nothing but a poor grade of coarse slough hay, which could be
used only for bedding.

In this section of Wisconsin, the low wet land lies in small
scattered areas over the entire drainage district, thus making
it necessary to construct long lines of drains, in order to pro-
vide an outlet for all the owners of wet land. This fact makes
it necessary to design the drains as economically as possible,
which sometimes, leads to the adoption of a plan with a very
low factor of safety with little or no allowance for such condi-
tions just mentioned.

I have taken up a great deal of your time, and before we part,
let me add, "Get your drains deep enough, and wide enough,
and don't do as one engineer did." When he discovered that a
certain contractor had dug the ditch deeper than the specifica-
tions provided, he called the contractor to task. The contractor,
who was a large-hearted, generous German was surprised and
hurt at the lack of appreciation of his generosity, and he set up
this defense, "I make de deepinings and de widenings yust like
de paper call for, only a little bit deeper."

DRAINAGE ENGINEERING IN NORTHERN WISCONSIN.

Warren Moore, Drainage Engineer, Ladysmith, Wisconsin.

Being located as we are, on the great glacial drift of the north
part of the state, we have none of the big problems of the more
level lands of the central and southern parts of the state, but
what our problems lack in size, they make up in number.

The glacial action left us with such a variety of soils and
topography that it is only with the most careful investigation
that we can determine what really is needed to drain the land
sufficiently for agricultural purposes.

We have flat land that is dry, and hilly land that is wet, and
the thing that makes it most difficult to determine the most
economical system that will answer the purpose, is, that the
nature of the surface soil does not seem to make very much dif-
ference. It took me a number of years to determine why it was
that lands of the same surface quality situated only a compara-
tively short distance apart would differ so much in regard to natural drainage. I know now that the subsoil is more to be reckoned with than the surface soil.

With only a few exceptions our marshes and swamps have sufficient fall so that about the only engineering problem is to determine what system will give the best drainage for the least money.

Most of our marshes and swamps containing five hundred or more acres have more than one outlet. The Deer Tail District has eight distinct outlets. Many of our drainage projects consist of several small marshes more or less connected. Sometimes these small marshes in the same general drainage proposition will differ greatly in the nature of their subsoil and if the greatest care is not exercised, there will be a needless expense incurred by putting too much tile in some places while the same amount in an adjoining piece will not give sufficient drainage.

Money spent in a thorough survey before making the plans, and especially in subsoil survey, is money well spent. Fortunately one dense growth of brush does not interfere seriously with a subsoil survey. It does interfere with the topographic survey.

For the preliminary survey, the first thing I do is to take a pocket compass and hand level and go over the project making a rough sketch of its boundaries, water-sheds, etc. With this map for a guide I can plan how to get enough levels to enable me to arrive at a very close conclusion as to what will be needed to put in an adequate drainage system. In most cases I can get the necessary levels by following roads and other open ground and hitting the wet lands at controlling points, without cutting very many brush.

If the proposition is being backed by some one that is paying the bills as we go on, I do all of this work before the petition is prepared, but if I am doing it to promote a proposition for parties who feel that they cannot put much into it, I make only the sketch of the project at first and run the levels after the petition is out and enough signers secured to indicate that it will be a going proposition.

In many cases I go out and make the preliminary examination without making any charges; simply having the understanding
that if it develops I will have the job of completing the preliminary work.

In this way there have been projects started that would otherwise have died for the lack of someone to put up the money for the first examinations.

Of course I don't base any real plans on anything short of actual knowledge but in most cases I am able to give them a very good idea of what will have to be done with only the information gained with the pocket compass and the hand level; in fact, I am often surprised at the accuracy of some of these preliminary estimates.

I am getting the best results on final surveys by first running a line of Check levels to establish a good set of benches.

Then I start at some convenient point, preferably near the outlet, and run a traverse line and take enough elevations to give me data for a fairly accurate contour map of the whole project. By using two rods and making all the measurements with the stadia, I get very accurate results with a minimum of expense.

On the open marsh lands, I have one rodman work on each side and when I want to move ahead on the main traverse line, I have the rodman who happens to be located most conveniently set the hub and guard-stakes. These, when well set, make a basis for the location lines for the tile without having to run any extra lines.

I also get the aid of property owners as the work is carried on and by locating these corners on the map can fill in the property lines with very little work; thereby getting a good map from which to figure acreage in making up the estimates. In our country very few of the property lines are marked and we have to pick up the old government sections and quarter corners and use them as a basis for the property lines.

Where it is brushy I have got the best results by having a good man take a couple of good axemen and cut out lines along the margin of the wet lands, keeping as close to the margin of the benefited land as is practicable without making too many angles. The better engineer I can get to look after this work the better the results. In fact, I would attend to all of this cutting myself if possible as the proper locating of these lines will greatly reduce the subsequent work. Then I follow up the brush cutting
with the transit and stadia as I would in the open marsh; taking advantage of the openings and high points as much as possible to get topography.

In this way I can keep the transit at work on the open ground while the brush is being cut. This saves considerable time that would be wasted if the transit had to wait for the brush cutters. At first I had considerable difficulty in keeping the notes of both the traverse lines and the levels in one book and have them in shape to plat up handy, but I have worked out the form of notes shown in the table.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>a.</td>
<td>S.80° 00' W.</td>
<td>5.60</td>
<td></td>
<td>39.97</td>
<td>5.30</td>
<td>34.67</td>
<td>W. Side marsh.</td>
</tr>
<tr>
<td>0</td>
<td>b.</td>
<td>S.80° 26' W.</td>
<td>4.00</td>
<td></td>
<td></td>
<td>4.80</td>
<td>35.17</td>
<td>E. Side marsh.</td>
</tr>
<tr>
<td>0</td>
<td>c.</td>
<td>S.80° 00' W.</td>
<td>1.75</td>
<td></td>
<td></td>
<td>5.00</td>
<td>34.37</td>
<td>S. W. &quot; &quot;</td>
</tr>
<tr>
<td>0</td>
<td>d.</td>
<td>S.00° 35' W.</td>
<td>1.10</td>
<td></td>
<td></td>
<td>7.43</td>
<td>32.54</td>
<td>W. L. in creek.</td>
</tr>
<tr>
<td>0</td>
<td>1.</td>
<td>S.01° 40' W.</td>
<td>2.41</td>
<td></td>
<td></td>
<td>4.13</td>
<td>35.84</td>
<td>Turning point.</td>
</tr>
<tr>
<td>1</td>
<td>2.</td>
<td>S.00° 35' W.</td>
<td>1.18</td>
<td></td>
<td></td>
<td>4.26</td>
<td>34.40</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>a.</td>
<td>S.16° 30' W.</td>
<td>3.20</td>
<td></td>
<td></td>
<td>4.30</td>
<td>34.36</td>
<td>End of circuit.</td>
</tr>
</tbody>
</table>

The book used for these notes is the standard field book and by carrying the elevations on a separate sheet of paper it makes room enough for all the items required; if I were depending on one set of notes I wouldn't like the idea of carrying the elevations on loose sheets, but I have bench marks of the check level survey to keep checked up on, and I consider the time used in running the check levels and establishing benches ahead of the work well spent. It doesn't take long to run a mile of check levels and it furnishes a means of double checking all of the level work which is really the main thing in a drainage survey.

The traverse notes on the left page can be platted in the usual way by latitude and departure. You will notice that there is no column for corrected distance. This is omitted because there is so little need for making corrections of horizontal distance for vertical angles on this kind of work and by omitting this and the space generally used to carry the elevations in the
usual way, it leaves plenty of room for the remarks column which is very important on this kind of work.

As a rule I prefer not to set the final stakes for the ditch or tile lines until the contractor is ready to use them. Where there is clearing to be done I find that nine-tenths of the mistakes in the field are caused by the stakes being moved after they have been set.

In establishing the grades for tile work, I set hubs and reference stakes, and run levels on the hubs I mark the stakes merely with their consecutive number. In the office I compute the depth of cutting below the hub at each station and furnish the contractor with these figures in loose-leaf form.

Our first problem after the survey is made is an equitable assessment and in our work we have not considered any half way measures. We start in with the idea that every piece of land will ultimately be fitted for any kind of crop. On the first district we organized we were fortunate enough to get a man with years of experience in railroad construction and contracting, and thanks to him, we have organized a plan to take care of the problem of making assessments that is mathematically sound. We borrow the idea from the railroads that commissioners are not supposed to do the detail work of making assessments but should supervise the work of having it done correctly. This eliminates the mistakes made by making offhand assessments. It is apparent that the only way to do this is to reduce it to a mathematical basis, and it is also apparent that the engineer is the only one who has the data to work from and the office equipment to work it up with.

After the final survey and plans are made and the cost ascertained, the commissioners go over the district with the engineer and appraise the value of the various kinds of land in both an undrained and a completely drained condition without regard to property lines or ownership. The engineer makes notes of these appraised values and uses the Nye Jordan form. (See Second Annual Report.) He enters in the first three columns the number of acres of high, low, and wet lands—this he has already ascertained by his survey. In Columns 4, 5 and 6 he enters the appraised value in the present or undrained condition. This gives him the undrained value of the whole tract which he
enters in Column 7. Then he enters the appraised value of what this land would be worth if it were thoroughly tiled in Columns 8, 9 and 10, and the total value in Column 11. This minus the undrained value gives the gross benefit for column 12. Then he figures the cost of a complete tile system suitable to drain the land sufficiently for any crop, together with any sub-mains necessary to reach the main outlet as planned. This he enters in Column 13. This subtracted from the gross benefit gives us the net benefit for Column 14.

This eliminates the much discussed problem of making equitable assessments on forties that are not touched by the main outlet. And by the way, I don't think we should ever plan a system of mains that does not give every forty a direct outlet.

After the engineer has completed these assessments, the commissioners go over the whole proposition with him, picking out various forties and checking the results of his computations. This fully accords with the law requiring commissioners to make the assessments, and gives them a thorough check on the fairness of the work of the engineer.

There has been a question in the minds of some of our people as to whether tile would benefit the clay soils of Northern Wisconsin. Our experience has been limited but I believe from what I have observed that we have no clay in the glacial drift that is too tight to be benefited by tile. For instance, tile laid on the Shaw farm in the fall of 1915 in clay discharged water all summer in 1916 and dried the whole area thoroughly. Tile laid on the Decker farm in clay that was slightly wet on the surface and comparatively dry in the bottom of the tile ditch was discharging water at the outlet in ten days from the time it was laid with no rain in the mean time. I also notice that you in Southern Wisconsin are tiling successfully in soil where you can dig out a pit and have water in it all summer for stock. I can assure you that there is no place in our county where soil is that tight.

Discussion

Mr. Vaughan. You should subtract the cost of the tile from the cost of construction and not from the gross benefits.
Mr. Jones. Yes, or else multiply the cost of the supplementary tile by the ratio of benefits to get the "tile benefits" and subtract this product from the "total benefits" to get the "district benefits".

Mr. Vaughan. That is very ingenious and I believe it is sound.

STANDARD TESTS FOR DRAIN TILE.

E. R. Jones, Associate Professor of Soils,

Madison, Wis.

For years engineers, farmers, and tile manufacturers have been asking for a set of standards for drain tile. At last such standards have been established by a reliable authority. Committee C—6 of the American Society for Testing Materials has standardized the tests, and the Iowa Engineering Experiment Station has published the results. Dean Marston was kind enough to send me fifty copies of the report of the committee and I have them for distribution among the members of this association asking for them.

I shall speak of a few of the more important tests in the light of the committee's report.

Classes. The committee appointed for this work recognized clay, shale and concrete tile and have recognized three grades of each: (1) farm drain tile for private drainage work on farms for moderate sizes and depths; (2) standard drain tile for ordinary district land drainage at moderate depths; and (3) extra quality drain tile for district land drainage for considerable depths where an extra quality is desired. The purchaser should specify the class of tile he desires before holding the manufacturer to a particular standard.