Expert Opinion
Assessment of Health Risks and Health Impacts

of the Facility

Radioactive Waste Processing and Treatment Technology
by
JAVYS, a.s.

atJaslovskéBohunice Site
Trnava District

Prepared by:

MUDr.JindraHolíková
Homolova 12
841 02 Bratislava

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Signature:

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Annexes:

1. References and legislation
2. Copy of the certificate of professional competence to detect health risks in the environment for the purpose of assessment of their possible health impacts, No. OLP/4572/2007 of 24 May 2007, Public Healthcare Office of the SR
3. Copy of the certificate of professional competence for environmental impacts assessment in the field of health protection No. 483/2010/OHPV of 10 February 2010
4. Copy of the certificate of professional competence to assess impacts on public health, No. OOD/7839/2010 of 18 November 2010

1. General Information

Customer:
EKOS PLUS s.r.o., Župnénám. 7, 811 03 Bratislava
Business reg. no.: 31 392 547

Operator:
Jadrová a vyraďovaciaspoločnosť(JAVYS), a.s., Tomášikova 22, 821 02 Bratislava
Business reg. no.: 35 946 024

2. Purpose of Assessment

The assessment of health risks and health impacts will form part of the Assessment Report prepared under Act of the NC SR No. 24/2006 Coll. on environmental impacts assessment, as amended, and decision of the competent authority – the Ministry of Environment of the SR.
The activity already exists at the site and is subject to mandatory assessment under the act. The core parts of the operation underwent the process of approval in 1987 and 1993; the worksites gradually developed and were adjusted, and new technological procedures were introduced. The adjustments were completed and acquired the present form in 2012. The competent authority therefore did not require preparation of an alternative option.

3. Reference documents

- Project plan "Radioactive Waste Processing and Treatment Technology by JAVYS, a.s. at JaslovskéBohunice Site", EKOS PLUS s.r.o., Bratislava, 08/2012
- Decision of the Public Healthcare Office of the SR No. OOZPŽ/7119/2011 of 21 October 2011 on permitting activities causing irradiation (exemption from the administrative control of RAS discharge in fumes through the vent chimneys of the buildings in A1 NPP JaslovskéBohunice; exemption from the administrative control of RAS discharged to the Dudváh and Váh rivers; release of materials contaminated by radioactive substances from the A1 NF/NPP, RAWPTT, ISSF);
- Legislation and expert literature (see Annex 1).

4. Subject of Assessment

The facility with the radioactive waste processing and treatment technology (RAWPTT) and the A1 Nuclear Power Plant decommissioning facility are located in the south-eastern part of the JaslovskéBohunice nuclear facilities site within the cadastral territory of Bohunice, Trnava District.
It is a compound of buildings situated in the western part of the site within the area of the decommissioned A1 nuclear power plant which stopped its operation after the accident in 1977. This area is marked in the land use plan as built-up areas and yards.
The purpose of the activity is the processing and treatment low and medium activity radioactive waste ("RAW") arising during the decommissioning of the A1 NPP and V1 NPP.

The facility also processes RAW from the operation of other nuclear facilities and institutional RAW from research activities, medical diagnostic and therapeutic activities, etc.
The facility consists of three parts:

A. Technologies forming part of the nuclear RAWPTT facility, comprising the Bohunice Processing Centre (ensuring waste sorting, concentration, cementation, incineration and pressing), bituminisation lines, waste water treatment station, metallic RAW processing, AC filters processing, and large-capacity decontamination line.
B. Technologies in the former buildings of the A1 NPP serving for the decommissioning of the A1 NPP (sludge fixation, treatment of contaminated concrete, sorting of contaminated earth, decontamination of gas-holders, grinding and sorting of concrete blocks).
C. Technologies for the fulfilment of specific tasks related to the A1 NPP decommissioning in the main production block A1 (vitrification, treatment of cases of spent nuclear fuel, fragmentation of large-sized metallic RAW, decontamination units).

Treated waste is carried to the National RAW Repository in Mochovce, and only part of the waste with higher activity which fails to meet the conditions for being deposited in the NRAWR is placed in premises designed for RAW storage within the nuclear facilities site until a deep repository or an integrated RAW storage facility is constructed.
Service transport ensures the delivery of packages, raw materials and materials for processing, the carrying away of inactive waste to contractors, and of active treated waste to the NRAWR in Mochovce. The road transport service uses road III/504012 in two directions: through JaslovskéBohunicein the direction of Trnava, and through Žlkovceto road I/61 in the direction to Bratislava and Trenčín. The contribution of the transport service to the total road traffic on this road is 0.5%, and 3.7% for freight transport.
Rail transport is ensured through a 8.1km long spur track ending in the VeľkéKostoľany railway station.
The facility is connected to the internal distribution networks. Drinking water is supplied by Trnavskávodárenskáspoločnosť, a. s. (Trnava Water Company), and cold water is pumped from the Sĺňavawater basin through the SE, a. s., EBO V2 plant. Hot water is supplied from the heat exchange units of the commissioning and stand-by boiler room, and steam is supplied from the V2 NPP facility. The different types of contaminated waters are treated through the sewer collectors of the site, in contaminated waterstreatment plants, and by draining of treated waters to Dudváh and Váh watercourses.

5. Affected Population

The assessed activity is implemented within the nuclear facilities site of JaslovskéBohunice. There are 9 municipalities in total within the perimeter of 5km from the centre of the assessed activity with approx. 9,184 inhabitants (2011). The closest residential area is in the municipality of JaslovskéBohunice at a distance of approx. 2,200m from the assessed activity site. The municipalities form part of three districts (Trnava, Piešťanyand Hlohovec). The population size and the distance from the assessed activity site are provided in Table 1.
The rate of exposure of the population to ionising radiation is directly dependent not only on the distance, but also on the direction and dispersion of the chimney plume with radioisotopes contents, and on the impacts of contaminated waters discharges to recipients.

Table 1:
Population size of the municipalities (2011) in the vicinity of nuclear facilities site, and their approximate distance from the RAWPTT facility (in m)

Municipality	District	Population	Distance
JaslovskéBohunice	TT	2,015	2,200
Radošovce	TT	426	2,200
Malženice	TT	1,379	3,800
DolnéDubové	TT	649	4,200
VeľkéKostoľany	PY	2,708	3,800
Pečeňady	PY	511	3,200
Nižná	PY	529	4,200
Ratkovce	HC	329	4,100
Žlkovce	HC	638	4,500
Total		**9,184**	

Workers and the work environment
The facility mostly influences the work environment of workers in the facility building and in the entire nuclear facilities site.
Around 270 full-time workers work within the assessed facility.
The assessment of the work environment and potential health risks does not constitute the subject of this opinion. These aspects were assessed along with the issuance of the decision on permitting activity causing irradiation under Art. 45 of Act of the NC SR No. 355/2007 Coll. by the competent Public Healthcare Authority of the SR (PHA SR). At the same time, the conditions of operation with regard to the protection of health of workers and people in the operating instructions were specified.
Compliance with the set requirements for operation, preventative medical examinations and the cumulative effective dose to workers within the controlled zone is checked by the competent state healthcare supervision body – Public Healthcare Authority of the SR, and by the work health service MEDICHEM s.r.o., Bratislava.

6. Monitored Factors

The RAWPTT and A1 NPP decommissioning facilities can influence the following environmental factors and factors of the population´s living conditions:

- Ionising radiation
- Chemical factors – Air pollution impacts
  Water contamination impacts
  Soil contamination impacts
- Physical factors – Noise impacts
  Electromagnetic radiation
- Psychological impacts
- Sociological impacts

7. Ionising Radiation

7.1. Types of ionising radiation

When transformed, radionuclides emit part of their energy or matter to the environment in three ways:

- alpha radiation – emission of particles with two protons and two neutrons;
- beta radiation – emission of electrons and neutrinos;
- gamma radiation – electromagnetic radiation.

The differences lie in the ability to cause ionisation and the ability to penetrate to the ambient matter. Alpha and beta radiations cause ionisation, but have a very small penetration ability; on the other hand, gamma radiation has a very high penetration ability, but causes little ionisation.
The sources and effects are assessed on the basis of the following parameters:

- The activity of the radiation source is expressed in becquerels (Bq), 1 Bq = 1 disintegration per second in the given amount of substance.
- The dose determines the physical effect in the exposed substance, and is expressed as the amount of absorbed energy in grays (Gy), 1 Gy = 1 J/kg.
- The equivalent dose characterises the effect on exposed living matter, and is indicated in sieverts (Sv). 1 Sv = 1 J/kg. In general, a unit three orders of magnitude lower is used – milisievert (mSv), or microsievert (µSv).

7.2. Biological and Health Effects

While penetrating a living mater, radiation ionises the molecules of biologically important substances in cells. The biological effects are divided into two groups:

1. Deterministic (causal) effects – tissue reactions
2. Stochastic (chance) effects –
   2.1. Carcinogenic effects
   2.2. Reproduction damages

Ad 1:
The reactions of tissuesto radiation have a threshold dose, i.e. a dose without health effects, which is caused by the repair abilities of tissues.
Various target organs show different sensitivity to irradiation. Damage to the most sensitive tissues can be caused by a dose of tenths of a gray. Very sensitive tissues are testicles, lens of the eye, the bone marrow, and ovaries.
Tissue reactions are usually the consequence of higher exposure doses, and are either early (i.e. after several days or weeks of exposure) or delayed (after months or years of exposure).
The effects are manifested as inflammatory reactions up to damage to the issue caused by the death of a part of cells and subsequent functional disorders of organs.
The extent of harm increases with the exposure dose.

Ad 2:
Stochastic effects are characterised as the probable number of deaths or disabilities per certain number of people. The assessment of severity is based on the background of the occurrence of such phenomena, and expert literature uses the term *permissible (tolerable)*

risk, i.e. number of cases which are considered negligible in relation to the assessed burden. The USA EPA considers one case out of a million exposed persons ($1x10^{-6}$) as a permissible death risk; in Europe, the common permissible value is 1–5 cases out of one hundred thousand of exposed persons ($1 – 5 x 10^{-5}$).

Carcinogenic effects are the consequence of a damaged cell nucleus – deoxyribonucleic acid (DNA) as the carrier of genetic information. In this case, the relation between the dose and effect is without a threshold, i.e. there is no safe dose that would not represent any risk for the development of a disease.
It is caused by delayed effects which are manifested after a certain time period elapsed from the exposure to radiation. The individual doses throughout the life are added together.
The absorbed dose is linked to the increase of the probability of tumour occurrence, and not to the severity of damage.

Reproduction damages represent damage to the next generation by harming the reproductive organs, germ cells, the foetus or a developing organism. This can result in reproductive disorders, abortions, stillborn babies and survival of defective individuals (birth defects). This case also represents a threshold free relation between dose and effect.

It should be mentioned, though, that most cells damaged by radiation lose their reproductive ability and die. These cells are replaced with new, healthy cells. DNA double helices in cell nuclei also have the ability to repair defects. Thanks to these repair ability of the genetic material, cells and tissues cause the health effects of radiation in people manifestto a substantially smaller degree than expected.

The coefficient of the risk of death caused by malignant tumour, as specified in the literature, is $\mathbf{5x10^{-2}/Sv}$, which means that the exposure of 100 persons to 1Sv assumes five deaths more compared to the background for cancerous effects of such exposure.
The ICRP (International Commission on Radiological Protection) set a coefficient for health harm, i.e. curable and non-curable cancer and hereditary effects, at $\mathbf{5.7x10^{-2}/Sv}$**,** i.e. the exposure of 100 persons to 1 Sv causes health effects in 5–6 persons or their next generation (birth defects).

Government Regulation No. 345/2006 Coll. on basic safety requirements for the protection of health of workers and the population against ionising radiation specifies **1mSv**(= 10^{-3}Sv) as the permissible effective dose to the population in a calendar year. This dose concerns people living in the vicinity of radioactive radiation sources and includes all routes of exposure (air, water, food, etc.). This dose then represents an extra risk of death caused by cancer as a consequence of irradiation at a level of $\mathbf{5x10^{-5}}$, i.e. 5 persons out of 100,000 exposed persons. The current **background of mortality caused by cancer** is approx. $\mathbf{2x10^{-3}}$in our country, which are two persons in 1,000 deceased.

The population of the Earth is permanently exposed to *natural ionising radiation* from various sources. The estimated average annual effective dose is 3.7mSv/year, and represents up to 80% of the total absorbed dose for the majority of the population.

Table 2:
Average annual doses from natural sources among the population

Source	mSv/year
Cosmic radiation	0.3
From the geological subsoil (except for radon)	0.8
Inhalation of radon disintegration products	2.6
Natural sources in total	**3.7**

The burden from natural sources largely increases with long-term stay at higher altitudes (e.g. in plains) or depths (caves).

This burden is further increased by *medical examination and treatment methods*, the use of radiation sources in a work environment (laboratories, defectoscopy, etc.), radiation from nuclear arms tests, and also from the operation of nuclear power plants.

Table 3:
Doses from artificial sources from medical use of ionising radiation among the population

Source	Dose
Average dose from the use of ionising radiation in healthcare	1.5mSv/year
Mammography	3mSv
Tomography of the head	50mSv
Therapeutic radiation	1,000mSv

7.3. Sources of Ionising Radiation in the RAWPTT and A1 NPP Decommissioning Facilities

The facility produces air contaminated by radioactive isotopes of strontium (^{90}Sr), radionuclides emitting beta and gamma radiation (isotopes of Mn, Co, Zn, Nb, Ag, Sb, Cs, Ce), and radionuclides emitting alpha radiation (Pu, Am).
The facility is the source of gas discharges of radioactive substances to the air and liquid discharges of radioactive substances to the Dudváh and Váh rivers. These discharges can further contaminate fish, sediments, and food irrigated with contaminated water.

The decision of the PHA SR permitted the exemption of RAS from administrative control as a result of being discharged to the air, waters and by waste disposal, laying down the conditions for this activity, including permanent evaluation of the activity of discharged substances.
The decision also specifies annual limits of emissions for these discharges and for the respective groups of radionuclides. In 2011, the RAS released to the atmosphere through three discharges (buildings 46A, 46 and 808) reached 0.27–1.36% of the annual limit for strontium, 0.21–0.43% of the limit for beta and gamma emitters, and 0.10–0.18% of the limit for alpha emitters.

Pre-treated waste waters containing RAS are discharged via a common sewer system for all operation units within the JaslovskéBohunice site. In 2011, the total volume of waste waters drained through the SOCOMAN sewer system from the RAWPTT facilities reached 5,932m^{2}from the total volume of 961,117m^2 of waste waters discharged from the nuclear facilities site.
The disposed decontaminated waste meets the limits for residual radiation, and has no effect on the environment in the surroundings of the assessed activity.

7.4. Impacts of Ionising Radiation from the RAWPTT and A1 NPP Decommissioning Facilities

For assessment purposes, the location with an assumption of the highest impact of ionising radiation (chimney plume dispersion, direction of winds, etc.) has been chosen on the basis of calculations – in the uninhabited sector north from the site, and in the residential zone of the municipalities of Ratkovce and Žlkovce at a distance of around 4km south-east from the assessed facility.

The calculation made on the basis of actual meteorological measurements and joint measurement of discharges from all Proponent´s facilities within the site (including Interim Storage Facility for Spent Fuel and decommissioned V1 NPP) set the **total annual effective doses** to the critical age group of children of 2–12 years and 2–7 years in 2011 and 2012. These doses took into consideration all routes of exposure – by air, contact with contaminated water and soil (sediments) and from the food chain (consumption of contaminated fish and vegetables and fruit irrigated by contaminated water). Table 4 provides an overview of calculated doses.

Table 4: Calculated maximum total effective doses in 2011 and 2012 (in Sv)

Locality	Year 2011	Year 2012	Average
Uninhabited sector 1	$7.01x10^{-8}$	$6.63x10^{-8}$	**$6.82x10^{-8}$**
Ratkovce–Žlkovce	$4.14x10^{-8}$	$3.98x10^{-8}$	**$4.06x10^{-8}$**

The hypothetical maximum annual effective doses from **limit discharges from the RAWPTT** were also calculated, i.e. from values attained in case the set limits for all discharges to the environment (to the atmosphere and hydrosphere) are theoretically reached. These values are **$4.31x10^{-6}$Sv/year** for discharges to theVáhriver, and **$6.47x10^{-6}$Sv/year** for discharges to the Dudváh river. The critical points are located at a distance of 5–20km from the site.

Next, the maximum effective doses in the event of a hypothetical **accident** were assessed (earthquake, flood, explosion, plane crash, loss of service media and fire). In the least favourable combination of emergency situations, the effective dose reached **0.298mSv/year** (= 298 µSv/year) for children under 1 year at the most critical distance of 3km from the assessed activity.

The decision of the PHA SR specified the maximum effective dose of **12 µSv/year** to the population arising from the operation of the RAWPTT and A1 NPP decommissioning facilities (including ISSF). This dose is proportional and takes account of the exposure of individuals to also other sources within the nuclear facilities site so as to comply with Government Regulation No. 345/2006 Coll. This regulation specifies the limit value of **250 μSv/year** of the individual effective dose for the critical group of inhabitants in the vicinity of the nuclear facilities.

The table below provides an overview of the limit dose values and of the calculated doses.

Table 5:
Permissible and calculated maximum effective doses of ionising radiation for the population

Type of dose	**Dose (Sv/year)**
Limit for the population under Government Regulation No. 345/2006 Coll.	$1x10^{-3}$
PHA SR limit for the RAWPTT, A1 NPP and ISSF	$12x10^{-6}$
Limit for the critical group of the population from nuclear facilities under Government Regulation No. 345/2006	$250x10^{-6}$
Calculated max. total effective dose in the uninhabited zone for all Proponent´s facilities	$6.82x10^{-8}$
Calculated max. total effective dose in the inhabited zone for all Proponent´s facilities	$4x06.10^{-8}$
Calculated max. dose from limit discharges from RAWPTT	$6x47.10^{-6}$
Calculated max. dose from RAWPTT accident	$2x98.10^{-4}$

7.5. Risk Assessment

A comparison of the calculated maximum dose of exposure of **$4.06x10^{-8}$Sv/year** from the operation of all Proponent´s facilities in 2011 and 2012 within the **inhabited zone** to the dose permitted by the decisions of the PHA SR ($12x10^{-6}$) for the RAWPTT, ISSF and A1 NPP decommissioning suggests that the actual dose to an individual from the category of children in the most burdened zone is approx. **300 times smaller.** As far as the dose in the **uninhabited zone** is concerned – **$6.82x10^{-8}$**, it is approx. 175 times smaller.

In order to calculate the risk, the **cumulative dose** to which a person permanently living within the inhabited zone with the highest radiation would be exposed during *70 years of life*was considered. The average value of the monitored years – **$4.06x10^{-8}$Sv**is considered as the annual dose, which represents **$284x10^{-8}$Sv**during 70 years of life-long exposure. When multiplied with the coefficient of the risk of death caused by malignancy due to exposure ($5x10^{-2}$/Sv), the risk is **$1.4x10^{-7}$**, which is 1–2 more cases of death compared to the background per 10 million of inhabitants. In an analogue way, the risk for long-term stay in the uninhabited zone can be calculated – it is **$2.4x10^{-7}$,** i.e. 2–3 more deaths out of 10 million against the background.

The hypothetic maximum dose from **limit discharges** from the RAWPTT facility **–$6.47x10^{-6}$Sv**(for Dudváh), i.e. 6.47 μSv – represents only a **54% share** compared to the permissible dose specified in the decision of the PHA SR. In the event of an individual´s exposure during 70 years of life, the total dose would reach $453x10^{-6}$ Sv.The calculated risk would then be

$2.3x10^{-5}$, i.e. the risk of death would be about 2 more individuals out of 100,000 affected persons against the background. With regard to the low share of the use of limit discharges, this burden on the population is improbable.

Table 6
Overview of annual doses, life-long doses and relative risk

Locality	**Annual dose**	**Life-long dose**	**Risk** (calculation)	**Risk**
Inhabited zone	$4.06x10^{-8}$	$284x10^{-8}$	$1,420x10^{-10}$	**$1.4x10^{-7}$**
Uninhabited zone	$6.82x10^{-8}$	$477x10^{-8}$	$2,385x10^{-10}$	**$2.4x10^{-7}$**
Limit zone	$6.47x10^{-6}$	$453x10^{-6}$	$2,265x10^{-8}$	**$2.3x10^{-5}$**

Given the background of deaths caused by malignant tumours in Slovakia – **$2x10^{-3}$**(i.e. 2 persons out of 1,000 deaths) and when compared to the risk of death of smokers caused by cancer – **$1x10^{-2}$**(i.e. death of one person out of one hundred smokers), this risk is negligible.

The maximum **accident dose** that an inhabitant of the critical zone can be theoretically exposed to in combination with several hazard events in the RAWPTT facility – **$2.98x10^{-4}$Sv** – can only be compared to the limit for the population under the decree of the Ministry of Healthcare of the SR, which is $1x10^{-3}$Sv. The resulting ratio is **0.3%** of the permissible annual dose. In this respect, the exposure of the population in the vicinity of the facility in the event of an accident does not represent a risk to health. However, the recommended maximum equivalent doses to the thyroid, bone marrow and skin may be exceeded. In emergency cases, it would be suitable to adopt maximum measures for health protection (e.g. iodine prophylaxis) and exclude any further useless exposure to ionising radiation in the given year.

Conclusion:
Radioactive radiation from the sources of the RAWPTT and A1 NPP decommissioning facilities within the JaslovskéBohunice nuclear facilities site is not expected to threaten the health of the population, not even in the case of hypothetic combined accidents.

8. Chemical Factors

8. 1. Impacts of Air Pollution

The RAWPTT and A1 NPP decommissioning facilities do not constitute an independent source of air contamination. Waste air is extracted from the operation premises via air-conditioning system to three vent chimneys. The waste air containing radioactive substances (RAS) is treated by aerosol filters with 99.9% efficiency. Other pollutants present in the waste air are limited amounts of emissions of volatile organic substances (VOCs) from heated bitumen or dust particles (solid pollutants – SP) from cementation, fragmentation or grinding. Waste air containing dust particles passes through SP filters.
Another source of air pollution is **service transport –** delivery of over-packs, raw materials and materials for processing, carrying away of inactive waste and active treated waste to the NRAWR in Mochovce. The road transport uses road III/504012 in two directions: through

JaslovskéBohunice in the direction of Trnava, and through Žlkovce to road I/61 in the direction to Bratislava and Trenčín. The contribution of the service transport to the total road traffic on this road is 0.5%, and 3.7% for freight transport (2–3 freight cars/day for maximum use of the technologies). These values suggest that service transport does not constitute a substantial share in total traffic, and its impact on the air quality along the roads is insignificant, and will therefore not be included in the risk calculation.

With regard to the potential impacts on air quality in the vicinity of the assessed facilities, the **radioactive waste incinerator** is the most important unit. The natural gas-based shaft incinerator serves for the incineration of solid and liquid RAW at the temperature of up to 1,050°C in the upper part of the surface; flue gases pass through the post-incineration chamber (850 – 1,100^{o}C), and after sudden cooling to 340^{o}C as a prevention of the occurrence of dioxins they are washed in two wet washers and filtered by the self-regeneration sleeve filters and HEPA filters with 99.9% efficiency. Incinerator capacity: 240 t/year. The incinerator is the source of air pollution, and the flue gases are released, together with the treated waste air, from the air-conditioning system to the chimney at a height of 40m over the ground. According to the calculations, a chimney height of 19m would be sufficient for the amount and quality of emissions, which means compliance with the dispersion conditions beyond standard requirements.
The following pollutants are discharged from the incinerator to the atmosphere:

Table 7:
Overview of pollutants emitted from the radioactive waste incinerator

Name	**Chemical symbol**
Dust particles <10 µm	SP/PM_{10}
Nitrogen oxides	NO_x
Sulphur dioxide	SO_2
Carbon monoxide	CO
Total organic carbon	TOC
Hydrogen chloride	HCl
Hydrogen fluoride	HF
Mercury, thallium, cadmium	Hg,Tl,Cd
Arsenic, nickel, chrome, cobalt	As,Ni,Cr,Co
Lead, copper, manganese	Pb,Cu,Mn
Dioxins, furans	CDD/CDF

Risk identification –
Toxicological description of pollutants

Dust particles
Dust particles are released during incineration processes, and are also contained in exhaust fumes of motor vehicles. They get into the air by the swirl of settled particles – secondary dust.

Their harmful character depends on the size and composition of particles. Larger particles of over 10μm irritate the upper respiratory tract and conjunctiva of the eyes, smaller particles get into the lower respiratory tract and deteriorate the development of inflammatory and allergic diseases of the respiratory system. Particles under 2.5 μm can penetrate to the bloodstream through the pulmonary alveoli, which is significant also with regard to the composition of toxic substances. The immission limits are therefore set for the fraction of fine dust **PM_{10}**.

Dust particles (PM_{10})

Fine dust particles under 10 μm pass through barriers in the respiratory tract and get to the lower respiratory tract. $PM_{2,5}$particles which are part of the PM_{10} can also pass through pulmonary alveoli and get into the bloodstream.

Dust is mainly considered a pollutant with irritating effect to the upper respiratory tract and the conjunctiva of the eyes. Increased mortality was detected in the case of long-term exposure of the population to fine dust particles. Their concentrations are therefore monitored, and measures are taken to reduce dust.

The sensitive population groups include allergic and asthmatic people, people with respiratory diseases, very small children, and old persons.

Nitrogen oxides (NO_x)

$NO_x$is produced during incineration processes; the most important components are nitrogen dioxide (NO_2) and nitric oxide (NO)which is, however, unstable and changes to nitrogen dioxide.

NO_2 is an irritant gas which causes irritation of the respiratory tract and its constriction. Mainly asthmatic people and people with respiratory tract diseases therefore react to higher concentrations. Very small children and old people are also more sensitive.

Sulphur dioxide (SO_2)

SO_2 is the product of incineration processes and is produced by the incineration of solid fuel and waste with sulphur contents. It is also released from refineries and chemical production.

Sulphur dioxide is a gas that reacts with water steam, producing acid. It irritates the respiratory tract and the conjunctiva of the eyes, and causes the constriction of the bronchi when inhaled. Long-term exposure to sulphur dioxide was found to cause higher occurrence and longer duration of diseases of the respiratory tract, mainly in children.

Besides children, sensitive population groups also include allergic people, people suffering from diseases of the respiratory tract, and old people.

Carbon monoxide (CO)

CO is a toxic gas which arises during incomplete combustion. It can also be found in exhaust fumes of motor vehicles and is absorbed by inhalation. Smoking is also a major source of carbon monoxide.

It penetrates the blood where it is tied to the red blood pigment, producing carboxylhemoglobine which loses the ability of oxygen transfer, and resulting in reduced oxygen supply to tissues. The body can, however, tolerate relatively high concentrations without any health damage symptoms (high CO concentrations in smokers´ blood).

Pregnant women and their foetuses (insufficient oxygenation, lower birth weight), small children and people suffering from cardiovascular diseases are most sensitive to CO.

Organic gases and steam as total organic carbon (TOC)

Mixture of various organic substancesarisingin the environment(metabolism of animals, theirdecomposition) and by means of anthropogenic activity(during incineration, from WWTP, landfills, industrial production, etc.).The mixtureis not characterisedas hazardous substance in legislation, but it containsubstances withodourproperties.

Hydrogen chloride, hydrogenfluoride
Vapoursareirritating and corrosiveat higher concentrations. Long-term exposureto higherconcentrations(usuallyin the working environment) causes damage tomucous membranesof the respiratorytract, conjunctivitis, damageto the tooth enameland chronicskin irritation, especially in theface. Suddenhighexposure (in the event of an accident) can result in pulmonary oedemaanddeath.

Heavy metals
It is amixture ofrelativelylow concentrationsof metals, falling under subgroup1.3of inorganicpollutants. In higher concentrations, they are all toxic to human beings, though toxicityisdifferent, as well as the targetorgans(like the nervoussystem, kidneys,heamatopoiesis, liver). Moreover,cadmium, arsenic, nickeland6-valent chromiumareprovenhuman carcinogens.
The highest doses of these substancescome from the food chain;the absorptionfrom air by the respiratorytractis partly restricted. Most of thesemetals, however, form part of the group of essentialelements that the body(though in small amounts) needs for the productionof biocatalysts–enzymes.

Dioxins and furans
It is a mixture of about 210 toxic substances (congeners), classified as halogenated aromatic compounds. They are produced during waste incineration, metal smelting, pesticide production, and in chemical industry. Their development can be partially prevented by observing the combustion temperatures and chimney temperatures. They may arise during fires and volcanic activity, and were also found in cigarette smoke. Acute poisoning can cause irritation of eyes, the respiratory tract and skin, and high concentrations may also result in chloracne. As for chronic effects, the most serious are carcinogenic effects which were only confirmed in congener 2,3,7,8-TCDD.

Exposure assessment

Exposed persons:
The assessment is based onthe critical point of the dispersion study locatedat a distance of400m from the source of pollution (chimney). Atthis point, the maximum concentrationsof pollutants were calculated. The values in the territorycloserand also more distant from the source, the valuesare smaller. Although exposure ofthe populationto thesemaximum values is notrealistic, the calculation of the risk is based on these values under a conservative approach.

Routes of exposure:
As far as air pollution is concerned, it is involuntaryexposure by breathing, which practicallycannotbe influenced by individuals. As far as the duration of exposure is concerned, a long-term stay of 70 years of life is considered, including sensitive population groups (small children, pregnant women, peoplewith chronic diseases,and elderly people). Under thisconservative approach,the WorldHealth Organisationrecommends limit concentrationsof pollutantsin the ambient airusedto set the limitsin different countries.

Exposureto emitted pollutants through theskin andthe gastrointestinal tractcan be considered negligible in this case.

Risk assessment (dose/effect)

Assessment method:

Concentrations of dominant pollutants calculated in the dispersion study were used to assess the risk. Maximum short-term concentrations of pollutants at a risk distance of 400m from the source of pollution and the values reached close to the boundary of the residential area at a distance of 2,000m from the site of the assessed activity (the closest inhabited area is situated at a distance of approx. 2,200m) were taken into consideration.

With regard to dust particles, the dispersion study calculated the total solid substance dust compared to PM_{10} fine particles which are insignificant in terms of health.

The short-term limits for PM_{10}, CO, SO_2 and NO_2 laid down in the Decree of the Ministry of Agriculture, Environment and Regional Development No. 360/2010 Coll. on Air Quality were used as comparison limits.

For other pollutants (the limit values of which are not specified in our legislation), the limit value was derived from the "S" value for the calculation of the chimney height (Bulletin of the MoE SR No. 5/1996) according to sub-groups of metals and for HCl and HF. The limit values recommended by the World Health Organisation were used for dioxins and furans.

The content of solid pollutants as an indicator of organic contamination is not limited in the air, and is used as an indicator of water contamination. Given its unclear toxicological properties, it was not included in the calculation of the hazard index.

The hazard index (HI) for the different substances was calculated from the ratio between the calculated maximum short-term concentration (C) and the limit value or recommended concentration (L):

$$HI = C/L$$

The summary hazard index was calculated as the sum of the hazard indexes for the different pollutants. The indexes were rounded to three decimal places.

The summary hazard index represents the assumed risk level – if it is under 1, there is no assumption of health risk; if it is over 1, further analysis is needed, as well as health protection measures.

Tables 8 and 9 provide a calculation of hazard indexes for various pollutants, and the summary index for both localities assessed in this report.

Table 8:

Comparison of maximum short-term concentrations of pollutants from the incinerator at a distance of 400m from the source (in µg/m^3) and the hazard index

Ref. no.	Pollutant	Concentration	Limit[x]	Hazard index
1	PM_{10}	0.762	50	0.015
2	NO_3	2.581	200	0.013
3	SO_2	9.348	125	0.075

4	CO	2.493	10,000	0.000
5	HCl	0.951	100.0	0.010
6	HF	0.043	40.0	0.001
7	Hg,Tl,Cd	3.744×10^{-3}	5.0	0.001
8	As,Ni,Cr,Co	18.726×10^{-3}	1.0	0.018
9	Pb,Cu,Mn	93.636×10^{-3}	5.0	0.019
10	CDD/CDF	1.874×10^{-6}	100×10^{-6}	0.019
	∑ HI			**0.171**

Notes: ^{x} Limits no. 1 – 4 under Decree of the MoAERD SR No. 360/2010
Limits no. 5 – 9 derived from "S" coefficient under Bulletin of the MoE SR No. 5/1996
Limit no. 10 under SZO recommendations

Table 9:

Comparison of maximum short-term concentrations of pollutants from the incinerator at a distance of 2,000 from the source at the boundary of the inhabited zone of JaslovskéBohunice(in µg/m^3) and the hazard index

Ref. no.	Pollutant	Concentration	Limit^{x}	Hazard index
1	PM_{10}	0.141	50	0.003
2	NO_3	1.092	200	0.005
3	SO_2	1.729	125	0.014
4	CO	0.461	10,000	0.000
5	HCl	0.176	100.0	0.000
6	HF	0.008	40.0	0.000
7	Hg,Tl,Cd	0.692×10^{-3}	5.0	0.000
8	As,Ni,Cr,Co	3.464×10^{-3}	1.0	0.003
9	Pb,Cu,Mn	17.319×10^{-3}	5.0	0.003
10	CDD/CDF	0.347×10^{-6}	100×10^{-6}	0.000
	∑ HI			**0.028**

Notes: ^{x} Limits no. 1 – 4 under Decree of the MoAERD SR No. 360/2010
Limits no. 5 – 9 derived from "S" coefficient under Bulleting of the MoE SR No. 5/1996
Limit no. 10 under SZO recommendations

Risk description

The final summary **hazard index** for the most burdened area within the nuclear facilities site at a distance of 400m from the source of air pollution (air shaft from the radioactive waste incinerator) reached **0.17.** This value proves that no health risk exists in the given locality with regard to the inhalation of pollutants from the incinerator. Moreover, the methodology based on the calculation for the population was used (24 hours a day, 365 days/year, 70 years of life) which means that an exposure of 8 hours a day, 250 days a year during 35 years of life would be a significant reduction of the hazard index.

The summary hazard index for the peripheral part of the inhabited area (at a distance of about 2,200m, though the calculation is based on a distance of 2,000m, which means higher values!) attained about **0.03.** This means that people living in the surroundings of the assessed source of air contamination are not exposed to a health risk due to the discharged pollutants.

Conclusion:
The RAWPTT and A1 NPP decommissioning facilities are not expected to have negative impacts on human health and on the living conditions of people in the vicinity of the nuclear facilities site due to air pollution.

8.2. Water Contamination Impacts

The quality of water can affect human life when used for drinking, cooking, personal hygiene and recreation.
The facility´s operation gives rise to active and inactive waste waters.
Storm waters are drained to the Dudváhriver via a separate storm sewer, passing through dosimetry control before the retaining tanks inlet through the open Manivier channel.
Sewer waters from the staff sanitary facilities in the JAVYS buildings are drained by the sewer systems to the Bioclar mechanical and biological waste water treatment plant within the V1 NPP site, and the treated waters are discharged to Drahovskýkanál and Váhriver through the SOCOMAN pipe collector.
Active waste waters are drained by pipelines to collecting vessels and are treated at the radioactive waters treatment station. **The waste waters treatment station** works on the principle of evaporation technology and final treatment at the ion exchanger filtration station. After the check of volume activities, the treated waters are discharged to the SOCOMAN collector pipe and to the Váhriver.
The total volume of discharged technological waste waters arising from the assessed activity is approx. 6,000 m^3/year. The required quality of discharged waters is specified in the permit of the Regional Environmental Office Trnava, and is monitored.
The contamination of ground waters is permanently monitored, and to prevent the spreading of tritium contamination outside of the A1 NPP site, recovery pumping of ground waters is ensured, and the waters are then drained to the SOCOMAN pipe collector at a volume of approx. 200,000 m^3/year. The estimated radiation burden of the population due to contaminated surface waters, including impacts on the food chain, is described in Chapter 7.
There is no water source protected zone in the site´s vicinity for the supply of drinking water to inhabitants, or any recreation area using surface waters for bathing.

Conclusion:
The health of the population living in the vicinity of the RAWPTT and A1 NPP decommissioning facilities is not expected to be affected by the contamination of drinking water and ground waters. The contamination of surface waters complies with the set health protection limits.

8.3. Soil Contamination Impacts

Soil pollution can affect people's health both directly – by swirling of the contaminated surface soil layers and entering through the respiratory tract or digestive tract – by contaminated hands or food. The distance of the residential area from the assessed facility site is so big that no direct impacts are realistic.
Pollutants from contaminated soil can enter the food chain, including watering of gardens by contaminated water and penetration into consumed crops. This problem has been taken into account in the radiation exposure estimation (see Chapter 7).

All kinds of waste (contaminated RAS and common waste of "N"type /hazardous/ and "O" type /other/) are stored in the prescribed way; common waste is carried away for recycling or disposal outside of the nuclear facilities site.
Processed RAW is transported to the National Radioactive Waste Repository in Mochovce.
Inactive waste of "O" (other) and "N" (hazardous) type is also carried away for disposal on the basis of contracts with authorised organisations.
The agricultural soil in the surroundings does not get contaminated by any kind of waste.

Conclusion:
Harm to the health of people living in the vicinity of the proposed activity by soil contamination and penetration of pollutants emitted from the technological equipment to the food chain is not realistic. The radiation burden complies with the set health protection limits.

9. Physical Factors

9.1. Noise Impacts

Noise is a sound with disturbing effects. With higher intensity (over 85dB) it can cause damage to the hearing system with subsequent deterioration of hearing up to deafness (usually in a work environment, but also with badly regulated in-ear listening to music). Long-term exposure to lower intensity has neurotisation effects with trouble sleeping, anxiety, up to psychosomatic diseases (stomach ulcers, increased blood pressure, heart rhythm disorders, increased blood sugar levels, etc.) as a consequence. There are big differences in individual sensitivity to noise among people. Due to its permanent increase, noise is becoming the most significant environmental harmful factor. The current legislation protects approx. 80% of the population, but the protection of more sensitive people is not realistic and requires individual protection.
The assessed activity represents a source of noise from the operation of the technological equipment. The equipment is mostly situated indoors, and its impact on the noise level of the entire nuclear facilities site is minimal. The technological equipment is run in fully closed premises. The external environment is only affected by the air-conditioning outlet to the vent chimney. Given the distance from the closest protected developed area (2,200m), there is no realistic assumption of exceeding the permissible noise levels on the facades of residential buildings.
Mobile sources of noise include service transport during day-time with a maximum frequency of one to three trucks per day. The share of the service transport in the frequency of other traffic on road III/504012 in the vicinity of the JAVYS and SE, a. s. site, EBO plant, is around

0.5%. For this traffic frequency in the form of equivalent noise level under Decree of the MoH SR No. 549/2007 Coll., the noise exposure of the population is practically not measurable.

Conclusion:
Harm to the health of people living in the vicinity of the assessed operation of the RAWPTT and A1 NPP decommissioning facilities due to excessive noise is not realistic.

9.2. Impacts of Electromagnetic Radiation

Electromagnetic radiation is non-ionising radiation. It represents a wide scale of radiations of various wave-lengths (pm up to km) and frequencies (10^3–10^{20}), producing electromagnetic field with increased intensity. The natural sources include solar activity, magnetic field of the Earth, or storms. The anthropogenic sources include television and radio transmitters, mobile operators´ stations, radars, rail and trolley-bus transport (contact of trolleys with electric conductors), conductors of electricity, as well as TV sets and computers, micro-wave ovens and mobile telephones indoors.
Though the World Health Organisation has not issued a final opinion on the harmful nature of long-term effects of the electromagnetic field on people (which may get manifested in the next generations), measures should be taken to permanently reduce these effects caused by sources and receivers, and to protect the sensitive groups of population (especially children). It is assumed that there are differences in individual sensitivity. The limits for electromagnetic field intensity are laid down in a decree.
High-voltage conductors in the nuclear facilities site and its vicinity represent the main source of electromagnetic radiation.
The operation of the RAWPTT and A1 NPP facilities cannot be considered a major source of electromagnetic field.

Conclusion:
Health-related harm to people living in the vicinity of the RAWPTT and A1 NPP decommissioning facility caused by electromagnetic field is not realistic.

10. Psychological Impacts

The facility is situated within the nuclear facilities site, and given the operation conditions it forms its inseparable part. Since the facility handles radioactive substances, fears from health hazards can arise among some people. These can be promoted by actions organised by opponents of nuclear power use for energy purposes who not always present information in a serious way.
It is therefore necessary to communicate with the inhabitants of the surroundings and with the nearby municipalities, explain to them the technological processes, and provide them with information about the actual outputs of potential pollutants in the environment.
The municipalities in the vicinity of the nuclear facilities established the Association of Towns and Municipalities of the Region of JaslovskéBohunice Nuclear Power Plants with 180 members. A Civil Information Committee was created within the Association which

intensively cooperates with the company JAVYS, a.s. and answers the questions of inhabitants and businesses concerning the facilities within the site and their safety.
Given the long period of operation of the nuclear facilities within that locality, the population of the area seems to be reconciled with its existence.

Conclusion:
Health-related harm to people living in the vicinity of the assessed activity caused by excessive stress from the operation of the RAWPTT and A1 NPP decommissioning facilities is improbable.

11. Sociological Impacts

The facilities have around 270 full-time workers, which is a positive factor for an area with a relatively high unemployment rate. The operator of the JAVYS site promotes the development of the nearby municipalities by financial and material means. From this point of view, the activity can be perceived positive.

Conclusion:
No negative sociological impacts on the population in the surroundings of the RAWPTT and A1 NPP decommissioning facilities have been identified.

12. Discussion

Uncertainties concerning the assessment, and other assessment aspects

- The assessmentof health risks andhealth impacts is mainly based on the calculation of theshare of the environment burdendue to ionising radiationfrom the operation of RAWPTT and A1 NPP decommissioning facilities in the overall operation of the JaslovskéBohunice nuclear facilities site. The officiallysetburden limits were also based on this aspect.
- The maximum radiation burdens of the population were calculated for a life-long stay of 70 years in the given locality. This calculation is based on a highly conservative approach and does not take into consideration the natural short-term and long-term movement of people. In this respect, no health risk for inhabitants beyond the permissible level has been identified.
- In the case of a maximum accident dose as a result of a hypothetical combination of accidents, the permissible annual dose to individuals under the current legislation would not be exceeded. In the event of an accident it is recommended to use prophylaxis and to avoid any excessive (not indicated) radiation burden (e.g. avoiding preventative health checks, senseless repetition of health checks, etc.);
- With regard to air pollution impacts, the hazard index was calculated on the basis of maximum possible immission values, and not on the basis of the annual average, which is more relevant with regard to potential health impacts. No probability of health impacts of pollutants has been identified through calculations based on maximum values attained near the incinerator´s air shaft within the nuclear facilities site.

- Given the distance of the assessed activity from the closest residential zone (approx. 2,200m), the possibility of noise impacts due to the activity and the air-conditioning system is practically excluded. The related service transport is relatively small, and the noise contribution from traffic to the surroundings of roads will probably not be detectable by ear.
- The facilities affect the quality of waters and soil in the surroundings within the extent of permissible limits, without the probability of negative impacts on people´s health.
- The impacts of the facilities mainly affect the staff, and are continuously monitored by the state health regulatory authority and by the contractual work health service.

13. Conclusion

The results of the impacts assessment of the “Radioactive Waste Processing and Treatment Technology and A1 NPP Decommissioning facility within the nuclear facilities site of JaslovskéBohunice have not demonstrated any negative impacts on people´s health in the nearby residential area.

Annex No. 1 –

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