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GROUNDWATER GLY 265 – 2009 – PRACTICAL 1		

EXERCISE 1

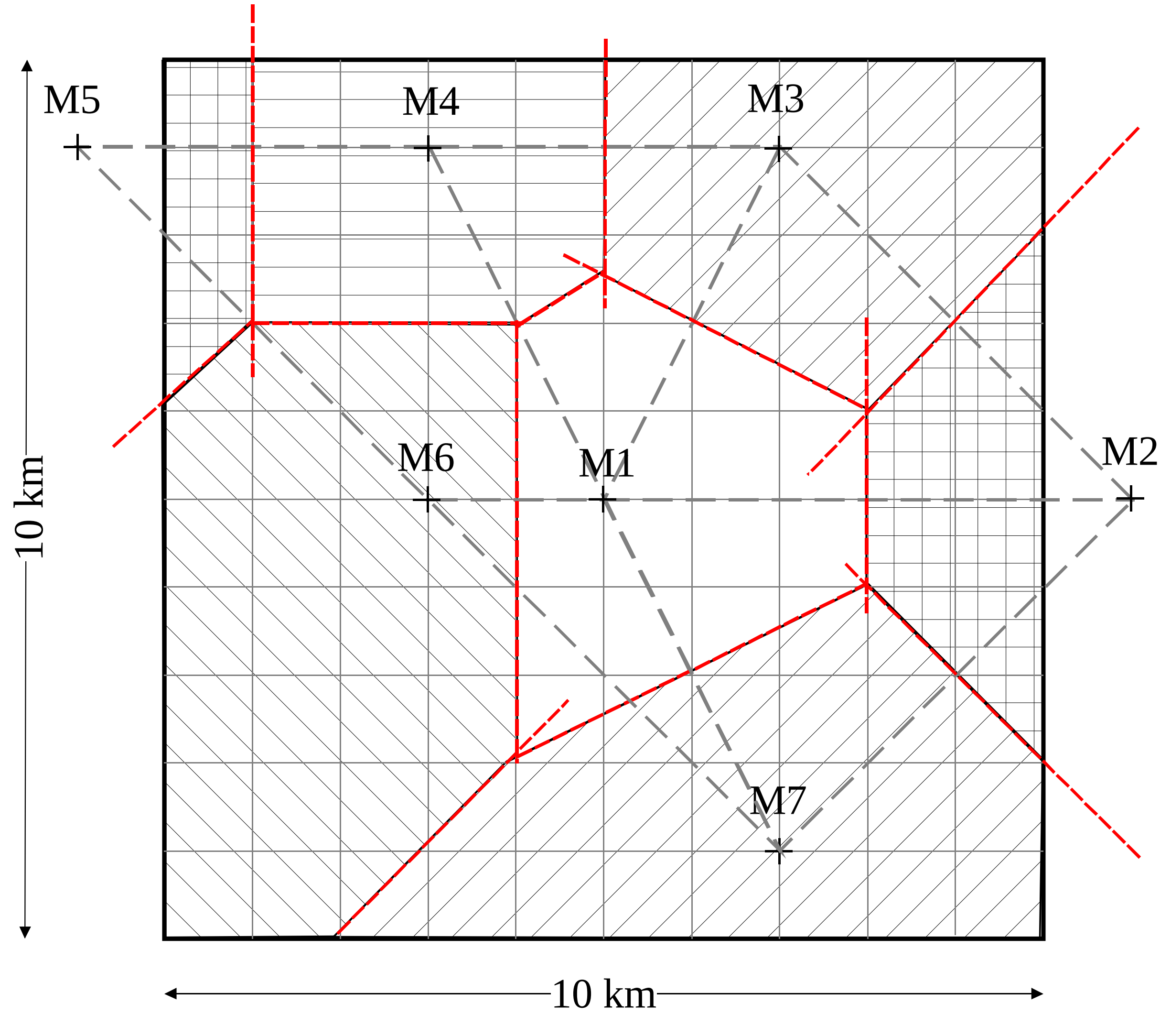
Calculate the average depth [mm] and volume [m^3] of precipitation and precipitation yield [$l\ s^{-1}\ km^{-2}$] for the drainage basin (10 km x 10 km) using the Thiessen method.

Station	*Coordinates [km]*	*Depth of precipitation [mm]*
1	0/0	1100
2	6/0	1400
3	2/4	1300
4	-2/4	1000
5	-6/4	800
6	-2/0	900
7	2/-4	1200

SOLUTION: EXERCISE 1

Thiessen Method: Steps

1. Draw rain gage network on a map of the drainage basin
2. Connect adjacent (closest) stations by a network of lines
3. Draw a perpendicular line at the midpoint of each line connecting two stations (bisector)
4. Extensions of perpendicular bisectors build polygons around each station
5. **Weigh** each datum with the **surface area** of the polygon containing the datum and calculate global sample statistics



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$$\overline{P} = \frac{\sum P_i A_i}{\sum A_i} = \frac{P_1A_1 + P_2A_2 + P_3A_3 + P_4A_4}{A_1 + A_2 + A_3 + A_4}$$

Station	*P_{st} [mm]*	*Area A_i [km^2]*	*Weighting factor $W_i = A_i / A_{total}$*	*$P_i = W_i * P_{st}$ [mm]*
1	1100	15.50	0.155	170.5
2	1400	8.00	0.080	112.0
3	1300	15.75	0.158	204.8
4	1000	11.75	0.118	117.5
5	800	3.50	0.035	28.0
6	900	25.50	0.255	229.5
7	1200	20.00	0.200	240
		A_{total} [km^2]		**P_{av} = EUD [mm]**
		100.00	1.00	**1102.3**

$$V_p = \left(1102.3 \times 10^3 m^3.km^{-2}\right)\left(100km^2\right)$$
$$= 1.1 \times 10^8 m^3$$

$$P_q = \frac{\left(1.1 \times 10^8 m^3\right)\left(10^3 m^3.km^{-3}\right)}{100km^2} \times \frac{1}{\left(365d \times 24h \times 60' \times 60''\right)}$$
$$= 34.95 l.s^{-1}.km^{-2}$$

EXERCISE 2

Calculate the average depth [mm] and volume [m^3] of precipitation and precipitation yield [l s^{-1} km^{-2}] for the drainage basin (figure attached) using the following methods:

a. Arithmetic average
b. Thiessen method
c. Isohyetal method.

Station	*Depth of precipitation [mm]*
1	1100
2	1000
3	900
4	920
5	840
6	860
7	820

SOLUTION: EXERCISE 2

ARITHMETIC AVERAGE:

$$P_{ave} = \frac{(P_1 + P_2 + ... + P_{12})}{12}$$
$$= 739.2mm$$

$$A = estimated = 25km^2$$

$$V_p = \left(739.2 \times 10^3 m^3.km^{-2}\right)\left(11.29km^2\right)$$
$$= 1.04 \times 10^7 m^3$$

$$P_q = \frac{\left(1.04 \times 10^7 m^3\right)\left(10^3 m^3.km^{-3}\right)}{11.29km^2} \times \frac{1}{\left(365d \times 24h \times 60' \times 60''\right)}$$
$$= 29.21 l.s^{-1}.km^{-2}$$

1. Determine Effective Uniform Depth (EUD) of precipitation.
2. Calculate Volume by converting mm to m
3. Determine Precipitation Yield → Vp (km2) / Area corrected for time in seconds; 365days.

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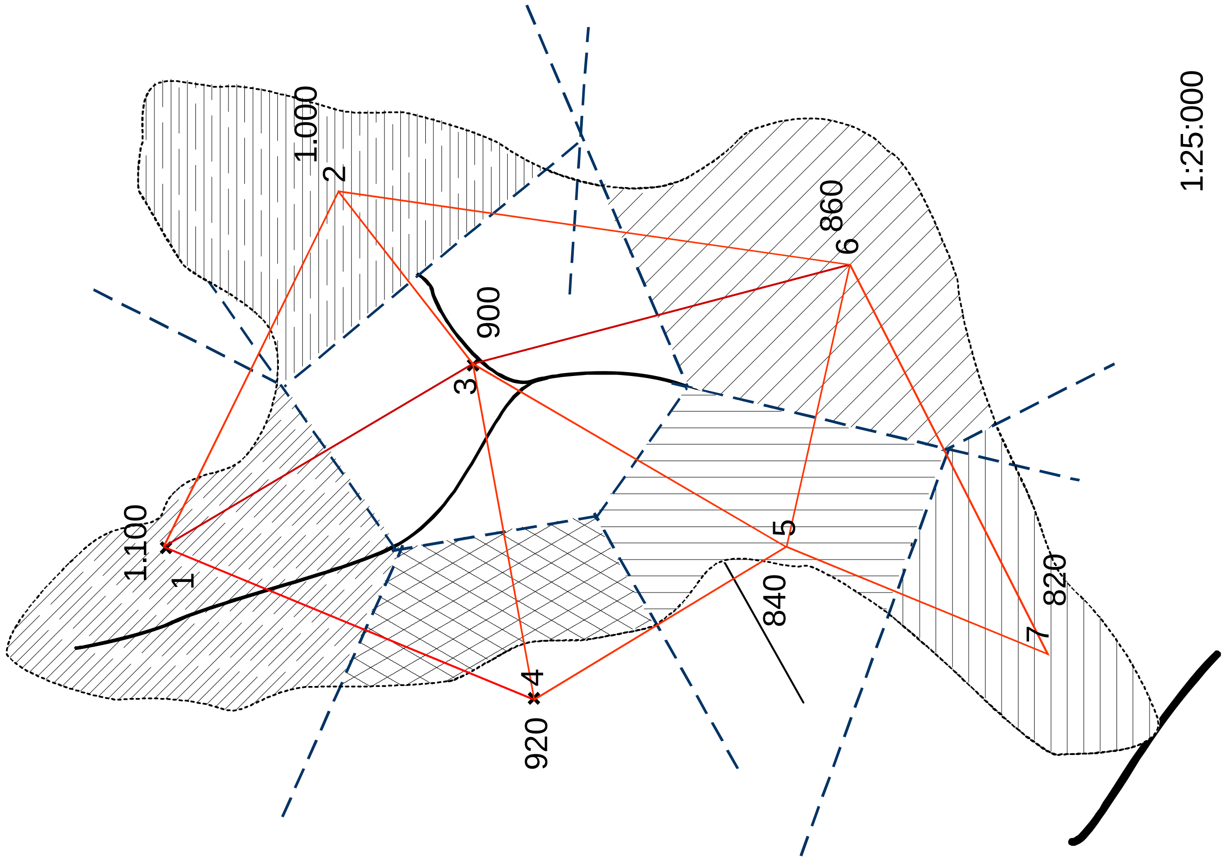

THIESSEN:

$$V_p = \left(921.3 \times 10^3 m^3.km^{-2}\right)\left(11.29 km^2\right)$$
$$= 1.04 \times 10^7 m^3$$

$$P_q = \frac{\left(1.04 \times 10^7 m^3\right)\left(10^3 m^3.km^{-3}\right)}{11.29 km^2} \times \frac{1}{\left(365d \times 24h \times 60' \times 60''\right)}$$
$$= 29.21 l.s^{-1}.km^{-2}$$

ISOHYETAL:

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EXERCISE 3

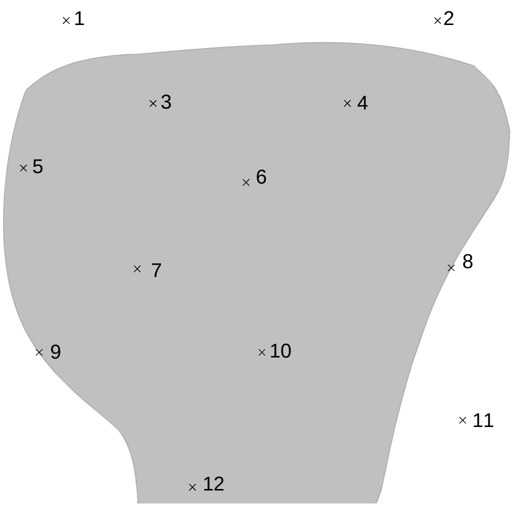
Calculate the effective uniform depth [mm] and volume [m^3] of precipitation and precipitation yield [l s^{-1} km^{-2}] for the drainage basin using the following methods:

a. Arithmetic average
b. Thiessen method
c. Isohyetal method (100 m isohyets).

Station	*Depth of precipitation [mm]*
1	780
2	800
3	950
4	920
5	800
6	850

Station	*Depth of precipitation [mm]*
7	750
8	650
9	720
10	520
11	550
12	580

SOLUTION: EXERCISE 3



Arithmetic average: 739.2 mm

$V_P = 739.2 * 10^3$ [m^3/km^2] * 7.5 [km^2] = $5.544 * 10^6$ m^3

$P_q = 5.544 * 10^8 * 10^3$ / 100 * (365*24*60*60) [l/s*km^2] = 23.4 l/s*km^2

Theissen method

	P [mm]	Area [km^2)	W_i	P_i [mm]
1	780	0.11	0.015	11.4
2	800	0.25	0.033	26.7
3	950	0.69	0.092	87.4
4	920	0.97	0.129	119.0
5	800	0.51	0.068	54.4
6	850	0.97	0.129	109.9
7	750	0.88	0.117	88.0
8	650	0.25	0.033	21.7
9	720	0.45	0.060	43.2
10	520	1.45	0.193	100.5
11	550	0.21	0.028	15.4
12	580	0.76	0.101	58.8
Σ		**7.5**	**1.000**	**736.4**

$N_Q = 736.4 * 10^3$ [m^3/km^2] * 7.5 [km^2] = $5.523 * 10^6$ m^3

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N_q = 5.523 * 10^6 * 10^3 / 7.5 * (365*24*60*60) [l/s*km^2] = 23.4 l/s*km^2

Isohyetal method

	P [mm]	Area [km^2]	W_i	P_i [mm]
500 – 600	550	2.00	0.267	146.7
600 – 700	650	1.25	0.167	108.3
700 – 800	750	1.65	0.220	165.0
800 – 900	850	2.00	0.267	226.7
> 900	950	0.60	0.080	76.0
Σ		**7.5**	**1.000**	**722.7**

N_Q = 722.7 * 10^3 [m^3/km^2] * 7.5 [km^2] = 5.420 * 10^6 m^3
N_q = 5.523 * 10^6 * 10^3 / 7.5 * (365*24*60*60) [l/s*km^2] = 22.916 l/s*km^2

EXERCISE 4

For the surface area supplied, calculate the average precipitation depth, precipitation volume and precipitation yield using the:

a. Arithmetic average
b. Thiessen method
c. Isohyetal method.

Assuming 3% recharge of MAP and no groundwater inflows:

d. Schematically depict the hydrological balance and the volume of water available for overland flow, interflow and baseflow.
e. Address whether a farmer located at the residential dwelling can safely pump water consistently at 0.4 litres per second without affecting the streamflow.

Station	*Depth of precipitation [mm]*
1	980
2	1050
3	1100
4	850
5	970
6	830
7	770
8	720

SOLUTION: EXERCISE 4

1. **Connect three stations together to form triangles, preferably with all angles smaller than 90 degrees (if possible). → red lines on next page**
2. **Bisect the constructed sides of the triangles to create polygons. In other words, draw a line which halves each triangle side. Aim to draw as close to perpendicular as possible and let three bisectors connect in the middle of each triangle. → double black lines on next page**
3. **Polygons should now be completed where each station is surrounded by a polygon. Count the blocks to determine the area of each polygon as well as the total area.**
4. **Weighting: A1/A = W1; A2/A = W2; etc. W1 + W2 + W3 + … Wi = 1.**
5. **Calculate each station's influence on precipitation by: P1 = P.W1; P2 = P.W2; etc.**
6. **Total average precipitation depth = P1 + P2 + P3 + … + Pi.**

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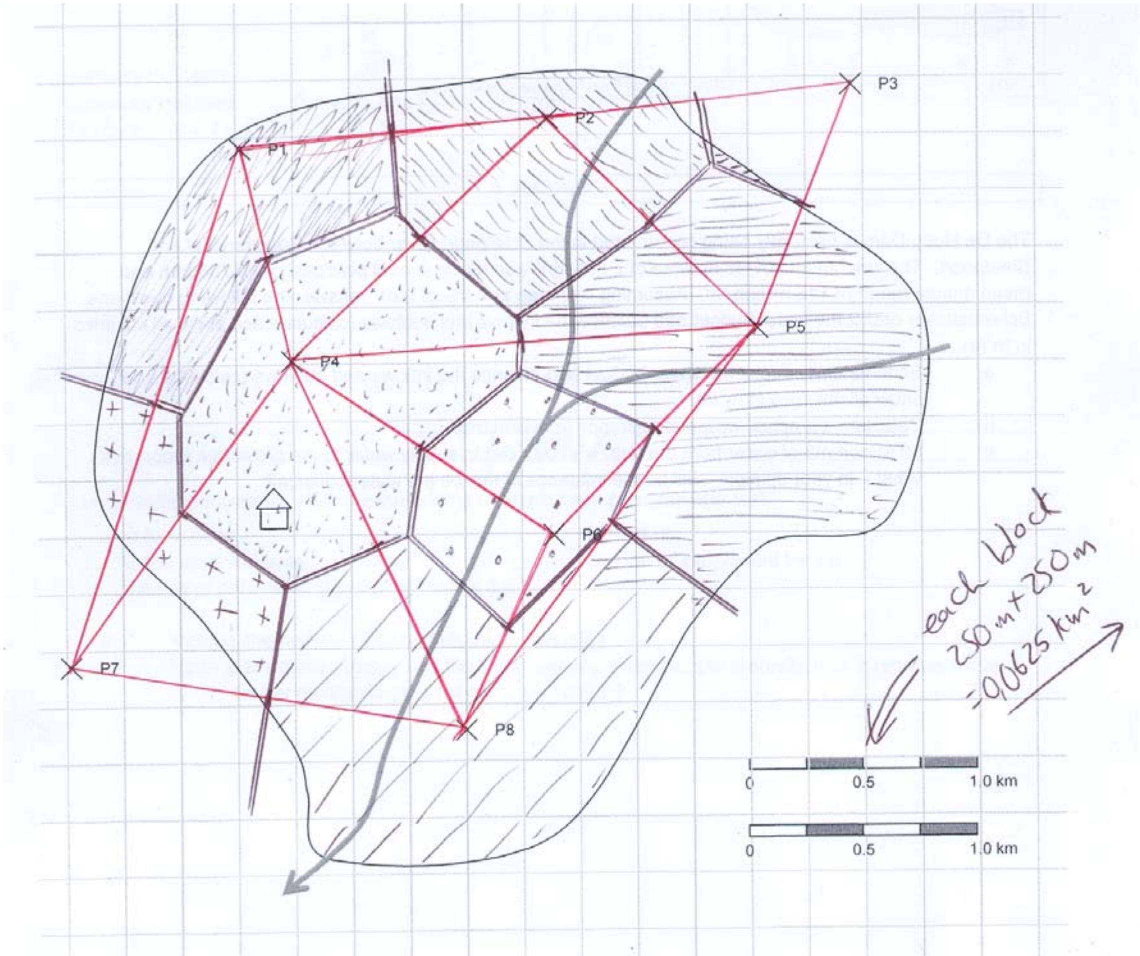

Station	Precipitation mm	blocks	Wi	Pi
1	980	13	13/138.5 = 0.094	(980)(0.094) = 92mm
2	1050	16	16/138.5 = 0.116	(1050)(0.116) = 121.8mm
3	1100	0.5	0.0036	3.96mm
4	850	26.5	0.191	162.4mm
5	970	33	0.238	230.9mm
6	830	11.5	0.083	68.9mm
7	770	7	0.051	39.3mm
8	720	31	0.224	161.3mm
		Sum = 138.5	Sum = 1	Sum = 880.6mm

Average precipitation depths = 880.6mm

Volume of precipitation: A = 138.5 blocks x 0.25km x 0.25km (according to scale bar)

$= 8.66\text{km}^2$

$V_P = A \times P = (8.66\text{km}^2)(10^6\text{m}^2/\text{km}^2) \times (880.6\text{mm})(0.001\text{m/mm})$

$= 7.62 \times 10^6\text{m}^3$

Precipitaytion yield: Remember: precipitation is annual unless noted otherwise! Therefore, convert one year to seconds!

$$P_Q = \frac{(7.62 \times 10^6\text{m}^3)(1000\ell/\text{m}^3)}{(8.66\text{km}^2)(365\text{d/y} \times 24\text{h/d} \times 60\text{m/h} \times 60\text{s/m})} = 0.67\ell.\text{s}^{-1}.\text{km}^{-2}$$