

sequence. The following list of formations is compiled from a large number of sections seen in different localities :—

Conglomerates and sandstones (Siwālik)	} Upper Tertiary.
Sandstone and red clay (Nāhan or lower Siwālik)	
Unconformity.	
Nummulitic limestone, underlain by shale, sandstone, and coal	} Lower Tertiary.
Unconformity.	
Whitish sandstone	} Lower Cretaceous.
Dark shales and limestone, with ammonites and belemnites	
	} Jurassic.
Unconformity.	
Limestone with ceratites (upper ceratite limestone)	} Lower Trias.
Sandstone do. (ceratite sandstone)	
Marl do. (ceratite marl)	
Limestone do. (lower ceratite limestone)	
Limestone with ammonites and brachiopods (Chidru group, or upper Productus limestone)	} Upper Permian.
Limestone with Xenaspis and brachiopods (Virgal group, or middle Productus limestone)	
Sandstone with brachiopods (Amb group, or lower Productus beds)	
Lavender clay	} Lower Permian,
Speckled sandstone	
Olive sandstone	
Boulder-bed	
	} perhaps, in part,
	} Upper Carboniferous.
Unconformity.	
Sandstone with pseudomorphs after salt (Salt pseudomorph zone)	} Cambrian.
Magnesian sandstone	
Shales with <i>obolus</i> and trilobites	
Purple sandstone	} Age unknown.
Red salt marl, with rock-salt and gypsum	

[The following publications of the Geological Survey of India may be consulted : *Records*, vols. xix, pt. 2 ; xxiv, pts. 1 and 4 ; xxv, pt. 1 ; *Memoirs*, vols. xiv, xvii, pt. 2 ; *Palaeontologia Indica*, Series xiii, vols. i, pts. 1-7 ; iv, pts. 1-2 ; and New Series i, pt. 1. Also *Neues Jahrbuch für Mineralogie, &c.*, 1896, Bd. ii, p. 61 ; and 1901, Bd. xiv, p. 369.]

Jumna (*Yamuna* ; the *Diamouna* of Ptolemy, *Jomanes* of Pliny, and *Jobares* of Arrian).—A great river of Northern India. Rising in the Tehri State ($31^{\circ} 1' N.$, $78^{\circ} 27' E.$), eight miles west of the lofty mountain Bandarpunch (20,731 feet), it flows past the sacred shrine of Jamnotri, and winds through the Outer Himālayas for eighty miles, receiving a few small streams. At the point where it passes into the Dūn, the valley between the Himālayas and the Siwāliks, it receives the Tons, which is there the larger stream. Its course now runs south-west for 22 miles, dividing the Kiarda Dūn (Punjab) from Dehra Dūn

(United Provinces); two large affluents, the Giri from Sirmūr on the west and the Asan from Dehra on the east, join it here. The Jumna pierces the Siwāliks 95 miles from its source, at Khārā, and divides Ambāla and Karnāl Districts in the Punjab from Sahāranpur and Muzaffarnagar in the United Provinces. It is a large river at Faizābād, where it gives off the WESTERN and EASTERN JUMNA CANALS. Near Bidhauri in Muzaffarnagar it turns due south, and runs in that direction for 80 miles, dividing Meerut District from the Punjab, till it reaches Delhi. Ten miles below Delhi it gives off the AGRA CANAL from its western bank at Okhla. It then turns south-east for 27 miles to Dankaur, when it again resumes a southerly course. In this portion it receives on the east the Kotha Nadi and the HINDAN, and on the west the Sabi Nadi. Below Delhi the river forms the boundary between Gurgaon District in the Punjab and Bulandshahr and Aligarh Districts in the United Provinces. It then enters Muttra and, crossing it, turns east till the borders of Agra are reached. Throughout its course in this District, where it receives the BĀNGANGĀ, and also in Etāwah, it winds in a remarkable manner, its bed lying deep between high banks which are furrowed by steep ravines. Just before Jālaun District is reached the great river CHAMBAL from Rājputāna joins it, and the Jumna then divides the three Districts of Cawnpore, Fatehpur, and Allahābād from Jālaun, Hamīrpur, and Bāndā. In Cawnpore District the Sengar, and in Fatehpur the Non and Rind, flow into it; close to Hamīrpur it receives the BETWĀ, and in Bāndā District the KEN. It finally falls into the GANGES below Allahābād, 860 miles from its source.

The Jumna, after issuing from the hills, has a longer course in the United Provinces than the Ganges; but it is not so large or important a stream, and does not carry as much water as is required by the canals taken from it. The supply is therefore increased from the Ganges by means of the cut into the HINDAN; and the Irrigation Commission (1901) recently proposed to make more water from the Ganges available by increasing the supply of the Lower Ganges Canal through a cut from the SĀRDĀ. The Jumna supplies drinking-water to the cities of Agra and Allahābād, which possesses, when fresh, special virtue in destroying the enteric microbe. It is crossed by railway bridges near Sarsāwā in Sahāranpur, at Delhi, Muttra, Agra, Kālpi (2,626 feet in width), and Allahābād (3,230 feet). The breadth of water-surface in the dry season varies from 2,600 feet at Okhla and 1,500 feet at Kālpi to 2,200 feet at

Allahābād. The discharge in flood at Okhla is about 41,000 cubic feet per second, but this dwindles away to less than 200 in the dry season. The Jumna drains a total area of about 118,000 square miles.

The traffic on the Jumna was formerly of some importance, and large sums were spent in clearing away reefs of *kankar* (nodular limestone) and conglomerate in Etāwah District. Before the opening of the East Indian Railway, much cotton grown in Bundelkhand was sent down the river from Kālpi. At present timber is carried down the upper portion, and stone and grain in the lower courses. The principal towns on or near its bank are: Delhi in the Punjab; and Bāghpat, Māt, Brindāban, Muttra, Mahāban, Agra, Firozābād, Batesar, Etāwah, Kālpi, Hamirpur, and Allahābād in the United Provinces.

Chautang.—River in the Ambāla and Karnāl Districts of the Punjab, rising in the plains a few miles south of the SARASWATĪ, to which it runs parallel for a distance. Near Bālchhappar the two rivers apparently unite in the sands, but reappear in two distinct channels farther down, the Chautang running parallel to the Jumna, and then turning westward towards Hānsi and Hissār. The bed in this part of its course affords a channel for the Hissār branch of the Western Jumna Canal. Traces of the deserted waterway are visible as far as the GHAGGAR, which it formerly joined some miles below Bhatnair, after a course of about 260 miles; but the stream is now entirely diverted into the canal. In former days it lost itself in the sand, like others of the smaller cis-Sutlej rivers. Some authorities consider that the Chautang was originally an artificial channel. Cultivation extends along its banks in a few isolated patches, but for the most part a fringe of dense jungle lines its course.

Saraswati.—River of the Punjab, rising in Sirmūr State close to the borders of Ambāla District. It debouches on the plains at Adh Badri, a place held sacred by all Hindus. A few miles farther on it disappears in the sand, but comes up again about three miles to the south at the village of Bhawānipur. At Bālchhappar it again vanishes for a short distance, but emerges once more and flows on in a south-westerly direction across Karnāl, until it joins the Ghaggar in Patiāla territory after a course of about 110 miles. A District canal takes off from it near Pehowa in Karnāl District. The word Saraswatī, the feminine of Saraswat, is the Sanskrit form of the Zend Haragaiti (Arachosia) and means 'rich in lakes.' The name was probably given to the river by the Aryan invaders in

memory of the Haragaiti of Arachosia, the modern Helmand in Seistān.

Ghaggar.—A river of Northern India. It rises on the lower slopes of the Himālayas in the Native State of Sirmūr, in $30^{\circ} 4' \text{ N.}$ and $77^{\circ} 14' \text{ E.}$ Passing within three miles of Ambāla town and touching British territory, it traverses the Native State of Patialā, where it receives the SARASWATĪ, enters Hissār District, and finally loses itself in Bikaner territory near Hanumāngarh, formerly called Bhatnair. The river was once an affluent of the Indus, the dry bed of the old channel being still traceable. It is not a perennial stream, but depends on the monsoon rainfall for its supply. At present every village through which the stream passes in its upper course diverts a portion of its waters for irrigation, and no less than 10,000 acres in Ambāla District alone are supplied from this source. The dams thus erected check the course of the stream, while the consequent deposit of silt, greatly facilitated by the dams, has permanently diminished the power of the water to force its way across the dead level of the Karnāl or Patialā plains. Near Jakhāl station on the Southern Punjab Railway a District canal, the Rangoi, takes off from the main stream, and irrigates an average of 12,000 acres annually. The Bikaner Darbār constantly complained that the dams constructed in Hissār District prevented the water of the river from entering their territory; and in 1896 it was decided to construct a weir at the lower end of the Dhanūr lake at Otu, which supplies two canals, one on the north and the other on the south bank. The work was completed at a cost of 6 lakhs, of which the Bikaner State contributed nearly half. The two canals are nearly 95 miles in length ($51\frac{1}{2}$ miles in Bikaner and about $43\frac{1}{2}$ in British territory), and have more than 23 miles of distributaries. They form the most important irrigation works in the Bikaner State, and have supplied about 10,000 acres annually since 1897-8.

The Ghaggar water, in or near the hills, when used for drinking, produces disastrous results, causing fever, enlarged spleen, and goitre; families are indeed said to die out in the fourth generation, and the villages along its banks are greatly under-populated. Only the prospect of obtaining exceptional returns for their labours can induce cultivators to settle in such an unhealthy region. During the lower portion of its course in Hissār District the bed of the river is dry from November to June, and yields excellent crops of wheat and rice. Even in the rains the water-supply is very capricious, and from time

to time it fails entirely except in the immediate neighbourhood of the hills.

Sutlej (*Satlaj*; the *Zaradros* of Ptolemy and Arrian; the *Sutudri* or *Satadru* of the Vedas; 'flowing in a thousand channels').—One of the 'five rivers' of the Punjab from which the Province derives its name. Rising near the more westerly of the Mānasarowar Lakes in Tibet in $30^{\circ} 20'$ N. and $81^{\circ} 25'$ E., at a height of 15,200 feet, the Sutlej flows in a north-westerly direction along the southern slopes of the Kailās mountains to the Chinese frontier outpost at Shipki. Here its elevation is 10,000 feet above the sea. Thence turning south-west by south it enters the Kanāwār valley in Bashahr State, receiving the waters of the Li or river of Spiti near Dāhlang. Its course in Kanāwār is 80 miles. After leaving that valley it flows west-south-west through deep gorges in the hills, separating the Sarāj *taluk* of Kulū and Mandi State on the north from the Simla Hill States on the south. In this reach lie Rāmpur, the capital of Bashahr, and Bilāspur town. Then winding through Bilāspur State the Sutlej enters the Jaswān Dūn in Hoshiārpur, and turning suddenly south-east, past the town of Anandpur-Mākhawāl in that District, pierces the Siwālīks at Rūpar, after a course of 160 miles from the western extremity of Kanāwār. In the hills, the Sutlej is crossed by bridges at Wangtu, Rāmpur, Lohri, and Seoni. At Rūpar it takes a sudden bend to the west, and debouching upon the plains divides the Jullundur Doāb from the Sirhind plateau. At the south-west corner of Kapūrthala State ($31^{\circ} 11'$ N. and $75^{\circ} 4'$ E.) the sluggish waters of the Bein and the broad stream of the Beās flow into the Sutlej. From this point the united stream preserves an almost uniform south-westerly course, dividing the Bāri Doāb to the north from the sandy plains of Ferozepore and Bahāwalpur to the south, until after receiving the Chenāb at Madwāla it joins the Indus at Mithankot in Muzaffargarh District. The total length of the river is 900 miles. In the plains it is fringed by a fertile lowland valley, confined on either side by high banks leading to the naturally barren table-lands that form the watersheds of the Rāvi to the north and the Jumna to the south. The lower valley of the Sutlej is less fertile, and closely resembles the deserts of Rājputāna. As soon as it enters the plains the river is robbed of half its waters by the SIRHIND CANAL, which takes off at Rūpar from the southern bank of the river, and irrigates large tracts in Ludhiāna and Ferozepore Districts and the adjacent Native States. Soon after the Beās joins the Sutlej, the UPPER

SUTLEJ system of inundation canals takes off from its northern bank to irrigate parts of Lahore and Montgomery Districts. Finally, the LOWER SUTLEJ CANALS draw off most of the remaining water to irrigate the rainless tracts of south-west Multān. The river is open to small craft all the year round, but there is little traffic above Ferozepore. It is bridged by the North-Western Railway at Phillaur, Kasūr, and Adam-wāhan in Bahāwalpur.

After it leaves the hills the river is never called Sutlej by the people, and it has changed its course more than once in historical times. The history of those changes can be traced with considerable probability and detail. In the time of Arrian, the Sutlej found an independent outlet into the Rann of Cutch. In the year A.D. 1000 it was a tributary of the Hakra, and flowed in the Eastern Nāra. Thence the former bed can be traced back through Bahāwalpur and Bikaner into the Sirsa *tahsīl* of Hissār, until it is lost near Tohāna. From Tohāna to Rūpar this old bed cannot be traced; but it is known that the Sutlej took a southerly course at Rūpar, instead of turning west, as now, to join the Beās. Thus the Sutlej or the Hakra—for both streams flowed in the same bed—is probably the lost river of the Indian desert, whose waters made the sands of Bikaner and Sind a smiling garden. By 1245 the Sutlej had taken a more northerly course, the Hakra had dried up, and a great migration took place of the people of the desert—as it thus became—to the Indus valley. The course then taken by the Sutlej was apparently a continuation of the present course of the Ghaggar. About 1593 the Sutlej left the Ghaggar and went north once more. The Beās came south to meet it, and the two flowed in the same channel under various names—Machhu Wah, Hariāni, Dand, Nūmi, Nīli, and Gharah. Then the Sutlej once more returned to its old course and rejoined the Ghaggar. It was only in 1796 that the Sutlej again left the Ghaggar and finally joined the Beās.

Beās (*Hyphasis* of the Greeks; *Arjikuja* of the Vedas; Sanskrit *Vipāsa*).—One of the 'five rivers' of the Punjab from which the Province derives its name. Rising on the southern face of the Rohtang pass in Kulū, 13,326 feet above the sea, the Beās traverses the State of Mandī and enters Kāngra District at Sanghol, 1,920 feet above sea-level. During the early part of its course the fall averages 125 feet per mile. A fine suspension bridge spans the river at Mandī town, and a bridge of boats is kept up during the cold season at Dera Gopipur in Kāngra District. During its lower hill course the Beās is

crossed by numerous ferries, at many of which the means of communication consists of inflated skins (*darais*). Lower down it meanders in a westerly course through hilly country, with a fall of 7 feet to the mile, and forms the main channel for the drainage of Kāngra. Near Reh in that District it divides into three channels, which reunite after passing Mirthal, 1,000 feet above sea-level. On meeting the Siwālik Hills in Hoshiārpur, the river sweeps sharply northward, forming the boundary between that District and Kāngra. Then bending round the base of the Siwāliks, it takes a southerly direction, separating the Districts of Hoshiārpur and Gurdāspur. In this portion of its course through the uplands of the Punjab plains, a strip of low alluvial soil fringes its banks, subject in floodtime to inundation from the central stream. The main channel is broad and ill-defined, full of islands and expanding from time to time into wide pools. The depth does not exceed 5 feet in the dry season, increasing to 15 feet during the rains. Broad flat-bottomed country boats navigate this portion of the stream throughout the year. No bridges span the Beās in the Districts of Hoshiārpur or Gurdāspur. After touching Jullundur District for a few miles, the river forms the boundary between Amritsar and the Kapūrthala State. At Beās station it is crossed by a railway bridge on the North-Western Railway; and a bridge of boats on the grand trunk road is also maintained there during the cold season. The channel shifts from year to year through the alluvial valley according to the action of the floods. Finally, the Beās joins the Sutlej at the south-western boundary of the Kapūrthala State, after a total course of 290 miles. It ranks sixth in size among the rivers of the Punjab.

The chief tributaries are the Chakki and the Bein. The Chakki collects the drainage of the Chamba hills and its main stream joins the Beās near Mirthal, while the other branch, formerly a tributary of the Rāvi, has been turned aside by the Bāri Doāb Canal and forced to return to the Beās lower down. The Bein—called the 'Black' (*siyāh*) Bein to distinguish it from the 'White' (*safed*) Bein—rises in the Siwāliks, and joins the Beās 10 miles above its junction with the Sutlej.

The old course of the Beās can be traced from its present point of junction with the Sutlej through Lahore and Montgomery Districts to the place where it used to join the Chenāb, near Shujābād, before the Chenāb turned westwards. The united waters of the Jhelum, Chenāb, and Rāvi joined the Beās in those days 28 miles south of Multān. Since the end

of the eighteenth century the course of the Beās has changed but little.

Rāvi (the *Hydraotes* of Arrian, the *Parushni* of the Vedas, and the *Irāvati* of classical Sanskrit authors. The present name means 'sun').—One of the 'five rivers' of the Punjab from which the Province derives its name. Rising in the Kulū subdivision of Kāngra District, it immediately passes into the Chamba State, after which it re-enters British territory on the borders of Gurdāspur District, opposite Basoli in the Jammu district of Kashmīr, forming the boundary of that State for 25 miles, with a general south-westerly course. It leaves the hills at Shāhpur, but still flows between high cliffs, while on the Jammu side the mountains rise from its very brink. At Mādhopur, the head-works of the Bāri Doāb Canal draw off a large portion of its waters. Thenceforward the banks sink in height, and the river assumes the usual character of the Punjab streams, flowing in the centre of an alluvial valley, with high outer banks at some distance from its present bed. In 1870 it carried away the Tāli Sāhib shrine near Dera Nānak, a place of great sanctity with the Sikhs, and still threatens that town. The Rāvi next passes between Siālkot and Amritsar Districts, preserving its general south-westerly direction. The depth here is not more than a foot in March and April, swelling in June and September to 18 or 20 feet. Entering the District of Lahore, it runs within a mile of Lahore city, and throws out several branches which soon, however, rejoin the parent stream. A railway and foot-bridge spans the river a few miles north of Lahore, and the grand trunk road crosses it by a bridge of boats. After entering Montgomery District it receives its chief tributary, the Degh, on its north-western bank. The Degh rises in Jammu and flows through Siālkot and Lahore Districts, bringing with it large deposits of silt and affording great facilities for irrigation by wells. The Rāvi then passes into Multān District, where it is again bridged by the North-Western Railway near Sidhnai, and finally falls into the Chenāb in $30^{\circ} 31' N.$ and $71^{\circ} 51' E.$, after a total course of about 450 miles.

Throughout its course in the plains, the Rāvi flows everywhere in a comparatively narrow valley, often only a couple of miles in width, with generally a very tortuous channel. In one part, however, the river runs a perfectly straight course for 12 miles from Kuchlumba to Sarai Sidhu in Multān District, between high wooded banks, forming a beautiful reach called the Sidhnai, where the SIDHNAI CANAL takes off. Few islands

are formed, but the bed shifts occasionally from place to place. The floods of the Rāvi fertilize only a fringe of one or two miles on either side, and it is little employed for direct irrigation, although it supplies water to the Bāri Doāb and Sidhnai Canals. Navigation is difficult, but grain is shipped from Lahore in considerable quantities. *Deodār* timber, floated down in rafts from the Chamba forests during the rains, only finds its way to Lahore in seasons of heavy flood. In 1397 the Rāvi still flowed east and south of Multān and united with the Beās, as it did in the time of Chach (A.D. 800). The change of course northwards has been comparatively slight, and its date is uncertain. Even now, at times of high flood, the water finds its way to Multān by the old channel.

Chenāb (the *Acesines* of the Greeks and *Asikni* of the Vedas).—River in Kashmīr and the Punjab, and one of the 'five rivers' from which the Punjab derives its name. It rises in the Himālayan canton of Lāhul in two streams: the Chandra, which issues from a large snow-bed on the south-east side of the Bāra Lācha at a height of 16,221 feet; and the Bhāga, which rises on the north-west slopes of the pass. The Chandra, after flowing south-east for 55 miles, sweeps round the base of the mid-Himālayas and joins the Bhāga at Tandi, after a total course of 115 miles. The course of the Bhāga to Tandi is only 65 miles, its average fall being 125 feet per mile. The united stream, now known as the Chandra-Bhāga or Chenāb, flows through the Pāngi valley in Chamba State and then enters the Padar district of Kashmīr at an elevation of 6,000 feet. Thence for 180 miles it flows between steep cliffs of the high mountains, and then for 25 miles through the lower hills to Akhnūr, where it becomes navigable. There are three remarkable bends in the Chenāb. Where it reaches Kishtwār from a north-west course it suddenly twists due south; at Jangalwār it tacks from south to west; and at Arnas it leaves its westerly course and flows due south past Riāsi to Akhnūr. At each of these turns the Chenāb is joined by a stream of considerable size, and at every change of course the river seems to cut through the mountain range along which it had been flowing.

The chief tributaries in its passage through Kishtwār, Bhadrawār, and Jammu are the Uniar and Shudi, and the Bhutna and Māru Wardwan rivers. Between Kishtwār and Akhnūr it receives the waters of the Golan Lar and Lidar Kol, and the Bichlari and Ans, and between Riāsi and the western boundary of Jammu it is joined by the Tāwi. There are

several bridges, two of which, on the routes from Jammu to Kashmīr and from Kashmīr to Kishtwār respectively, are of a superior description. The rest are of the primitive *jhūla* type—three ropes stretched across the stream in the form of a triangle.

The Chenāb re-enters the Punjab at Khairi Rihāl in Siālkot District. The Tāwi joins it almost at once, and the first place of importance in British territory is Wazīrābād, where the Alexandra Bridge carries the North-Western Railway across the river. Throughout its course in the plains the river flows in a wide and shifting bed of sand. A few miles south-west of Wazīrābād the main branch of the LOWER CHENĀB CANAL takes off at Khānki; and thence the river flows on greatly diminished in bulk, dividing the Chaj Doāb on the west from the Rechna Doāb on the east, until the Jhelum joins it in Jhang District at Trimmu. Thence the two rivers flow under the name of the Chenāb, till joined by the Rāvi near Sidhu and the Sutlej at Madwāla. The North-Western Railway crosses it again at Sher Shāh. Thence it flows on under the name of the PANJNAD, to join the Indus at Mithankot. Small boats can navigate the river in the plains all the year round, but there is little traffic above Chiniot.

There is evidence to show that the Chenāb flowed to the east of Multān as late as A.D. 1245. The Beās then occupied its old bed, passing Dipālpur; and the Jhelum, Chenāb, and the Rāvi met north-east of Multān, and flowing to the east of that city joined the Beās 28 miles south of it and east of Uch. Thus Multān and Uch were both in the Sind-Sāgar Doāb. By 1397 the Chenāb had altered its course westward and was flowing to the west of Multān, as it still does. The part of the river which divides the modern District of Gujrāt from Gujrānwāla was known to the Muhammadan historians as the Sūdharā (SODHRA), from the town of that name on its left bank.

Bhimbar.—Torrent in Gujrāt District, Punjab. Rising in the second Himālayan range, it drains a considerable valley within the mountain region, passes round the Pabbi hills, runs due south for 25 miles, and fertilizes a low fringe of land upon its banks. Four miles north-west of Gujrāt town it loses itself in the surface of the country, moistening and enriching the surrounding plain; it collects again near the village of Hariāl-wāla, and runs north-west until it reaches the Jalālia nullah, a branch of the Chenāb. The Bhimbar is an unmanageable stream during the rains, but completely dry in the winter months, leaving its bed a broad waste of sand. It is

fordable at all points, except for some hours after heavy rains in the hills.

Jhelum (*Jehlam*).—River of Kashmīr and the Punjab, being the most westerly of the 'five rivers' from which the Punjab derives its name. It was known to the Muhammadan historians as the Bihat, Wihat, or Bihatah, corruptions of its Sanskrit name *Vitastā* (which Alexander's historians graecized into *Hydaspes*, but Ptolemy more correctly as *Bidaspes*), while its modern Kashmīrī name is *Veth*. It may be said to have its source in a noble spring of deep-blue water which issues from the bottom of a high scarp of a mountain spur. The spring is known as Vernāg; and at Khānabal, 15 miles north, its waters join the streams of Adpat, Bring, and Sandran, and form the starting-point of navigation. The river is navigable without a single lock from Khānabal to Bāramūla, 102 miles. In its course to the Wular Lake, which may be regarded as a delta of the river, the fall is 165 feet in the first 30 miles and 55 feet in the next 24 miles. From the Wular Lake to Bāramūla the fall is very slight.

The Jhelum river has many tributaries. On its right bank it receives the Liddar or Lambodri, which comes down from the everlasting snows overhanging the head of the Liddar valley, and from the mountain lake of Tarsar. Below Srīnagar at Shādīpur—the 'place of the marriage' of the two rivers—the Sind river joins the Jhelum, and beyond the Wular Lake the Pohru stream, which drains the Lolāb valley, merges in the great river. On the left bank the chief tributaries are the Vishav, Rembiara, Ramshi, Dudgangā, Suknāg, and Ferozepura. The Dudgangā joins the Jhelum at the lower end of Srīnagar city.

Below Bāramūla (5,000 feet) the placid Jhelum leaves the fertile banks of the valley, and rushes headlong down a deep gorge between lofty mountains of the Kazināg range on the north and an extension of the Pīr Panjāl on the south to Kohāla, 2,000 feet. At Muzaffarābād the Kishangangā river joins the Jhelum on its right bank, while a few miles lower down, and on the same side, the Kunhār river, which drains the Hazāra country, adds no inconsiderable volume of water. Between Khānabal and Bāramūla there are many bridges, but between Bāramūla and Domel, where the Kishangangā joins the Jhelum, the bridges are scarce and primitive. Much of the internal commerce of Kashmīr depends on the Jhelum. An account of the various descriptions of boats used will be found in the article on SRĪNAGAR.

Below its junction with the Kishangangā the Jhelum forms the boundary between Kashmīr State and the British Districts of Hazāra and Rāwalpindi, flowing in a narrow rocky bed, shut in by mountains on either side. Numerous rapids here render navigation impossible; though large quantities of timber are floated down from Kashmīr. A handsome suspension bridge at Kohāla, in Rāwalpindi District, connects Kashmīr with British territory. Below Dangalli, 40 miles east of Rāwalpindi, the Jhelum becomes navigable. Passing into Jhelum District, it skirts the outlying spurs of the Salt Range, receiving the waters of the Kahan, and finally debouches upon the plains a little above the town of Jhelum, about 250 miles from its source. Below Jhelum inundation of the lowlands begins to be possible, and low sandy islands stud the wide bed of the stream. The Bunhā, in the rains a roaring torrent which sometimes spreads over a mile of country, joins the Jhelum at Dārāpur. After a south-westerly course of more than 100 miles, during which the river divides the District of Jhelum from Gujrāt and Shāhpur, it enters the latter District entirely, and trends thenceforth more directly southward. The width in this portion of its course averages 800 yards in flood, dwindling during the winter months to less than half that width. Sudden freshes occur after heavy rains, and cause frequent inundations over the lowlands, greatly increasing the productive power of the soil. The Jhelum next enters the District of Jhang, where it preserves the same general characteristics, but with a wider valley, bounded by the high uplands known as the Bār. It finally joins the Chenāb at Trimmu, in $31^{\circ} 11' N.$ and $72^{\circ} 12' E.$, 10 miles to the south of Maghiāna, after a total course of not less than 450 miles, of which about 200 lie within British territory. The current in the plains has an average rate of 4 miles per hour. The wedge of land between the Jhelum and the Chenāb is known as the Chaj Doāb; while the tract stretching westward to the Indus bears the name of the Sind-Sāgar Doāb.

The principal towns upon the Jhelum are Kashmīr or Srīnagar, Jhelum, Pind Dādan Khān, Miāni, Bhera, and Khushāb. According to General Cunningham, the point where Alexander crossed the Hydaspes may be identified with Jalālpur in Jhelum District; while nearly opposite, on the Gujrāt bank, stands the modern battle-field of Chilianwāla. Other writers hold that the passage was effected near Jhelum town. A bridge of boats crosses the river at Khushāb. The permanent railway bridge of the North-Western Railway also crosses it at the

town of Jhelum, and the Sind-Sāgar line at Haranpur. The LOWER JHELM CANAL takes off at Mong Rasūl in Gujrāt District.

Panjnād.—River in the Punjab, formed by the united waters of the SUTLEJ, BEĀS, RĀVI, CHENĀB, and JHELM. Its length is 44 miles to the junction with the Indus.

Indus (Sanskrit, *Sīndhu* ; Greek, *Sinthos* ; Latin, *Sindus*).—The great river of North-Western India. The Indus rises in Tibet, and then flows through Kashmīr, the Frontier Province, and the Punjab, and after a final course through Sind falls into the Arabian Sea in $23^{\circ} 58' \text{ N.}$ and $67^{\circ} 30' \text{ E.}$ The drainage basin of the Indus is estimated at 372,700 square miles, and its total length at a little over 1,800 miles. The towns of importance on or near its banks in British territory are, beginning from the south: Karāchi, Kotri, Hyderābād, Sehwan, Sukkur, Rohri, Mithankot, Dera Ghāzi Khān, Dera Ismail Khān, Mianwali, Kalābāgh, Khushālgarh, and Attock.

The first section of the course of the Indus lies outside British territory, and must be briefly dealt with here. The river rises, as above stated, in Tibet (32° N. and 81° E.) behind the great mountain wall of the Himālayas, which forms the northern boundary of India, and is said to spring from the north side of the sacred Kailās mountain (22,000 feet), the Elysium of ancient Sanskrit literature. Issuing from the ring of lofty mountains about Lake Mānasarowar, whence also the Sutlej, the Brahmaputra, and the Kauriālā spring, it flows north-west for about 160 miles under the name of Singh-ka-bāb, until it receives the Ghar river on its south-western bank. A short distance below the junction of the Ghar, the Indus, which is supposed to have an elevation of 17,000 feet at its source, enters the south-eastern corner of Kashmīr at an elevation of 13,800 feet, flowing slowly over a long flat of alluvium. Following a steady north-by-west course it skirts Leh at a height of 10,500 feet and drops to 8,000 feet in Baltistān, just before it receives the waters of the Shyok river. At Leh it is joined by the Zāskār river, and is crossed by the great trade route into Central Asia via the Karakoram Pass. Early travellers like Dr. Thomson and Mr. Blane have described this portion of the Indus. The former found numerous hot springs, some of them with a temperature of 174° and exhaling a sulphurous gas. Still flowing north, but more westerly, through Kashmīr territory, it passes near Skārdū in Baltistān, and reaches the Haramosh mountain (24,300 feet) in about $34^{\circ} 50' \text{ N.}$ and $74^{\circ} 30' \text{ E.}$ Here it takes a turn southwards

Course in
Tibet and
Kashmīr.

at an acute angle, and passing beneath the Hattu Pīr, at an elevation of 4,000 feet, enters Kohistān in the Dīr, Swāt, and Chitrāl Agency near Gur. The steepness of its fall varies, now becoming greater, now less. This inequality of slope has been connected with the changes that occurred in the glacial period from the damming of the river by huge glaciers and the formation of great thicknesses of lacustrine deposit. The Indus has been the cause of serious and disastrous floods; the rapid stream dashes down gorges and wild mountain valleys; and in its lower and more level course it is swept by terrific blasts. Even in summer, when it is said to dwindle down to a fordable depth during the night, it may during the course of the day swell into an impassable torrent from the melting of the snows on the adjoining heights. Opposite Skārdū in Baltistān it is, even in the depth of winter, a grand stream, often more than 500 feet wide and 9 or 10 feet in depth. After leaving Gur, it flows for about 120 miles south-west through the wilds of Kohistān, until it enters the North-West Frontier Province ($35^{\circ} 25' \text{ N.}$ and $73^{\circ} 51' \text{ E.}$), near Darband, at the western base of the Mahāban mountain. The only point to which special allusion can be made in the long section of its course beyond British territory is the wonderful gorge by which the river bursts through the western ranges of the Himālayas. This gorge is near Skārdū, and is said to be 14,000 feet in sheer descent.

In the
Punjab
and the
Frontier
Province.

The Indus, on entering the Hazāra District of the North-West Frontier Province, 812 miles from its source, is about 100 yards wide in August, navigable by rafts, but of no great depth, and studded with sandbanks and islands. It is fordable in many places during the cold season; but floods or freshes are sudden, and Ranjīt Singh is said to have lost a force, variously stated at from 1,200 to 7,000 horsemen, in crossing the river. Even the large and solid ferry-boats which ply upon it are sometimes swept away. Almost opposite Attock it receives the KĀBUL river, which brings down the waters of Afghānistān. The two rivers have about an equal volume; both are very swift, and broken up with rocks. Their junction during floods is the scene of a wild confusion of waters. The Kābul river is navigable for about 40 miles above the confluence, but a rapid just above it renders the Indus impracticable. Attock, the limit of the upward navigation of the Indus, forms the first important point on the river within British territory. By this time it has flowed upwards of 860 miles, or nearly one-half of its total length, its further course to the sea being about

940 miles. It has fallen from an elevation of 17,000 feet at its source in Tibet to about 2,000 feet, the height of Attock being 2,079 feet. In the hot season, opposite the fort, its velocity is 13 miles an hour; and in the cold season, 5 to 7 miles. The rise of ordinary floods is from 5 to 7 feet in twenty-four hours, and the maximum is 50 feet above cold-season level. Its width varies greatly with the season—at one time being more than 250 yards, at another less than 100. The Indus is crossed at Attock by the railway bridge opened in 1883, a bridge of boats, and a ferry. The main trunk road to Peshāwar also crosses the river by a subway on the railway bridge.

After leaving Attock, the Indus flows almost due south, forming the western boundary of the Punjab, parallel to the Sulaimān Hills. The great north road from Bannu to Sind runs for several hundred miles parallel with its western bank; and from Attock to Mahmūd Kot the Māri-Attock, Māri, and Sind-Sāgar branches of the North-Western Railway run along its eastern bank. Twelve miles below Attock the Indus receives the waters of the Haroh, a rapid stream which, rising in the Murree hills as the Dhānd, meets the Karrāl coming down from the Mochpuri peak, and rushes through steep banks for a total course of 90 miles. At Makhad, the Sohān brings in all the drainage of Rāwalpindi and Jhelum Districts that is not taken by the Jhelum river. The Indus forms the eastern border of the two frontier Districts of Dera Ismail Khān in the North-West Frontier Province and Dera Ghāzi Khān in the Punjab with the Sind-Sāgar Doāb on its eastern bank, and only a narrow strip of British territory between it and the hill tribes of the Sulaimān ranges on the west. Just above Mithankot, in the south of Dera Ghāzi Khān District, it receives the accumulated waters of the Punjab. Between the Indus and the Jumna flow the five great streams from which the Punjab (Panj-āb, literally 'The five waters') takes its name. These are the JHELUM, the CHENĀB, the RĀVI, the BEĀS, and the SUTLEJ. After various junctions these unite to form the river PANJNAD, literally 'The five streams,' which marks for a short space the boundary between British territory and the Bahāwalpur State, and unites with the Indus near Mithankot, about 490 miles from the sea. In the cold season the breadth of the Indus above the confluence is about 600 yards, its velocity 5 miles an hour, its depth from 12 to 15 feet, and its estimated discharge 10,000 to 25,000 cubic feet per second. During flood-times the breadth sometimes increases to 5 miles, and the

discharge to 1,000,000 cubic feet per second. The dimensions of the Panjnad above the point of junction are somewhat less than those of the Indus during the cold season, but during the monsoon floods they are almost as large. The whole course of the Indus through the Punjab is broken by islands and sandbanks; but beautiful scenery is afforded along its banks, which abound with the date, acacia, pomegranate, and other trees.

In Sind.

Mithankot has an elevation of only 258 feet above the level of the sea. From Mithankot the Indus forms the boundary between the Punjab and Bahāwalpur State, until, near Kashmor, it enters Sind in $28^{\circ} 26' N.$ and $69^{\circ} 47' E.$ From Bukkur (in Sind) to the sea the river is known familiarly among the Sindis as the Daryā ('the river'). Pliny writes of *Indus incolis Sindus appellatus*. It first touches Sind close to Kashmor town in the Upper Sind Frontier District, separating it from the Bahāwalpur State and Sukkur District. Formerly in years of high inundation its floods reached Jacobābād, finding their way thence into the Manchhar Lake. To prevent this, the Kashmor embankment, which is the largest in Sind, was erected. Leaving Kashmor the river crosses Sukkur, divides Lārkāna and Karāchi from the Khairpur State and Hyderābād District, finally emptying itself by many mouths into the Arabian Sea near Karāchi after a south-western course of 450 miles through Sind. It ranges in width from 480 to 1,600 yards, the average during the low season being 680 yards. During the floods it is in places more than a mile wide. Its depth varies from 4 to 24 feet. The water, derived from the snows of the Himālayas, is of a dirty brown colour, and slightly charged with saline ingredients, carbonate of soda, and nitrate of potash. Its velocity in the freshes averages 8 miles per hour; at ordinary times 4 miles. The discharge per second varies between a minimum of 19,000 and a maximum of 820,000 cubic feet. On an average the temperature of the water is 10° lower than that of the air. Near the station of Sukkur and again at Kotri the river is spanned by a fine railway bridge. The Sukkur bridge was opened in 1889, and resembles the Forth Bridge in having a central girder with a span of 200 feet, supported at the ends of two cantilever arms, each 310 feet long. The Indus begins to rise in March, attains its maximum depth and width in August, and subsides in September. The maximum rise registered at Kotri, near Hyderābād, was 22 feet 7 inches in 1894. There are many other gauges on the river.

The delta of the Indus covers an area of about 3,000 square miles, and extends along the coast-line for 125 miles. It is almost a perfect level, and nearly destitute of timber, the tamarisk and mangrove alone supplying fuel. In these respects the delta is similar to that of the Nile, but dissimilar to that of the Ganges. The marshy portions contain good pasturage, and rice grows luxuriantly wherever cultivation is possible; but the soil generally is not fertile, being a mixture of sand and clay. In the Shāhbandar *tāluka* are immense deposits of salt. The climate of the delta is cool and bracing in the winter months, hot in the summer, and during the floods most unhealthy.

The Indus formerly flowed down the middle of the THAL. Basira, a village in the centre of the Muzaffargarh Thal, was called Bet Basira; and at Shāhgarh, near the southern end of the Thal, a long lake is still extant which once formed the Indus bed. In 1800 the river at the apex of the delta divided into two main streams, known as the Baghlār and Sītā; but in 1837 it had entirely deserted the former channel. The Khedewāri passage also, which before 1819 was the highway of water traffic to Shāhbandar, was in that year closed by an earthquake. In 1837 the Kakaiwāri, which had then increased from a shallow creek to a river with an average width at low water of 770 yards, was recognized as the highway; but before 1867 this also was completely blocked. In 1897 the river suddenly cut 3 miles inland, north of Rohri, destroying the cultivated fields and the Mando-Dahiro road. Tando Nijābat on the right bank and Mithani on the left have been swept away four times and rebuilt farther off. For the present the Hajāmro, which before 1845 was navigable only by the smallest boats, is the main estuary of the Indus. The shape of the Hajāmro is that of a funnel, with the mouth to the sea; on the east side of the entrance is a beacon 95 feet high, visible for 2 miles; and two well-manned pilot boats lie inside the bar to point out the difficulties of navigation.

The following facts illustrate further the shifting nature of the Indus. In 1845 Ghorābāri, then the chief commercial town of the delta, was on the river bank; but in 1848 the river deserted its bed. The town of Ketī was built on the new bank. The new bank overflowed a few years later, and a second Ketī had to be built farther off. At present one of the chief obstructions to navigation is a series of rocks between Tatta and Bhimān-jo-pura, which, in 1846, were 8 miles inland. In 1863 a thousand acres of the Dhāreja forest were swept

The Indus
delta.

Changes in
the river
course.

away. The rapidity and extent of the destructive action in constant progress in the delta may be estimated from the fact that travellers have counted by the reports as many as thirteen bank slips in a minute. In some places the elephant grass (*Typha elephantina*) does good service by driving its roots very deeply (often 9 feet) into the ground, and thereby holding it together.

Inundations and irrigation.

The entire course of the Indus in British territory, from Attock to the sea, lies within the zone of deficient rainfall, the annual average being nowhere higher than 10 inches. Cultivation, therefore, is absolutely dependent upon artificial irrigation, almost to as great an extent as in the typical example of Egypt. But the Indus is a less manageable river than the Nile. Its main channel is constantly shifting; at only three places—Sukkur, Jerruck, and Kotri—are the river banks permanent; and during the season of flood the melted snows of the Himalayas come down in an impetuous torrent which no embankment can restrain. From time immemorial this annual inundation, which is to Sind what the monsoons are to other parts of India, has been utilized as far as possible by an industrious peasantry, who lead the water over their fields by countless artificial channels. Many such channels, constructed in the days of native rule, extend 30 and even 40 miles from the river bank. Recently the systematic schemes of British engineers have added numerous perennial canals, such as the Jāmrao, constructed on scientific principles. The first recorded inundation of the Indus took place in 1833; another occurred in 1841 on a much larger scale. This flood was said to have been caused by the bursting of a glacier which formed over an accumulation of water in the Nubra Tso, into which there was a regular and steady flow from the surrounding hills. Eventually, the glacier was burst asunder by the pressure, and the released floods poured down the Shyok valley, carrying everything before them. There was another great flood in August, 1858, when the river rose 90 feet in a few hours, and the greater part of the private property in Naushahra cantonment was destroyed. Lower down in its course considerable damage has been caused in DERA GHĀZI KHĀN DISTRICT, where protective works were undertaken. Of recent years the Indus has been embanked from above Kashmor to the mouth of the Begāri canal, a distance of more than 50 miles. The embankment has proved a great protection to the North-Western Railway, which here runs at right angles to the river.

Principal canals.

A full account of irrigation in SIND will be found in the

article on that Province. It must suffice in this place to give a list of the principal works, following the Indus downwards from the Punjab. The country has recently been surveyed with a view to a canal being led from Kālābāgh down the Sind-Sāgar Doāb, but the difficulties in the way are at present considerable. The waters of the river are first utilized on a large scale in the INDUS INUNDATION CANALS, which water a narrow strip between the Indus and the Sulaimān mountains. The canals in this tract have an aggregate length of 690 miles, of which 108 have been constructed under British rule. In Muzaffargarh District the MUZAFFARGARH CANALS take off from the Indus and Chenāb, and in the Native State of Bahāwalpur the Chenāb and Sutlej, as well as the Indus, contribute to render cultivation possible. In Sind the following are the chief canal systems :—on the right or west bank, the Desert, Unar Wah, Begāri, Sukkur, Ghar, and Western Nāra ; on the left or east, the Nāra Supply Channel, Mahi Wah, JĀMRAO, a branch of the Eastern Nāra, and the EASTERN NĀRA with many distributaries, the principal being the Mithrao and Pinjāri. Other important canals are the Fuleli with two mouths, the Nasrat, and the Dād. The total area irrigated by canals from the Indus in 1903-4 was :—in the Punjab, 714 square miles ; in Sind, 4,925 square miles.

As a channel of navigation, the Indus has disappointed the ^{Navigation.} expectations that were at one time formed. Before British arms had conquered Sind and the Punjab, it was hoped that the fabled wealth of Central Asia might be brought by this course down to the sea. But, even so far as local traffic is concerned, experience has proved in this case, as with most other Indian rivers, that the cheapness of water communication cannot compete with the superior speed and certainty of railways. Since the opening of the Indus Valley State Railway (now included in the North-Western system) in the autumn of 1878, navigation on the Indus, whether by steamer or by native boat, has greatly fallen off. The general character of the Indus trade may be inferred from the statistics of imports and exports into the PUNJAB by 'rail and river,' which refer only to traffic borne in part or wholly on the Indus. The original 'Indus Flotilla,' which was broken up in 1862, placed its first steamer on the river in 1835. In 1859 a company established another Indus flotilla in connexion with the Sind Railway, with which it was formally amalgamated in 1870, the joint head-quarters being removed to Lahore. The railway flotilla was abolished in 1882-3. These were not the only flotilla

experiments on the Indus. In 1856 the Oriental Inland Steam Company obtained a yearly subsidy of Rs. 50,000 from Government; but, as the current proved too powerful for its steamers, the company stopped the traffic, and eventually collapsed.

For the conservancy of the lower part of the river, Act I of 1863 (Bombay) provides for the registration of vessels, and the levy of pilotage fees by an officer called the Conservator and Registrar of the Indus, the sum realized being expended on the improvement of navigation¹. A special export board, known as the Indus Commission, was constituted in 1901.

The boats of the Indus are the *dundo* and *zaurak*, both cargo-boats, the *kauntal*, or ferry-boats, and the *dundi*, or fishing-boats. The cargo-boats are sometimes of 60 tons burden, and when laden draw 4 feet of water. The state barges or *jhamptis* of the Sind Mirs were built of teak, four-masted, and sometimes required crews of thirty men.

Fish abound. At the mouths, the salt-water varieties include the *Clupea neowhii*, a species of herring largely consumed along the coast and in the delta. The chief of the fresh-water varieties are the *palla*, placed by Dr. Day under the *Clupeidae*, and nearly allied to, if not identical with, the *hilsa* of the Ganges; and the *dambhro*. The local consumption and also the export of dried *palla* are very large. Otters, turtles, porpoises, water-snakes, and crocodiles of both species are numerous.

[Notes on the Indus River (Karāchi, 1901).]

Jumna Canal, Western.—An important perennial irrigation work in the Punjab, taking off from the west bank of the river Jumna, and irrigating Ambāla, Karnāl, Hissār, Rohtak, and Delhi Districts, and parts of the Native States of Patiala and Jind. It is by far the oldest of the great canals in the Province, and originated in 1356, when Fīroz Shāh III utilized the torrent-bed now known as the Chautang to conduct water to the royal gardens at Hissār and Hānsi. This was little more than a monsoon supply-channel, and after about a hundred years water ceased to flow farther than the lands of Kaithal. In 1568 the emperor Akbar re-excavated the work of Fīroz Shāh and brought a supply from the Jumna and the Somb into the Chautang, and so on to Hānsi and Hissār. This was undoubtedly a perennial canal, as is testified by the ancient bridges at Karnāl and Safidon, and the complete set of water-courses with which the canal was provided, besides the original *sanad* or working-plan of the canal which is still in existence.

¹ The Indus Conservancy department and fees levied for its up-keep were abolished in March, 1906.

and promises a supply of water all the year round. A yet more ambitious scheme was undertaken in 1626 by Ali Mardān Khān, the engineer of the emperor Shāh Jahān. The river supply in the western branch of the Jumna was dammed up annually about 14 miles below the present head-works of the canal, and the water led along the drainage line at the foot of the highland through Pānīpat and Sonepat to Delhi. Drainages and escapes were fairly well provided for; and the Pulchaddar aqueduct, which took the canal across the Najafgarh *jhil* drain near Delhi, was, for the time, a great engineering feat, and was retained, with slight modifications, when the branch was reopened in 1819. The net revenue from the canal was reckoned equal to the maintenance of 12,000 horse. With the decay of the Delhi empire the up-keep of the canal was no longer attended to: water ceased to reach Hānsi and Hissār in 1707, the flow on Fīroz Shāh's line at Safidon ceased in 1720, and the Delhi branch ceased to flow in 1753-60. The Delhi branch was reopened in 1819, and the Hānsi branch in 1825. The alignment of the canal was, however, by no means satisfactory; and as early as 1846 it was noticed that the concentrated irrigation, the defective drainage, and the high banks which cut off the flow of the natural drainage of the country, all contributed to rapid deterioration of the soil and decline in health of the people. Saline efflorescence was rapidly spreading, and the inhabitants of the waterlogged area were affected with chronic disorders of the liver and spleen. Between 1870 and 1882 various remodelling schemes were sanctioned, with the object of securing increased control over the supply and its distribution, greater facilities for navigation, and improved drainage; and these have resulted in the complete disappearance of the swamps and accumulations of water, and a most marked improvement in the health of the people. The Sirsa branch was sanctioned in 1888, and this and subsequent minor extensions have largely increased the irrigating capacity of the canal. No less than 200,000 acres were rendered secure in 1896-7 by the Sirsa branch alone.

The head of the canal is at Tajewāla in Ambāla District in $30^{\circ} 17' N.$ and $77^{\circ} 37' E.$, about $1\frac{1}{2}$ miles from the point where the river emerges from the lower hills. The river is here crossed by a weir 1,700 feet in length, flanked at each end by a scouring sluice and head regulator for the Eastern Jumna Canal on the left bank and for the Western Jumna Canal on the right, the full capacities authorized being

respectively 1,300 and 6,380 cubic feet per second. The Western Jumna Canal has thus a maximum discharge more than three times that of the average flow of the Thames at Teddington. For the first 14 miles of its course the canal runs almost entirely in the old west branch of the Jumna river. It then effects a junction with the Somb river, a masonry dam across which holds up the combined streams and forces them into the canal head at Dādūpur, which is provided with a regulator and a rapid a short distance below. After a farther course of about 38 miles, chiefly in natural channels, there is at Indri a regulator with a lock and escape head, where the canal divides into the Sirsa branch and the new main line. The Sirsa branch has a capacity of 2,000 cubic feet per second, and runs for 115 miles, watering the arid tract of country between Indri and Sirsa. Some 31 miles farther on, the main line bifurcates into the Hānsi and new Delhi branches. The Hānsi branch has a length of 47 miles and a discharge of nearly 2,000 cubic feet a second, and gives off the Būtāna branch with a capacity of 700 cubic feet a second. The new Delhi branch has a capacity of 1,750 cubic feet a second and a length of 74 miles to the point where it meets the Okhla navigation canal at Delhi. The total length of main canal and branches is 343 miles, of distributaries (major and minor) 1,797 miles, of drainage cuts 657 miles, of escapes 76 miles, and of mill channels 9 miles. The total area commanded by the canal is 4,000 square miles, of which 3,300 square miles are cultivable. The average area of crops irrigated during the twenty years ending 1894-5 was 529 square miles, which rose in the four years ending 1903-4 to an average of 944 square miles; and the work is estimated to irrigate altogether 1,259 square miles. The capital outlay to the end of March, 1904 (excluding a contribution of 11½ lakhs from the Patiala State), was 172.7 lakhs. The gross revenue for the three years ending March, 1904, averaged 23 lakhs, and the net revenue, after paying all interest charges and working expenses, 7.6 lakhs, or 4.4 per cent. on the capital outlay. The main line and the new Delhi branch are navigable from the head-works to Delhi. The Hānsi branch is navigable to where it meets the Southern Punjab Railway at Hānsi. The expenditure on the provision for navigation is estimated at 16 lakhs; and, although near Delhi there is a certain amount of boat traffic, and timber is largely rafted down the canal, this large expenditure has proved hitherto a financial loss, and the combination of navigation with irrigation a failure. There are flour-mills at

several of the falls ; but the flour and the other mills at Delhi, which at one time were worked advantageously, are now closed, the water being too valuable to be used for this purpose.

Sirhind Canal.—A perennial canal in the Punjab, taking off from the Sutlej, and irrigating the high land between the Sutlej on the north-west and the Patiala and Ghaggar streams on the south-east, and extending as far south as the borders of Rājputāna, Bahāwalpur, and the Bikaner State. The canal was constructed by Government, in association with the Native States of Patiala, Nābha, and Jind. The preliminary survey work was begun in 1867, and the canal was formally opened in 1882, though irrigation did not commence until 1883. The area commanded by the canal is 8,320 square miles, of which 4,027 are in British territory, and the remainder in the States of Patiala, Nābha, Jind, Farīdkot, and Kalsia. The head-works are at the town of Rūpar, where the Sutlej issues from the Siwālik Hills into the plains. Here a weir 2,370 feet long crosses the river from bank to bank, having 12 arched undersluices each of 20 feet span. Extending up-stream on the east bank is the canal head regulator, with 13 arched openings of 21 feet span. About 500 feet farther up the river is the lock channel head, to admit of navigation between the river and canal. The crest of the weir is $7\frac{1}{2}$ feet higher than the canal bed, and along it extends a line of 586 falling shutters 6 feet high. When these are raised and the undersluices closed, the whole of the river supply is turned into the canal, and this is usually the case from early in October to the end of April. The main canal has for 39 miles a bed-width of 200 feet, with a depth of $11\frac{1}{2}$ feet, and can carry 8,000 cubic feet per second, or more than four times the ordinary flow of the Thames at Teddington. At the 39th mile it divides into two large branches, the combined branch on the west and the Patiala feeder on the east. The former, which has a bed-width of 136 feet and a capacity of 5,200 cubic feet per second, soon divides again into two branches. The northern of these, the Abohar branch, runs parallel to the Sutlej through Ludhiāna and Ferozepore Districts, terminating after a course of 126 miles at the town of Govindgarh. The southern or Bhatinda branch runs through Ludhiāna District and Patiala territory, with a length of 100 miles. The irrigation from these two branches is mainly in British territory, and the administration is entirely under the British Government, which retains all the revenue derived from them. They receive between them 64 per cent. of the supply of the main line. The Patiala feeder,

the eastern of the two large branches into which the main line bifurcates, runs to the town of Patiala, having a bed-width of 75 feet, and a capacity of 3,000 cubic feet per second. On its way it gives off to the south the three Native State branches, the Kotla (94 miles long), the Ghaggar (54 miles), and the Choa (25 miles). These three branches irrigate almost exclusively native territory, and the distributaries and irrigation arrangements are under the Native States, who receive the whole of the canal revenue; but the Patiala feeder and the branches are maintained by an officer of the Canal department as agent for the States, who distributes the water according to a fixed allotment, Patiala taking 83 per cent., Nabha 9 per cent., and Jind 8 per cent.

The distributaries were constructed so as to penetrate the border of every irrigated village, and thus to save the people the expense of making long watercourses and the difficulty of taking them through the land of other villages. This system, though expensive to construct and maintain, has been repaid by the rapidity with which irrigation has spread over the country. As during the cold season the whole of the river supply is turned into the canal, it was necessary to provide a substitute on the canal for the river navigation thus closed. Accordingly the main line, the combined branch, and 48 miles of the Abohar branch were provided with locks at the falls; and from the 48th mile of the Abohar branch a special navigation canal to the Sutlej near Ferozepore, 47 miles long, was constructed with a branch 4 miles long to Ferozepore. The Patiala feeder was also made navigable as far as Patiala. There is, however, little navigation along the branches, though the main line from Rūpar to the North-Western Railway is much used, and brings down a considerable amount of timber from the hills. There are 25 flour-mills at different falls along the branches. The greater part of the main line and branches is bordered by rows of trees, and the strip of land reserved for spoil or borrow pits is generally covered with plantations. A telegraph line extends from the canal head down the main line, the two British branches, the Patiala feeder, and part of the two longer Native State branches. Since 1896-7 the area irrigated has in only one year fallen below 1,560 square miles: the greatest area irrigated was 2,142 square miles in 1899-1900, of which 1,452 were in British territory. The total cost of construction to the end of 1903-4 has been 388.7 lakhs, of which 247.7 lakhs was paid by the Government, and 141 lakhs by the three Phulkian States. Of the cost of the head-works and main

line, the Government paid 64 per cent. and the Phūlkiān States contributed 36 per cent. The Government defrayed the whole cost of the British branches, and the Native States that of their branches. The charges for annual maintenance are divided in the same way.

The gross revenue on the British branches averages about 28 lakhs, and the net revenue 20 lakhs. On the Native States branches the gross revenue averages about 12.5 lakhs, and the net revenue about 7 lakhs. The return on the British capital outlay was as high as 10.8 per cent. in 1897-8, and averaged 8 per cent. during the six years ending 1902-3. On the Native States capital outlay the return for these six years averaged 5.3 per cent. This canal is now not only a successful commercial scheme paying a handsome profit, but its advantages in years of drought are incalculable. It saves from famine a large tract of country and also provides food for exportation. Since 1896-7 it has been steadily paying off the accumulated interest charges. The tract of country irrigated is now traversed in all directions by several different lines of railway, some of which would not have been required if no canal was in existence.

Bāri Doāb Canāl.—A perennial irrigation canal in the Punjab, taking off from the left bank of the Rāvi, and watering the Districts of Gurdāspur, Amritsar, and Lahore in the Bāri Doab or tract of country between the Beās and Rāvi. The present undertaking originated in a project for the improvement of an older work, the Hasli canal, constructed about the year 1633 by Alī Mardān Khān, the famous engineer of the emperor Shah Jahān. After the occupation of Lahore in 1846, Major Napier (afterwards Lord Napier of Magdāla) turned his attention at once to this project, and set on foot the necessary surveys. The progress of the work was interrupted by the outbreak of war. After annexation the work was pressed on, because the immediate construction of the canal was regarded as almost a matter of political necessity to provide employment for the disbanded Sikh soldiers, who, having their homes in the centre of the tract, would otherwise have had little encouragement to turn to agriculture. The alignment of the Hasli canal proved on examination to be so defective that the officers in charge decided upon the adoption of an entirely independent line, parts only of the original channel being utilized as distributaries. Irrigation began in 1860-1, but the present permanent weir and other regulating head-works were not completed till after 1875. The head-works are at the

village of Mādhopur in Gurdāspur District, where the river is crossed by a weir 2,700 feet long. The canal is capable of carrying 6,500 cubic feet per second: the highest average supply in the hot season is 4,850, while in the cold season it varies from 1,270 to 2,170 cubic feet per second. The main line terminates at its 31st mile, there separating into the Kasūr and main branches. The Kasūr branch 7 miles lower down gives off the Sobraon branch, and the main branch after 25 miles gives off the Lahore branch, the four branches following the crests of the ridges into which the tract is divided by its natural drainage. The total length of the main and branch canals is 369 miles, and there are 1,591 miles of distributaries, from which water is brought upon the fields by means of water-courses constructed and maintained by the cultivators. The canal is not navigable. The rainfall is greatest in the upper part of the system, which has necessitated a special system of irrigation in Gurdāspur District and in the portion of Amritsar District north of the North-Western Railway on the Kasūr and Sobraon branches. In that tract the distributaries are closed during the cold season after a watering has been given for sowing the spring crops, the winter rains with some help from wells being sufficient to mature those crops. The water thus set free has been utilized in extending irrigation in the driest part of Lahore District, where it borders on Montgomery—a tract for which it would otherwise have been impossible to provide a perennial supply. The gross area commanded by the canal is 2,710 square miles in Gurdāspur, Amritsar, and Lahore Districts. The lower portion of the Doāb in Montgomery and Multān is not irrigated, as there is not sufficient water available in the Rāvi during the winter. The area irrigated was 297 square miles in 1860, 677 square miles in 1880-1, 1,346 square miles in 1900-1, and 1,464 square miles in 1903-4. The total capital expenditure (exclusive of interest) up to the end of 1903-4 was 197 lakhs. The gross income for that year was about 33 lakhs, or, inclusive of the increase of land revenue due to irrigation (which is credited to the canal in the accounts), 36 lakhs. The working expenses amounted to 11 lakhs, leaving a net profit of 25 lakhs, or 12.68 per cent. on the capital outlay.

Chenāb Canal, Lower.—A perennial canal in the Punjab, taking off from the left bank of the Chenāb river and watering the tract between it and the Rāvi. The greater part of this area was before the introduction of irrigation a desolate region, unpeopled except for a race of pastoral nomads known as

Janglis. The land was for the most part Government waste, and was thus adapted for colonization on a scale hitherto untried in the history of India, if not of the world. The original work was designed as a small inundation canal and opened as such in 1887, but in 1889 it was decided to convert it into a perennial canal of the first magnitude. The head-works of the canal are at Khānki, a village in Gujrānwāla District, 8 miles below Wazīrābād. Here there is a weir across the river, by which the supply to the canal is regulated and controlled. The main line of the canal has a bed-width of 250 feet, and has been run with a depth of about 11 feet and a discharge of 11,000 cubic feet per second, or about six times the ordinary flow of the Thames at Teddington. This weir was commenced in 1890 and completed in 1892. The largest branch of the canal, the Gugera, carrying about one-half of the total supply, takes off from the left bank of the main line at the 28th mile. It has a length of 55 miles and then bifurcates into two subsidiary branches, the Gugera Lower and the Buralla, with lengths of 77 and 46 miles respectively. On the right bank, not far from the same off-take, is the Kot Nikka branch with a length of 18 miles. The extreme length of the main line is 40 miles, and it then divides into the Jhang, Rakh, and Miān Ali branches. The Jhang is the second largest branch of the system, and carries about 3,000 cubic feet per second. Its length is about 62 miles, before it bifurcates into the Jhang Lower (38 miles) and the Bhowāna ($7\frac{1}{2}$ miles long). The lengths of the Rakh and Miān Ali are 55 and 27 miles respectively. The total length of the main channels is 426 miles. For the distribution of the water-supply from the branches to the watercourses which directly irrigate the land there were, at the end of 1903-4, 2,323 miles of distributaries; and for the villages colonized by Government there had been constructed about 11,000 miles of watercourses. The total area commanded by the canal at the end of 1903-4 was 5,255 square miles in Gujrānwāla, Lahore, Jhang, and Montgomery Districts, of which 3,098 square miles were irrigated, an area which is capable of substantial increase. The total area of Government waste in the Doāb is about 3,817 square miles, of which 2,827 square miles of land commanded by the canal had been allotted by the end of 1903-4. The grantees are divided into three classes—capitalists, yeomen, and peasants; the greater part of the land has been distributed to peasants, who are by far the most satisfactory tenants. For the purpose of allotment the whole of

the Government waste has been divided into squares, the side of each square being 1,100 feet and the area about 28 acres. A peasant's grant consists of from one-half to three squares, a yeoman's of four or five, and a capitalist's of any number from five to twenty or more; and each settler is practically guaranteed water for the annual irrigation of a certain percentage of his holding. The Government retains the proprietary rights in the land, and the colonists are its tenants, the peasants for a term of years, the yeomen with right of continued occupancy so long as they pay their assessment, while the capitalists have also the right to purchase proprietary rights in their tenancy after the lapse of a certain period. There are also tenures which carry the liability to provide a certain number of camels for military service. For the purpose of distributing the land and of settling the colonists in villages, a special Colonization officer has been appointed with head-quarters at Lyallpur. There were 1,423 villages in 1903-4, the average size being about 50 squares or 1,400 acres. The population of the colony at the Census of 1901 was 782,690, and may ultimately reach two and a half millions. A railway for the transport of produce has been constructed, running the whole length of the Doāb from Wazirābād to Khānewāl, and several feeder-lines are under consideration. The capital cost of the canal up to the end of 1903-4 was about 280 lakhs. The canal earned a large revenue even while under construction, while the profits in 1903-4 amounted to 24 per cent. on the capital invested. The gross and net revenue derived therefrom in that year amounted to about 84 and 66 lakhs respectively. By 1913 the net revenue is likely to be very considerably increased, and the interest on the capital invested may amount to 30 per cent., while the value of the crops raised in a year is estimated to rise to 650 lakhs. The canal has thus not only enormously relieved the pressure of population in the congested Districts of the Punjab, but has proved a most remunerative investment, besides adding largely to the general wealth of the country. An extensive telegraph system runs from the head of the canal down its main line and branches, and along some of its larger distributaries, thus facilitating rapid regulation of supply.

Jhelum Canal, Lower.—A perennial irrigation work in the Punjab now approaching completion. It takes off from the left bank of the Jhelum, and will eventually supply perennial irrigation to the whole of the country lying between the Jhelum and Chenāb rivers, west of a line joining the town

of Miāni on the Jhelum with Pindi Bhattiān on the Chenāb. The head of the canal is near the village of Mong Rasūl in Gujrāt District. The river is dammed by a weir 4,100 feet long, and a regulator across the head of the canal takes the form of a bridge of 8 spans of $24\frac{1}{2}$ feet each. The main line has a bed-width of 140 feet and will have when running full a depth of 7.5 feet, and a discharge of 3,800 cubic feet per second, or twice the flow of the Thames at Teddington. The Shāhpur branch will take off at about the 28th mile of the main line. This branch has been designed to take up the irrigation now performed in Shāhpur District by the existing Imperial, Provincial, and privately owned inundation canals. After a course of 39 miles, in which it gradually approaches the centre of the highlands of the Doāb, the canal bifurcates into two main branches, watering the northern and southern portions of the Doāb respectively. The total length of the main line and main branches is about 167 miles, and about 960 miles of distributing channels will be constructed. The canal will protect an area of 2,400 square miles, and is expected to irrigate annually about 1,200 square miles. Of 2,400 square miles protected, about 850 are Government waste, which it is intended to turn into an immense horse-breeding colony for the supply of remounts to the Indian army. For this purpose the greater portion has been leased out to colonists on the condition of their keeping an approved brood mare, and other areas have been reserved for public and private breeding establishments and horse runs. The work of colonization is under an officer of the Indian Civil Service, who has his head-quarters at Sargodha in Shāhpur District. The land has been divided into squares of nearly 28 acres each, and one brood mare has to be maintained for every $2\frac{1}{2}$ squares. A railway has been constructed from Malakwāl on the Sind-Sāgar line to Shorkot on the Lyallpur-Khānewal line, affording facilities for the immigration of colonists and the export of produce.

Elaborate precautions have been taken to prevent water-logging of the soil by over-irrigation. The depth at which spring-water is found below the surface of the ground has been carefully observed over the whole of the commanded area, and the country has been divided into three zones according to these depths. Where the spring-level is 40 feet or more below the surface, 50 per cent. of the gross area commanded may be irrigated; where the depth lies between 25 and 40 feet, 40 per cent. of the area will be irrigated; and where the water is nearer to the surface than 25 feet, only 25 per cent. will be

allowed perennial irrigation, and powers have been reserved to reduce these supplies if they should be found to be in excess of requirements. On the Shāhpur branch 50 per cent. of the area will be irrigated.

The canal was opened on October 30, 1901; and irrigation is now well advanced, except on the Shāhpur branch, the construction of which has only just been commenced. It is estimated that this canal will cost when finished 187.5 lakhs, and will give a return of 15.8 per cent. on the capital spent upon it, and that ten years after completion the net revenue will exceed the interest charges by 192 lakhs.

Shāhpur Inundation Canals.—A system of inundation canals in the Punjab, fed from the Jhelum river and mainly situated in Shāhpur District. About sixteen of them are owned by private persons and six by Government. Of the latter three are classed as Imperial and two as Provincial, while one, the Pind Dādan Khān Canal in Jhelum District, has recently been made over to the municipal committee of Pind Dādan Khān for management. The three Imperial canals lie wholly in the Shāhpur *tahsil*, and are developments of a canal dug in 1864 by Colonel Sir William Davies, to supply water to the civil station of Shāhpur. In 1870 Government acquired this canal and added two new canals. The Imperial canals command an area of 105 square miles and irrigate 50 square miles a year on an average, yielding a net revenue of Rs. 50,000, or 24 per cent. on the capital outlay. Of the two Provincial canals the largest is the Rāniwāh, an old native canal which had fallen into disuse and was reopened in 1870-1. It commands 72 square miles in the Bhera *tahsil* and irrigates 30 square miles annually, yielding a net revenue of Rs. 11,000. It has extinguished its capital cost and yielded a net profit of 4.1 lakhs to Government. The Corbynwāh, constructed in 1879, irrigates about 4,500 acres, mostly grass lands, in the Khushāb *tahsil* on the right bank of the Jhelum.

The Pind Dādan Khān Canal does not pay expenses, but it supplies the town with sweet water. It performs a small amount of irrigation as well, the area irrigated in 1904-5 having been 395 acres. The private canals have a total length of about 227 miles and irrigate 87 square miles. Many of them are old canals which had silted up and were re-excavated, under Sir Donald McNabb and other Deputy-Commissioners of the District, by owners or lessees to irrigate their own lands. They also irrigate the lands of other persons on payment of a water rate. As noted in the article on the LOWER JHELUM

CANAL, most of these inundation canals will cease to exist as such when the Shāhpur branch of the Lower Jhelum Canal is constructed.

Sutlej Canals, Upper.—An Imperial system of four inundation canals in the Punjab, known as the Katora, Khānwah, Upper Sohāg, and Lower Sohāg (or Lower Sohāg and Pāra) Canals. They take off from the right bank of the river Sutlej, and irrigate the low-lying land bounded on the north by the old dry bed of the Beās, which separates it from the tracts commanded by the Bāri Doāb Canal. The tract commanded by the Katora Canal lies in Lahore District, and the remainder in Montgomery.

The canals existing at the end of 1903-4 aggregated 325 miles in length with 394 miles of distributaries, and carried an aggregate supply of 4,935 cubic feet per second. During the five years ending 1903-4 they irrigated an average annual area of 409 square miles and yielded an average gross revenue of 3.5 lakhs or, inclusive of the land revenue due to irrigation (which is credited to the canals in the accounts), 5.4 lakhs per annum. The average annual working expenses during the same period were 3.6 lakhs. There was, therefore, an annual profit of 1.8 lakhs. No capital expenditure was recorded against the canals till 1854-5; up to the end of 1903-4 it has amounted to 17 lakhs.

The Katora Canal has a bed-width of 55 feet, and an authorized discharge of 685 cubic feet per second. It was made in 1870-1, and follows the bed of a nullah for 21 miles, when it separates into three channels called the Pakhoki, Atāri, and Chuniān distributaries. The Khānwah has a bed-width of 65 feet, and an authorized full supply of 1,290 cubic feet per second. The date of first opening is not known: it is, however, recorded that the canal was improved by Mirza Khān, a minister of the emperor Akbar; but it was neglected by his successors, and silted up. In the time of Ranjit Singh, Dīwān Rādha Rām repaired the head and cleared the channel, and the canal flowed from 1807 to 1823. It was again neglected till 1841, when Fakīr Chirāgh-ud-dīn, under the orders of Mahārājā Sher Singh, had the canal repaired, and it was in flow when taken over by the Irrigation department on the annexation of the Punjab. The Upper Sohāg Canal has a bed-width of 60 feet, and an authorized discharge of 1,540 cubic feet per second. It appears to have been made in 1827, and worked till 1840, when it was neglected; and nothing further was done to it till 1855, when, the canal having been

taken over by the Irrigation department, the channel was again put into working order. The Lower Sohāg Canal has a bed-width of 90 feet, and an authorized discharge of 1,420 cubic feet per second. It may be said to date from 1816, when the first attempt to irrigate was made by means of a dam across the Sohāg nullah, which caused it to overflow its banks. In 1831 another dam was made, and the water was led on to the lands of Jawand Singh at Dipālpur, who is said to have obtained a large return from the water. After some fighting the dam was demolished in 1835; and from that date the canal existed only in name, irrigation being effected on only 3,000 acres by lifts by means of a narrow cut 20 feet wide. In 1885-6 the present regular canal was opened. The canal follows generally the Sohāg nullah for 33 miles, till it gives off the Pāra nullah. The canal continues in the form of two branches, one along the Pāra nullah and the other along the Sohāg nullah. The channel, however, was not formed in the bed, but consists of an artificial cut, which is crossed and re-crossed by the tortuous dry nullahs. The canal was constructed mainly for the purpose of bringing under cultivation 142 square miles of Government waste. This area was colonized by allotting parcels of land to chosen peasants from adjacent over-populated Districts. For the purpose of allotment the land was divided into squares, 27.7 acres in area, and each allotment consisted of 4 squares or 111 acres. The canals being dry in the cold season the colonists were required to construct wells, at least one well per holding being necessary.

Grey Canals.—A system of inundation canals in the Punjab, taking off from the south bank of the Sutlej and irrigating the low-lying tracts of Ferozepore District. They take their name from Colonel L. J. H. Grey, under whose orders, as Deputy-Commissioner of the District, they were constructed. The work was begun in 1875-6, when 11 canals were made; the number was increased to 13 in 1883; and in 1885, after the incorporation of the Fāzilka *tahsil* in Ferozepore District, two of the canals were remodelled and extended so as to irrigate this *tahsil*. In addition to these, a new canal, named Kingwāh, has just been completed at a cost of 1.7 lakhs. The 14 canals as they now exist vary in length from 28 to 107 miles, in bed-width from 30 to 80 feet, and in discharge from 283 to 640 cubic feet per second. Their total length is 1,034 miles, and their aggregate discharge 6,340 cubic feet per second. Being inundation canals, they run only when the Sutlej is at a sufficient height. Up to and including 1905-6