<Reference>
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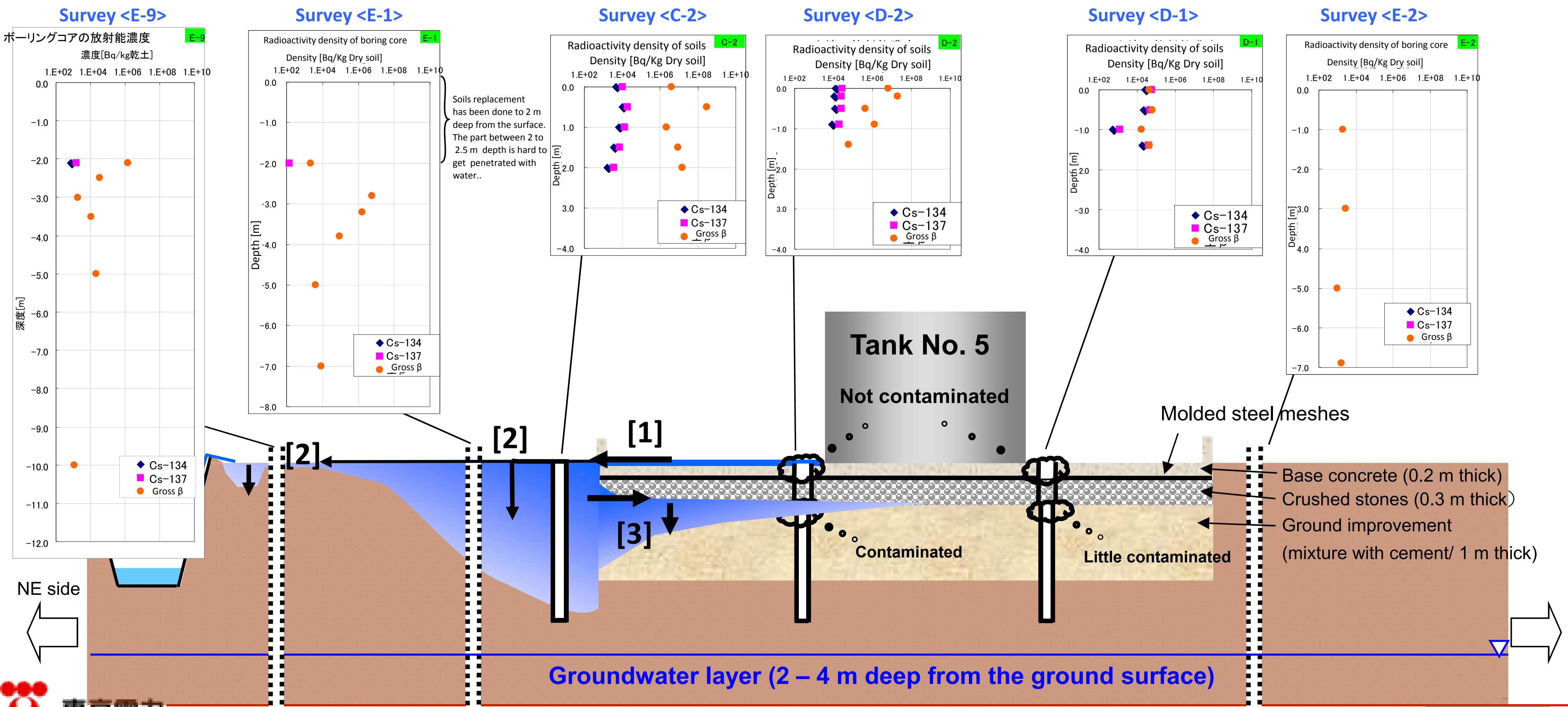
Tokyo Electric Power Company

# Environmental Impact Assessment on Leakage from RO Concentrated Water Storage Tank at Contaminated Water Storage Facilities in Fukushima Daiichi Nuclear Power Station

東京電力
TEPCO

# 1. Contamination around tank No. 5 at H4 Tank area
# (Estimation and summaries of the leakage circumstances)

[1] Leaked contaminated water flowed out to the outside of the dike located on the northeast side through the drain valve being opened under constant operation.
[2] Penetrating into the soil around the dike, the contaminated water flowed down to the northeast through a break in the earthen dam and seeped down to underground when reaching near the bank on the drainage B side. Moreover, some of such water flowed in a drain ditch after passing through a bank when rain fell, etc.
[3] Some of the contaminated water seeped down to the underground right outside the dike, entered under the tank area passing through crushed stones layer built under the base concrete. Of which, some went further to reach almost right under the tank.



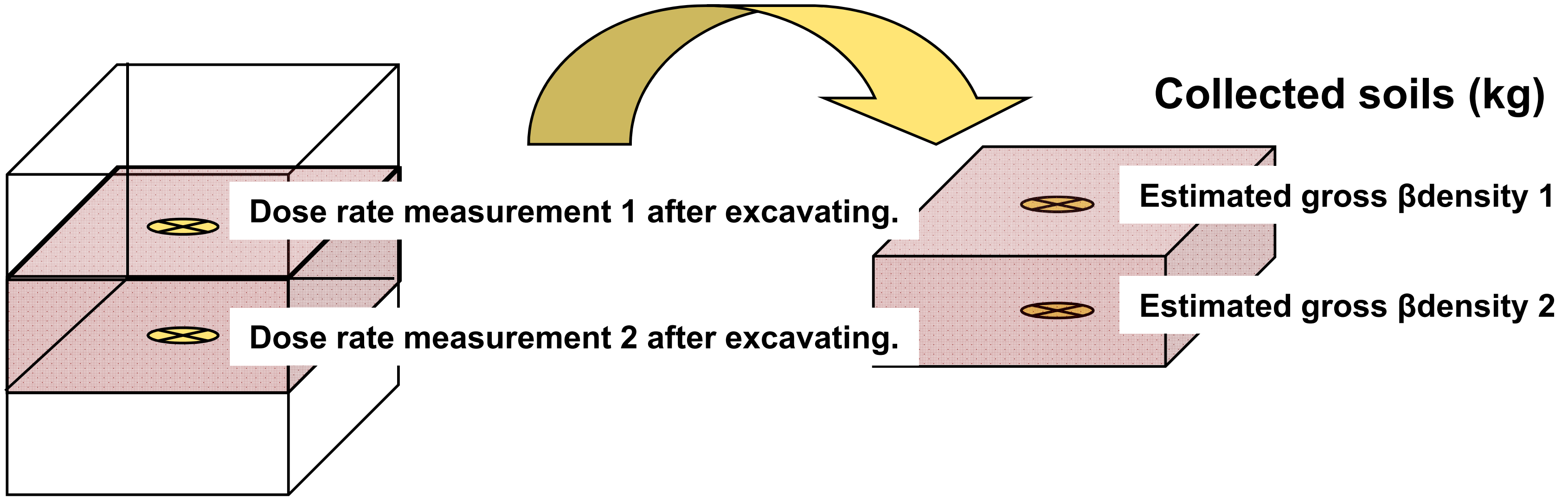
# 2.1 Evaluation on the amount of collected leaked radioactive materials

**(Evaluation methods)**

■ Evaluation was conducted on the amount of collected radioactive materials through collecting contaminated soils.

■ Since the leaked water highly contains strontium 90 (Sr-90) which is βnuclide, providing gross βradiation density as an index, an estimation on the collected amount of leaked strontium 90 was made following the procedures shown below:

- Based on the ground surface dose rate measured at site when collecting relevant soils, gross β radioactive density of the soils was estimated per block and per depth.
- Calculating the product of the collection volume of soils and the average density, the sum was set as an overall amount of collected gross β radioactive materials (Bq) to determine its half amount as the collected amount of strontium 90.

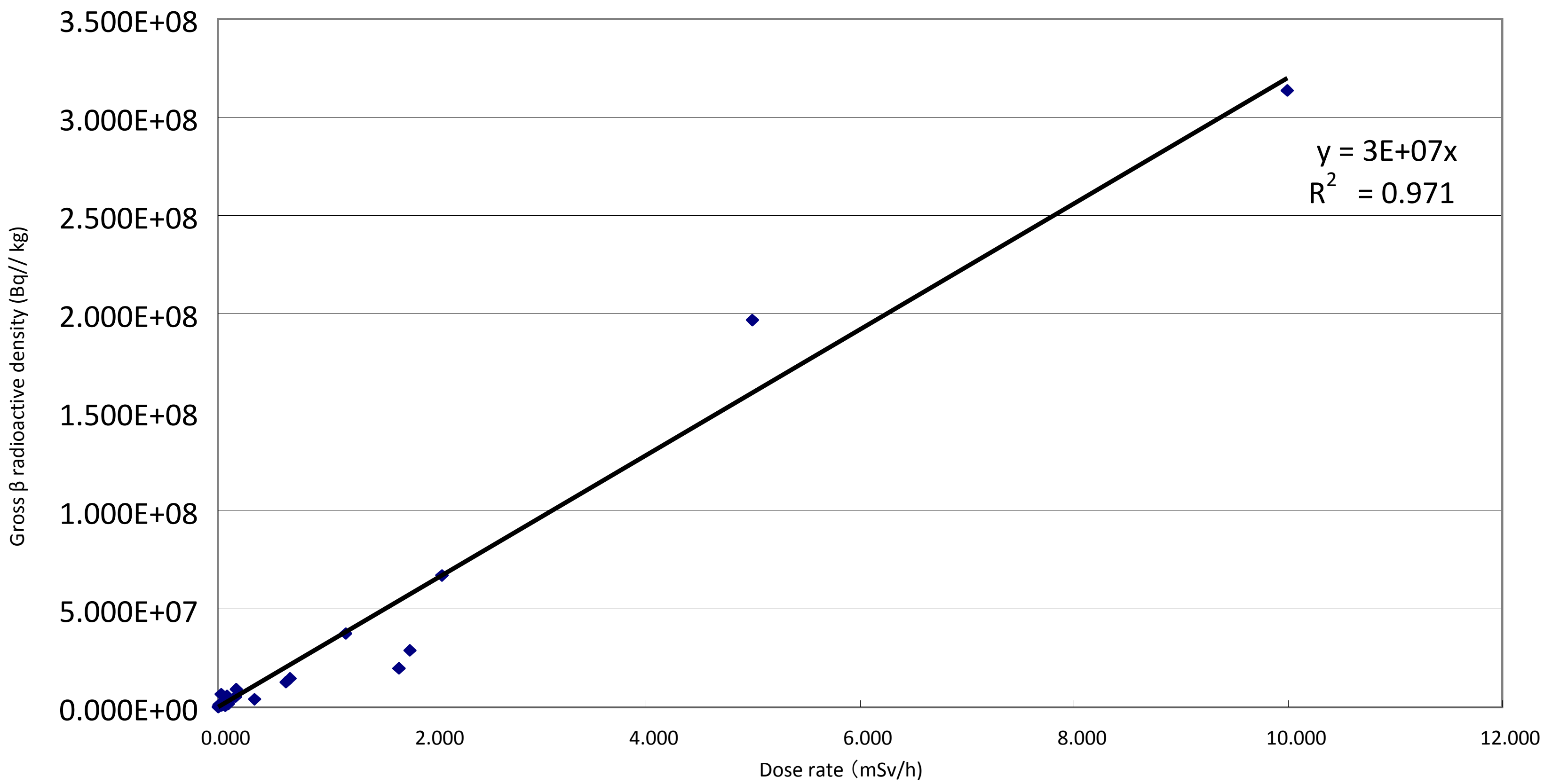



- Average density per block and per depth (Bq/Kg) = (Estimated gross βdensity 1 + 2) /2
- The volume of soils collected per block and per depth = the volume of soils collected (Kg) X average density ( Bq/kg)
- Calculate the volume of collected soils with the sum of all of each volume of soils collected per block and per depth.
- Calculate with specific gravity of soils at 1.5.

## 2.2 Estimation on gross β radioactive density of the collected soils (conversion based on the dose rate)

- Having analyzed gross β radioactive density of soil samples taken by the boring core at around H4 area, the conversion module to estimate gross β radioactive density of the collected soils is determined to be $3.0 \times 10^7$ ((Bq/kg) / (mSv/h)), based on the relation with the dose rate measurement results.
- Gross β radioactive density of the collected soils was estimated by multiplying the dose rate data measured at the time of collecting soils by the said conversion modules.

Relation between the dose rate of the boring core and Gross β radioactive density



# 2.3 Provisional calculation results of the collection volume

- Provisional calculation results of the collection volume per block are shown as below. It is noted that the total amount of collected radioactive materials is 7.4 X $10^{13}$ Bq, based on the evaluation using gross βradioactivity.

Table: Provisional calculation results of the collection volume of radioactive materials per block (Gross βradioactivity)

| Block No. | Depth in boring | Ground surface after excavating 70μm dose equivalent rate（β）（mSv/h) | Collection vol. of soils （m3) | Collection vol.（Bq） calculated based on Gross β |
|---|---|---|---|---|
| 1 | G.L.−3,000 | 0.009 | 60 | 5.0E+12 |
| 2 | G.L.−3,000 | 0.009 | 96 | 9.6E+12 |
| 3 | G.L.−3,000 | 0.009 | 64 | 1.4E+12 |
| 9 | G.L.−1,080 | 0.005 | 16 | 5.2E+11 |
| 10 | G.L.−1,480 | 0.008 | 24 | 3.4E+12 |
| 11 | G.L.−840 | 0.008 | 15 | 6.4E+12 |
| 12 | G.L.−860 | 0.008 | 16 | 6.6E+12 |
| 13 | G.L.−550 | 0.009 | 10 | 5.6E+12 |
| 14 | G.L.−400 | 0.006 | 3 | 1.0E+12 |
| 15 | G.L.−1,050 | 0.009 | 17 | 1.0E+11 |
| 16 | G.L.−900 | 0.004 | 21 | 1.9E+11 |
| 17 | G.L.−600 | 0.006 | 10 | 1.8E+11 |
| 18 | G.L.−600 | 0.007 | 15 | 2.2E+11 |
| 19 | G.L.−700 | 0.004 | 18 | 3.9E+11 |
| 20 | G.L.−600 | 0.006 | 21 | 3.7E+11 |
| 21 | G.L.−600 | 0.008 | 3 | 3.7E+10 |
| 22 | G.L.−900 | 0.005 | 7 | 3.5E+12 |
| 23 | G.L.−900 | 0.008 | 3 | 1.7E+12 |
| 24 | G.L.−1,650 | 0.35 | 3 | 2.3E+12 |
| 25 | G.L.−1,000 | 0.34 | 9 | 2.4E+12 |

| Block No. | Depth in boring | Ground surface after excavating 70μm dose equivalent rate（β）（mSv/h) | Collection vol. of soils （m3) | Collection vol.（Bq） calculated based on Gross β |
|---|---|---|---|---|
| 26 | G.L.−1,000 | 0.35 | 6 | 1.5E+12 |
| 27 | G.L.−1,000 | 0.007 | 29 | 6.6E+11 |
| 28 | G.L.−2,500 | 0.04 | 26 | 2.5E+11 |
| 29 | G.L.−2,500 | 0.1 | 17 | 4.5E+11 |
| 30 | G.L.−1,000 | 0.008 | 18 | 1.2E+12 |
| 31 | G.L.−2,500 | 0.11 | 23 | 7.2E+11 |
| 32 | G.L.−3,000 | 0.007 | 30 | 2.0E+12 |
| 33 | G.L.−3,000 | 0.13 | 10 | 7.0E+11 |
| 34 | G.L.−1,500 | 0.006 | 6 | 4.1E+11 |
| 35−1 | G.L.−2,000 | 13 | 10 | 3.9E+12 |
| 35−2 | G.L.−2,000 | 1.7 | 9 | 2.2E+12 |
| 36 | G.L.−2,000 | 0.8 | 19 | 3.0E+12 |
| 37 | G.L.−2,000 | 2.2 | 15 | 2.6E+12 |
| 38 | G.L.−800 | 0.006 | 25 | 7.2E+11 |
| 39 | G.L.−1,000 | 0.008 | 27 | 6.2E+11 |
| 40 | G.L.−1,600 | 0.008 | 16 | 7.6E+10 |
| 40−1 | G.L.−1,800 | 0.007 | 16 | 7.6E+10 |
| 41 | G.L.−1,500 | 0.008 | 24 | 4.4E+11 |
| 42 | G.L.−1,300 | 0.009 | 31 | 5.7E+11 |
| 43 | G.L.−1,500 | 0.008 | 19 | 1.3E+11 |
| 44 | G.L.−1,500 | 0.007 | 32 | 5.8E+11 |
| 45 | G.L.−1,500 | 0.005 | 39 | 2.7E+11 |
| Total | | | 878 | 7.4E+13 |

Note: Soils in blocks 4 to 8 have been collected to be included in the soils belonging to other blocks located around the said blocks, by which, their block numbers are omitted on the table.

## 2.4 The amount of radioactive materials leakage out of Tank No. 5 in H4 area

- Nuclide analysis results of Tank No. 5 water and evaluation results on the leakage amount are as below. To note, the leakage amount was sought by multiplying the density of each nuclide by 300 $m^3$ of leakage amount.
- Strontium 90 (Sr-90), the most highly concentrated and great impact on environment, was calculated to become 4.5 X $10^{13}$ Bq.
- Of the other nuclides, tritium (H-3) shows high concentration status, but still it is no more than 1/50 of the strontium 90 concentration, moreover, that of cesium 137 (Cs-137) or other nuclides all went below 1/10 of the said fraction shown for the strontium 90.
- In addition, there shows not much difference in the analysis results of leakage water collected from within the dike.

Table: Radioactive materials density of Tank No. 5 water and evaluation results on the leakage amount

| Nuclide | Tank No. 5 Water | | (Ref.) Leakage water (collected from dike) | |
|---|---|---|---|---|
| | Density (Bq/$cm^3$) | AMT. of leakage (Bq) | Density (Bq/$cm^3$) | AMT. of leakage (Bq) |
| Cs-134 | 4.4E+01 | 1.3E+10 | 4.6E+01 | 1.4E+10 |
| Cs-137 | 9.2E+01 | 2.8E+10 | 1.0E+02 | 3.0E+10 |
| Co-60 | ND(3.8E+00) | 1.1E+09 | 1.2E+00 | 3.6E+08 |
| Mn-54 | ND(5.2E+00) | 1.6E+09 | 1.9E+00 | 5.7E+08 |
| Sb-125 | 5.3E+01 | 1.6E+10 | 7.1E+01 | 2.1E+10 |
| Sr-90 | 1.5E+05 | 4.5E+13 | — | — |
| H-3 | 2.4E+03 | 7.2E+11 | 2.1E+03 | 6.3E+11 |
| Gross β | 4.1E+05 | 1.2E+14 | 2.8E+05 | 8.4E+13 |

Note: Of the leakage amounts of Tank No. 5 water, the leakage amounts of Co-60 and Mn-54 are sought using detection limit value.

# 2.5 Provisional calculation results of the collection rate

- When calculating the collection rate of strontium 90, with an assumption that the half of 7.4 X $10^{13}$ Bq, the amount of radioactive materials collected from soils, is strontium 90 (and the rest is yttrium 90), the collection rate became approx. 80 %.
- On the other hand, when calculating the collection rate based on the gross β radioactive density of tank water and leakage water within the dike, it became approx. 60 to 90 %.

Table 1: The leakage amount of radioactive materials attributed to the leakage of Tank No. 5 in H4 area and the collection rate by collecting soils.

| Sample name | Tank No. 5 water | | (Ref.) Leakage water H4 area | Remarks |
|---|---|---|---|---|
| Evaluation Nuclide | Sr-90 | (Ref.) Gross β radioactive | Gross β radioactive | |
| Density [Bq/cm³] -> [1] | 1.5E+05 | 4.1E+05 | 2.8E+05 | |
| Leakage amount（300 m³) -> [2] | 300 | 300 | 300 | |
| Leakage amount（Bq) -> [3]= [1]×[2] | 4.5E+13 | 1.2E+14 | 8.4E+13 | |
| Collection volume of soils (Bq) -> [4] | 3.7E+13 | 7.4E+13 | 7.4E+13 | The collection amount of Sr-90 is determined to be the half of the amount underwent evaluation for gross β |
| Collection rate -> [5]＝[4]/[3] | 80% | 60% | 90% | |

## 2.6 Summaries of the evaluation results of the collection rate of radioactive materials leakage by collecting soils

- For the strontium 90 that was contained largely in the tank water made the leakage, its collection rate by means of collecting soils was calculated using an index of gross β radioactivity, to become approx. 80%.
- Not all of leaked strontium 90 were successfully collected, but since almost no rise of gross βradioactivity has been observed in the groundwater of observation holes on the east side of the drainage B, it is considered that mostly have remained in the soils around H4 area but hard to collect it because of the location such as under the facilities located around the radio station or under the tank area base.
- While monitoring activities on the groundwater are continuously carried out, preventive measures for contamination expansion are to be addressed by pumping up groundwater from well points and controlling rainwater leakage through facing, etc.
- In addition, as for the contaminated soils remaining under the H4 tank area base, it will be investigated at the time of replacing tanks to collect radioactive materials.