DRAINAGE WORKSHOP

PROBLEMS 1, 2, 3

Problem #1

A pattern drainage system is being designed for a 55 acre field for subsurface drainage flow only. The field is composed of mineral soil with a silty loam texture at the surface and a silty clay loam texture near the drain tile. The owner plans to grow spinach, radishes, and other truck crops that are easily damaged by excess surface water.

Given:	Area Drained	=	55 acres
	Soils	=	Mineral, silt loam to silty clay loam
	Crops	=	Truck crops easily damaged by excess surface water

a) Determine the drainage coefficient to be used in the design (inch / 24 hours).

b) Calculate the required capacity of the main outlet in cubic feet per second (cfs).

c) Using the required main capacity and a grade of S = 0.50%, calculate the size of corrugated plastic tubing that is needed.

d) What is the velocity when the tubing is flowing full (feet/second)? Is this velocity in the safe range for the soils if sedimentation is not a concern?

Drainage Workshop

Problem #2

Design a drainage system for an 85 acre field with mineral soils, general field crops, subsurface flow only. Field has flat topography with surface ponding.

Given:	Field	=	85 acres
	Soils	=	Mineral, silty clay loam
	Crops	=	Field crops (soybeans and corn)
	Drainage	=	Subsurface pattern only with flat topography

a) Determine the required main capacity.

b) What size of corrugated plastic tile is needed for the main if it will be installed on a 0.20% grade.

c) Using the same required capacity, what is the minimum grade necessary to reduce the tile size to the next diameter?

Drainage Workshop

Problem #3

A grassed waterway is to be built, but a 12” corrugated plastic tile main exists in the center of the watercourse and needs to be replaced and moved to the edge of the waterway. The old and new tile mains have the same grade of 0.50%.

a) What is the capacity of the existing 12” main (cfs)?

b) If the main is to be replaced with two new tiles of equal size, one on each side of the waterway, what size of corrugated plastic tubing is needed?

c) The owner has a large stockpile of 6” corrugated plastic tile on the farm and wants to use it. How many 6” tile lines would be needed to replace the 12” main?

DRAINAGE WORKSHOP

PROBLEM 4

Contouring

1. Complete the contour line representing elevation 95.0. This is accomplished by calculating slope between points, dividing the difference in elevation between the two points by the slope, and measuring this computed distance on the paper between points, starting at the lower point.

2. Complete contour lines for elevations 92.0, 94.0 and 96.0 using the same method above.

Main #1

Design **Main 1** for the field represented by the contour map just competed. The main is planned along the eastern edge of the field. Use a drainage coefficient of 3/8 inch per day.

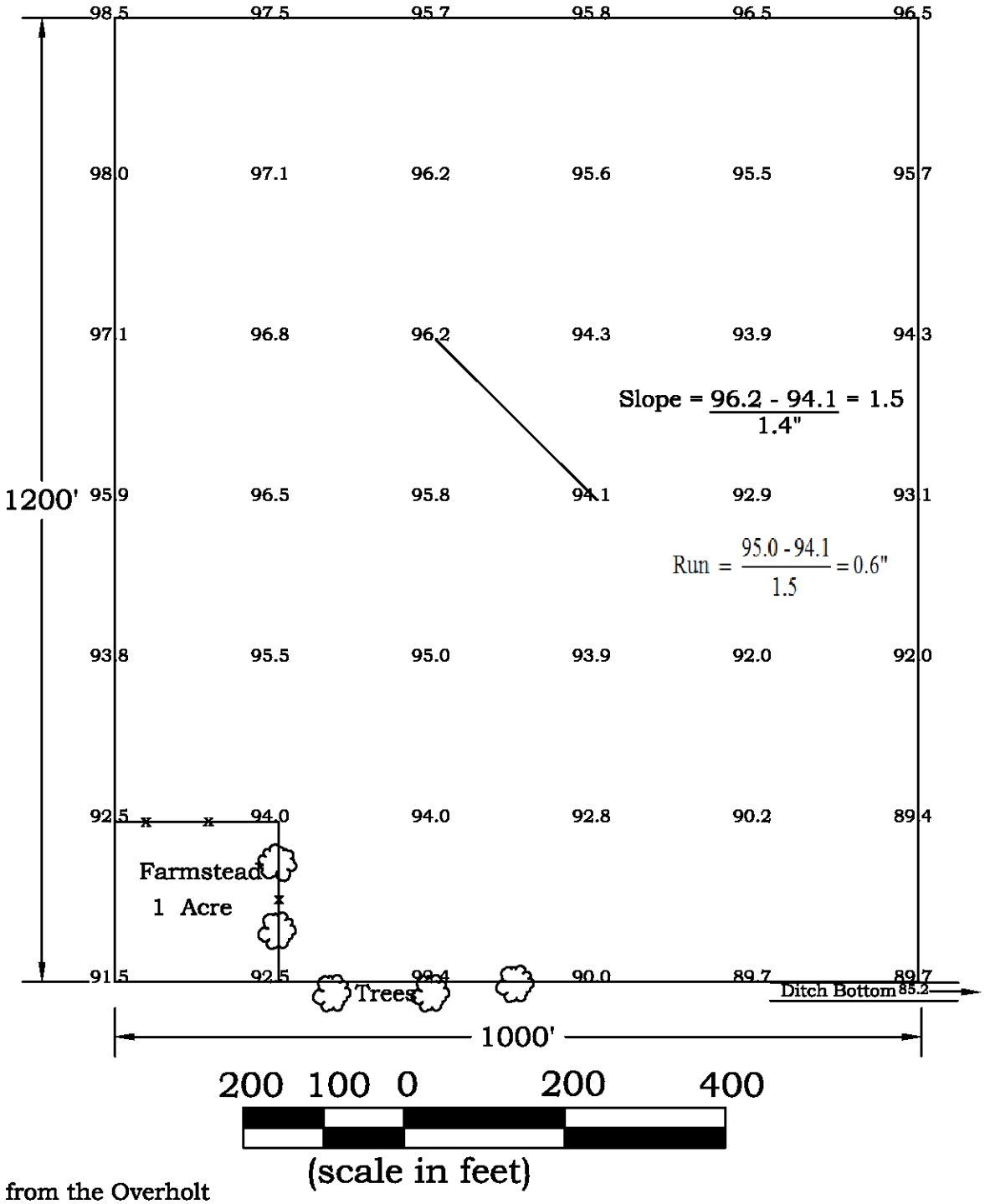
1. Using the contour map plot the existing ground line profile for Main 1 using the provided graph paper. This is necessary to compute grade for Main 1 while ensuring adequate burial depth for the pipe. (at least 2' of cover)

2. Compute the lengths of laterals and area drained by the laterals assuming a lateral spacing of 50'.

3. Using the grades plotted for Main 1 in step 1, determine the drain tile sizes for Main 1 starting with a 5" CPT at Station 11+75 and increasing the main size as necessary until the outlet is reached.

CONTOUR MAP

Problem #4 Complete Contour ine for ele ation .

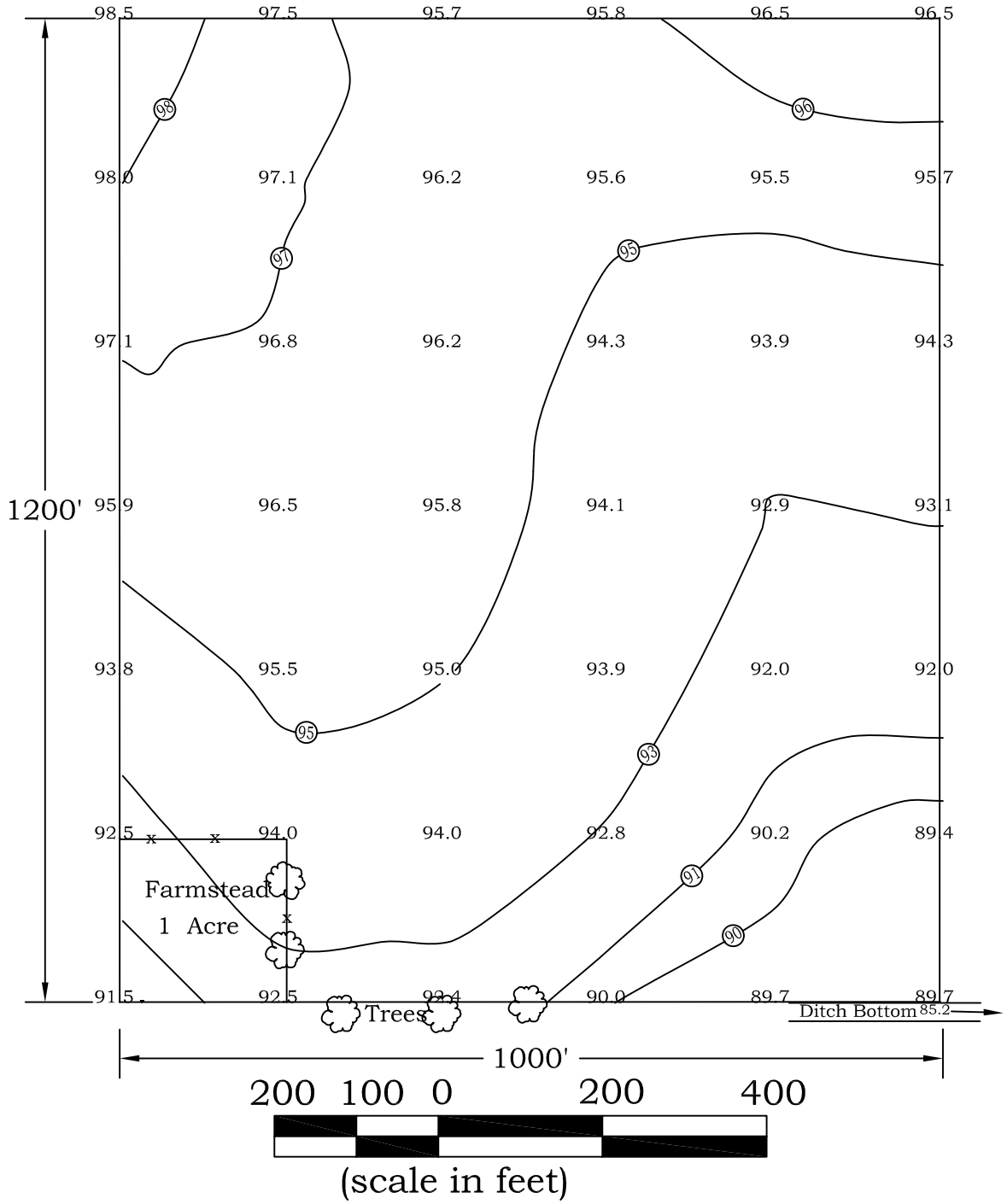


Adapted from the Overholt Drainage School
January 2006

Slope = Rise / Run	*Run = Rise / Slope*

CONTOUR MAP

Problem #4



Adapted from the
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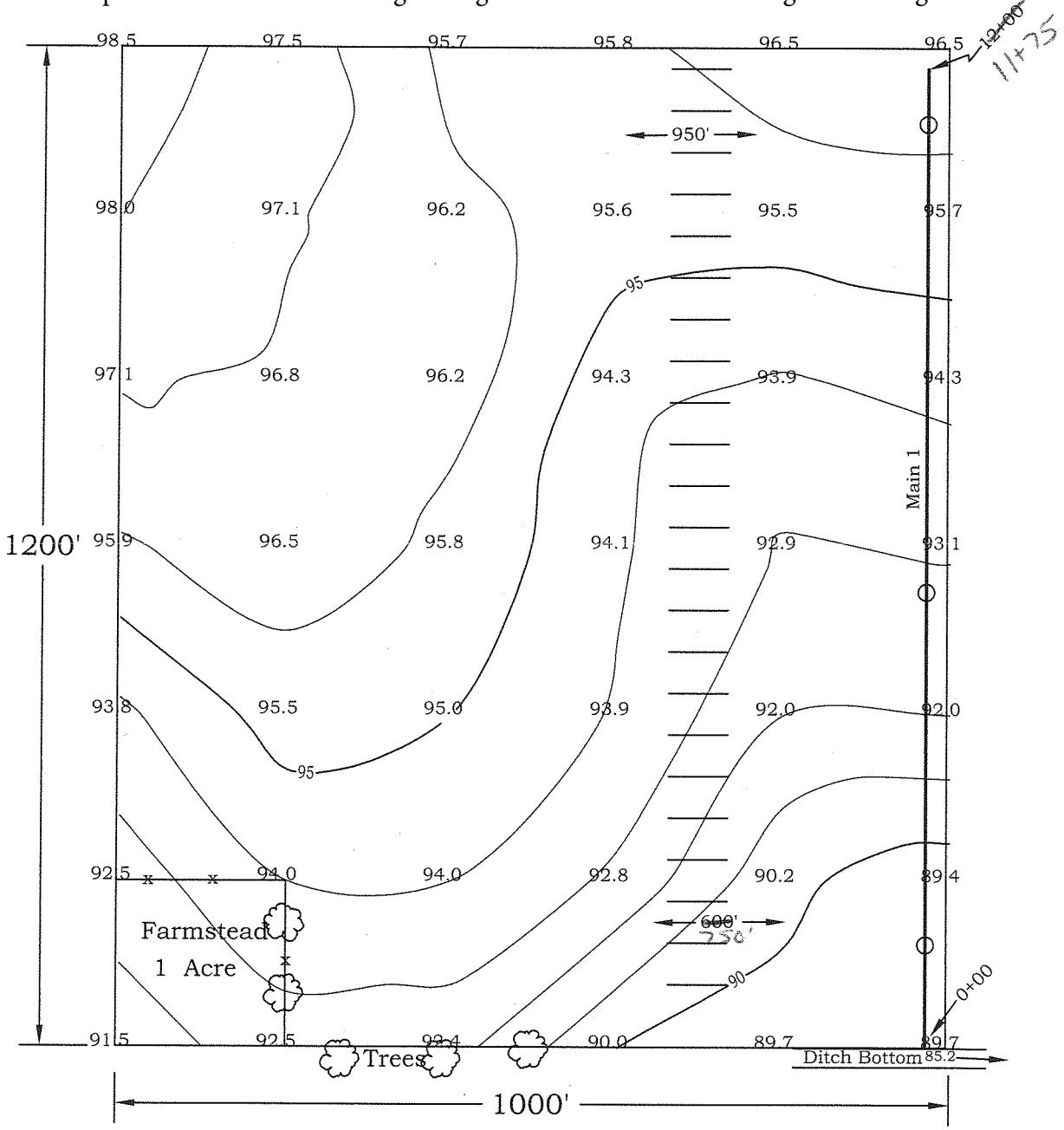
January 2006

Complete the contour map by adding the contour lines for elevations 92, 94 and 96.

CONTOUR MAP

Problem #4 -Main1

Complete main and lateral design using main location shown along eastern edge of field.



Adapted from the Overholt Drainage School January 2006

Problem #4 - Main 1

Solution Calculations

Sta. 11+75 to 5+75 0.7% grade DC = $^{3}/_{8}$ inch

Begin with 5 inch CPT - Maximum Capacity (from slide rule) = 16 Ac

Laterals are 950 ft. long with 50' spacing.
Contribution by each lateral= 1000' to include area drained by main.

$\frac{1000' \times 50'}{43{,}560}$ = 1.15 Ac. Per lateral

Number of laterals to fill tile: $\frac{16}{1.15}$ = 13.9 laterals Use 13 laterals

Actual drainage at 13 tiles = **15 acres**, 1 acre unused main capacity

Sta. 5+75 to 2+25 0.7% grade

Try 6 inch CPT - Maximum Capacity = 26 Ac

Capacity remaining in tile = 26-15 (from sta. 11+75 to 5+75) = 11 Ac

Number of laterals to fill tile: $\frac{11}{1.15}$ = 9.6 laterals Use 9 laterals

However, only 7 laterals at 50' spacing can tie into the main between sta. 5+75 to 2+25 (350'/50'=7)
Actual Drainage at 7 tiles = **8.05 Ac**, leaving 3 acres of unused main capacity.

Sta. 2+25 to the Outlet 0.1% grade

Due to farmstead, lateral lenghts are reduced to 750' at 50' spacing.
Contribution by each lateral= 800' to include area drained by main.

4 Laterals can fit in the space between sta. 2+25 and the outlet.
Total Acres contributed by these laterals =

$\frac{800' \times 50'}{43{,}560}$ = 0.92 Ac. Per lateral

4 x 0.92 acres = **3.68 acres**.

Total main capacity required at outlet = 15+8.05+3.68 = **26.73 Acres**
From slide rule, 27 acres at 0.1% grade using 3/8 dranage coefficient=
Use 10 inch CPT - Capacity = 34 acres

DESIGN TABLE FOR SUBSURFACE DRAINAGE

Project: Problem #4, Main #1 Location:

Designed by: Date: Checked by: Date:

Drainage Coefficient, DC: 3/8 in/day Lateral Diameter: 4 inch ver 1/10/2013

Lateral Design									
Main Connect Station ft	Lateral ID or Group ID ID	Number of Laterals in Group ea	Grade %	Spacing (S) ft	Lateral Length (L) ft	Drained Length (S+L) ft	Drained Area per Lateral* ac	Drained Area per Group ac	Accum. Drained Area ac
5+75	A	13		50	950	1000	1.15	14.95	15.0
2+25	B	7		50	950	1000	1.15	8.0	23.0
0+25	C	4		50	750	800	0.92	3.68	26.68

** Includes area drained by main and upper end of lateral =* **S x (S + L) ÷ 43,560**

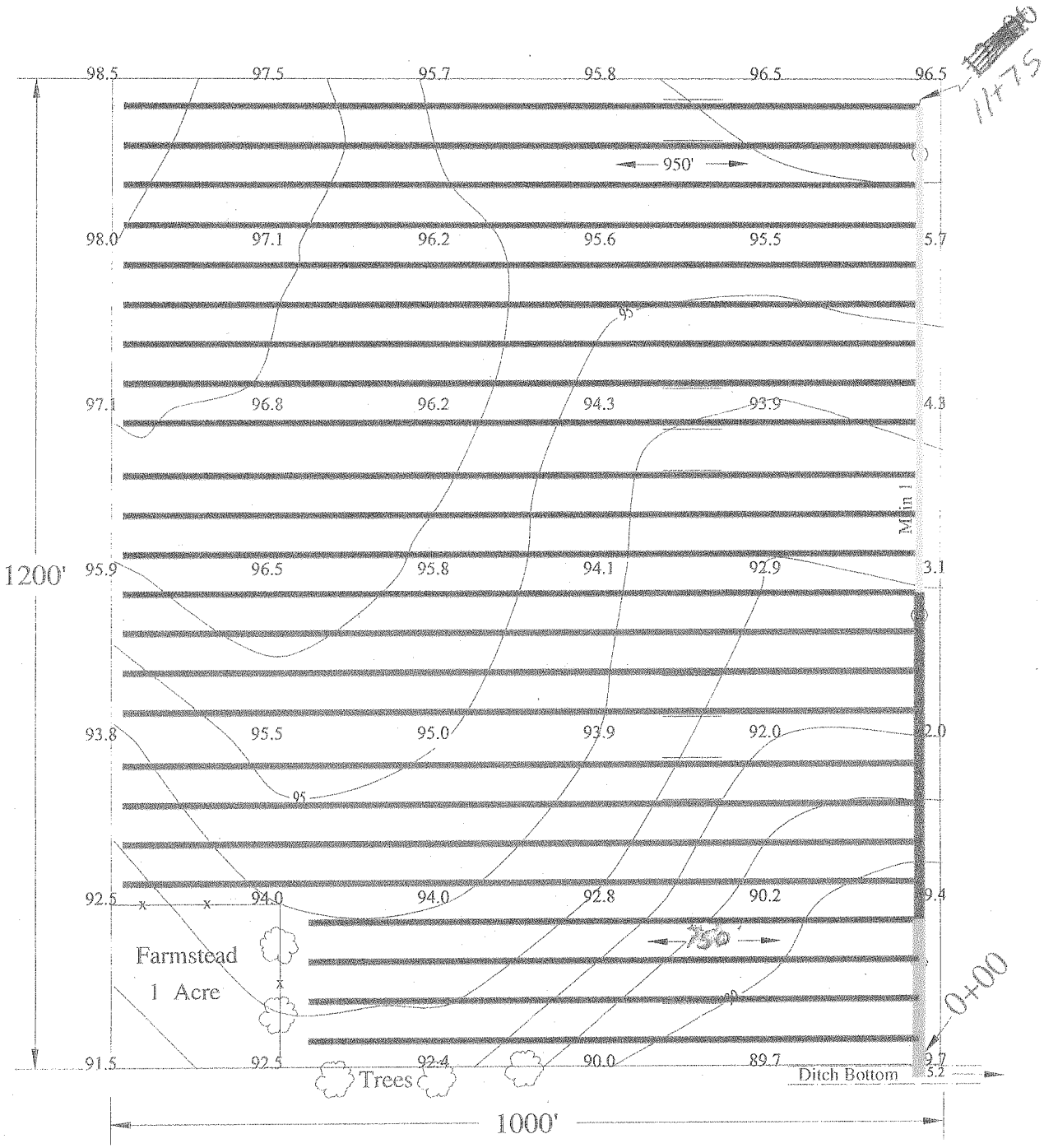
Main ID: Main # 1 Pipe Material: CPT

Main Design									
Main Reach					Main Reach Capacity			Drained Area	
From Station ft	To Station ft	Length ft	Grade %	Main Dia. in	Maximum Flow Volume (Q_{max}) cfs	Maximum Flow Velocity (V_{max}) fps	Maximum Drained Area (DA_{max}) ac	Lateral Accum. Drained Area ac	Unused Main Capacity ac
11+75	5+75	600	0.7	5		1.9	16.0	15.0	1.0
5+75	2+25	350	0.7	6		2.1	26.0	23.0	3.0
2+25	0+00	225	0.1	10		1.0	34.0	26.7	7.3

Comments:

Outlet Size: 10 in Material: PVC - SDR 35 *1 acre = 43,560 square feet*

Length: 20 feet Animal Guard (Y/N): Y $Q_{req} = 0.0421 \times DC \times DA$



5" (13 lat)
15.0 ac

6" (7 lat)
8 Ac

Total 23.0 ac

10" (4 lat)
3.7 ac

Total 26.7 ac

DRAINAGE WORKSHOP

PROBLEM 4
Main #2

Design **Main 2** for the field represented by the same contour map as used for Main 1 only this time switch the location of the main to the south end of the field.

Use a drainage coefficient of 3/8 inch per day.

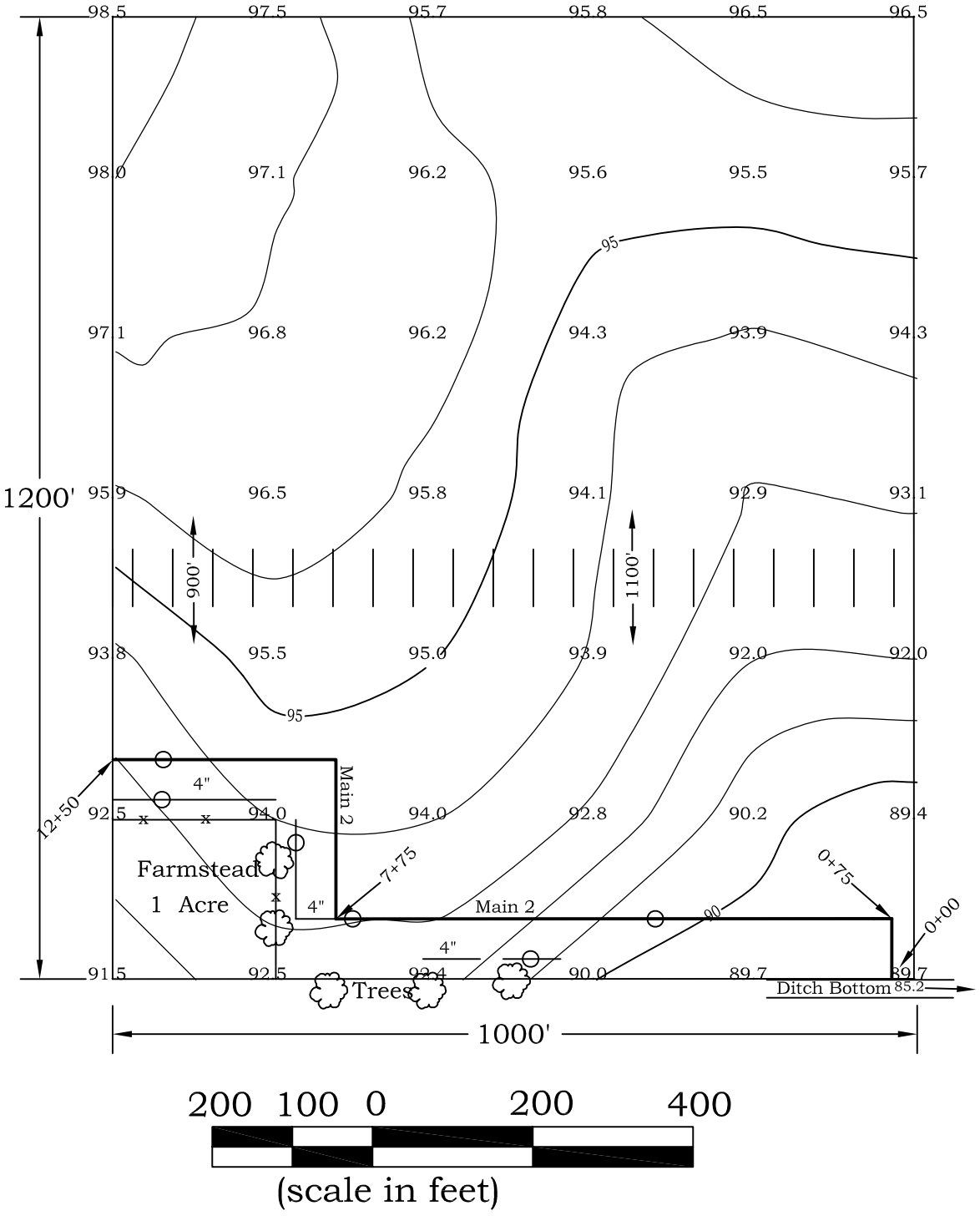
1. Using the contour map plot the existing ground line profile for Main 2. The profile of Main 2 has already been plotted on the profile.

2. Compute the lengths of laterals and area drained by the laterals.

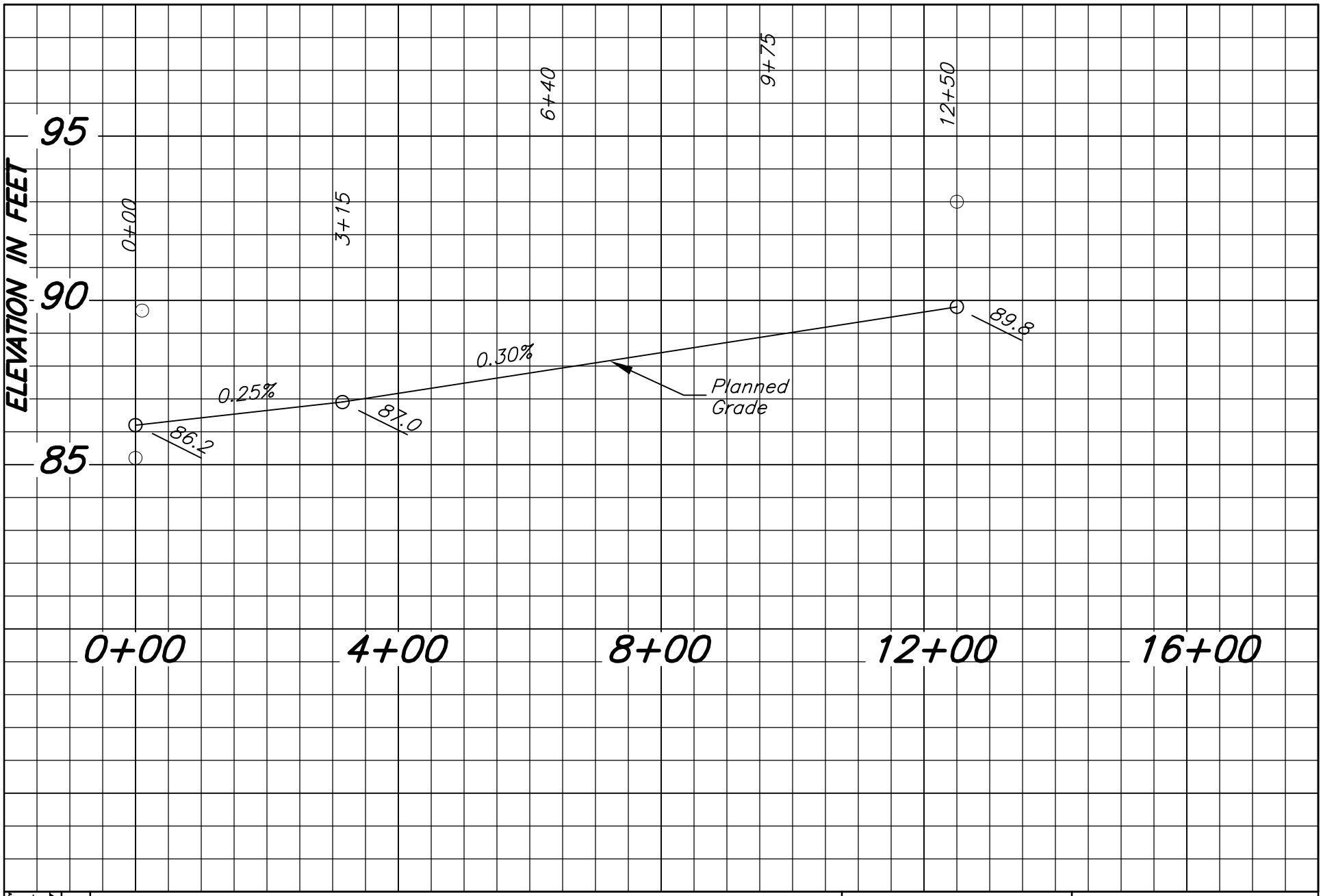
3. Using the grades plotted for Main 2, determine the drain tile sizes for Main 2 starting with a 5” CPT at Station 12+50 and increasing the main size as necessary until the outlet is reached.

CONTOUR MAP

Problem #4 - Main2



Adapted from the
Overholt
Drainage School
January 2006



Overholt Drainage School
Profile – Problem #4 – Main 2

USDA – NATURAL RESOURCES CONSERVATION SERVICE

	DATE		DATE
Designed	A. Brate 5/90	Approved	
Drawn	P. Chester 3/91	Title	
Traced		Const. Approved	
Checked		Title	

Sheet ___ of ___ | DRAWING NUMBER | CAD FILE I.D.

MLICA 8-19

MLICA Drainage Workshop
Problem 5

Whitham Farm, Chariton County, Missouri
(NW ¼, SE ¼, Section 29, T55N, R20W)

Prepare a subsurface drainage plan for the 30 acre field shown. The farmer raises corn, soybeans, and wheat.

The farmer's main interest is to provide pattern drainage, but depending upon cost, would also consider a system that also provides for controlled drainage management; therefore, prepare two designs for the field.

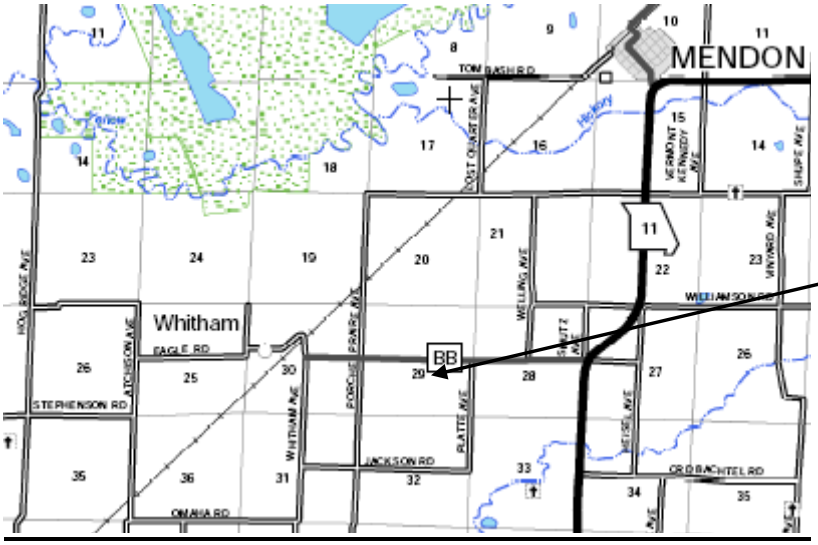
Design 1: Design a pattern drainage system that will provide uncontrolled drainage.

Design 2: Design a controlled pattern drainage system that will allow water table control throughout the growing season.

For each design complete or determine the following items:

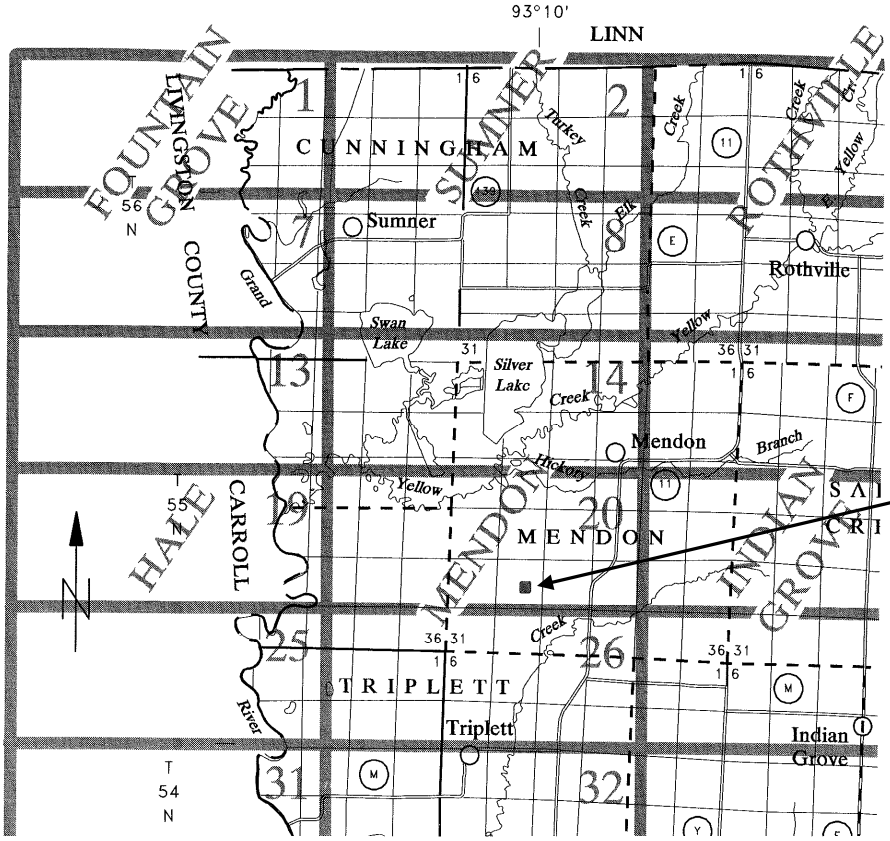
1. Create a topographic map using a 1 foot contour interval.
2. What soil series are found within the field?
3. What drainage coefficient will you use?
4. What lateral spacing and depth?
5. Determine the size of the main(s), and plot a profile of the main(s) and any key laterals showing the:
    a. Existing ground line.
    b. Outlet elevation.
    c. Grade of main and locations of any changes in grade.
6. Show the layout of the system on the topographic map indicating sizes and lengths of mains and laterals. (Note drawing scale.)

Site Location Maps



Site Location

NW ¼, SE ¼,
Section 29,
T55N, R20W



Site Location

NW ¼, SE ¼,
Section 29,
T55N, R20W

Web Soil Survey, Soil Data Explorer, Soil Reports, **Engineering Properties**

Report — Engineering Properties

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textu

Chariton County, Missouri

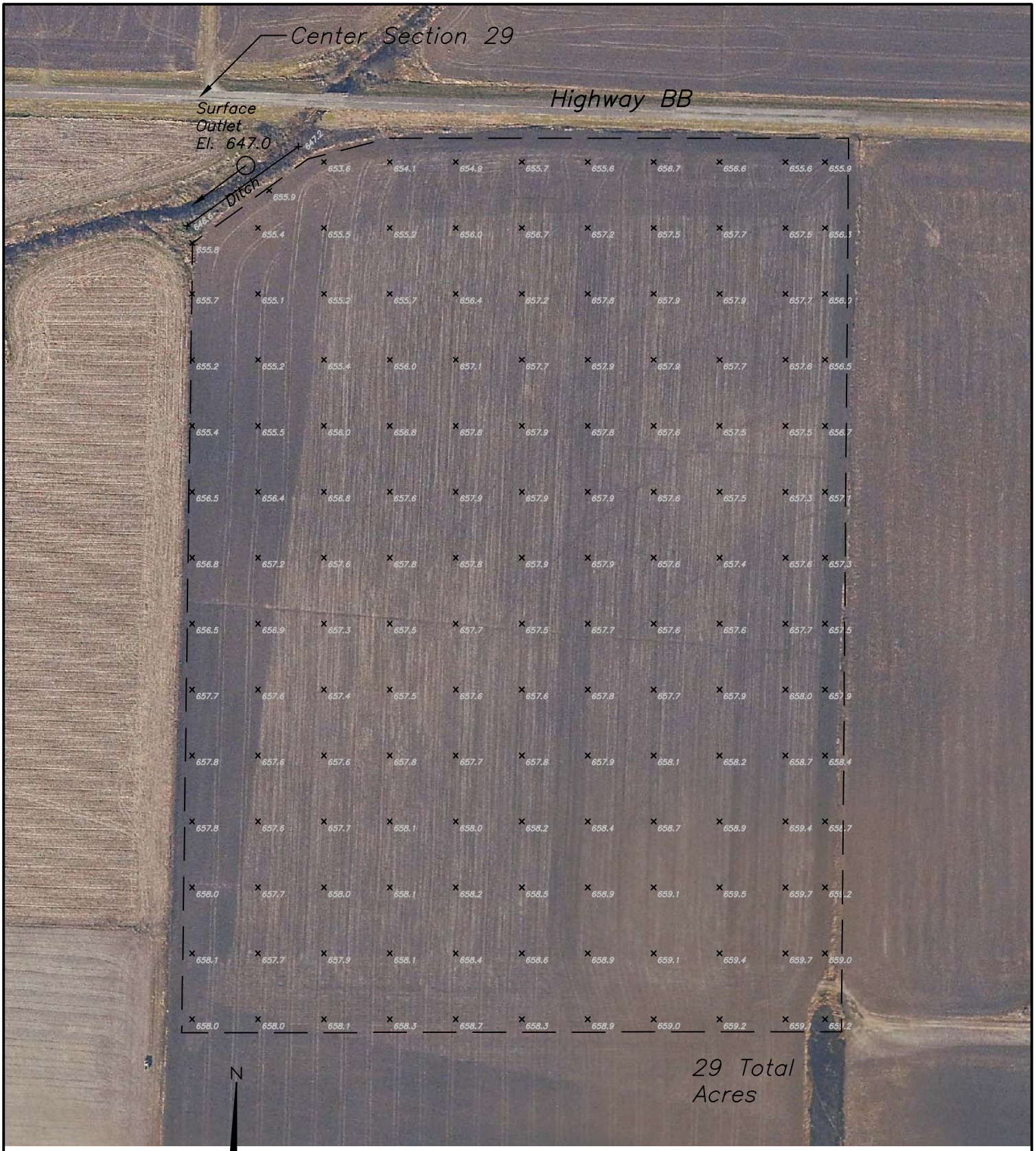
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—			
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200
	In				*Pct*	*Pct*				
64029—Tina silt loam, 0 to 2 percent slopes, rarely flooded										
Tina	0-12	*Silt loam	ML, CL	A-6, A-7-6	0	0	100	100	95-100	85-100
	12-41	*Silty clay, Silty clay loam	CL, CH	A-7-6, A-7-5	0	0	100	100	95-100	85-100
	41-80	*Very fine sandy loam, Loam, clay loam	CL-ML, CL	A-4, A-7-6	0	0	100	100	95-100	50-80
66106—Speed silt loam, 0 to 2 percent slopes, occasionally flooded										
Speed	0-15	*Silt loam	CL, CL-ML	A-4, A-6	0	0	100	100	95-100	90-100
	15-27	*Silt loam	CL, CL-ML	A-4, A-6	0	0	100	100	95-100	90-100
	27-38	*Silt loam, Silty clay loam	CL	A-7-6, A-6	0	0	100	100	95-100	90-100
	38-80	*Silt loam, Silty clay loam	CL	A-6, A-7-6	0	0	100	100	95-100	90-100

Web Soil Survey, Soil Data Explorer, Soil Reports, **Physical Soil Properties**

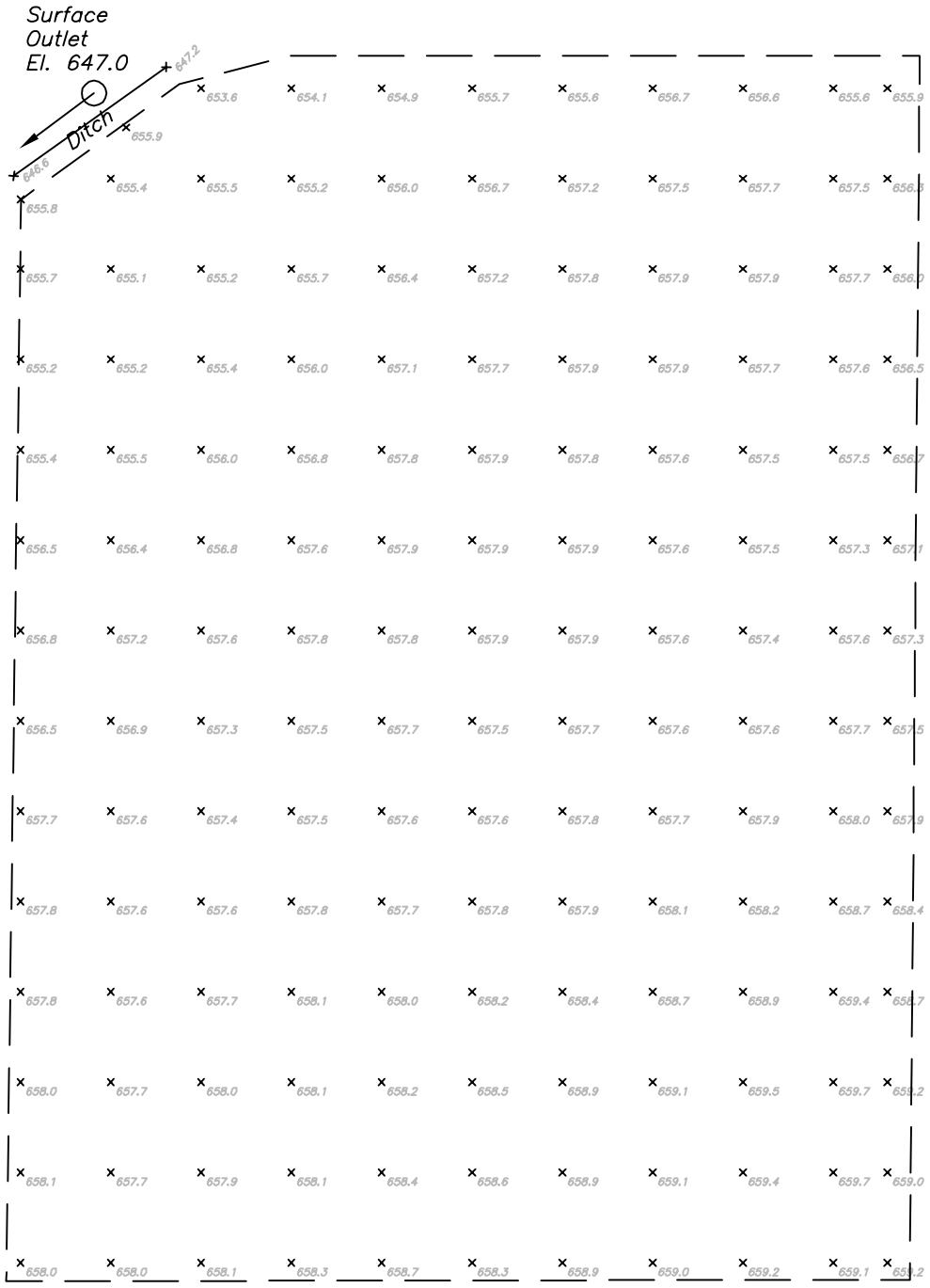
Report — Physical Soil Properties

Chariton County, Missouri

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors		
										Kw	Kf	T
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*			
64029—Tina silt loam, 0 to 2 percent slopes, rarely flooded												
Tina	0-12	15-25-30	50-53-60	18-23-27	1.20-1.35	4.00-14.00	0.22-0.24	3.0-5.9	3.0-4.0	.32	.32	5
	12-41	2-7-12	40-52-60	35-42-48	1.20-1.40	0.40-1.40	0.11-0.13	6.0-8.9	1.0-4.0	.32	.32	
	41-80	45-60-70	15-25-30	10-15-30	1.35-1.55	4.00-14.00	0.17-0.19	0.0-2.9	0.5-1.0	.43	.43	
66106—Speed silt loam, 0 to 2 percent slopes, occasionally flooded												
Speed	0-15	5-14-25	50-69-75	12-17-22	1.25-1.45	4.00-14.00	0.22-0.24	0.0-2.9	1.0-3.0	.43	.43	5
	15-27	5-14-25	50-70-80	12-16-20	1.30-1.50	4.00-14.00	0.20-0.22	0.0-2.9	1.0-2.0	.49	.49	
	27-38	5-9-25	50-67-75	18-24-30	1.30-1.50	4.00-14.00	0.20-0.22	3.0-5.9	0.5-1.0	.49	.49	
	38-80	5-9-25	50-65-75	20-26-32	1.30-1.50	4.00-14.00	0.20-0.22	3.0-5.9	0.5-1.0	.49	.49	


Center Section 29
Highway BB
Surface Outlet El. 647.0
Ditch
29 Total Acres
N
200 100 0 200 400
Scale in Feet

Problem #5



30 Total Acres

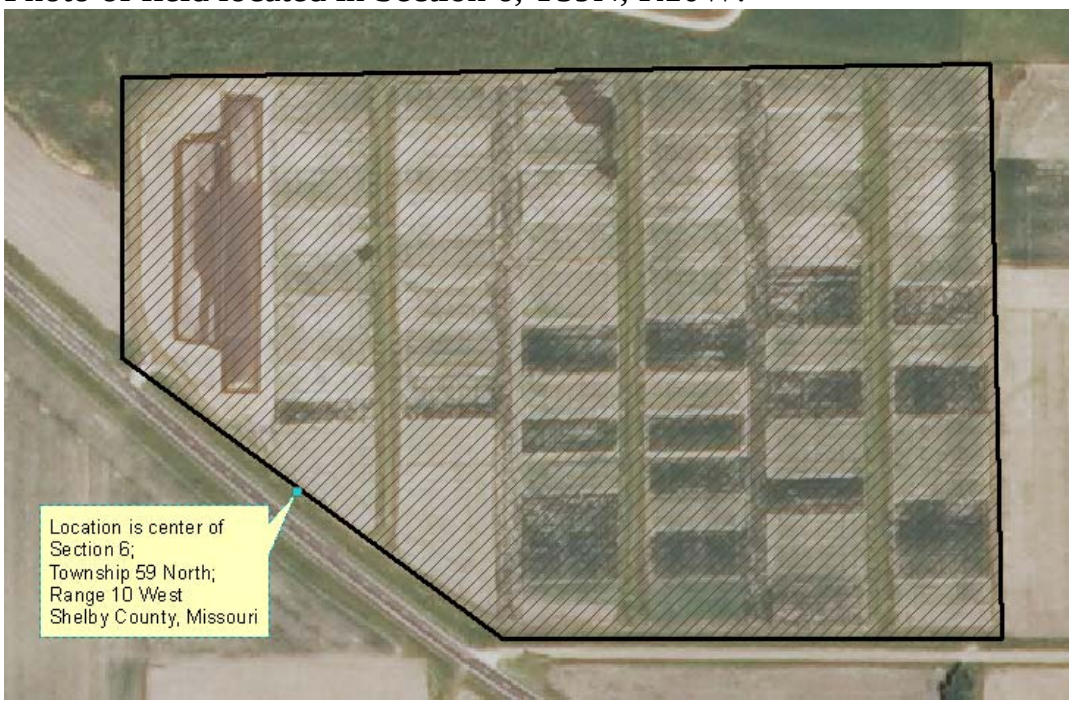
Problem #5

MLICA Drainage Workshop
Design Problem 6

Greenley Farm, Shelby County, Missouri

Prepare a subsurface drainage plan for the 26 acre field shown. The farmer raises corn, soybeans, and wheat and is interested in controlled drainage where feasible.

Photo of field located in Section 6, T59N, R10W:



In addition to soil survey information, also consider the following observations about soil texture from soil probing at the site to a depth of 30 inches:

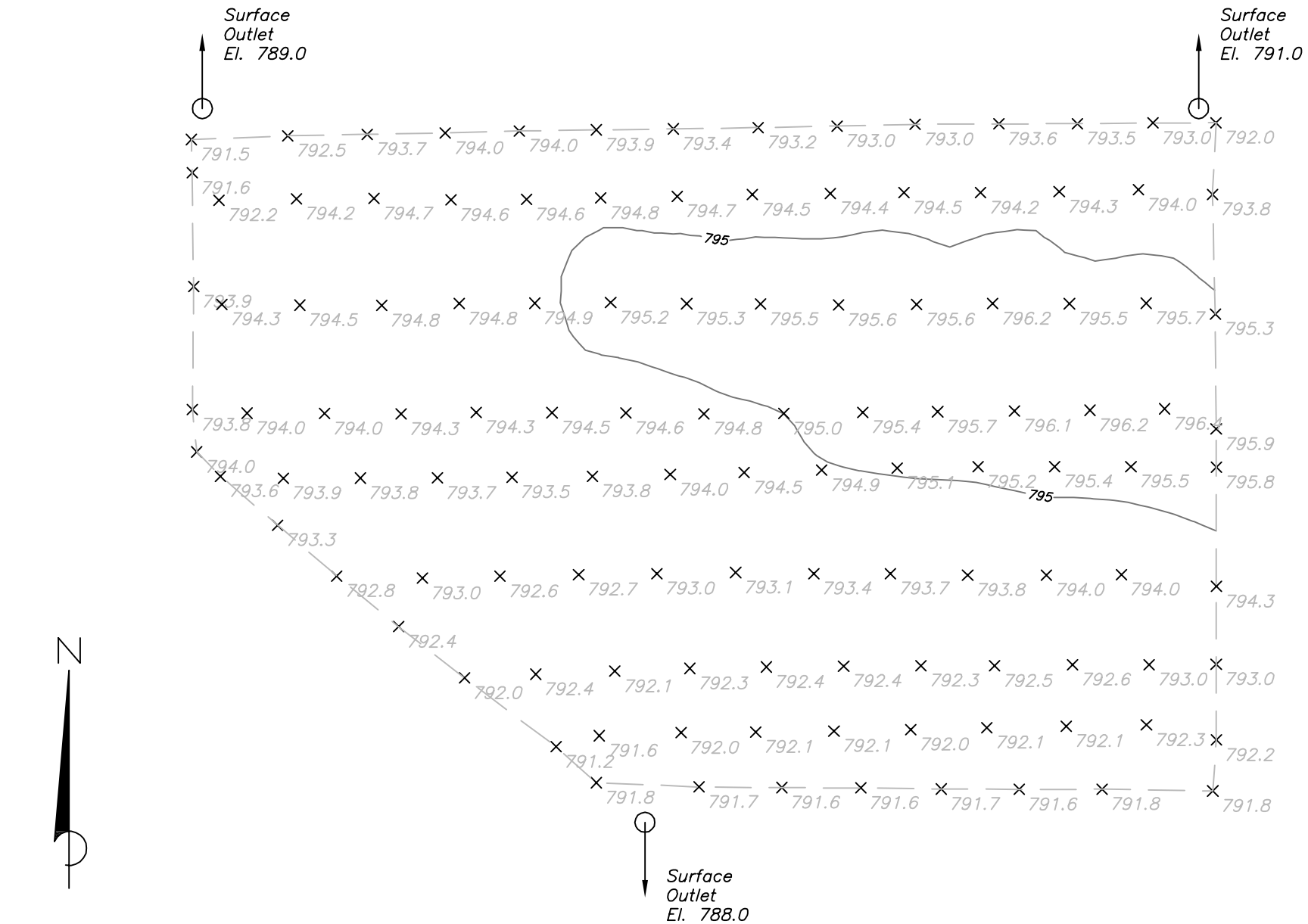
> From 0 to 22 inches the soil is texture is a silt loam (ML)
> from 22 to 30 inches the soil texture is silty clay loam (CL).

Design two pattern drainage systems:

- One that will provide the most economical uncontrolled drainage,
- The second system will incorporate drainage water management.

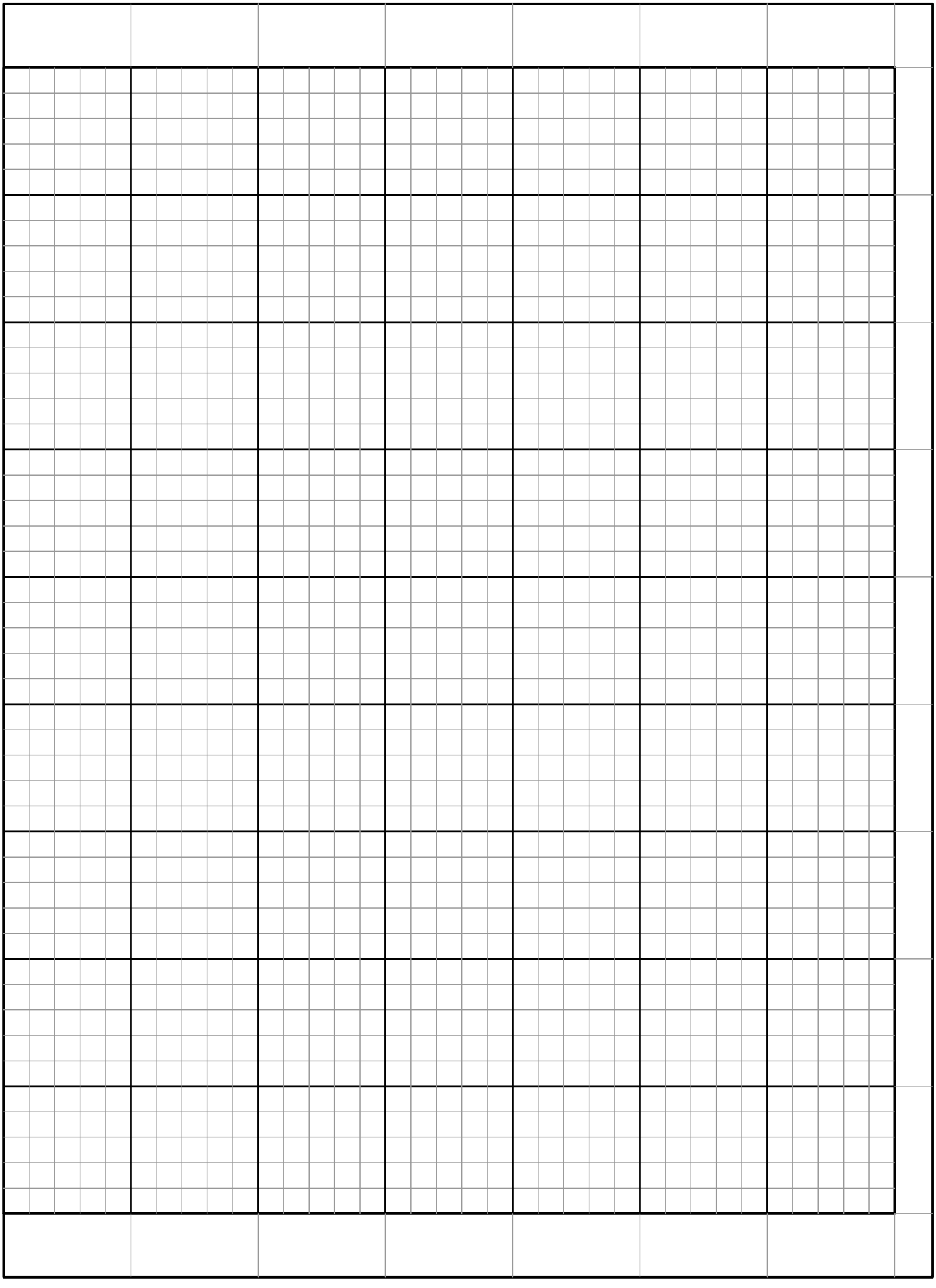
1. Complete a contour map from the survey data provided.
2. Collect soils information from the Soil Survey.

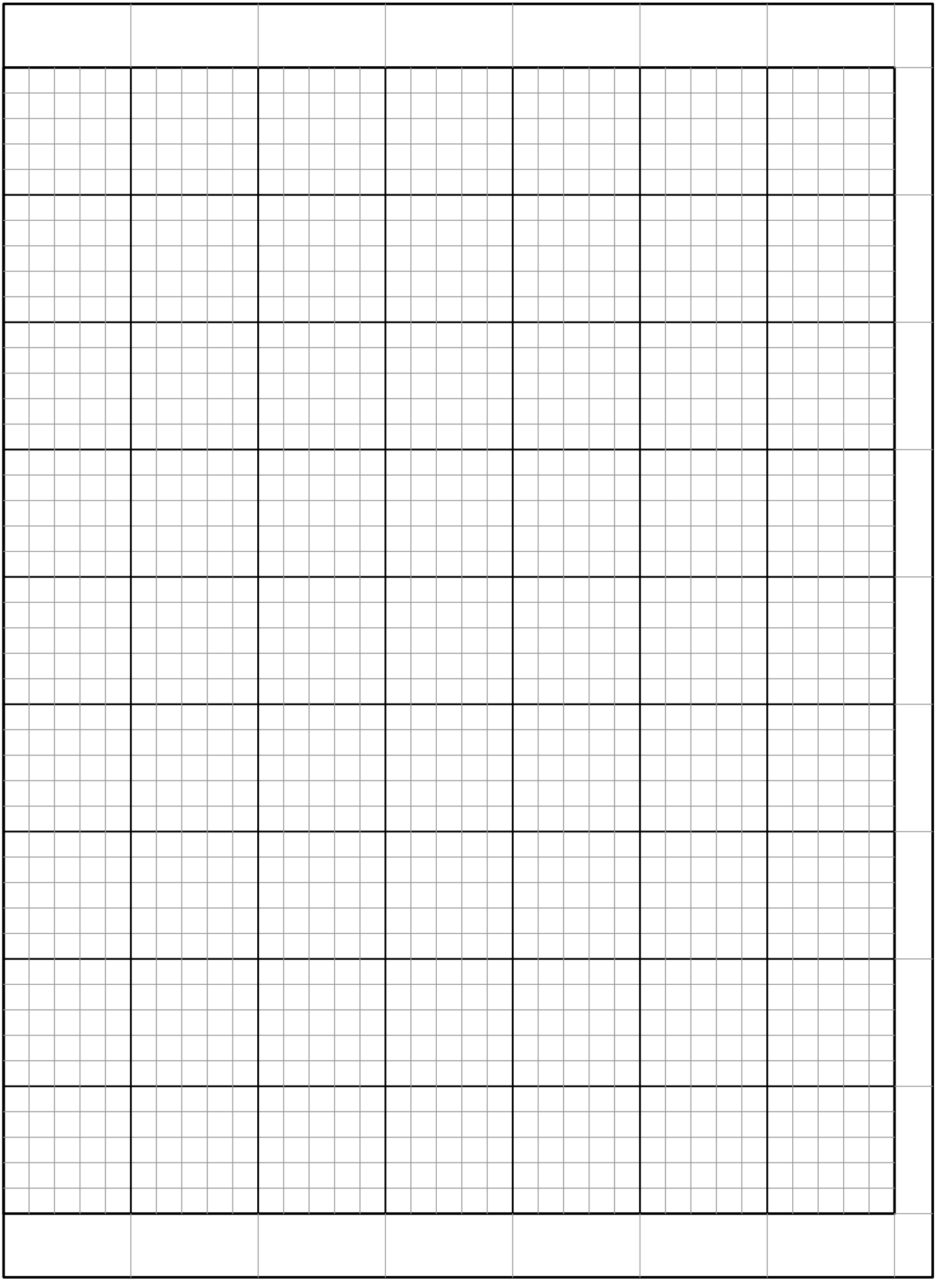
3. Select a drainage coefficient.
4. Select lateral depth and spacing.
5. Determine the size of the main(s), and plot a profile of the main(s) and any key laterals showing the:
    a. Existing ground line.
    b. Outlet elevation.
    c. Grade of main and locations of any changes in grade.
6. Show the layout of the system on the topographic map indicating sizes and lengths of mains and laterals. (Note drawing scale.)
7. Complete a table of estimated quantities and cost for materials and installation for each system and compare the per acre cost.
8. Gather the information needed to make a Missouri One Call locate request.

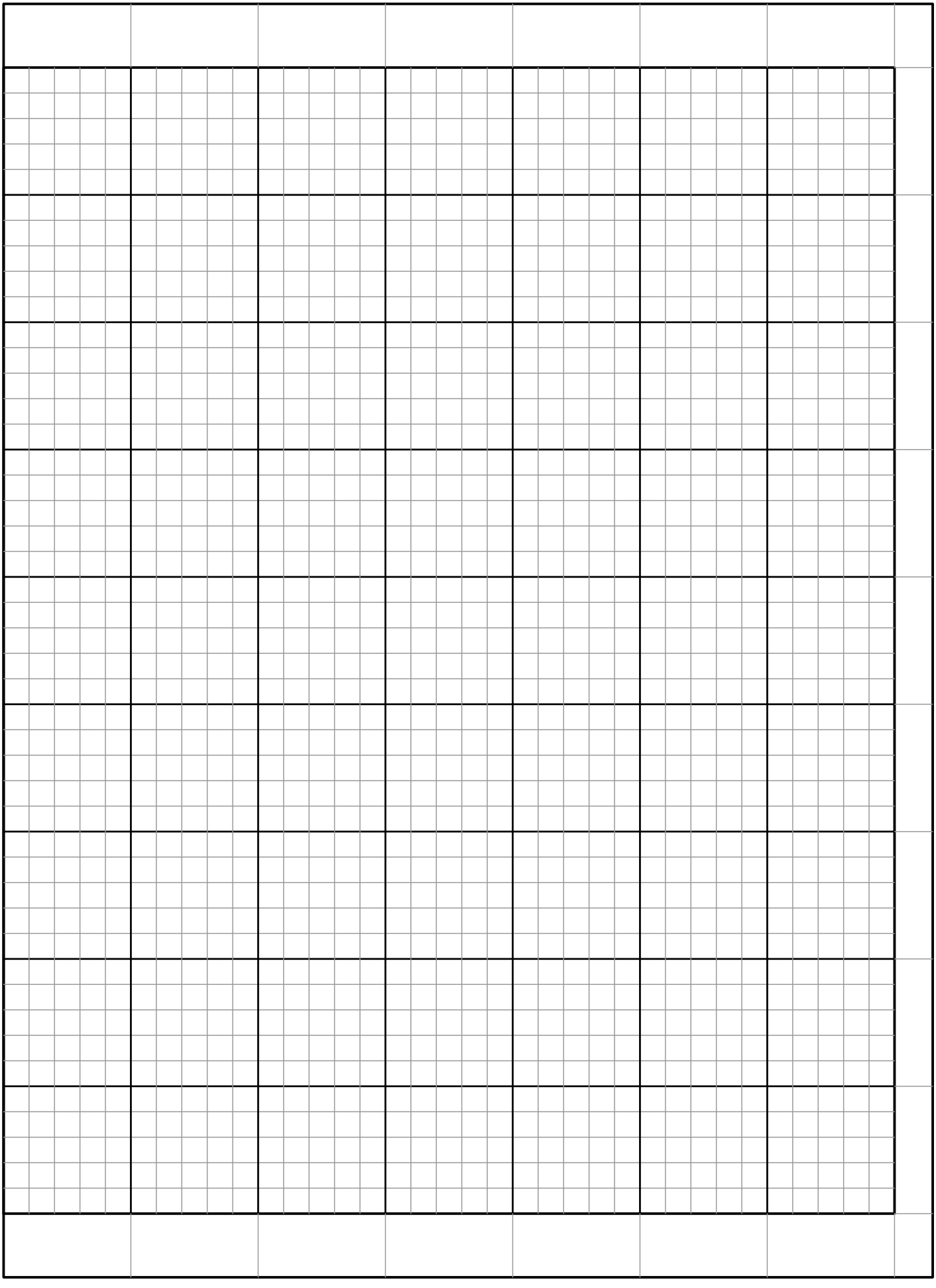


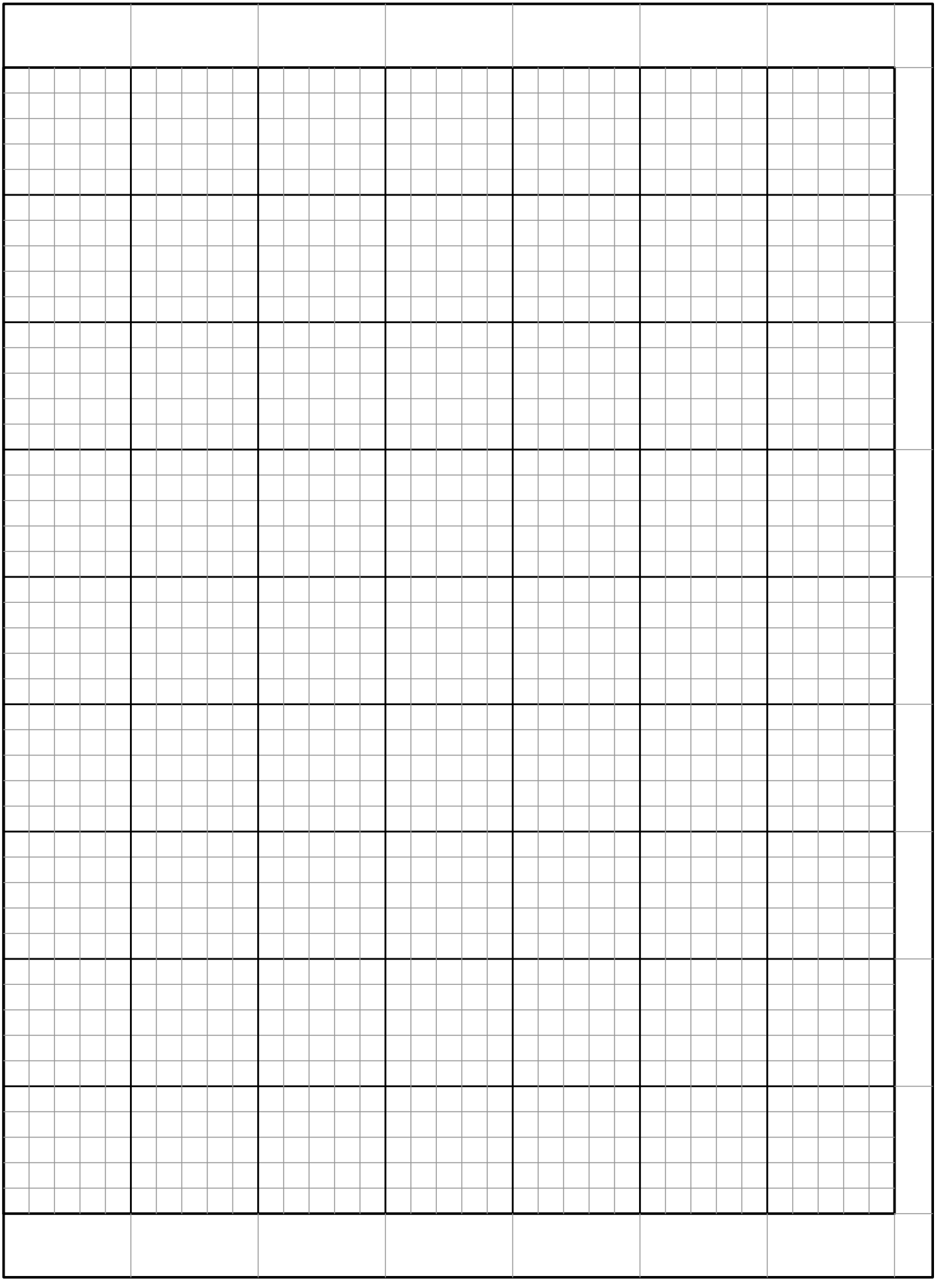
Problem #6

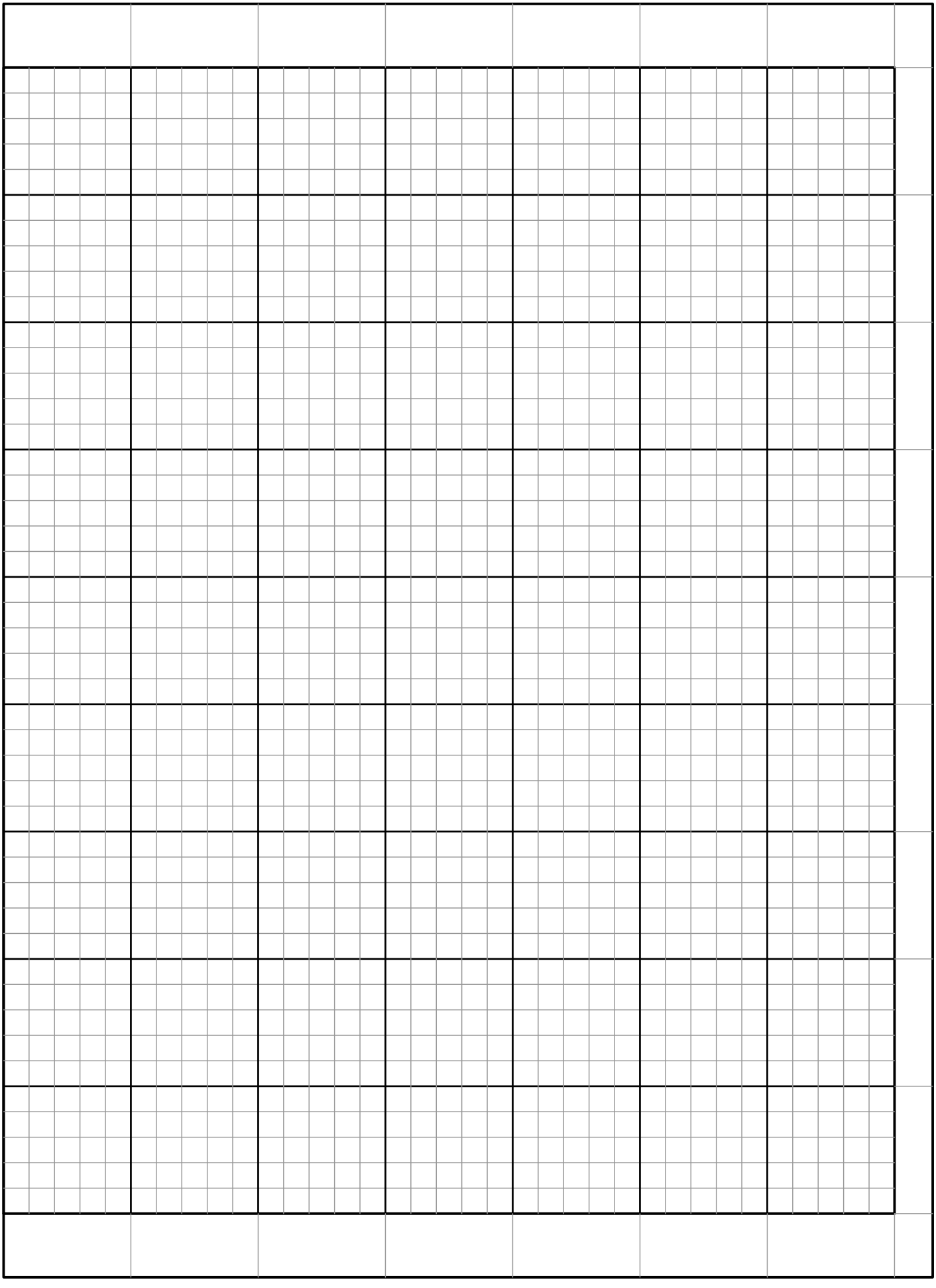
MLICA 8-29

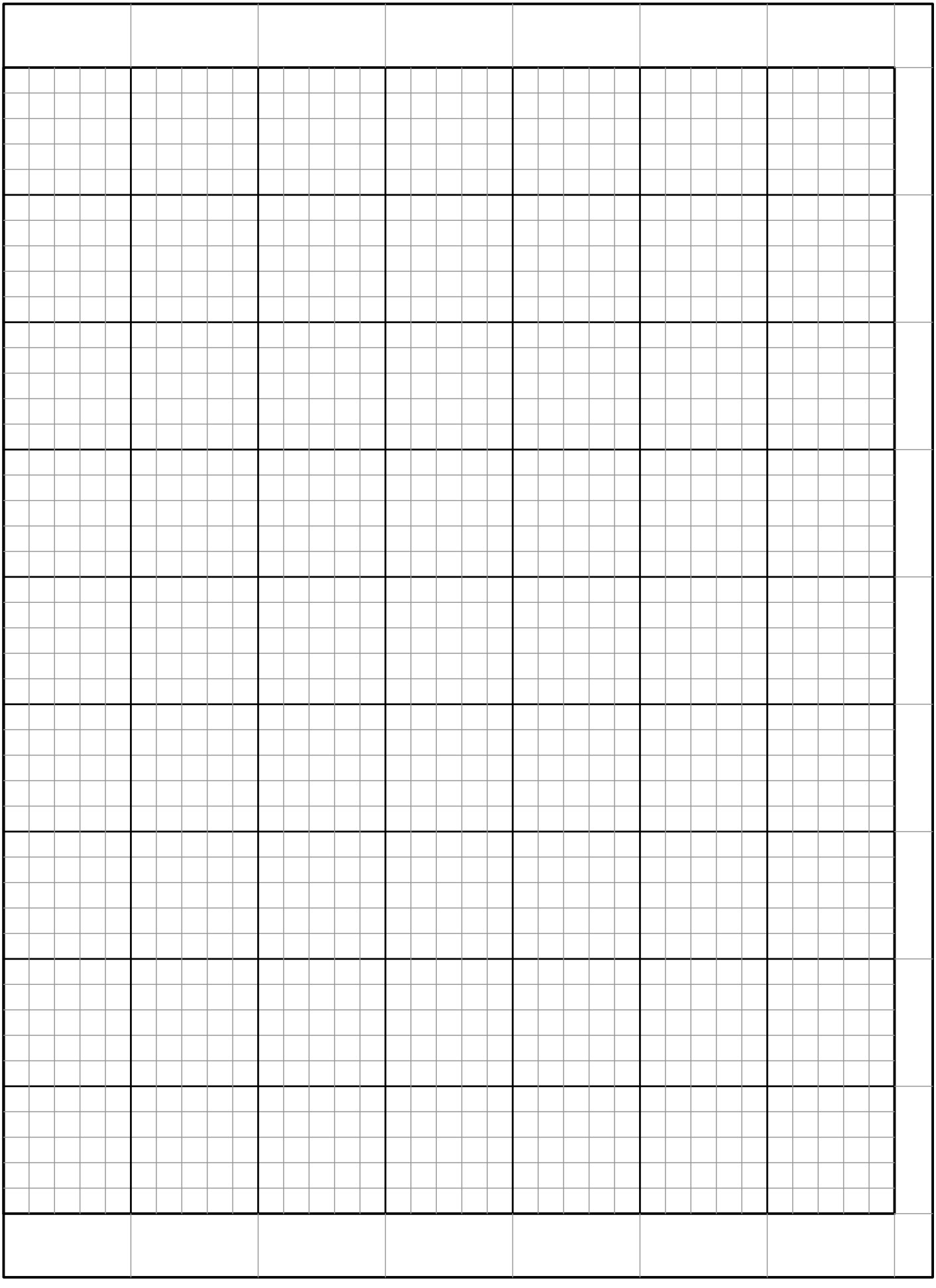


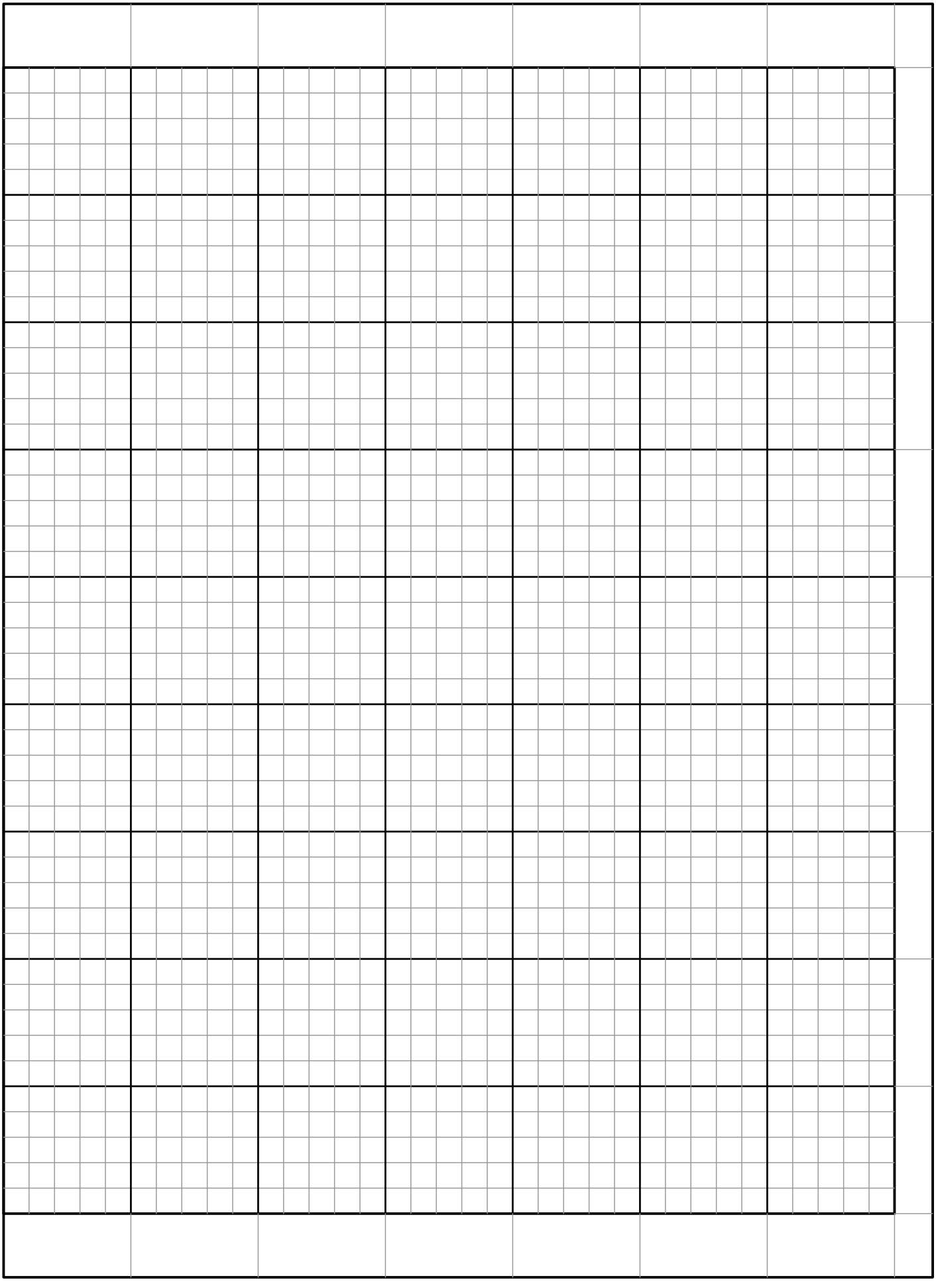


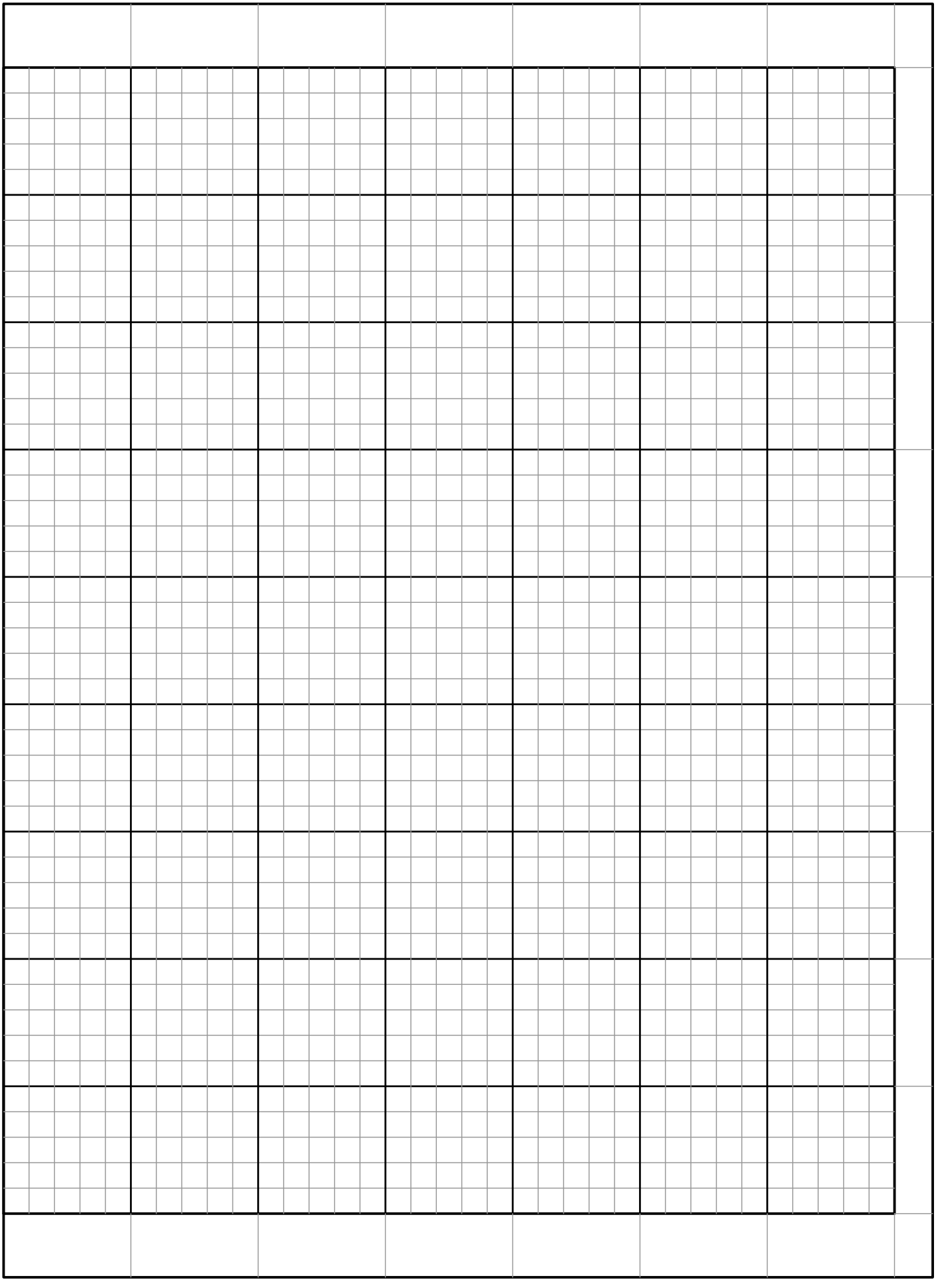


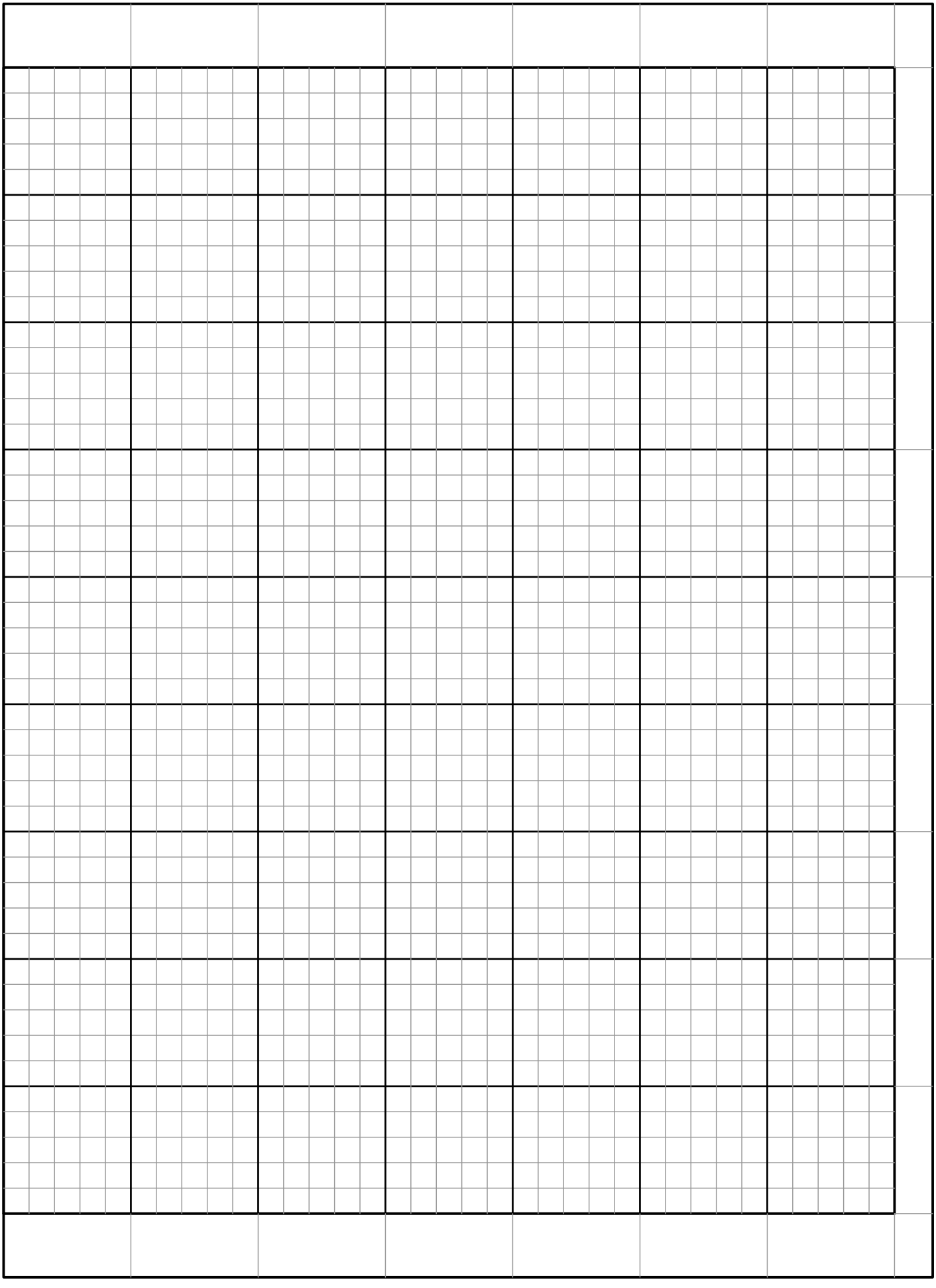


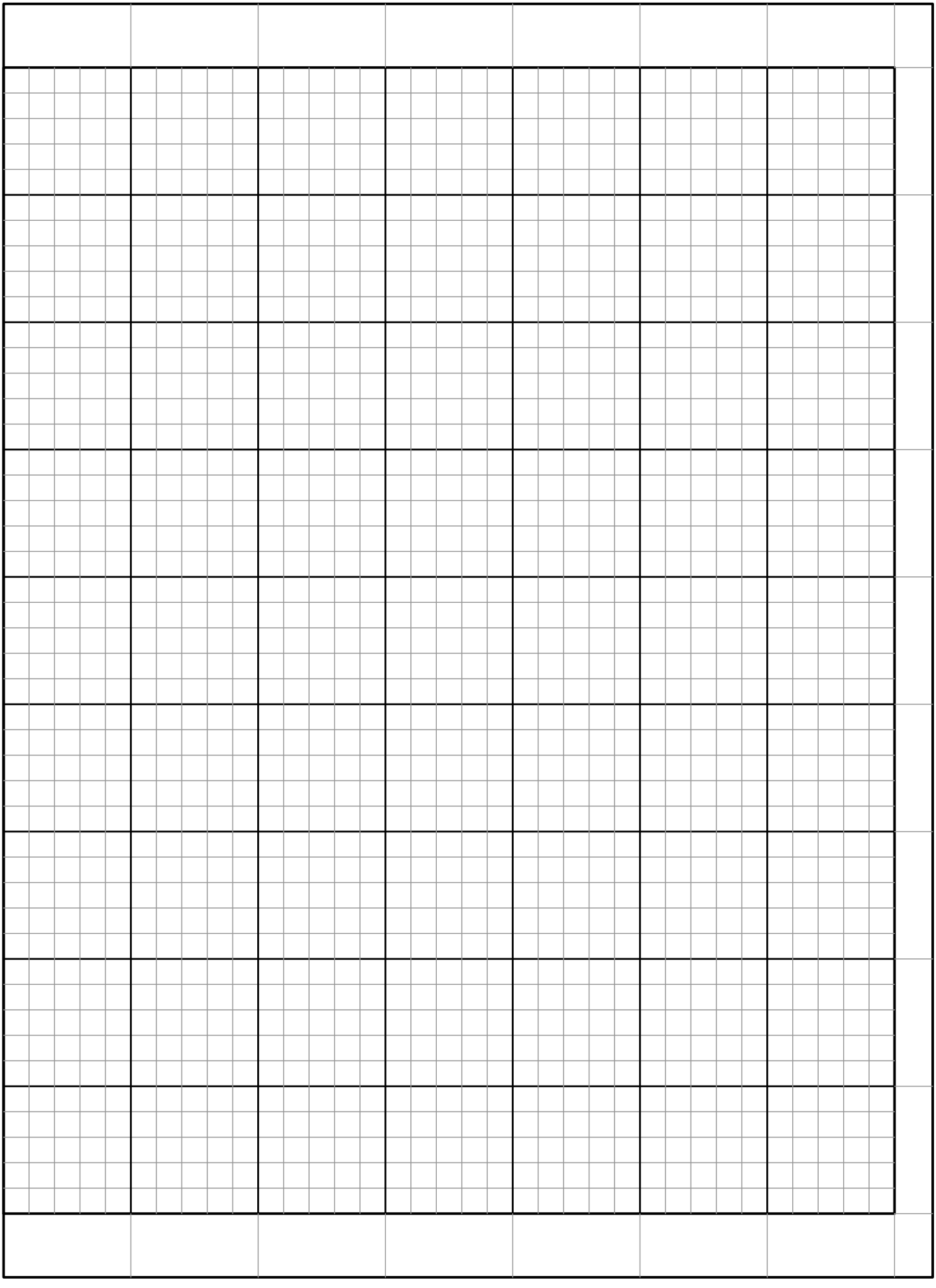












DESIGN TABLE FOR SUBSURFACE DRAINAGE

Project: _____ Location: _____

Designed by: _____ Date: _____ Checked by: _____ Date: _____

Drainage Coefficient, DC: _____ in/day Lateral Diameter: _____ inch *ver 1/10/2013*

Lateral Design									
Main Connect Station ft	Lateral ID or Group ID ID	Number of Laterals in Group ea	Grade %	Spacing (S) ft	Lateral Length (L) ft	Drained Length (S+L) ft	Drained Area per Lateral* ac	Drained Area per Group ac	Accum. Drained Area ac

** Includes area drained by main and upper end of lateral =* **S x (S + L) ÷ 43,560**

Main ID: _____ Pipe Material: _____

Main Design									
Main Reach					Main Reach Capacity			Drained Area	
From Station ft	To Station ft	Length ft	Grade %	Main Dia. in	Maximum Flow Volume (Q_{max}) cfs	Maximum Flow Velocity (V_{max}) fps	Maximum Drained Area (DA_{max}) ac	Lateral Accum. Drained Area ac	Unused Main Capacity ac

Comments: _____

Outlet Size: _____ in Material: _____ *1 acre = 43,560 square feet*

Length: _____ feet Animal Guard (Y/N): _____ Q_{req} *= 0.0421 x DC x DA*

DESIGN TABLE FOR SUBSURFACE DRAINAGE

Project: _____ Location: _____

Designed by: _____ Date: _____ Checked by: _____ Date: _____

Drainage Coefficient, DC: _____ in/day Lateral Diameter: _____ inch *ver 1/10/2013*

Lateral Design									
Main Connect Station ft	Lateral ID or Group ID ID	Number of Laterals in Group ea	Grade %	Spacing (S) ft	Lateral Length (L) ft	Drained Length (S+L) ft	Drained Area per Lateral* ac	Drained Area per Group ac	Accum. Drained Area ac

** Includes area drained by main and upper end of lateral =* **S x (S + L) ÷ 43,560**

Main ID: _____ Pipe Material: _____

Main Design									
Main Reach					Main Reach Capacity			Drained Area	
From Station ft	To Station ft	Length ft	Grade %	Main Dia. in	Maximum Flow Volume (Q_{max}) cfs	Maximum Flow Velocity (V_{max}) fps	Maximum Drained Area (DA_{max}) ac	Lateral Accum. Drained Area ac	Unused Main Capacity ac

Comments: _____

Outlet Size: _____ in Material: _____ *1 acre = 43,560 square feet*

Length: _____ feet Animal Guard (Y/N): _____ Q_{req} *= 0.0421 x DC x DA*

DESIGN TABLE FOR SUBSURFACE DRAINAGE

Project: _____ Location: _____

Designed by: _____ Date: _____ Checked by: _____ Date: _____

Drainage Coefficient, DC: _____ in/day Lateral Diameter: _____ inch *ver 1/10/2013*

Lateral Design									
Main Connect Station ft	Lateral ID or Group ID ID	Number of Laterals in Group ea	Grade %	Spacing (S) ft	Lateral Length (L) ft	Drained Length (S+L) ft	Drained Area per Lateral* ac	Drained Area per Group ac	Accum. Drained Area ac

** Includes area drained by main and upper end of lateral =* **S x (S + L) ÷ 43,560**

Main ID: _____ Pipe Material: _____

Main Design									
Main Reach					Main Reach Capacity			Drained Area	
From Station ft	To Station ft	Length ft	Grade %	Main Dia. in	Maximum Flow Volume (Q_{max}) cfs	Maximum Flow Velocity (V_{max}) fps	Maximum Drained Area (DA_{max}) ac	Lateral Accum. Drained Area ac	Unused Main Capacity ac

Comments: _____

Outlet Size: _____ in Material: _____ *1 acre = 43,560 square feet*

Length: _____ feet Animal Guard (Y/N): _____ Q_{req} *= 0.0421 x DC x DA*

DESIGN TABLE FOR SUBSURFACE DRAINAGE

Project: _____ Location: _____

Designed by: _____ Date: _____ Checked by: _____ Date: _____

Drainage Coefficient, DC: _____ in/day Lateral Diameter: _____ inch *ver 1/10/2013*

Lateral Design									
Main Connect Station ft	Lateral ID or Group ID ID	Number of Laterals in Group ea	Grade %	Spacing (S) ft	Lateral Length (L) ft	Drained Length (S+L) ft	Drained Area per Lateral* ac	Drained Area per Group ac	Accum. Drained Area ac

** Includes area drained by main and upper end of lateral =* **S x (S + L) ÷ 43,560**

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