Status and Challenges of the Stormwater Drainage System in the Lviv City

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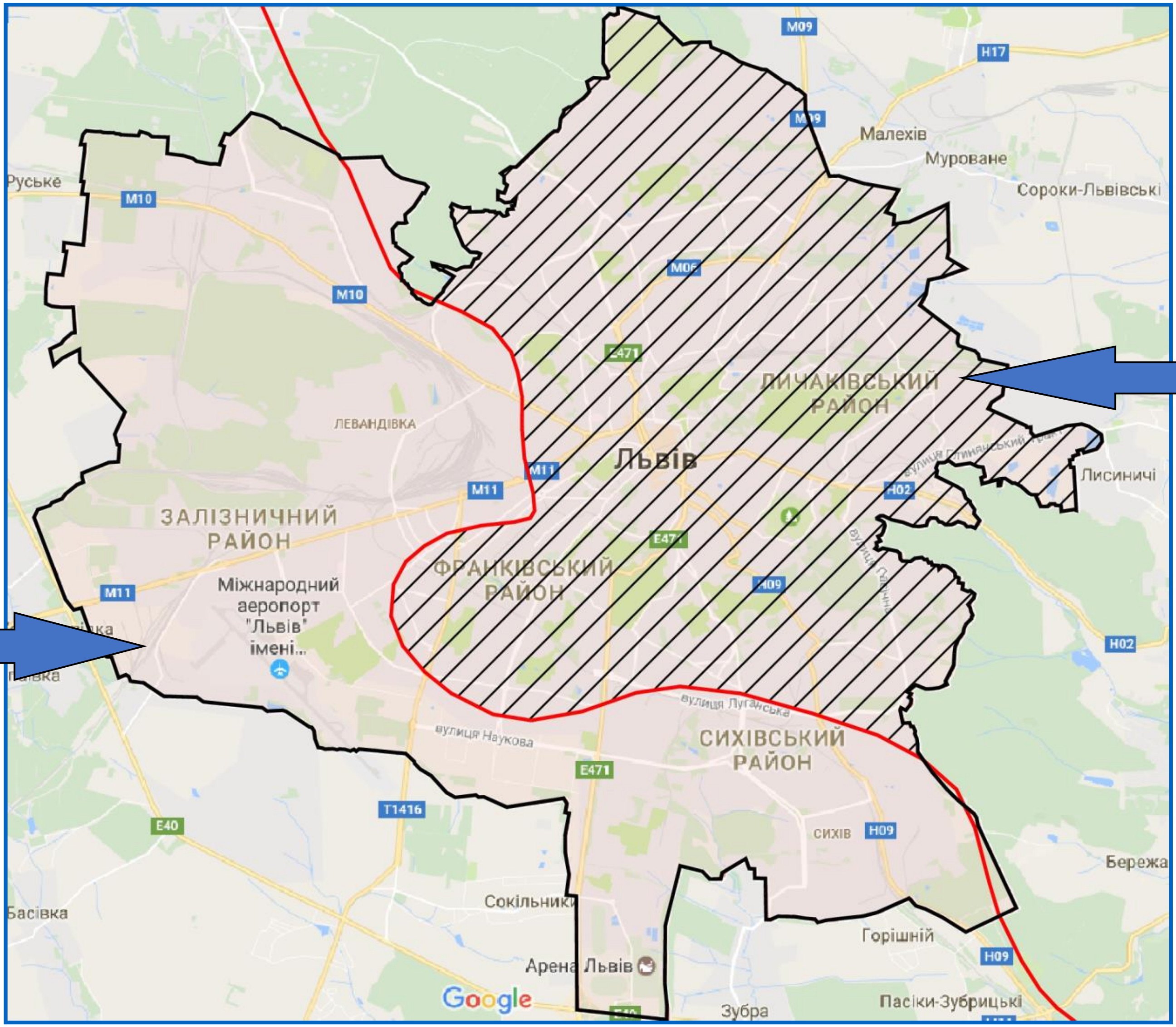
Lviv city and the Main European watershed



Baltic Sea basin

Area in the city borders: 59.5 km^2

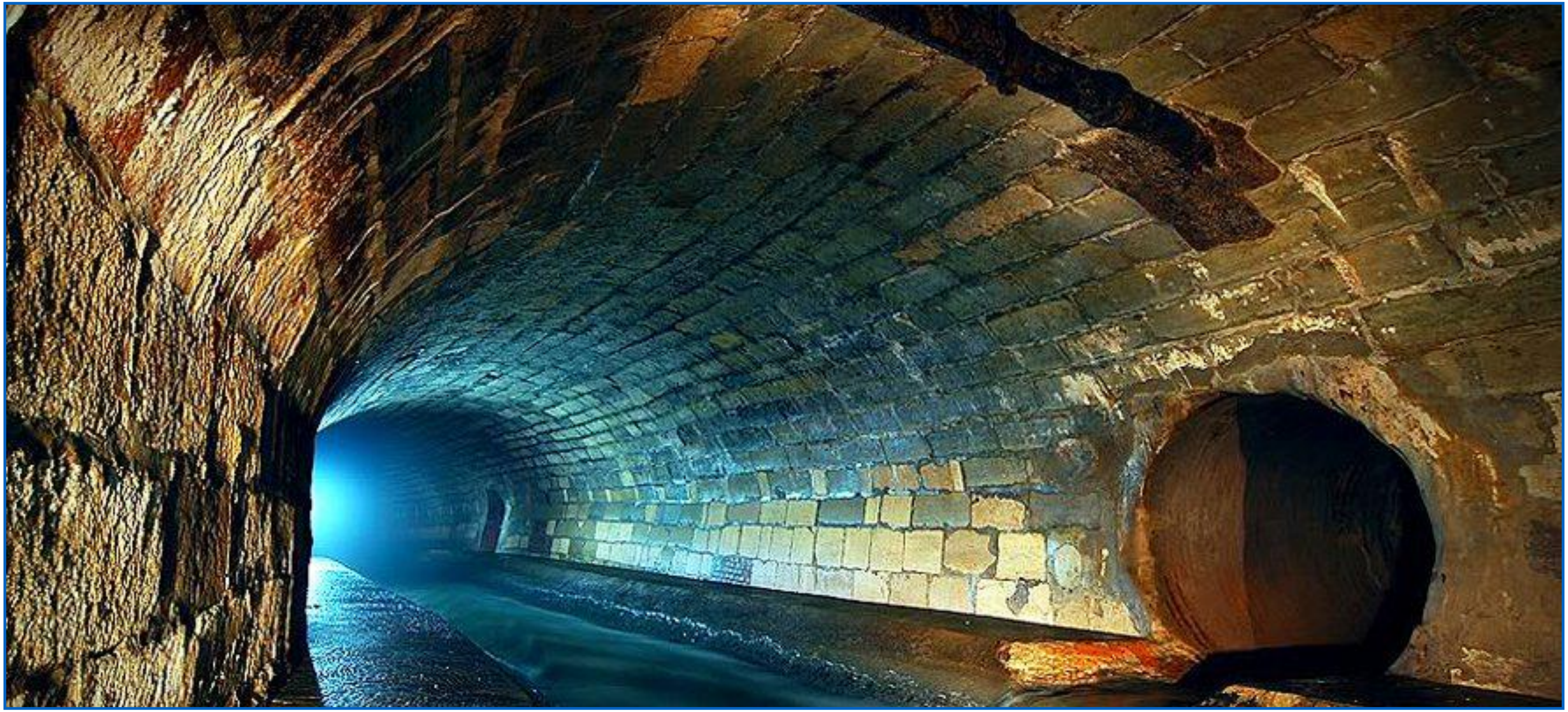
Black Sea basin

Area in the city borders: 62.1 km^2

Poltva river in 1880 (Mitskevych Square)

Poltva river now (Sakharova-Zarytskykh Str.)

Poltva river now (Svobody Avenue)



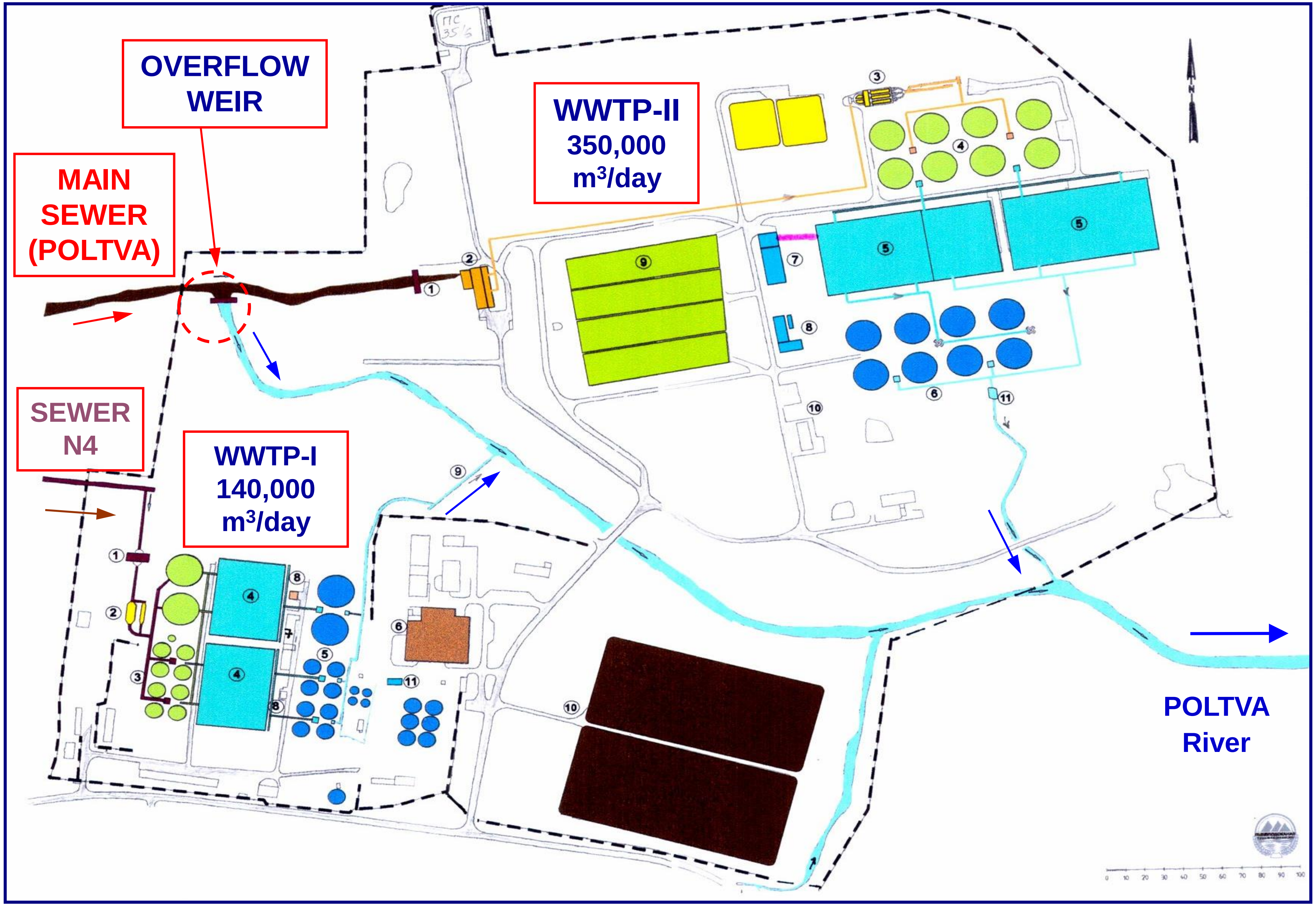
Flooding in Lviv, 17.08.2018

Flooding at Sakharova Str.

Flooding in Lviv, 17.08.2018

Horodotska Str.

Lviv center



LVIV WASTEWATER TREATMENT PLANT

WWTP-I is in operation since 1963 (first stage) and since 1965 (second stage).

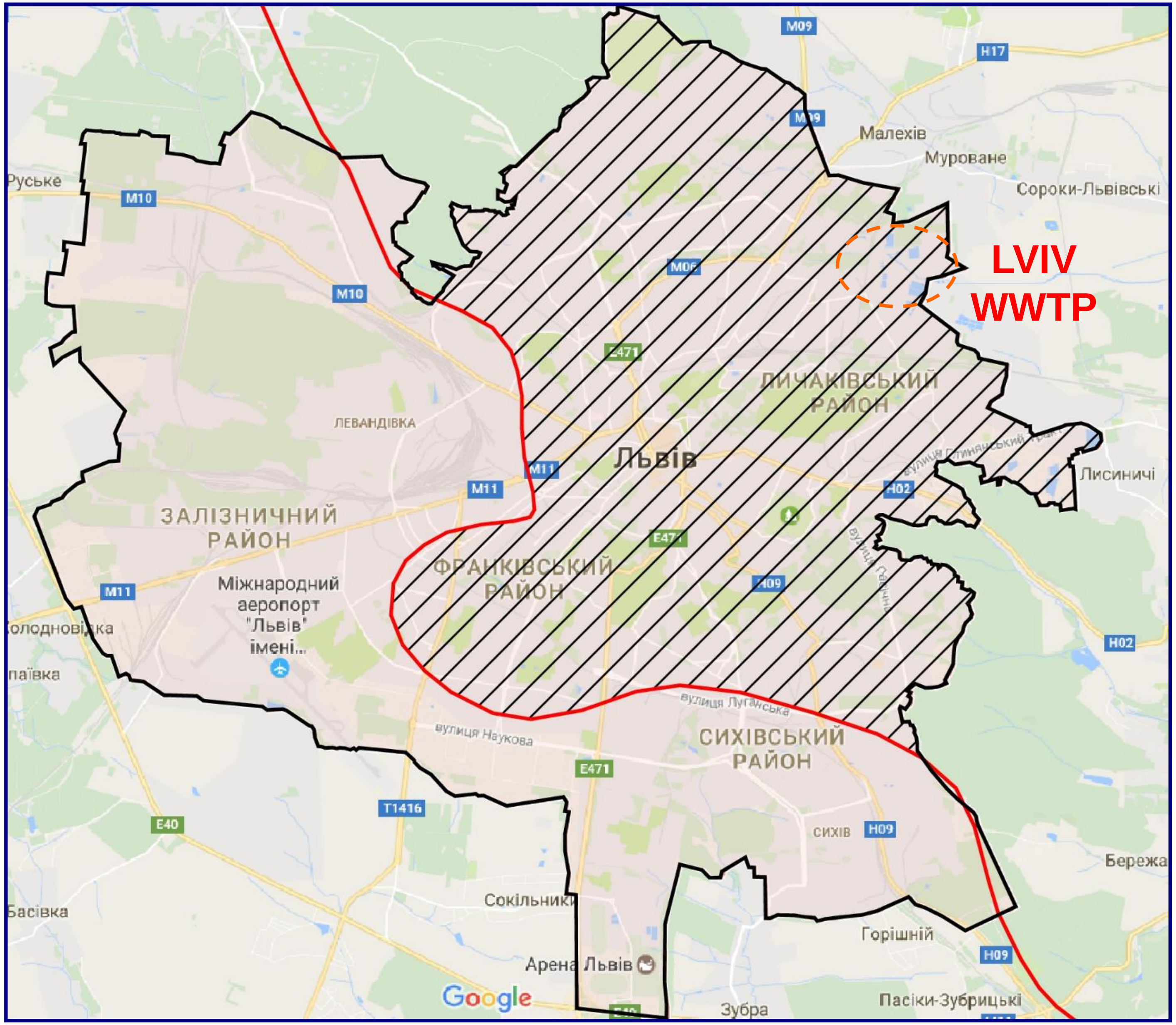
Capacity: 140,000 m^3/day

WWTP-II is in operation since 1976 (third stage) and since 1988 (4th stage).

Capacity: 350,000 m^3/day

Total capacity:

490,000 m^3/day



AVERAGE VOLUMES of RUNOFF at LVIV WWTP

Approximation #1 (Rational formula)

$$W_{an} = \sum \psi_i F_i H_{an}$$

Area of the Baltic Sea catchment: **59.5 km²**

Area of the Black Sea catchment : **62.1 км²**

Average annual rainfall depth: **742 mm/year**

No of rainfall events: **125**

Runoff coefficient (Codes-2008):

-Baltic Sea catchment: **0.45** - Baltic Sea catchment: **0.1**

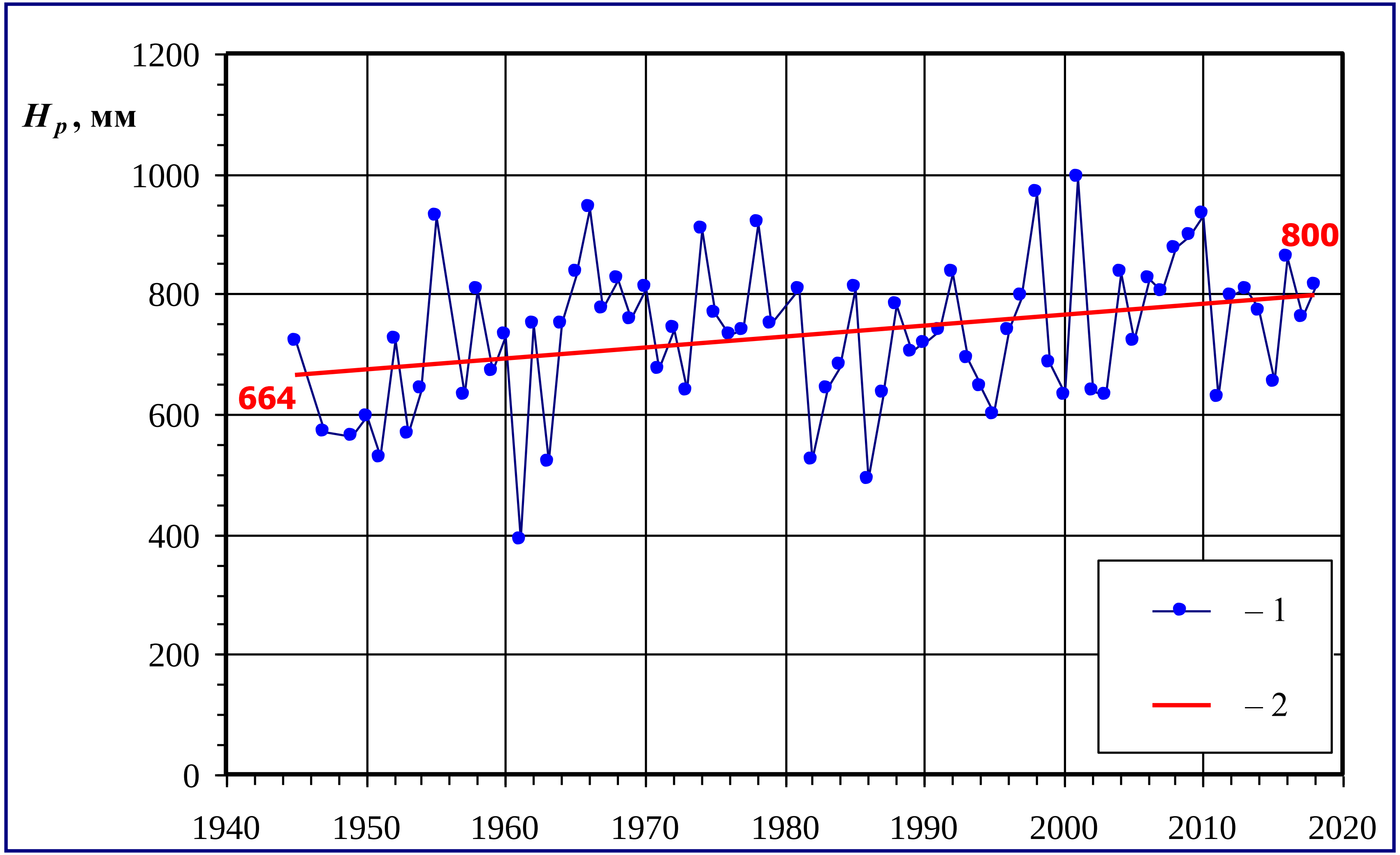
Average annual runoff: 24.5 mln. m³ / year

Average daily runoff: ≈ 200,000 m³ / day

Average wastewater flowrate: ≈ 190,000 m³ / day

Average Poltva flowrate: ≈ 100,000 m³ / day

Total average flowrate at WWTP: 490,000 m³ / day



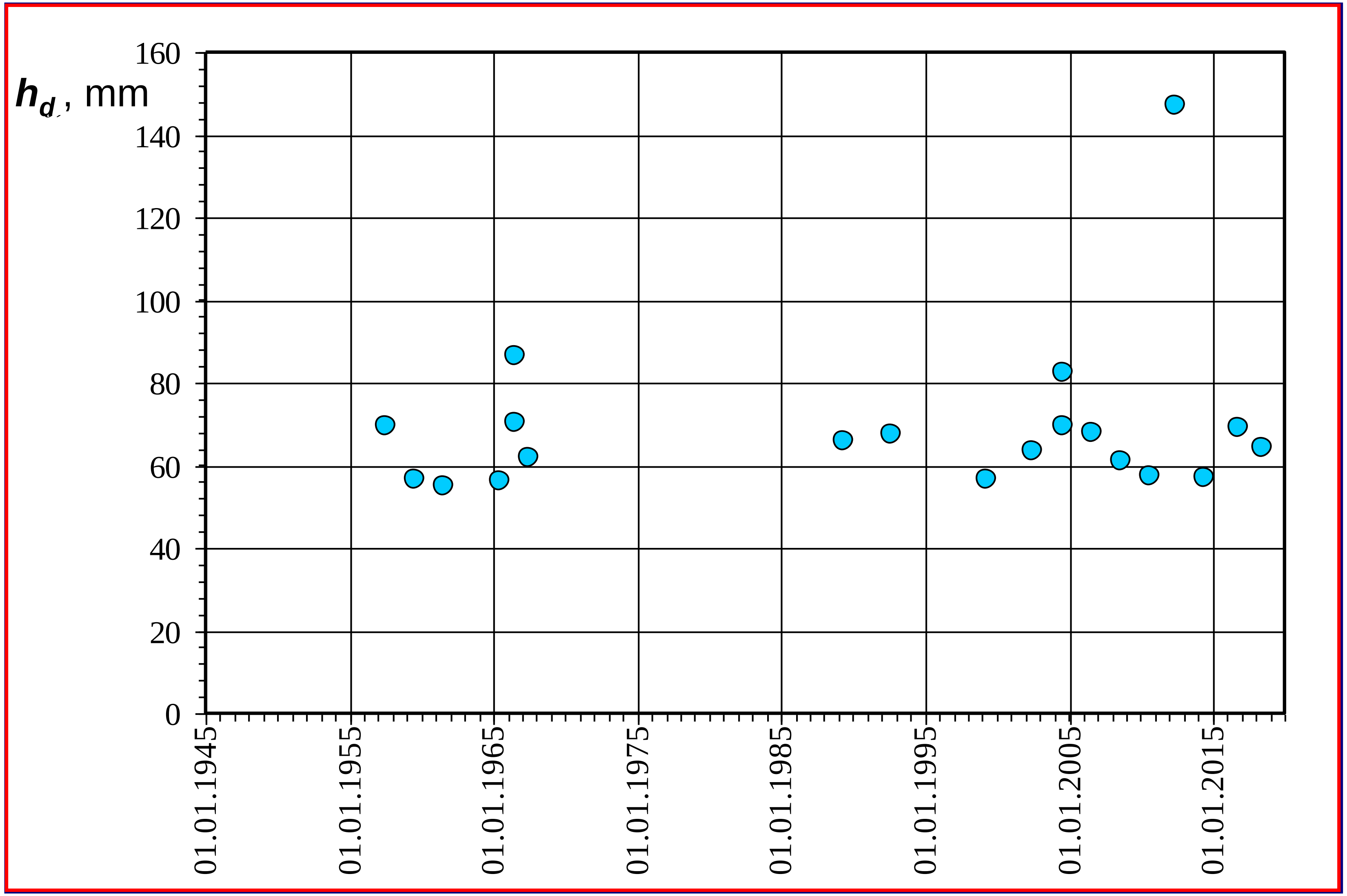
ANNUAL RAINFALL DEPTH IN LVIV in 1945-2018

$$H_{an} = 1{,}811\ Y - 2858,$$

mm/year

Average value in 1945-2018:
$(H_p)_{mid}$ = 730.2 mm;
ДСТУ-Н Б В.1.1-27:2010 "Climatology in the Civil Engineering":
$(H_p)_{mid}$ =742 mm

INCREASING: 1.81 mm/year
(from 664 mm/year in 1945 to 800 mm/year in 2020 or 20.4 %)



Maximum daily rainfall depths in LVIV (1945-2018)

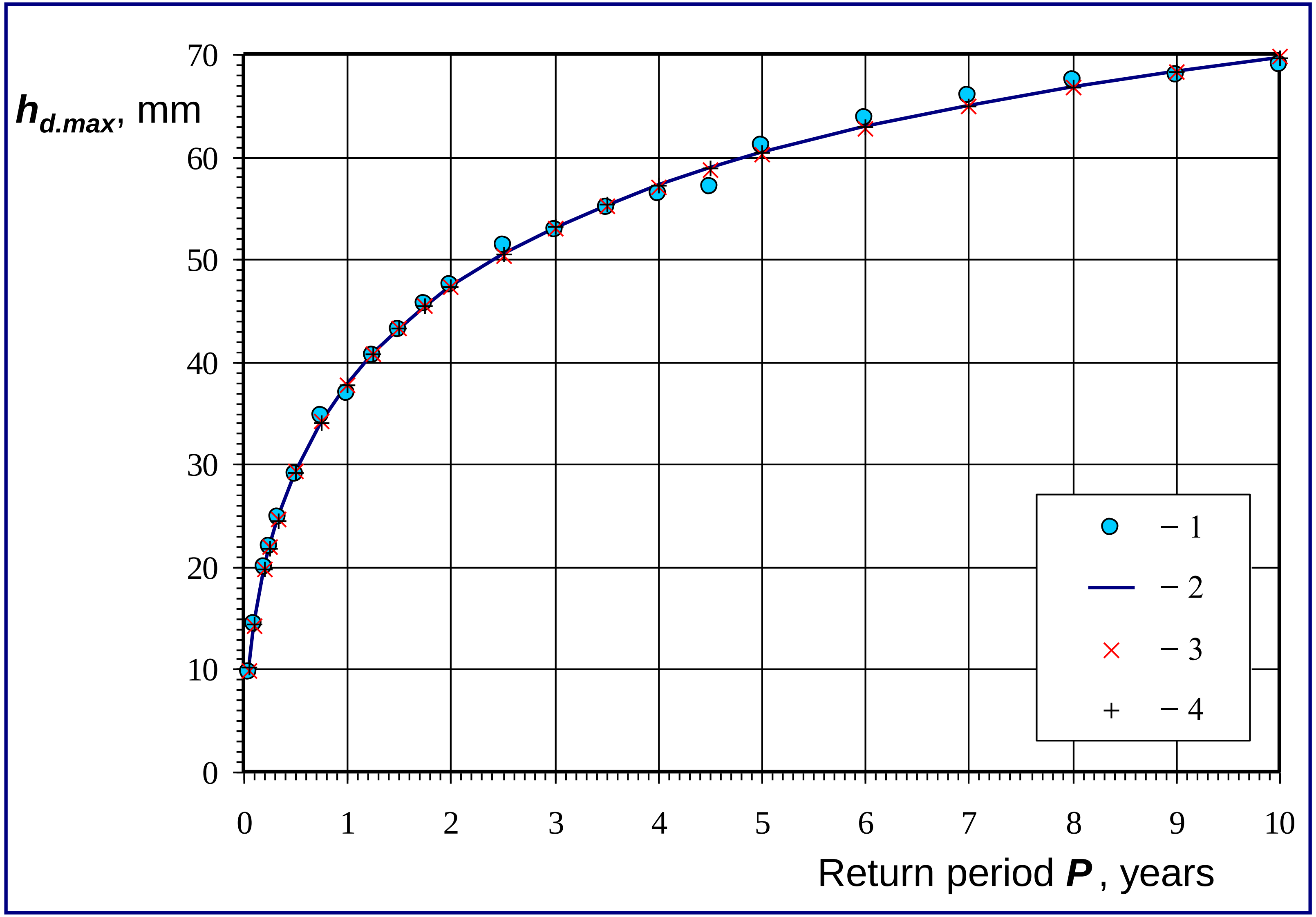
Increasing the frequency of maximum rainfall events over time is noticeable.

The difference becomes more pronounced with the analysis of less number of maximum rainfalls.

From 20 maximum rainfall events in 1945-2018:

– 13 (or 65 %) – in the second half;

– 10 (or 50 %) – in the last quarter of this period.



Maximum daily rainfall depths in LVIV (1945-2018)

1 – real data

2 – Weibull Model

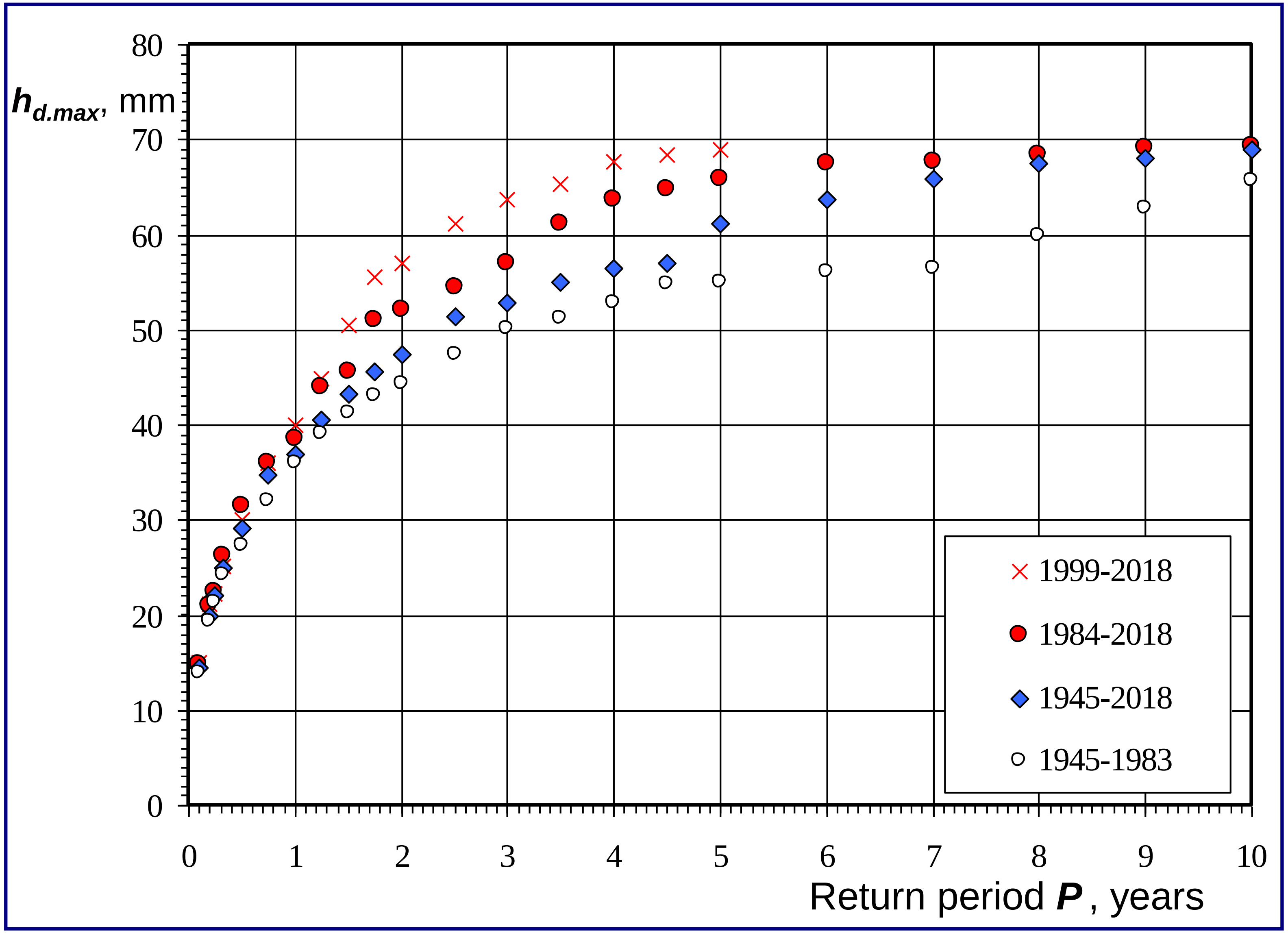
$$h_d = 88.0 - 93.3e^{-0.619 \cdot P^{0.420}}$$

3 – MMF Model

$$h_d = \frac{-4.58 + 111 \cdot P^{0,502}}{1.814 + P^{0,502}}$$

4 – Logistic Power Model

$$h_d = \frac{104.3}{1 + \left(\frac{P}{2.80}\right)^{-0,550}}$$



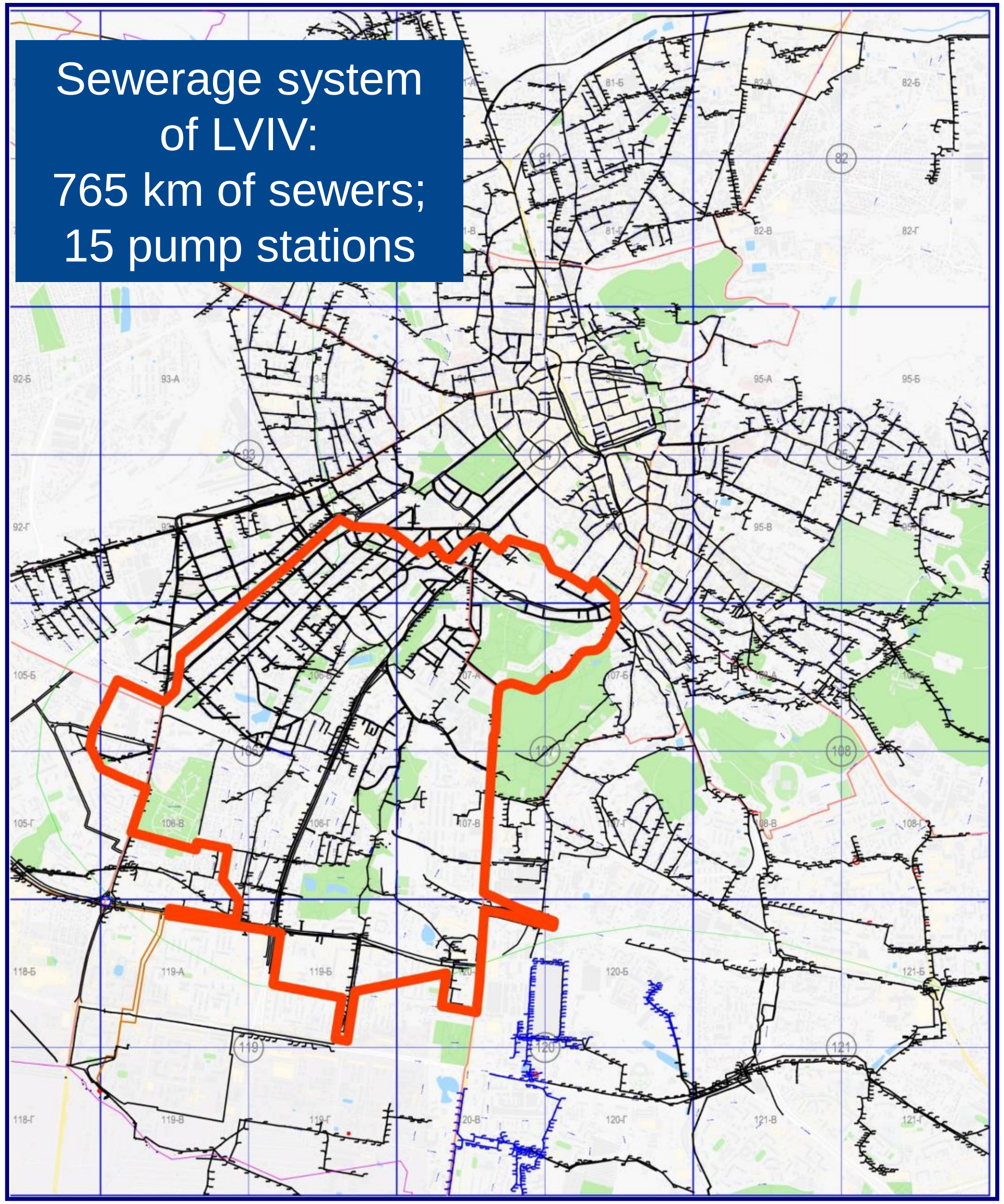
Maximum daily rainfall depths in LVIV

For last 35 years (1984-2018):

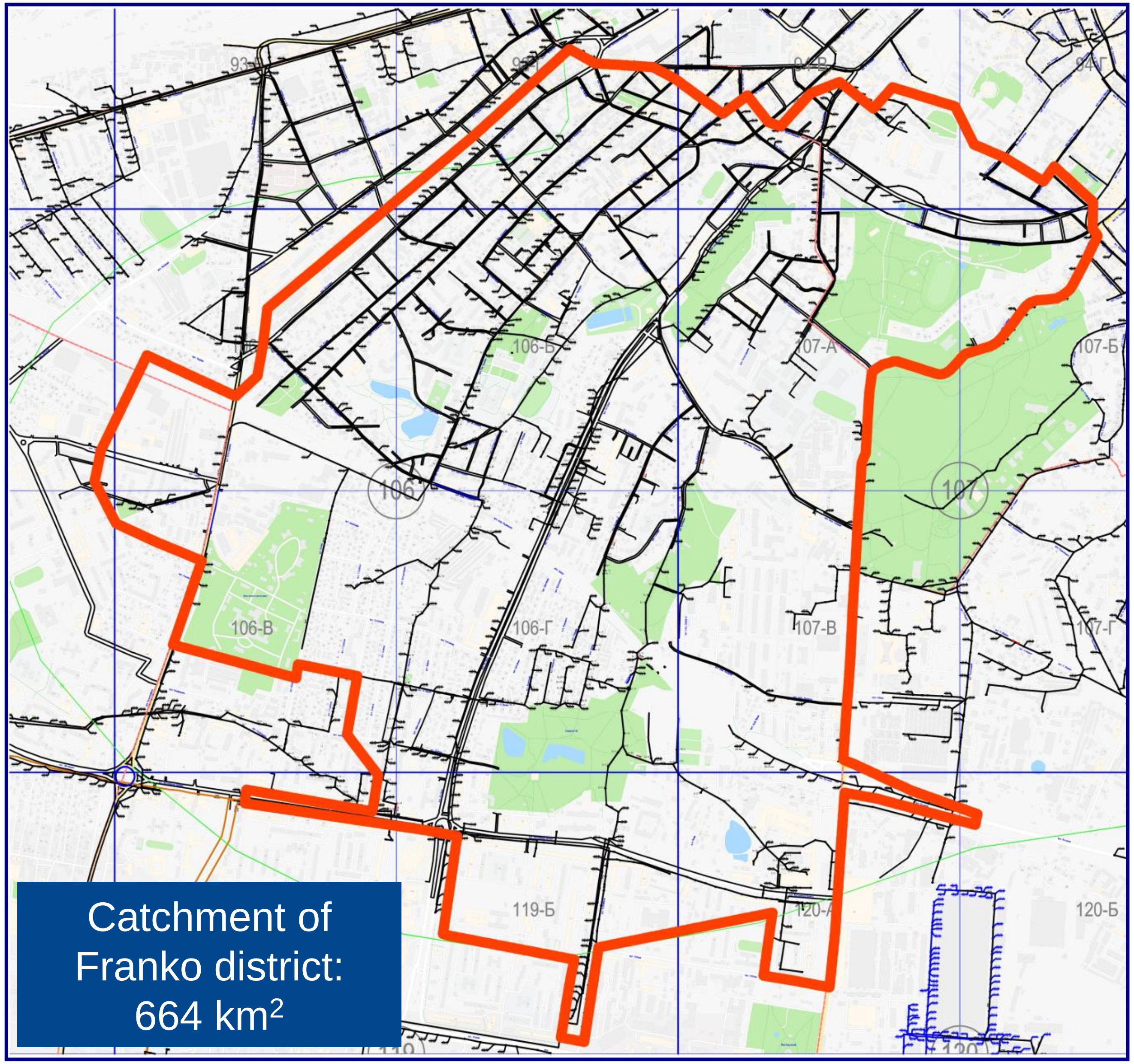
$$h_d = 72.1 - 67.5e^{-0.765 \cdot P^{0,667}}$$

For last 20 years (1999-2018):

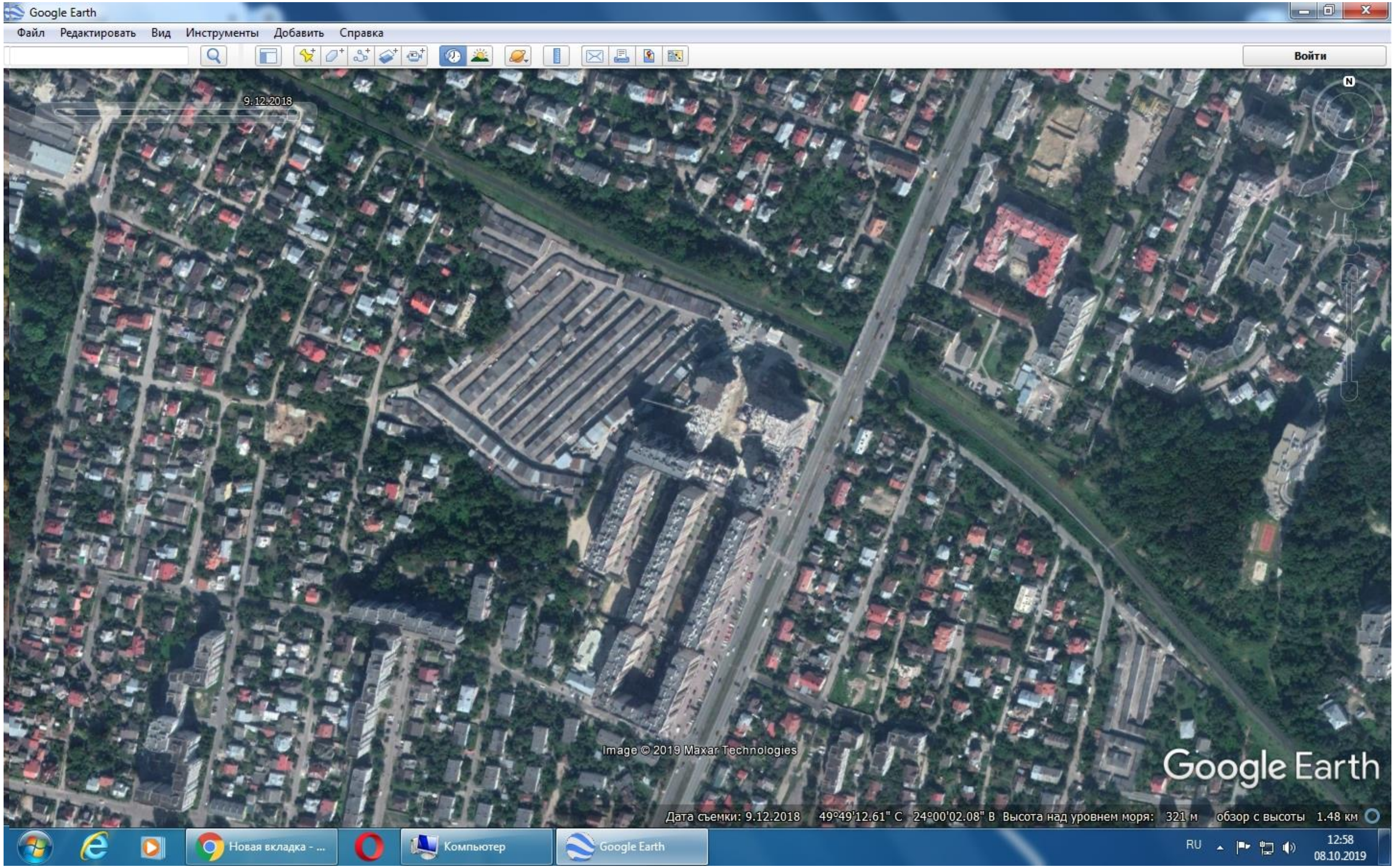
$$h_d = 73.0 - 64.6e^{-0.742 \cdot P^{0,862}}$$



Sewerage system of LVIV:
765 km of sewers;
15 pump stations

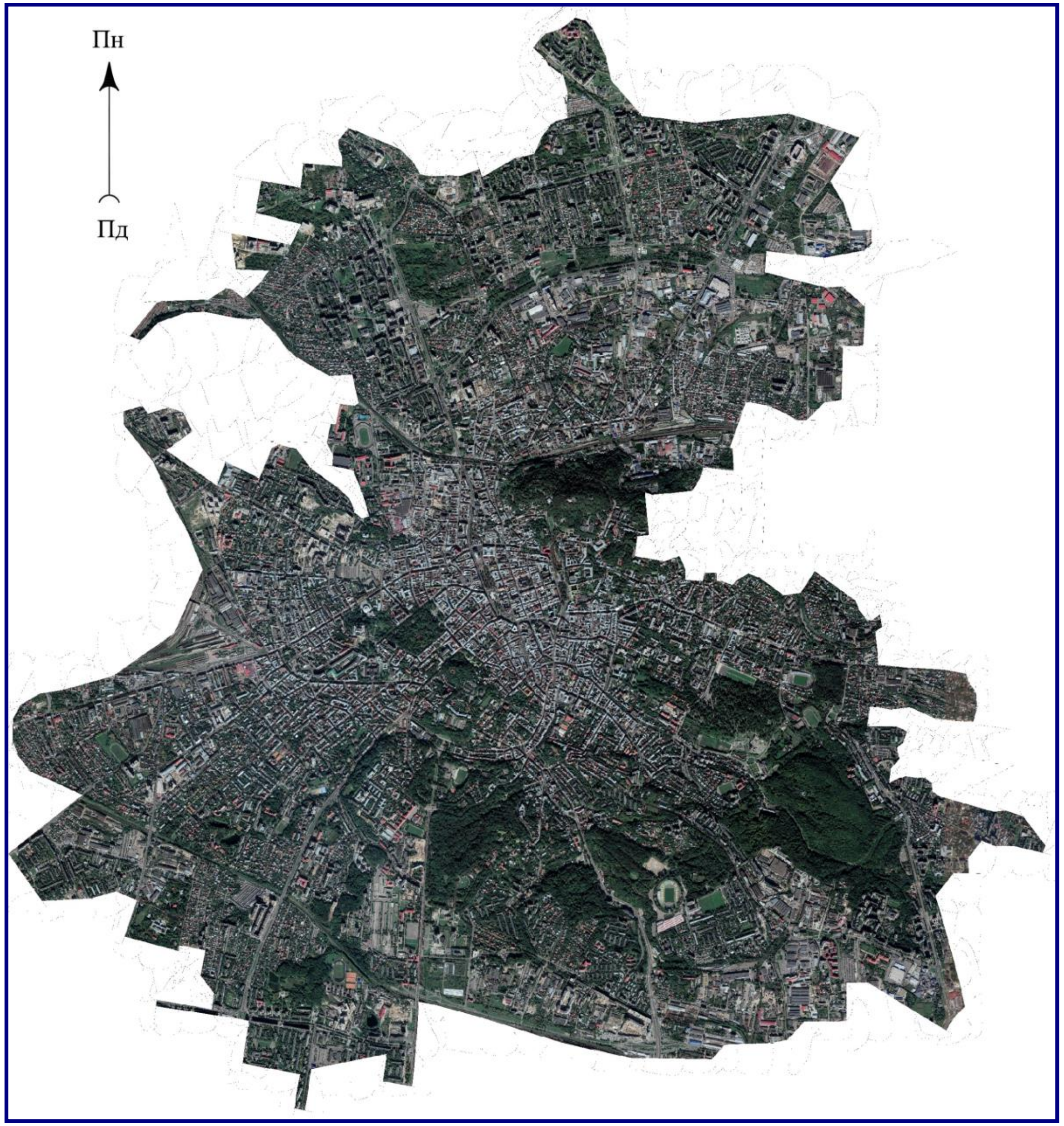


Catchment of Franko district:
664 km^2



EXAMPLE OF URBANIZATION IN LVIV CITY

Transformation of the quarter at Kn. Olga Str. in 2007-2018:
from the territory of military depots to a highly urbanized residential quarter



Simple random sampling of 20 000 elementary cells of the satellite photographic image of the Baltic Sea catchment within the city of Lviv is fulfilled.

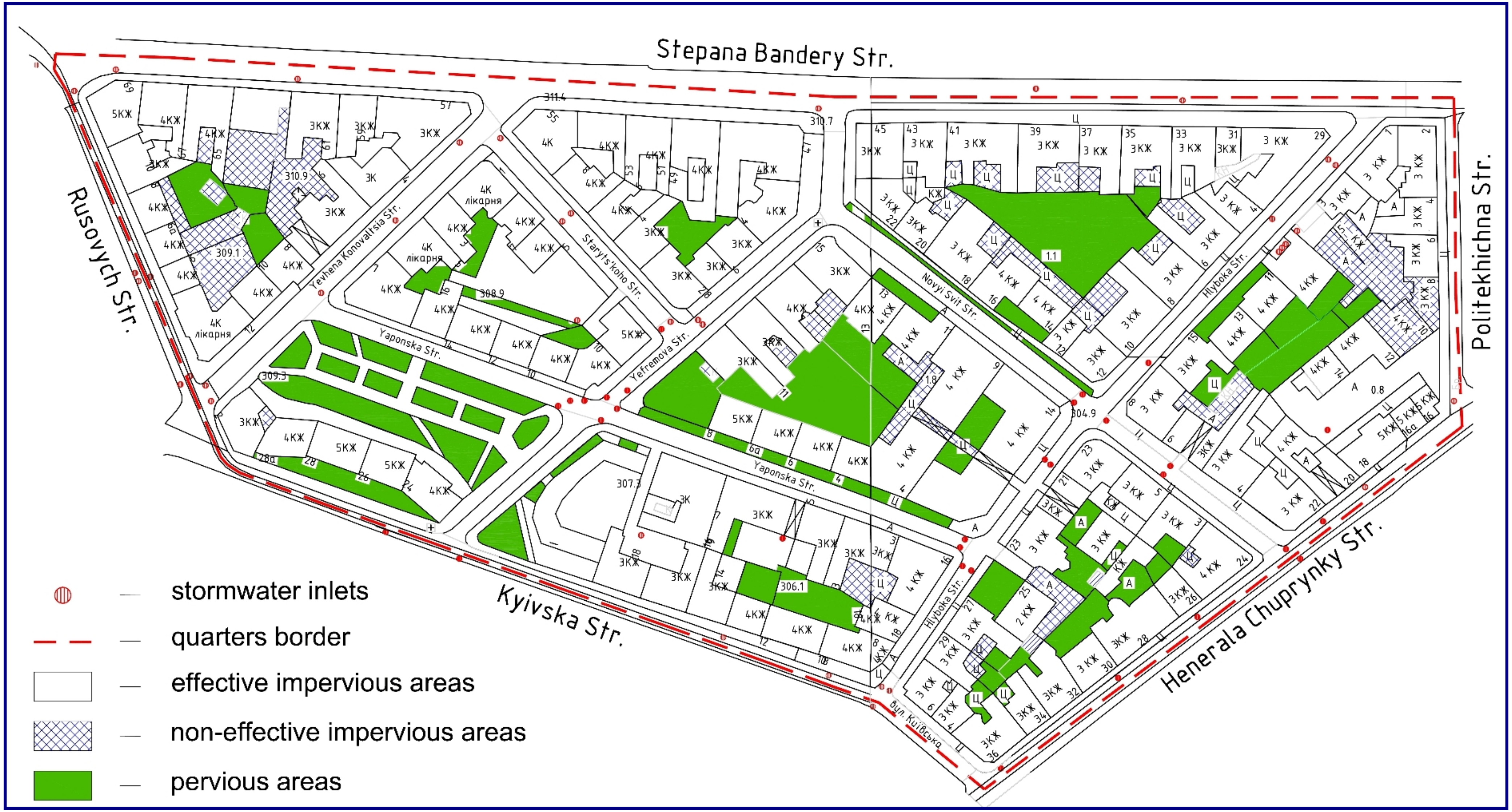
The number of impervious cells is 10157.

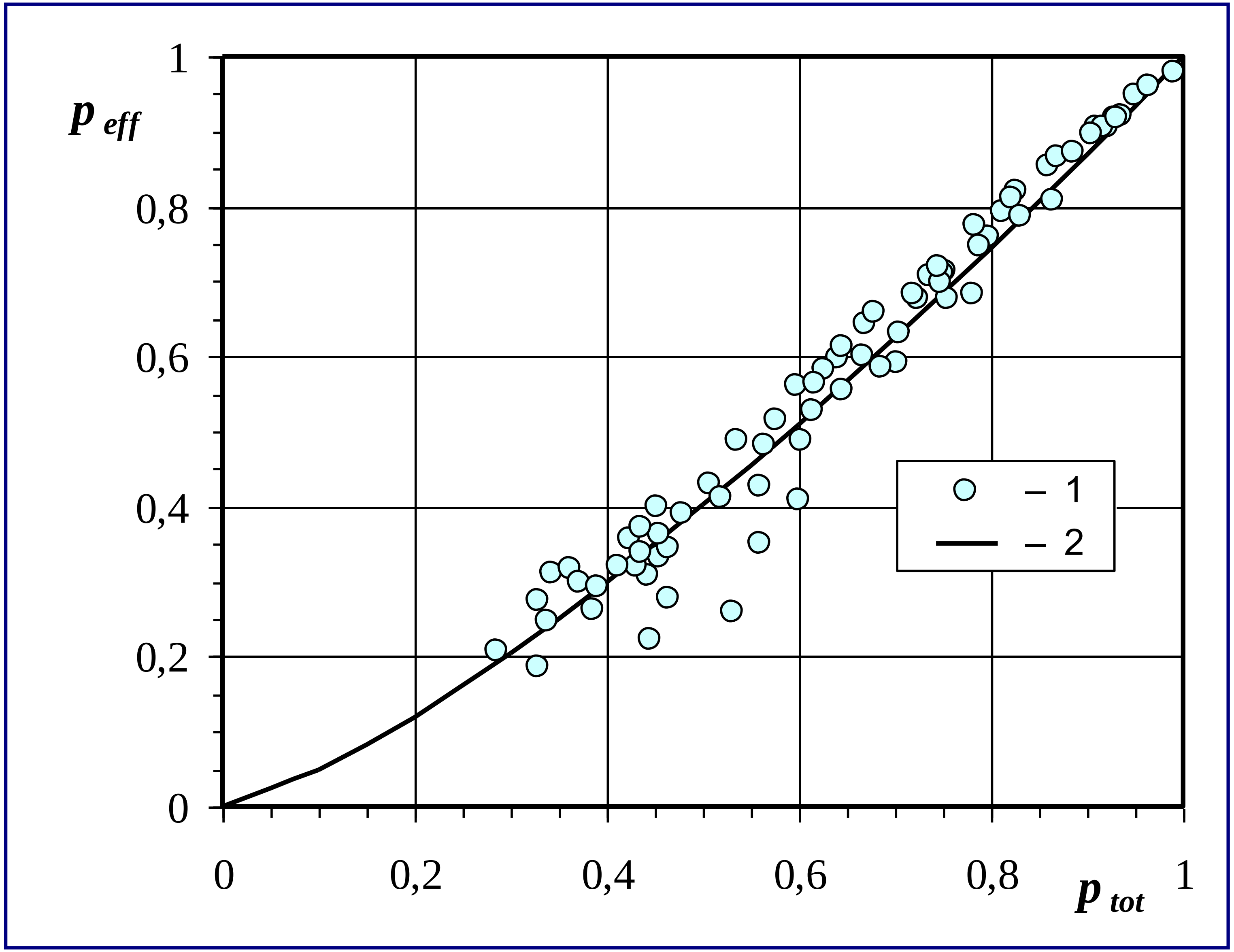
The proportion of total water impervious surfaces:
50.8 % (p_{tot} = 0.508).

The relative error of this value:
± 0.9 % at a confidence interval of 99 %,
or ± 0.7 % at a confidence interval of 95 %.

Total area of the Baltic Sea catchment:
$\boldsymbol{F_{tot} = 40.79\ km^2}$
with relative error ± 1.3 %.

Natural investigation of 75 quarters with total area 1000 ha





Natural investigation of 75 quarters with total area 1000 ha

$$p_{ef} = p_{tot}^{1.318}$$

p_{tot} – total imperviousness;

p_{ef} – effective imperviousness.

If $p_{tot} = 0.508$ then $p_{ef} = 0.410$

***P*, years**	$h_{d.max}$, mm	**$W_{d.max}$, m³/day**	Relative errors	
			+ δW_{max}, %	− δW_{max}, %
0.1	14.85	**182,42**	2.34	2.31
0.2	20.13	**252,74**	2.49	2.46
0.25	22.27	**285,55**	2.50	2.47
0.33	25.25	**334,84**	2.50	2.47
0.5	30.41	**428,96**	2.45	2.42
0.75	36.80	**559,15**	2.37	2.34
1	42.24	**680,06**	2.30	2.27
1.5	50.45	**877,57**	2.20	2.17
2	56.23	**1026,0**	2.13	2.11
2.5	60.40	**1137,2**	2.09	2.07
3	63.46	**1220,8**	2.06	2.04
3.5	65.73	**1284,0**	2.04	2.03
4	67.43	**1331,8**	2.03	2.01
4.5	68.72	**1368,4**	2.02	2.00
5	69.69	**1396,1**	2.01	1.99

Maximum daily flow rates at the inlet of Lviv WWTP as function of the return period *P*

$$W_{d.max} = 1470.7 - 1347.3 \cdot e^{-0.535 \cdot P^{1,046}}$$

P – in years;

$W_{d.max}$ – in thous. m³ / day

Prospects of Stormwater Drainage System in the City of Lviv

– Legislative regulation at the level of the local government of issues related to the discharge of surface runoff into the city sewerage system

– Stimulation of measures for the regulation of stormwater runoff by developers, industrial enterprises, etc. on their territory, directly in the places where surface runoff is formed (improvement of the policy of issuing technical conditions for connection to the city sewerage system, permits for wastewater discharge, etc.)

– Full hydraulic model of stormwater drainage system in SWMM

– Feasibility studies for renovation of combined sewerage in the most problematic nodes with local stormwater detention and retention (Torfiana Str., Horodotska Str., Sakharova Str.)

– Elaboration of the stormwater management plan for Lviv city with maximum possible implementation of the relevant best management practices


KONFERENCJA
Stormwater Poland 2020
Gdańsk, 3-5 marca 2020 r.