Drainage

FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture, Food and Fisheries

Order No. 532.000-1
Revised August 1999
Agdex: 752

SUBSURFACE DRAINAGE PLAN

INTRODUCTION

Before installing subsurface drainage pipe, we recommend that a complete topographic survey is carried out and a drainage plan prepared for the farm. The survey, used in conjunction with soils and groundwater information, enables the contractor or designer to layout the drain system in the most effective and cost-efficient way. As well, the plan allows the landowner to install the system as time, labour or finances permit. The plan provides a record for future modification or maintenance and should be passed on to subsequent landowners.

TOPOGRAPHIC SURVEY

Topographic surveys of varying degrees of detail are normally required for the design of both surface and subsurface drainage systems. The purpose of the survey is to develop a topographic map showing important elevations and key physical features of the property. Used in conjunction with the soils and groundwater information, it enables the designer to layout the system, as well as providing the necessary construction details.

PRELIMINARY ASSESSMENT

As a first step, obtain any existing mapping for the farm. Air photos are often very useful in preliminary assessments of the drainage problem and to augment survey data. They are readily available for most areas of BC. To obtain airphotos for a particular piece of property, send the legal description to:

Ministry of Environment, Lands and Parks
Resource Mapping Branch
Geodetic Reference System Unit,
Data Services
4th Floor, 1802 Douglas Street
Victoria, BC V8V 1X4
Phone: (250) 387-3164, Fax: (250) 387-7831
Internet: http://www.env.gov.bc.ca

Airphoto enlargements can be made as well. In properties involving substantial areas of land development (e.g. land clearing and reclamation) and drainage over large areas of irregularly shaped fields where local detail is less important, airphoto enlargement portions can be used as base maps for plotting the survey and layout data. Engineering or design firms best handle this type of graphic and drafting work.

CARRYING OUT THE SURVEY

Before beginning the survey, the crew should walk the property with the farmer with airphotos or other maps in hand. The farmer will often have had years of experience to relate to the drainage problem. Discuss with him the normal and high water levels in the adjacent ditches, streams and poorly drained areas. Locate existing and potential outlets, the property boundaries, all problem areas and any other important topographic features that should be included in the survey.

Suggested survey information and procedure is as follows:

- Start the survey from an existing permanent geodetic bench and elevation mark, if located within a reasonable distance.
- Mark a **permanent** bench mark on the farm on concrete footings of existing buildings or set a new bench mark stake. Make a detailed note and description of the location of this bench mark.
- Survey the farm on an approximate grid of 30-m x 30-m. On level or uniform topography this grid spacing may be increased. On hilly or irregular fields the grid spacing should be reduced. Spot readings of erratic features should be taken as well. The field data should be sufficient to provide an accurately contoured topographic map.
- As well, record the following:
  - Elevations and locations of ditch bottoms, banks and water levels at time of survey. These may be required for drain outlets. Data taken here should be adequate to plot an accurate ditch profile.
  - Fences. These determine field and property boundaries. It may be necessary to design the system around these.
  - Existing culverts. The diameter, invert elevations and condition should be noted.
  - Existing buildings.
- Establish temporary bench marks throughout the farm in locations convenient for the start of drain installation.
- Close the survey by taking a reading back to the permanent farm bench mark. Although a high level of horizontal accuracy is not required, because of the frequently low grades in agricultural land drainage, good vertical accuracy is required.

CALCULATIONS AND PLOT

Complete the survey calculations in the field book checking each calculation of elevation. Plot the data to suit the topography and the size of the drafting paper. Use a standard scale such as 1:1000, 1:1500 or 1:2000 (1:1250 is an acceptable although not standard ratio scale). Draw the topographic elevation contour lines. A contour interval of 0.5 m is usually sufficient; however, 0.25 or 0.20 m contours and spot elevations may be required on very level fields.

SOILS SURVEY

A soils survey, to establish subdrain spacing and depth requirements based on the hydraulic conductivity of the soil should be carried out concurrently with the topographic survey. A preliminary survey should be carried out during the winter or whenever the problem is well in evidence. Visual observations are made of field conditions, location of poorly drained areas, topographic and soil features, land use, etc. From these observations, the need for hydraulic conductivity measurements and other data is determined and a preliminary evaluation of the anticipated cost and benefits can be made.

A base map is prepared by tracing or transferring land boundaries, roads, creeks and other landscape features from an aerial photo to a convenient size field sheet. (see example plan attached). Soil boundaries from soil survey reports, if available, are also transferred to the base map along with the location and brief description of profile pits.

A profile pit can be excavated by hand to a depth of about 1 m to examine the texture, structure;, stones, gravel, hardpan, water table depth, colour and any other features having a bearing on the design or construction of the drainage system. The observed features are recorded on the base map.

The auger hole method is a rapid, simple and reliable method for measuring hydraulic conductivity of soil below a water table. This method is limited to areas with a high water table, refer to the BC Agriculture Drainage Manual for more information.

SUBSURFACE DRAINAGE

Subsurface drainage is generally practiced for soils that are permeable enough for economical drain spacings and productive enough to justify the investment. Refer to factsheet 545.000-1 Economics of Subsurface Drainage.

DRAINAGE COEFFICIENT

In subsurface drainage, the drainage coefficient is expressed as the depth of water (in mm) that a drainage system can remove from its entire drainage area in 24 hours.

The frequency, intensity, duration of rainfall, the porosity and hydraulic conductivity of the soil and the kind of crop grown should be considered in selecting the drainage coefficient.

Drainage coefficients in **Table 1** are recommended for subsurface drainage systems where no surface water is admitted directly into the system. **Table 2** is recommended for subsurface drainage where surface water is to be admitted into the system through surface inlets.

Higher drainage coefficients as indicated in **Tables 1** and **2** should be used for high value truck crops, as they are more vulnerable to damage caused by standing in water for 2 to 4 hours during hot weather

Table 1 **Drainage Coefficient for Subsurface Drainage (mm/day)**

SOIL	FIELD CROPS	TRUCK CROPS
Mineral	10 to 13	13 to 20
Organic	13 to 20	20 to 38

A drainage coefficient of 12 mm/day (0.5 in/day) has been traditionally used in the Lower Fraser Valley.

DRAIN DEPTH AND SPACING

The depth and spacing of drains varies greatly, and are dependent upon the soil permeability (hydraulic conductivity), crop and soil management practices, type of crop and the extent of surface drainage.

Generally, the narrower the spacing, the better the control of water table in the ground.

Table 2 **Drainage Coefficient Where Surface Water Enters Subsurface Drainage System (mm/day)**

SOIL	FIELD CROPS		TRUCK CROPS	
	Blind Inlet	Open Inlet	Blind Inlet	Open Inlet
Mineral	13 to 20	13 to 25	20 to 25	25 to 38
Organic	20 to 25	25 to 38	38 to 50	50 to 100

From 1984 Standards, ASAE

However, selection of the most economic systems calls for determination of the maximum drain spacing which can be tolerated by the crops to be grown. Typically, drain spacings in the Lower Fraser Valley range form 9 to 20 m.

If the hydraulic conductivity is known through estimation or measurement, the drain spacing can be calculated using Hooghoudt's equation. See **Figure 1**. For homogeneous soils, the equation can be expressed as:

$$S^2 = \frac{4K(2d_eh + h^2)}{R}$$

and for a two layered soil as

$$S^2 = \frac{8k_bd_eh + 4k_ah^2}{R}$$

where:

S = spacing between drain laterals (m)
k = saturated hydraulic conductivity (m/day)

d_e = equivalent depth, or effective flow depth below drains (m) (use **Figures 2** or **3** for 100 mm or 150 mm diameter drains)

h = water table height above the drain center at mid-spacing (m). As can be seen from **Figure 1**.

$$h = DD - DWD$$

where:

DD = drain depth (m)

DWD = desirable water table depth (m) (ranges from 0.3 to 0.5 m depending on type of crop and rooting depth)

R = drainage coefficient (m/day)

It is recommended that the depth of the drains (DD) be in the range of 0.9 to 1.2 meters. This may be reduced to 0.8 m where depth of outlet or subsoil is limited.

The minimum cover to protect a subdrain from breakage by farm machinery is 0.6 m.

If it is impossible or uneconomical to secure the minimum cover specified above, high-strength non-perforated pipe should be used.

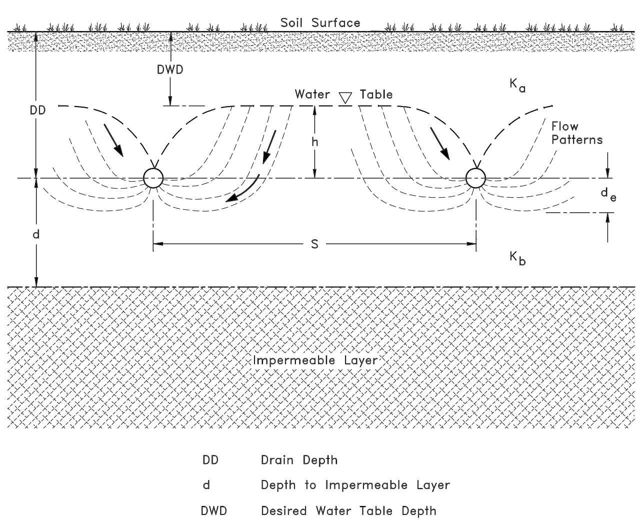


Figure 1

Definition of Parameters for Hooghodt's Equation

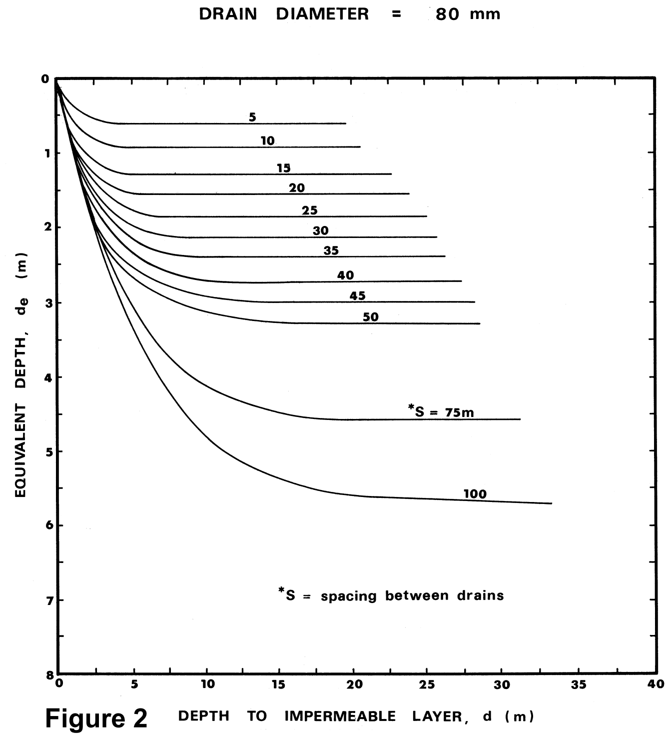


Figure 2

Relationship between d and d_e, where S is the spacing between drains and drain diameter is 100 mm.

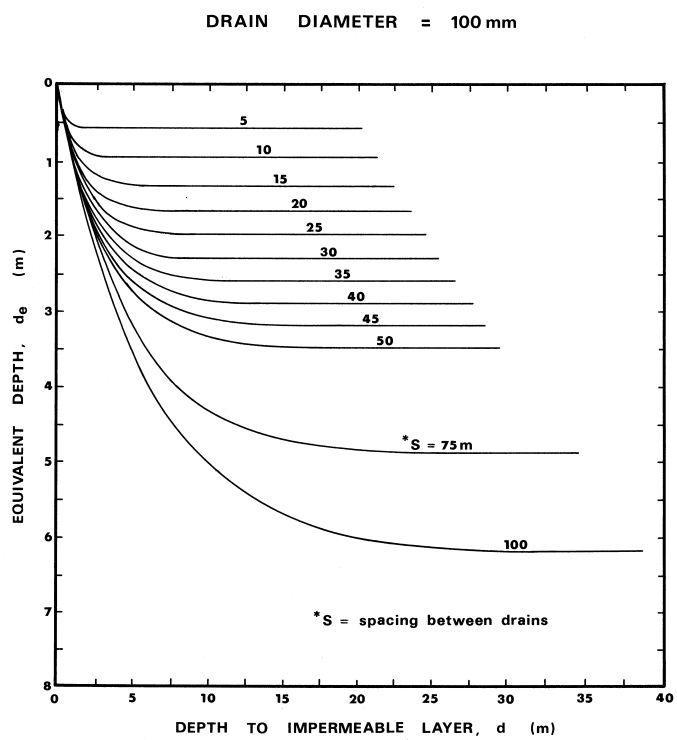


Figure 3

Relationship between d and d_e, where S is the spacing between drains and drain diameter is 150 mm

DRAIN PIPE SELECTION

The required capacity of subdrain pipes is based on the drainage coefficient and the area drained. The area drained is a function of drain spacing and length. The diameter of the pipe depends upon its grade and the internal roughness of the pipe.

To assist in pipe selection, refer to the Factsheet No. 532.100-1 Subdrain System Design Nomograph.

Subsurface drains, with very little or reverse grade, tend to fill with sediments. If the grades of the drains are too steep, excessive velocities may occur and result in erosion hazard to the soils surrounding the drains.

Minimum and maximum grades given in **Table 3** are recommended. Because of the possibility of subsidence, a minimum grade of 0.3% is suggested in deep organic soils.

Short lateral drains not subject to pressure flow may be installed on grades up to 5%. For mainlines, grades up to 2 to 3% are acceptable, provided the capacity of the main is over-designed to prevent pressure flow.

Use non-perorated mainlines with grades over 2 to 3% and install breather and relief wells at the upper and lower ends of the steep sections.

Table 3	**Grade of Drains in Percent**		
MINIMUM GRADE	**DIAMETER (MM)**		**GRADE %**
	80 100 150 and more		0.20 0.10 0.05
MAXIMUM GRADE	**TYPE**	**SOIL TYPE**	**GRADE %**
	Lateral	All	2%
	Collector	Sandy Silt or Loam Clay	1% 2% 6%

**Under Full Flow Conditions*

DRAIN LAYOUT

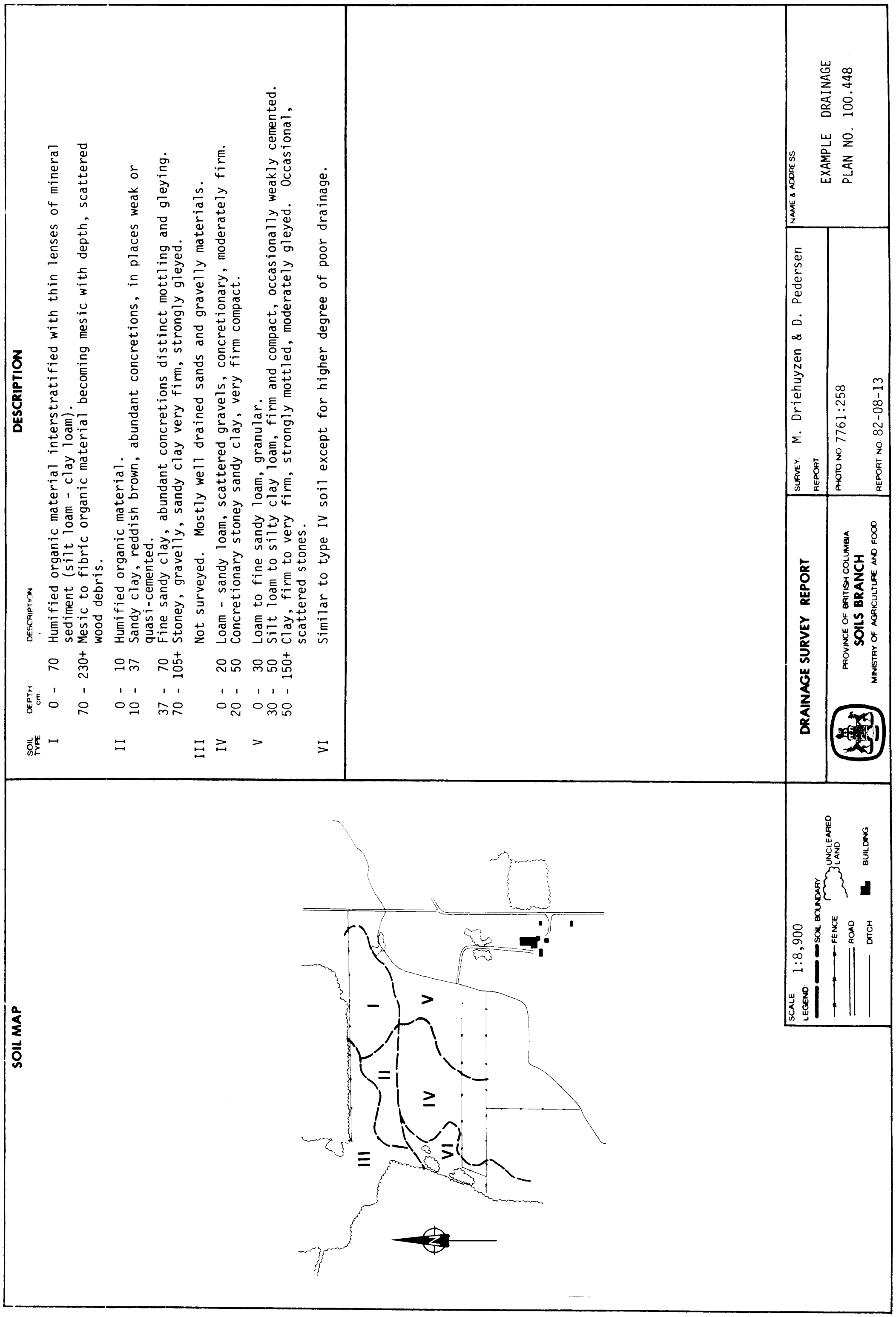
A drain layout is essential for system installation and future maintenance. Refer to the following recommended standard features and the attached **Example Drainage Plan**:

- Show bench marks and give descriptions and elevations.
- Location of ditches, drains, miscellaneous structures and landmarks should be shown.
- Sizes, grades, lengths, control elevations of drains, locations of changing grades and sizes of drains should be given.
- Cross-section and profile of new and existing outlet ditches should be given.
- Show maximum, minimum and normal water level of the outlets.
- Provide a clear legend of symbols used.
- A table of total length of drains and sizes should be given.
- Provide special notes and recommendations, if any, for the system designed.
- Provide a map of soil units with description and recommendations.
- A north arrow should be drawn on the plan at an appropriate space.

REFERENCES

CHIENG, S-T, R.S. BROUGHTON and S.R. AMI. 1981. Graphical solutions to drainage equations. Can. Agric. Eng. 23:91-96.

VAN BEERS, W.F.J. 1979. The auger hole method. Bull. No. 1 I.L.R.I., P.O. Box 45, Wageningen, The Netherlands



SOIL MAP

DESCRIPTION

SOIL TYPE	DEPTH cm	DESCRIPTION
I	0 - 70	Humified organic material interstratified with thin lenses of mineral sediment (silt loam - clay loam).
	70 - 230+	Mesic to fibric organic material becoming mesic with depth, scattered wood debris.
II	0 - 10	Humified organic material.
	10 - 37	Sandy clay, reddish brown, abundant concretions, in places weak or quasi-cemented.
	37 - 70	Fine sandy clay, abundant concretions distinct mottling and gleying.
	70 - 105+	Stoney, gravelly, sandy clay very firm, strongly gleyed.
III		Not surveyed. Mostly well drained sands and gravelly materials.
IV	0 - 20	Loam - sandy loam, scattered gravels, concretionary, moderately firm.
	20 - 50	Concretionary stoney sandy clay, very firm compact.
V	0 - 30	Loam to fine sandy loam, granular.
	30 - 50	Silt loam to silty clay loam, firm and compact, occasionally weakly cemented.
	50 - 150+	Clay, firm to very firm, strongly mottled, moderately gleyed. Occasional, scattered stones.
VI		Similar to type IV soil except for higher degree of poor drainage.

SCALE 1:8,900

LEGEND: SOIL BOUNDARY, FENCE, ROAD, DITCH, UNCLEARED LAND, BUILDING

DRAINAGE SURVEY REPORT

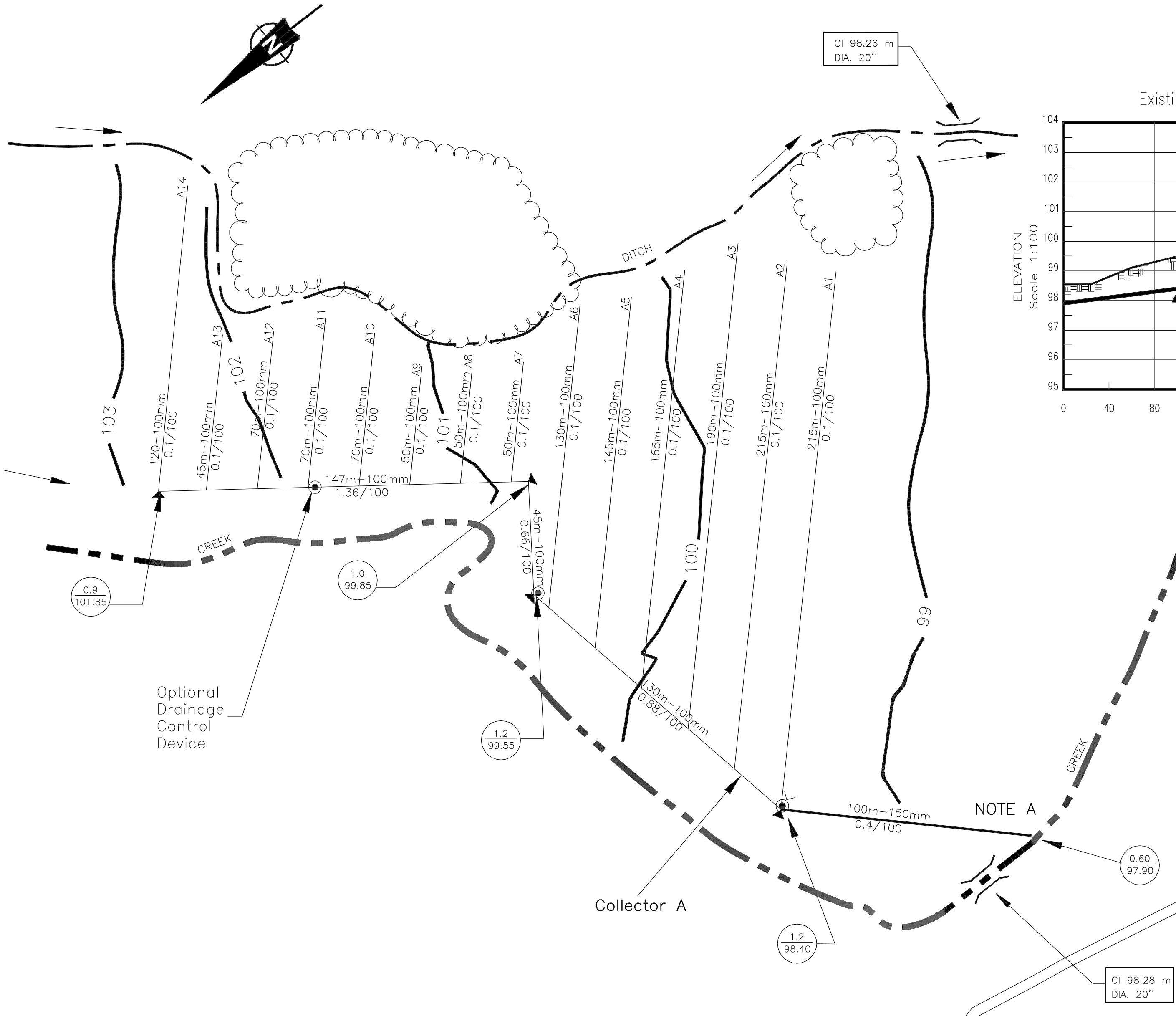
PROVINCE OF BRITISH COLUMBIA
SOILS BRANCH
MINISTRY OF AGRICULTURE AND FOOD

SURVEY: M. Driehuyzen & D. Pedersen
REPORT
PHOTO NO 7761:258
REPORT NO 82-08-13

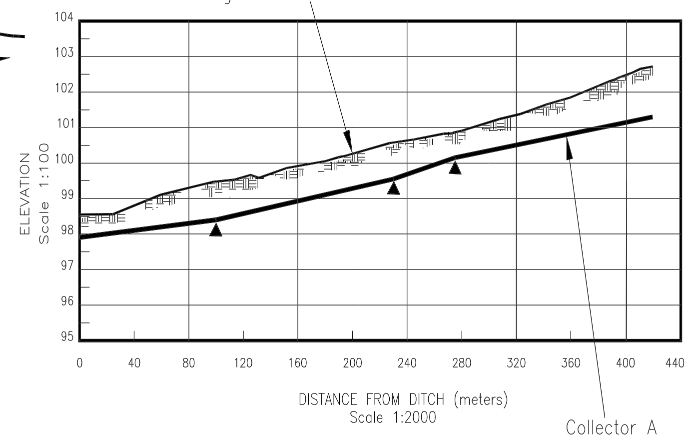
NAME & ADDRESS
EXAMPLE DRAINAGE
PLAN NO. 100.448

FOR FURTHER INFORMATION CONTACT
Janine Nyvall, Water Management Engineer
Phone: (604) 556-3113
Email: Janine.Nyvall@gems5.gov.bc.ca

Resource Management Branch
Ministry of Agriculture and Food
1767 Angus Campbell Road
Abbotsford, BC CANADA V3G 2M3 2M3



PROFILE OF COLLECTOR A



LIST OF MATERIALS

Diameter	Material	Quantity
100 mm	PE Perforated Drainage Pipe	1907 m
150 mm	PE Perforated Drainage Pipe	100 m
100 mm	End Caps	14
100 mm	T Connectors	13

NOTE A

Minimum required depth. The outlet area should be surveyed for the location of the outlet. The ditch should be deepened down stream of the outlet to provide clearance between the bottom of the collector and the ditch bottom.

Air Photo Number:
30BC000 no 000

Surveyed by: VL and DM
Survey Date: 1 June 1996
Survey No: 100–644

LEGEND

- PROPOSED DRAIN
- LENGTH – DIAMETER (above) / GRADE (below) — 120m – 100mm / 0.3/100
- CHANGE IN DRAIN SIZE
- CHANGE IN DRAIN GRADE
- CONTOUR LINE — 99.50
- DEPTH OF TRENCH BOTTOM / TRENCH BOTTOM ELEVATION — 1.10 / 92.63
- FENCELINE
- ROAD — ROAD
- EXISTING DRAIN
- SURFACE INLET TO DRAIN
- CREEK, STREAM
- CULVERT — CI 26.25M DIA. 18"
- BENCH MARK — BM#1 100.00
- FILL — F
- CUT — C
- BUILDING
- BUSH
- WATER CONTROL STRUCTURE
- LOT LINE
- DITCH
- CREEK
- CROSS SECTION

B.C. Ministry of Agriculture, Fisheries and Food
RESOURCE MANAGEMENT BRANCH

Mr. Farmer Ranch
DRAINAGE PLAN

DATE	23 August 1996	SCALE	1=2000
DESIGNED	V LALONDE	SHEET	1 OF 2
DRAWN	D MOSCHINI	PLAN No.	100–644
CADNo. 10064401 / CADPlot 1=2.0 / DISKNo. 10064401			