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"Dredging on the Lower Danube."

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THE European Commission of the Danube has now charge of the lower river from the Roumanian town of Galatz, 92 nautical miles from Sulina to the sea, the powers of the Commission having been extended over the part of the river from Isaktcha to Galatz by the Treaty of Berlin in 1878.

The important works at the Sulina mouth of the river have been described by the Engineer-in-chief of the European Commission, Sir Charles A. Hartley, M. Inst. C.E.[1] No dredging has been required at the Sulina mouth, the scour caused by the piers having been sufficient to form and maintain a commodious channel, with a depth of 20½ feet across the old bar. The Sulina branch from the sea to the 18th mile has not required improvement, the channel being regular, and having a depth of not less than 17 feet at zero. A shoal, which extended from 18½ to 19½ miles, was removed by the construction of groynes in 1861–62. From the 20th mile to the St. George's chatal, or bifurcation, at the upper end of the Sulina branch, 44½ nautical miles from the sea, shoals are frequent; many have been removed, but new ones appear from time to time. An isolated shoal at the 54th mile, the Ismail chatal, having been dredged and permanently removed by training works executed in 1873, the part of the river between 44½ miles and Galatz has been cleared of its single obstruction. The only section of the lower Danube now requiring improvement is consequently the upper part of the Sulina branch, from 20 to 44½ miles. Before the existence of the European Commission, the minimum depth in the Sulina branch was 8 feet. Up to the present time an extra depth of 5 feet has been gained. Dredging and other works have been constantly required, the object being to secure a minimum depth of 15 feet at zero.

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[1] *Vide* Minutes of Proceedings Inst. C.E., vol. xxi., p. 277, and vol. xxxvi., p. 37.

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In dealing with the shoals in the lower Danube, it is, considering the vast quantities of sediment and sand carried in suspension by the river during floods, practically or financially impossible to effect permanent improvement by dredging alone. The average quantity of detritus transported by the Sulina branch is above 5,000,000 tons per annum. During ordinary land floods 50,000 tons in twenty-four hours are frequent, and the extraordinary quantity of 135,000 tons in twenty-four hours has been reached on several occasions, when the average quantity of sediment in suspension amounted to 980 grains per cubic foot. The latter occurrence takes place after very heavy rains in the Roumanian plains. These plains consist of rich loam, easily carried away by attrition, and readily transported by the swift current of the lower tributaries of the Danube on the left bank, the Pruth, Sereth, &c.

Shoals occur in reaches of the river which are of an abnormal width, by preference between counter curves in the river course, where in consequence the main current and the channel have to cross the river-bed from one concave bank to the other opposite and below; also in long straight reaches, where, instead of following one bank as in curves, the main current meanders over the whole area of the river section from one bank to the other. These can only be permanently dealt with by the construction of groynes, or training works, reducing the river to its normal width.

The shoals in the Sulina branch are subject to constant changes, increasing during floods, and being gradually worn down during low-water seasons. The range between the maximum flood level and extreme low water at the upper end of the Sulina branch is 12 feet. A shoaling of 3 feet has been known to take place within twenty-four hours, when no particular reason for its sudden formation could be assigned; in many cases, however, where ships have grounded, a small bank has formed below before the ship could be got off, which in its turn has disturbed the regularity of the current, forming a series of banks below, and causing a whole reach to shoal. In these cases, when the construction of groynes would take months to execute, dredging is at once resorted to, and gives immediate relief, re-establishing the former depth in the shortest possible time. Under ordinary circumstances dredging operations on the shoal offering the least depth at zero are proceeded with as soon as the spring land-flood begins to subside, which generally takes place in June. This equalises the depths on the different shoals, and assists in maintaining a deep and uniform channel

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during the period of low water in the autumn, which coincides with the greatest activity of navigation, the new crops of the Danubian Principalities being exported immediately after the harvest. The channel dredged across shoals is, as a rule, of a width of 150 feet, and 15 feet deep below zero. The time occupied in dredging the shoals is very variable, six months having been required in 1872, seven months in 1873, one month in 1875, three months in 1876, and one month in 1880.

The shoals consist chiefly of fine sand; but at Veniko, at the 37th mile, a shelf of hard clay, which the current had not been able to remove, was met with in dredging to 15 feet below zero, and the same occurred in the Argagnis reach, at the 41st and 42nd mile, and a permanent increase of depth was thus obtained. On the ordinary shoals the increase of depth by dredging is as a rule lost during the first flood after the operation.

The European Commission has at present two ordinary bucket steam-dredgers, the one of 16 HP. nominal, the other of 40 HP.; another 40-HP. dredger is being built. The dredgers are open-ended single-ladder machines, fitted with Messrs. Burt and Freeman's mud-pumps, as used on the Amsterdam ship canal, and now employed on the St. Petersburg ship canal. These pumps have been fully described in "Engineering;"[1] for dredging shoals consisting of fine sand, in some cases slightly mixed with vegetable deposit and alluvial silt, they answer admirably. The Sulina branch has a maximum width of 600 feet, so that either bank can in every case be easily reached by the floating tubes, and the height of the banks above ordinary low water hardly ever exceeds 8 feet, which is also very suitable. The excavated material is thus got rid of in the most efficient and economical manner.

The 40-HP. power steam-dredger has a length of 115 feet, a breadth of beam of 25 feet, and a depth of 10 feet 9 inches. It has a single side-lever low-pressure engine with tubular boiler, and can dredge 1,300 cubic yards per day of twelve working hours in favourable ground, to a maximum depth of 24 feet. The 16-HP. dredger has not been used lately. It requires nearly the same crew as the 40-HP. machine, is antiquated and not economical.

The Sulina branch in its upper part being very tortuous, there is ample room for improving it by cuts, for shortening and straighten-

[1] July 17th, 1868; and again November 8th, 1872.

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ing the course by suppressing sharp bends, which, as steamers navigating the river increase in size and number, become more and more objectionable. The largest steamer which has passed through it up to the present, had a length of 300 feet, a net register of 1,384 tons, and 2,036 tons gross.

The cut between the 23rd and 24th mile was finished in 1870. It shortens the river by 5,790 feet, and does away with three of the worst bends. The length of the cutting is 1,900 feet; its bottom width was 180 feet, and depth 16 feet below zero. This cutting was widened in 1874–75 to a bottom width of 260 feet. The width at the waterline at zero is 300 feet. The old part of the river cut-off has now silted up entirely in its upper end without artificial aid, and is overgrown by willow bushes several feet high.

A second cut is under execution at the St. George's chatal, with a view of giving an improved entrance to the upper end of the Sulina branch. This cut has a length of 3,100 feet; it will do away with two sharp bends, and shorten the river by 2,900 feet. The bottom width is 260 feet, and the width at zero is 300 feet. It will be dredged to a depth of 16 feet below zero, or deeper if the scour does not itself produce the normal section. Of the 869,000 cubic yards to be removed, 123,750 were dredged last year by the 40-HP. machine. The site of this cut consists of alluvial deposit, the same as the whole of the delta. The height of the ground varies from 4 feet above zero in the middle of the cutting to 11 feet above zero near the river banks. The upper stratum is very hard clay and loam interlaced with the strong and tenacious roots of reeds, for a depth of several feet; below, layers of clay, vegetable deposit of a peaty nature, and fine river sand occur in irregular layers. The clay, down to 12 feet below the waterline, is dredged into hopper barges, which are towed into the St. George's branch, and discharged behind the St. George's chatal spur, close to the left bank of the river, the average distance being 4,000 feet. The lower sandy layers will be removed by dredging in combination with the mud pump.

The prime cost of the plant employed has been as follows:—

	£
One steam-dredger 40 HP. nominal	14,700
„ screw steamer for towing of 15 HP.	800
Two bottom hopper barges (capacity 90 cubic yards).	3,200
„ side „ („ 30 „).	880
Total	19,580

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The cost of dredging per cubic yard has averaged as under :—

		Pence per Cubic yard.	Pence per Cubic yard.	Pence per Cubic yard.
Dredger .	Coal and stores . .	0·675	1·944	3·102
	Crew and wages . .	1·269		
Repairs of Dredger	Stores	0·341	1·158	
	Labour	0·817		
Transport :—				
Towage 4,000 feet	Coal and stores . .	0·362	0·586	1·050
	Crew	0·224		
Hopper barges	Stores	0·020	0·464	
	Crew	0·444		
	Total . .	4·152	4·152	

This is the actual cost for wages and stores, including repairs of plant, but excluding the cost of plant, depreciation and interest. In estimating for these latter items the quantity dredged and transported per annum by the above plant would have to be taken at 250,000 cubic yards, as no more than two hundred working days per annum can be counted upon on the lower Danube, the winter being long and rigorous.

When using the mud-pump in combination with the dredger, the engine has to exert greater power ; additional men for looking after the tubes are also required. This does away with the transport, but slightly enhances the cost of dredging proper, which becomes 2·592*d.* per cubic yard for wages, coals, and stores, making a total cost of 3·750*d.* per cubic yard, including repairs. The cost of repairs of the wear and tear of the dredger, 1·158*d.* per cubic yard, is high. In pure clay, of a soapy nature, it would be less ; it is due to the sand, which cuts up the links and buckets. The age of the dredger, which was built in 1866, must also be taken into account.

For comparison with other places, it must be remarked that the price of coals on the lower Danube is at present from 26*s.* to 30*s.* per ton. Stores are proportionately expensive, as compared with prices in England. Wages are high for skilled labour. Sailors earn 3*s.* per day ; labourers, 2*s.* 6*d.*

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