

latter they need only close during the freshet)—all tend to require very careful examination and much experience before deciding upon the proper design for the gates. In fact, almost every locality requires a gate of a design unique in itself, with some special features differing probably very materially from that required in a locality not half a mile distant. The boxes required for the sloughs located on the river above the effect of the tides are subjected to a very severe test and strain during high water. They are often subjected to a pressure of water due to a head of from 18 to 20 feet and lasting from a month to six weeks. On the other hand, those located on that part of the river affected by tidal waters are relieved twice every day during ebb tide.

The writer gives a description of two of these boxes built by him, one in March, April and May, and the other in August and September, 1896, all being under the same contract. They are built in two sloughs, discharging into the Fraser, through what is known as the Matsqui Prairie. They were designed in 1893 by Fred. J. L. Tytler, C.E., at present supervising engineer for reclaiming lands for the Provincial Government of British Columbia, and were built with several changes under contract by the writer. It may also be mentioned that in each of these sloughs prior to the construction of the ones described, there had been built three different and distinct boxes, each of which had succumbed to the effects of the freshets, and had been torn apart or scoured out, and carried by the flood for long distances over the prairies. One of the present boxes, the only one built at the time, was subjected to a very heavy freshet in July last, the water in the river reaching to a point only 2 feet 11 inches below that reached during the disastrous flood of 1894; but although the work was barely completed when the flood came, and had in consequence barely reached its true bearing, still there was no sign of leakage, or scour, or damage in any one particular. The lumber used in the boxes was all of rough sound cedar, with the exception of the clappers or doors, which were of dressed Douglas fir. The boxes are identical in design, each being 80 feet long by 26 feet wide by 5 feet 8 inches outside measurement, having four openings each 4 feet by 5 feet. They have also each an entrance apron 30 feet x 40 feet, and a discharge apron 60 feet x 40 feet, each contains about 90,000 feet B.M. All spikes were specified to be galvanized.

The most important part of the work is the method of setting the box, and the proper placing of the brush and clay and packets, and this will be now described. At this point of the Fraser River, there is an ordinary rise and fall of tide, due to the backing up of the river, of about 4½ feet, while during the freshet no difference of rise and fall is perceptible. Both boxes being identical in design it is only necessary to describe the manner of placing one—the most difficult—and located in what is known as No. 3 slough. This slough is about 80 feet wide at the top, and from 25 to 30 feet deep, with water at the time of construction about 10 to 16 feet deep. It drains a large portion of the prairie, besides receiving a large creek from the surrounding hills, and as the weather was very wet at the time, it was necessary for it or the off-take ditch to carry away a large amount of water. The banks of the slough sloped at about ¾ to 1 and were interwoven with roots, and gave signs of sliding from adjacent springs and seepage of water. The method devised and afterwards adopted for placing the box was to build a temporary dam a short distance above the site of the box, another a short distance below the site, excavate an off-take ditch, and having pumped out the portion of the slough between the dams, to commence operations. The off-take ditch was excavated through fairly good clay, being about 12 feet wide at the bottom, with side slopes of about 1 to 1, and varying in depth from 4 to 14 feet. In constructing the upper dam a crib of logs was first built across, notched down and securely drift-bolted together, the logs on the upper side having a batter of about 6 inches to the foot. Along the upper side were driven sheet piles, consisting of 3 and 4 inches plank which penetrated from 4 to 8 feet into the bottom, but on account of the presence of many sunken logs and stumps, it was impossible to get all the plank down to a proper bearing, but they were intended merely to hold the brush and earth, afterwards conveyed in, from being swept down by the current so soon as it was deposited.

At first it was considered practicable to commence this sheet piling at one side, and continue along, finishing at the other, but it was found that the banks were of such a treach-

erous nature, that the increased current due to the narrowing of the channel, would scour away the banks more quickly than the sheet piles could be driven, and thus destroy the location of the box. It was then decided to commence at both ends, make them thoroughly secure, and work toward the centre. This was done, the sheet piling from each side being closely followed by laborers dumping earth to form an embankment on the upper side of the crib, keeping plenty of brush on the outside, to prevent the earth being scoured away by the current. After having proceeded thus toward the centre, and when the current became too strong, due to the narrow opening to hold the earth from being washed away, the gap in the sheet piling was closed, and the backing deposited as soon as possible. But the material in the bottom of the slough was of such a treacherous nature, that no sooner had the water on the upper side begun to rise on the piling than it broke through underneath, the water following the piles down, where it encountered a coarse, red sand, which was soon scoured out, and in a very short time an open channel was made underneath the piling. Sacks were immediately obtained and filled with earth (about 1,200 of them), and these dumped into the channel or hole with loose hay and earth, finally held the current until a large earth embankment was built across. No more trouble was afterwards encountered, although it was subjected at one time to a pressure due to a 27-foot head. The lower dam was built in much the same way, but with less difficulty, there being only a 4 foot tide to contend against. The specifications required all ooze, logs, sticks or perishable matter to be removed from the bottom of the slough, between the two dams, to a maximum depth of 6 feet below the bottom of the box, in order to secure a proper foundation on which to lay the brush and clay. Should the material below that be soft and mushy, then wild hay was to be tramped in below that again, until a firm bed was obtained. But it was to be left to the judgment of the engineer as to how deep up to the six feet the excavation was to be made.

After having pumped out the location—a centrifugal pump with a 4 inch discharge having been used with a maximum lift of about 15 feet—the bottom of the slough was carefully examined and the material tested. The first 2 feet or thereabouts consisted of ooze, slime, brush, logs, stumps and every imaginable kind of worthless matter. Beneath this for from 4 to 6 feet was a bed of silt, of a bluish color, containing minute particles of mica, and very gritty to the touch, but the particles of sand being fine. This when left in its natural bed, and not disturbed, is impervious to water, but once it is moved and displaced, and exposed to the action of water under pressure, it becomes a veritable quicksand. Beneath this was a bed of fairly coarse, red sand. After having made this examination, the cause of the former boxes having been scoured out was apparent to the writer. They had been constructed in the form of coffer-dams built by driving rows of sheet piles braced to ordinary piles, and filling the intervening space with earth or clay. These piles have penetrated this bluish silt, and were driven into the red sand. When the water acquired the necessary head on the outside, after the closing of the gates, it followed down the piles through the silt, into the sand and up again on the other side. The intervening earth was soon washed out, and with it the bottom of the piles, until a channel was formed underneath, and very little time elapsed before the whole structure was scoured out. After having been enlightened as to the nature of the bottom, it was decided to lay the foundation upon this bed of bluish silt, without disturbing it more than necessary. This was done after all the decayed material—logs, ooze, etc.—had been removed from the bottom, and all roots, slides and loose material cleaned off the sides of the banks, and proper slopes of about 1½ to 1 excavated from them. The foundation under the box proper was built up of clay and brush, that under each apron of rip-rap. The specifications for the clay read as follows: "To be of first-class quality, and when kneaded stiff into a pyramid of an inch or so in height, and immersed in water, will remain intact for 24 hours without crumbling. The brush was to be of green bushy fir or cedar trees, of young growth, not more than 15 feet in length, when the stem is cut close to the head, which it shall be, or limbs similar in character." The separate limbs were afterwards practically excluded, and bush allowed much longer than specified, which served the purpose better. The first intention of the writer was to obtain the clay from a bed about a mile up the slough, above the site of the box; but after