putrid marsh would only be an infecting neighbour. It may be proposed to drain it by one or more canals, and it is required to determine their lengths and other dimensions, so as to produce the best effects. It is evident that there are many circumstances to determine the choice, and many conditions to be attended to.

If the canals AC, AD, AE, are respectively equal to the proportions BC, BD, BE, of the river, and have the same slopes, they will have the same discharge ; but they are not for this reason equivalent. The long canal AE may drain the marsh completely, while the short one AC will only do it in part ; because the difference of level be­tween A and C is but inconsiderable. Also the freshes of the river may totally obstruct the operation of AC, while the canal AE cannot be hurt by them, E being so much lower than C. Therefore the canal must be carried so far down the river, that no freshes there shall ever raise the waters in the canal so high as to reduce the slope in the upper part of it to such a level that the current shall not be sufficient to carry off the ordinary produce of water in the marsh.

Still the problem is indeterminate, admitting many solu­tions. This requisite discharge may be accomplished by a short but wide canal, or by a longer and narrower. Let us first see what solution can be made, so as to accomplish our purpose in the most economical manner, that is, by means of the smallest equation. We shall give the solution in the form of an example.

Suppose that the daily produce of rains and springs raises the water 1½ inch on an area of a square league, which gives about 120,000 cubic fathoms of water. Let the bot­tom of the basin be three feet below the surface of the freshes in the river at B in winter. Let the slope of the river be two inches in 100 fathoms, or 1/1600, and the canal six feet deep.

The canal being supposed nearly parallel to the river, it must be at least 1800 fathoms long before it can be ad­mitted into the river, otherwise the bottom of the bog will be lower than the mouth of the canal ; and even then a hundred or two more fathoms added to this will give it so little slope, that an immense breadth will be necessary to make the discharge with so small a velocity. On thc other hand, if the slope of the canal be made equal to that of the river, an extravagant length will be necessary before its ad­mission into the river, and many obstacles may then inter­vene ; and even then it must have a breadth of thirteen feet, as may easily be calculated by the general hydraulic theorem. By receding from each of these extremes, we shall diminish the expense of excavation. Therefore,

Let *x* and *y* be the breadth and length, and *h* the depth (six feet), of the canal. Let *q* be the depth of the bog be­low the surface of the river, opposite to the basin, D the discharge in a second, and - the slope of the river. We must make *h* x *y* a minimum, or *x d y + y d x =* 0*.*

The general formula gives the velocity

\*\*\*y \_ √⅞g (√rf-0∙l) \_ 0.3 ∕√rf\_ 0∙]). This would √s — L *»/s* + l-6

give *X* and *y ;* but the logarithmic term renders it very complicated. We may make use of the simple form y \_ \*z N <7 <Z , making √ N <7 nearly 296. This will be sufficiently exact for all cases which do not deviate far from this, because the velocities are very nearly in the subdu­plicate ratio of the slopes.

To introduce these data into the equation, recollect that \*\*\*\*\*\*D *h ∙c*

*V = —, d~* Γ7∙ As to S, recollect that the canal

*h X* a: + 2 Λ being supposed of nearly equal length with the river, - will express the whole difference of height, and *— q* is the dif­ference of height for the canal. This quantity being divided y

by y, gives the value of ι =- ∙ Therefore the equation

s *υ*

*h. — q* for the canal becomes ≡ √N *g J—x.. fL*

*hx X + 2h y*

Hence we deduce y —3 , and

⅛λ~L-D"*(x* + 2 *h)*

*a*

*, \_ 3^H g q hi x\* d x*

~~j~~ ~~Ny⅛~~~~3~~~~a~~~~3~~~~-d~~~~≡ (~~~~a~~~~,~~ ~~+ 2~~

α

xτ λa j ∕3N *g h5 x3 τxo∖* N *g q* Λ3 <r3 *d x* i - D2 )

- [^\_D.(:+2<)]··

If we substitute these values in the equation *y dx* + *xdy* = 0, and reduce it, we obtain finally

— 3 *x =* 8 *h.*

*a* D\*

If we resolve this equation by making N *g* = (296)’, or 87616 inches, *h* = 72, = y7⅛j, and D = 518400, we

obtain *x* = 392 inches, or 32 feet 8 inclies, and —5-, or

Ä *x*

V = 18-36 inches. Now putting these values in the exact formula for the velocity, we obtain the slope of the canal, which is 1/11664, nearly 0∙62 inches in 100 fathoms.

Let Z be the length of the canal in fathoms. As the river has two inches fall in 100 fathoms, the whole fall is 2*l*/100, and that of the canal is 0·62*l*/100. The difference of these two must be three feet, which is the difference between the river and the entry of the canal. We have therefore \*\*\*(9 0,62∖

——j-- *j l* = 36 inches. Hence Z = 2604 fathoms ; and this multiplied by the section of the canal gives 14,177 cubic fathoms of earth to be removed.

This may surely be done, in most cases, for eight shillings each cubic fathom, which does not amount to L.6000, a very moderate sum for completely draining nine square miles of country.

In order to judge of the importance of this problem, we have added two other canals, one longer and the other shorter, having their widths and slopes so adjusted as to insure the same performance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Width. Feet.** | **Velocity. Inches.** | **Slope.** | **Length.** | **Excavation.** |
| 42 | 14∙28 | 1/18988 | 2221 | 15547 |
| 322/3 | 18·36 | 1/11664 | 2604 | 14177 |
| 21 | 28∙57 | 1/4781 | 7381 | 15833 |

We have considered this important problem in its most simple state. If the basin is far from the river, so that the drains are not nearly parallel to it, and therefore have less slope attainable in their course, it is more difficult. Perhaps the best method is to try two very extreme cases and a middle one, and then a fourth, nearer to that extreme which differs least from the middle one in the quantity of ex­cavation. This will point out on which side the minimum of