and 27 is in many places only a thin covering of gravel on the top of some ice not yet melted. Last year the pinnacles were 100 yards from the river but this year they are about 800 yards from the cliffs, showing a retreat of about 500 yards. The size of these pinnacles also was much diminished.

At the Chong Kumdun glacier there were no signs of any dead pinnacles, and it was only near the right bank of the river that I could see any signs of a terminal moraine. Near the spot where the Chong Kumdun emerges from the hills a small tributary glacier joins it, the white ice in Fig. 30 is this small glacier and it can also be seen beyond the dam in Fig. 20. A short distance from this glacier is the heap of shingle shown in Fig. 30 with the figure of a man beside it while a hundred yards or so farther on is the small heap shown in Fig. 29.

The first heap is about fifteen feet high and only about 50 yards long, and the stream from the junction of the two glaciers is eroding the end of it. The second heap was only about seven feet above the general level of the riverbed but the stream had cut away a great deal of it along with about eighteen inches depth of the surrounding bed. I am of the opinion that these two gravel heaps were due to the retreat of the tributary glacier and not to the main body of ice. It is possible that Figs. 13, 16 and 17 may give some information to an expert but all I can say is that I saw no signs of dead pinnacles or a terminal moraine, unless the heaps of gravel against the snout are the commencement of one.

The snout of the Rimo Glacier shown in Fig. 31 shows two small gravel ridges in front of the nearer tongue of ice but there are no dead pinnacles about and I can only say that I saw no general signs of retreat. In the photograph of the Mamostong glacier a small heap of moraine matter can be seen along the left side of the snout and the same heaps of shingle as are visible at the Chong Kumdun. It is

Fig. 25. Terminal pinncles of Kichik Kumdun Glacier shewing fresh shingle deposits.

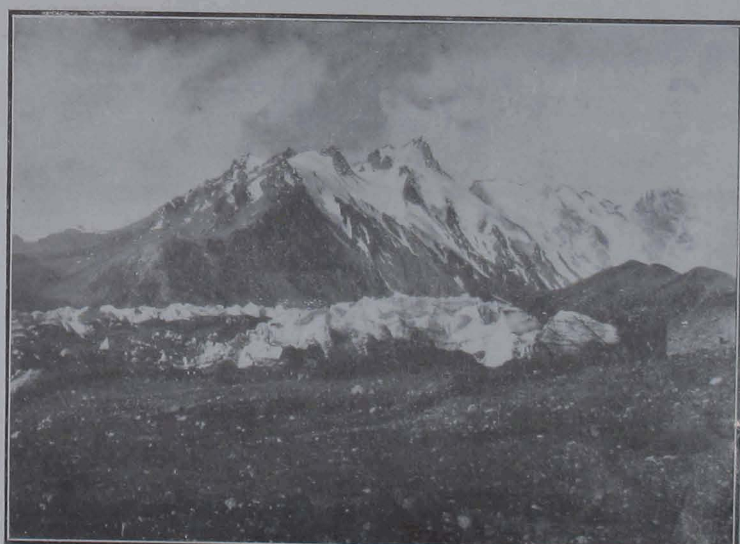


Fig. 26. Terminal pinacles of Kichik Kumdun Glacier.

Fig. 27. Terminal pinnacles of Kichik Kumdun near right lateral moraine.

Fig. 28. Kichik Kumdun snout from above with river bed at foot of Cliffs.

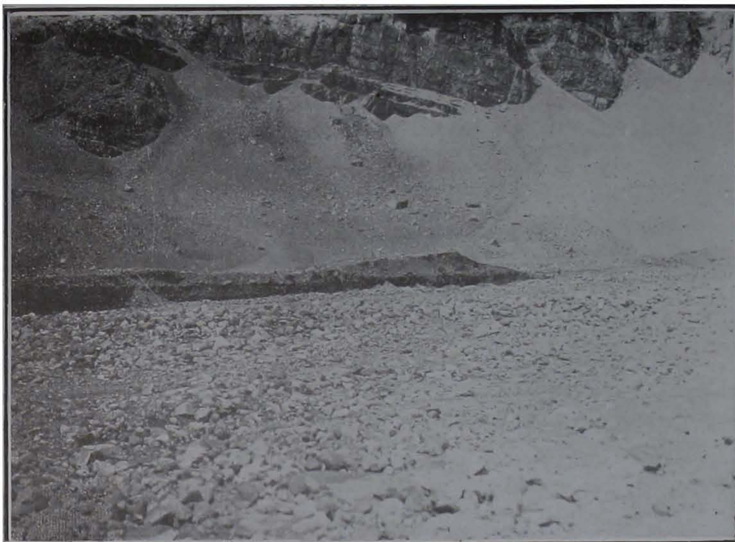


Fig. 29. Small heap of shingle at Chong Kumdun snout.

Fig. 30. Chong Kumdun glacier snout shewing tributary glacier and heap of shingle.

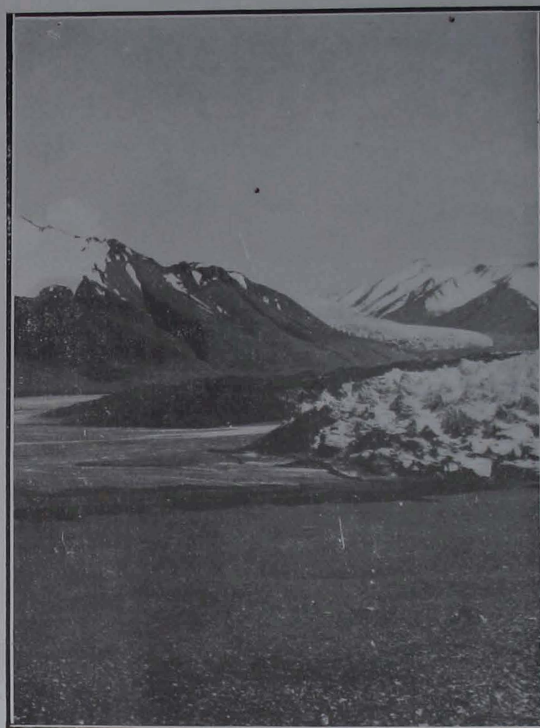


Fig. 31. Snout of Rimo, shewing small gravel ridges.

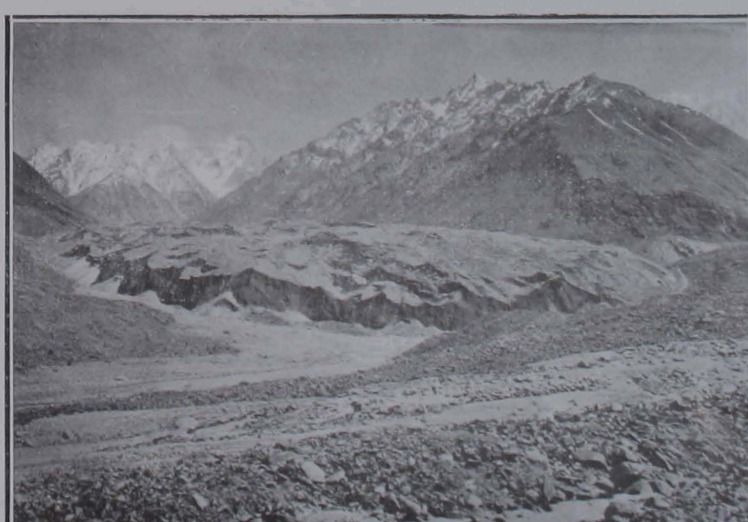


Fig. 32. Mamostong Glacier.

possible, however, that a small stream of water from the glaciers farther up the main valley may be eroding the ice at this place, but this idea only occurred to me later and I did not verify it at the time ; I can only put forward the photograph for some expert to deal with.

The shape and position of the break in the Chong Kumdun may afford some evidence too. To my mind the only possible explanation for the burst is a contraction crack and the fact that it burst in the early morning seems to confirm this idea. If this is so it is obvious that the ice in the valley of the glacier can have been exerting little, if any, force on the ice in the river bed.

I was informed by Mr. Visser that his investigations showed that the periods of glacial activity in Switzerland correspond with those in the Karakoram, and it is just possible that a detailed examination might bring out some information of use in foretelling the probable state of the Chong Kumdun early in the year before it is possible to cross the Sasir pass.

The conclusion I have arrived at is that for this group of glaciers, all of which have their snouts at altitudes between 15,000 and 16,200 feet, the period of advance has come to an end and that the smaller ones have begun a definite era of retreat, but so far as the larger ones are concerned the signs of retreat are not yet sufficiently definite for me to recognise, and I would not be in the least surprised if this winters' snowfall was sufficient to cause the Chong Kumdun to move forward and completely block the river once more.

CHAPTER III.

In this section I have concentrated my remarks on the hydraulic side of the expedition so that the results can be readily referred to when required.

Two different subjects are touched on, firstly, the prediction of effects at Attock of the water impounded by the Shyok dam and secondly, the general effect of turbulent flow on the conventional co-efficients used in flood discharge observations. The bursting of the dam once the volume of water impounded was known gave a unique opportunity of checking in a fashion, however rough, the assumptions that underlie all observations of flood discharges, and as such are worthy of serious consideration.

Shyok river.

To enable the nature of the Shyok river bed to be appreciated I have given longtitudinal sections at Sasir Brangsa and from Sati to Diskit and a rough plane table sketch of the course of the river in the latter reach in plates II to IV. The points at which the 1926 flood levels were observed along with their values are shown on the plane table sketch, the underlined values show the 1929 flood levels.

The cross sections at the gauge site, plate V, were taken along a line which I anticipated would be at right angles to the direction of the current during floods. I selected a site on the left bank above Khalsar for the gauge where a cliff rose straight out of the water. From our information it seemed that the water surface here was more or less level in the 1926 flood, but this year's flood which gave 28 feet cross slope at this point shows that either the nature of the flow was different or that our original information was incorrect. The latter is probably the case as no flood marks could be seen on the rock. The local inhabitant had no interest in that particular spot and probably drew on his imagination.

As can be seen from the cross sections, plate V, the river during the flood scoured its bed about nine and a half feet at the site of the gauge and concentrated the flow into one channel.

In the reach from Sati to Diskit the general slope of the water surface over a distance of about twelve miles is 3·75 feet per thousand feet or 18·75 feet per canal mile of 5,000 feet. In the upper reach above Sasir Brangsa the slope over about six miles is 8·20 feet per thousand feet or 41 feet per canal mile, while in one reach it drops fifty feet in half a mile. These mean slopes of 3·75 feet and 8·20 feet per thousand feet have been adopted in the calculations of discharges.

Cross sections of the Shyok between Sati and Diskit are reproduced on plates VI and VII as an indication of the general nature of the bed and explain why the seemingly open bed at the Shyok-Nubra confluence has such a slight effect on the flow.

The flow in floods is extremely turbulent and influenced largely by local conditions. I have therefore not attempted to draw a longitudinal section to show the high flood levels but have indicated the position of observed points with their values. It will be seen from the sketch on plate IV that the floods of 1926 and 1929 varied greatly in height over a comparatively short distance.

Flood levels.

Taking the right bank of the river, where the marks of the 1926 flood were in general better defined, half a mile above the gauge the 1929 flood was 18 feet higher than that of 1926, at the gauge it was only 8·47 feet higher, while six miles further down in the region of Thirit differences of 46·2 feet and 47·19 feet were observed, as the levels were followed up the Nubra towards Teggur the difference gradually fell off to 16·48 feet.

It will be seen from these figures that it is impossible to compare the magnitude of any two floods by a comparison of their maximum levels observed at any one place. Without some such observations it is almost impossible to conceive the irregularity of flow that occurs during floods, and I am of the opinion that no gauge set up in the Shyok can give a quantitative prediction of the effect at Attock.

Flood travel.

The rate of travel of the floods of 1926 and 1929 is given in the table below. The distances have been scaled off the latest available ¼″ maps while the times have been obtained by local enquiry and can only be taken as approximate. The same information is plotted on plate VIII and shows a fairly satisfactory agreement between the data. This plate also shows the mean velocities and velocities as calculated in table 3 for certain points. The actual times from the warning gauge at Khalsar to Attock were approximately fifty-six hours for the 1926 flood and fifty-nine hours for the 1929 flood.

TABLE 1.

Serial No.	Particulars.	No. of miles (distance travelled).	No. of hours.	Velocity in miles per hour.	Velocity in feet per second.	Mean velocity in feet per second.
	Flood 1929.					
1	Sasir Brangsa to Khalsar	130	22	5·91	8·67	12·31
2	Khalsar to Skardu ..	165	16	10·31	15·12	
3	Skardu to Bunji ..	96	14	6·857	10·06	
4	Bunji to Attock ..	289	29	9·965	14·62	
		680	81			
5	Attock to Kalabagh ..	99	8½	11·65	17·08	
	Flood 1926.					
1	Diskit to Skardu ..	153	16	9·56	14·03	14·47
2	Skardu to Bunji ..	96	8	12·0	17·60	
3	Bunji to Chilas ..	47	5½	8·55	12·53	
4	Chilas to Attock ..	242	25	9·68	14·20	
		538	54½			

Gapshan Lake.

It is not practicable to reproduce the map of the lake to original scale but plate IX shows a reduced map on a scale of 1″ to a mile as surveyed. The contours can not be reproduced but the lines on which soundings were taken are shown together with the level of the bottom, plate X shows the area at each contour plotted as a curve and the table shows the actual areas together with the volumes between successive contours and the total volume up to any contour, this last quantity is also shown on the diagram as a curve.

From observations taken during our stay at the lake we found the total rise, which was nearly uniform, was 5·9 feet in 211 hours giving a daily inflow of 6,581 foot-acres per day. The total volume in the lake was 1,095,500 foot-acres.

To get an approximation to the rate of inflow in a year I made certain assumptions. I had taken that the burst in 1926 occurred late and that there would be no more melting that year, or rather that the dam reformed before the melting in 1927 began, and that there was no water left after the 1926 burst. Also I neglected evaporation and absorption and assumed that the water in the lake was the result of three years' melting. This gave an average annual inflow of 365,000 foot-acres.

To check these assumptions I referred to Mr. Ludlow who stated that, at the time of his visit in 1928, a slight fall of snow occurred on the first night he reached the lake and that the next two days were abnormally hot ; he considered that the inflow was probably above the normal ; his estimate of the rate of rise was about 1½ foot per day for the two days he was there. It was almost exactly a year later that we visited the lake so that at the time of Mr. Ludlow's previous visit the volume in the lake would probably be 730,000 feet-acres. From the curves this gives the level of the water as 15,850 and the area about 7,300 acres. This gives a rise of 0·9 feet per day for normal inflow. Considering the difficulty of estimating a rise in water level, and the light snowfall followed by abnormal heat, I consider that we may accept the figures and presume that the assumptions are correct.

To get some idea of the variation in the rate of inflow I have based an estimate on the discharge of the river at Khalsar. The river above Khalsar is almost entirely glacier fed but in the early part of the year much water will come from the snow melting. As the flood scoured the bed down low at the gauge site the discharges for a whole year are not available. I have however plotted on plate XI a curve of the monthly mean maximum temperatures at Leh and Dras, both a mean of years and this year's mean, and also on the same time scale a curve of discharges at Khalsar. By assuming that the general shape of the discharge curve will conform to the temperature curve, I have taken the mean daily discharge for each month at Khalsar and assumed that the inflow into the lake occurred in the same proportion. The results are given in the table below, from which it is possible to forecast roughly what the level of the water in the lake will be in any month when one observation of the water level is available in any year.

TABLE 2.

Month.	Assumed discharge at Khalsar, cusecs.	Assumed monthly inflow at Lake, foot-acres.
June	1,000	5,183
July	22,000	114,610
August	35,000	182,600
September	12,000	62,514

As the main object of the expedition was to ascertain the probable effect at Attock of a flood from the Shyok, I devoted some time to trying to get a calibration curve for the Khairabad gauge situated a mile and a half above Attock Bridge. The only data available from which this could be done were the daily discharges observed at Kalabagh a hundred miles below Attock. These observations are made with current meters, observing the mean velocity in low supplies and surface velocities in high supplies, while surface floats are used when the discharge is very big and velocities too high to enable a boat at anchor to remain steady.

Attock gauge.

Owing to the river bed at Attock silting and scouring it was not possible to get any results from points that were not selected with care, but after allowing for time-lag and selecting points when the river discharge was steady and conditions generally indicating no abnormal silt I derived the formula

$$\log Q = 0{\cdot}805 \log G + 4{\cdot}3014$$

for Khairabad. The range of observations for which this appeared to hold is between gauges of 5 feet and 30 feet with discharges of 70,000 cusecs and 300,000 cusecs respectively. From this I plotted a timedischarge curve from the observations available, plate XII, for Khairabad.

I also endeavoured to find a similar relation for the Attock Bridge gauge but the channel section is not so uniform there and I could get no satisfactory curve.

Like all empirical formulae this discharge equation needs to be applied with care and can only be expected to hold for a certain state of the river.

The Indus had been running with a discharge of 200,000 to 300,000 cusecs from the middle of July and had reached over 400,000 cusecs on the 2nd August at Kalabagh falling to 200,000 on the 11th and had only increased slightly to 237,000 on the 17th, from which one would expect a certain amount of silt to have been deposited and not removed up to the 17th by the gradual rise of the river. That this discharge is below the formula discharge was only to be expected. The deposit however would readily be moved by the rapidly rising flood and I have adopted the formula discharges for the rising river and peak discharges. On the falling river silt must again have deposited, and so long as the formula gave a fairly uniform rate of fall in discharge I have adopted these discharges ; but from 8 A. M. on the 20th I have adopted lower discharges following approximately the same rate of fall, as the comparatively sudden change in slope of the curve indicated that silt was depositing.

I have taken as the Indus component of this flood 237,000 cusecs as that discharge was measured at Kalabagh on the 17th and 22nd and brought the time-discharge curve for Attock to this value on the 21st to allow for time-lag. There was little rain during the 19th and 20th anywhere in the Indus Valley but after the 21st a gradual rise set in, and perhaps the discharge on the closing day gives the Indus credit for a slightly larger quantity of water than it should.

Treated by this method however, the total run-off in three days at Attock due to the Shyok dam bursting comes to 884,300 foot acres as compared with 1,095,500 feet acres in the lake. In the case of the similar flood in 1926 approximately 10 per cent. of the total run off, as ascertained from the records of the Discharge Division, occurred after the third day, but in the case of this flood the river started to rise due to rain and no proper account can be kept of the Indus component after the third day. The agreement between the calculated run-off at Attock and the quantity in the lake is reasonably close and would show that the formula gives reasonably close results for flood peaks, and the extension of the formula beyond the range of observations seems justified.

The only way which I see of making any estimate of the effect at Attock of a burst in the Shyok dam depends on the use of this discharge diagram. From the diagram it appears that approximately a quarter of the total volume in the lake passed Attock with a fairly uniform discharge in twelve hours, the dotted lines show the twelve hours interval. And from this it would appear possible to estimate the Attock discharge from the volume of the lake, within reasonable limits

The following method was adopted in preparing a diagram for predicting the heights to which a flood from the Shyok dam might raise Attock Gauge. One quarter of the total volume of the lake is presumed to pass Attock at a uniform gauge in twelve hours as that is what the time discharge curve for this flood shows, that is, one quarter of the volume in foot-acres gives the discharge at Attock in cusecs.

It is also assumed that, no matter what the amount of silt in the bed of the river before a flood is, in high flood the silt is scoured out and the formula gives the discharge passing. The standard discharge for various gauges at Attock was then calculated, to these were added successively the expected {flood} discharges from the lake and the corresponding gauges calculated. To allow for the effect of local heading up a margin of five feet was added to the calculated gauges. Then taking the gauges before the flood as abscissae and the maximum flood gauge as ordinates curves for each depth of water in the lake were drawn. See plate XIII.

To allow for the probable departure from the standard formula discharge three more scales are shown. These correspond to states of the river when two, four and six feet gauge above the standard are required to give the formula discharge. The Executive Engineer, Discharge Division, can tell at any time which scale should be employed.

The method of using the curve is simple. On being informed which scale of abscissae is to be used, the intersection of the ordinate through the gauge reading of the day and the curve of lake level gives the height to which the Attock Gauge may be expected to rise.

I do not consider this method of flood prediction very satisfactory owing to the vast number of uncertain factors involved but at least it will give some guide. Also as the level of lake this year was within a small distance of the maximum traceable lake level it is unlikely that a greater effect will ever occur at Attock.

Hydraulic Formulae

The following paragraphs deal with certain aspects of turbulent flow and give some guides for experimental investigations that may be valuable where not actual flood levels, but volumes passed, are under consideration.

With a view to ascertaining, if possible, how far the formulae for smooth flow could be adapted to flood conditions by a modification of the constants, I examined such data as were available at various sites and made use of the fact that the volume in the lake was known.

The data for the upper reaches of the Shyok are unsatisfactory from the point of view of any great accuracy but even then they give valuable indications.

At Sasir Brangsa it was possible to obtain fairly satisfactory cross sections as the ice had left berms at various points, but the man, who is stationed there to conduct caravan across the ford, could not give any reasonable idea of the times at which these levels occurred. On the 18th he stated originally that the dam had broken on the 14th instead of the 15th, and I am very doubtful altogether of the times at which he states the levels occurred.

At Khalsar the times were probably more or less accurate as far as could be judged but only levels on the left bank at the gauge could be got with any accuracy as no marks were visible on the right bank.

At Skardu levels were read off the gauge and times taken with a watch but as the gauge was washed away the rate of fall below 25 feet is conjectural.

Unsatisfactory as these data are, the results of calculations indicate that the conventional coefficients in the usual formulae are far from correct for turbulent flow such as occurs in floods.

The method of examining the data was based on Manning's formula $V = \frac{1{\cdot}486}{n} \times S^{\frac{1}{2}} R^{\frac{2}{3}}$ in which n has the same value as in Kutter's formula. I assumed that the portion $\frac{1{\cdot}486}{n} \times S^{\frac{1}{2}}$ remained constant for each site throughout the flood. Then from the observed cross sections shown in plates V, XIV, XV, the area and hydraulic mean radius were calculated for each stage. The Attock and Kalabagh data were given by this discharge division.

The discharge for each stage is given by—

$$Q = A \times R^{\frac{2}{3}} \times \frac{1{\cdot}486}{n} \times S^{\frac{1}{2}} = K\,A\,R^{\frac{2}{3}} \text{ say.}$$

Plotting the quantity $A\,R^{\frac{2}{3}}$ as ordinate on a time basis the area of the curve when multiplied by the factor K, assumed constant for each site, gives a cusec-time quantity which is readily convertible to foot acres.

By equating the volume of the lake in foot-acres to this quantity the value of K is easily determined. In the diagram shown on plate XVI one square is equivalent to 8 × 200,000 K cusec-hours or $\frac{8 \times 200{\cdot}000 \times 2}{24} \times K$ foot-acres.

In the case of Skardu, Attock and Kalabagh a correction was applied for the amount of water already in the river when the flood came down, but in the case of Sasir Brangsa and Khalsar the time of passing the flood was short and the initial discharge small and no correction was made.

At Skardu the discharge of the Indus was estimated by assuming n='030 and working out the initial discharge from the cross section, hydraulic mean radius and slope at Attock and Kalabagh the correction taken was the measured discharge of 237,000 cusecs.

A table is given below showing the quantities for the various sites, the calculations for each site are shown in detail in Appendix E, see also plate XVI.

TABLE 3.

Serial. No.	Sites.	Slope per thousand.	Area.	H.M.R.	K.	Discharge.	n.	Mean Velocity $R^{\frac{2}{3}} \times K$
1	2	3	4	5	6	7	8	9
1	Sasir Brangsa	8·2	133,400	54·67	0·82	1,574,120	0·1651	11·8
2	Khalsar	3·75	104,896	48·00	1·05	1,454,900	0·0872	13·87
3	Skardu	2·00	57,300	25·80	2·009	1,005,000	0·0332	17·54
4	Attock	0·29	51,875	58·50	0·815	637,020	0·0315	12·28
5	Kalabagh	0·50	32,658	30·10	1·57	496,400	0·0212	15·20

These variations in " n " are remarkable from the range of values obtained, a certain variation was to be expected but these variations would indicate that turbulence has an effect vastly in excess of what was expected.

During this flood certain observations were taken at Attock and calculations made on the usual departmental lines to determine the maximum discharge. Owing to the sudden nature of the flood the observers were only able to obtain four surface velocities from floating logs. Then calculating from a previously observed cross section and applying a factor of 0·9 to reduce the observed velocities to mean velocities a discharge of 841,000 cusecs was calculated. Again working from an assumed value of Kutters " n " of ·025 and the previously observed cross section a discharge of 755,000 cusecs was calculated, against a maximum of 511,300 given by the formula.

If either of these values be accepted as the maximum then the run off at Attock would be vastly in excess of the volume of water contained in the lake. From this it can be seen that the co-efficients in general use for flood discharges are open to grave doubts. However in the absence of any other formulae it is necessary to see what constants are desirable to bring the calculated results more in accordance with the actual discharges.

Some light may be thrown on the question by the examination of the discharges at Attock. By this method of calculation a value of n= ·0315 is obtained, while a calculation of the discharge based on a cross section and slope of the river with a value of n=·043 gives a discharge of 5,10,917 which is very close to the discharge given by the logarithmic formula. The difference between these two values of " n " is not hard to explain, the increase is due to turbulence and as turbulence increases so the value of " n " rises to a maximum of ·043 while the value of ·0315 is an intermediate value between the maximum and the ordinary value of n=·020. This implies as might be expected that the coefficient K is not a true constant for the whole range of the flood at any site but varies with the degree of turbulence. This indicates that the values of " n " tabulated for the various sites are not absolutely the maximum values, but some intermediate value. The value of ·0872 for Khalsar is vastly in excess of the value of ·030 obtained from a discharge at low water.

Nearly all the discharges of rivers and torrents in heavy flood depend on surface velocity observations and here again a check on the conventional coefficient of 0·9 is afforded by the calculated discharge at Attock.

Taking the discharge given by the logarithmic formula as correct a mean velocity of 9·86 feet/second is deduced from the area of the cross section, against a mean velocity of logs observed as 18·02 feet/second and from this it appears that the coefficient used in the discharge 0·9 should be 0·55. It must be carefully noted however that the velocity of logs is not a true surface velocity, far from it, however as long as the only practicable way of observing flood velocities is by timing objects floating past it would seem desirable to reduce the coefficient.

Nearly all our observations of daily discharges in high rivers depend on surface velocities and it would appear imperative to carry out some investigations to ascertain more exactly the relation between surface velocities and mean velocities in turbulent motion. I do not consider the results given above to be sufficiently accurate to justify the adoption of these coefficients without further enquiry, but I consider that no storage project should be entered into till some further information is available on these points.

APPENDIX A.

Skardu Gauge.

While at Leh a telegram was received from the Chief Engineer stating that the gauge at Skardu was reported to be damaged and instructing us to see what could be done to put this right. I consulted the Tehsildar, Leh, who had been transferred from Skardu only a few months previously, as well as the Wazir Wazirat, who has his winter headquarters at Skardu. Both these officers knew the gauge well and on their information I decided to send B. Abdul Rahim to carry out the necessary work.

When B. Abdul Rahim arrived at Skardu he found that the wooden portion of the gauge up to 25 feet had been washed away, and he marked out the gauge on the rock below this level down to 11 feet. He also arranged with the Kashmir State Public Works Department engineer to carry on this graduation downwards as the water fell.

A cross section of the river at Skardu gauge site was also taken and is shown in plate XV.

After completing this work B. Abdul Rahim reached Srinagar on September 29th.

APPENDIX B.

Flood Warnings.

As already mentioned the system for conveying warning of a flood in the Shyok due to a burst of the Chong Kumdun dam depended on a gauge reader at Khalsar and three pairs of dak runners, one of each pair had always to be present at his post. To avoid any delay in conveying the warnings horses were to be provided for the dak runners in the event of a burst.

To get the system into working order the gauge reader at Khalsar sent off postcards with gauge readings to the Executive Engineer, Discharge Division, by one of the runners, while the other had to remain at his post. It was arranged that in the event of a flood the gauge reader should send a special letter to the Wazir Wazirat, Leh, stating at what time the flood began to rise, the height reached on the gauge and the time during which the water remained at this highest reading.

The necessary authority was issued for the Wazir Wazirat to send " clear the line " telegrams to the Punjab Government regarding any flood.

The system worked satisfactorily when the flood came at 8 A. M. on the 16th ; information reached Leh in twelve hours the messengers having started from a height of 10,000 feet, crossed a pass 17,600 feet high and dropped down to 11,500 feet at Leh in a distance of 37 miles, and the warning wire from Leh was delivered in Simla at 6-15 A. M. on the 17th.

While the warning system worked satisfactorily this year the danger of relying solely on these measures to communicate with Leh lies in the fact that the Khardung pass is frequently closed for two or three days at a time due to storms even during the height of summer. It is even more undesirable to employ a system of bonfires or other visual signals over the pass as quite frequently clouds gather on it for days on end though there may be no heavy precipitation.

I therefore strongly recommend that a duplicate warning be arranged for from Skardu. The flood reached Skardu very few hours after this year's warning reached Leh and the two wires should arrive at almost the same time.

I recommend that the following works should be undertaken as soon as possible next year so as to facilitate the prediction of the amount of water in the lake and also to give some idea of the size of any future flood.

At the lake itself I recommend a series of cairns suitably marked be erected at each fifty and hundred foot contour level working from the bench mark fixed by the party this year. These should so far as possible be erected along some even slopes in straight lines and a section of the ground supplied to the Punjab Government so that it may be possible for any one in future to report that the water level was so many paces from a certain cairn, on receipt of this information the water level could be derived from the section. This would enable the volume of water to be estimated from the curve in plate X.

At Khalsar the rock is rough, and I do not anticipate that after a few years the marks made this year will remain visible. I therefore recommend that the gauge at Khalsar be properly dressed in a smooth strip, graduated by feet and quarter feet from as far as possible below this year's zero up to a 10 foot reading after this only feet need be graduated up to a level about five feet above this year's flood level.

These works could be readily done by the Kashmir State Public Works Department who have an overseer at Leh.

Then in any year in which it is reported that the dam exists a gauge reader and dak runners should be engaged to work between Khalsar and Leh, and a man despatched to the lake as soon as the Sasir pass is open to report the water level in the lake and the state of the glacier.

I do not consider it necessary to wait for any information about the duration of the flood peak in future as even the maximum gauge reading cannot be relied on for a prediction and the height of the flood peak at Attock is determined from the volume in the lake. The orders for the gauge reader would be to report the time at which the gauge began to rise and the height to which it rose.

At the same time I recommend that the Skardu gauge be read and reported regularly in future.

The necessary authority should be arranged for the Wazir Wazirat and Tehsildar Skardu to send " clear the line " messages to the Punjab Government about any flood. The duplicate warning is necessary as the Khardung pass may be blocked, or the telegraph line to Skardu may be out of order as was the case this year.

APPENDIX C.

1929 Flood Rises.

Sasir Brangsa.

The dam broke in the early hours of the 15th August, and the flood reached Sasir Brangsa, 10 miles below the dam, at about 6 A.M., it rose 85 feet in four hours to about 10 A.M. and remained at this level till about 11 A.M. After this the water gradually subsided and fell 52 feet in six hours to a level 33 feet above the morning gauge by 5 P.M. After this the fall was very slow and in 24 hours the fall was nine feet, that is according to the statement of the man in charge of the ford, and on the 16th at 5 P.M. the water was still 24 feet above its initial level, while on the 17th morning the level was little above normal.

Khalsar.

The flood reached Khalsar about 8 A.M. on the 16th August, and rose 45 feet from a gauge of 8 feet to 53 feet in about half hour, it remained at this level up to 10 A.M. and then rose suddenly 18 feet to a gauge of 71 feet at which level it remained till 3 P.M. giving a total rise of 63 feet. After this it dropped 50 feet in an hour to a gauge of 21 feet and continued to fall and by the 17th morning the water was 9½ feet below its original level on the 16th.

I am of the opinion that the sudden rise at 10 A.M. and fall at 3 P.M. of the gauge was due to movement of a large shingle bar.

Skardu.

The flood reached Skardu at 8-30 P.M. on the 16th, the gauge being 17 feet at 6 P.M. By 9 P.M. the gauge had risen 8 feet in half an hour to a gauge of 25 feet ; it reached its peak of 42 feet at midnight having risen 17 feet in 3 hours. The water remained at this level up to 3 A.M. on 17th, after which it dropped 7 feet in 4 hours and stood at a gauge of 35 feet at 7 A.M. The gauge was carried away but the fall continued, and it is estimated that the gauge was about 19 feet at 7 P.M. on the 17th.

Bunji.

According to information received from the Resident in Kashmir the flood reached Bunji at 5 A.M. on 17th August and rose (presumably from 7 feet) to 31 feet at 8-10 A.M. and reached its peak of 44 feet at 1-45 P.M. At 7-50 P.M. it subsided from 44 feet to 34 feet and early in the morning of 18th August it fell to 19 feet finally falling to 7 feet at mid-day.

Attock.

On the evening of 17th August the Attock gauge was 27·5 feet, the flood arrived at 2-15 A.M. on 18th August and rose 16·5 feet to a 44 feet gauge by 8 A.M., by 11 A.M. it had risen a further 6 feet to a gauge of 50 feet and by 2 P.M. it had risen a further 4·5 feet to a gauge of 54·5 feet. The peak of 56 feet was reached at 6 P.M. giving a total rise of 28·5 feet in about 16 hours. The gauge remained steady at the peak for about 2½ hours and then began to fall, reaching a gauge of 50 feet at 6 A.M. on 19th August. It fell 4½ feet by 11-30 A.M. and by 5-30 P.M. had fallen to 40 feet. The fall then became more gradual and the gauge of 28 feet was reached at 8 A.M. on 21st August.

APPENDIX D.

Flood Levels at Attock.

The observations of flood levels taken this year showing the Shyok flood on the 18th August as well as the flood on the 28th August are shown in plates XVIII to XXI, while an index plan showing the position of the cross sections is shown on plate XVII.

The levels of the flood of 1841 are also shown on the plates for purposes of comparison. Taking into consideration that the volume impounded by the dam this year was very nearly the maximum ever held up it is obvious that the menace from the Shyok is not so great as had been anticipated.

A certain amount of heading up occurred at Attock due to the Shyok flood, but this was not of long enough duration to affect the Kabul river very far up, while the rain flood had a very much greater effect.

It can be clearly seen that no rain flood could produce levels equal to the flood of 1841.

The flood in 1841 was due to a block at the Hatu Pir spur of Nanga Parbit. A portion of the hillside fell into the river bed and completely blocked the Indus for about six months. When this dam broke a tremendous volume of water was let loose. It is only from some similar catastrophe that the levels of 1841 could again be reached.

APPENDIX E.

Calculation of Hydraulic Constants.

Sasir Brangsa.

The table below shows the various quantities got from the cross section and the product $AR^{\frac{2}{3}}$ for Sasir Brangsa. :—

	Area.	W. P.	H.M.R.	$R^{\frac{2}{3}}$	$A \times R^{\frac{2}{3}}$	Slope per thousand.
Stage 1	133,400	2,440	54·67	14·4	1,920,960	8·2 or S=·0082
,, 2	26,220	1,270	20·65	7·52	197,174	
,, 3	16,460	980	16·79	6·55	107,813	

The quantity $AR^{\frac{2}{3}}$ is plotted on a time basis. Taking 8 hours per inch and 200,000 per inch as the unit for $AR^{\frac{2}{3}}$.

The area of this figure comes to be 10 sq. ins. Then area in sq. ins. $\times 2 \times K \times \frac{8}{24} \times 2 =$ lakhs of foot acres in lake.

$$\frac{10 \times 4}{3} K = \text{Volume of lake in lakhs of ft. acres.}$$
$$= 10{\cdot}95$$
$$\therefore K = 0{\cdot}82$$
$$\text{and } 0{\cdot}82 = \frac{1{\cdot}486}{n} \times S^{\frac{1}{2}}$$
$$= \frac{1{\cdot}486}{n} \times {\cdot}0082^{\frac{1}{2}}$$
$$n = 0{\cdot}1651$$

and mean velocity $= R^{\frac{2}{3}} \times K = 14{\cdot}4 \times 82. = 11{\cdot}8$ ft./sec.
and peak discharge $= A \times V = 133{,}400 \times 11{\cdot}8$
$= 1{,}574{,}100$ cusecs.

Khalsar.

Calculations of Shyok Flood Discharge at Khalsar.

	Area.	W.P.	H.M.R.	$R^{\frac{2}{3}}$	$A \times R^{\frac{2}{3}}$	Slope per thousand.
Stage 1	86,022	2,167	39·69	11·63	100,436	3·75 or S=·0038
,, 2	104,896	2,185	48·00	13·21	1,385,676	
,, 3	32,575	1,724	18·89	7·09	230,957	
,, 4	..	..	..	..	11,604	

Area of $(A \times R^{\frac{2}{3}}) \times 2 K \times \frac{8}{24} \times 2 =$ foot acres in lake
Area by diagram $= 7{\cdot}80$ sq. inches.
$\therefore 7{\cdot}8 \times \frac{4}{3} K = 10{\cdot}95$
or $K = 1{\cdot}05$

and as $K = \frac{1\cdot486}{n} \times S^{\frac{1}{2}}$

$\therefore \quad 1\cdot05 = \frac{1\cdot486}{n} \times \cdot0038^{\frac{1}{2}}$

$\therefore \quad n = 0\cdot0872$

and mean velocity $= R^{\frac{2}{3}} \times K = 13\cdot21 \times 1\cdot05 = 13\cdot87$ ft./sec.

$\therefore$ Discharge $= A \times V = 104{,}896 \times 13\cdot87$

$= 1{,}454{,}900$ cusecs.

In the original drawing from which these calculations were made the scales used for Skardu, Attock and Kalabagh were 1″ = 8 hours and 100,000 = 1″ for the A $R^{\frac{2}{3}}$ scale, but they were replotted to the same scales as Khalsar and Sasir Brangsa on plate XVI for purposes of comparison.

Skardu.

In the cases of Skardu due allowance must be made for the water already in the river.

To estimate this calculations for stage 4, *i.e.* a gauge of 17 ft. were worked out assuming a value of n = 0·030.

$$Q = A\,V = A \times \frac{1\cdot49}{n} \times S^{\frac{1}{2}}\,R^{\frac{2}{3}}$$
$$= 14{,}670 \times 11\cdot30$$
$$= 165{,}771 \text{ cusecs.}$$

As the period of passing of the flood was 48 hours the volume passed by the normal river supply is 165,800 × 4 foot acres = 6·63 lakhs of foot acres.

The quantities in the table below were then plotted on a time base.

	Area.	W.P.	H.M.R.	$R^{\frac{2}{3}}$	$A \times R^{\frac{2}{3}}$	Slope per thousand.	Remarks.
Stage 1	26,110	1,605	16·27	6·42	167,626	2·0	
„ 2	57,300	2,220	25·81	8·73	500,229	or S= ·0020	
„ 3	43,710	2,370	18·44	6·98	305,096		
„ 4 .. .. with gauge 17 ft.	14,670	1,288	11·4	5·07	74,377	..	Flowing at normal conditions

Then K × area of curve × $\frac{2}{3}$ = Volume in lake.
+ *volume in river for 2 days.*

or $13\cdot2 \times \frac{2}{3} \times K = 10\cdot95 + 6\cdot63$

i, e. $K = 2\cdot009$

since $K = \frac{1\cdot486}{n} \times S^{\frac{1}{2}}$

$2\cdot009 = \frac{1\cdot486}{n} \times \cdot0020^{\frac{1}{2}}$

$n = 0\cdot0332$

and mean velocity $= R^{\frac{2}{3}} \times K = 17\cdot54$ ft./sec.

and discharge $= AV = 57{,}300 \times 17\cdot54$

$= 1{,}005{,}040$ cusecs.

Attock.

In the same way for Attock assuming that the water in the river is 237,000 as measured at Kalabagh and plotting the curve from the observations in the table below the following results are obtained.

Area.	H.M.R.	$R^{\frac{2}{3}}$	$A \times R^{\frac{2}{3}}$	Slope per thousand.
51,875	58·5	15·07	781,756	0·29
49,437	56·5	14·72	727,713	
45,369	52·5	14·02	636,073	or S = ·0003
41,283	49·1	13·41	553,605	
33,376	41·0	11·89	396,841	

Area of curve $\times K \times \frac{8}{24} \times 2 =$ Volume in lake + volume in river.

$$\text{or } 38{\cdot}32 \times \tfrac{2}{3} \times K = 10{\cdot}95 + \tfrac{50}{24} \times 2 \times 2{\cdot}37$$

$$\text{or } K = 0{\cdot}815$$

$$\text{and } K = \frac{1{\cdot}486}{n} \times S^{\frac{1}{2}}$$

$$\text{or } n = \frac{1{\cdot}486}{0{\cdot}815} \times {\cdot}0003^{\frac{1}{2}} = 0{\cdot}0315$$

$$\text{and mean velocity} = R^{\frac{2}{3}} \times K = 15{\cdot}07 \times {\cdot}815 = 12{\cdot}28 \text{ ft./sec.}$$

$$\text{Discharge} = A \times V = 51{,}875 \times 12{\cdot}28 = 637{,}020 \text{ cusecs.}$$

Kalabagh.

For Kalabagh making the same assumption as before regarding the water in the river, the area of the curve plotted from the data below is 2·14 sq. ins.

Area.	H.M.R.	$R^{\frac{2}{3}}$	$A \times R^{\frac{2}{3}}$	Slope per thousand.
29,737	28·61	9·35	278,041	0·5
30,867	29·40	9·53	294,163	or S = ·0005
31,819	29·87	9·63	307,517	
32,658	30·10	9·68	316,129	

Area $\times K \times \frac{2}{3} =$ volume in lake + volume in river.

$$21{\cdot}4 \times \tfrac{2}{3} \times K = 10{\cdot}95 + \tfrac{58}{24} \times 2 \times 2{\cdot}37$$

$$K = 1{\cdot}57$$

$$\text{and } K = \frac{1{\cdot}486}{n} \times {\cdot}0005^{\frac{1}{2}}$$

$$\text{or } n = \frac{1{\cdot}486}{1{\cdot}571} \times {\cdot}0005^{\frac{1}{2}} = 0{\cdot}212$$

$$\text{and mean velocity} = R \times K = 9{\cdot}68 \times 1{\cdot}57 = 15{\cdot}20 \text{ ft./sec.}$$

$$\text{and discharge} = A \times V = 32{,}658 \times 15{\cdot}20 = 496{,}400 \text{ cusecs,}$$

PLATE 1.

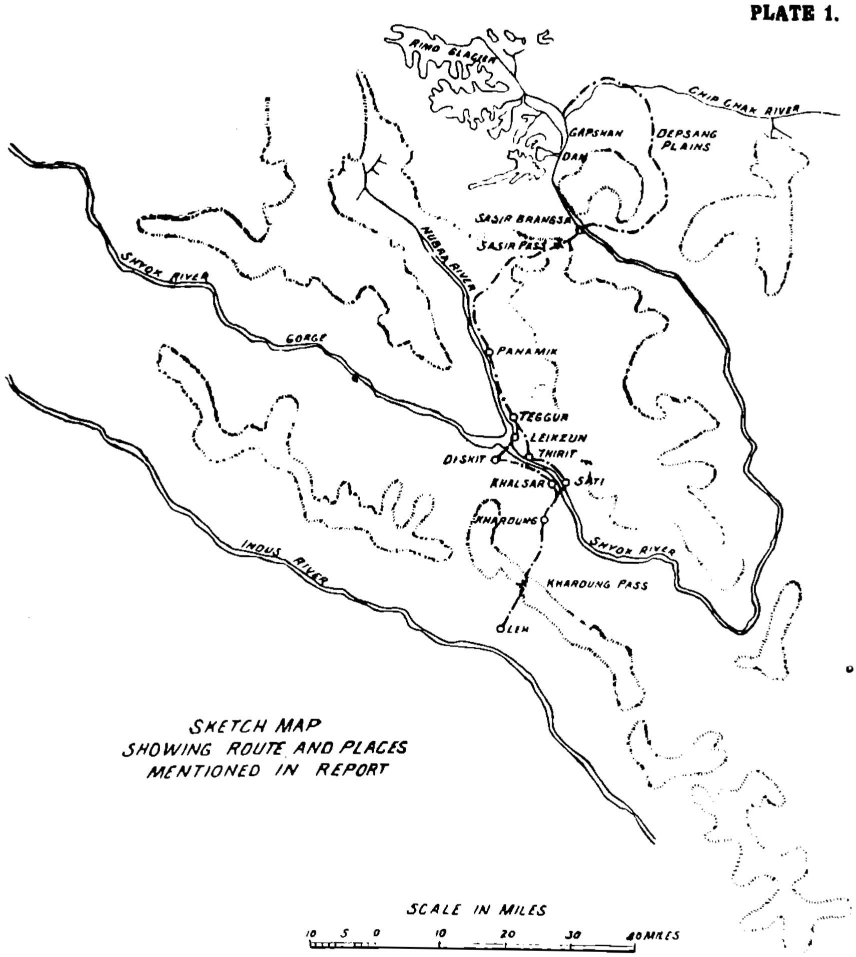

RIMO GLACIER
CHIP CHAK RIVER
GAPSHAN
DEPSANG PLAINS
DAN
SASIR BRANGSA
SASIR PASS
NUBRA RIVER
SHYOK RIVER
GORGE
PANAMIK
TEGGUR
LEIKZUN
THIRIT
DISKIT
KHALSAR
SATI
KHAROUNG
SHYOK RIVER
INDUS RIVER
KHAROUNG PASS
LEH
SKETCH MAP
SHOWING ROUTE AND PLACES
MENTIONED IN REPORT
SCALE IN MILES
10 5 0 10 20 30 40 MILES

PLATE III.

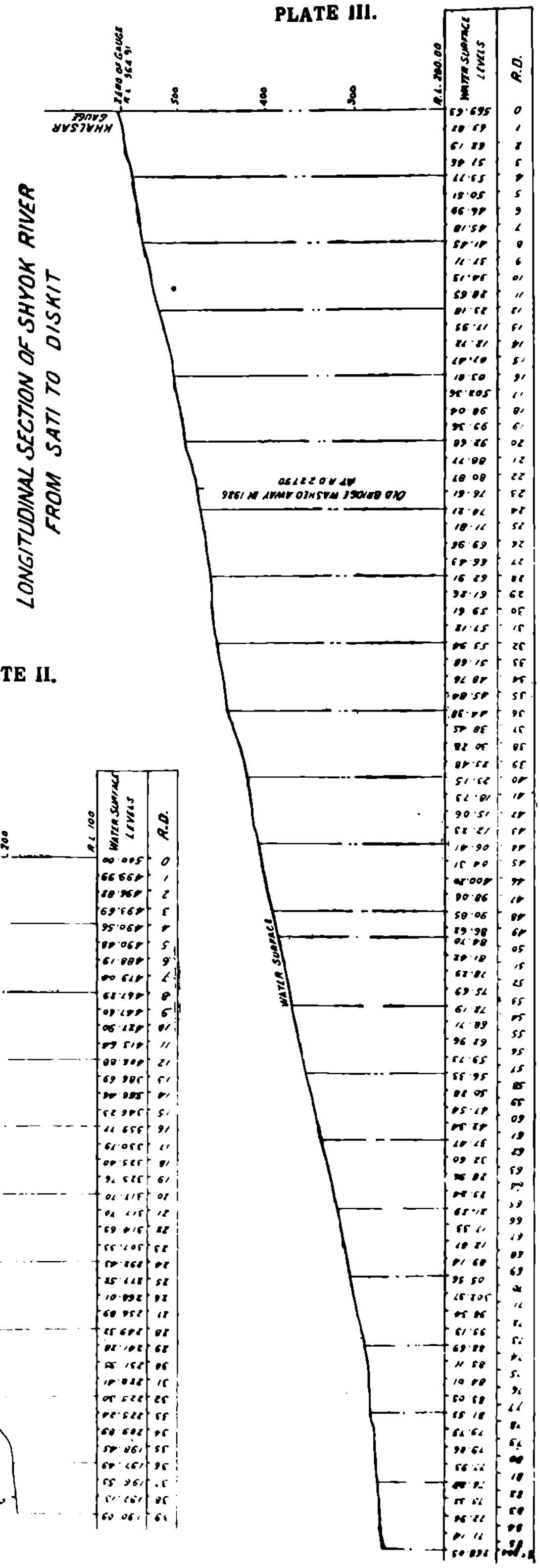


PLATE II.

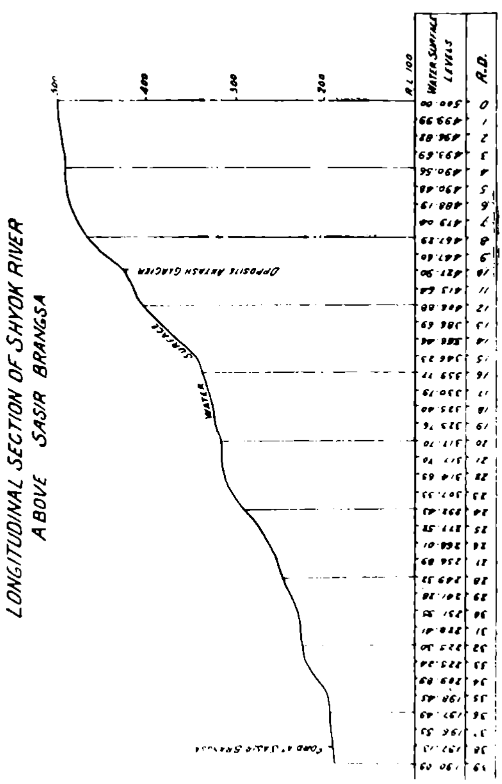


PLATE IV.

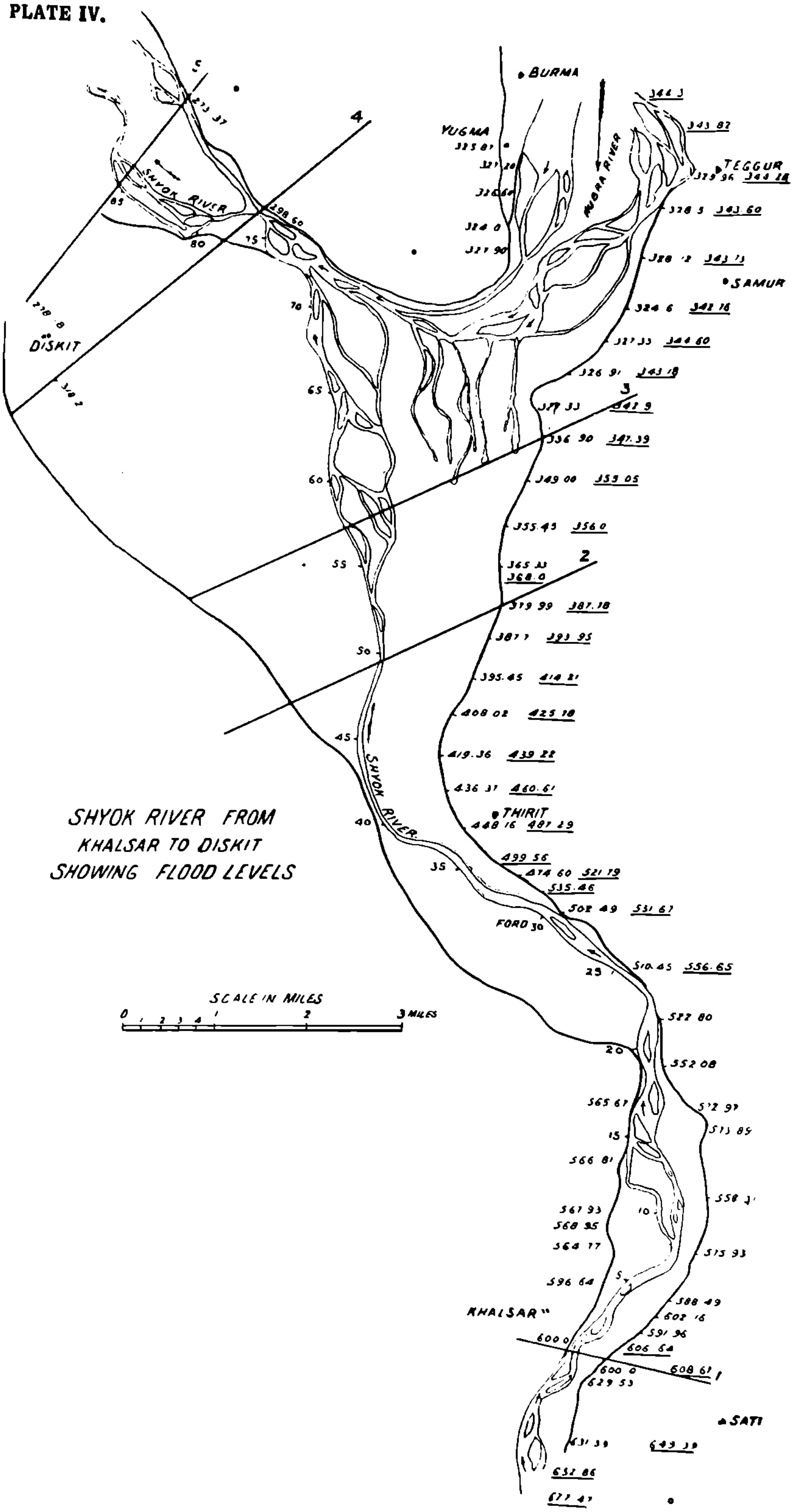

SHYOK RIVER FROM
KHALSAR TO DISKIT
SHOWING FLOOD LEVELS
SCALE IN MILES
3 MILES
SHYOK RIVER
NUBRA RIVER
BURMA
YUGMA
TEGGUR
SAMUR
DISKIT
THIRIT
FORD
KHALSAR
SATI

PLATE. V.

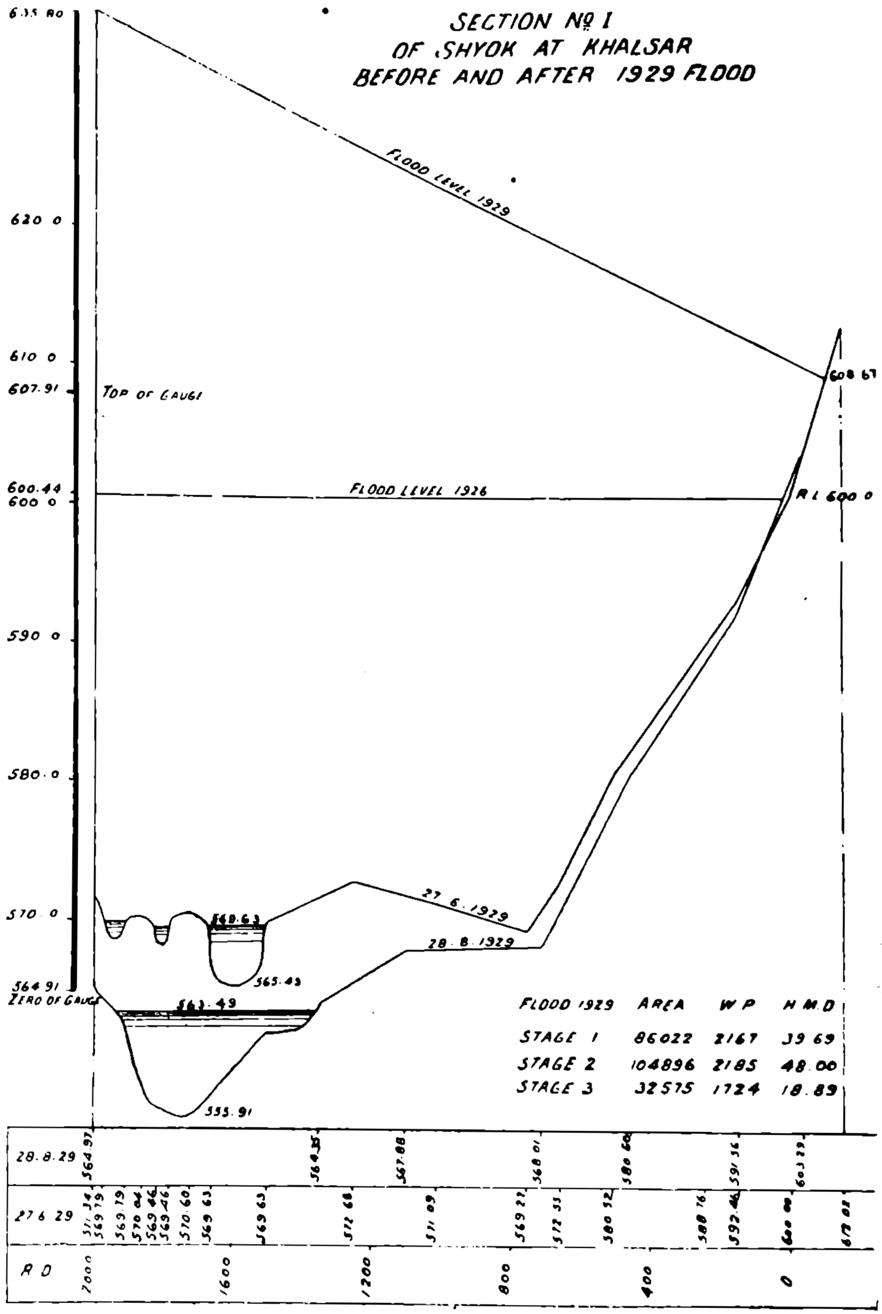
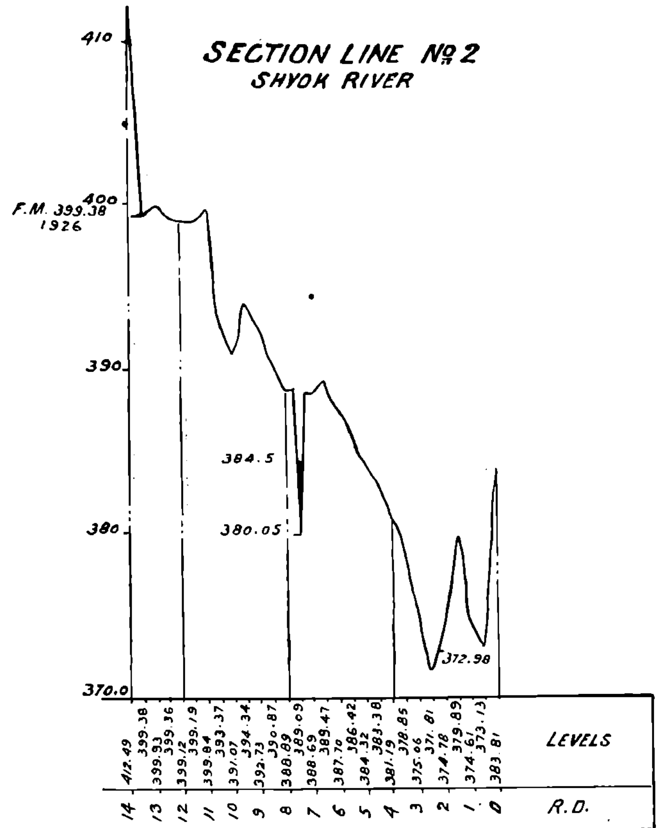
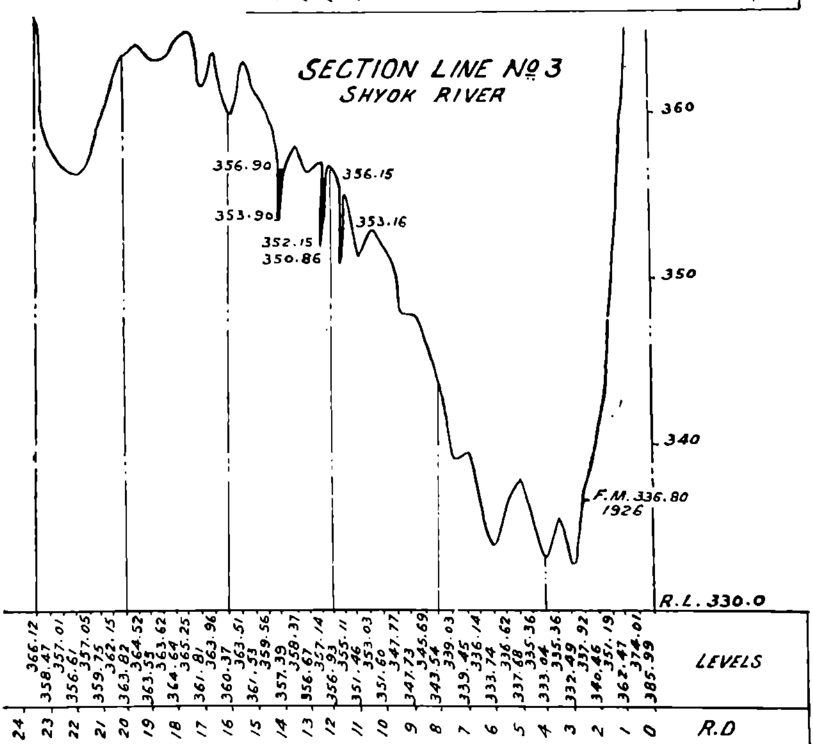

SECTION No. I
OF SHYOK AT KHALSAR
BEFORE AND AFTER 1929 FLOOD
FLOOD LEVEL 1929
TOP OF GAUGE
FLOOD LEVEL 1926
R L 600 0
608 67
620 0
610 0
607.91
600.44
600 0
590 0
580.0
570 0
564 91
ZERO OF GAUGE
27 6 1929
28 8 1929
569.63
565.43
563.49
555.91
FLOOD 1929 AREA W P H M D
STAGE 1 86022 2167 39 69
STAGE 2 104896 2185 48.00
STAGE 3 32575 1724 18.89
28.8.29
27.6.29
R D
2000
1600
1200
800
400
0

PLATE VI.


SECTION LINE No 2
SHYOK RIVER
410
400
F.M. 399.38
1926
390
384.5
380
380.05
372.98
370.0
LEVELS
412.49
399.38
399.93
399.36
399.12
399.19
399.84
393.37
391.07
394.34
392.73
390.87
388.89
389.09
388.69
389.47
387.70
386.42
384.32
383.38
381.19
378.85
375.06
371.81
374.78
379.89
374.61
373.13
383.81
R.D.
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0


SECTION LINE No 3
SHYOK RIVER
360
356.90
353.90
356.15
353.16
352.15
350.86
350
340
F.M. 336.80
1926
R.L. 330.0
LEVELS
366.12
358.47
357.01
356.61
357.05
359.75
362.15
363.82
364.52
363.55
363.62
364.64
365.25
361.81
363.96
360.37
363.51
361.53
359.56
357.39
358.37
356.67
357.14
356.93
355.11
351.46
353.03
351.60
347.77
347.73
345.69
343.54
339.03
339.45
336.14
333.74
336.62
337.68
335.36
333.04
335.36
332.49
337.92
340.46
351.19
362.47
374.01
385.99
R.D
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

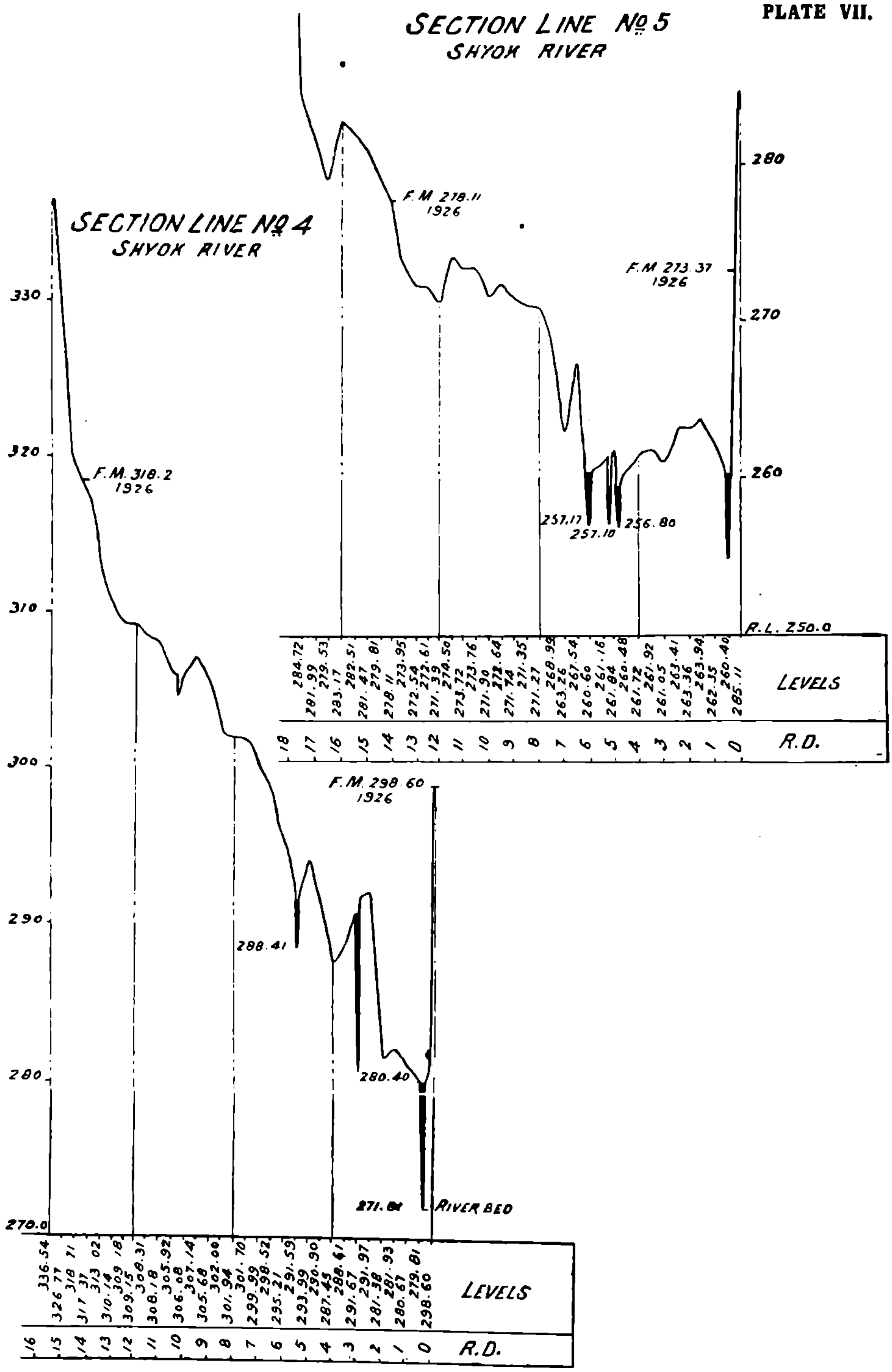
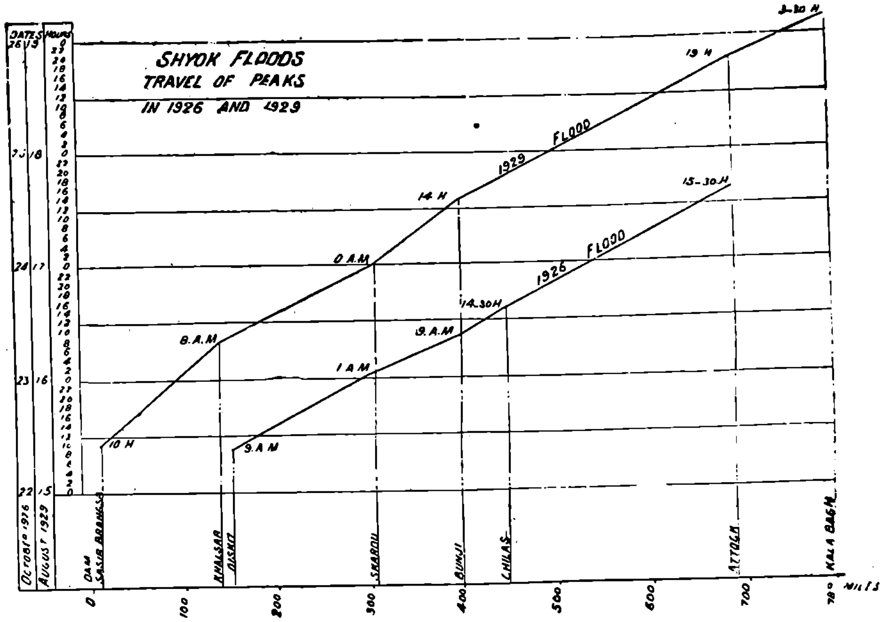

SECTION LINE No. 5
SHYOK RIVER
F.M. 278.11
1926
F.M. 273.37
1926
280
270
260
257.17
257.10
256.80
R.L. 250.0
LEVELS
R.D.
SECTION LINE No. 4
SHYOK RIVER
330
320
310
300
290
280
270.0
F.M. 318.2
1926
F.M. 298.60
1926
288.41
280.40
271.84
RIVER BED
LEVELS
R.D.

PLATE VIII.


SHYOK FLOODS
TRAVEL OF PEAKS
IN 1926 AND 1929
1929 FLOOD
1926 FLOOD
DATES
HOURS
October 1926
August 1929
SASIR BRANGSA
KHALSAR
DISHIT
SKARDU
BUNJI
CHILAS
ATTOCK
KALA BAGH
MILES

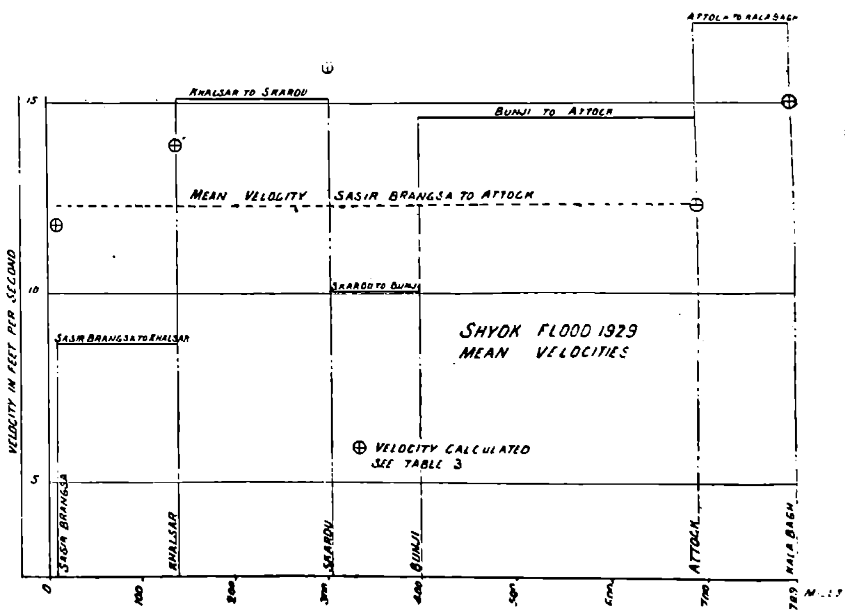

SHYOK FLOOD 1929
MEAN VELOCITIES
VELOCITY IN FEET PER SECOND
KHALSAR TO SKARDU
BUNJI TO ATTOCK
ATTOCK TO KALA BAGH
MEAN VELOCITY SASIR BRANGSA TO ATTOCK
SKARDU TO BUNJI
SASIR BRANGSA TO KHALSAR
⊕ VELOCITY CALCULATED
SEE TABLE 3
SASIR BRANGSA
KHALSAR
SKARDU
BUNJI
ATTOCK
KALA BAGH

PLATE IX.

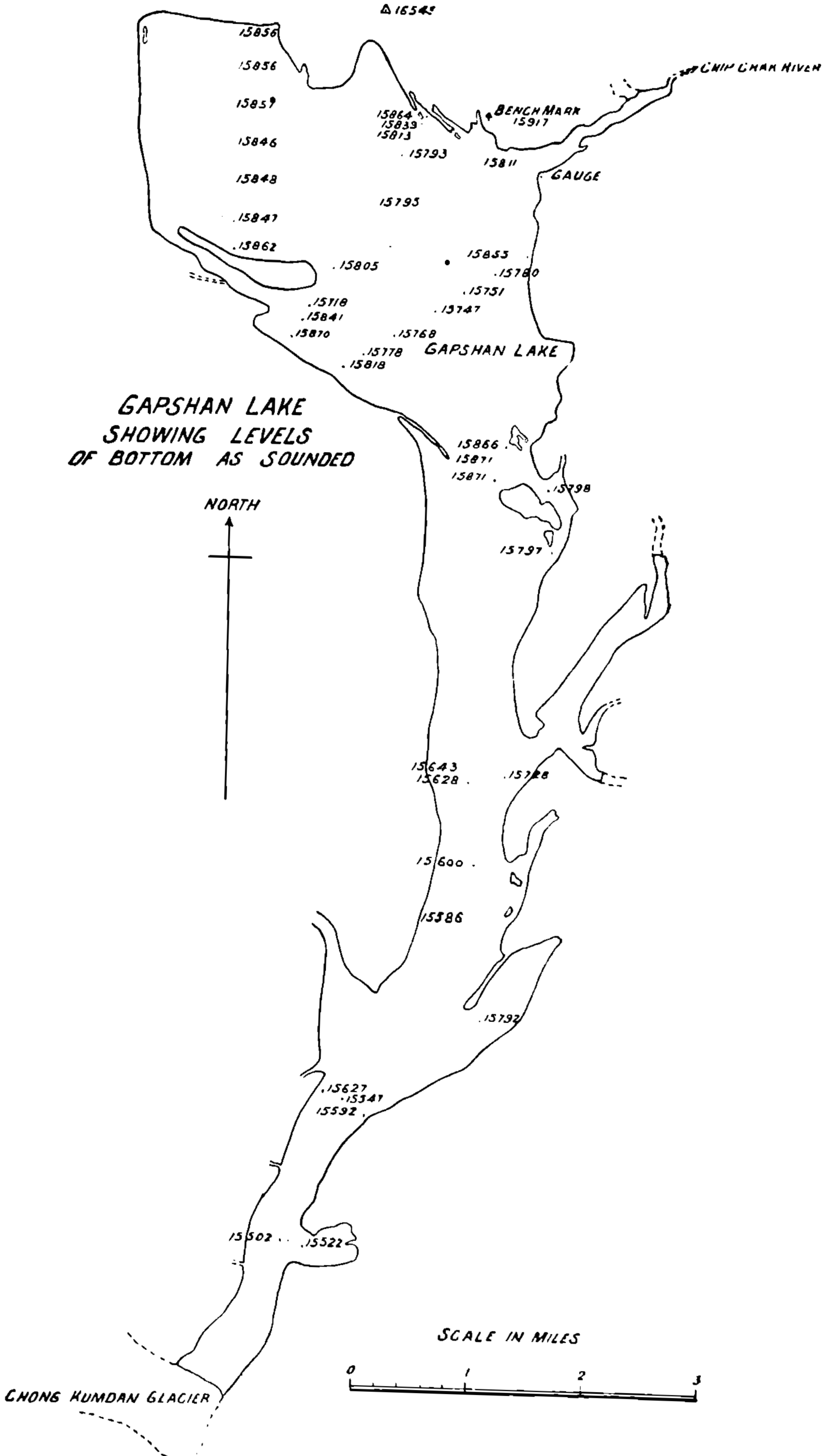
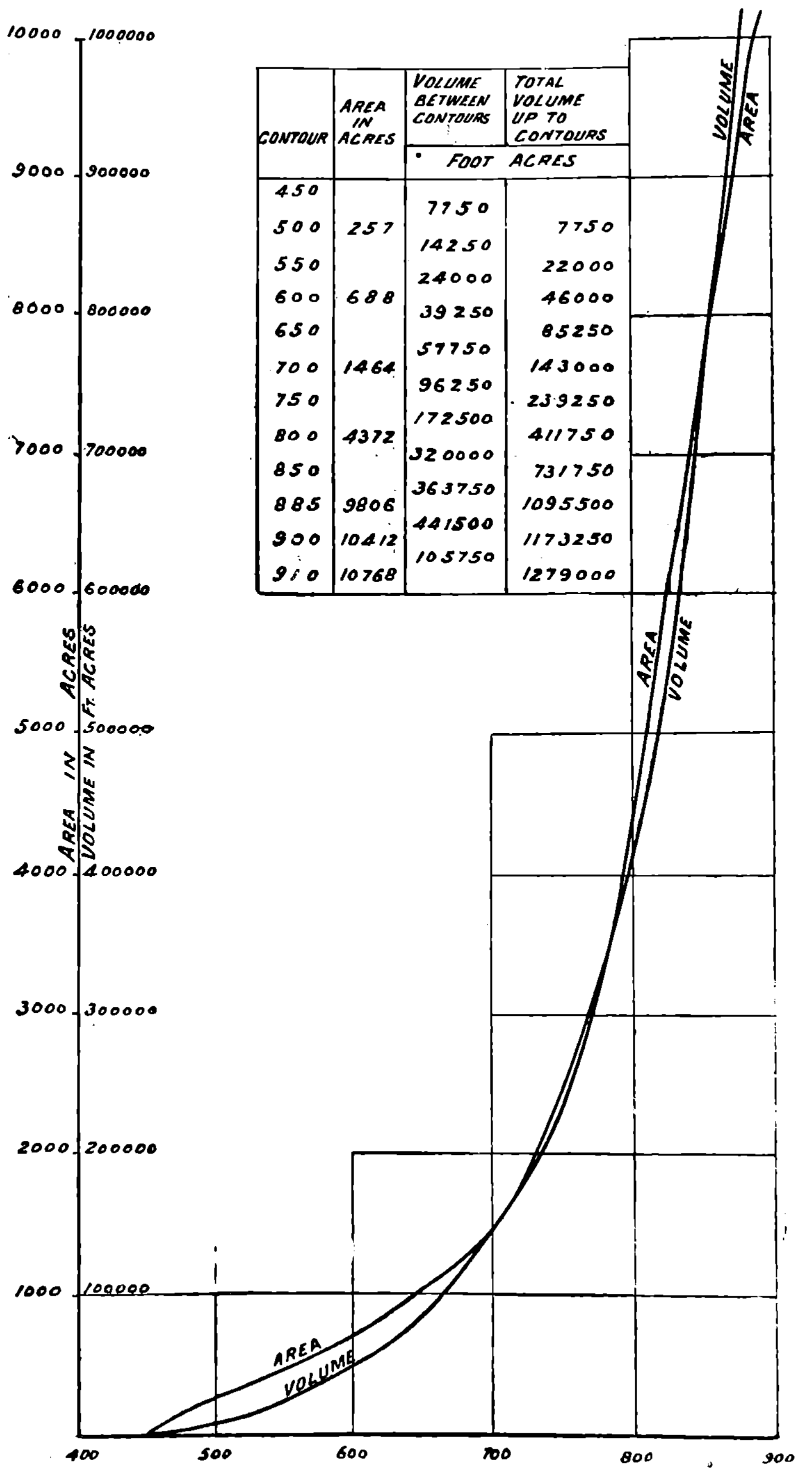

GAPSHAN LAKE
SHOWING LEVELS
OF BOTTOM AS SOUNDED
NORTH
SCALE IN MILES
0
1
2
3
BENCH MARK
15917
GAUGE
GAPSHAN LAKE
CHONG KUMDAN GLACIER
15856
15856
15846
15848
15862
15805
15793
15795
15811
15853
15780
15751
15747
15718
15841
15870
15768
15778
15818
15866
15871
15871
15798
15797
15643
15628
15600
15586
15792
15627
15592
15502
15522

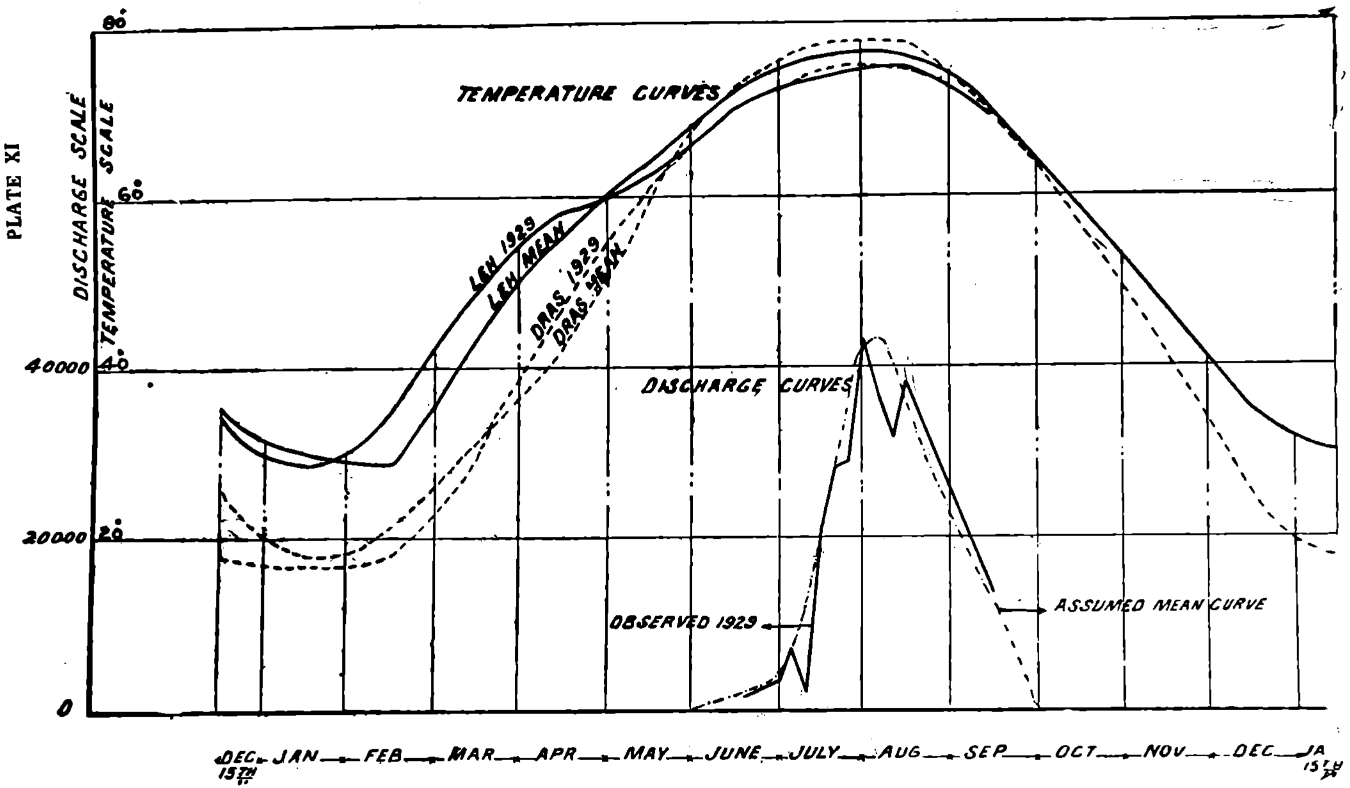
PLATE X.

GAPSHAN LAKE
AREAS AND VOLUMES



CONTOUR	AREA IN ACRES	VOLUME BETWEEN CONTOURS	TOTAL VOLUME UP TO CONTOURS
		FOOT ACRES	
450			
		7750	
500	257		7750
		14250	
550			22000
		24000	
600	688		46000
		39250	
650			85250
		57750	
700	1464		143000
		96250	
750			239250
		172500	
800	4372		411750
		320000	
850			731750
		363750	
885	9806		1095500
		441500	
900	10412		1173250
		105750	
910	10768		1279000

PLATE XI



TEMPERATURES AT LEH AND DRAS
DISCHARGE AT KHALSAR

PLATE XII.

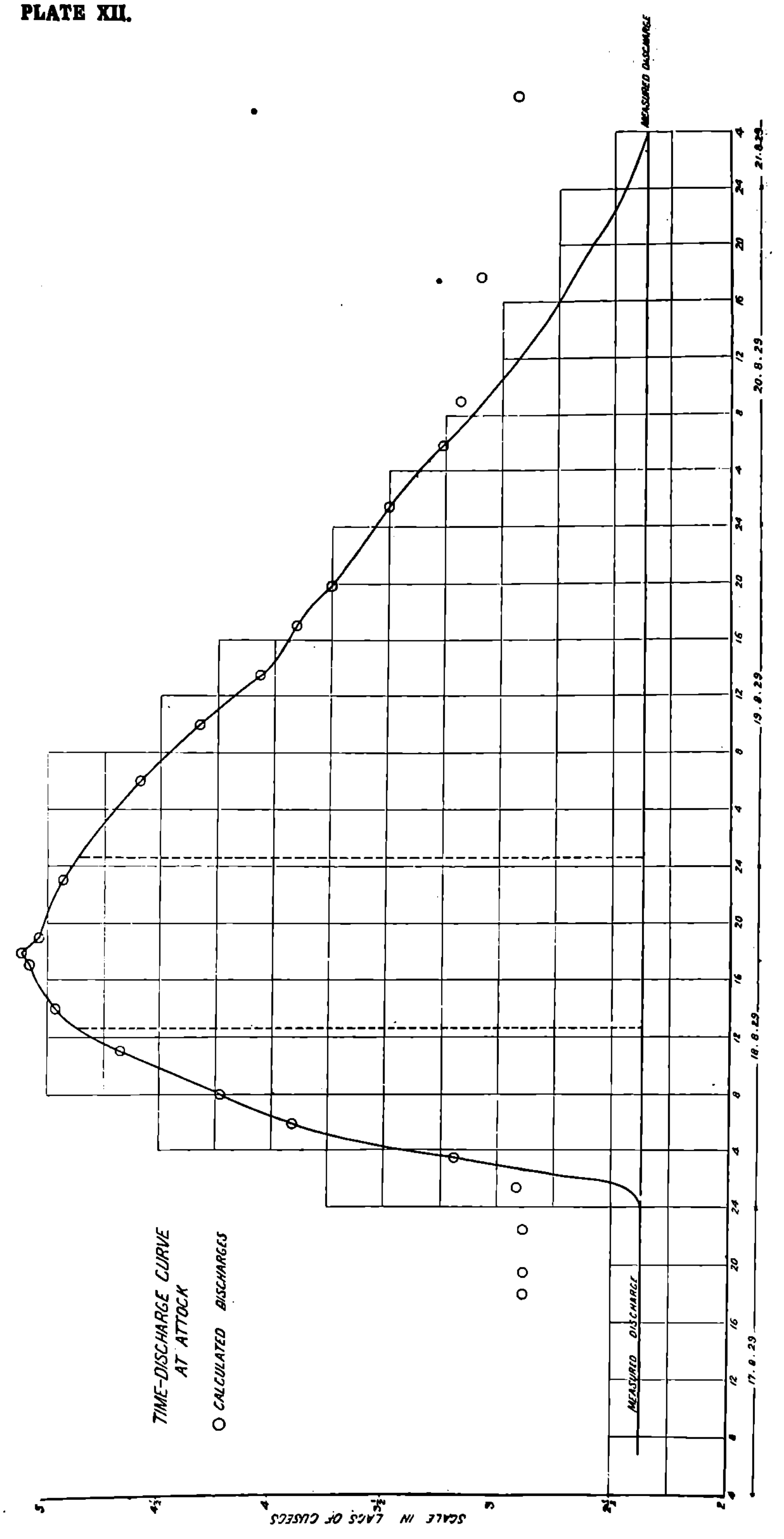

TIME-DISCHARGE CURVE
AT ATTOCK
O CALCULATED DISCHARGES
MEASURED DISCHARGE
MEASURED DISCHARGE
SCALE IN LACS OF CUSECS
17.8.29
18.8.29
19.8.29
20.8.29
21.8.29

PLATE XIII.

CURVE FOR PREDICTION OF MAX: RISE AT ATTOCK FROM GAPSHAN LAKE LEVELS

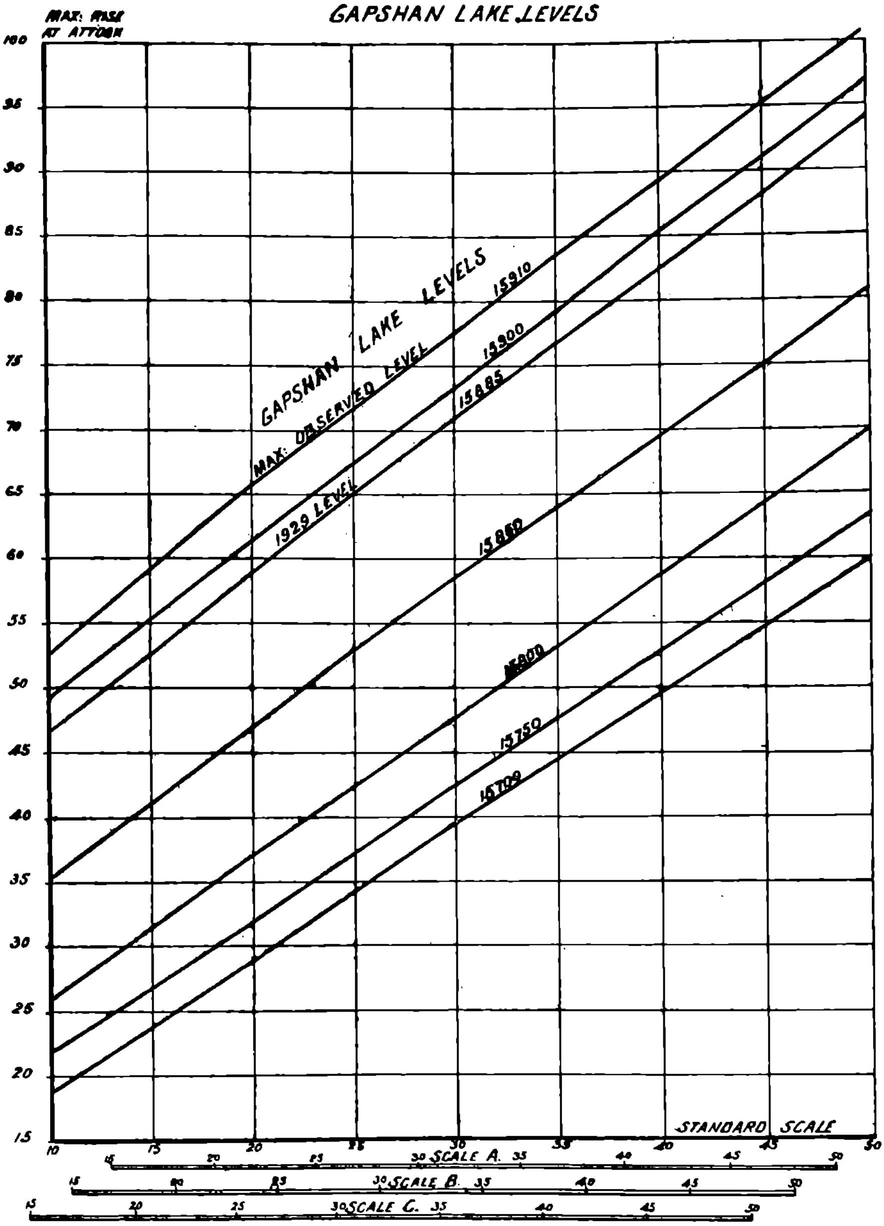
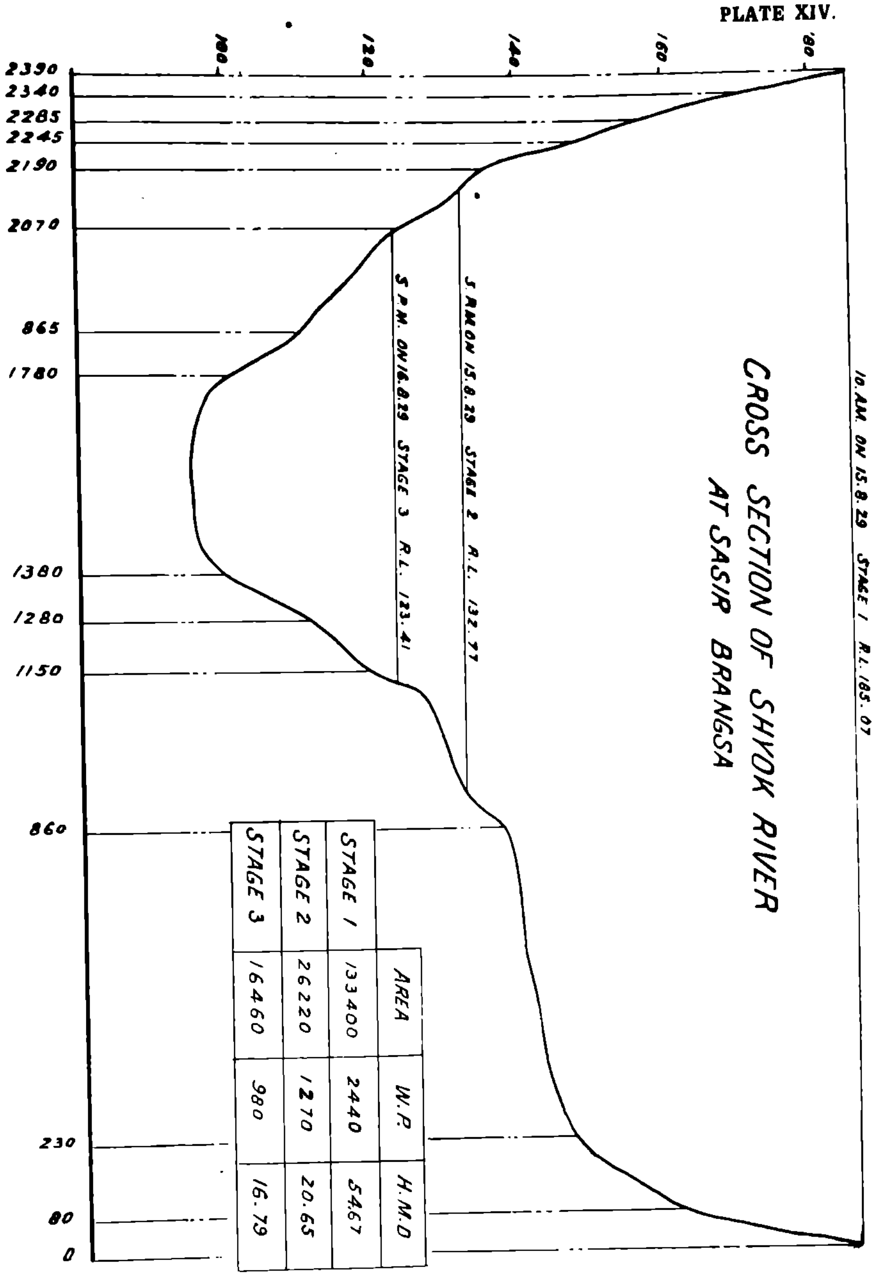
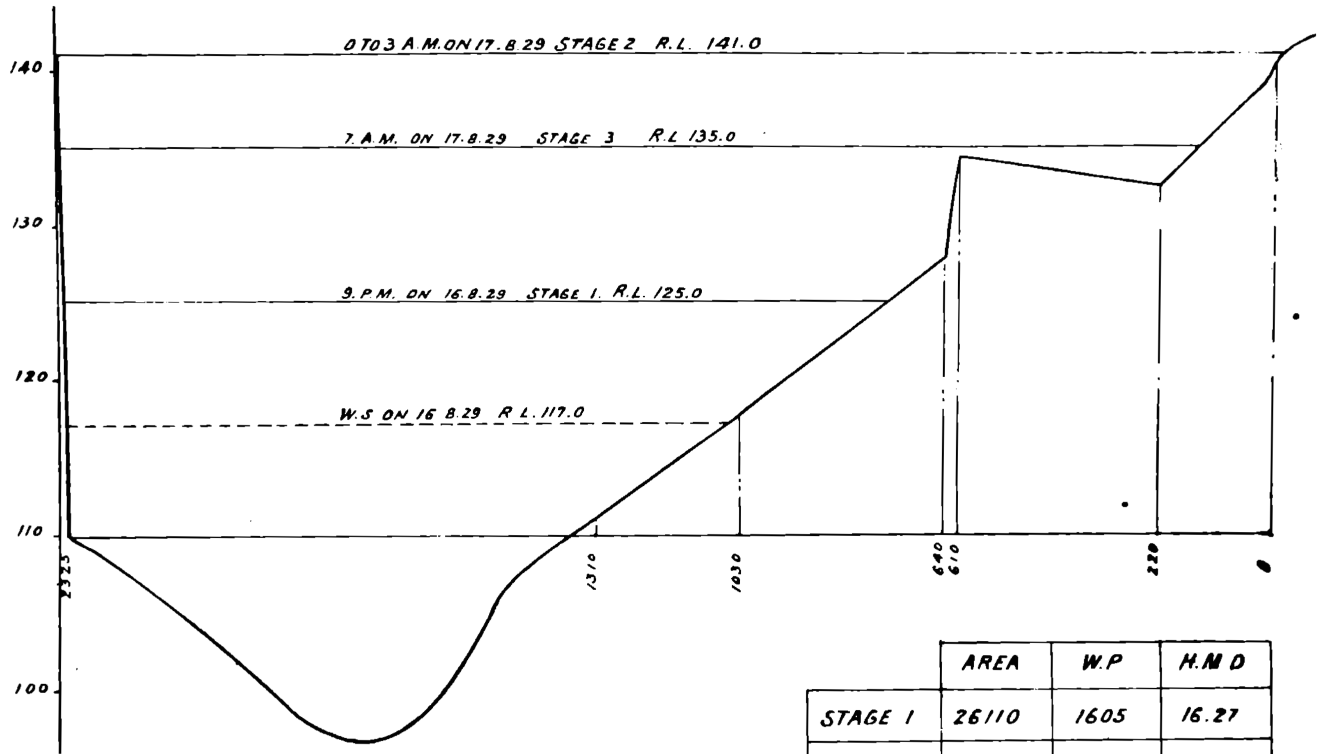


PLATE XIV.



	AREA	W.P.	H.M.D
STAGE 1	133400	2440	54.67
STAGE 2	26220	1270	20.65
STAGE 3	16460	980	16.79



CROSS SECTION OF INDUS
AT SKARDU

	AREA	W.P	H.M.D
STAGE 1	26110	1605	16.27
STAGE 2	57300	2220	25.81
STAGE 3	43710	2370	18.44
STAGE 4 WITH GAUGE 17	14670	1288	11.40

PLATE XV.

PLATE XVI.

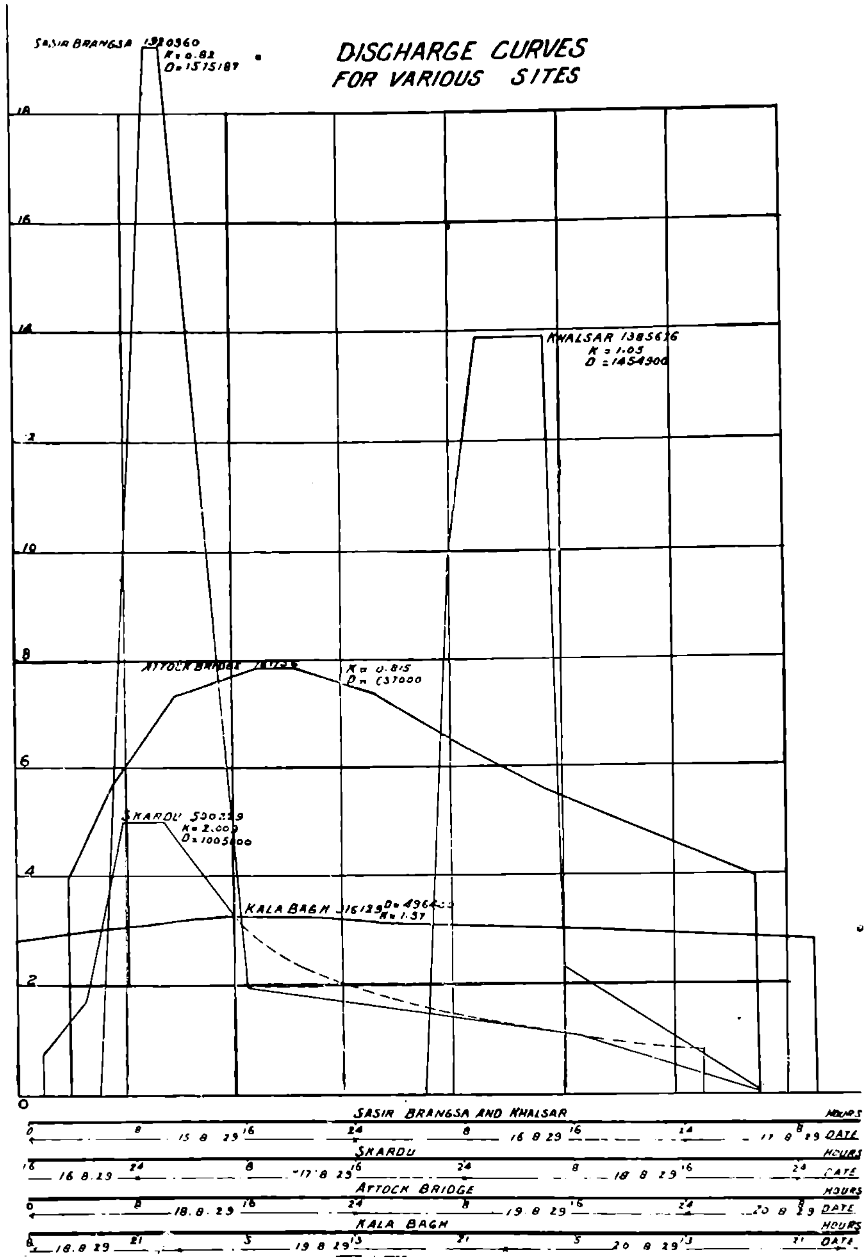

DISCHARGE CURVES
FOR VARIOUS SITES
SASIR BRANGSA
K = 0.82
D = 1575187
KHALSAR
K = 1.05
D = 1454900
K = 0.815
SKARDU
K = 2.009
KALA BAGH
K = 1.57
18
16
14
10
8
6
4
2
0
SASIR BRANGSA AND KHALSAR
HOURS
DATE
SKARDU
HOURS
DATE
ATTOCK BRIDGE
HOURS
DATE
KALA BAGH
HOURS
DATE

PLATE XVII.

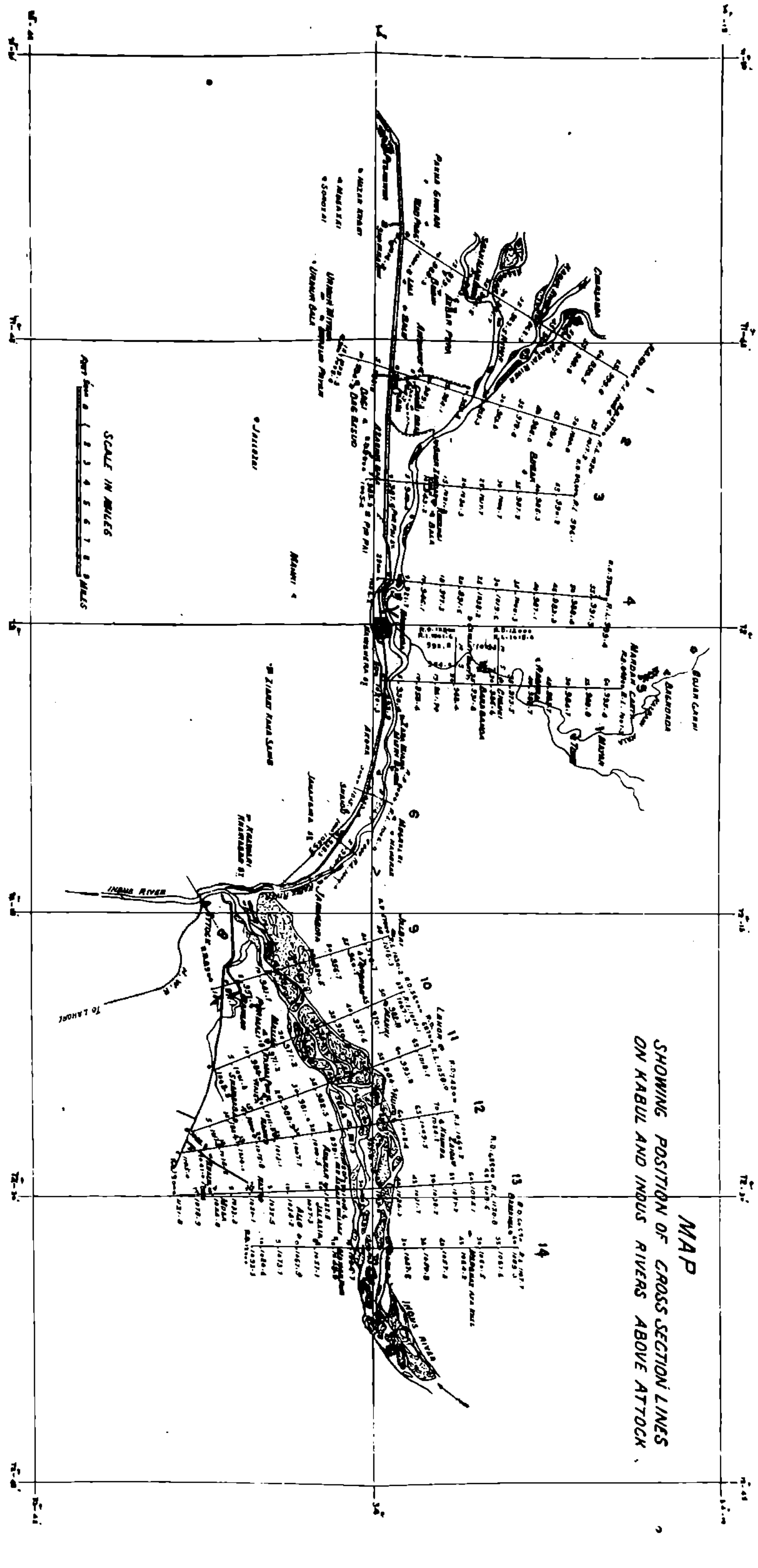
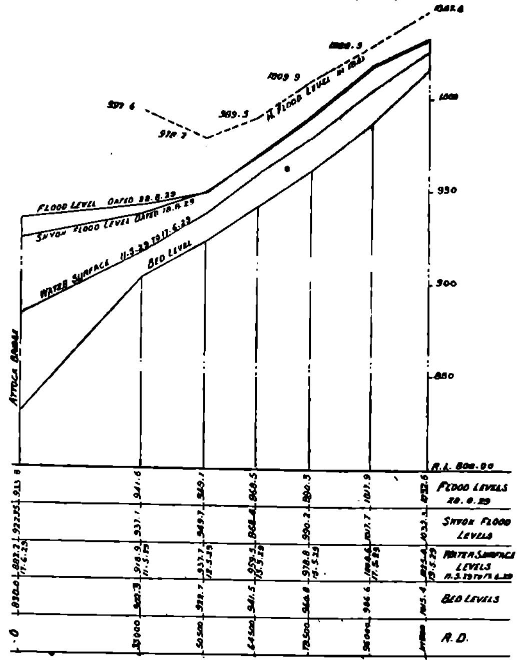

MAP
SHOWING POSITION OF CROSS SECTION LINES
ON KABUL AND INDUS RIVERS ABOVE ATTOCK.
SCALE IN MILES
INDUS RIVER
TO LAHORE

PLATE XVIII.

LONGITUDINAL SECTION OF INDUS RIVER



LONGITUDINAL SECTION OF KABUL RIVER

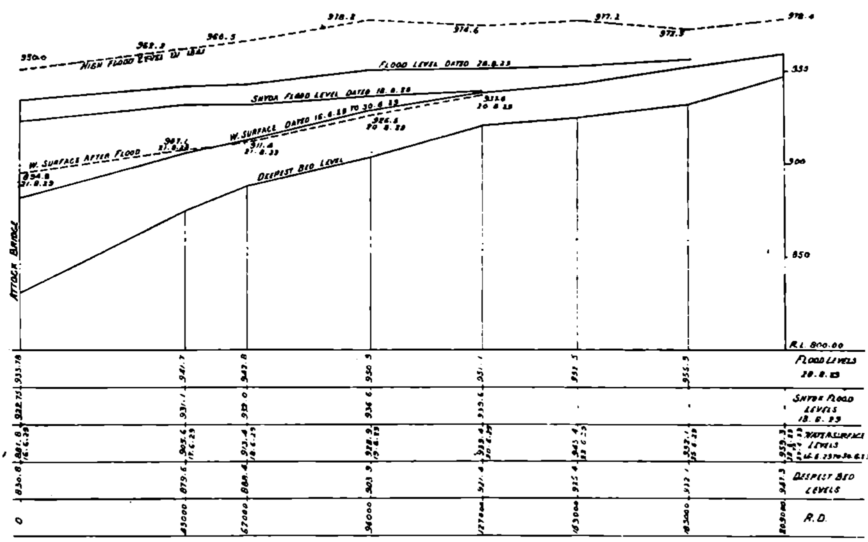


PLATE XIX.

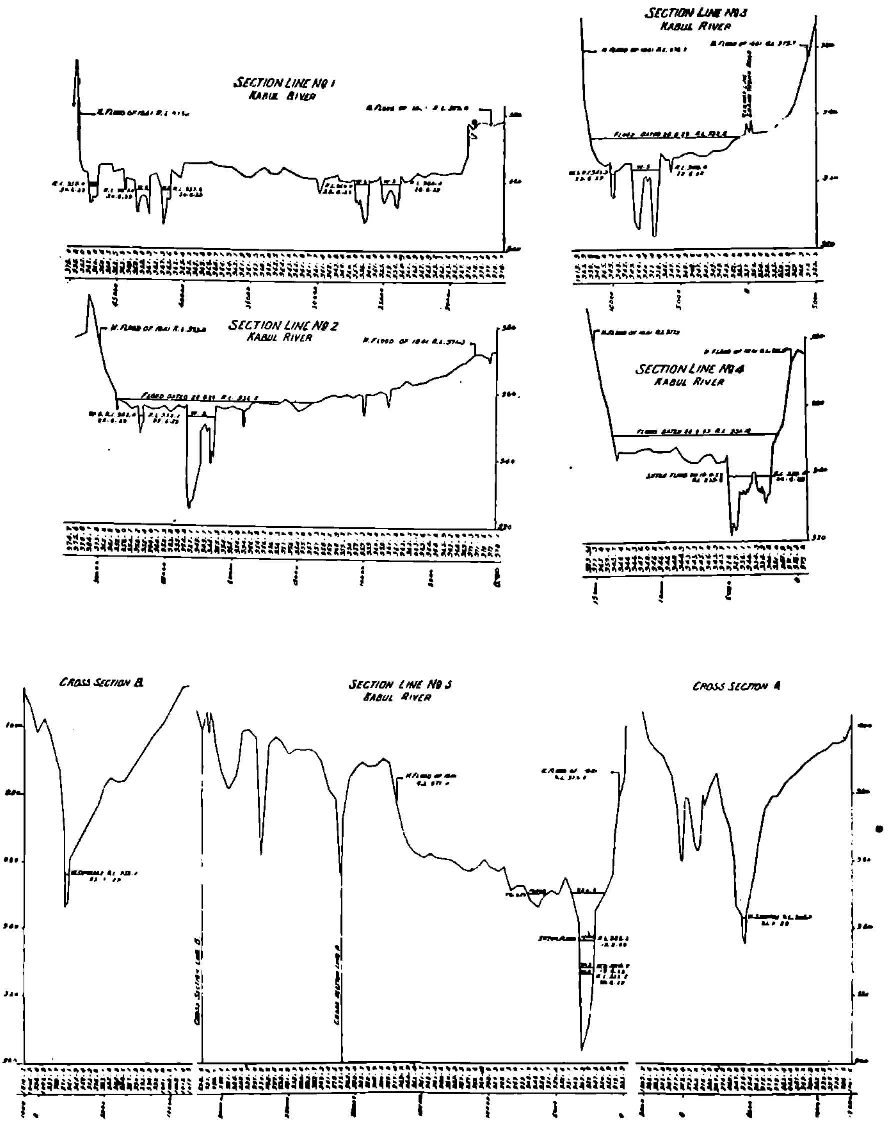
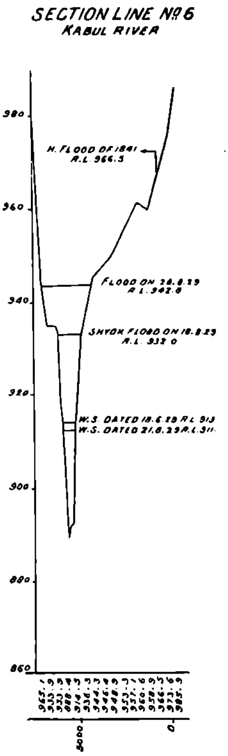
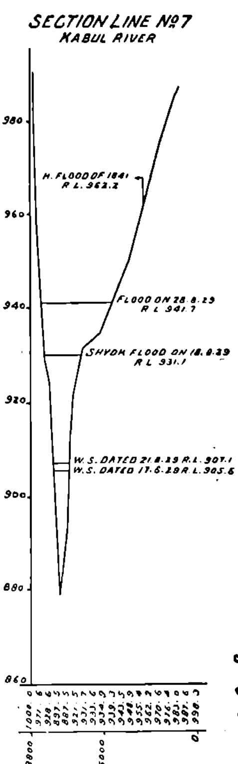

SECTION LINE Nº 1
KABUL RIVER
SECTION LINE Nº 2
KABUL RIVER
SECTION LINE Nº 3
KABUL RIVER
SECTION LINE Nº 4
KABUL RIVER
CROSS SECTION B
SECTION LINE Nº 5
KABUL RIVER
CROSS SECTION A

PLATE XX.


SECTION LINE No 6
KABUL RIVER
H. FLOOD OF 1841
R.L. 966.5
FLOOD ON 28.8.29
R.L. 942.8
SHYOK FLOOD ON 18.8.29
R.L. 932.0
980
960
940
920
900
880
860
5000
0


SECTION LINE No 7
KABUL RIVER
H. FLOOD OF 1841
R.L. 962.2
FLOOD ON 28.8.29
R.L. 941.7
SHYOK FLOOD ON 18.8.29
R.L. 931.1
W.S. DATED 21.8.29 R.L. 907.1
W.S. DATED 17.6.29 R.L. 905.6
980
960
940
920
900
880
860
8000
5000
0

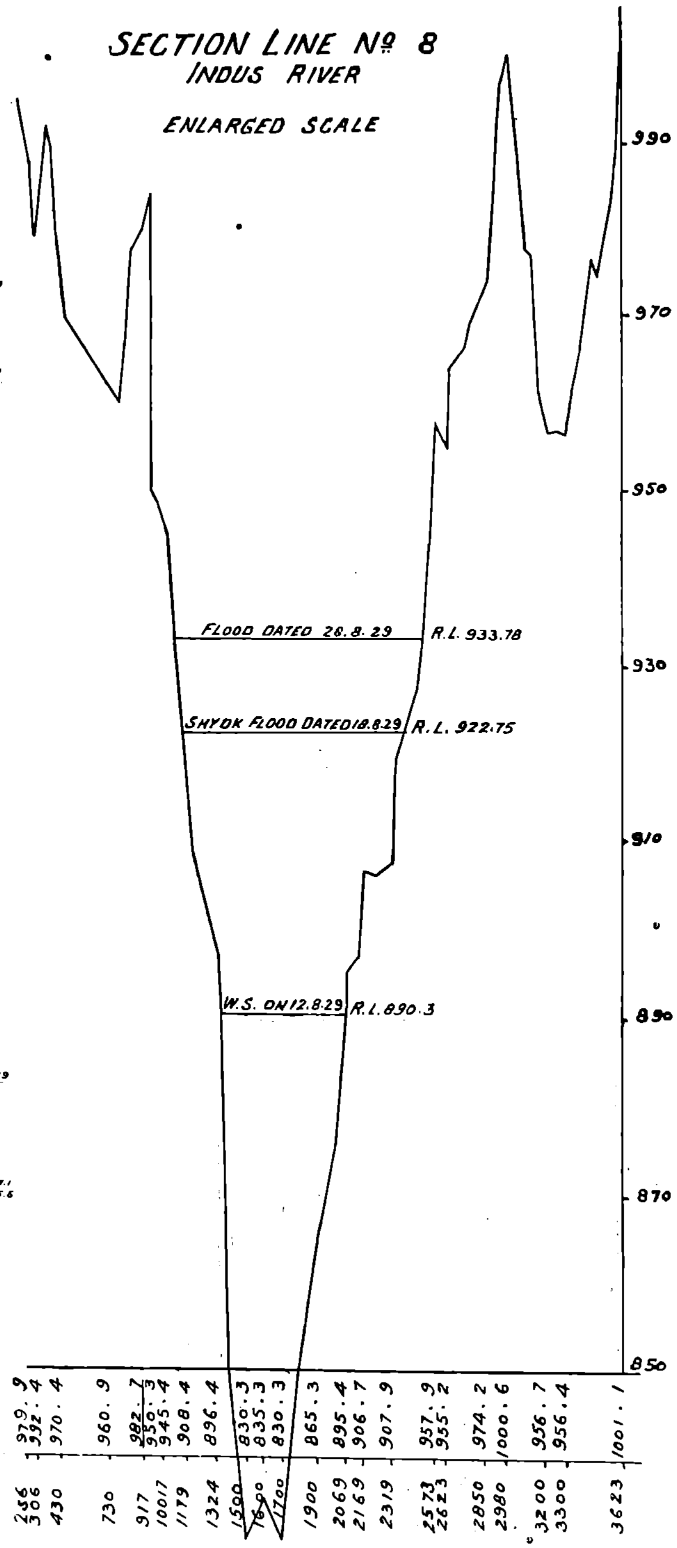
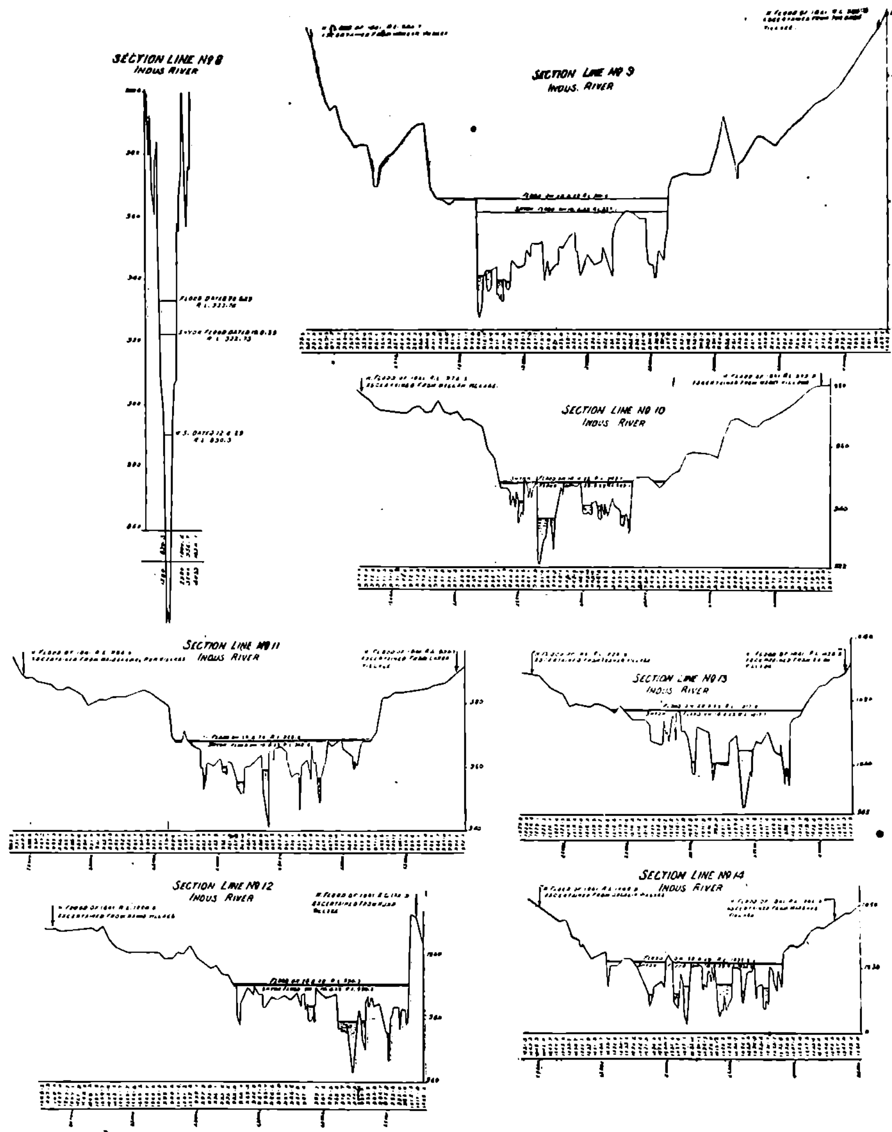

SECTION LINE No 8
INDUS RIVER
ENLARGED SCALE
FLOOD DATED 28.8.29
R.L. 933.78
SHYOK FLOOD DATED 18.8.29
R.L. 922.75
W.S. ON 12.8.29
R.L. 890.3
990
970
950
930
910
890
870
850
979.9
992.4
970.4
960.9
982.7
950.3
945.4
908.4
896.4
830.3
835.3
830.3
865.3
895.4
906.7
907.9
957.9
955.2
974.2
1000.6
956.7
956.4
1001.1
256
306
430
730
917
1001
1179
1324
1500
1600
1700
1900
2069
2169
2319
2573
2623
2850
2980
3200
3300
3623

PLATE XXI.


SECTION LINE No 8
INDUS RIVER
SECTION LINE No 9
INDUS RIVER
SECTION LINE No 10
INDUS RIVER
SECTION LINE No 11
INDUS RIVER
SECTION LINE No 13
INDUS RIVER
SECTION LINE No 12
INDUS RIVER
SECTION LINE No 14
INDUS RIVER


MAP OF
UPPER SHYOK
GLACIERS
&
GAPSHAN LAKE
Contour interval 1000 feet
Scale 1 Inch 4 miles or 1:253,440
GAPSHAN LAKE SHOWING SITE
OF
BENCH MARK GAUGE AND BURIED BOATS
Scale 1" = 2 Miles
Chipchak R
Site of Boats
B.M. 15917
Gauge
LAKE
16545
RIMO GLACIER
KARAKORAM
Chong Kumdun Glacier
Kichik Kumdun Glacier
Ak-tash Glacier
Mamostong Glacier
SHYOK R
NUBRA R
Gapshan (Yapchan)
Saser Brangsa
15200 Ford
Saser P
Open July to November
Skyangpo-che 15070
Tut Yailak
Chanlung
Basoma
Umlung
Wusak 19571
Aranu
Ayi
Takshai
Kubet
Popoche
Panamik
35° 30'
35° 0'
77° 45'
GAPSHAN LAKE
CHONG KUMDUN GLACIER
Line of Break
SHYOK RIVER
Sketch plan of Glacier snout
Photo station and direction of photo