



**EUROPEAN COMMISSION**  
DIRECTORATE-GENERAL FOR ENERGY

DIRECTORATE D – Nuclear energy, safety and ITER  
**D.3 – Radiation protection and nuclear safety**

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**Verification under the terms of Article 35 of the Euratom Treaty**

**Technical Report**

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**CZECH REPUBLIC**

**Dukovany Nuclear Power Plant**

**Discharge and environmental monitoring and national  
environmental radioactivity monitoring network in the vicinity**

**2 - 5 October 2017**

**Reference: CZ 17-03**

**VERIFICATIONS UNDER THE TERMS OF ARTICLE 35  
OF THE EURATOM TREATY**

FACILITIES

- Facilities for monitoring discharges of gaseous and liquid radioactive effluents into the environment at the Dukovany nuclear power plant
- Facilities for monitoring environmental radioactivity in the vicinity of the Dukovany nuclear power plant
- Associated analytical laboratories

LOCATIONS                      Dukovany, Moravský Krumlov, Brno, České Budějovice

DATES                              2 – 5 October 2017

REFERENCE                        CZ 17-03

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**Legend**

|                |   |
|----------------|---|
| A <sub>s</sub> | Surface activity  |
| A <sub>v</sub> | Volume activity   |
| BAPP           | Buildings of active auxiliary operations                          |
| ČEZ            | utility – operator the NPP  |
| ČEZ EDU        | the Dukovany NPP  |
| ČHMÚ           | Czech Hydrometeorological Institute                               |
| ČMI            | Czech Metrological Institute                                      |
| ERML           | Environmental Radiation Monitoring Laboratory                     |
| FWHM           | Full Width at Half Maximum  |
| HVB            | "main production block" [of gaseous discharges]                   |
| IAEA           | International Atomic Energy Agency                                |
| LRKO EDU       | Environmental radiation monitoring laboratory of the NPP Dukovany |
| MMS            | Mobile monitoring group   |
| MSVP           | Spent fuel storage building                                       |
| NPP            | Nuclear Power Plant   |
| PDE            | Dose rate, dose equivalent rate                                   |
| PFDE           | Photon dose equivalent rate                                       |
| RMMS           | Fast mobile monitoring group                                      |
| RMN            | Radiation Monitoring Network                                      |
| RPLD           | Radiophotoluminescent dosimeter                                   |
| RVP            | radioactive noble gas   |
| SDS            | Environmental radiation monitoring station                        |
| SODAR          | SONic Detection And Ranging                                       |
| SW CISRK       | Software of the Central Radiation Monitoring Information System   |
| TDS            | Teledosimetric system   |
| TLD            | Thermoluminiscent dosimeter                                       |
| WWTP           | Waste Water Treatment Plant                                       |
| ZHP            | Emergency planning zone   |

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## TECHNICAL REPORT

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### 1 INTRODUCTION

Under Article 35 of the Euratom Treaty, all Member States must establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the basic safety standards<sup>1</sup>. Article 35 also gives the European Commission (EC) the right of access to such facilities to verify their operation and efficiency. The radiation protection and nuclear safety unit of the European Commission's Directorate-General for Energy is responsible for undertaking these verifications. The Joint Research Centre Directorate-General provides technical support during the verification visits and in drawing up the reports.

The main purpose of the verifications under Article 35 of the Euratom Treaty is to provide an independent assessment of the adequacy of monitoring facilities for:

- liquid and airborne discharges of radioactivity from a site into the environment;
- levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant exposure pathways;
- levels of environmental radioactivity on the territory of the Member State.

Taking into account previous bilateral protocols, a Commission Communication<sup>2</sup> describing practical arrangements for Article 35 verification visits in Member States was published in the *Official Journal of the European Union* on 4 July 2006.

### 2 PREPARATION AND CONDUCT OF THE VERIFICATION

#### 2.1 PREAMBLE

The Commission notified the Czech Republic of its decision to conduct an Article 35 verification in a letter addressed to the Czech Republic Permanent Representation to the European Union. The Czech Government subsequently designated the State Office for Nuclear Safety (SÚJB) to lead the preparations for this visit.

#### 2.2 DOCUMENTS

To assist the verification team in its work, the Czech national authorities supplied an information package in advance<sup>3</sup>. Additional documentation was provided during and after the visit. The information provided was used extensively in drawing up the descriptive sections of this report.

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<sup>1</sup> Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L 159 of 29.6.1996) and Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation; repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom with effect from 6 February 2018 (OJ L 13 of 17.1.2014)

<sup>2</sup> Commission Communication *Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty — Practical arrangements for the conduct of verification visits in Member States* (OJ C 155, 4.7.2006, pp. 2-5)

<sup>3</sup> Replies to the preliminary information questionnaire addressed to the national competent authority, received on 1 September 2017.

## 2.3 PROGRAMME OF THE VISIT

The EC and SÚJB discussed and agreed on a programme of verification activities in line with the Commission Communication of 4 July 2006.

The opening meeting held at the Dukovany NPP included presentations on the following:

- Radionuclide regulation in the Czech Republic
- Dukovany NPP basic information and main radiation protection indicators
- Dukovany NPP safety
- Environmental radioactivity monitoring
- State Office for Nuclear Safety

The verification team pointed to the quality and comprehensiveness of all the presentations and documentation. The team carried out the verifications in accordance with the programme in Annex 1. It met the following representatives of the national authorities and other parties involved:

### SÚJB

|                 |   |
|-----------------|---|
| Karla Petrová   | Head of Section for Radiation Protection  |
| Milan Hort      | Head of Department of Radiation Protection in Fuel Cycle                              |
| Dagmar Fuchsová | Head of Regional Centre Brno  |
| Hana Bílková    | Radiation Protection Inspector – Regional Centre Brno                                 |
| Eva Šindelková  | Radiation Protection Inspector – Regional Centre České Budějovice                     |
| Jiří Havránek   | Radiation Protection Inspector – Regional Centre České Budějovice                     |
| Ondřej Chochola | Radiation Protection Inspector – Department of Radiation Protection in the Fuel Cycle |

### SÚRO

|                  |  |
|------------------|--|
| Daniela Ekendahl | Head of the Dosimetry Department                                       |
| Lubomír Gryc     | Head of the Mobile Group Department                                    |
| Petr Kuča        | Head of the Early Warning Network and Analytic Expert Group Department |
| Pavel Žlebčík    | Deputy Head of the Spectrometry Department                             |

### ČEZ, a s.

|                     |   |
|---------------------|---|
| František Klímek    | Head of Department of Radiation Risk Management         |
| Rostislav Striegler | Head of Department of Radiation Protection Laboratories |

## 3 LEGAL FRAMEWORK FOR RADIOACTIVITY MONITORING

### 3.1 NATIONAL LEGISLATION IN THE CZECH REPUBLIC

In the Czech Republic the following legislative acts regulate environmental radioactivity monitoring, radiological surveillance of foodstuffs and monitoring of radioactive discharges:

- Act No. 263/2016 Coll., Atomic act
- Decree No. 360/2016 Coll. on radiation situation monitoring
- Decree No. 422/2016 Coll. on radiation protection and security of a radioactive source
- Act No 254/2001 Coll. on water and on amending certain acts (Water Act)
- Government Regulation No. 401/2015 Coll. on indicators and values of permissible pollution of surface waters and wastewater, details of the permit to discharge wastewater into surface water and into sewage systems and on sensitive areas (Appendix 3 – indicators of surface water, environmental quality standards and requirements for the water use)

### 3.2 INTERNATIONAL LEGISLATION AND GUIDANCE DOCUMENTS

The list below includes the main international legislative and guidance documents issued by the European Union (EU) and the International Atomic Energy Agency (IAEA), that form the basis for environmental radioactivity monitoring, the radiological surveillance of foodstuffs and the radiological surveillance of radioactive discharges.

#### The European Union

- The Euratom Treaty (1957)
- Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L 159 of 29.6.1996)
- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation; repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom with effect from 6 February 2018 (OJ L 13 of 17.1.2014)
- Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption (OJ L 296 of 7.11.2013)
- Commission Recommendation 2000/473/Euratom of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole (OJ L191 of 27.7.2000)
- Commission Recommendation 2004/2/Euratom of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation (OJ L36 of 6.1.2004)

#### International bodies, in particular the International Atomic Energy Agency (IAEA)

- *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards*, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna, 2014
- *Clearance of materials resulting from the use of radionuclides in medicine, industry and research*, IAEA-TECDOC-1000, IAEA, Vienna, 1998
- *Generic models for use in assessing the impact of discharges of radioactive substances to the environment*, Safety Reports Series No 19, IAEA, Vienna, 2001
- *Handbook of parameter values for the prediction of radionuclide transfer in temperate environments*, Technical Reports Series No 364, IAEA, Vienna, 1994
- *International basic safety standards for protection against ionising radiation and for the safety of radiation sources*, Safety Series No 115, IAEA, Vienna, 1996
- *Management of radioactive waste from the use of radionuclides in medicine*, IAEA-TECDOC-1183, IAEA, Vienna, 2000
- *Regulatory control of radioactive discharges to the environment: Safety Guide*, Safety Standards Series No. WS-G-2.3, IAEA, Vienna, 2000

#### International conventions

- The Convention on Nuclear Safety
- The Convention on Early Notification of a Nuclear Accident
- The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency



## 4 BODIES HAVING COMPETENCE IN THE FIELD OF ENVIRONMENTAL AND DISCHARGE RADIOACTIVITY MONITORING

### 4.1 MINISTRY OF ENVIRONMENT

Under § 218 of the Atomic Act the Ministry of Environment participates in radiation monitoring in accordance with § 149, and performs monitoring, including observation and forecasts of the development of the meteorological situation and distribution of released radionuclides as part of accidental monitoring, and ensures the operation of the measurement laboratory and its participation in comparative measurements.

### 4.2 MINISTRY OF AGRICULTURE

Under § 217 of the Atomic Act the Ministry of Agriculture participates in radiation monitoring in accordance with § 149, and performs monitoring on monitoring sites and ensures the operation of the measurement laboratory and its participation in comparative measurements.

### 4.3 MINISTRY OF DEFENCE

Under § 216 of the Atomic Act the Ministry of Defense participates in radiation situation monitoring in accordance with § 149 and performs this monitoring on monitoring routes and sites.

### 4.4 STATE OFFICE FOR NUCLEAR SAFETY

The State Office for Nuclear Safety (SÚJB) is a governmental body (stipulated by Act. No. 2/1969 Coll., as amended) responsible for administration and supervision in the fields of nuclear energy, radiation protection, emergency preparedness, monitoring of radiation on the territory of the Czech Republic and chemical, biological and toxic weapons prohibition. The SÚJB is headed by the Chairman who is appointed by the Government of the Czech Republic. It has its headquarter in Prague and eight Regional Centres and two offices at NPP sites (Figure 1).



**Figure 1. SÚJB regional centres and nuclear sites in the Czech Republic**

The authority and responsibilities of the SÚJB are stipulated by Act. No. 263/2016 Coll., Atomic Act (§ 208, 209). The SÚJB, among others, shall

- Issue licences for the performance of activities and register and receive notifications of activities;
- Approve documentation for licensed activities;
- Establish emergency planning zones;
- Monitor, assess and regulate the exposure of natural persons, including exposure from natural sources of radiation. Draw up, in cooperation with the relevant administrative authorities, national plans to address and provide information about situations;
- Ensure international cooperation within the field of its competence, provide information from the field of its competence to the International Atomic Energy Agency, EURATOM and other EURATOM authorities and ensure implementation of other obligations arising from EURATOM legislation. In particular, it deals with the national and international evaluation of the exercise of State Authority over nuclear safety of nuclear installations and management of nuclear materials and high-activity sources;
- Decide on the management of nuclear items, sources of ionising radiation or radioactive waste in cases where they are managed in conflict with legislation, e.g. in a situation that has arisen is not being rectified, including cases when sources have been found. If necessary, it organises a search for such sources of ionising radiation;
- Present to the Government and to the public a report on its activities and an annual report on radiation monitoring on the territory of the Czech Republic;
- Draw up the national monitoring programme and, after it has been approved, forward it to the persons referred to in § 149(2)(a) of the Atomic Act;
- Manage and carry out radiation monitoring on the territory of the Czech Republic in accordance with § 130 of the Atomic Act, including the interlaboratory comparisons organised by the European Commission. It evaluates its results and report radiation monitoring data to the European Commission.

#### **4.5 NATIONAL RADIATION PROTECTION INSTITUTE**

The National Radiation Protection Institute (SÚRO) is a public research institution established by the decision of the chairman of the SÚJB on October 20, 2010, which became effective on January 1, 2011. The Institute, formerly a non-profit organisation, was established on 1995 on the basis of the former Centre for Radiation Hygiene of the National Institute of Public Health in Prague.

The Institute has its headquarter in Prague and regional branches (laboratories) in Hradec Kralove and Ostrava. The Institute's basic purpose, as stipulated by its foundation charter, is to provide

- research in radiation protection;
- support of the state supervision in radiation protection;
- other activities in radiation protection.

The institute has technical equipment that provides highly specialised analyses in radiation protection. The basic equipment is the following:

- Whole-body counter which is equipped with both scintillation and semiconductor spectrometry (for in-vivo nuclide counting in the human body - including low energy gamma nuclides) including a calibration phantom of the human body which is accepted as the standard by the EU;
- Gamma spectrometry laboratory (with 8 HPGe semiconductor spectrometric detectors surrounded by low background shields);
- Alpha/beta spectrometry laboratory (including low-level liquid scintillation analyser);
- Radiochemistry laboratory for artificial nuclide and trans-uranium element analysis;

- Special samplers for airborne nuclide sampling (*e.g.* cascade compactor, aerosol and gaseous iodine high-volume samplers, aerosol and gaseous iodine portable samplers, noble gas sampling pressurised bottles and fallout samplers);
- TL dosimetry laboratory (equipped with TLD readers and laser densitometer);
- Special instruments and software for the mobile team which performs emergency monitoring in the field in case of emergency: dose rate measurements in individual locations; automated continuous dose rate measurements which are related to geographical coordinates and are used for the survey of the radiation situation during vehicle drive or helicopter flight; in-situ gamma spectrometry for the identification of radionuclides and the quantitative determination of nuclide concentrations related to a surface terrain distribution; aviation spectrometry instrumentation; soil samplers; the equipment and software that correlate TLD doses for transport from the Institute to the individual locations (and vice versa) in the territorial TLD network.

#### 4.6 RADIATION MONITORING NETWORK

The task of the Radiation Monitoring Network (RMN) is to monitor spatial and temporal distribution of radionuclides and doses from ionising radiation on the national territory. Under normal radiological conditions, the purpose of the monitoring is to establish a long-term image of the radiological situation and identify at any time variations from this image. In an emergency situation, the task of the RMN is to assess the radiological situation on the national territory and provide background information for deciding on countermeasures to protect the population. RMN is focussing on the following artificial radionuclides:  $^3\text{H}$ ,  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{239+240}\text{Pu}$ ,  $^{85}\text{Kr}$  and  $^{14}\text{C}$  in the atmosphere,  $^{137}\text{Cs}$  and  $^3\text{H}$  in water,  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in food, and  $^{137}\text{Cs}$  in the human body.

The SÚJB, under the radiation situation monitoring management, when an emergency exposure situation occurs, initiates emergency monitoring and in accordance with the monitoring programme may determine the extent and manner of participation of each of the persons involved in the emergency monitoring. Radiological monitoring during emergency exercises, drills and comparative measurements shall follow the monitoring programme and the instructions given for emergency exercises, drills and interlaboratory comparisons by their organisers.

The RMN consists of several mutually co-operating partial networks:

##### **Early Warning Network, including the NPP teledosimetry systems**

- The territorial network covering the whole territory of the Czech Republic, composed of 72 measuring points (55 operated by SÚJB and 17 operated by the Czech Army) equipped with dose rate meters. Continuous monitoring is reported as the average dose rate value over 10-minute measuring periods. Data is transferred from measuring points to the central database of the RMN each 10 minutes.
- The local network around the Dukovany NPP, composed of 3 teledosimetric rings around the NPP (1<sup>st</sup> inner ring 27 points, 2<sup>nd</sup> middle ring 8 points, 3<sup>rd</sup> outer ring 16 points) operated by the operator of the Dukovany NPP, equipped with dose rate meters. Data is transferred from measuring points to the central database of the RMN each 10 minutes.
- The local network around the Temelín NPP, composed of 3 teledosimetric rings around the NPP (1<sup>st</sup> inner ring 24 points, 2<sup>nd</sup> middle ring 7 points, 3<sup>rd</sup> outer ring 16 points) operated by the operator of the Temelín NPP, equipped with dose rate meters. Data is transferred from measuring points to the central database of the RMN each 10 minutes.

##### **Network of integral measurement**

- The TLD Territorial Network with a total of 185 measuring sites evenly spread over the national territory. They are equipped with thermoluminescent dosimeters that are exchanged every three months. The results are evaluated as the average equivalent dose during the

measuring period. Similarly, the TLDs are used in the TLD local networks with 92 measuring points in the surroundings of the nuclear power stations.

#### **Spectrometry measurement network**

- Regular measurement of spectra at aerosol and iodine collection points (radionuclides in air). The points are located in 8 sites of the SÚJB Regional Centres (Praha, Brno, Ústí nad Labem, Plzeň, České Budějovice, Ostrava, Kamenná, Hradec Králové) and in 2 stations of the ČHMÚ (Cheb and Holešov).

#### **Monitoring routes network**

- A survey of the radiological situation based on the ground and aerial monitoring of the dose rate and surface contamination. Mobile groups also ensure the distribution of TL-dosimeters, perform qualitative and quantitative field evaluation of radionuclide activities (in-situ spectrometry) and sample and search for lost radioactive sources.

#### **Environmental sampling, including discharges network**

- Air samples (aerosols and gaseous discharges to the air), soil, water, sludge, sediments
- Water samples (ground water, surface water from rivers and lakes, drinking water)

#### **Food chain sampling network**

- Samples of milk, meat (pork, beef, poultry, rabbit and mutton, game, fish), potatoes, crop (wheat, barley, oats, rye, maize), vegetables (green, root, fruit bearing), fruit (usually 3 kinds), wild crops, mushrooms (different kinds) are collected and analysed;
- Sampling of milk and meat is made quarterly; sampling of potatoes, crop, vegetable, fruit, wild crops and mushrooms once a year (in harvest season);
- Activity levels of artificial radionuclides are determined by gamma spectrometry. The activity level of  $^{90}\text{Sr}$  is evaluated in samples of milk and grain.

#### **Human body measurement network**

- Internal contamination – radionuclide concentration in human body of about 30 persons (group of SÚRO staff - 15 men and 15 women) are measured every year by whole body counting.
- Internal contamination – about 60 persons from the whole Czech Republic collect urine during 24-hours on a given date.  $^{137}\text{Cs}$  content in urine is determined after radiochemical preparation.

Radiological monitoring data are used for a radiological situation assessment, for the monitoring and evaluation of the exposure and, in a case of an emergency, for the decision about countermeasures related to the exposure reduction. Storing, processing and publication of **Monitoring of Radiation Situation** results is ensured by the software tool **MonRaS**.

## **4.7 OTHER ORGANISATIONS**

The Czech Agriculture and Food Inspection Authority, the Customs Administration, the Fire Rescue Service and the Police participate in radiation situation monitoring in accordance with § 223 of the Atomic Act by performing monitoring on monitoring routes and sites.

## 5 DUKOVANY NPP ENVIRONMENTAL RADIATION MONITORING PROGRAMME

### 5.1 SITE DESCRIPTION

The Dukovany Nuclear Power Plant (Figure 2) is located in the south-western part of Moravia, approximately 30 km southeast of Třebíč in a triangle formed by the municipalities of Dukovany, Slavětice and Rouchovany. The nearest city is Moravský Krumlov located approximately 16 km from the power plant. The territory is flat; the power plant is located on a plateau 389 m above sea level. The plant is located 35 km from the state border with Austria and 27 km from Brno, the second biggest city in the Czech Republic.

The Dukovany plant total area is approximately 100 ha. The current fenced area includes four production units.

NPP Dukovany has four Russian-design pressurised water reactors of type VVER 440 (water-water energy reactor) – Model V 213. Each of these reactors has a thermal capacity of 1,375 MW and electric capacity of 510 MW. The first reactor unit was put into operation on 4 May 1985 and the last (the fourth) unit on 20 July 1987.

The Dalešice waterworks with a pumped-storage hydroelectric power plant of 450 MW capacity is located in the vicinity of the power plant on the Jihlava River. Its equalising reservoir serves as a water resource for the nuclear power plant.



**Figure 2. Dukovany nuclear power plant**

### 5.2 OPERATOR'S ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

#### 5.2.1 Routine monitoring

Radiation monitoring in the NPP vicinity is used to check compliance with the discharge limits and to identify and assess the discharges and their consequences on the population and the environment around the NPP. In normal operation it is also used to confirm the operational safety in relation to the environment. This is carried out by monitoring, measuring, evaluating and recording the quantities and parameters characterising the radiation field and the occurrence of artificial radionuclides in the environment in the area of the emergency planning zone of the Dukovany NPP.

Table I summarises the basic monitoring parameters and monitored radionuclides of the Dukovany routine monitoring programme. Detailed monitoring methodology is described in Annex 2. Monitoring locations are presented in Annex 4.

**Table I. Dukovany NPP routine environmental monitoring programme**

| Monitored constituent     | Measuring points  | Measuring frequency, sampling interval  | Monitored radionuclides  |
|---------------------------|---|---|--|
| Aerosols in the air       | SDS Moravský Krumlov<br>SDS Dolní Dubňany<br>SDS Slavětice<br>SDS Mohelno<br>SDS Rouchovany   | <i>weekly</i> ,<br>continuous sampling –<br>weekly filter exchange<br>interval  | Gamma-emitting<br>nuclides in the combined<br>sample                               |
| Gaseous iodine in the air | SDS Moravský Krumlov<br>SDS Dolní Dubňany<br>SDS Slavětice<br>SDS Mohelno<br>SDS Rouchovany   | <i>weekly</i> ,<br>continuous sampling –<br>weekly cartridge<br>exchange interval   | <sup>131</sup> I   |
| Atmospheric fallouts      | SDS Moravský Krumlov<br>SDS Dolní Dubňany<br>SDS Slavětice<br>SDS Mohelno<br>SDS Rouchovany   | <i>monthly</i> ,<br>continuous sampling –<br>monthly sampling interval  | Gamma-emitting<br>nuclides: measuring of<br>the combined sample<br>from all places |
| Precipitation             | SDS Moravský Krumlov<br>SDS Dolní Dubňany<br>SDS Mohelno<br>SDS Rouchovany<br>Meteorological station at Dukovany NPP  | <i>monthly</i> ,<br>weekly sampling interval  | Tritium  |
| Surface water             | Jihlava River before the connection of the drainage: Vladislav, Dalešice reservoir<br>Jihlava River in the place of the connection of the drainage: Mohelno reservoir<br>Jihlava river under the connection of the drainage: Mohelno Mill, Hrubšice, M. Bránice, Dobřínský brook, Heřmanický brook, Moravský Krumlov – Rokytná river, Rešice – Olešná rivulet | Measurement and sampling:<br><i>quarterly</i> – waste channel, Mohelno Mill and the reservoir;<br><i>Annually</i> – other waters  | Gamma-emitting nuclides  |
|                           |   | Measurement and sampling: <i>annually</i> only Heřmanice brook, Mohelno Mill, Mohelno reservoir, Vladislav;<br><i>and others operatively</i> – in case of exceeding investigation level for the gamma-emitting nuclides | <sup>90</sup> Sr   |
|                           |   | Measurement and sampling:<br><i>monthly</i> – waste channel, Mohelno mill and the reservoir;<br><i>quarterly</i> – other waters   | Tritium  |
| Ground water              | Hydrological wells of surroundings – HVP No. 11÷18, 20, 21; HVM No. 31÷38   | Measurement and sampling:<br><i>annually</i> – wells HVP No. 21, HVM No. 36;<br><i>operatively</i> – other wells in case of exceeding investigation level for H3  | Gamma-emitting nuclides  |

| Monitored constituent   | Measuring points  | Measuring frequency, sampling interval   | Monitored radionuclides                             |
|---|---|--|---|
|   |   | Measurement and sampling:<br><i>quarterly</i> – HVP 21, HVM 36;<br><i>annually</i> – other waters  | Tritium   |
|   | Hydrological wells of surroundings – HVP No. 11÷18, 20, 21; HVM No. 31÷38                             | Measurement and sampling:<br><i>operatively</i> – in case of exceeding investigation level for AAŠP  | <sup>90</sup> Sr                                    |
| Drinking water:<br>Public water   | Water wells - Dukovany, Mohelno, Rouchovany, Kordula, Hrubšice<br>Water main - Ivančice, Mor. Bránice | Measurement and sampling:<br><i>monthly</i> – water main – Ivančice, M. Bránice;<br><i>annually</i> – Dukovany, Rouchovany, Mohelno, Kordula, Hrubšice               | tritium   |
|   |   | <i>annually</i>  | Gamma-emitting nuclides                             |
|   |   | <i>Annually</i> – Kordula, Hrubšice, water main – Ivančice, Mor. Bránice;<br><i>operatively</i> – others in case of exceeding investigation level for gamma nuclides | <sup>90</sup> Sr                                    |
| Sediments   | a) Jihlava river – profile Vladislav and Mohelno Mill<br>b) storage tank under WWTP                   | Measurement and sampling:<br><i>Annually</i>   | Gamma-emitting nuclides                             |
| Uncultivated land (fraction smaller than 2 mm):<br>The layer 0 to 10 cm | Dolní Dubňany, Mohelno, M. Krumlov, Rouchovany, Slavětice   | Measurement and sampling:<br><i>annually</i>   | Gamma-emitting nuclides                             |
| Fertile ground  | Dukovany  | Measurement and sampling:<br><i>annually</i>   | Gamma-emitting nuclides                             |
| Milk  | ZD Rouchovany   | Measurement and sampling: <i>once per two weeks</i>  | Gamma-emitting nuclides                             |
|   |   | Measurement and sampling:<br><i>annually</i>   | <sup>90</sup> Sr: combined sample per calendar year |
| Agricultural crops:<br>grass, clover,                                   | To the distance of approximately 6 km from Dukovany NPP   | Measurement and sampling: <i>once per vegetation period</i>  | Gamma-emitting nuclides                             |

| Monitored constituent  | Measuring points  | Measuring frequency, sampling interval  | Monitored radionuclides  |
|--|---|---|--|
| corn, beet, cereals (wheat, barley), potatoes, fruit – apples, leafy vegetable – cabbage |   | Measurement and sampling:<br><i>Annually – clover, wheat, apples, cabbage</i>   | <sup>90</sup> Sr   |
| Fish   | Dalešice–Mohelno  | Measurement and sampling:<br><i>Annually</i>                                    | Gamma-emitting nuclides  |
| The external environment of the Dukovany NPP, URAO, MSVP (TLD measurements)              | 55 measuring points <sup>4</sup> –external environment URAO – 4 measuring points, External environment MSVP, SVP – 6 measuring points   | continuous measurement<br><i>Quarterly</i> TLD exchange and evaluation interval | Average dose rate of photon equivalent of gamma emitting radiation |
| The external environment of the Dukovany NPP (gamma spectrometry in situ)                | Stationary dosimetric stations (Slavětice, Dolní Dubňany, M. Krumlov, Mohelno, Rouchovany) Biocentre, Municipal waste landfill Petrůvky | Measurement: <i>annually</i>  | Surface gamma emitting nuclides activity                           |
| The external environment of the Dukovany NPP, MSVP                                       | Stationary dosimetric stations (Slavětice, Dolní Dubňany, M. Krumlov, Mohelno, Rouchovany) Biocentre, Municipal waste landfill Petrůvky | Measurement: <i>annually</i>  | Average dose rate photon equivalent of gamma emitting radiation    |
| The external environment of the Dukovany NPP, MSVP (measuring using TDS 2, TDS 3)        | Surrounding villages <sup>5</sup>   | <i>continuously</i>   | Average rate of dose photon equivalent of gamma emitting radiation |

<sup>4</sup> Bačice, Běhařovice, Biskupice, Březník, Dalešice, Dobřínsko, Dolní Vilémovice, Dukovany, Džbánice, Hartvíkovice, Horní Dubňany, Horní Dunajovice, Horní Kounice, Hostěradice, Hostim, Hrotovice, Ivančice, Jamolice, Jaroměřice nad Rokytnou, Jevišovice, Ketkovice, Kladeruby n. Oslavou, Kralice nad Oslavou, Kramolín, Mikulovice, Miroslavské Knínice, Mohelno, Moravský Krumlov, Myslibořice, Náměšť nad Oslavou, Neslovice, Ocmanice, Odunec, Oslavany, Přešovice, Pyšel, Rešice, Rouchovany, Senorady, Slatina, Slavětice, Studenec, Tavíkovice, Trstěnice, Tulešice, Újezd u Rosic, Valeč, Vedrovce – Zábrdovice, Vémyslice, Višňové, Vladislav, Výčapy, Zastávka u Brna, Zbraslav, Zbýšov

<sup>5</sup> Slavětice, Rouchovany, Kordula, Rešice, Horní Dubňany, Dukovany, Mohelno, Moravský Krumlov, Březník, Senorady, Biskoupky, Jamolice, Dolní Dubňany, Vémyslice, Džbánice, Horní Kounice, Tavíkovice, Újezd, Přešovice, Krhov, Hrotovice, Dalešice, Kramolín, Sedlec



## 5.2.2 Emergency monitoring

Table II summarises the basic parameters of emergency monitoring, such as the monitored component of the environment, measuring points, measurement frequency and monitored radionuclides. Detailed monitoring methodology is described in Annex 3.

**Table II. Dukovany NPP emergency monitoring programme**

| Monitored component of the environment  | Method of sampling           | Locality Measuring points   | Measurement frequency  |
|---|------------------------------|---|--|
| Dose equivalent rate in the ZHP   | Continuous and discontinuous | Selected places in the ZHP  | <ul style="list-style-type: none"> <li>– stable TDS I, II, III systems continuously</li> <li>– portable RMMS and MMS devices discontinuously after the leakage</li> <li>– emergency TLD placed on a predetermined route after a leakage</li> <li>– stationary TLDs permanently located in 55 outdoor NPP locations</li> </ul>  |
| Air and soil in the ZHP – dose rate   | Continuous and discontinuous | <ul style="list-style-type: none"> <li>– predetermined places on the monitoring route</li> <li>– 16 places out of the NPP area</li> <li>– 16 places on the border of the NPP area</li> <li>– operationally selected locations in the ZHP</li> </ul> | <ul style="list-style-type: none"> <li>– stationary TDS I, II, III systems continuously</li> <li>– RMMS and MMS portable devices at least once every 6 hours from the beginning of the leakage on the monitoring route and always after the change of wind direction to another sector</li> <li>– emergency TLD placed on a predetermined route after No. 17 in after-leakage phase in all 16 sectors</li> </ul> |
| Air in the ZHP (gamma semiconductor spectrometry): <ul style="list-style-type: none"> <li>a) volume activity of aerosols</li> <li>b) volume activity of <sup>131</sup>I</li> <li>c) surface activity of the fallouts</li> </ul> | Continuous and discontinuous | Stationary dosimetric stations: Slavětice, Dolní Dubňany, NPP area, M. Krumlov, Mohelno, Rouchovany and operatively chosen locations in ZHP   | Immediately after the end of the leakage phase and at least once a week from the beginning of the leakage  |

| Monitored component of the environment  | Method of sampling | Locality<br>Measuring points   | Measurement frequency  |
|---|--------------------|--|--|
| Soil in the ZHP (gamma semiconductor spectrometry and field gamma semiconductor spectrometry):<br>a) surface activity of gamma emitting radionuclides<br>b) mass activity of gamma emitting radionuclides | Discontinuous      | <ul style="list-style-type: none"> <li>– uncultivated land: NPP area, Dolní Dubňany, Mohelno, M. Krumlov, Rouchovany, Slavětice</li> <li>– arable land: Dukovany</li> <li>– operationally selected locations in the ZHP</li> </ul> | At least two locations every 6 hours from the beginning of the leakage                                       |
| Water in the ZHP (gamma semiconductor spectrometry):<br>Surface and drinking water in the ZHP   | Discontinuous      | <ul style="list-style-type: none"> <li>– the Jihlava river under the drainage connection: Mohelno Mill</li> <li>– water main – Ivančice, Mor. Bránice</li> <li>– operatively chosen locations in ZHP</li> </ul>                    | Every 6 hours from the beginning of the leakage  |
| Agricultural crops (gamma semiconductor spectrometry):<br>agricultural crops according to the season in the ZHP   | Discontinuous      | Operatively chosen locations in affected ZHP   | At least two types of agricultural crops, at least once per every 12 hours from the beginning of the leakage |
| Milk in the ZHP (gamma semiconductor spectrometry)  | Discontinuous      | Sampling place in NPP surroundings in the ZHP  | 1 place in the prevailing wind direction at least once every 12 hours from the beginning of the leakage      |

### 5.3 SÚJB INDEPENDENT ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

The independent monitoring of Dukovany NPP surroundings is organised by the SÚJB. Monitoring is periodic with monthly, quarterly or annual sampling. If necessary, the inspector may decide to take extra samples. Part of the monitoring of the Dukovany NPP surroundings is the local TLDs quarterly collected by a mobile group.

Sampling points and frequency of sampling for independent monitoring are set out by the SÚJB and may not be the same as the sampling points of the NPP operator. The SÚJB Brno laboratory performs sampling for independent monitoring. An exception is the sampling of groundwater from wells or boreholes at the Dukovany NPP. Access to the wells is controlled so sampling can only be performed by the NPP staff. The inspector of the SÚJB can carry out random inspection of the sampling.

The details for monitoring of individual environment and food chain samples in the surroundings of the Dukovany NPP are given in table III. Monitoring locations are presented in Annex 4. The monitoring includes the determination of artificial radionuclides in the food chain (raw milk, corn, fruits, berries, mushrooms and feed) and in the environment (fallout, water, soil). All measurement results are uploaded and archived in the MonRaS database.

**Table III. Independent monitoring of Dukovany NPP surroundings**

| Item               | Quantity   | Sampling method                              | Sampling provided | Sample measurement | Frequency of monitoring  |
|--------------------|--|--|-------------------|--------------------|--|
| Surface water      | $A_V \text{ } ^3\text{H}$  | sample of water                              | RC Brno           | RC Brno            | <b>monthly:</b><br>River Jihlava – Vladislav<br>DR Dalešice – Hartvíkovice<br>DR Dalešice – the dam<br>DR Mohelno – under the dam<br>DR Mohelno – pumping station<br>River Jihlava – Mohelno<br>River Jihlava – Ivančice<br>River Jihlava – Ivančice under the confluence<br>Skryje stream |
| Surface water      | $A_V (\alpha)$<br>$A_V (\gamma)$<br>$A_V (\beta\text{sum})$            | sample of water                              | RC Brno           | RC CB              | <b>quarterly:</b><br>River Jihlava – Vladislav<br>River Jihlava – Mohelno<br>River Jihlava – Ivančice  |
| Surface water      | $A_V (\gamma)$<br>$A_V (\beta\text{sum})$<br>$A_V \text{ } ^3\text{H}$ | sample of water                              | RC Brno           | RC CB,<br>RC Brno  | <b>yearly:</b><br>ponds near EDU (tab. 3),<br>River Olešná (Rešice),   |
| Ground water       | $A_V \text{ } ^3\text{H}$  | sample of water                              | NPP               | RC Brno            | <b>yearly:</b><br>EDU: wells ČS1, ČS2, 4 holes in the EDU area   |
| Drinking water     | $A_V \text{ } ^3\text{H}$  | sample of water – public water pipeline      | RC Brno           | RC Brno            | <b>quarterly:</b> EDU surroundings: Ivančice – water supply system   |
| Drinking water     | $A_V (\gamma)$<br>$A_V (\beta\text{sum})$                              | sample of water – water supply system        | RC Brno           | RC CB              | <b>quarterly:</b> EDU surroundings: Ivančice – water supply system   |
| Rain water         | $A_V \text{ } ^3\text{H}$  | monthly sample                               | RC Brno           | RC Brno            | <b>monthly:</b><br>Dukovany,<br>Moravský Krumlov   |
| external radiation | PFDE   | TLD  | RC Brno           | SÚRO               | <b>quarterly</b>   |
| external radiation | PFDE   | measuring along the route of collection TLD  | –                 | RC Brno            | <b>quarterly</b>   |
| fallout            | $A_S (\beta\text{sum})$<br>$A_S (\gamma)$                              | collection on water surface (monthly sample) | RC Brno           | RC Brno<br>RC CB   | <b>monthly:</b><br>Dukovany, Moravský Krumlov  |
| soil               | $A_m (\gamma)$   | sampling                                     | RC Brno           | RC CB              | <b>yearly:</b><br>Dukovany   |
| food chain         | $A_m (\gamma)$   | sampling                                     | RC Brno           | RC CB, SÚRO        | <b>yearly:</b><br>according to the situation   |

## **5.4 MOBILE MONITORING SYSTEMS**

### **5.4.1 Mobile groups**

In the case of a radiological emergency, mobile groups (MS) can be established at each SÚJB regional centre (8 groups). Their main task is radiological emergency monitoring and monitoring during other events (dirty bomb, orphan sources, etc.). In the case of a radiological emergency, a two-person MS performs the monitoring within the Emergency Planning Zone (ZHP), or even beyond its borders. The monitoring comprises monitoring of PDE on pre-defined routes; potentially also the collection of gamma radiation spectra and monitoring of aerosols and iodine in the atmosphere with portable devices. Later they perform also water sampling, soil sampling and in-situ gamma spectrometry. All MS participate in regular training and exercises. The SÚJB MS regularly practise also the measurements on established routes. They perform route measurements during the TLD replacements every quarter.

ČEZ EDU has mobile groups that exchange TLDs and carry out changing filters, sampling on pre-defined routes and other activities in the ZHP.

### **5.4.2 Aerial monitoring**

Aerial monitoring is carried out by the SÚRO using a helicopter of the Czech Republic Army. During aerial monitoring a photon dose equivalent rate (PFDE) is determined, which is continuously and automatically converted into a dose at the height of one meter above ground. Gamma spectroscopic measurements can also be performed to determine the surface activity of selected radionuclides. Airborne monitoring can be performed by measuring instruments located in the helicopter flying about 100 m above the terrain on pre-defined routes. Measured values are entered on the map using computer programs; locations with different PFDE levels and activities are color-coded on the map. Aerial monitoring of a selected area is exercised once or twice a year.

## **5.5 METEOROLOGICAL MONITORING**

### **5.5.1 Czech Hydrometeorological Institute**

ČEZ has a monitoring contract with the Czech Hydrometeorological Institute (ČHMÚ), which is a specialised organisation providing hydrological and meteorological services at the national and international level. It is a state-subsidised organisation operating under the Czech Ministry of Environment.

The ČHMÚ's activities include the following: monitoring of quantitative and qualitative parameters of the air and water within the Czech territory; collecting, verifying, interpreting and archiving data and information on the condition of air and water; describing developments in the atmosphere and hydrosphere and issuing forecasts, warnings and other information regarding the atmosphere and hydrosphere.

The ČHMÚ obtains most of its data on the quality of air and water from the various monitoring facilities of the state hydrological and meteorological network. A key aspect of the institute's activities is the international cooperation and the exchange of data with counterpart services abroad.

### **5.5.2 Dukovany NPP meteorological observatory**

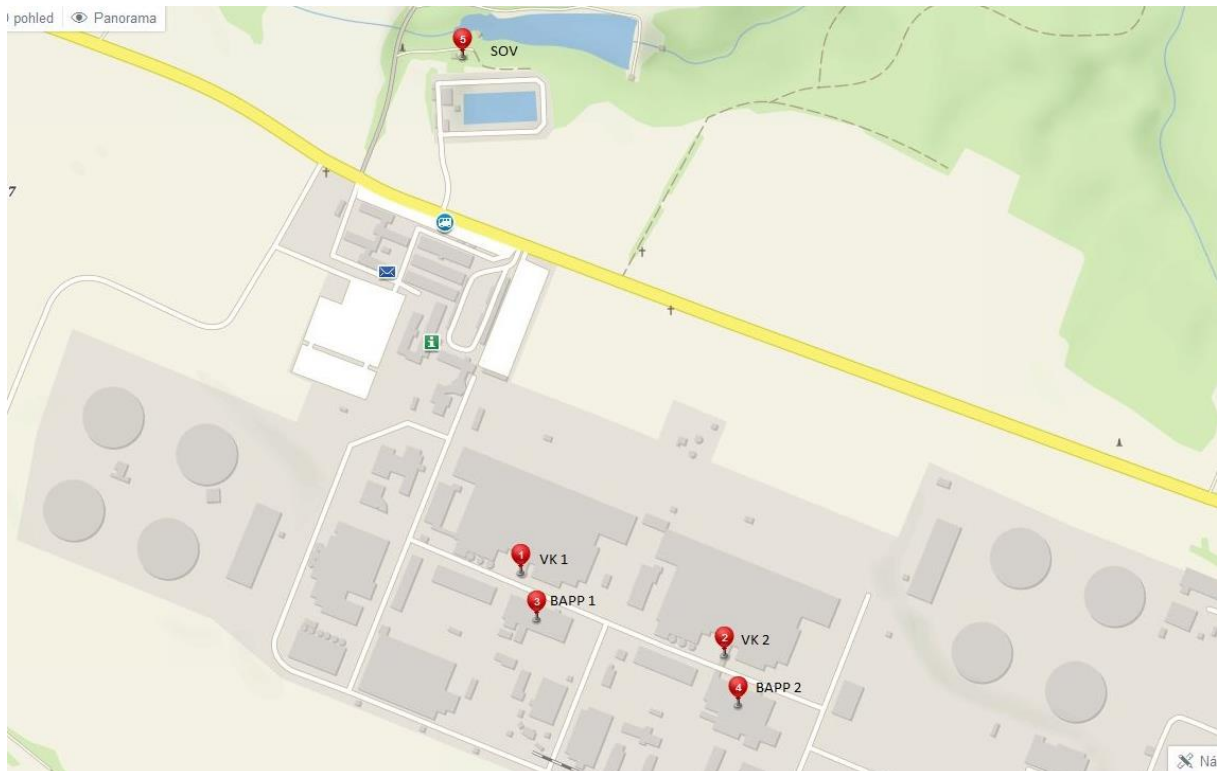
About 1 km northwest of the power plant there is an observatory for measuring meteorological parameters and radiation, which includes a 136 m high meteorological mast (for measuring the wind direction and speed, temperature and humidity at the given levels), complemented by measuring the vertical profile of atmospheric turbulence with a SODAR acoustic system. All measurements and observations for the Dukovany power plant are carried out in accordance with the applicable international standards of the IAEA.

## 6 DUKOVANY NPP LIQUID AND GASEOUS RADIOACTIVE DISCHARGE MONITORING PROGRAMME

### 6.1 INTRODUCTION

The four reactor units in the Dukovany NPP discharge gaseous radioactive material to the atmosphere via ventilation stacks and liquid radioactive material to the river Jihlava via a common sewage discharge channel.

Discharges are monitored by sampling and continuous on-line methods to ensure compliance with the statutory discharge limits. Regular discharge reports are prepared for the authorities. Figure 3 shows the monitoring locations.



**Figure 3. Monitoring locations of gaseous and liquid discharges (VK 1, 2 – Ventilation Stack, BAPP 1, 2 – Building of ancillary operations (control tanks), SOV – Waste water station)**

### 6.2 DISCHARGE LIMITS

#### 6.2.1 Gaseous discharges

Gaseous discharges are monitored in order to check compliance with the statutory limits and to notify when the radioactive substance limits for release to the environment are exceeded.

The conditions concerning radioactive substances releases to the environment are stipulated in the SÚJB Decision No. 12135/2007 of 5<sup>th</sup> April 2007 concerning the Dukovany NPP operator's application for "Radionuclide releases to the environment in the form of gaseous effluents". This decision permits radionuclide releases to the environment in the form of gaseous effluents in an amount not exceeding the authorised annual dose limit of 40  $\mu$ Sv for an individual from the critical population group. The dose is expressed as the sum of effective doses resulting from external radiation and the committed effective doses resulting from internal radiation. The verification of compliance with these limits is based on the following conditions:

1. The critical population group consists of individuals permanently residing within 5 km distance from the nuclear power plant central point.
2. The annual assessment (comparison between the actual values and the authorised limit) is performed by software approved by the SÚJB with a method in compliance with the SÚJB Directive VDS 030.
3. For the purpose of the effluents monitoring and control during the calendar year, the estimation of the sum of effective doses resulting from external radiation and total effective doses resulting from internal radiation is determined as a sum of the product of individual radionuclide activity released to environment during the given period and the conversion coefficient specified in table IV below. In the case that the released radionuclide activity for the given period is lower than the minimum significant activity (MSA) the released activity of such radionuclide shall be estimated as half of the MSA.

**Table IV. Dose conversion coefficients for gaseous releases**

|                  | h (Sv/Bq) |                    | h (Sv/Bq) |                   | h (Sv/Bq) |                    | h (Sv/Bq) |
|------------------|-----------|--------------------|-----------|-------------------|-----------|--------------------|-----------|
| <sup>3</sup> H   | 5,20E-22  | <sup>76</sup> As   | 1,08E-19  | <sup>124</sup> Sb | 8,46E-18  | <sup>135m</sup> Xe | 2,98E-21  |
| <sup>14</sup> C  | 1,93E-19  | <sup>85m</sup> Kr  | 2,55E-21  | <sup>125</sup> Sb | 3,57E-17  | <sup>135</sup> Xe  | 4,11E-21  |
| <sup>41</sup> Ar | 1,43E-21  | <sup>85</sup> Kr   | 4,31E-23  | <sup>129</sup> I  | 2,61E-16  | <sup>138</sup> Xe  | 7,02E-21  |
| <sup>51</sup> Cr | 8,48E-20  | <sup>87</sup> Kr   | 1,04E-20  | <sup>131</sup> I  | 1,34E-18  | <sup>140</sup> Ba  | 2,30E-19  |
| <sup>54</sup> Mn | 1,96E-17  | <sup>88</sup> Kr   | 3,00E-20  | <sup>132</sup> I  | 6,58E-20  | <sup>140</sup> La  | 3,94E-19  |
| <sup>59</sup> Fe | 4,04E-18  | <sup>89</sup> Sr   | 1,33E-19  | <sup>133</sup> I  | 2,29E-19  | <sup>141</sup> Ce  | 4,03E-19  |
| <sup>57</sup> Co | 3,06E-18  | <sup>90</sup> Sr   | 5,62E-17  | <sup>134</sup> I  | 4,29E-20  | <sup>144</sup> Ce  | 7,88E-18  |
| <sup>58</sup> Co | 5,37E-18  | <sup>95</sup> Zr   | 3,88E-18  | <sup>135</sup> I  | 1,07E-19  | <sup>238</sup> Pu  | 4,70E-15  |
| <sup>60</sup> Co | 3,39E-16  | <sup>95</sup> Nb   | 2,15E-18  | <sup>134</sup> Cs | 8,30E-17  | <sup>239</sup> Pu  | 5,16E-15  |
| <sup>65</sup> Zn | 1,22E-17  | <sup>103</sup> Ru  | 1,73E-18  | <sup>137</sup> Cs | 1,41E-16  | <sup>241</sup> Am  | 5,34E-15  |
| <sup>75</sup> Se | 4,69E-18  | <sup>110m</sup> Ag | 3,58E-17  | <sup>133</sup> Xe | 5,63E-22  |                    |           |

### 6.2.2 Liquid discharges

Liquid discharges are monitored in order to prove the statutory limits are met and to notify situations when the radioactive substance limits for release to the environment are exceeded.

The conditions concerning radioactive substances released to the environment are stipulated in the SÚJB Decision No. 12136/2007 of 5<sup>th</sup> April 2007 concerning the Dukovany NPP operator's application for "Radionuclide releases to the environment in the form of liquid effluents". This decision permits radionuclide releases to the environment in the form of liquid effluents in an amount not exceeding the authorised annual limit of 6 µSv for an individual from the critical population group expressed as the sum of effective doses resulting from external radiation and the committed effective doses resulting from internal radiation. The verification of how these limits are respected is based on the following conditions:

1. The critical population group consists of individuals permanently residing within the 10 km distance from the place of discharges of nuclear power plant.
2. The annual assessment (comparison between the actual values and the authorised limit) is performed by software approved by the SÚJB within a process performed according to the SÚJB internal directive VDS 030.
3. For the purpose of the effluents monitoring and control during the calendar year the estimation of the sum of effective doses resulting from external radiation and total effective doses resulting from internal radiation is determined as a sum of the product of individual

radionuclide activity released to environment during the given period and the conversion coefficient specified in table V. In the case that the released radionuclide activity value for the given period is lower than the minimum significant activity (MSA) the released activity of such radionuclide shall be estimated as half of the MSA.

**Table V. Dose conversion coefficients for liquid releases**

|                  | h (Sv/Bq) |                    | h (Sv/Bq) |                   | h (Sv/Bq) |
|------------------|-----------|--------------------|-----------|-------------------|-----------|
| <sup>3</sup> H   | 1,23E-19  | <sup>95</sup> Nb   | 7,41E-16  | <sup>240</sup> Pu | 1,79E-16  |
| <sup>14</sup> C  | 1,14E-16  | <sup>103</sup> Ru  | 6,93E-17  | <sup>241</sup> Am | 1,66E-20  |
| <sup>51</sup> Cr | 3,52E-18  | <sup>110m</sup> Ag | 5,22E-17  | <sup>242</sup> Cm | 1,13E-21  |
| <sup>54</sup> Mn | 7,40E-16  | <sup>124</sup> Sb  | 3,57E-18  | <sup>244</sup> Cm | 8,53E-22  |
| <sup>57</sup> Co | 1,09E-16  | <sup>125</sup> Sb  | 2,82E-19  | <sup>89</sup> Sr  | 1,22E-17  |
| <sup>58</sup> Co | 2,02E-16  | <sup>134</sup> Cs  | 4,53E-15  | <sup>90</sup> Sr  | 1,35E-16  |
| <sup>59</sup> Fe | 1,08E-17  | <sup>137</sup> Cs  | 5,88E-15  | <sup>131</sup> I  | 1,35E-16  |
| <sup>60</sup> Co | 1,27E-14  | <sup>141</sup> Ce  | 9,14E-18  | <sup>140</sup> Ba | 8,12E-19  |
| <sup>65</sup> Zn | 3,71E-16  | <sup>144</sup> Ce  | 2,37E-17  | <sup>76</sup> As  | 2,52E-19  |
| <sup>75</sup> Se | 3,11E-19  | <sup>238</sup> Pu  | 4,18E-17  | <sup>140</sup> La | 3,43E-18  |
| <sup>95</sup> Zr | 1,38E-16  | <sup>239</sup> Pu  | 4,26E-17  | <sup>181</sup> Hf | 8,34E-19  |

### 6.3 MONITORING OF GASEOUS DISCHARGES

Gaseous discharges are produced by air released from liquid agents of the NPP primary circuit and auxiliary systems or by possible occurrence in controlled areas of the NPP contaminated with radioactive gases and aerosols (noble gas radionuclides, tritium, radioactive aerosols, iodine radionuclides and other halogens and <sup>14</sup>C).

Handling of gaseous radioactive discharges is based on the separation of radioactive substances from contaminated air by filtration or delaying their release. Gaseous radioactive waste disposal starts with the organised collection from individual sources. The largest proportion of gaseous radioactive discharges is generated during the expansion of the released primary coolant. These gases are sent into the system of technological degassing where mechanical filtration, condensation and adsorption are used to reduce their activity. These methods separate most of the activity of aerosols, active gases and vapours (iodine and noble gases). The activity of noble gases is reduced by radioactive decay during their adsorption on activated carbon. Gaseous radionuclides are captured into liquid and solid phase, which can be further processed or stored. Another source of gaseous radioactive waste is gas released from liquids in liquid media tanks and radioactive liquid storage tanks. After checking its activity, the released gases are led through a ventilation stack shared by two units of the Dukovany NPP.

Radioactive discharges from the power plant are monitored by:

- standard system (measurement system under normal operating conditions – autonomous system PIGM-300E and measurement system under emergency conditions NGM-400E, PIS-300E)
- non-standard systems (continuous spectrometer of RVP discharges and sampling of aerosols, gaseous radioiodine, tritium and <sup>14</sup>C for laboratory analysis)

The two ventilation stacks (there is one ventilation stack shared by two units that create so called main production block – HVB) are the main release points of gaseous discharges in the Dukovany

NPP. All airborne discharges from both ventilation stacks (HVB1 and HVB2) enter in the register for the discharge of gaseous activities.

The range of radionuclides or groups of radionuclides monitored as part of the gaseous discharge is based on the SÚJB decision on releasing radionuclides into the environment in the form of gaseous discharges.

#### **6.4 MONITORING OF LIQUID DISCHARGES**

The activities of radioactive substances discharged from the NPP to watercourses are monitored in the place of origin (i.e. control tanks) in both active auxiliary operations (BAPP) buildings and then at the place of water discharged into the Jihlava river (in the waste channel). According to the sampling point, the monitoring of the discharges into the watercourse is divided into:

- Monitoring of volume activity of water released from control tanks
- Monitoring of the volume activity of water in the waste channel

In the control tanks, the activity in the water is controlled before its release begins. The control consists of sampling and spectrometric determination of total gamma activity per L and the activity per L of tritium in the chemical laboratory of a relevant HVB. If results are below the legal limits (<40 Bq/l for the total gamma activity and <1 E+6 Bq/l for activity of tritium) it is allowed to release the content of the control tank into the outside sewage system. In case of exceeding limits, it is not possible to release the tank to the sewage system and it is necessary to bring back its content to the sewage treatment plant.

Each control tank has to be released separately. A record of control tank releases into the sewage system is kept and archived. Water activity in the waste channel is continuously monitored regardless if any control tank is discharged. There are no automatic discharge cut-off systems in the event of unexpected high activities in the waste channel; the discharge cut-off is performed manually on the basis of monitoring.

Apart from the water samples for discharge analysis, a sample of water is taken from each control tank before its discharge to assess the activity of individual gamma radionuclides and tritium to the watercourses at the ERML in Moravský Krumlov. The samples from released control tanks for the whole month are collected, chemically modified, and transformed to enable determination the activity of individual radionuclides.

#### **6.5 SÚJB INDEPENDENT DISCHARGE MONITORING PROGRAMME**

##### **6.5.1 Gaseous discharges**

SÚJB carries out its own independent monitoring programme for gaseous discharges (Table VI). This monitoring includes:

- Determination of activity of noble gases in air samples from ventilation stacks (VK1 and VK2). Sampling is usually done during the refuelling outage.
- Determination of activity of gamma radionuclides captured on the aerosol filters in ventilation stacks (VK1 and VK2). Samples cover usually the first week of the refuelling outage.
- Determination of gaseous iodine from ventilation stacks (VK1 and VK2). Samples cover usually the first week of the refuelling outage.
- Determination of activity of <sup>3</sup>H in samples from ventilation stacks (VK1 and VK2). Samples cover usually the first week of the refuelling outage.
- Determination of activity of <sup>14</sup>C in samples from ventilation stacks (VK1 and VK2). Monthly sample covering usually first week of refuelling outage is evaluated.



- Determination of activity of alfa radionuclides and  $^{90}\text{Sr}$  captured on the aerosol filters in ventilation stacks (VK1 and VK2) – analysis of a joint sample from all filters of calendar year (1/4 of each week aerosol filter).

**Table VI. SÚJB independent monitoring of gaseous discharges**

| Item   | Quantity                            | Method of sampling  | Sample measurement | Frequency of monitoring                      |
|--|-------------------------------------|---|--------------------|--|
| RVP (outside $^{85}\text{Kr}$ )              | $A_v$<br>(instant value)            | NPP sampling to SURO's pressurised bottles (supervised by SÚJB) | SÚRO               | 2x/year VK-1, VK-2                           |
| Aerosols                                     | $A (\gamma)$<br>(weekly accounting) | whole filter NPP (weekly sample)                                | SÚRO               | 4x/year VK-1, VK-2                           |
| Iodine                                       | $A (\gamma)$<br>(weekly accounting) | weekly sample after measurement in the NPP                      | SÚRO               | 4x/year VK-1, VK-2                           |
| $^3\text{H}$                                 | $A (\beta)$<br>(weekly accounting)  | part of the weekly sample NPP                                   | SÚRO               | 4x/year VK-1, VK-2                           |
| $^{14}\text{C}$                              | $A (\beta)$<br>(monthly accounting) | combined weekly samples NPP                                     | SÚRO               | 4x/year VK-1, VK-2                           |
| Strontium ( $^{90}\text{Sr}$ ) in aerosols   | $A (\beta)$<br>(yearly accounting)  | ¼ filter NPP (weekly sample)                                    | SÚRO               | yearly – combined weekly samples VK-1, VK-2; |
| $\alpha$ -emitting radionuclides in aerosols | $A (\alpha)$<br>(yearly accounting) | ¼ filter NPP (weekly sample)                                    | SÚRO               | yearly – combined weekly samples VK-1, VK-2; |

### 6.5.2 Liquid discharges

SÚJB carries out its own independent monitoring programme for liquid discharges (Table VII). This monitoring includes:

- Monitoring of activity per L of  $^3\text{H}$ , gamma emitting radionuclides and total beta activity in samples of water from control tanks before discharge (proportional composite sample of the monthly release)
- Monitoring of activity per L of  $^3\text{H}$ , gamma emitting radionuclides and total beta activity in samples of water from the wastewater channel (sewer) (proportional compound weekly sample)

**Table VII. SÚJB independent monitoring of liquid discharges**

| Item                             | Quantity   | Monitoring method                           | Sample measurement | Frequency of monitoring |
|----------------------------------|--|---|--------------------|-------------------------|
| $^3\text{H}$ (tritium)           | A ( $\beta$ )<br>(monthly accounting)                    | part of the monthly compound sample from KN | RC Brno            | monthly BAPP EDU        |
| $\gamma$ -emitting radionuclides | A ( $\gamma$ )<br>(monthly accounting)                   | part of the monthly compound sample from KN | RC CB              | monthly BAPP EDU        |
| $\beta$ -emitting radionuclides  | A ( $\beta_{\text{sum}}$ )<br>(monthly accounting)       | part of the monthly compound sample from KN | RC CB              | monthly                 |
| $^3\text{H}$ (tritium)           | $A_v$ ( $\beta$ )<br>(average weekly value)              | part of the compound sample from SOV        | RC Brno            | weekly                  |
| $\gamma$ -emitting radionuclides | $A_v$ ( $\gamma$ )<br>(average weekly value)             | part of the compound sample from SOV        | RC CB              | weekly                  |
| $\beta$ -emitting radionuclides  | $A_v$ ( $\beta_{\text{sum}}$ )<br>(average weekly value) | part of the compound sample from SOV        | RC CB              | weekly                  |

## 7 LABORATORIES PARTICIPATING IN THE DUKOVANY NPP DISCHARGE AND ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMMES

### 7.1 SÚJB LABORATORY IN THE REGIONAL CENTRE ČESKÉ BUDĚJOVICE

#### 7.1.1 Introduction

The České Budějovice laboratory is responsible for independent monitoring of samples of liquid discharges by gamma spectrometry and total beta activity analysis. The activity of gamma emitting radionuclides is measured in liquid samples before discharge from the control tanks and from the wastewater channel. Total beta activity is determined in samples from the wastewater channel. Sampling is performed by the NPP operator. The SÚJB carries out random control of the sampling procedure. Requirements on independent monitoring are stipulated in the SÚJB internal document VDS 052.

Each sample received at the laboratory is identified by a unique number and registered in the “Book of samples” and in an MS Access database. A dispatch note is issued for each sample; this accompanies the sample from preparation through the processing and measurement to the evaluation. Dispatch notes are archived together with measurement results.

#### 7.1.2 Sample preparation and measurement

Water samples from control tanks, reservoirs and the waste channel are acidified to pH=1 and dried. Dry ash is burned at a temperature of 320°C. Then it is put into a petri dish and marked before gamma spectrometric and total beta activity analysis. Determination of radionuclide activity ( $^{51}\text{Cr}$ ,  $^{54}\text{Mn}$ ,  $^{57}\text{Co}$ ,  $^{60}\text{Co}$ ,  $^{110\text{m}}\text{Ag}$ ,  $^{124}\text{Sb}$ ,  $^{125}\text{Sb}$ ,  $^{134}\text{Cs}$ ,  $^{137}\text{Cs}$ ) by gamma spectrometric analysis is carried out using HPGe detectors and the NUVIA GAMWIN software.

The laboratory has 5 gamma spectrometry systems with HPGe detectors (Canberra, Ortec); standard counting time for a sample is 24 – 48 hours. GAMWIN analysis software is used for the spectrum analysis. The measurement equipment is metrologically verified by an authorised metrological institute (ČMI) every two years. Calculation of activity and measurement uncertainty is done automatically by the GAMWIN software.

Total beta activity is measured with a gas proportional detector Alfa-beta Automat EMS-3 (EMPOS). The standard counting time is 5000 seconds. Calculation of measurement results is done by built in software.

#### 7.1.3 Measurement results recording and archiving

The GAMVIN software calculates the results and generates reports for each measured sample. For samples below the detection limit, the GAMWIN calculates MSA and MDA which are then registered as the measurement result.

#### 7.1.4 Data handling and reporting

The lab has not introduced any electronic laboratory information management system. Sample identification and measurement results are manually inserted into the MonRaS database after internal validation by the responsible SÚJB inspector. The inspector can request for a new/repeated measurement or decide on the disposal of the sample.

The analysis results serve for the SÚJB inspectors in inspections of the NPP operator's compliance with the approved monitoring programme. The results serve also as a basis for the SÚJB annual report.

Samples are not stored. They are disposed of after validation of the measurement results based on a decision of the responsible SÚJB inspector.

### **7.1.5 Quality assurance and control**

The procedures for the laboratory operation – sampling, processing and measurement of samples – are described in SÚJB internal documents. Requirements on metrological verification of monitoring equipment and on quality assurance are listed in the SÚJB internal document VDS 044. A plan for calibrations and inter-laboratory comparisons is in place.

The laboratory is not accredited and no accreditation is required by law. The measurement equipment is metrologically verified by the ČMI every 2 years. The laboratory participates in the inter-laboratory comparison exercises organised by the SÚJB.

## **7.2 SÚJB LABORATORY IN THE REGIONAL CENTRE BRNO**

### **7.2.1 Introduction**

The SÚJB regional laboratory in Brno is responsible for independent monitoring of  $^3\text{H}$  in samples of liquid discharges by liquid scintillation analysis.  $^3\text{H}$  activity is measured in liquid samples taken before it is discharged from the control tanks and from the wastewater channel. Sampling is performed by the NPP operator. The SÚJB carries out random control of the sampling procedure. Requirements on independent monitoring are stipulated in the SÚJB internal document VDS 052.

### **7.2.2 Sample reception**

Each sample received at the laboratory is identified by a unique number and registered in the “Book of samples” and in an MS Excel database. Each sample is directly labelled with its number and a description. The lab has not introduced any electronic laboratory information management system. Sample specification (including the number of sample) and measurement results are manually inserted into the MonRaS database after internal validation by the responsible SÚJB inspector.

### **7.2.3 Sample preparation and measurement**

The  $^3\text{H}$  samples are prepared by distillation. The measuring cocktail (10 ml water sample + 10 ml liquid scintillator UltimaGold) is mixed in a 20 ml vial. The measurement of  $^3\text{H}$  is performed by a Tri-Carb 2910 TR liquid scintillation analyser. Standard measuring time of each sample is 180 min. The analysis procedure is described in the SÚJB internal document VDMI 070.

### **7.2.4 Measurement equipment**

The SÚJB laboratory in Brno has a Perkin Elmer Tri-Carb 2910 TR liquid scintillation analyser, serial number DG09118293 equipped with the QuantaSmart software. The equipment is metrologically verified by the ČMI every 2 years.

### **7.2.5 Measurement results recording and archiving**

All measurement results are recorded in the QuantaSmart software and report files are printed for each group of samples. The measurement result and their uncertainties are calculated automatically by the software. Detection limits are calculated depending on the individual measurement conditions (e.g. time of measurement).

Sample specification and measurement results are manually uploaded into the MonRaS database after internal validation by the responsible SÚJB inspector. The inspector can request new/repeated measurement or decide on the disposal of the sample.

Results are stored in the MonRaS database. The results serve for the SÚJB inspectors to verify the NPP operator compliance with the approved monitoring programme. The results serve also as a basis for the SÚJB annual report.

Samples are not stored. They are disposed of after the validation of measurement results by a decision of the responsible SÚJB inspector.

### 7.2.6 Quality assurance and control

Requirements on metrological verification of the monitoring equipment and on quality assurance are listed in the SÚJB internal document VDS 044. The measurement equipment is metrologically verified by the ČMI every 2 years.

Stability control is performed by the measurement of standards before the measurement of each sample set. The history of the IPA report files including the results is stored by the Tri-Carb software. Measurement control is performed by the measurement of samples of known activity (a  $^3\text{H}$  standard of the ČMI).

The laboratory is not accredited as no accreditation is required by law. The laboratory participates in the inter-laboratory comparison measurements organised by the SÚJB.

## 7.3 DUKOVANY NPP ENVIRONMENTAL RADIATION MONITORING LABORATORY IN MORAVSKÝ KRUMLOV

### 7.3.1 Introduction

The environmental radiation monitoring laboratory of the NPP Dukovany (LRKO EDU) is located in Moravský Krumlov and serves for the processing and evaluation of NPP discharge samples into the atmosphere and watercourses, and for the processing and evaluation of environmental samples.

The environmental radiation monitoring serves for control of discharges and early detection and evaluation of any potential leakages and their consequences for the inhabitants in the surrounding areas as well as on the environment. The monitoring includes measuring, monitoring, assessing and recording of values and parameters that characterise the radiation field and radionuclides present in the environment. The methods and means of this monitoring are described in document B116 – *Monitoring program for radiation protection* (discharge part). This document defines the requirements for controlling the components of gaseous and liquid discharges from the Dukovany NPP.

No third party is charged with the measurement of environmental samples. Only for measurement of trans-uranium elements in gaseous and liquid discharges the laboratory cooperates with the environmental radiation monitoring laboratory of the Temelín NPP.

### 7.3.2 Sample reception

In the LRKO EDU, the Spectrometer Information System (SPIS) is used for identification and registration of samples. Every received sample is registered in the SPIS and the system assigns a unique sample number to it. The number accompanies the sample during the processing and measurement. The measurement results are also stored under this number.

### 7.3.3 Sample preparation and measurements

The following methods are used for sample preparation before gamma spectrometric analysis:

- aerosols: the exposed filter is folded and inserted into plastic foil and labelled;
- gaseous iodine: the exposed iodine filter is inserted into plastic foil and labelled;
- water: samples from control tanks, reservoirs, waste channel are acidified to pH=1, put into the PE bottles and labelled.

Determination of radionuclide activity ( $^{51}\text{Cr}$ ,  $^{54}\text{Mn}$ ,  $^{57}\text{Co}$ ,  $^{60}\text{Co}$ ,  $^{110\text{m}}\text{Ag}$ ,  $^{131}\text{I}$ ,  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$ ) is performed by gamma spectrometric analysis using an HPGe detector and Canberra Genie software.

Measurement of  $^{89}\text{Sr}$  and  $^{90}\text{Sr}$  is performed by a FHT 770 beta radiation total activity meter with a gas proportional detector; samples are prepared by the Oxalate methodology.

Measurement of  $^3\text{H}$  is performed by TRICARB 3170 and TRICARB 3180 liquid scintillation analysers. Sample preparation involves distillation of the sample and mixing the sample cocktail (10 ml water sample + 10 ml liquid scintillator UltimaGold) in a 20 ml vial.

Measurement of  $^{14}\text{C}$  is performed by TRICARB 3170 and TRICARB 3180 liquid scintillation analysers. Sample preparation is done by mixing the sample cocktail (1 g precipitate  $\text{BaCO}_3$  + 7 ml water + 10 ml liquid scintillator InstaGel) in a 20 ml vial.

Measurement of  $^{14}\text{C}$  and  $^3\text{H}$  is performed by liquid scintillation analysers TriCarb 3170 and TriCarb 3180.

#### **7.3.4 Measurement equipment**

The LRKO EDU laboratory has the following measurement equipment:

- Laboratory and in-situ gamma spectrometry – 7 HPGe detectors with Canberra Genie 2000 software;
- Beta spectrometry laboratory – 1 Thermo Eberline FHT with FHT 770T Multi-Low-Level Counter software. Calculation of measurement results is performed by the SPIS software;
- Liquid scintillation analysers (TriCarb 3180 and 3170 with the Quanta Smart software).

The measurement equipment, including sampling equipment used for the radiation monitoring is subject to an annual calibration as well as to calibration by an authorised metrological institute (ČMI) every two years.

#### **7.3.5 Data handling and reporting**

All measurement results are recorded in the SPIS application. The SPIS automatically calculates measurement results, calculates detection limits and at defined intervals archives the results. The results are backed up and archived.

Measurement results are reported to the SÚJB in monthly, quarterly and yearly reports (activity of radionuclides in effluent samples, volume of effluents, effluents accounting, and results of calculation of a representative person effective dose). Moreover, measured data are inserted directly into the MonRaS database via a web interface. When exceeding the maximum permitted levels stated in the monitoring programme, the SÚJB is alerted within the same day.

After the measurement, approval and verification of the results, samples are archived or disposed of according to the type of sample. The LRKO sample archive provides sample storage for comparative and repeated measurements. Also the surveillance samples (samples before the start of the NPP operation and samples taken at the time of the Chernobyl accident) are stored in the LRKO archive. Physical sample protection is provided by the electronic security system installed in the LRKO building.

#### **7.3.6 Quality assurance and control**

The LRKO EDU is accredited according to ČSN EN ISO / IEC 17025:2005 for measurement of atomic and nuclear physics quantities, measurement of samples of media released from nuclear power plants into the environment, and measurement of environmental samples (No. 297/2014). The laboratory participates in the inter-laboratory comparison exercises organised by the SÚJB and ASLAB (Certification Office for Laboratory Eligibility of VÚV Prague).

## 8 VERIFICATIONS

### 8.1 MONITORING OF RADIOACTIVITY IN THE ENVIRONMENT AT THE DUKOVANY NPP AND IN ITS VICINITY

Both the NPP operator (ČEZ) and the regulator (SÚJB) conduct comprehensive monitoring programmes in the immediate vicinity and in the surrounding area of the Dukovany NPP. These programmes comprise online gamma dose rate stations, air and precipitation samplers and sampling points for various matrices (water, foodstuffs etc.). A detailed description can be found in Annex 2.

#### 8.1.1 On-site and off-site environmental monitoring

The verification team visited sampling points in the immediate vicinity of the power station where environmental samples are taken.

##### Mohelno village

The monitoring station on the outskirts of the village of Mohelno was visited. The sampling equipment consists of the following:

- Aerosol sampler: airflow of 40 m<sup>3</sup>/h collected on a filter, which is then measured with gamma spectrometry;
- Iodine sampler: airflow of 2.5 m<sup>3</sup>/h collected on an active carbon cartridge
- Wet deposition
- Dry deposition

The four samples are collected every Monday by staff from the NPP operator lab in Moravský Krumlov where they are subsequently analysed.

All equipment is installed inside a fenced and locked area free of obstructions. A TLD is also located inside the fenced area. Ambient gamma dose rate is also monitored regularly at this location using portable equipment.

The sampling station has no back up power or alarm in case of power shut down, but restarts automatically after a power interruption. All instruments are calibrated and store logs of the sampling volumes.

##### Mohelno dam

A common sampling point (NPP operator/regulator) close to the Mohelno dam, downriver of the NPP liquid discharge point, for surface water and sediments was visited. A staff member from the NPP operator lab demonstrated how surface water samples are taken. The sampler and bottle are rinsed before the definitive sample is taken. This sample was followed during the whole analysis cycle, i.e. from sampling and labelling to final reporting of the analysis results. It demonstrated how samples are taken, handled, analysed and reported during the analytical process.

##### Discharge locations

Although not strictly part of the environmental monitoring programme two liquid discharge locations were visited:

- The point where a weekly composite sample of the discharge water is taken to be analysed by both the NPP operator and SÚJB (gamma-emitters and <sup>3</sup>H)
- The point where discharged water (gamma-emitters and <sup>3</sup>H) mixes with water in a small stream just before entering the reservoir. Water from the reservoir is subsequently pumped uphill to supply cooling water to the NPP.

### **Meteorological station**

The meteorological station located at 1 km northwest of the NPP was visited. In this station all meteorological elements and radiation dose rate are monitored. A 136 meter mast allows monitoring the characteristics of the air turbulences.

### **Mohelno town centre**

A permanent gamma dose rate monitoring probe (ionisation chamber) situated in the town centre of Mohelno was visited. In total 51 such ionisation chambers are installed; 27 in the NPP fence, 8 in circle one (older type, planned to be replaced), and 16 in circle two (newer type) around the NNP. The two latter are equipped with radio transmission to transfer the data to the NPP control room and to the MonRaS monitoring system, as 10 minute real time averages.

The functionality control of the measurement stations is done once per year by the NPP operator using a  $^{137}\text{Cs}$  source. Every two years a metrological laboratory performs a calibration of the ionisation chambers. The equipment is covered by a service contract. Spare chambers are available. A maximum of two probes may be out of operation simultaneously. The device is fixed to the side of the building as shown on the Figure 4. It is not ideally situated (shielding from the building); the position had been determined for security reasons. The read-out is displayed on a screen at the entrance to the building (current reading, daily average for the current day as well as the previous day). A number of similar measurement stations and screens were seen during the course of the verification, but not visited.



**Figure 4. Gamma dose rate monitor in the Mohelno town centre**

### **Other locations**

A TLD (exchanged quarterly) belonging to SÚJB and a number of probes forming part of the Early Warning System (EWS) were verified. The latter are covered by a service and calibration contract with an industrial partner (Nuvia).

*No remarks.*

#### **8.1.2 SÚJB mobile measurement systems**

SÚJB has no mobile radiation laboratory vehicles, but each regional centre has hand-held radiation monitoring systems available for use in emergency situations. During the course of the visit a portable Mob-DOSE MK mobile gamma dose rate meter (manufactured by NUVIA with PICO Envirotec detector) was carried by a SÚJB staff member. It contains two energy compensated Geiger Tubes. The device covers a wide measurement range from 50 nSv/h up to 400 mSv/h of GDER (Gamma-Dose Equivalent Rate). The user interface and data acquisition system are based on the Android OS and can be hosted on any portable device such as a smartphone, a tablet or a notebook. The downloaded plot (data point every 2 seconds) from the portable PDOSE-3 mobile gamma dose rate meter which accompanied the verification team the previous day was shown, together with the upload of the data to the MonRaS system. These data can also be sent to a suitably equipped smartphone and thereafter sent by SMS allowing rapid updates to be gathered during field work. The



MonRaS system is a very powerful tool for analytical data management. All the analytical data uploaded in MonRaS are accessible for the general public.

The verification team verified also the mobile MOB-DOSE dose rate monitoring system used by the SÚJB Regional Centre in Brno. This hand-held system monitors the dose rates and maps them with GPS for transmission directly to the MonRaS database. In addition the centre has a hand-held nuclide identification system, a contamination monitor and several dose rate measuring devices.

*No remarks.*

## **8.2 MONITORING OF RADIOACTIVE DISCHARGES AT THE DUKOVANY NPP**

### **8.2.1 Gaseous discharges**

The verification team verified the arrangements for monitoring gaseous discharges at the common ventilation stack of units 3 and 4. The systems at the common ventilation stack for units 1 and 2 are identical to the verified systems. A bypass flow from the main stack at a height of 60 metres is directed to the sampling systems. The following radioactivity monitoring systems are in operation:

- Iodine sampler including a charcoal filter, pump and a flow counter (3.4 m<sup>3</sup>/h);
- Particulate material sampler including a filter (15×15 cm), pump and a flow counter;
- Noble gas monitor (ENVINET) based on an electrically cooled HPGe detector in a pressurised (10 bar) Marinelli container;
- gaseous discharges sampling system including an air compressor – used for an independent monitoring performed with SURO's pressurised sampling bottles ;
- 2 identical on-line systems for monitoring aerosols and iodine;
- Tritium and <sup>14</sup>C bubbler sampler.

Stack total flow is calculated using the average flow value of two identical ultrasonic flow measurement systems located at a height of 74.5 metres. Typically the total flow is about 45 000 m<sup>3</sup>/h.

The emergency monitors located in the auxiliary building next to the main stack gas outflow were also verified. These systems comprise an iodine filter sampler (P15-300E) and an emergency dose monitor (MDG-04 - 2 Geiger-Müller tubes designed for very high dose rates).

All the systems were operational and together form a very comprehensive monitoring arrangement for gaseous discharges. The reliability of the system is ensured by regular testing and inspections.

*No remarks.*

### **8.2.2 Liquid discharges**

The verification team verified the sampling arrangements from the Dukovany plant liquid discharge control tanks. All the systems were operational and together form a comprehensive monitoring arrangement for liquid discharges from the controlled areas.

The team was informed that the control tanks are filled and sampled within a few hours before the actual discharge takes place. This is necessary to have homogenous tank content before sampling and to avoid sedimentation inside the tank, as there are no mixing systems in the control tanks.

The final discharge valve is locked to avoid an accidental unmonitored discharge to the environment. The key is provided to the plant field operators only when the tank has been sampled and is ready for discharge.

*No remarks.*

### 8.2.3 Central dosimetry control room

The verification team visited the central dosimetry control room in order to verify the arrangements for taking the liquid samples from the control tanks, handling the sample data in the specific database and the approval steps taken before each tank discharge.

Sampling is carried out using a new plastic bottle with appropriate labels. Typically there are less than 10 liquid samples per week and 30-40 tank discharges per month.

*No remarks.*

## 8.3 ASSOCIATED ANALYTICAL LABORATORIES

### 8.3.1 SÚJB regional centre in Brno

The verification team visited the laboratory of the SÚJB regional centre in Brno. This is a small laboratory with a staff of 3-4 persons. It carries out  $^3\text{H}$  analysis in water samples from Dukovany and Temelín NPPs using a liquid scintillation counter (Perkin Elmer Tricarb 2910 TRI). Analysis results are introduced manually to the MonRaS system.

The number of samples is about 500 per year, some 300 of them from the Dukovany NPP. Samples are discarded after measurement. Sample records are kept on paper and on an MS Excel sheet. This system is simple, but could be difficult to manage if the number of incoming samples would increase, for example in an emergency situation.

The Brno laboratory is not accredited. Its LSC calibration standards are verified against a commercial standard twice a year. Every five years the laboratory participates in an inter-laboratory comparison exercise.

The verification team was informed that SÚJB plans to relocate the liquid scintillation counter in Brno to the České Budějovice laboratory.

*Verification team recommends that SÚJB considers improving the Brno laboratory capabilities in an emergency situation where the number of incoming samples significantly increases, both in terms of sample management and LSC counting capacity.*

*Verification team suggests more frequent participation in inter-laboratory comparison exercises*

### 8.3.2 ČEZ laboratory at the Dukovany NPP

The verification team verified the arrangements and equipment at the Dukovany NPP laboratory for analysing the samples received from the gaseous and liquid sampling systems. The laboratory carries out measurement of  $^3\text{H}$ , gamma emitting nuclides and  $^{14}\text{C}$  (charcoal filters). The laboratory equipment includes two HPGe detectors (Canberra / Genie 2000), two alpha spectrometers (Canberra 7401) and two liquid scintillation counters (HIDEX 300SL and HP TriCarb). Sample management, counting equipment and data management were found to be adequate. The use of the sample database was demonstrated to the verification team.

The laboratory is not accredited. It has participated in a few inter-laboratory comparison exercises with laboratories measuring samples from the environment, but not with similar nuclear facility laboratories.

HPGe detector management includes regular controls of detector energy, efficiency and resolution (FWHM) stability, but the monitored parameters are not plotted for long-term trend analysis.

*The verification team recommends that the plant laboratory investigates the possibility of having additional intercomparison exercises with other nuclear power plant laboratories.*

*As a matter of good laboratory practise, the verification team suggests long-term trend analysis of HPGe-detector calibration parameters, in particular resolution (FWHM of the  $^{60}\text{Co}$  peak at 1332 keV).*

### 8.3.3 ČEZ laboratory in Moravský Krumlov

The verification team visited the ČEZ laboratory in Moravský Krumlov, some 16 km from the Dukovany NPP. The laboratory carries out analysis of both environmental and discharge samples. It has been operational since 1982 - already before the NPP was constructed in order to characterize the original environmental conditions of the Dukovany site. It is staffed with nine people.

The laboratory is very well equipped to carry out analysis of both discharge (waste water, aerosol filters, iodine cartridges and  $^{14}\text{C}/^3\text{H}$  bubbler bottles) and environmental samples. Its main analysis equipment is the following:

- Thermo Scientific FHT 770T Multi Low Level counter for alpha/beta counting ( $^{90}\text{Sr}$  analysis)
- Perkin Elmer TriCarb 3180 and TriCarb 3170 TR/SI liquid scintillation counters ( $^3\text{H}$  and  $^{14}\text{C}$  analysis)
- Berthold LB770 10-channel alpha/beta counter (back-up unit)
- 6 Canberra HPGe detectors for gamma spectroscopy
- 1 mobile Canberra HPGe detector for in-situ gamma spectroscopy
- TLD-reader Harshaw 66000 PLUS for environmental radiation dose monitoring

ISO17025 accreditation is held for all analytical methods, with the exception of TLD readings. Strict separation measures are in place to avoid cross contamination as the laboratory deals with gaseous and liquid discharge samples containing more activity compared to the less active environmental samples. Two rooms are reserved, with appropriate access procedures, in the event of an emergency.

At the time of the visit 7 persons were employed to perform routine analysis. All equipment used for analysis is clearly labelled with the calibration date, whilst the relevant calibration certificates from the Czech Metrological Institute are readily available. All written measurement procedures are to hand beside the equipment.

Of note was that the laboratory carrying out  $^3\text{H}$  analysis has 5 separate columns for different water types and activities (ranging from 20-2000 Bq/l).

All relevant performance criteria of the analytical equipment are plotted against time. This allows the laboratory to assess the performance of the equipment and to take measures when underperformance is noticed.

The laboratory building is spacious and well suited for the purpose. UPS systems and one diesel generator are available for electrical power back-up. All analytical equipment is connected to the UPS system.

*No remarks.*

### 8.3.4 SÚJB regional centre in České Budějovice

Some analysis of environmental matrices (gamma emitters in environmental samples, gamma emitters in waste waters and total beta activity) is carried out in the SÚJB Regional Centre in České Budějovice. This building was built after the Chernobyl accident and was initially under the responsibility of the Ministry of Health, before passing to SÚJB in 1995. In 2018 it is planned to transfer the TriCarb monitoring apparatus currently located at Brno to České Budějovice and then to transfer ownership and responsibility for the laboratory to SURO.

### **Sample registration and preparation**

Samples are registered upon receipt in a logbook; sample information is written down on a small sheet kept with the sample during the whole analysis. Samples are clearly identified with their sample number. Water is concentrated; filters are dried and ashed. Samples for wet fallout (in dedicated pans for the various sites) and aerosol filters are also prepared. Analytical operations are noted down in logbooks. No electronic media is used. The sample throughput is of the order of 600 samples per year, mainly for gamma spectrometric and total beta analyses. As SURO already operates LIMS at other sites and will take over the ownership and responsibility of the laboratory it is planned to be implemented also at this location. This would facilitate the information management during of the whole analytical process.

### **Balances**

Calibration of the 2 electronic balances used for precision measurements is carried out yearly by an ISO certified metrology laboratory; meanwhile no routine checks with e.g. a check mass standard are performed.

### **Gamma spectrometers**

Five HPGe detectors, each colour coded, are available. GAMWIN software is used to obtain and analyse spectra. Samples for analysis are registered manually. A restricted nuclide library is used for environmental samples ( $^7\text{Be}$ ,  $^{40}\text{K}$ ,  $^{131}\text{I}$ ,  $^{134/137}\text{Cs}$ ,  $^{210}\text{Pb}$ ) whilst a more extensive library is used for discharge samples. A background spectrum of the individual detectors is taken only once a year, while the full energy peak efficiency is determined every two years. There is no systematic follow up of the instruments analytical performance parameters by means of e.g. control chart. Energy calibration is adjusted if necessary. All obtained spectra are saved and regular backups are made. A print out of the analytical report is attached to the sample sheet.

### **Reporting and archiving**

All analytical data are manually introduced in the MonRaS system - automatization would prevent transcription errors. If the same sample is analysed for other compounds in another lab the data of the sample are combined. The data must nevertheless be validated by an administrator before becoming available online. Reference levels have been set for each analysis. These would alert the administrator if exceeded.

The samples are archived for a maximum of 5 years. The print outs of the reports are also archived.

### **Quality assurance**

Currently participation in interlaboratory comparison exercises is limited to one annual exercise organised within the Czech Republic. This involves normally an unknown liquid sample measured during 2 hours with the results to be given within 24 hours.

### **Environmental monitoring**

A JL Hunter 150 aerosol sampler is situated in the garden adjoining the building of the laboratory. There is also a wet fallout collector belonging to the national monitoring network. Furthermore a gamma dose rate and aerosol monitor belonging to the Austrian radiation monitoring network is installed under a bilateral agreement.

*The verification team recommends introducing control charts for all detectors in order to follow up the analytical equipment performance (stability of energy calibration, efficiency calibration and resolution (FWHM)).*

*The verification team recommends increasing participation in interlaboratory comparison exercises (possibly at international level) to benchmark the laboratory's analytical performance.*

*The verification team suggests automating the transfer of analytical data to the MonRaS system. Digital media could be used to store the analytical reports.*

*As a matter of good laboratory practise, the verification team suggests introducing control charts to monitor the balances' performances.*

## 9 CONCLUSIONS

All planned verification activities were completed successfully. The information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, proved very useful.

The information provided and the verification findings lead to the following observations:

- (1) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the air, water and soil on and around the Dukovany NPP site are adequate. The Commission could verify the operation and efficiency of a representative part of these facilities.
- (2) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the gaseous and liquid discharges at the Dukovany NPP site are adequate. The Commission could verify the operation and efficiency of a representative part of these facilities.
- (3) A few recommendations and suggestions are formulated, in particular concerning quality management practises in the associated laboratories. Notwithstanding these remarks the verified parts of the monitoring system for environmental radioactivity and the discharge monitoring arrangements in place at the Dukovany NPP are in conformity with the provisions laid down under Article 35 of the Euratom Treaty.
- (4) The verification summary is presented in the 'Main Conclusions' document that is addressed to the Czech Republic competent authority through the Permanent Representative of the Czech Republic to the European Union.
- (5) The Commission services request a report on the implementation of the recommendations by the Czech authorities and about any significant changes in the set-up of the monitoring systems before the end of 2019. Based on this report the Commission will consider the need for a follow-up verification.
- (6) The verification team acknowledges the excellent co-operation it received from all persons involved in the activities it performed.

## VERIFICATION PROGRAMME

## Dukovany NPP discharge and environmental monitoring and national environmental radioactivity monitoring network in the vicinity

**2-5 October 2017**

| Day/date                   | Time          | Team 1  | Team 2   |
|----------------------------|---------------|---|--|
| <b>Monday 2 October</b>    | 15.30 – 17.00 | Opening meeting with national authorities and NPP representatives in Dukovany   |  |
| <b>Tuesday 3 October</b>   | 9.00 – 12.30  | Verification of liquid discharge monitoring   | Verification of operator's and regulator's on-site and off-site environmental monitoring and stations of national monitoring programme in the vicinity |
|                            | 13.30 -17.00  | Verification of gaseous discharge monitoring  |  |
| <b>Wednesday 4 October</b> | 9.00 – 17.00  | Visit to ČEZ, a. s. Environmental Radiation Monitoring Laboratory Moravský Krumlov (LRKO EDU)<br><br>Visit to SÚJB Regional Centre Brno | Visit to SÚJB Regional Centre České Budějovice   |
| <b>Thursday 5 October</b>  | 9.00 – 12.30  | Finalise verifications of liquid and gaseous discharge monitoring   | Finalise verifications of on-site and off-site environmental monitoring  |
|                            | 13.30 – 15.00 | Emergency monitoring arrangements   |  |
|                            | 15.00 – 16.00 | Closing meeting with national authorities and NPP representatives in Dukovany   |  |

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**MONITORING METHODOLOGIES IN THE DUKOVANY NPP VICINITY UNDER ROUTINE CONDITIONS**

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**INTRODUCTION**

For the processing and evaluation of the discharge samples of the NPP into the air and water, and for the processing and measuring samples for monitoring the radiation situation in the surroundings of NPP, a separate Environmental Radiation Monitoring Laboratory (ERML EDU) in Moravský Krumlov has been established, as well as the dosimetric radiation monitoring Stations in Dolní Dubňany, Mohelno, Moravský Krumlov, Rouchovany, Slavětice and in the ČEZ-EDU area.

Between the years 1982-1984, pre-operational monitoring of the Dukovany NPP surroundings took place. The monitoring facilitated gaining the necessary documentation on the original state of the Dukovany NPP environment as well as the necessary data and experience for the NPP operation period. It also checked the preparedness of the monitoring systems prior to the NPP operation. The selection and testing of optimal methods of sampling, processing and measuring of environmental samples in the vicinity of the Dukovany NPP was carried out. The method of evaluation and interpretation of the measured values was verified. All measuring devices are legally verified by the Czech Metrology Institute.

The radiation dose measurement by thermoluminescent dosimeters is linked to calibration in the accredited calibration laboratory of the Dukovany NPP. The radiometric measurements and radiochemical analysis carried out as part of the radiological control of the surroundings are linked to national standards.

Operational monitoring regularly provides quarterly and annual reports, which are transmitted to the state oversight and provided to the general public. These controls are provided by:

- ERML equipment for sampling and analysis
- Dosimetric stations for radiation monitoring of surroundings for aerosol samples, gaseous radioiodine, and precipitation water
- Groundwater monitoring system in and around the NPP
- Thermoluminescent dosimetry for measuring doses and dose rates of gamma radiation
- Mobile monitoring groups

In the Dukovany NPP emergency planning zone there are 6 circularly distributed dosimetric stations in operation. The location and number of stations was determined on the basis of the population density in the given sector, the geographical situation and the long-term monitoring of meteorological data (prevailing wind directions). They are located in the villages Dolní Dubňany, Mohelno, Rouchovany and Slavětice. One of the stations is located directly at the power plant area and one in the ERML area in Moravský Krumlov. The following monitoring is performed:

- The long-term radioactive aerosol control is carried out by continuous sampling by large-volume sampling devices with entrapment of aerosol particles on a fixed filter, which are placed at the dosimetric stations. The evaluation takes place once a week in the ERML.
- The control of the gaseous radioiodine is carried out by continuous sampling by a sampling device with entrapment of gaseous iodine on an iodine cartridge placed at the dosimetric stations. The evaluation takes place once a week in ERML.
- At the stationary dosimetric stations there are also devices for the collecting precipitation for a monthly evaluation in the ERML.
- At regular monthly and quarterly intervals, surface water is monitored in nearby rivers and dams.
- At regular quarterly and annual intervals, drinking water in neighbouring villages is monitored.



- At regular monthly intervals, groundwater in the NPP area and its vicinity is monitored in the network of control boreholes.
- Milk is sampled once every two weeks from the dairy in Rouchovany.
- Agricultural products are checked once per year out to a distance of about 5 km from the power plant. They are controlled with special regard to the protection zone, especially in the cadastres of the municipalities of Dukovany, Mohelno, Slavětice and Rouchovany.
- The sediment control in the Jihlava River and in the wastewater channel is carried out annually.
- Soil control is carried out annually at the fixed dosimetric stations in the municipalities of Dukovany, Mohelno, Slavětice, Rouchovany, Moravský Krumlov and ČEZ-EDU area.
- In the Dalešice reservoir, fish control is carried out once per year.

Measurement and sampling is performed by mobile monitoring groups. For this task, ERML is equipped with a car with increased terrain mobility. The vehicle is equipped with a radio. Further equipment differs according to the activity of the monitoring group (in particular the dose and dose rate measuring device, the contamination measuring device, the aerosol and iodine take-off device from the air, sampling of the environment, gamma radiation spectroscopy device with a semiconductor detector).

### **BASIC METHODS OF MONITORING**

The Environmental Radiation Monitoring Laboratory of the Dukovany NPP in Moravský Krumlov serves for the processing and evaluation of samples of NPP discharges into the air and watercourses, and for the processing and evaluation of environmental samples.

By a decision of the State Office for Nuclear Safety's, the ERML workplace is classified in category I and is allowed to handle sources of ionising radiation. It is an accredited testing laboratory No. 1241.3. The accreditation certificate is issued by the Czech Accreditation Institute based on the assessment of compliance with accreditation criteria according to ČSN EN ISO/IEC 17025:2005. The subject of accreditation is the measurement of quantities in atomic and nuclear physics, the measurement of samples of media discharged by the nuclear power plant into the environment and the measurement of environmental samples.

The ERML carries out the laboratory determination of the artificial radionuclides activity using spectrometric analysis of gamma radiation with semiconductor detectors, determination of activity of artificial radionuclides based on beta radiation by liquid scintillation spectrometry, determination of integral doses by thermoluminescent dosimeters and operational determination of beta and gamma activity of samples. Furthermore, the determination of artificial radionuclides by in-situ gamma spectrometric analysis is carried out, as well as dose rate measurements.

The methods and means of monitoring, measuring, evaluation and recording the quantities and parameters characterising the field of ionizing radiation and the occurrence of artificial radionuclides for the assessment of discharges and the control of potential leakages and their consequences for the population in the vicinity of ČEZ-EDU and for the environment are described in document B117 – Radiation Protection Monitoring Program, approved by the State Office for Nuclear Safety.

### **MONITORING METHODOLOGY**

The following sections describe in more detail the devices used for the sampling of individual components of the environment and their analysis.

#### **Aerosols and iodine**

Aerosol sampling for determination of gamma radionuclides is carried out in stationary dosimetric stations using high-volume air sampler devices VOPV-200, VOPV-12 and NuRMS EGS-40 with a flow rate of 40 m<sup>3</sup>/h (flow control capability ranges from 5 to 140 m<sup>3</sup>/h). Air sampling for <sup>131</sup>I determination is carried out in stationary dosimetric stations using air sample devices VOPV-200,

VOPV-12 and NuRMS EGS-40 with a flow rate of 2,4 m<sup>3</sup>/h (flow control capability ranges from 1 to 6 m<sup>3</sup>/h). Aerosols and gaseous iodine are evaluated regularly, once per week.

Determination of volume activity of radionuclides emitting gamma radiation in aerosol filters and determination of volume activity of <sup>131</sup>I in iodine cartridges is performed using gamma semiconductor spectrometry software Genie 2000 by Canberra.

#### **Atmospheric fallouts**

Fallout is sampled monthly by sampling devices placed in the radiation control stations in the surroundings. The sampling area is 0.031 m<sup>2</sup>. The device does not allow the differentiation of wet and dry fallouts. Determination of volume activity of selected radionuclides emitting gamma radiation is performed using the gamma semiconductor spectrometry software Genie 2000 by Canberra.

#### **Surface water**

5 litres of surface water is sampled for the determination of gamma nuclides. Samples are adjusted for measurement by evaporation. Determination of volume activity of selected radionuclides emitting gamma radiation is performed using the gamma semiconductor spectrometry Genie 2000 by Canberra. For volume activity determination of <sup>90</sup>Sr, a sample of 5 litres is taken. Strontium separation utilises the oxalate methodology. The measurement is carried out on the Thermo FHT 770 T6 flow proportional detector. Samples for tritium determination are taken separately and are distilled for measurement. Measurements are carried out on a TRICARB liquid scintillation analyser.

#### **Groundwater**

5 litres samples for gamma nuclides analysis are taken at the given wells. Samples are treated in the same way as for surface water.

#### **Drinking water**

5 litres of drinking water is sampled for the determination of gamma nuclides. Samples are treated in the same way as for surface water.

#### **Sediments**

Sampling and analysis of sediment samples according to the monitoring program are carried out once a year at the surface water sampling points. Determination of gamma radiation radionuclides is carried out in a surface layer taken up to a depth of 5 cm, a fraction with a particle size of less than 2 mm is taken for measurement. Determination of the specific activity of selected radionuclides emitting gamma radiation is performed using the gamma semiconductor spectrometry software Genie 2000 by Canberra.

#### **Soil**

Soil sampling of is carried out once a year. Determination of the specific activity of selected radionuclides emitting gamma radiation is performed using the gamma semiconductor spectrometry software Genie 2000 by Canberra.

#### **Milk**

Milk samples are taken at fourteen-day intervals. 3 litre samples of raw milk are measured for gamma nuclide content. Determination of the specific activity of selected radionuclides emitting gamma radiation is performed using the gamma semiconductor spectrometry software Genie 2000 by Canberra. In the combined milk samples per calendar year, the <sup>90</sup>Sr volume activity is determined using oxalate precipitation method. The <sup>90</sup>Sr measurement is carried out on the Thermo FHT 770 T6 flow proportional detector.

### **Agriculture crops**

The specific activity of gamma nuclides in agricultural crops (grass, clover, wheat, barley, apples, corn, potatoes, cabbage, beet) is determined once a year in ash (i.e. it is based on 3 kg of fresh matter). Determination of the specific activity of selected radionuclides emitting gamma radiation is performed using the gamma semiconductor spectrometry software Genie 2000 by Canberra. In the samples of agricultural crops (clover, wheat, apples, cabbage), the  $^{90}\text{Sr}$  volume activity is determined using the oxalate precipitation method. The  $^{90}\text{Sr}$  measurement is carried out on the Thermo FHT 770 T6 flow proportional detector.

### **Measurement of photon dose equivalent rate of gamma radiation using TLD**

Quarterly average values of photon dose equivalent rate of gamma radiation is determined using the TLD-100H thermoluminescence dosimeter and the HARSHAW 6600 TLD reader.

### **Portable semiconductor gamma spectrometry (measurement in-situ)**

A portable gamma spectrometric set consisting of an HPGe detector placed on a rack at a height of 1 m above the ground is used to determine the surface activity of gamma nuclides deposited on the surface. A portable analyser (Canberra Inspector) is connected to it and measurements are evaluated using the Genie 2000 software.

### **Measurement of photon dose equivalent rate of gamma radiation using portable devices**

Measurement of photon dose equivalent rate is carried out using portable devices in parallel with field gamma spectrometric measurements on uncultivated soils near dosimetric stations. A RSS 131 pressure ionisation chamber by Reuter-Stokes is used for the measurement.

### **Measurement of photon dose equivalent rate of gamma radiation using teledosimetric system**

These measurements are part of the early detection network of the Czech Republic. In the vicinity of the Dukovany NPP there are 24 measuring points, which are equipped with BITT probes and GammaTracer XL 2 probes, which record minute averages of dose rate equivalent. This is an online measurement. Values are transferred to Dukovany NPP, where they are displayed on the relevant service points and stored in the SW CISRK system after conversion to ten-minute averages.

In addition, there are 27 monitors of dose equivalent rate located on the Dukovany NPP fence, from which the information is also transferred to the relevant service points.

### **Fast mobile monitoring group**

A fast mobile monitoring group is activated in emergency situations. Its main focus is TLD collection and direct dose input measuring. It uses the following equipment:

- off-road monitoring vehicle
- dose rate gamma radiation device with fittings
- surface contamination meter
- electronic dosimeter
- vehicle radio
- mobile phone
- GPS navigation

### **Mobile monitoring group**

The main task of the mobile monitoring group is to collect environmental samples, including aerosols and iodine samples or dose equivalent input measurement. It uses the following equipment:

- off-road monitoring vehicle
- dose rate of gamma radiation device with fittings (RSS 131 or RadEye B20-ER)
- RadEye B20-ER surface contamination meter

- large volume sampling device with fittings (VOPV-200, VOPV-12, NuRMS EGS-40)
- device for soil samples
- electronic dosimeter
- Honda Ex 1000 power generator with fittings
- mobile phone
- vehicle radio

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## MONITORING METHODOLOGIES IN THE DUKOVANY NPP VICINITY UNDER EMERGENCY CONDITIONS

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The purpose of emergency environmental monitoring is:

- **fast identification of essential information** for early implementation of urgent measures to protect the population, for detection of leakage outside the NPP area, for prediction and monitoring of the radioactive cloud movement and for determination of the first forecasts of the radiation situation in the vicinity;
- **gradual finding of detailed information** for implementation of follow-up measures to regulate the use of contaminated food and water and for subsequent measures for resettlement of the population.

Emergency monitoring of Dukovany NPP vicinity is connected to the monitoring of the environment under normal operation. It is carried out according to the SÚJB approved Monitoring Program of Radiation Protection.

Monitoring is carried out in the emergency planning zone, which is divided into 16 sectors. For monitoring purposes by fast mobile monitoring groups, 16 monitoring routes are prepared according to the expected radionuclide spread in the affected area, and one route, which includes monitoring across all 16 sectors. In the event of a significant change in the meteorological situation, a change of the monitoring route is made.

Monitoring of the territory outside the emergency planning zone is ensured by state organisations organised in the national radiation monitoring network.

**Monitoring of dose rate in the vicinity of NPP** is done in the following ways:

- TDS II, III – stationary teledosimetric system of the II and III circuit – 24 measuring points in municipalities around the NPP (TDS II includes 8 measuring points; TDS III includes 16 measuring points);
- RMMS and MMS – dose rate measuring on the selected monitoring route using portable devices;
- dose rate measuring using TLD (RPLD) – evaluation TL-dosimeters distributed in the outdoor NPP environment in 55 stationary measuring points.

**Emergency air monitoring in the vicinity of NPP** is done in the following ways:

- gamma aerosols volume activity in stationary dosimetric stations;
- $^{131}\text{I}$  volume activity in stationary dosimetric stations;
- surface activity of fallouts;
- aerosols volume activity at selected places using a mobile sampling device.

In the vicinity of the Dukovany NPP there are 6 stationary dosimetric stations with sampling devices to determine the volume activity of aerosols,  $^{131}\text{I}$  and the surface activity of fallout. The MMS vehicle is equipped with a mobile air sampling device for sampling aerosols at selected places.

**Emergency ground surface monitoring in the vicinity of NPP** is carried out in the following ways:

- in-situ surface gamma activity
- mass gamma activity of soil

The MMS vehicle is equipped with a special sampling device for soil sampling. Samples are measured by semiconductor spectrometry in the ERML. The vehicle is also equipped with a device for measuring surface activity of radionuclides by an in-situ method using a semiconductor detector.

The measuring points are determined in the affected areas. Priority is given to measuring and sampling “hot” spots detected during the dose rate input measuring in ZHP. MMS will ensure soil monitoring within the required range (at least 2 places every 6 hours from leakage).

**Emergency water monitoring in the vicinity of NPP** is done in the following ways:

- gamma volume activity of surface water in the Jihlava River under the drainage channel connection at the Mohelno Mill;
- gamma volume activity of drinking water in public water supply systems.

The MMS vehicle is equipped with a PE sampling device for sampling water, which is then measured by semiconductor spectrometry in the ERML. MMS will ensure the monitoring of water within the required range – every 6 hours from the leakage.

**Emergency agricultural crop monitoring in the vicinity of NPP** is done in the following ways:

- the mass gamma activity of agricultural crops samples in the emergency planning zone

MMS ensures the monitoring of agricultural crops within the required range. Two available types of agricultural crops will be sampled. These types will be chosen on the basis of the growing season at least once per 12 hours from the beginning of the leakage. The samples are taken in a manner appropriate to the given crop and then measured by gamma spectrometry in the ERML.

**Emergency milk monitoring in the vicinity of NPP** is done in the following ways:

- gamma mass activity of milk in the vicinity of NPP

The agricultural cooperative personnel take a sample of milk from the milk storage room and hand over to the crew of the MMS vehicle. Samples are then transported to ERML and measured using gamma spectrometry. MMS will monitor the milk within the required range (1 point in the prevailing wind direction at least every 12 hours from the beginning of the leakage).

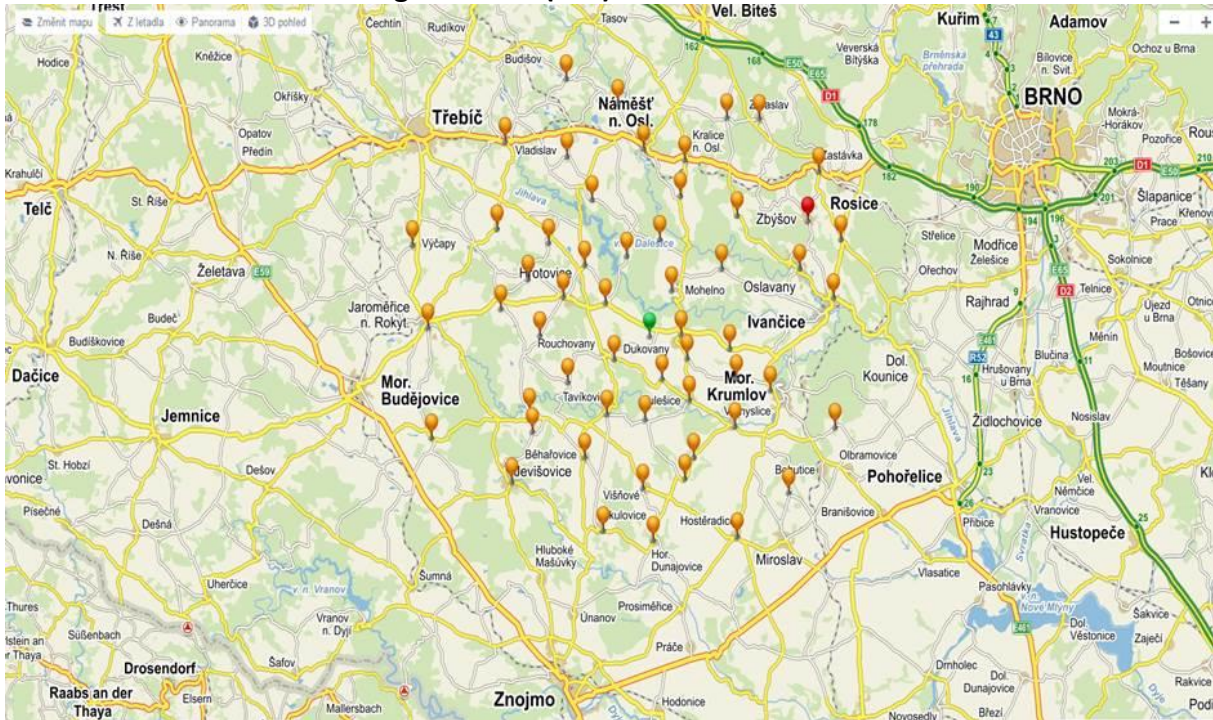
The monitored constituents of the environment and food chain links, monitored quantities and sampling frequencies in the emergency planning zone during the leakage are listed in the table below.

| Monitored constituent of the environment | Measured quantity   | Measurement frequency  |
|--|---|--|
| Air + soil                               | Dose rate   | At least once per 6 hours after the leakage announcement and always down the wind to another sector in terms of portable device monitoring.<br>For monitoring by TLD, the period is determined operably. |
| Air                                      | Volume activity of artificial radionuclides in the air                              | Immediately after the leakage and then at least once a week  |
| Soil                                     | Surface and mass activity of soil   | Every 6 hours after the leakage  |
| Water                                    | Volume activity of water under the drainage connection and in the public water main | Every 6 hours after the leakage  |
| Agricultural crops                       | Mass activity of artificial radionuclides   | At least once per every 12 hours from the beginning of the leakage   |
| Milk                                     | Volume activity of artificial radionuclides   | At least once per every 12 hours from the beginning of the leakage   |

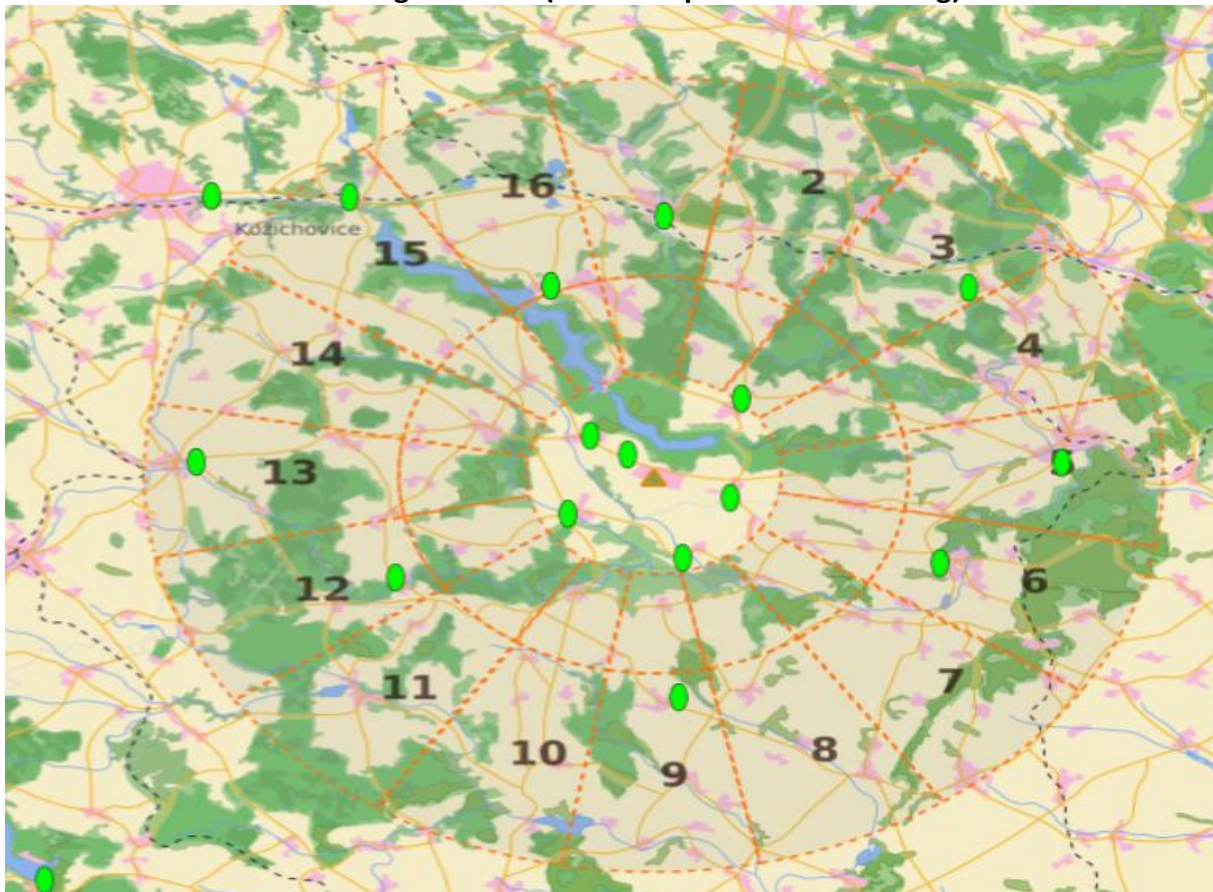


MAPS OF ENVIRONMENT MONITORING LOCATIONS

TLD radiation dose monitoring locations (ČEZ)

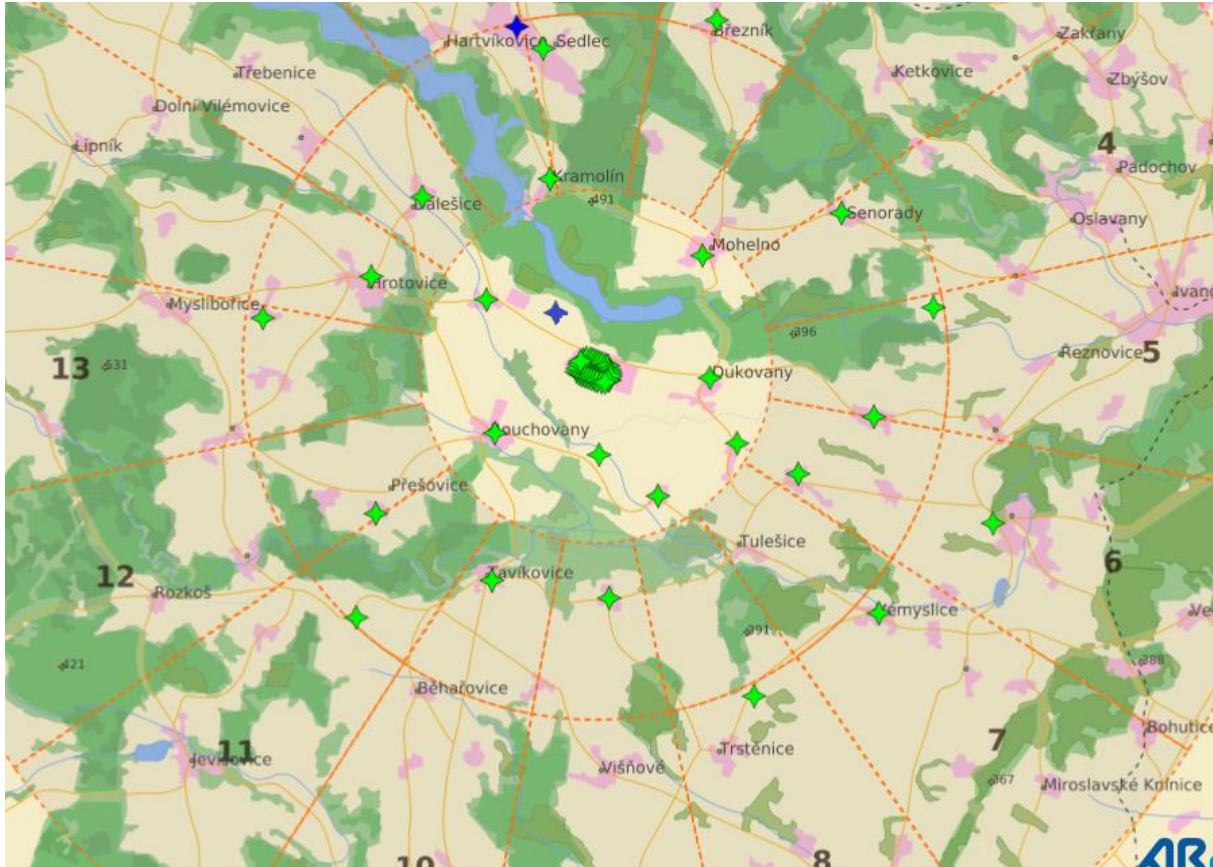




TLD radiation dose monitoring locations (SÚJB independent monitoring)



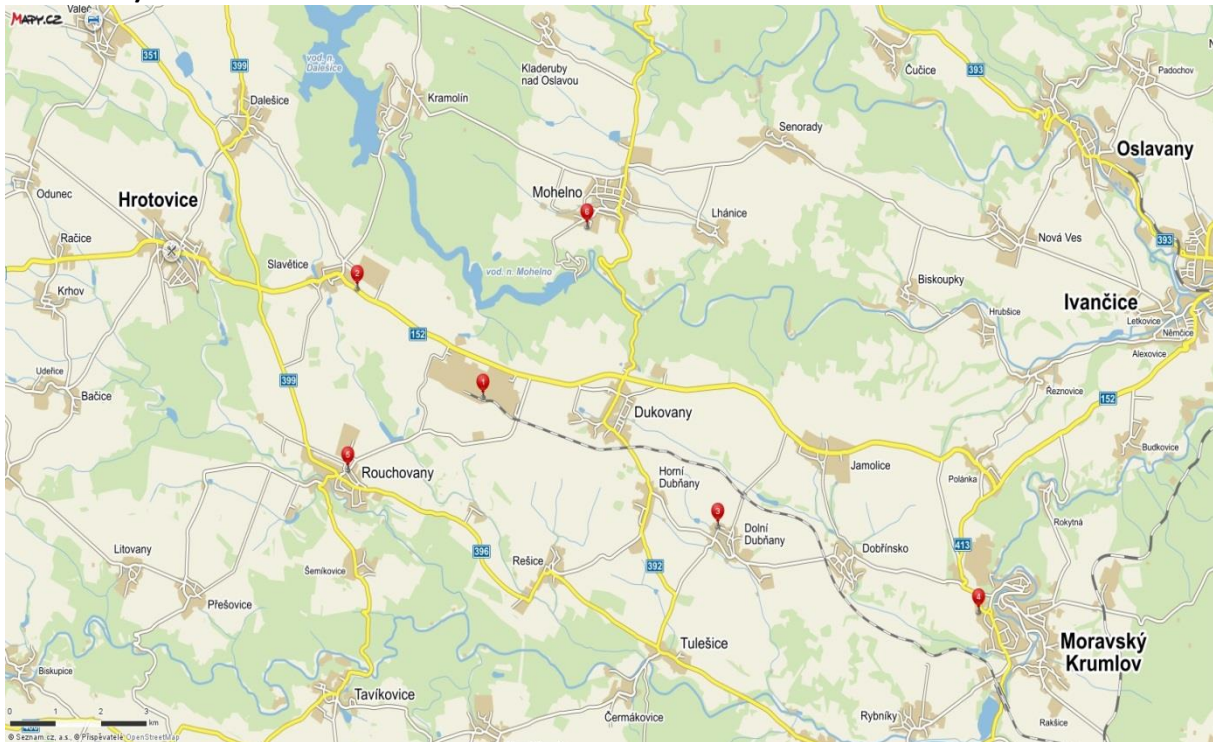


### Monitoring locations of the telemetric network (ČEZ and SVZ SÚJB)



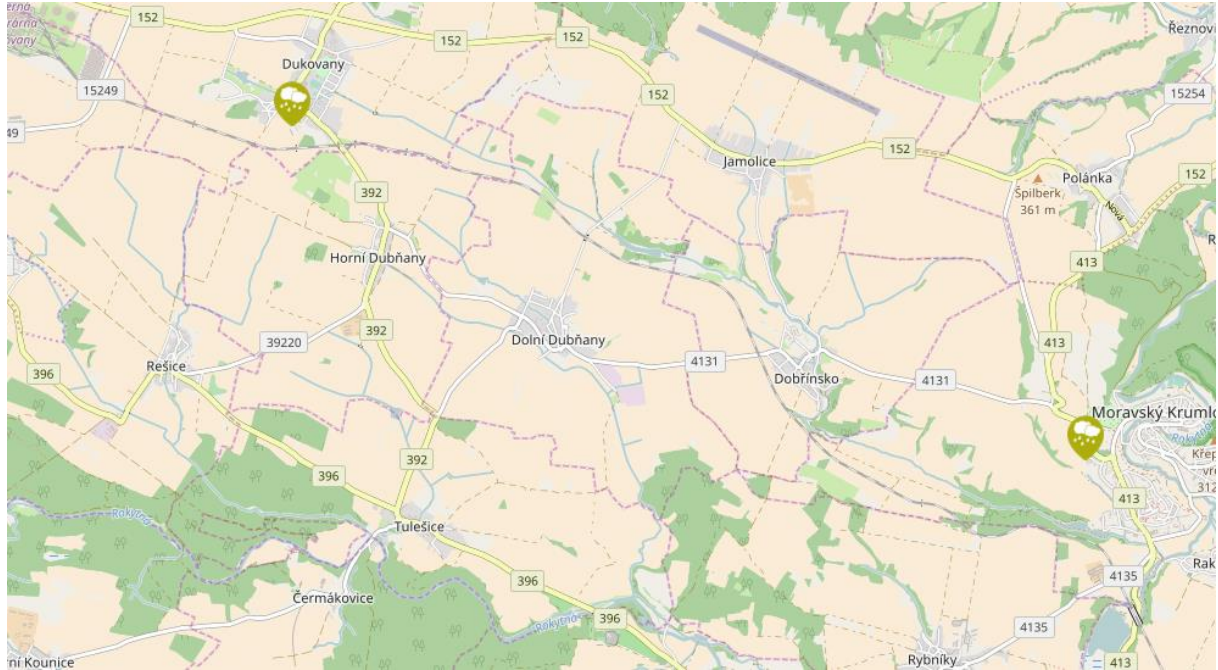
TDS ČEZ  Early Warning System of SÚJB 

### Atmospheric sampling devices (ČEZ – air particular matter, iodine and dry/wet deposition collectors)

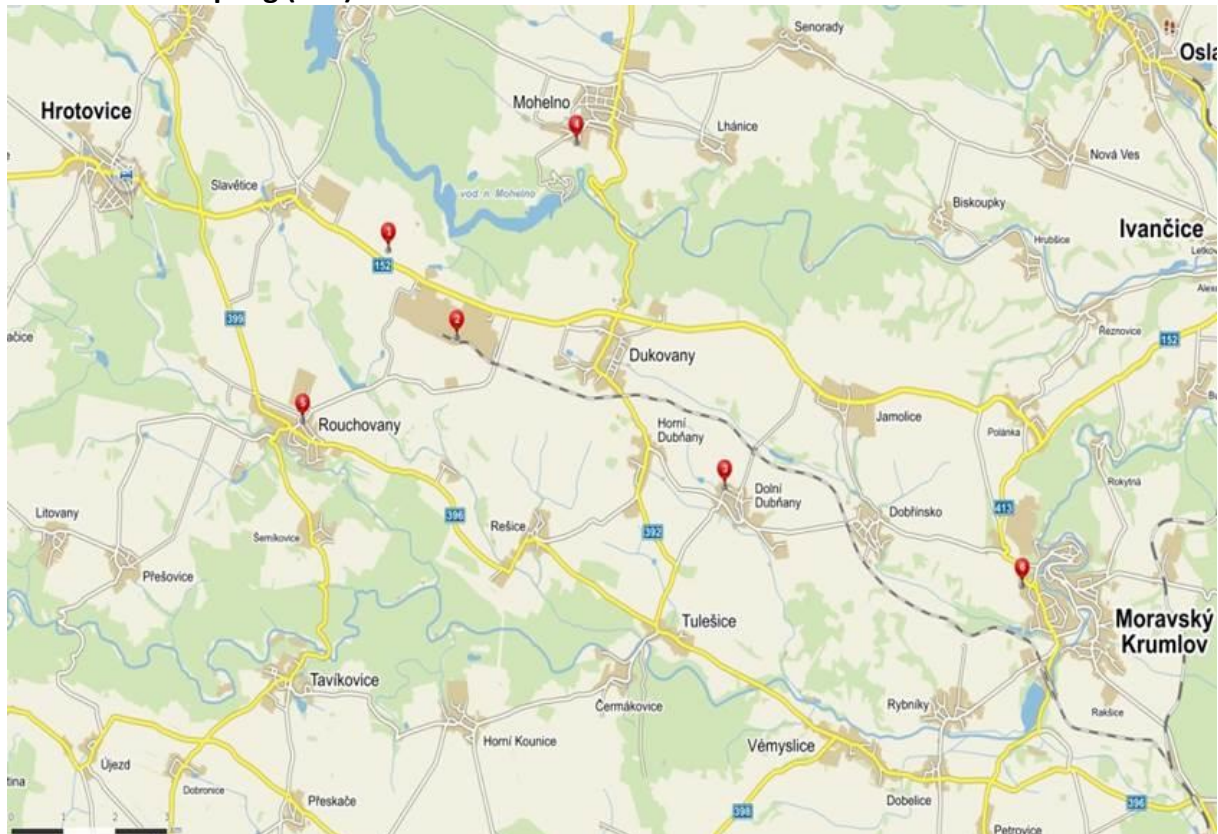




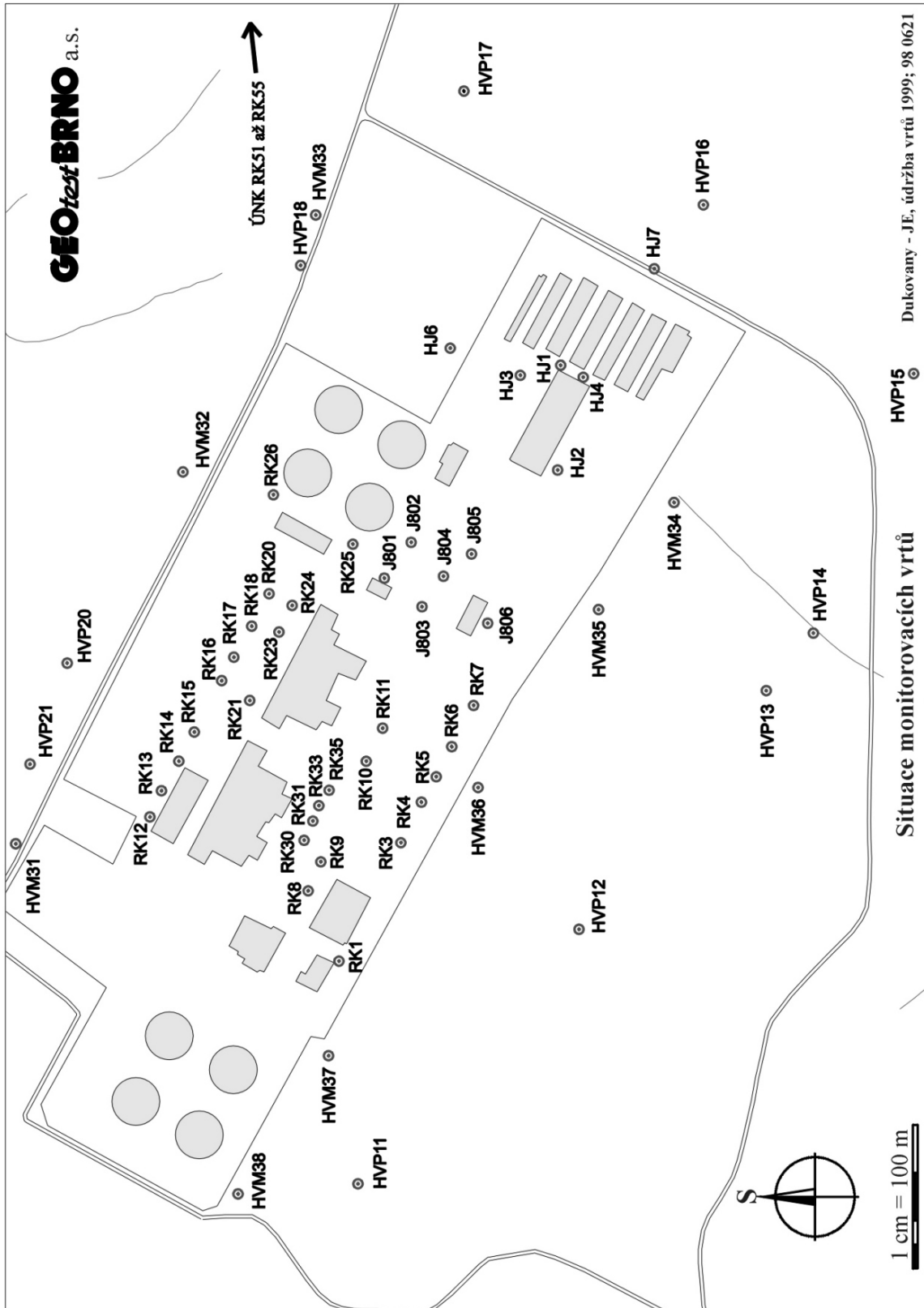
### Atmospheric dry/vet deposition and rain water collectors (SÚJB)



### Rain water sampling (ČEZ)

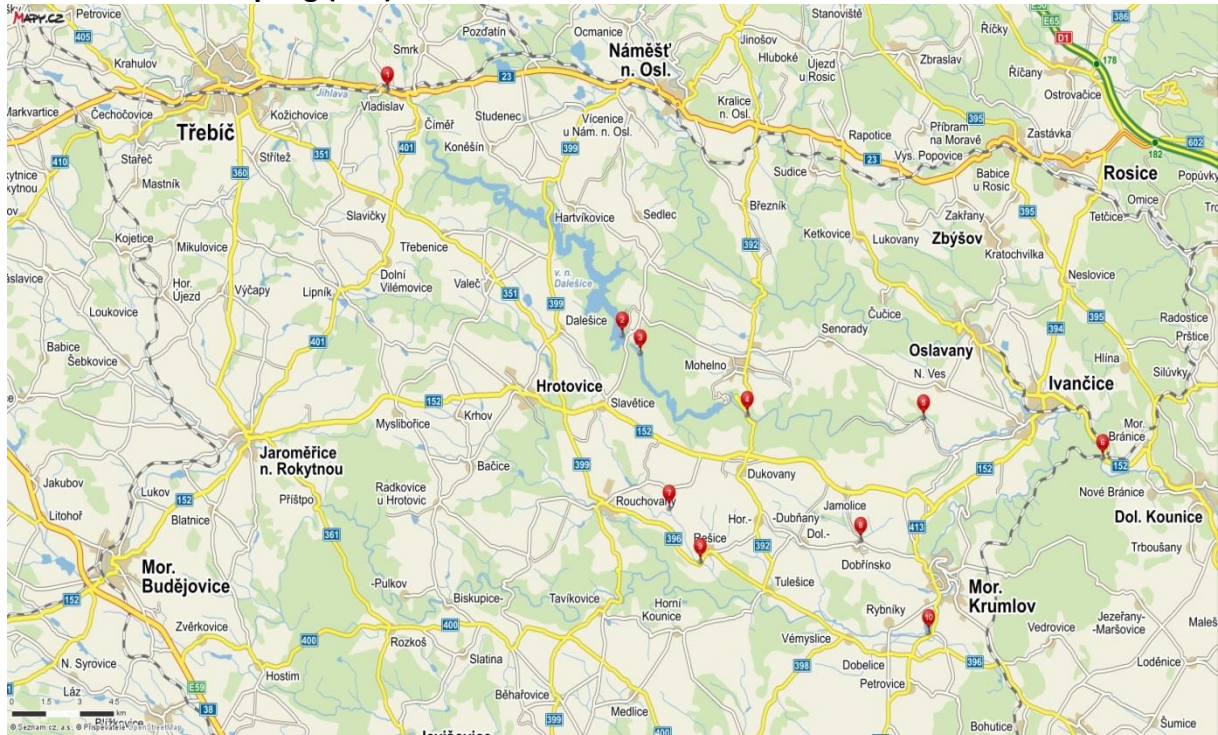


### Ground water sampling (ČEZ)

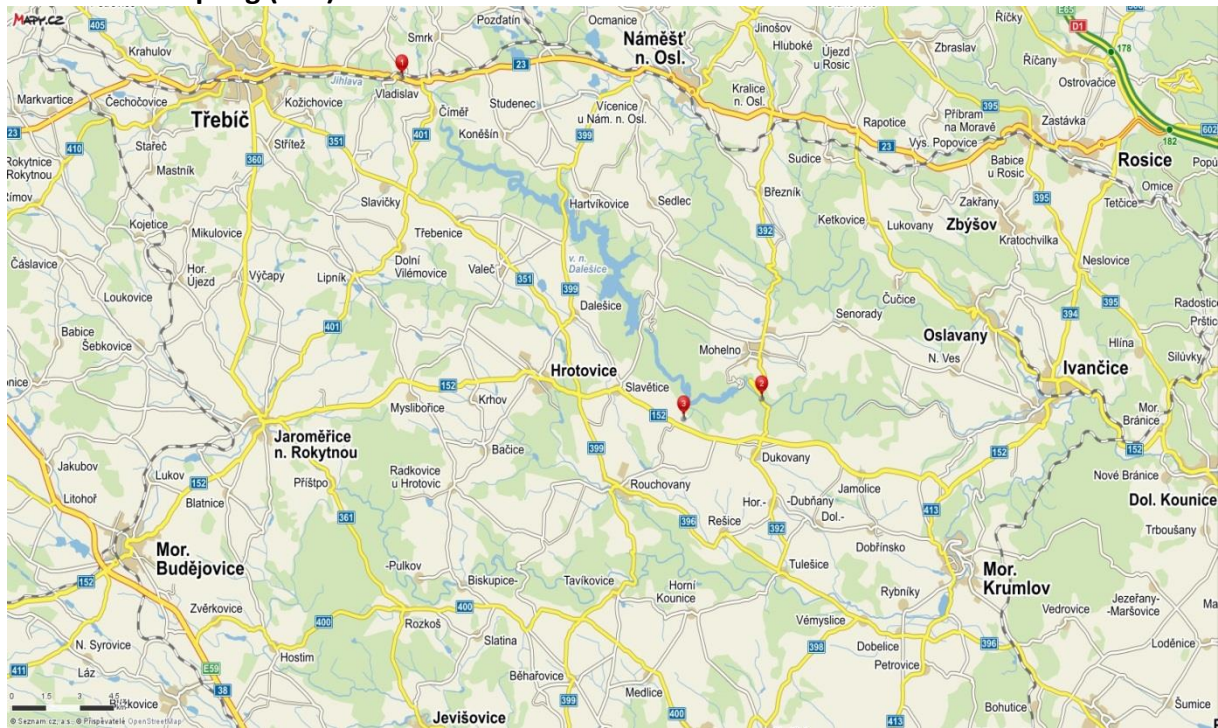




### Surface water sampling (ČEZ)

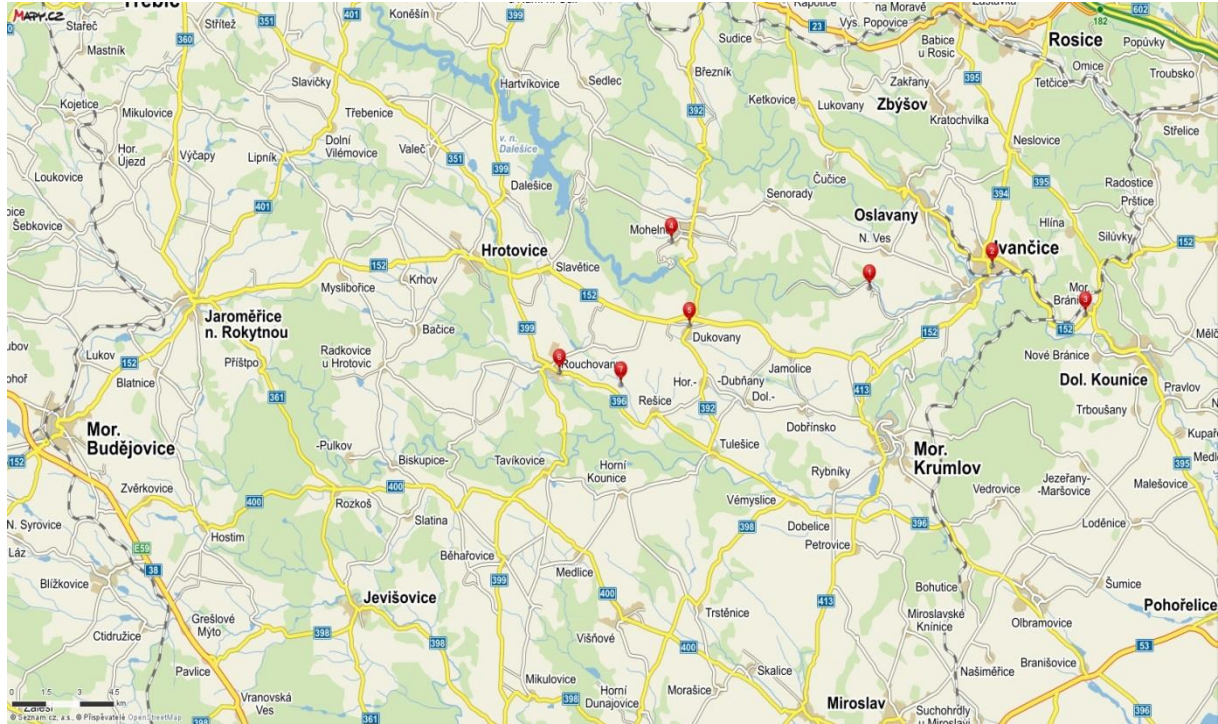


### Sediment sampling (ČEZ)

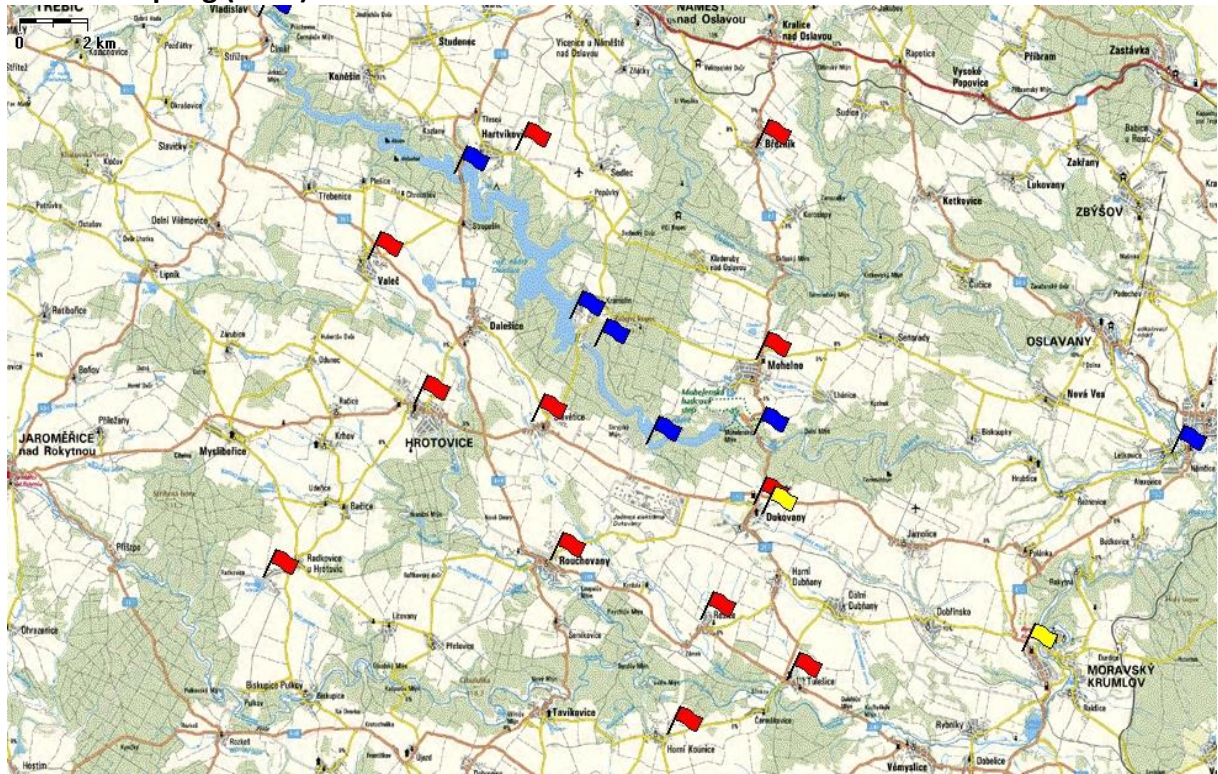




### Drinking water sampling (ČEZ)



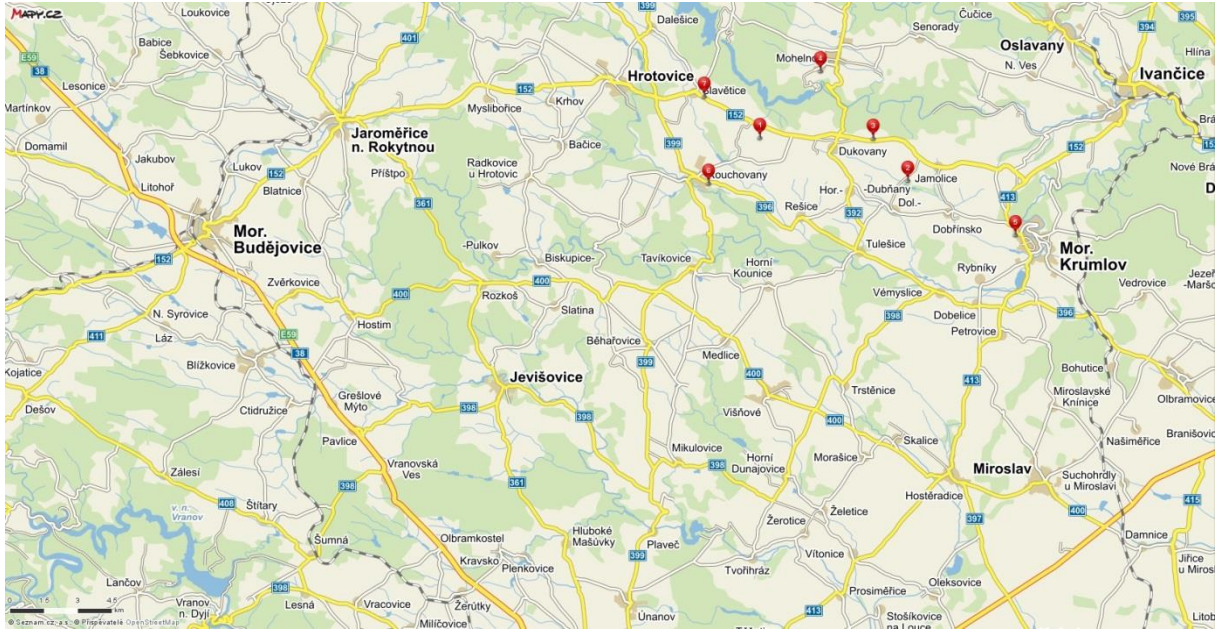
### Water sampling (SÚJB)



Blue River Jihlava and Dam reservoir Mohelno and Dukovany,  
 Red Small ponds  
 Yellow Rain water



### Soil sampling (ČEZ and SÚJB)



### Mushroom and forest fruit sampling (SÚJB)

