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PART I BASIC COURSES

I — 1 Rivers

Rivers differ greatly in character. There are swift-flowing rivers, slow, sluggish rivers, mighty rivers with several mouths, rivers that carry vast loads of alluvium to the sea, clear, limpid rivers, rivers that at some seasons of the year have very much more water than at others, rivers that are made to generate vast quantities of electricity by their power, and rivers that carry great volumes of traffic①.

Most rivers begin in springs or by the joining-up of numerous rivulets and streams of water②. Some emerge from lakes. Practically every river has an upper, a middle, and a lower part③. (upper or lower reaches)

In its upper part a river usually occupies the whole of the foot of its valley — for the valley is likely to be④ narrow, steep-sided, and ravine-like. It flows swiftly and turbulently and its bed is generally rocky.

Lower down⑤, in its middle reaches, the river flows more slowly, but still swiftly enough to cut away⑥ its bank. So it usually runs between well-defined margins, and there is little⑦

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① **great volumes of traffic**: 大量的交通运输，繁忙的交通运输。同样可用 "heavy traffic", 反之 "little traffic". ② **streams of water**: 水流；多股水流。 ③ **... an upper, a middle and a lower part.**: upper 及 middle 后面均省略了 part 一词。 ④ **is likely to be ...**: 像是...，有可能成为...。 ⑤ **lower down**: 形容后面主语 the river. ⑥ **swiftly enough to cut away**: 迅速得足以削去(切掉)...。 ⑦ **little ...**: 没什么，与 "a little" 意思是"有一点"不同。

danger of flooding. The lower stretches of rivers show considerable variety. Many wind across their valley floor in broad loops. These are continually being changed by the cutting action of the water, so that near the river there are usually remnants of earlier courses. Such rivers often cause floods, since their banks are low and the 'flood plain' bordering them is flat. Other rivers flow so slowly that the alluvium they carry is deposited on the river bed and in time of flood, along its sides in embankments①. Eventually this may result in② the river being raised above the level of the surrounding country. Still other rivers deposit their load③ as a delta — a fan-shaped deposit -- through which channels wind their way to the sea or lakes into which the river flows④.

All rivers change in volume with the season of the year⑤ — some vary considerably. In tropical areas, variation results mainly from the uneven distribution of rainfall: with the rains the river rises. In regions where rainfall is distributed throughout the year, rivers are fullest in winter, since rainfall is greatest then and there is less evaporation. Rivers which are fed from snow-fields become swollen with the melting of the snow and ice, but in winter they have practically no flow. In countries with Mediterranean climate, hot weather and lack of rainfall coincides — so that rivers which have been torrents in winter often have dry beds in summer.

(to be continued)

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① **along its sides in embankments**: 其前省略了谓语 is deposited. ② **result in**: 产生...的结果。 ③ **load**: 负荷，此处指"泥沙"。 ④ **sea or lakes into which the river flows**: 河流所注入的海或湖。 ⑤ **change in volume with the season of the year**: 河流水量随一年的季节不同而改变。

I — 2 Rivers (continued)

Rivers have many important functions. They have been used from earliest times as boundaries and as routeways and in dry countries to irrigate the land. More recently they have provided power for the generation of electricity. In early times before the development of efficient land transport, rivers were often the only route-ways. Frequently the country through which① they flowed was marshy or forested, or very hilly, and the only easy means of movement was by water. In other regions river transport is important, because it is cheaper than road or rail transport, especially for heavy raw goods② such as grain, iron, or coal.

Electricity is generated by water-power in practically every part of the world where the need exists and the water is available. Then, locks are constructed to enable shipping to overcome obstacles such as shallows, rapids and waterfalls, dams and reservoirs are built to regulate③ flow for power or irrigation schemes, as well as to reduce flooding.

I — 3 Applied Hydrology

The applied science of hydrology, in the broadest sense of the word, is concerned with circulation of water from the sea, through the atmosphere, to the land, and thence via overland and subterranean routes, back to the sea. For this reason many textbooks, devoted exclusively to hydrology, contain

① ... **the country through which they flowed** ... : 也可与成 ... the country which they flowed through .... ② **heavy** ...: 大量的,大批的,沉重的。"goods" 货物(复数)。 ③ **regulate**: 此处作"调节"讲。

chapters not only on precipitation and run-off but also on climate, soil physics, river morphology, open-channel hydraulics, and regulation of reservoirs. In this chapter, hydrology will be treated in a more limited sense, as being the applied science that provides the hydraulic engineer with the stream flow data that are needed for the planning, design and operation of water development projects.

When the hydraulic engineer collects stream flow data for the planning, design and operation of water development projects, he makes an important assumption: he assumes that the characteristics or the recorded flows of the past will apply to stream flow behavior in the future. In most cases this is a reasonable assumption, to a degree. If one has observed, for instance, at a certain gauging station, a minimum stream flow of 9,870 cusec, during the past 40 years, it is likely that the minimum stream flow during the forthcoming 40 years will also be about 10,000 cusec, plus or minus a few thousand cubic feet per second. However, to use the figure of 9,870 cusec in power or irrigation studies for determining the scope of development①, without considering the consequences of substantial deviations from this figure, would be② a bit unrealistic. In the applied science of hydrology it③ would be a good policy to keep the refinement of computations commensurate with the chance nature of the basic data and with④ the fact that we are primarily interested in an intelligent estimate of future stream flow conditions and not in⑤ a precise analysis of the past. Admittedly,

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① ... **to use** ... **development**: 为不定式短语，在句中作主语。 ② ... **would be** ...: 就会是，可说是。动词虚拟语气表示委婉语气，现在时。 ③ **it**: 是形式主语，真正主语是: to keep ... 直到句末。 ④ **with**: 前省略了 commensurate. ⑤ **in**: 之前省略了 interested.

the precise analysis will improve the intelligent estimate, but even the most precise analysis of the past is only a vague indication of what may happen in the future①.

I — 4 Function of Hydrology

I. Water resources inventory② (the collecting and processing of all data pertaining to the availability of water in the drainage basin).

1. Data collecting (the systematic collecting of stream flow, precipitation, ground water and other pertinent records).

2. Missing records (analytical studies to complete or to supplement the above records).

3. Data processing (transformation of the raw data into hydrograph, duration curves, mass curves, etc., so that a quick appraisal of the available water resources can be made).

II. Project planning

(to assist in project planning the hydrologist will often make special studies of available records; for instance, dependable flow for an irrigation project or evaporation losses of a proposed reservoir).

III. Design of structures (for the design and construction of hydraulic works, the hydraulic engineer must determine design conditions such as the spillway design flood, or cofferdam design flow, or a culvert design flow. To obtain such design flows, a statistical analysis of recorded flows must be made. In exceptional cases a synthetic study of extreme river flow conditions is required).

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① what may happen in the future: 在将来可能发生的事情。 ② water resources inventory: 水资源帐目(清单)。

IV. Economic analysis (to appraise the relative merits of a proposed project, a benefit-cost analysis is required. To determine the benefits of a water development project, statistical data are needed; for instance, duration curves for roughly determining the benefits of irrigation and power project; flood frequency curves for determining the benefits of flood control projects).

V. Project operation. (the efficiency of operating reservoir for water supply, power or flood control purpose can be greatly increased when river flows can be forecast. To this end, a study must be made of① the relationship between antecedent moisture conditions, precipitation, and runoff).

(From *Water Resources Development*, by E. Kuiper)

I — 5 Surface-water Supplies — Yield

The quantity of water that may be drawn② continuously from a stream or lake depends upon the area of the watershed, the topography, vegetation, rainfall, climate and amount of storage. The maximum quantity of water that may be drawn continuously after deducting③ losses due to evaporation from the proposed reservoir surface, leakage through and under dams, and necessary withdrawals for riparian owners downstream④ is called the safe yield⑤. The estimated safe yield must exceed the estimated future demand if a proposed water supply is to be

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① **a study must be made of the ...**: 正常词序为 "a study of the ... must be made", 由于后面短语较长，并为了突出 must be made 的意思，所以适当颠倒了词序。 ② **drawn**: 是 draw 的过去分词，此处作 "引出"解。 ③ **deduct**: 扣除，除去。 ④ **riparian owners downstream**: 此处 downstream 为形容词，放在所修饰的名词 owners 的后面，以突出名词的意思。 ⑤ **safe yield**: 保证出水率，或可靠出水率。

adequate①.

The safe yield of a source of supply can be estimated only from records of the past. The most reliable information from which to predict yield② is a hydrograph of the stream for a long period of years at the location of the proposed intake of dam. The hydrograph should be of sufficient duration③ to include a period of extreme drought. If no such hydrograph exists, it④ is necessary to supply equivalent data by adjusting hydrographs made at other points⑤ near by⑥ or by computing runoff from rainfall records. The methods that may be used for estimating runoff are described in the next section. Surface supplies are more frequently taken from small up-land streams than from large rivers both because of the superior quality of the water and because of the savings to be had⑦ in pumping costs. Hydrographs are seldom available for the smaller streams, although rainfall records are usually available at near-by stations. Hence, the computation of runoff from watersheds by means of the rainfall loss method is more commonly desirable for water supplies than for water-power projects.

If the minimum runoff from a watershed is insufficient to satisfy the estimated demand but the average runoff over a

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① **is to be adequate:** is + 不定式 to be 有"将要"、"就要"或"打算"之意。此处可解释为: 能(要求)达到足够量。 ② **from which to predict yield:** 是形容词从句,修饰 information 一词,句中省略了 we are, 即全句为: "from which we are to predict yield" 或 "which we are to predict yield from". ③ **should be of sufficient duration:** should be 是虚拟语气,表示"应该是"的意思。"of sufficient duration"是表语,说明主语 "hydrograph" 的性质。 ④ **it:** 是形式主语,代表 "necessary" 后面的真正主语, 即由 "to" 引出的不定式短语。 ⑤ **made at other points:** 过去分词短语作定语,修饰其前 "hydrographs". ⑥ **near by:** 附近,形容词短语,by 为副词。 ⑦ **to be had:** 表示"能够有"。被动语态。

period including the driest period of record is more than sufficient, the demand can be met by the construction of one or more impounding reservoirs. The methods of estimating the amount of storage necessary to provide or, conversely, the safe yield from a watershed having a given reservoir capacity are described in the next section.

(From *Handbook of Applied Hydraulics,* by C. V. Davis)

I — 6 Flood Control

It is generally understood that flood control includes all measures which aim at reducing the harmful effect of floods. It① is important to place the emphasis on the word 'reduce', since flood control measures very seldom, if ever②, eliminate the hazard of flooding. Flood control measures may be divided into the following categories:

I Engineering measures: (1) the construction of reservoirs, (2) the construction of dikes, (3) the diversion of flood flows, (4) the improvement of river channels;

II Administration measures: (1) flood for-casting, (2) flood plain zoning, (3) flood insurance.

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Levees are small earthen dams placed at varying distances from the banks of a stream to serve as artificial banks during flood periods when the stream gets out of its natural banks, and to protect the major portion of the bottom land from overflow.

Levees are justified and should be used in any valley where the interest on their first cost and the cost of annual maintenance

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① It: 为形式主语，代表后面的真正主语: "to place ... 'reduce'." ② if ever: 是非限定性状语从句，"if flood control measures ever eliminate the hazard of flooding" 的省略式。

is less than the annual increase on the returns from the land which is protected by them.

Levees are the oldest known form of flood protection, and have been used more extensively for this purpose than any other form of either flood protection or flood prevention. On the lower reaches of long rivers they afford the only sure means of flood control.

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It is clear that reservoirs as a means of flood prevention, are appreciable mainly to small watersheds, and that they are especially effective in preventing floods from intense precipitation of the cloud-burst type. The total run-off for small watersheds is such that large reservoirs are not required; and further, the lands to be protected are near enough to the reservoir to receive the protection desired①.

For medium — size watersheds of about 5,000 square miles, a single reservoir is seldom sufficient to② prevent floods at the lower end of the watershed; but a system of reservoirs, one on each of the principal flood producing tributaries, will in many cases prove the solution of the flood problem. The Miami watershed in Ohio is an example of this type of watershed. The flood protection works recently completed in this valley consist of five retarding basins, one at the head-waters, one on the mainstream above Dayton, and one each on the three tributaries.

For large streams, however, flood protection in the lower reaches cannot be economically secured by the construction of

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① ... **are near enough to the reservoir to receive the** ...: 句中"near"后面要求 "to", 作接近于...解。**enough to receive**: 足以接受...。"enough"为副词,修饰形容词 near. ② ...**sufficient to**...: 足够…。

storage reservoirs or retarding basins. For example, it is estimated that to have prevented the Mississippi River from overflowing its banks during the 1912 flood, a reservoir in the vicinity of Cairo, Illinois, would have been required, covering 7,000 square miles to a depth of 15 feet-assuming the reservoir to have been empty when the river reached the bankful stage. Evidently it would be out of the question① to use such a large area in this part of the valley for reservoir purposes.

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In any case, two main requirements must be met in establishing a reservoir site for flood protection, one physical and the other economic. First, the physical conditions of the watershed must be such that one or more reservoirs can be constructed of sufficient size to store or retard the excess flood waters; and second, the cost of such reservoirs must be reasonable and less than the benefits which will result from their construction.

(From *Drainage and Flood-control Engineering*, by G. W. Pickels)

I — 7 Open Channel Flow

We may divide open channel flow into steady and unsteady flow. Steady refers to time. If the discharge in a channel at any one point does not change with time, we are dealing with steady flow. If it does② change with time, we have unsteady flow, for instance, when a wave is travelling in a channel or when the discharge is gradually increasing.

We may divide open channel flow also into uniform and

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① **... out of the question ...**：根本不可能...。 ② **... does change with time ...**：此处 does 用以强调语气，本身并无意义，可译为"果真随时间而改变"。

non-uniform flow. Uniform refers to distance. If the wetted cross-sectional area of an open channel is the same from one location to another, we are dealing with uniform flow. If it does change from place to place①, we have non-uniform flow; for instance, when the slope of the channel steepens, when the channel contains an obstruction, or when the flow is backed up② by a dam.

In the following paragraphs we shall first deal with steady, uniform flow. The main problem here is to determine the discharge of a channel when its characteristics are given, or vice versa. In order to solve such problems we will derive the Manning formula③. The next topic will be steady, non-uniform flow. This subject will be divided into two parts. The first group of problems will be concerned with situations where④ friction losses are relatively unimportant. In other words, the non-uniformity of flow takes place over short distances: for instance, channel transitions and channel obstructions. The main problem here is to determine the water surface profile. This will be done by using the Bernoulli equation⑤ and by introducing such concepts as the specific head⑥. The second group of problems in steady, non-uniform flow will be concerned with situations whereby⑦ friction losses do play an important role. This group includes back-water problems.

(From *Water Resources Development*, by E. Kuiper)

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① **... does change from place to place:** 各处真的都有变化。 ② **... backed up:** 挡住。 ③ **Manning formula:** 曼宁公式。 ④ **... where friction losses are ... :** where 是关系副词，在句中引出定语从句，修饰前面的 situation. ⑤ **Bernoulli equation:** 伯努利方程。 ⑥ **... such concepts as the specific head:** 句中 "such" 为形容词，"as" 为连词，连接同级比较名词，与 concepts 同为句中动名词"introducing" 的宾语。 ⑦ **whereby:** 是关系副词，此处在句中引出定语从句，修饰 "situation".

I — 8 Flow Development in Closed Conduit

Flow in closed conduits involves a combination of steady or unsteady flow, uniform or nonuniform flow, laminar or turbulent flow, and flow over smooth or rough boundaries.

At the up-stream end of a pipe there is a region of flow development in which the boundary layer is developing and the flow is technically nonuniform because the velocity varies from point to point along the streamline. Therefore the velocity distribution changes from section to section, which means that, in this region of flow development, a standard calibration of measuring devices and the standard loss coefficients for pipe fittings (minor losses) are not applicable. In other words, calibrations must be made and coefficients must be determined in place① if reasonable accuracy is to be achieved. Furthermore, in this region the greater boundary shear and any intial separation cause a greater amount of energy loss per unit length of pipe than in the region② of fully developed flow downstream. The length of the region of flow development in a pipe of diameter D is approximately $0.06\ ReD$③ for laminar flow and $0.7\ Re^{0.25}\ D$④ for turbulent flow throughout the length from the pipe entrance.

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① **... in place**: 在适当的位置。 ② **... than in the region of ...**: 是 "than the amount of energy loss per unit in the region of ..." 的省略语。 ③ **0.06 *ReD***: 读为 "point o six Renold number (雷诺数) multiplied by *D*". ④ **0.7 $Re^{0.25}$ D**: 读为 "point seven Renold number to the point two fifths power multiplied by *D*" 或 "point seven one-fourth power of Renold number multiplied by *D*".

I — 9 States of Stress

A brief review of the relationships existing among the stresses acting on various planes which pass through a point in a stressed body will serve as an introduction to the basic mechanics to be used in this chapter. The relationships given apply equally well to steel, concrete, wood, soil, or any other substance because they are independent of the physical properties of the material.

The state of stress at point P in a body acted on by a system of forces Q may be described by reference to the stresses on one or more planes N, which pass through the point P. In general, it will be found that the resultant stress on any plane has an obliquity θ. The resultant R may be resolved into component σ and the component τ. The component σ perpendicular to the plane is called the normal stress, and the component τ or δ acting tangentially to the plane is called the shearing stress.

If plane N, passing through the stressed body, is rotated in space, it will be discovered that there are three mutually perpendicular planes on which the shearing stress is zero①. The normal stress acting on one of these planes is algebraically the largest normal stress acting on any plane. On another of the planes the normal stress is algebraically the smallest, while on the third plane the normal stress has a value intermediate between the stresses acting on the other two planes. The three

① **it will be discovered that there are three mutually perpendicular planes on which the shearing stress is zero:** 这句中的 "it" 为形式主语，代表其后 "that" 引出的从句，其中 "on which ... zero" 是定语从句，修饰其前的名词 planes.