Session F, Track 2:
Lessons Learned from Chernobyl II

Friday, September 11, 1998
8:00 a.m. - 9:50 a.m.

Chair: Jim Fairobent, United States Department of Energy

Cleanup Criteria and Technologies for a ^{137}Cs-contaminated Site Recovery

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INTRODUCTION

The 19 km long banks of the Bohunice NPP waste water recipient has been identified as contaminated by ^{137}Cs as a result of two accidents on the CO_2 cooled and heavy water moderated NPP-A1 unit in 1976 and 1977. Until 1992, NPP waste water had been derived through the 5 km-long, concrete paved Manivier canal to the smaller rated Dudvah River (Qaverage=1.8 m^3/s which is conjucted with the Vàh River (Qa=150 m^3/s) after 13 km downstream at 90 km from Vah's mouth into the Danube River (see Fig.1). In the period between 1976 and 1978, when both accidents happened, construction of a flood control project on Dudvah River had just been implemented in the length of 8 km upstream of its mouth. In the next upstream part of the River approximately a 5 km long river section which was affected by NPP, the flood control conditions are insufficient and have, hitherto, caused permanent public concern.

The contamination of the banks and its significance was discovered in 1991 in connection with preparation of a flood control project implementation. As a result of the conducted radiological survey of the concerned banks, the flood control project implementation was stopped during its licensing. Soon after, proper restoration action was requested by the competent authority from the operator of the Bohunice NPP who has been considered responsible for the bank contamination. A preliminary cleanup level was given as well, being set up ad hoc by the authority on a low level of 1 Bq/g of ^{137}Cs.

The goal of this paper is to give a brief characterization of the site and to summarize the working efforts spent after discovery of the site contamination problems in line of the post-emergency response and planning for recovery of the site. Emphasis is put on the cleanup criteria development and the proposed characterization and remediation technologies for the ^{137}Cs contaminated banks.

DISCUSSION

Initial Response and Radiological Site Characterization

In 1992, a bank restoration project including site characterization for the concerned part of the river was initiated by the NPP with a projected disposal capacity of 5,000 m^3 of removed soil. It was assumed that the soil would be dumped into a subsurface concrete structure inside the NPP area, which is considered to be the most acceptable disposal site of the removed soil for the

nearby public. Consequently, during the ongoing monitoring exercises, other parts of the affected river banks were found to be contaminated as well. Therefore, a comprehensive post-emergency survey was needed to be conducted on the overall potentially influenced banks and its nearby surroundings.

First, a mobile ground based screening survey exercise was applied to the flood plain area of the Dudvah (18 km) and Vàh rivers (25 km) including the Kralova Reservoir to identify locations of the contamination in the site. Gamma radiation readings and sliced bulk soil samples for laboratory gamma-spectrometric and radiochemical analysis were taken at the surface of the banks inside and outside of the built levees. These analyses determined that ^{137}Cs is the dominant contaminant in the site.

For the accessible places in the outer side of levees, scanning by a vehicle mounted mobile gamma survey system (VMGS) was used.[1] A contaminated land-field in a spread of 2000 m^2, alongside the Dudvah bank and in a limited flood plain area of the Vàh and the former Dudvàh River were discovered and evaluated this way, as well. Inside the levees, a hand-held gamma survey meter was used for discrete measurements, mostly, with about 20 m spacing within the monitoring line established on the 18 km-long banks.

The detailed and comprehensive survey done between 1991 and 1994 shows that the top soil contamination on the banks widely varies from background level to 20 Bq/g (3.8 MBq/m^2) on the Dudvah River and reaches 250 Bq/g of ^{137}Cs for the spottily-contaminated section on the Manivier canal banks. The contamination is spread over a 0.5 to 3m wide strip on the lower part of the banks and the average level of ^{137}Cs in the top 10 cm soil layer reaches 6.3 Bq/g. The overall contaminated area in the site with activity level exceeding 1 Bq/g of ^{137}Cs has been identified as to be about 67,000 m^2 and the volume of soil which had to be removed according to this preliminary cleanup criterion exceeds 13,000 m^3.

After finalization of the monitoring exercises, it was recognized that the applied 1 Bq $^{137}Cs/g$ is too low and inappropriate for use as a justified cleanup criteria. The previous restoration project demonstrated that it was necessary to reconsider with emphasis the complexity of the proposed cleanup measures including alternative remedial technologies (fencing, clean covering, trenching), the cost-analysis and development of justified cleanup criteria. Since 1993, VUJE Research Institute has been involved in comprehensively addressing of the above mentioned contamination problems.

A typical feature of these efforts, clear legislation in the field has been hitherto absent. This is why a primary demand to develop some principles for evaluation of the justified scale of cleanup measures including appropriate cleanup criteria development became the first priority in order to achieve confidence and authorization of the final reconsidered environmental restoration plan. Of course, this demand was realized in close cooperation with competent hygiene authorities and experts.

Dose Assessments and Cleanup Criteria Development

The contaminated banks are accessible for 16,000 residents living in a 3.5 km wide strip alongside the river. Selected exposure pathway scenarios with authorized parameters (stay on the bank and land field residential use of the contaminated soil for housing) were applied for dose characterization assessments and development of the proper cleanup criteria for the proposed cleanup measures. Ingestion pathways using transfer factors for goat's milk, meat and loamy soil according to the reference[2] was also part of the completed dose assessments.

Moving a large amount of the contaminated soil from the river banks, and its release into the environment during and after a planned flood control project implementation poses the most serious potential risks for the nearby population.

The contaminated soil from the banks is assumed to be relocated, and used as a landfill or fertile soil around a resident's living house. This type of radiation risk, but with a smaller amounts of contaminated soil arising (e.g., even from some maintenance works on an arbitrarily contaminated bank section could be considered as the most critical exposure pathway for the site). So, according to these conditions, the effective dose from a stay on a bank does not exceed 0.35 mSv/a, although, the potential risk from the use of contaminated soil reaches higher levels of effective dose to up to about 2 to 3 mSv/a. The annual collective dose from the stay on the banks is low, maximally, on the level of about 100 - 200 man mSv, accordingly to not too-intense use of the banks.

Cleanup criteria for the contaminated banks were derived on the basis of authorized principles and the mentioned site specific soil use scenario dose factors[3] (0.14 or 0.21 mSva=1/(Bq.g=1)). According to the recovery approach of the ICRP, accepted by the authority, both the actual dose and potential risk to critical individuals from the contaminated banks must not exceed 1 mSv/a. Average ^{137}Cs activity concentration levels in the bank soil (top 10 cm) AL200=6.0 or 8.0 Bq/g over 300 or 80 m long sections, competently, correspond to the above dose constraint requirement. In addition, ^{137}Cs activity concentrations AL.3 =25 Bq/g for isolated small spots on the canal banks.

The derived criteria are in good relation with the results of the volume distribution of the activity concentration analysis carried out on the basis of detailed measurements for the bank soil. It was possible to demonstrate by this way that cleanup measures, even, for a small part of the identified contaminated area on the banks-namely clean soil cover or removing, only, of the mostly contaminated soil (i.e. the soil with contamination above 6-7 Bq.g-1) would lead to significant improvement in remediation of the contaminated banks in the site.

Technologies and Scale of Resulting Cleanup

Exceeding the developed cleanup criteria justifies implementation of more cost-consuming restoration techniques, from which two remedies have been selected as the most appropriate for the contaminated banks remediation:

a) dilution/fixation of contaminated top soil by clean cover on flat contaminated areas; and
b) removing/disposal of top soil layer for the steep banks.

The clean cover technique sufficiently reduces the anticipated radiation risk, however, its price is about 10 times lower compared to the standard removing/disposal technique.

To be in compliance with these criteria, it is necessary to subject to cleanup measures about 11,000 m^2 of contaminated area on the Dudvàh River banks and 8,000 m^2 on the Manivier canal banks. As engineered flat terraces prevail on the Dudvàh River banks, according to the authorized principles, clean soil cover is sufficient to be applied over 9,500 m^2 of contaminated flat area.[4] On the spotty contaminated Manivier canal section, only the isolated spots of contamination are proposed to be removed. So, the resulting volume of soil to be removed from the steep banks and safely buried in a disposal facility inside the Bohunice NPP area equals to about 1,100 m^3.[3]

CONCLUSION

Re-evaluation of a ^{137}Cs contaminated bank restoration project has been conducted for NPP Bohunice site on the basis of comprehensive and detailed site characterization technique application. As there is no clear legislation in the subjected field, principles for contaminated bank evaluation had been developed and approved by the competent authorities. Site-specific cleanup criteria have been developed, which are 6 or 8 Bq $^{137}Cs/g$ in soil depending on the size of the contaminated area. Thanks to the application of consistent site characterization techniques and planning of clean covering use as a justified cleanup measure, unnecessary waste soil disposal is going to be avoided within the prepared new bank restoration project.

REFERENCES

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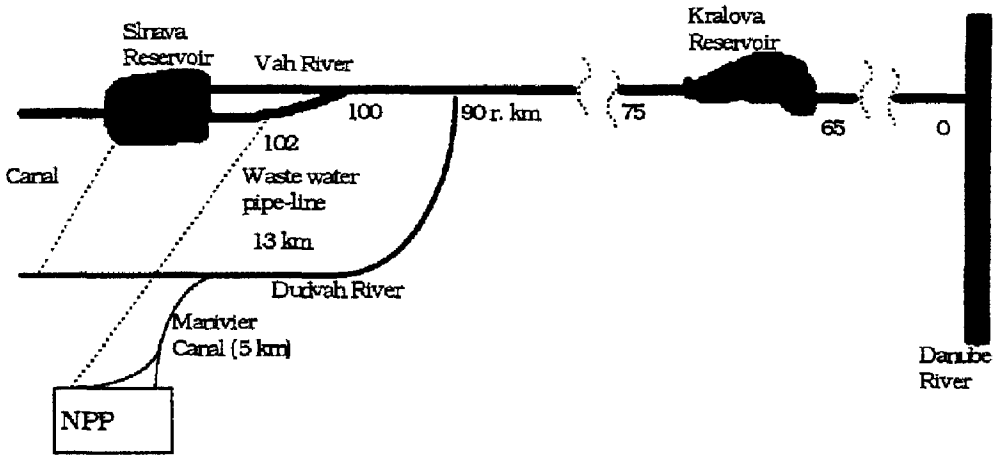
Sinava
Reservoir
Vah River
100
90 r. km
102
Canal
Waste water
pipe-line
13 km
Dudvah River
Manivier
Canal (5 km)
NPP
Kralova
Reservoir
75
65
0
Danube
River