

# **EXTERNAL HAZARDS STUDIES FOR RESEARCH REACTOR LVR-15 SITE EVALUATION**

“Equipment Qualification in Nuclear Installations”  
**2<sup>nd</sup> International Meeting**

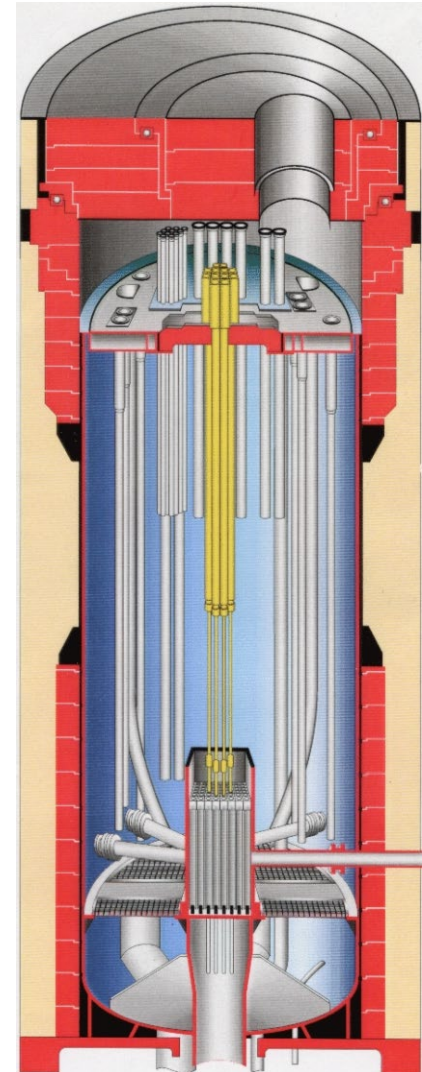
*23 – 26 May 2022*

*ÚJV Řež, a. s., Hlavní 130, Řež, Czech Republic*



# Research Reactor LVR-15

- **LVR-15:** a light water tank type research reactor placed in non-pressure steel vessel under the shielding cover
- **Fuel:** IRT-4M (19.7%  $^{235}\text{U}$  enriched)
- **Operation power:**  $10 \text{ MW}_{\text{therm}}$
- **Cooling:** forced with 3 circuits
- **Purpose:** universal research nuclear facility for Czech industry
  - Loop/probe material, physical-metallurgical research
  - Neutron physics horizontal canal experiments
  - Radioisotope and radiopharmaceutical production
  - Neutron radiography





# Research Reactor LVR-15



Heavy concrete reactor shaft in reactor hall



Reactor building administrative and operation part



# LVR-15 Licensing Extension

- **LVR-15** operated by the company Research center Řež (CVR) based on the Czech nuclear regulator's (SÚJB) conditions needed to extend its operational license to work beyond the year 2020.
- **SAR** (Safety Analysis Report), had to be updated to account for the current conditions. Some studies related to external hazards defined by Czech regulation No. 378/2016 Coll. (siting of the nuclear facility) were outdated, some were missing in view of newly issued nuclear legislation.
- Nuclear regulator SÚJB required to **re-assess the design criteria** of the LVR-15 facility.



# LVR-15 Licensing Extension

- **Rizzo Associates Czech** built a team of partner companies, institutions and individual experts to develop the new studies for selected external hazards:

§5 Seismicity	<b>Geinform Consultants; Institute of Rock Structure and Mechanics of the Czech Academy of Sciences</b>
§6 Deterioration of the nuclear facility site by faults	<b>Geinform Consultants; Ing. Jiří Pospíšil, Ph.D., Prof. Ing. Otakar Švábenský, CSc.</b>
§7 Floods	<b>VUT Brno, Faculty of Civil Engineering, Institute of Water Structures</b>
§8 Underground water circulation	<b>AQUA ENVIRO s.r.o.</b>
§9 Other geodynamic effects and geotechnical parameters of foundation soils	<b>MINING DESIGN s.r.o.</b>
§10 Climatic and meteorological effects	<b>VŠB Technical University of Ostrava, Faculty of Mining and Geology, Department of Geodesy and Mine Surveying</b>
§14 partially: External explosions	<b>VŠB Technical University of Ostrava, Faculty of Safety Engineering</b>
§15 Collisions with protection and safety zones	<b>MINING DESIGN s.r.o.</b>



# LVR-15 Licensing Extension

- Other hazards listed in Regulation No. 378/2016 Coll. were covered by LVR-15 owner: **Research center Řež.**
- **Studies** for those external hazards covered by the team of **Rizzo Associates Czech and their partners were developed in an extremely short time**, from summer 2020 to early 2022 to support CVR's application for LVR-15 operating license extension. We also consider this as an expertise and organizational success of the whole team.



# Population: Distribution & Density

- § 17 of the Regulation No. 378/2016 Coll. requires to analyze the **distribution and density of population in 30 km perimeter** of the nuclear facility. This is to be used in further analyses (extraordinary events mgmt, PSA Level 2 etc).
- The area with the radius of 30 km from LVR-15 represents 633 communities and total number of inhabitants 1 725 833.

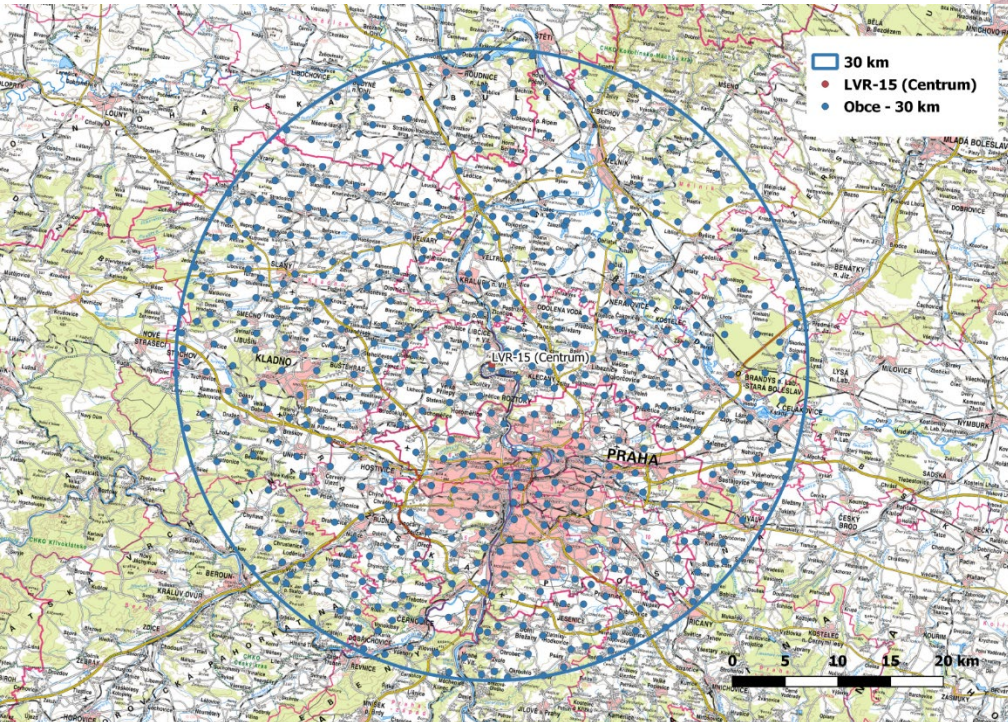
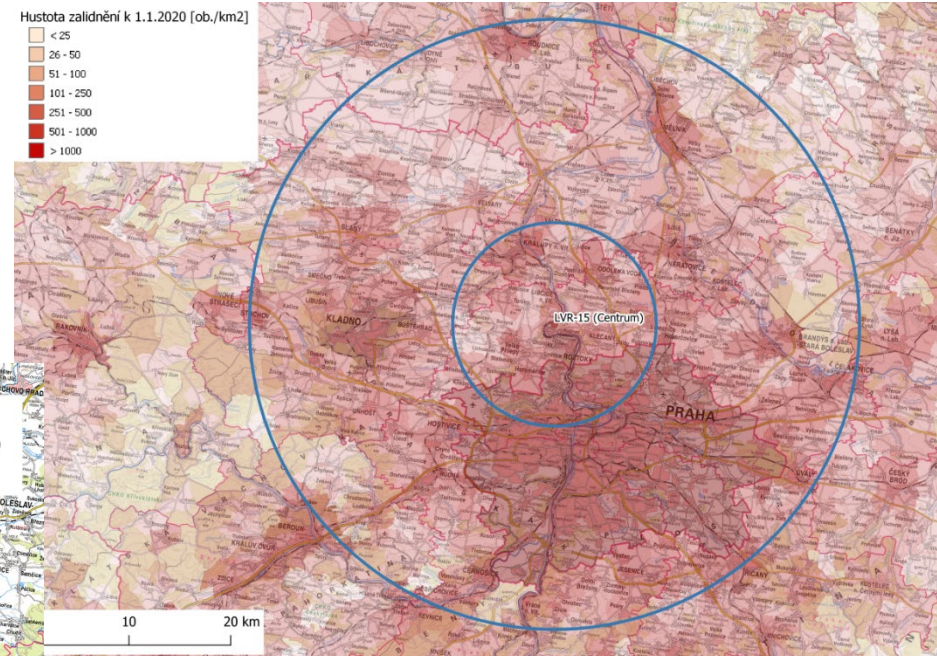
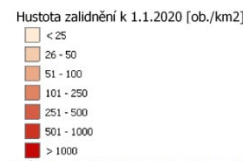
Distance from ÚJV Řež	Number of inhabitants
Up to 1 km	1 150
Up to 2 km	5 074
Up to 3 km	13 765
Up to 5 km	31 149
Up to 10 km	222 167
Up to 25 km	1 598 271
Up to 30 km	1 725 833

Source: ČSÚ, 2019



# Population: Distribution & Density

Overview of communities in 30 km perimeter from LVR-15; total number of communities: 633, total number of inhabitants: 1 725 833 (Source: database ARCDATA PRAHA, ZÚ, ČSÚ (2014): ArcČR 500 - digital geographic database, version 3.2. www.arcddata.cz as of 31.12.2019



Population density + Maps of seismic hazards of LVR-15 (According to the CENIA – Population density in communities ČR (2020) to map cuts of the National Geoportal INSPIRE)



# Seismicity, faults

- The study covering the §5 Seismicity and §6 Faults of Regulation No. 378/2016 Coll. is the most extensive of all studies the goals of it were:
  - Development of a seismotectonic model and analysis of the current earthquake database for the LVR-15 site and development of a methodology for use to assess historical seismicity. The seismicity and earthquake source parameters of the study area were described and include discussion and revision to current conceptual seismotectonic models in use and previous seismic source area models.
  - Data collection and database development, and creation of a comprehensive overview of map background documents which summarize existing and ongoing geological, geomorphological and geophysical studies conducted in the vicinity of the LVR-15 site by specialists in individual methods and methodologies.



# Seismicity, faults

- The study covering the §5 Seismicity and §6 Faults of Regulation No. 378/2016 Coll. is the most extensive of all studies the goals of it were:
  - Compilation of a database and processing of geodetic GNSS and VPL monitoring results from the nearest GNSS permanent stations in the vicinity of the area of interest and their updates for the purpose of monitoring movement trends on a regional scale for current and future studies in the area of the LVR-15 site.
  - Analysis of recent evolution, study of Quaternary history and current tectonic movement within the area of study. Using remote sensing, DEM tools, a detailed, exogenous-dynamic model of the area of LVR-15 site was constructed.

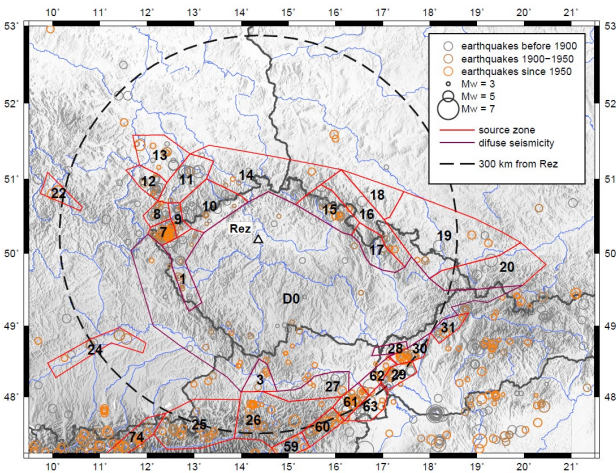


# Seismicity, faults

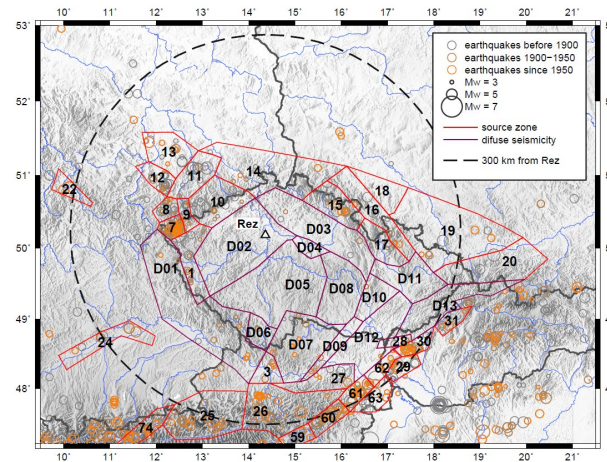
## Seismotectonic model

Prepared in consistence with Regulation No. 378/2016 Coll. and IAEA SSG-9. Radius of 300 km from LVR-15 is accounted.

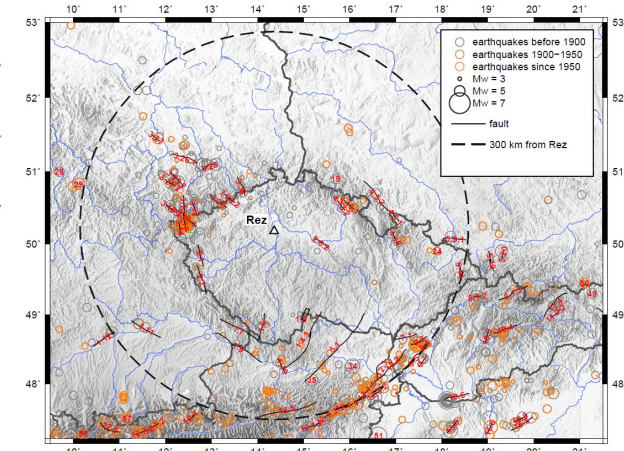
3 various models for source zones were used as variants of calculations of seismic hazard.



Model A of source zones



Model B of source zones



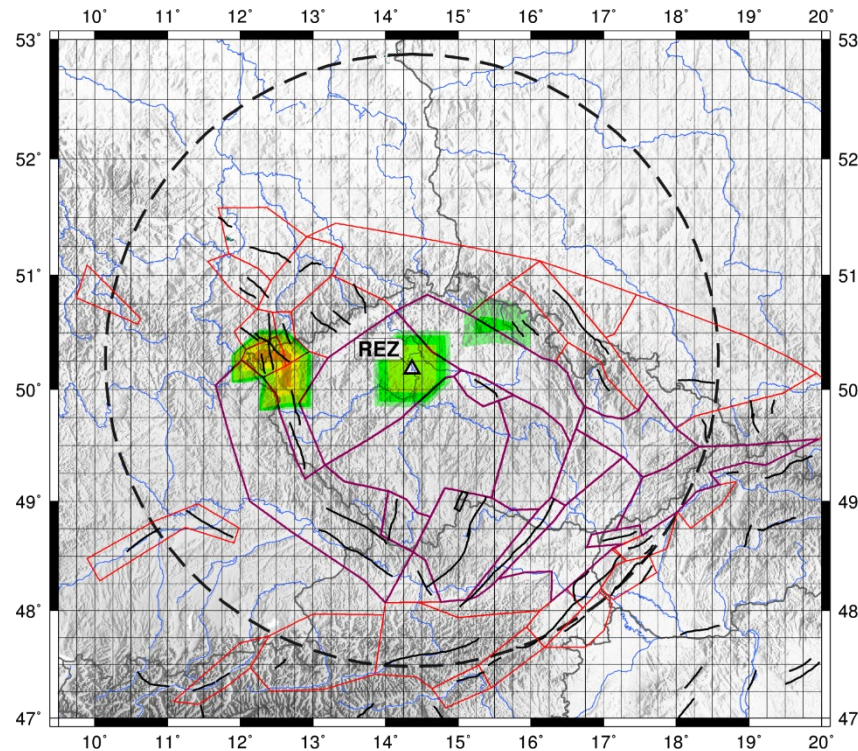
Model F of source zones



# Seismicity, faults

## Seismotectonic model

Probabilistic seismic hazard calculations were performed using the standard and internationally recognized OpenQuake software.



Seismic hazard deaggregation



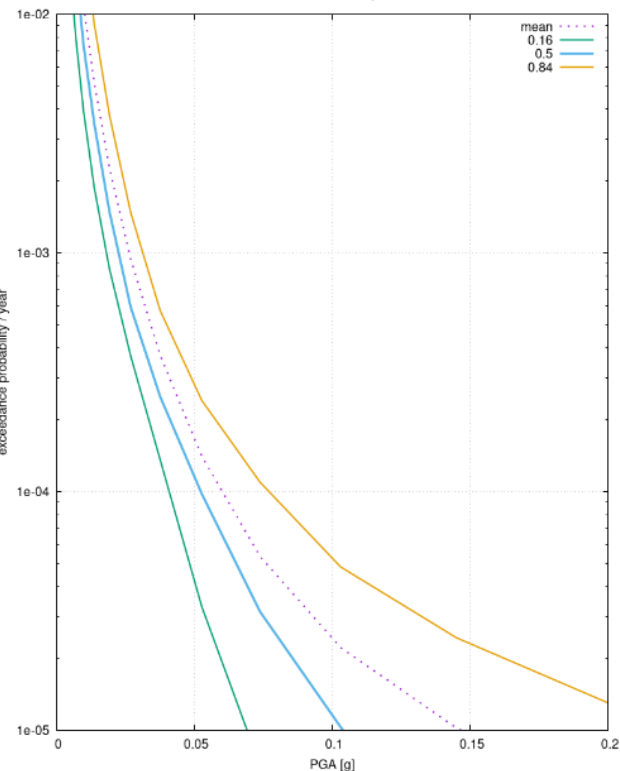
# Seismicity, faults

## Seismotectonic model

To account the local conditions for seismic wave impact, the average S-wave velocity in 30 m under surface was measured by MASW method on two profiles near the reactor building, giving the  $V_{S30} = 495$  m/s.

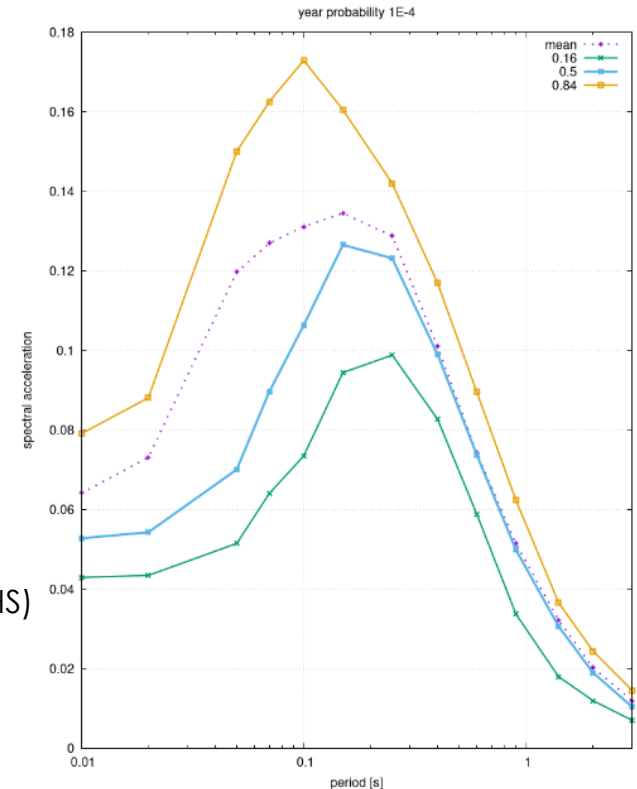
Rez Research Reactor LVR-15,  $V_{S30} = 495$  m/s

Seismic hazard curves



rem-sed006-22.rcz

Uniform hazard spectrum (UHS)  
for return period  $10^{-4}$  yr<sup>-1</sup>  
 $PGA_{84\%} = 0,078g$   
 $PGA_{50\%} = 0,053g$

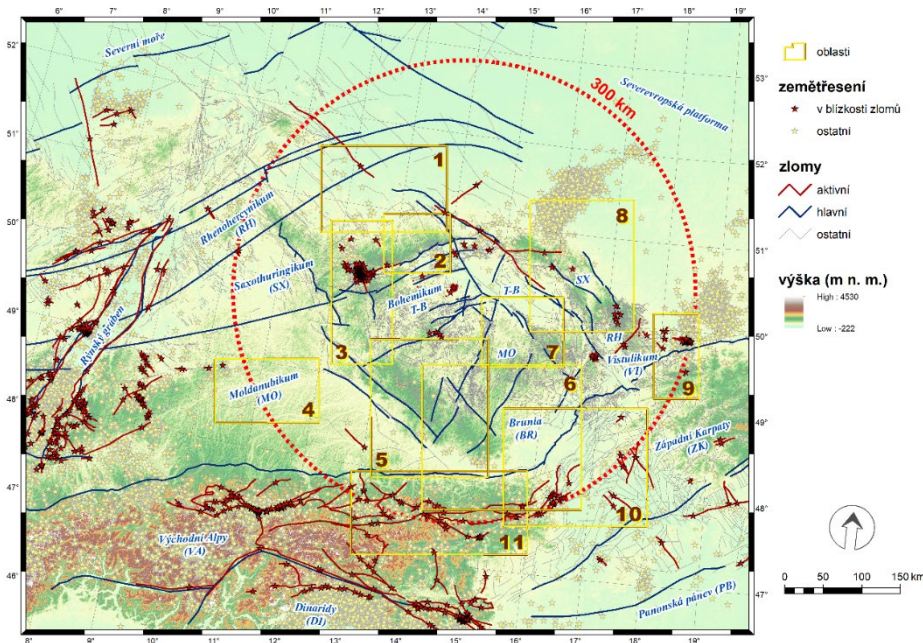




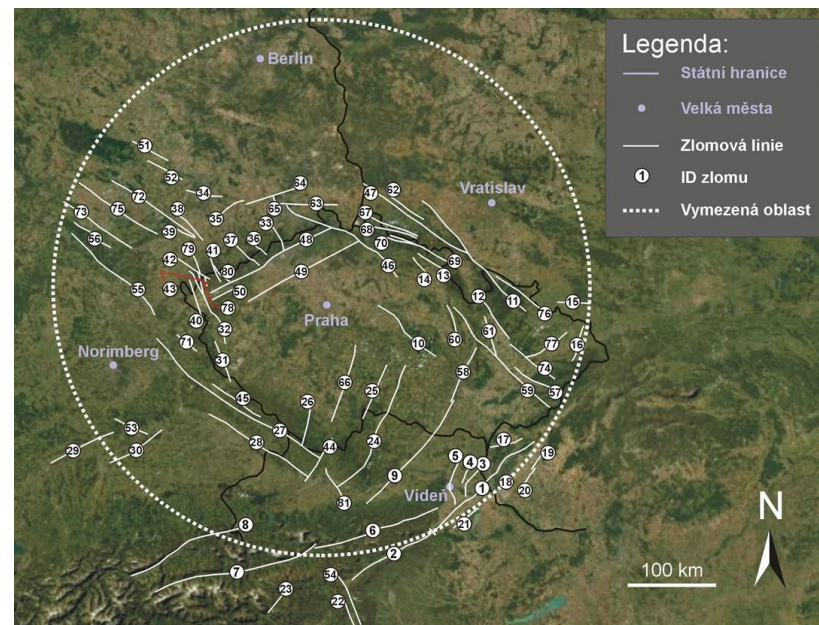
# Seismicity, faults

## Newly specified seismotectonic zones

For the purpose of geological-geophysical and geomorphological verification and delineation of recently active structures and faults in the area with  $R = 300$  km, the delineated seismotectonic zones were modified into 11 areas described further in the study.



Modified seismotectonic zones



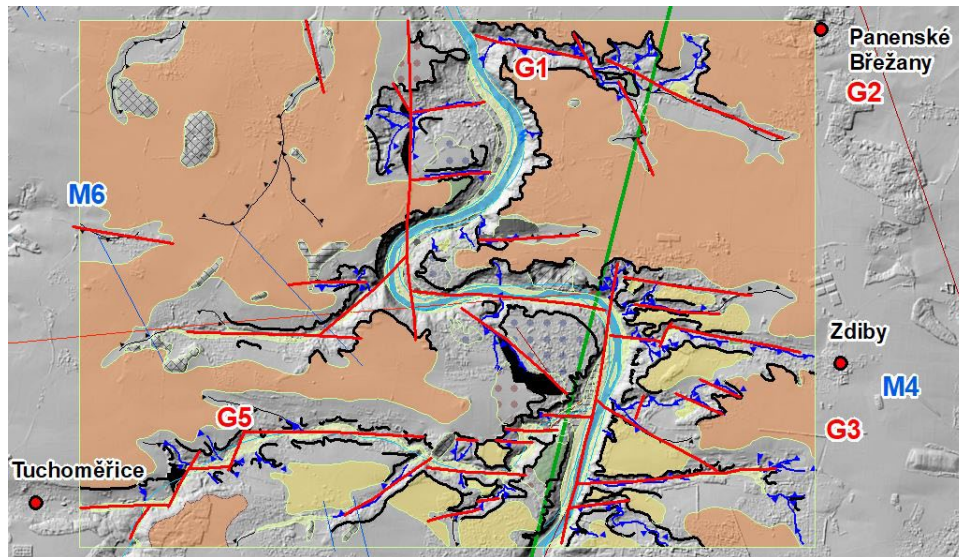
Map of faults based on up-to-date geological, geophysical, remote sensing and geodetical data



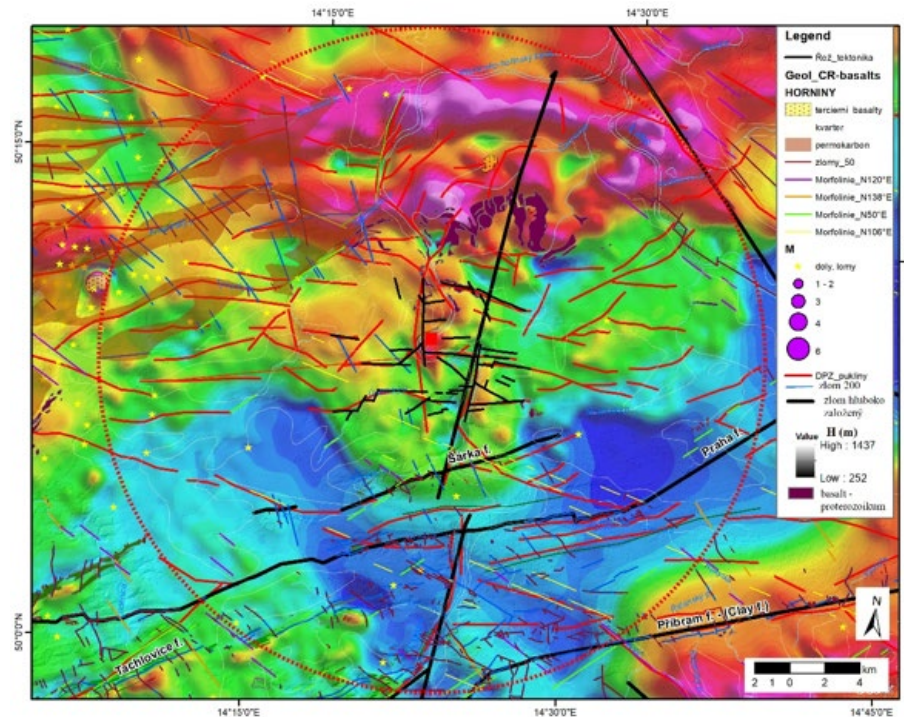
# Seismicity, faults

## Exogenous-geodynamic analysis

Geodynamic analysis of the evolution of relief belongs to relatively inexpensive methods that use sometimes existing map background documentation, instruments and material.



More detailed view of exogenous-geodynamic results based on interpreted current literature, satellite sensing, stereoscopic aerial and LIDAR data.



Comparison of interpreted remote sensing and geomorphological faults with map of magnetic anomalies  $\Delta T$



# Other geodyn effects and geotech parameters of soils

- The study covering the §9 of Regulation No. 378/2016 Coll. - Other geodynamic effects and geotechnical parameters of foundation soils had the following goals:
  - Collect data on LVR-15 site and its specified vicinity
    - From State geologic database Geofond,
    - Specific geotechnical research from other sources
    - By aerial investigation (photogrammetry, LIDAR)
    - Own in-situ observations and measuring



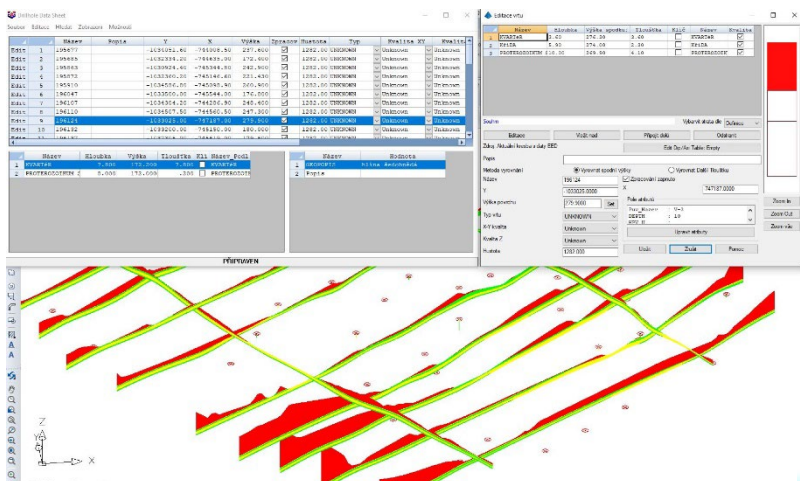
# Other geodyn effects and geotech parameters of soils

- The study covering the §9 of Regulation No. 378/2016 Coll. - Other geodynamic effects and geotechnical parameters of foundation soils had the following goals:
  - Assess the effects
    - Volcanism and manifestations of post-volcanic activity (up to 25 km)
    - Slope movements, including snow avalanches (up to 5 km)
    - Depressions and deformation of the land surface, incl. undermining (up to 5 km)
    - Technical seismicity (nearby active quarry)
    - Unfavorable properties of foundation soils (on LVR-15 site)



# Other geodyn effects and geotech parameters of soils

- All the collected data were introduced into the BIM model of the LVR-15 facility



GUI and picture of geologic boreholes exploration (Carlson Civil)

Screen captures of 3D BIM model from NW and from E (Autodesk Civil 3D)





# Other geodyn effects and geotech parameters of soils

- All required exclusion criteria were assessed based on existing data with positive results, however, to prove some of them needed further research.
  - Verify the effects of technical seismicity originating from nearby quarry onto the LVR-15 building (against the criteria of ČSN 730040)



Seismograph placed in the basement of the LVR-15 building to measure the response from the Klecany quarry blasts

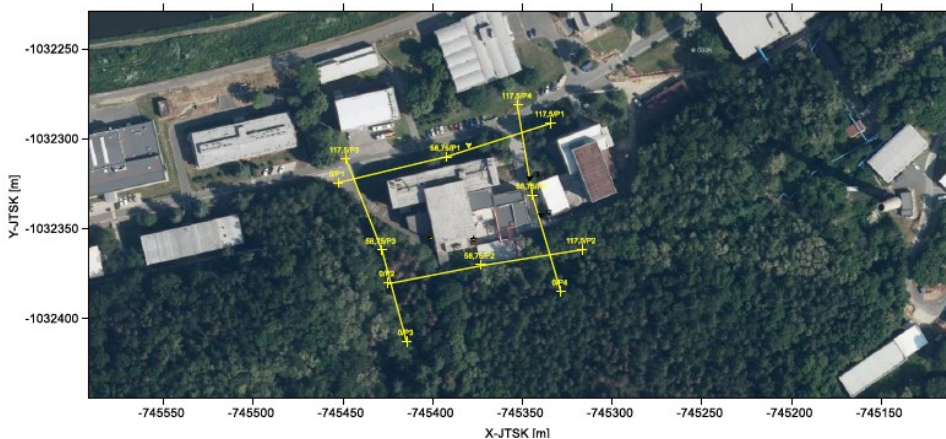


Picture from the Klecany quarry blast footage



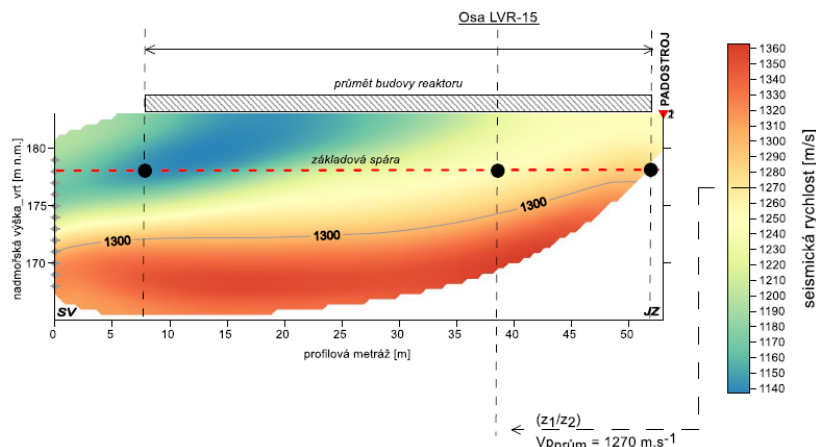
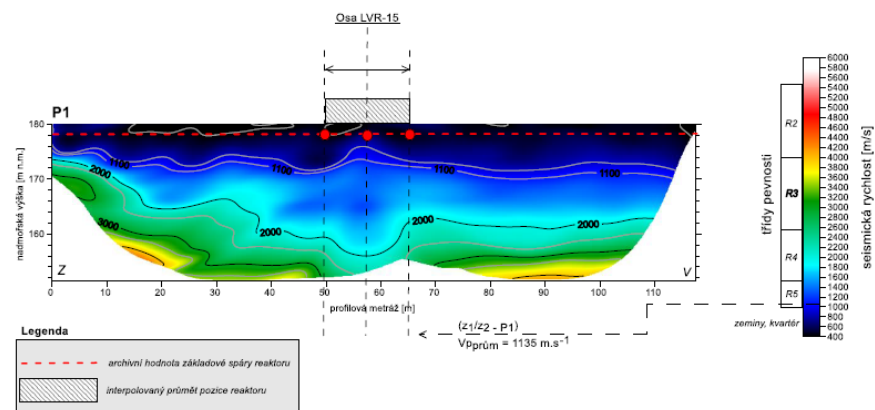
# Other geodyn effects and geotech parameters of soils

- Verify the propagation velocity of seismic P-waves in foundation soils on profiles around and under the LVR-15 building by method of shallow refraction seismic and seismic tomography



Map of seismic profiles to measure by shallow refraction seismic

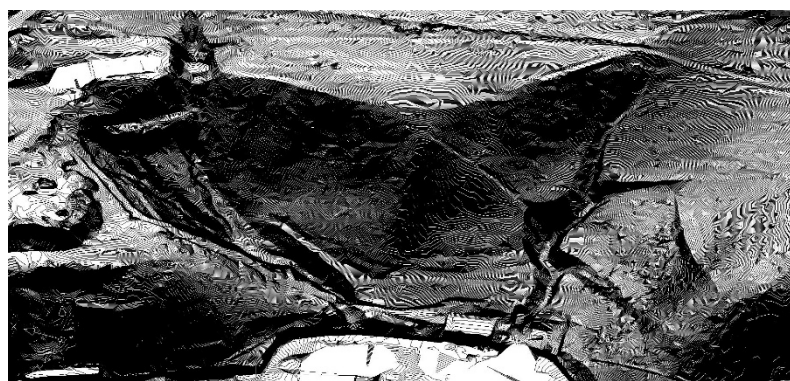
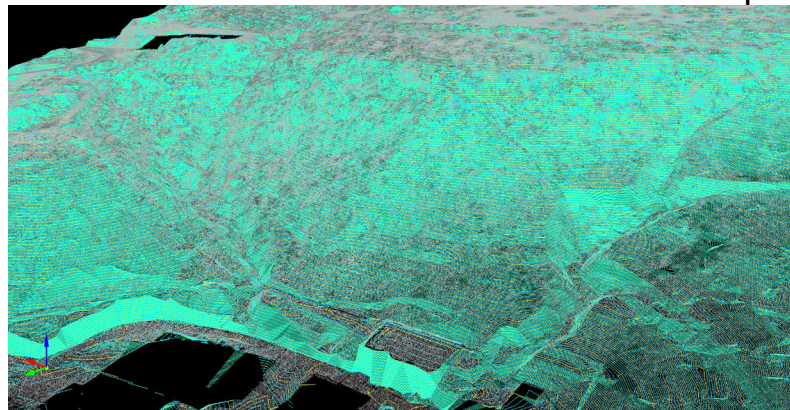
Interpretation of results of seismic velocity tomography from front of the LVR-15 building and under the building.



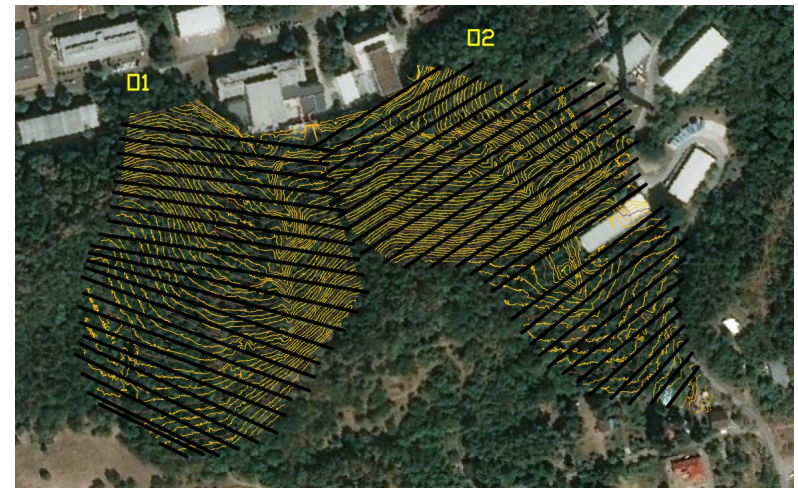


# Other geodyn effects and geotech parameters of soils

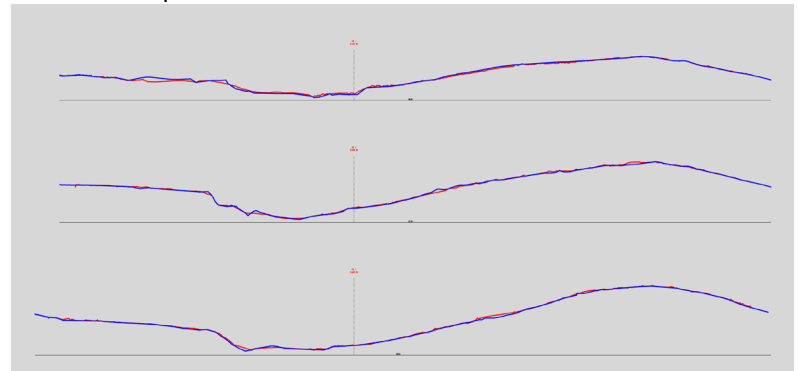
- Verify the stability of erosion rills in the slope above the LVR-15 building. Plan is to assess the stability periodically each year. Two assessments made up to now.



Terrain digital model and currently measured elevation of erosion rills based on aerial LIDAR records



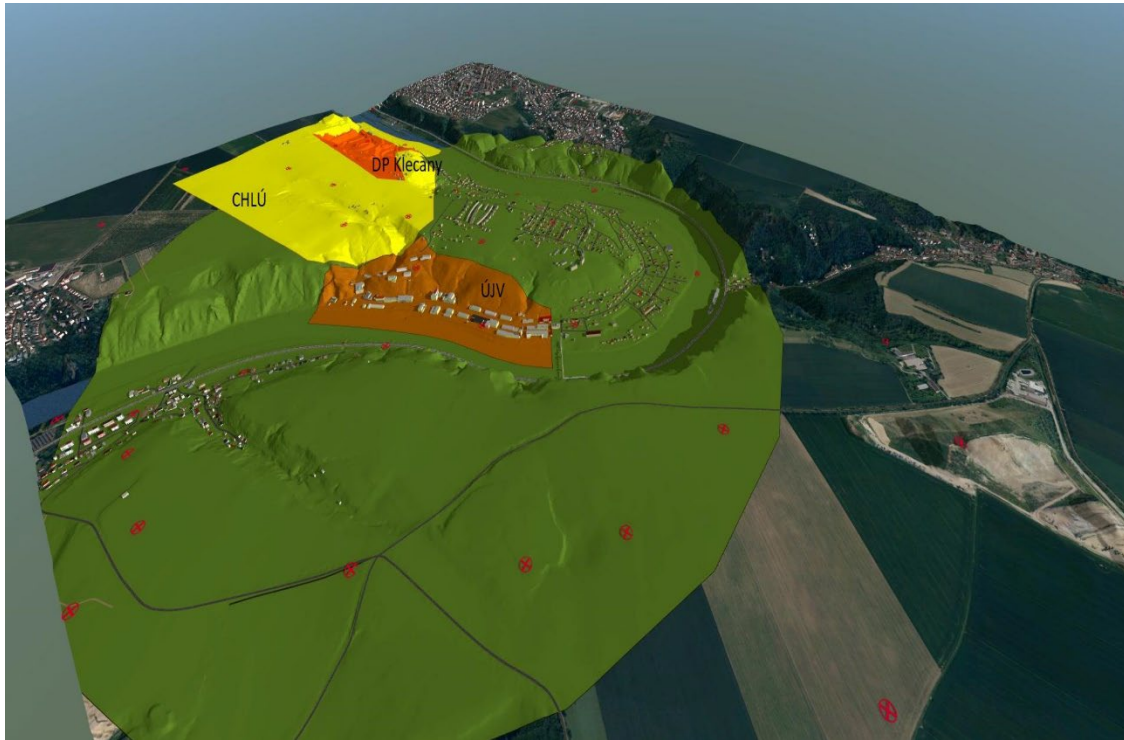
Definition of vertical cross cuts on both erosion rills and comparison of cross cuts #1-3 on area O1





# Collisions with protection and safety zones

- The study covering the § 15 of Regulation No. 378/2016 Coll. - Collisions with protection and safety zones. All collisions verified surface/sub-surface and integrated into BIM model



Map background added with BIM model elements of a collision of Klecany quarry protection zone, ÚJV premises protection zone and LVR-15 reactor safety zone



# Floods

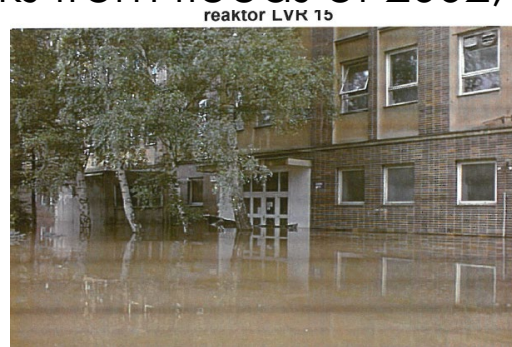
- The study covering the §7 Floods of Regulation No. 378/2016 Coll. has had the following goals:
  - Assess the possibility of flooding of LVR-15 facility site
  - Whereas consider the whole tributary area which may impact the LVR-15 facility site
  - And use meteorological, hydrographic a hydrologic data
  - Following shall be also accounted:
    - Possibility of flooding the site due to precipitation, snowmelt or storm
    - Possibility of the occurrence and effect of a „special flood“ caused by the failure or accident of a hydroengineering structure (dams etc)
    - Effect of water accumulation and upwelling as a result of sudden natural or technical barriers
    - Effect of erosion or sediment deposition
  - Assess the flood hazard on the facility site using the models of flood hazard (up to 500/10 000 years return period)



# Floods

## Hydrology data used:

- Basic hydrology data for profile Husinec-Řež, the bridge
- Specific hydrology study for theoretical flood waves with return period 100, 500, 1 000 and 10 000 years for profile Husinec-Řež, the bridge
- Specific ADCP measuring of flow rate for profile Husinec-Řež, the bridge
- 1968 – 1985 series of average day flow rate for profile Praha-Modřany
- 1900 – 1968 series of maximal seasonal flow rates summer/winter for profile Praha-Modřany
- Data from flood marks from floods of 2002, 2013.



2002 (500 years) flood pictures.  
View of a portion of UJV area.  
View of the water level at the  
LVR-15 building main entrance.

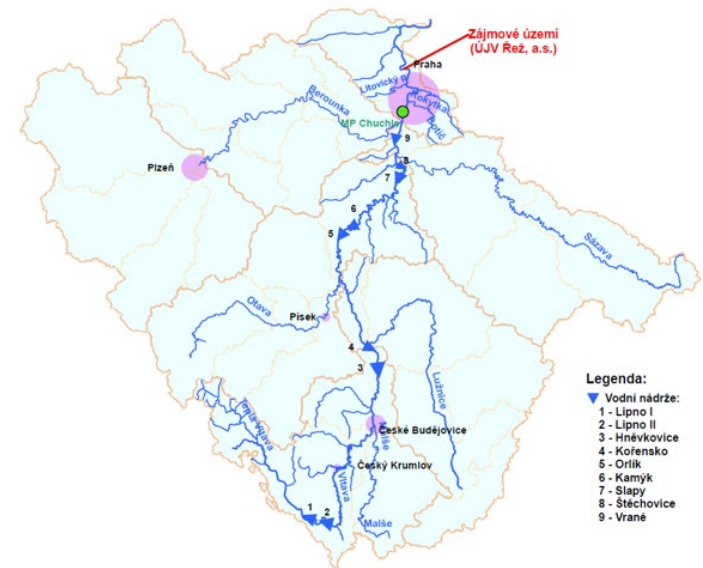


# Floods

Tributary area up to profile Husinec-Řež, the bridge



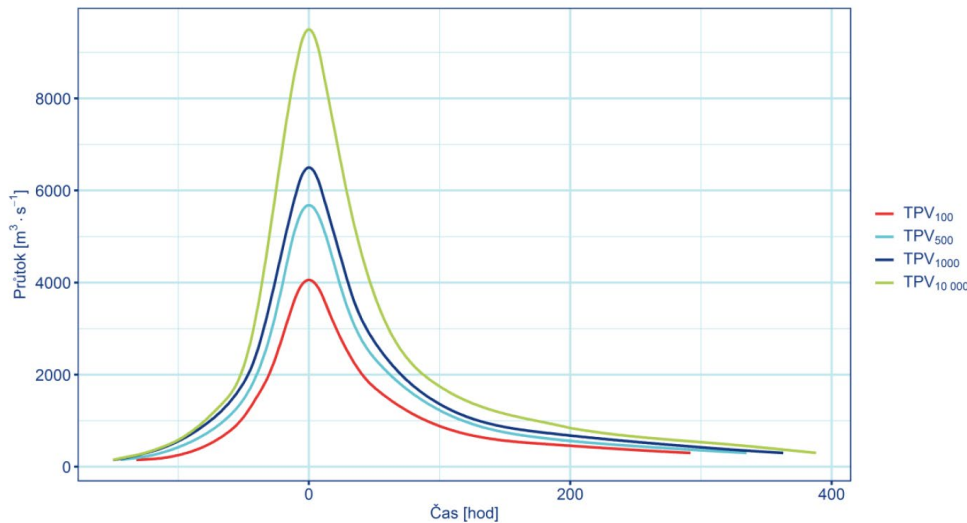
27 306 km<sup>2</sup>





# Floods

## Specific study (CHMI) – Theoretical natural flood waves for profile Husinec-Řež, the bridge



Theoretic flood waves with return period of 100, 500, 1000 and 10 000 years for profile Husinec-Řež, the bridge

N-yr critical flood flow rates $Q_N$ [ $\text{m}^3 \text{s}^{-1}$ ]					Date of study
Profile	100	500	1 000	10 000	
Vltava, bridge Husinec - Řež [66]	4 060	5 680	6 500	9 500	03/2021

Compare with 2002 flood of critical flow rate of  $5200 \text{ m}^3 \text{ s}^{-1}$ .

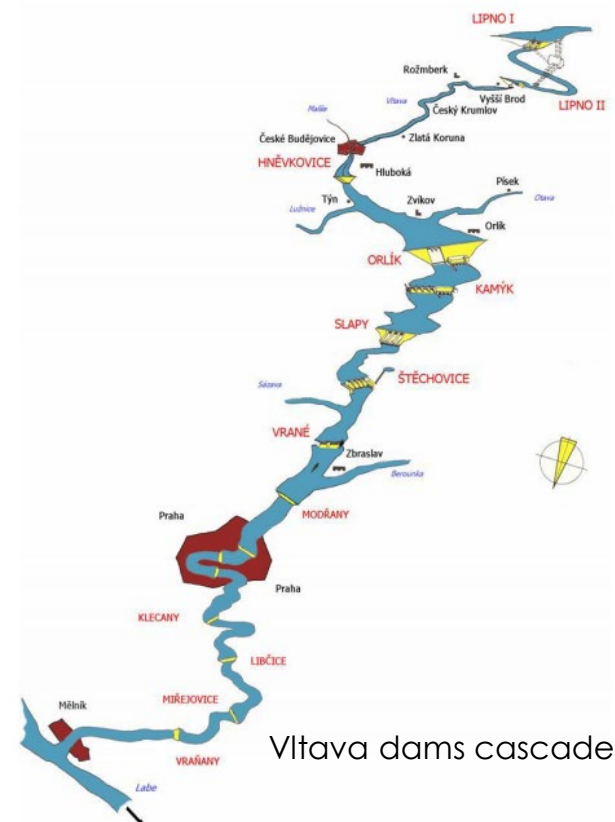


# Floods

## Specific study (DHI Hydroinform) – Special floods on Vltava cascade – Orlík dam failure

From several variants of the „special flood“ that was chosen for further analysis when the big dam Orlík will have the failure as a result of catastrophic flood giving intake flow rate  $Q_{10\,000} = 4300 \text{ m}^3 \text{ s}^{-1}$  and max. Vltava surface elevation of 189.00 m above the see level in UJV Řež. Thus also the dam Slapy would break down.

Note: Max. Vltava surface elevation in UJV Řež area in August 2002 was 181.28 m above the see level.

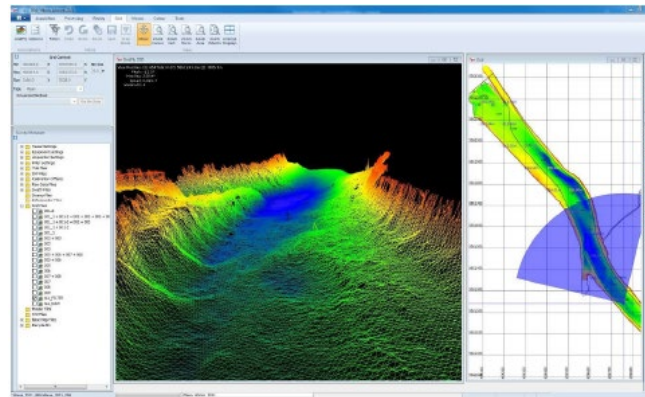


Vltava dams cascade

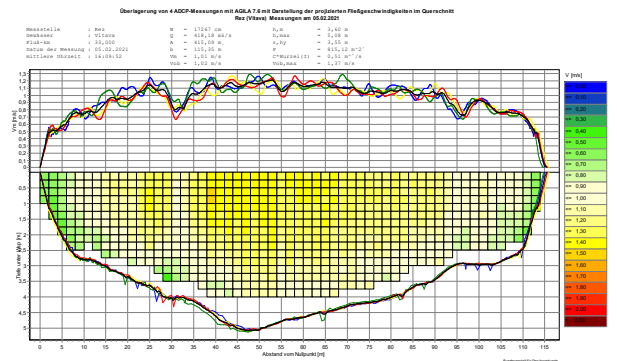


# Floods

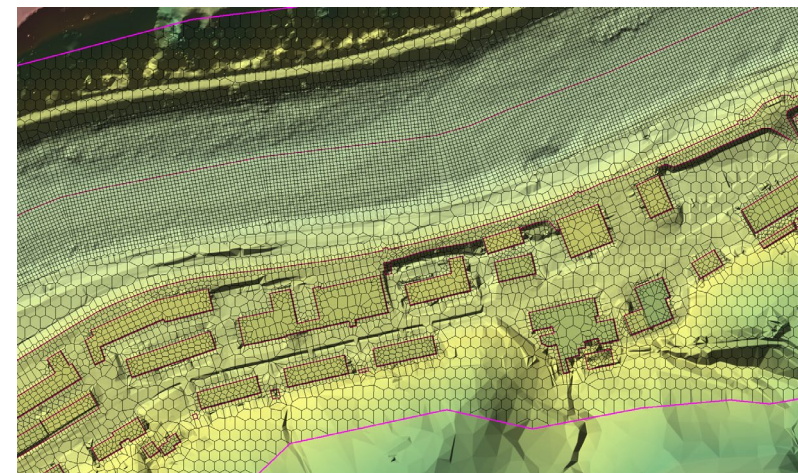
## 2D numeric model for flood calculations



Sonar record made to measure the morphology of the Vltava riverbed



Record of the flow rate field in the profile Husinec-Řež, the bridge; Feb 5, 2021

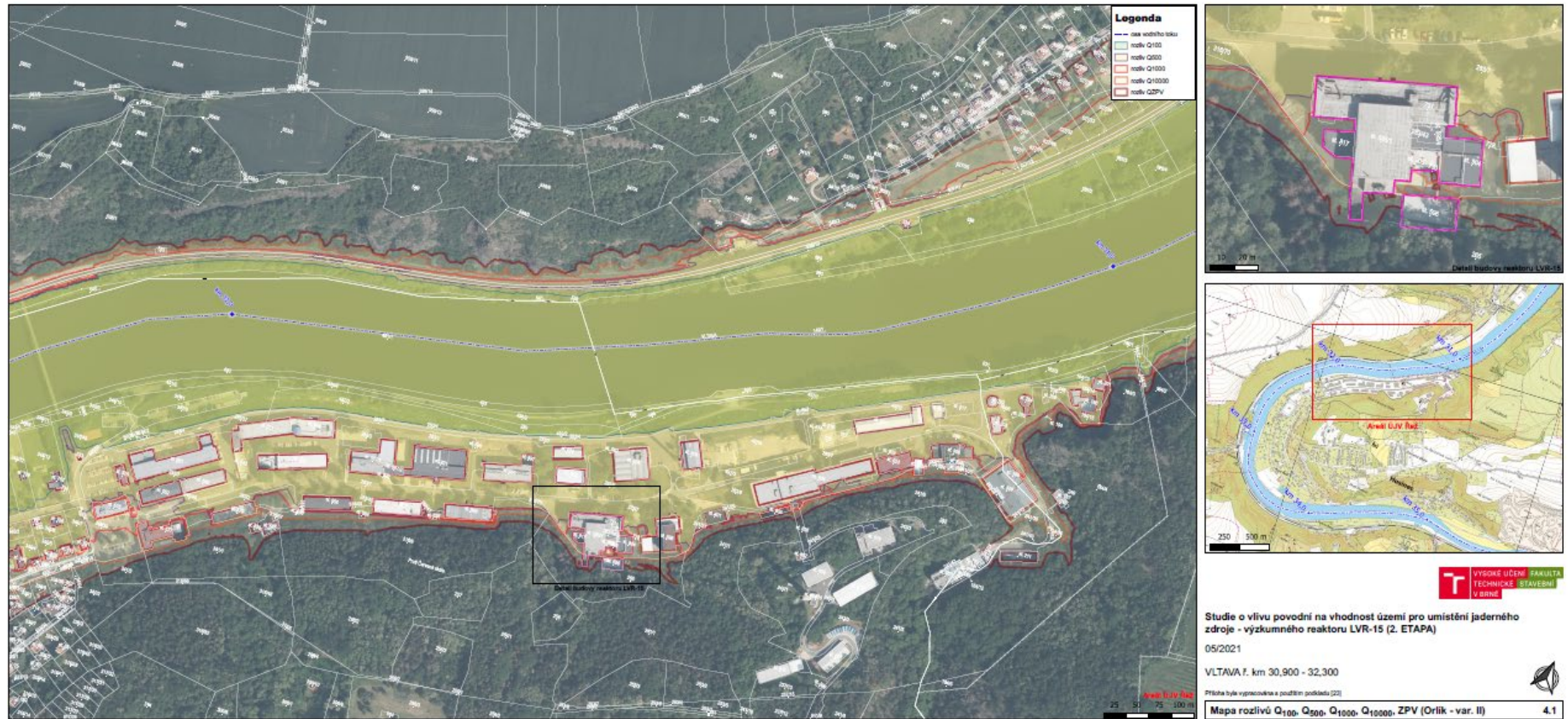


Calculation grid of the 2D numerical model in UJV Řež area



# Floods

## Maps of the flood hazard – levelling map

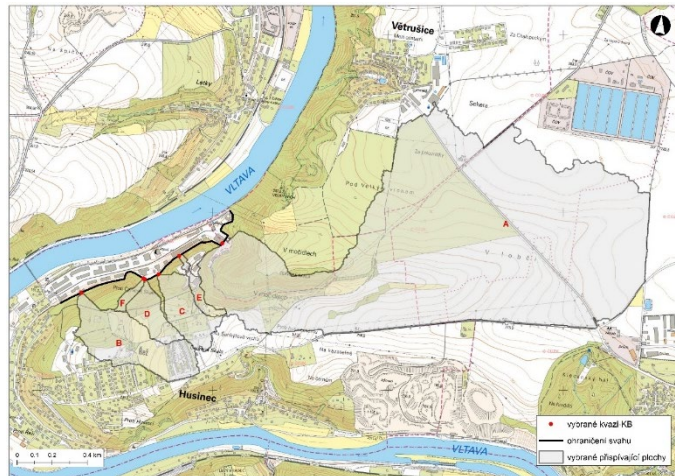


Levelling map for flow rates  $Q_{100}$ ,  $Q_{500}$ ,  $Q_{1000}$ ,  $Q_{10000}$ , ZPV (Orlík - var. II)

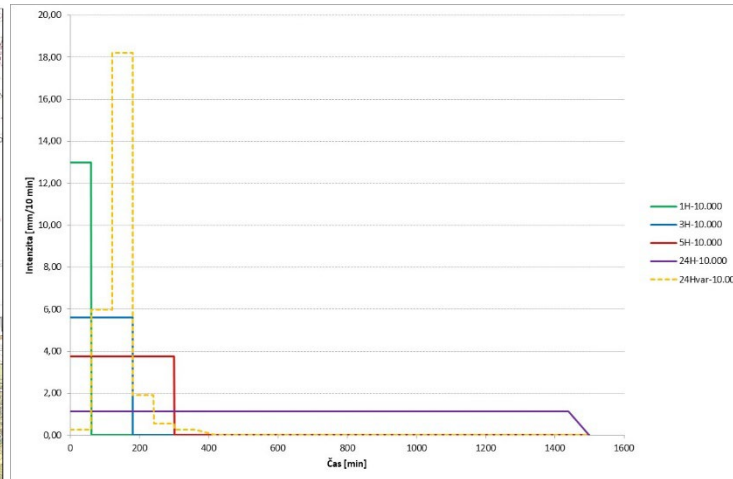


# Floods

## Hazard for the ÚJV Řež site from rain storms



Scheme of contributing areas (234 ha) where rain water will be collected and flow from the slope to the ÚJV Řež area



Time histories of rain storms scenarios and return period 10 000 years

Plocha [ha]	PVP III	1H-10.000	3H-10.000	5H-10.000	24H-10.000	24H-10.000	24H-10.000
	Intenzita [mm/10 min]	13,00	5,61	3,77	1,13	Var1	Var2
A 192,5	Hso [mm]	37,58	55,19	64,73	105,82	108,61	110,06
	Qmax [m <sup>3</sup> s <sup>-1</sup> ]	9,2	10	8,5	3	22,4	22,7
	Wpvt [tis. m <sup>3</sup> ]	72,4	106,3	124,7	203,9	209,3	212
B 16,6	Hso [mm]	39,14	58,31	68,73	114,1	114,14	114,03
	Qmax [m <sup>3</sup> s <sup>-1</sup> ]	1	0,98	0,81	0,29	2,3	2,3
	Wpvt [tis. m <sup>3</sup> ]	6,5	9,7	11,4	18,9	18,9	18,9
C 8,1	Hso [mm]	39,34	58,56	69,02	114,52	114,52	114,31
	Qmax [m <sup>3</sup> s <sup>-1</sup> ]	0,52	0,48	0,4	0,14	1,16	1,1
	Wpvt [tis. m <sup>3</sup> ]	3,2	4,7	5,6	9,3	9,3	9,3
D 5,2	Hso [mm]	29,51	59	64	108,94	109,2	109,09
	Qmax [m <sup>3</sup> s <sup>-1</sup> ]	0,26	0,28	0,24	0,09	0,62	0,58
	Wpvt [tis. m <sup>3</sup> ]	1,5	3,1	3,4	5,7	5,7	5,7
E 2,1	Hso [mm]	42,45	62,05	72,66	118,58	118,62	118,5
	Qmax [m <sup>3</sup> s <sup>-1</sup> ]	0,14	0,13	0,11	0,037	0,32	0,3
	Wpvt [tis. m <sup>3</sup> ]	0,9	1,3	1,5	2,5	2,5	2,5
F 1,0	Hso [mm]	29,37	49,69	56,432	99,03	103,55	103,35
	Qmax [m <sup>3</sup> s <sup>-1</sup> ]	0,05	0,053	0,045	0,017	0,13	0,125
	Wpvt [tis. m <sup>3</sup> ]	0,3	0,5	0,6	1	1	1

Summary of runoff characteristics for specific scenarios and return period 10 000 years

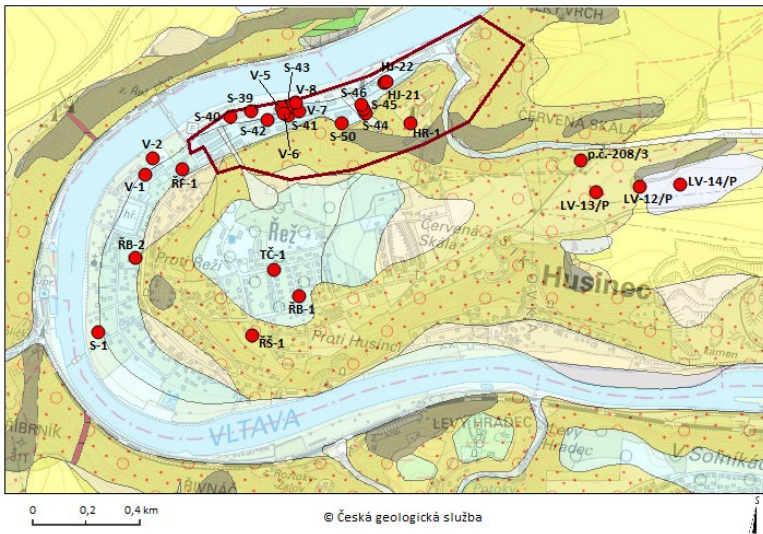


# Underground water circulation

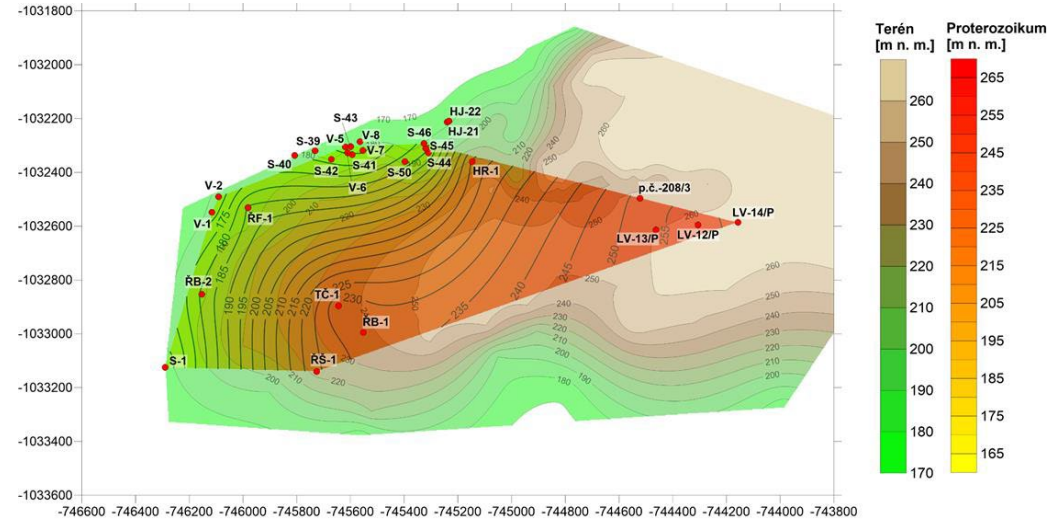
- The study covering the §8 Underground water circulation of Regulation No. 378/2016 Coll. has had the following goals:
  - Assess the occurrence of hydrogeological structures of underground water, including mineral waters and untapped groundwater and mineral water reserves on the LVR-15 facility site
  - Assess the effect of groundwater on LVR-15 facility incl. the chemical properties of the water in terms of aggressiveness
  - Include the preparation of a hydrogeological model of groundwater flow, including a description of hydrogeological beds
  - It shall be proved no significant bodies of groundwater which could be permanently contaminated by a radioactive substance



# Underground water circulation



Positions of archive boreholes (Geofond) in the UJV Řež area



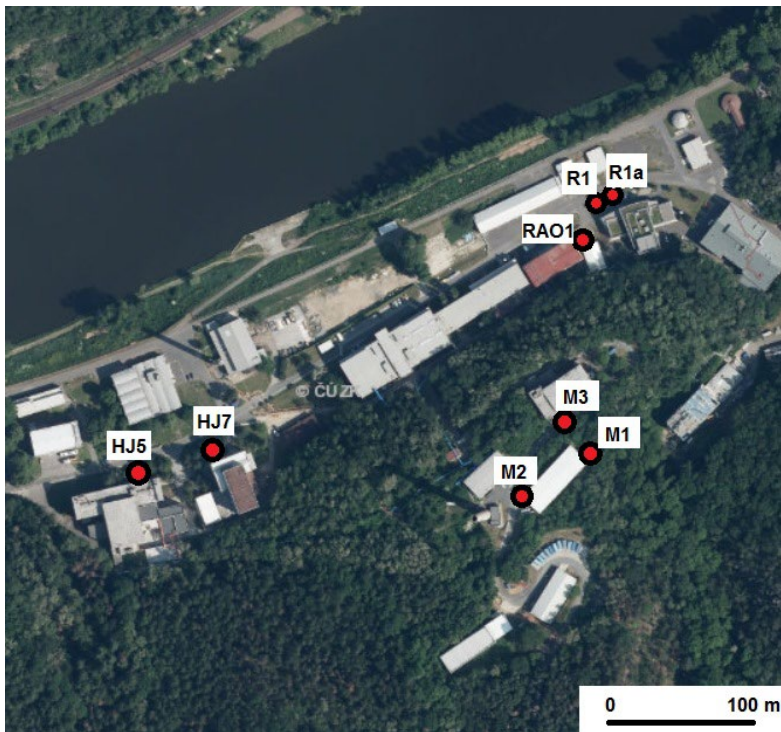
Approximate terrain surface of the right bank of the Vltava river and the surface of rocks of the upper Proterozoic (Surfer – Golden Software )

Most upper part of the rock environment is made Quaternary sediments of various depths (from 0.2 m borehole ŘŠ-1 to 16.7 m borehole S-1). Quaternary bedrock is built by rocks of upper Proterozoic (alternation of slates, siltstones and greywackes).

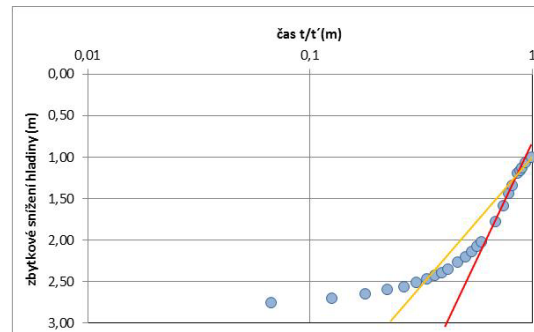
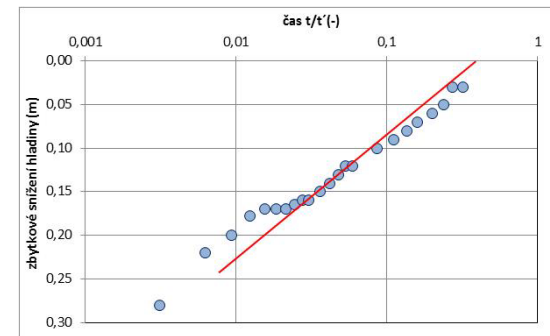
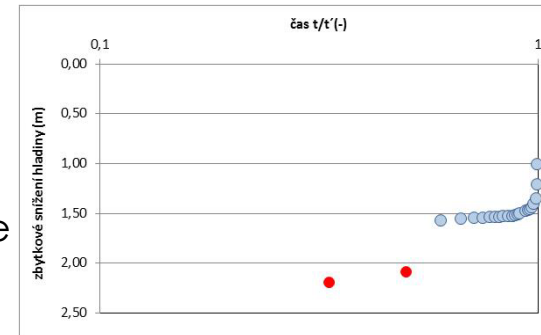


# Underground water circulation

On selected boreholes the water level was measured and the hydrodynamic pumping test performed



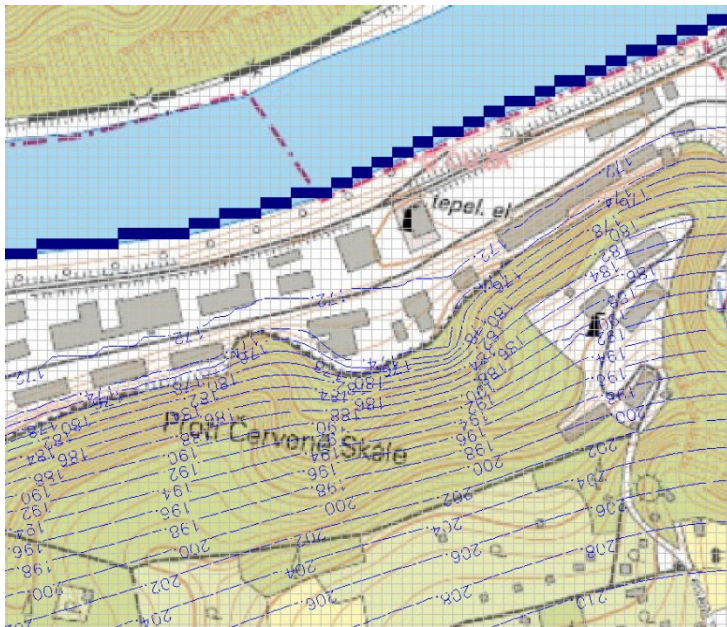
The time history of the water level onset for boreholes HJ-5, HJ7 and R1



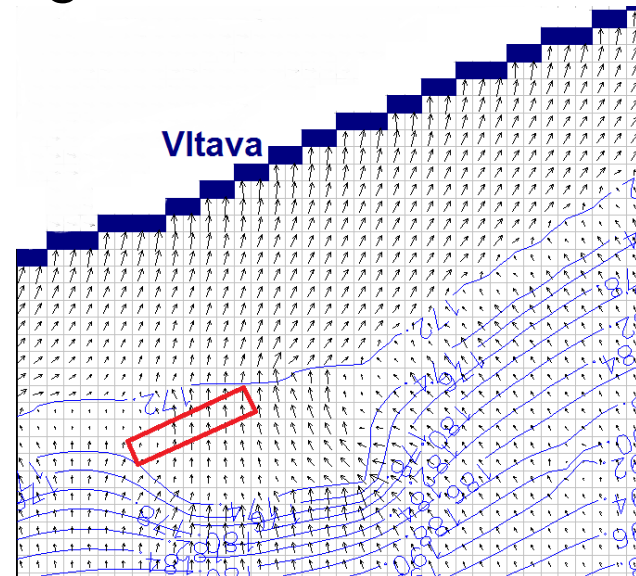


# Underground water circulation

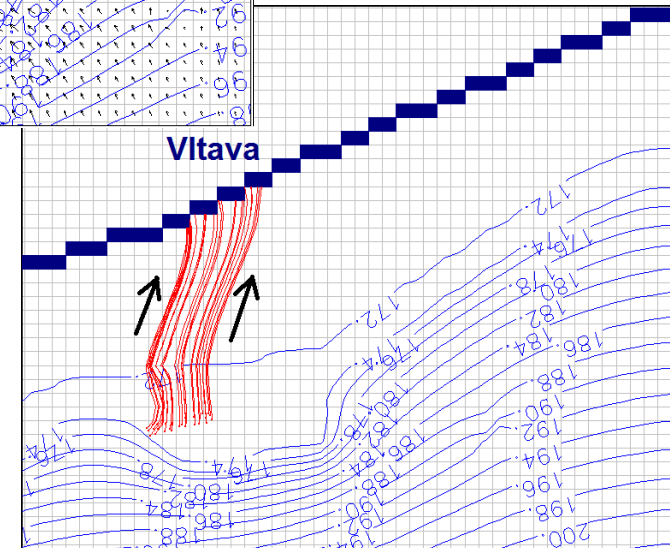
Numerical model of the underground water circulation (PMWIN ver. 8.2)



Hydroisohypses in the vicinity of the LVR-15 building (levelled by 2 m)



Flow vectors in the shallow aquifer in the collectors around the LVR-15 site



Streamlines from the subsoil of the LVR-15 facility area in SW direction to the Vltava River. Distance is 165 m and the time to go through is approx. 5.5 year. Only 0,08 l/s is the flow rate from the subsoil of LVR-15 building.



# Climatic and meteorological effects

- The study covering the § 10 Climatic and meteorological effects of Regulation No. 378/2016 Coll. was aimed to assess the following effects:
  - Atmospheric precipitation totals,
  - Average annual and monthly air temperatures,
  - Wind direction and strength,
  - Atmospheric stratification and stability
  - Temperature of the atmosphere and its sudden changes,
  - Occurrence of torrential rainfalls,
  - Occurrence of lightnings,
  - Occurrence of windstorms and tornadoes, and
  - Occurrence of rare meteorological events.



# Climatic and meteorological effects

## KLIMATICKÉ OBLASTI ČESKA klasifikace podle Quitta za období 1961–2000

**QUITTOVA KLASIFIKACE**  
 Quittova klasifikace klimatu České republiky rozlišuje 23 jednotek ve třech oblastech (horká, mírná teplota a chladná) definovaných určitými kombinacemi hodnot 14 klimatických charakteristik (počet mrazů, mrazových a ledových dnů, počet zamračených a jasných dnů, počet dní se srážkovou pokrývkou, počet dní se srážkami 1 mm a více, průměrná teplota vzduchu v lednu, v dubnu, v červenci a v říjnu, srážkový úhrn za vegetační období (duben až září) a v zimním období (říjen až březev) a počet dní s průměrnou teplotou 10 °C a více. Hranice oblastí a jednotek jsou určeny počtem změn těchto charakteristik.

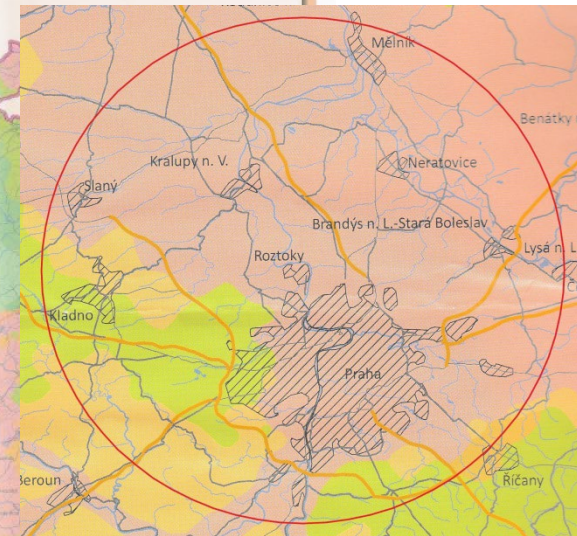
**QUITT'S CLASSIFICATION**  
 Quitt's classification of climate of the Czech Republic distinguishes 23 units in three regions (warm, moderately warm and cold), which are defined by certain combinations of values taken from 14 classes of climatic characteristics (annual number of warm, frost and ice days, number of overcast and clear days, number of days with snow cover, number of days with precipitation of 1 mm or more, the average air temperature in January, April, July and October, sum of precipitation in vegetation (April to September) and winter period (October to March), as well as the number of days with a daily average temperature of 10 °C and more. The borders of the regions and units are determined by the number of changes in the above-mentioned characteristics.

KLIMATICKÉ OBLASTI ČSR (E. Quitt, 1975)  
 CLIMATIC REGIONS OF ČSR (E. Quitt, 1975)  
 původní měřítko 1 : 500 000  
 upravené měřítko 1 : 1 000 000



## CLIMATIC REGIONS OF CZECHIA Quitt's classification during years 1961–2000

Region	Unit	Number of days with a daily average temperature of 10 °C and more												Number of days with a daily average temperature of 5 °C and more												Number of days with a daily average temperature of 0 °C and more											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I. Warm region	1	10	15	20	25	30	35	40	45	50	55	60	15	20	25	30	35	40	45	50	55	60	65	70	20	25	30	35	40	45	50	55	60	65	70	75	
	2	10	15	20	25	30	35	40	45	50	55	60	15	20	25	30	35	40	45	50	55	60	65	70	20	25	30	35	40	45	50	55	60	65	70	75	
II. Moderately warm region	3	5	10	15	20	25	30	35	40	45	50	55	10	15	20	25	30	35	40	45	50	55	60	65	15	20	25	30	35	40	45	50	55	60	65	70	
	4	5	10	15	20	25	30	35	40	45	50	55	10	15	20	25	30	35	40	45	50	55	60	65	15	20	25	30	35	40	45	50	55	60	65	70	
III. Cold region	5	0	5	10	15	20	25	30	35	40	45	50	5	10	15	20	25	30	35	40	45	50	55	60	10	15	20	25	30	35	40	45	50	55	60	65	
	6	0	5	10	15	20	25	30	35	40	45	50	5	10	15	20	25	30	35	40	45	50	55	60	10	15	20	25	30	35	40	45	50	55	60	65	

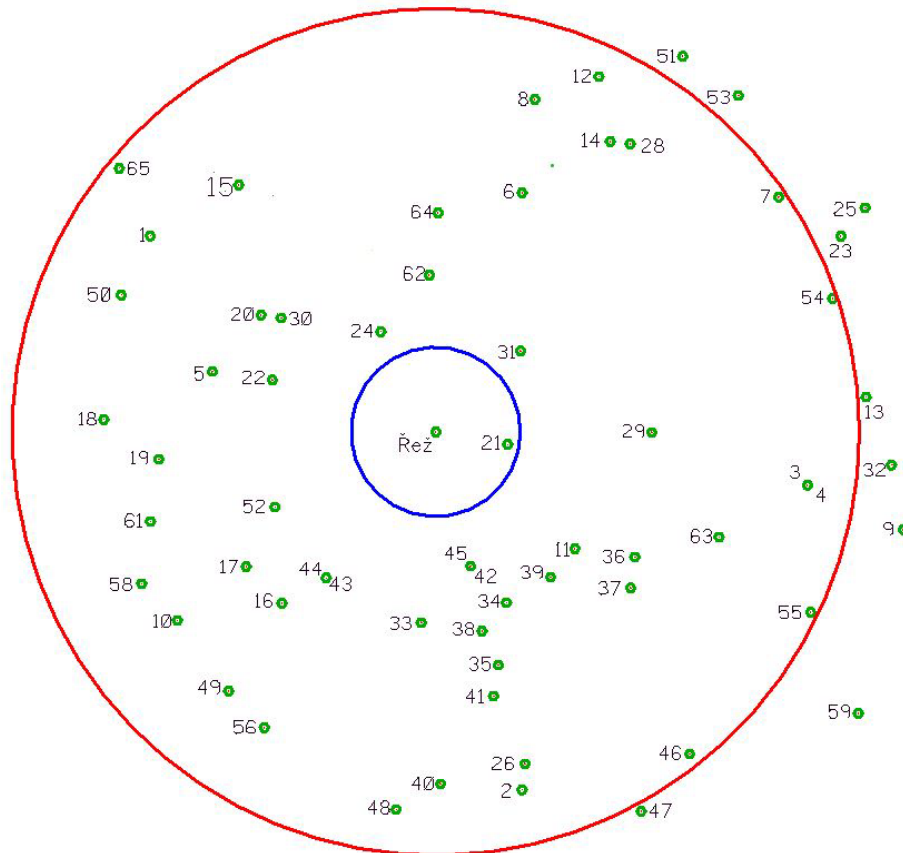


KLIMATICKÉ OBLASTI ČESKÉ REPUBLIKY: Klasifikace podle Quitta a za období 1961–2000, 1 : 500 000  
 CLIMATIC REGIONS OF THE CZECH REPUBLIC: Quitt's classification during years 1961–2000, 1 : 500 000  
 Analýza: M.A.P.S. – M. KUBIŠ, M. HODAVSKÁ  
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# Climatic and meteorological effects

Data from close meteorological CHMI stations were ordered and subsequently statistically processed.



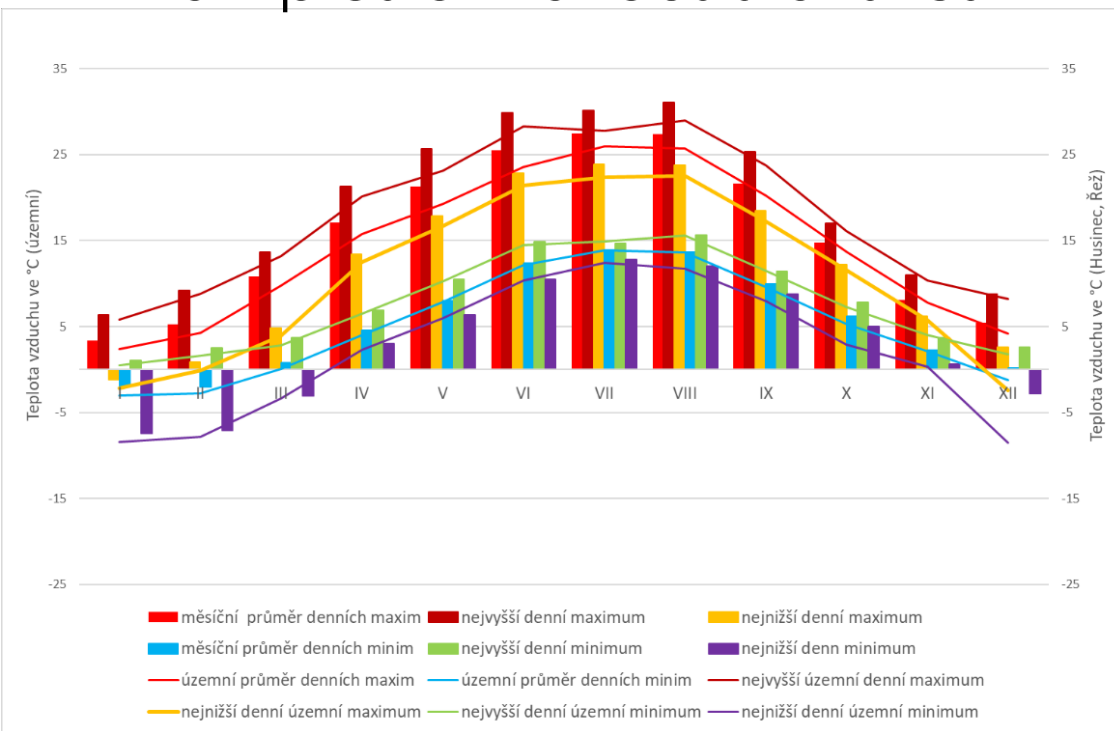
Location of used meteorological stations up to approx. 25 km from ÚJV Řež (red circle) and up to approx. 5 km from Řež (blue circle)

27  
32  
9  
60

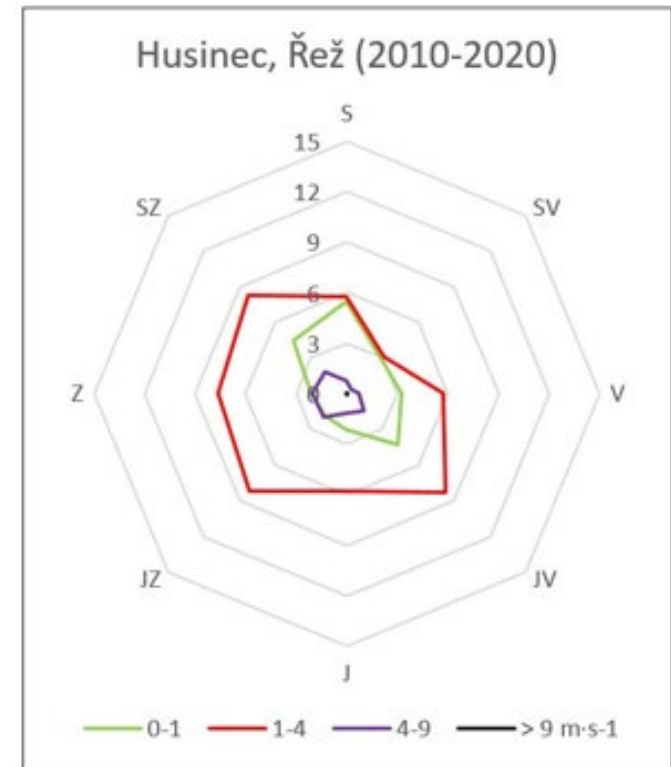


# Climatic and meteorological effects

## Examples of various statistics



Monthly and annual daily maximum and minimum temperatures in °C in the period 2011–2020 in Husinec, Řež and their comparison with territorial values for the period 2010–2020 (CHMI data)



Relative wind direction frequencies for individual wind speed classes per year (in%) in the period 2010-2020



# Climatic and meteorological effects

Recommended estimates of parameters of selected meteorological variables

Element	Method	Return period (years)								
		2	5	10	20	50	100	500	1 000	10 000
Max air temperature [°C]	Percentily/ Gumbel MLE	35,1	36,1	36,9	37,1	40,0	41,3	44,4	45,7	50,1
Min air temperature [°C]	Percentily/ Gumbel LM	-19,4	-22,1	-23,1	-24,3	-27,4	-29,6	-34,9	-37,2	-44,7
Instantaneous wind speed [m·s <sup>-1</sup> ]	GEV-MLE	29,4	34,3	37,3	40,0	43,3	45,7	50,5	52,4	58,0
Daily precipitation totals [mm]	Percentily, GEV-MLE	37,0	48,8	58,1	65,4	78,7	88,7	113,5	124,9	166,4
Height of snow cover [cm]	Gumbel -MLE	16,4	25,4	31,3	36,9	44,3	49,8	62,4	67,9	86,0
Water value of snow cover [mm]	GEV-MLE	20,1	33,8	43,9	54,3	69,0	81,1	112,7	128,0	187,9
Snow loads [kN·m <sup>-2</sup> ]	GEV-MLE	0,2	0,3	0,4	0,5	0,7	0,8	1,1	1,3	1,8



# External blast effects

- The study covering partially the § 14 of Regulation No. 378/2016 Coll. – Explosions and fires originating in human activities and their products – was aimed to:
  - Identify the possible sources of external blasts up to 10 km from LVR-15 facility site and
  - Quantify their effects to LVR-15 (and LR-0) buildings.



# External blast effects

Possible sources of external blasts identified are:

- Railway transportation
- Vltava river ship transportation
- Overhead automobile transportation (not existing yet, the highway bridge is however planned)
- Gas pipeline and oil pipeline running in the ÚJV Řež vicinity
- Oil refinery and other chemical plants zone in the town of Kralupy nad Vltavou

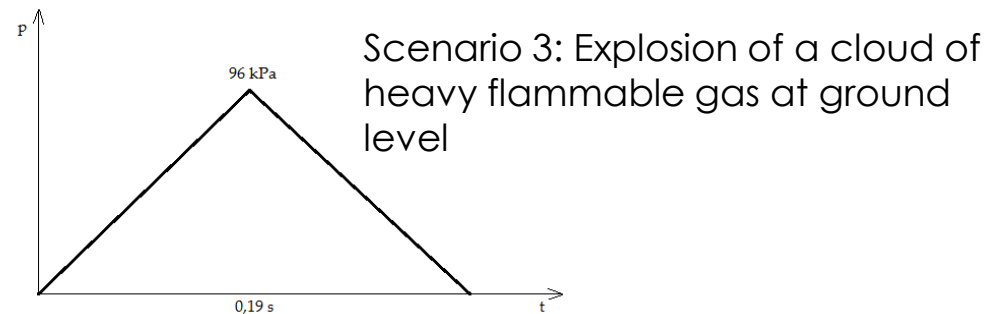
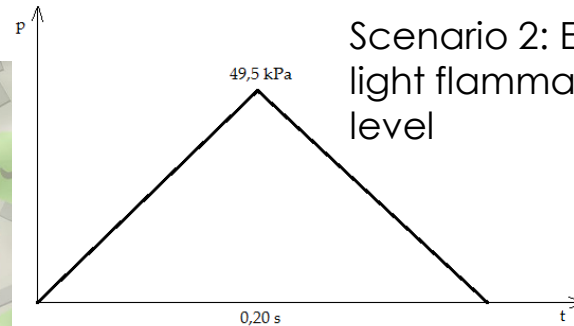


# External blast effects

Sources oil refinery and gas/oil pipelines could be omitted due to low pressure on the possible shock front. Following scenarios have been studied:



The distance of the railway line to the LVR-15 reactor building is 260 m



Scenario 4: Leakage of a gas cloud into the premises of the assessed objects

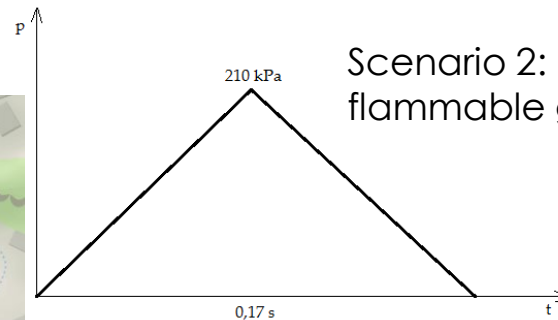


# External blast effects

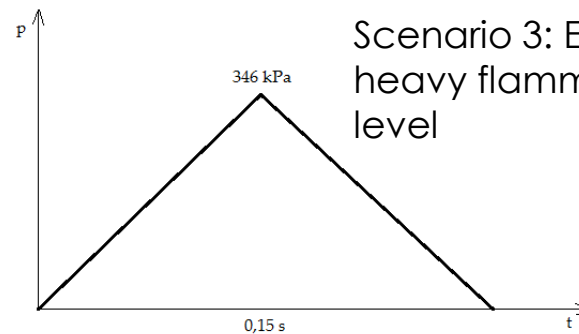
Following scenarios have been studied:



The distance of the water transport to the LVR-15 reactor building is 150 m



Scenario 2: Explosion of a cloud of light flammable gas above ground level



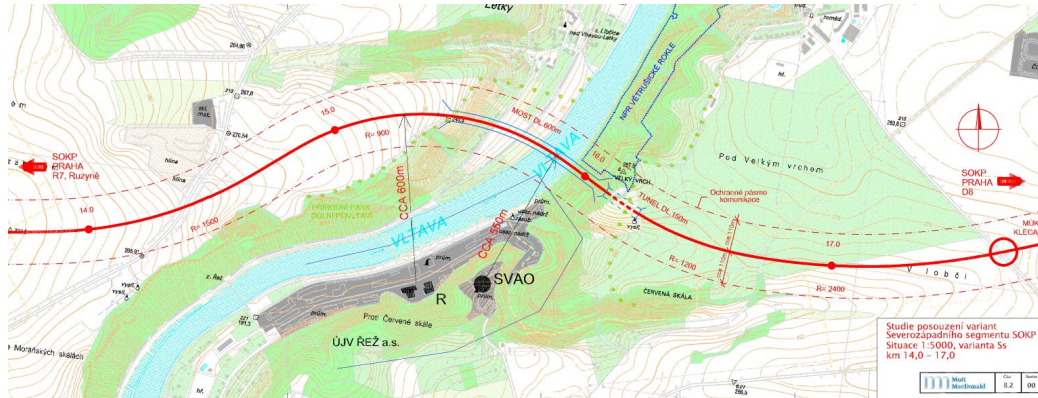
Scenario 3: Explosion of a cloud of heavy flammable gas at ground level

Scenario 4: Leakage of a gas cloud into the premises of the assessed objects



# External blast effects

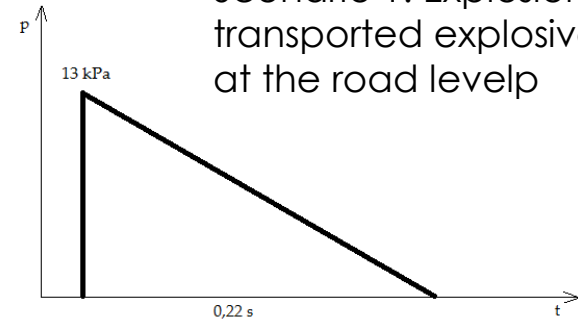
Following scenarios have been studied:



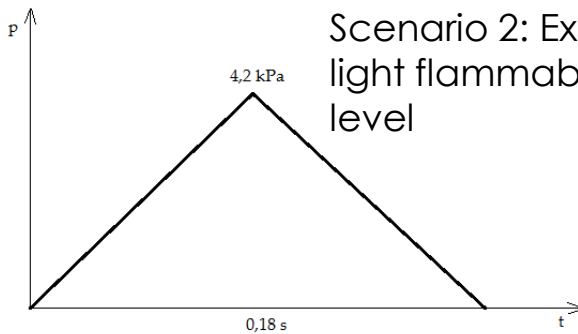
Map of the ring road around Prague (SOKP), northwestern segment.

The distance of the automobile transport (not existing yet) to the LVR-15 reactor building is 600 m

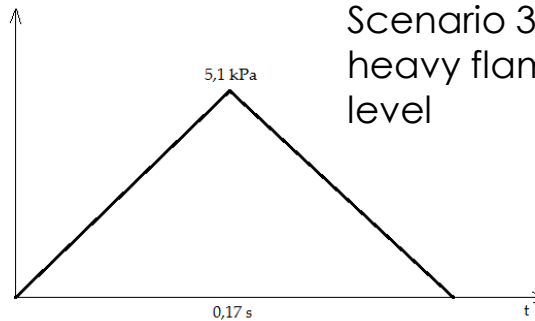
Scenario 1: Explosion of a transported explosive (TNT) at the road level



Scenario 2: Explosion of a cloud of light flammable gas above ground level



Scenario 3: Explosion of a cloud of heavy flammable gas at ground level





Thank you for your attention