Monitoring air dose rates from a series of aircraft surveys across the two years after the Fukushima Daiichi NPS accident

June 5, 2013

Radiation Monitoring Division

The Secretariat of the Nuclear Regulation Authority, Japan

NRA, Japan
Nuclear Regulation Authority

Contents

Surveys were carried out in the 80km zone from Fukushima Daiichi NPS on five/four occasions to create air dose rate maps for;

(i) the 80km zone from Fukushima Daiichi NPS

(ii) evacuation-directed zones

Methods of measuring radiation dose

Airborne Monitoring

Aircraft such as helicopters equipped with radiation detectors are used for monitoring. The detailed method is described in the next page.

Survey Meters

Radiation doses are measured by survey meters.

Mobile Monitoring

Cars equipped with radiation detectors are used for monitoring.

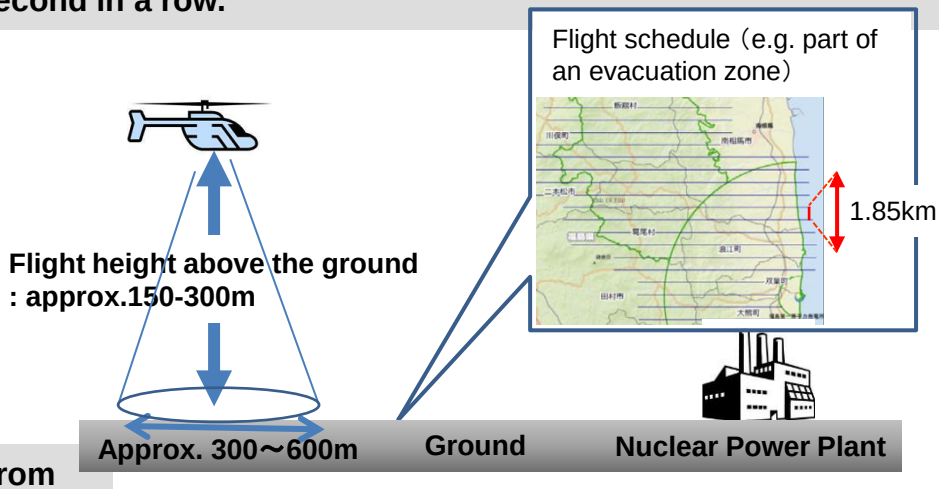
Monitoring Stations

Radiation doses are measured at monitoring stations. Approximately 3000 stations are located in Fukushima Prefecture.

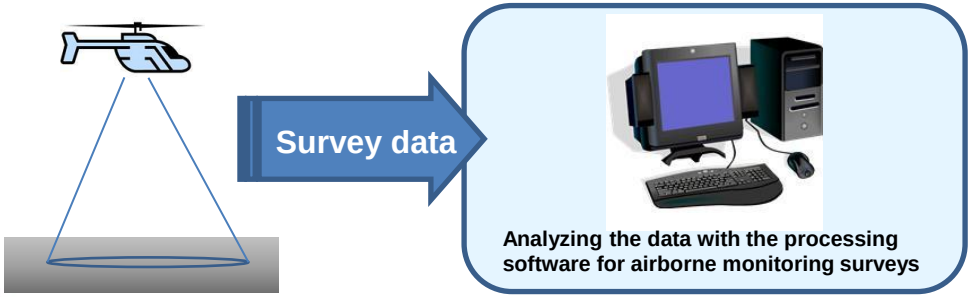
Airborne radiation dose monitoring by using aircraft

Airborne monitoring devices (left)
are installed in a helicopter (right)

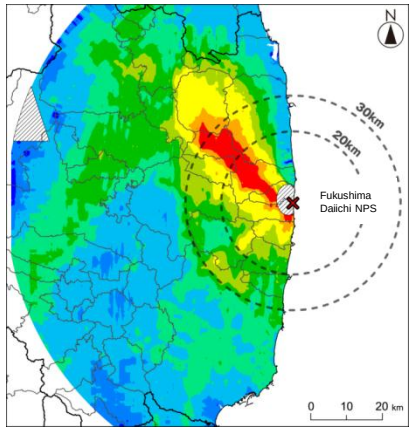
Gamma rays from the ground are detected by NaI scintillator installed in an aircraft (e.g. helicopter) while flying approximately 150 to 300m above the ground with every 1 second in a row.



Setting up the given points on the ground, gamma rays from these points were measured from the upper sky at different heights.
The calibration curves (heights vs. those rates) were created and air dose rates were normalized using these curves at 1m from the ground surface to create the map.



The data measured and interpolated were integrated to create the map.



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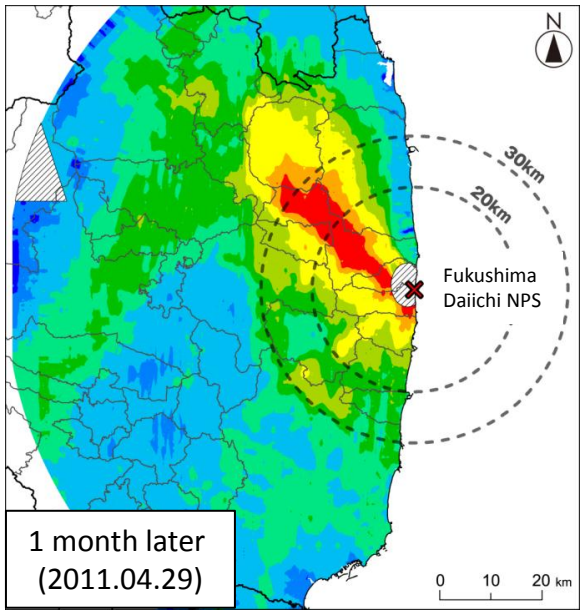
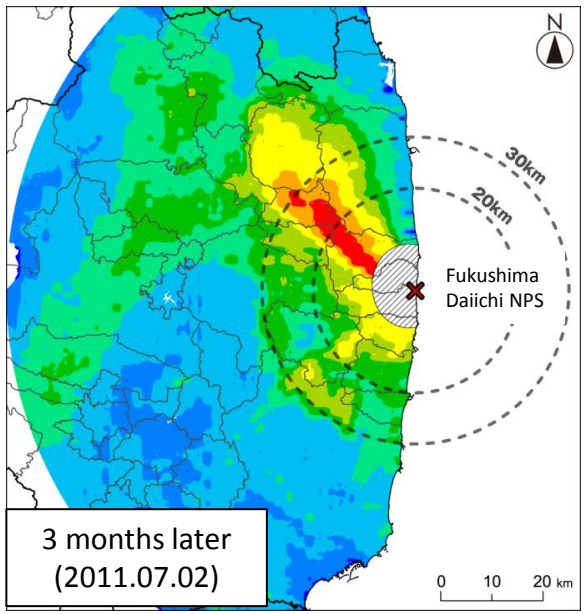
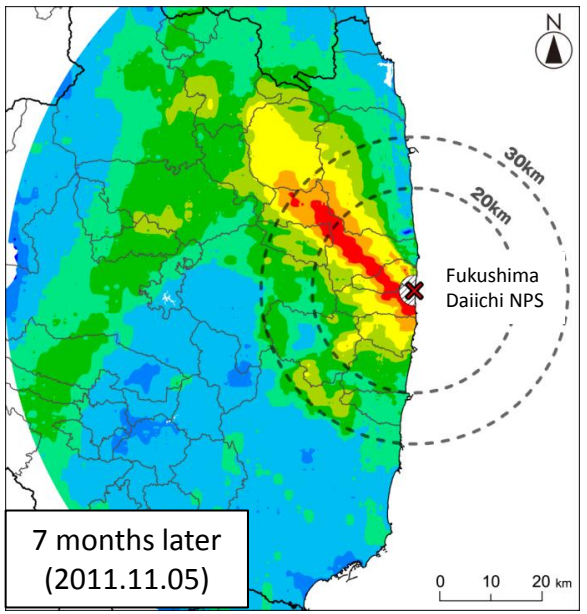
Air dose rates in the 80km zone from Fukushima Daiichi NPS



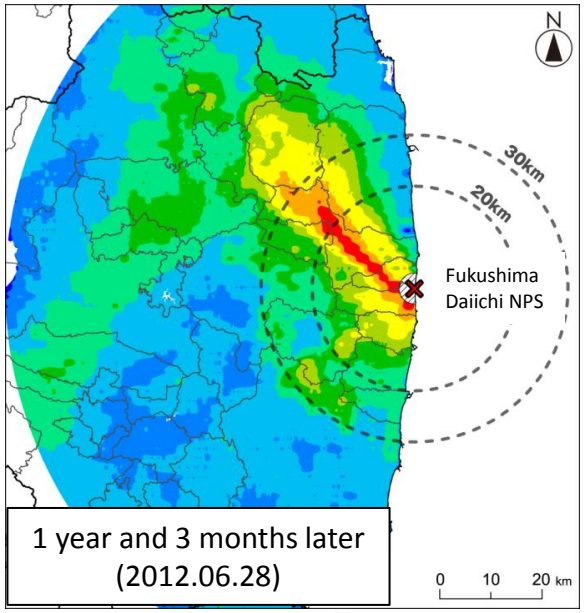
1 month later
(2011.04.29)



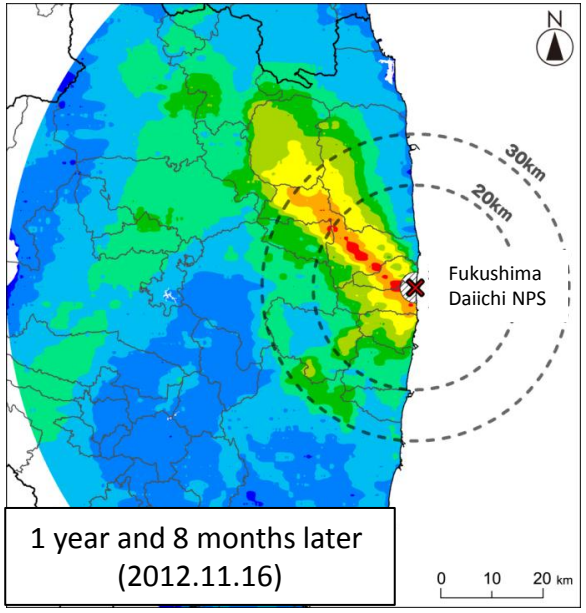
3 months later
(2011.07.02)



7 months later
(2011.11.05)

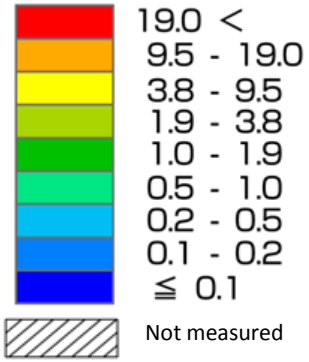


1 year and 3 months later
(2012.06.28)



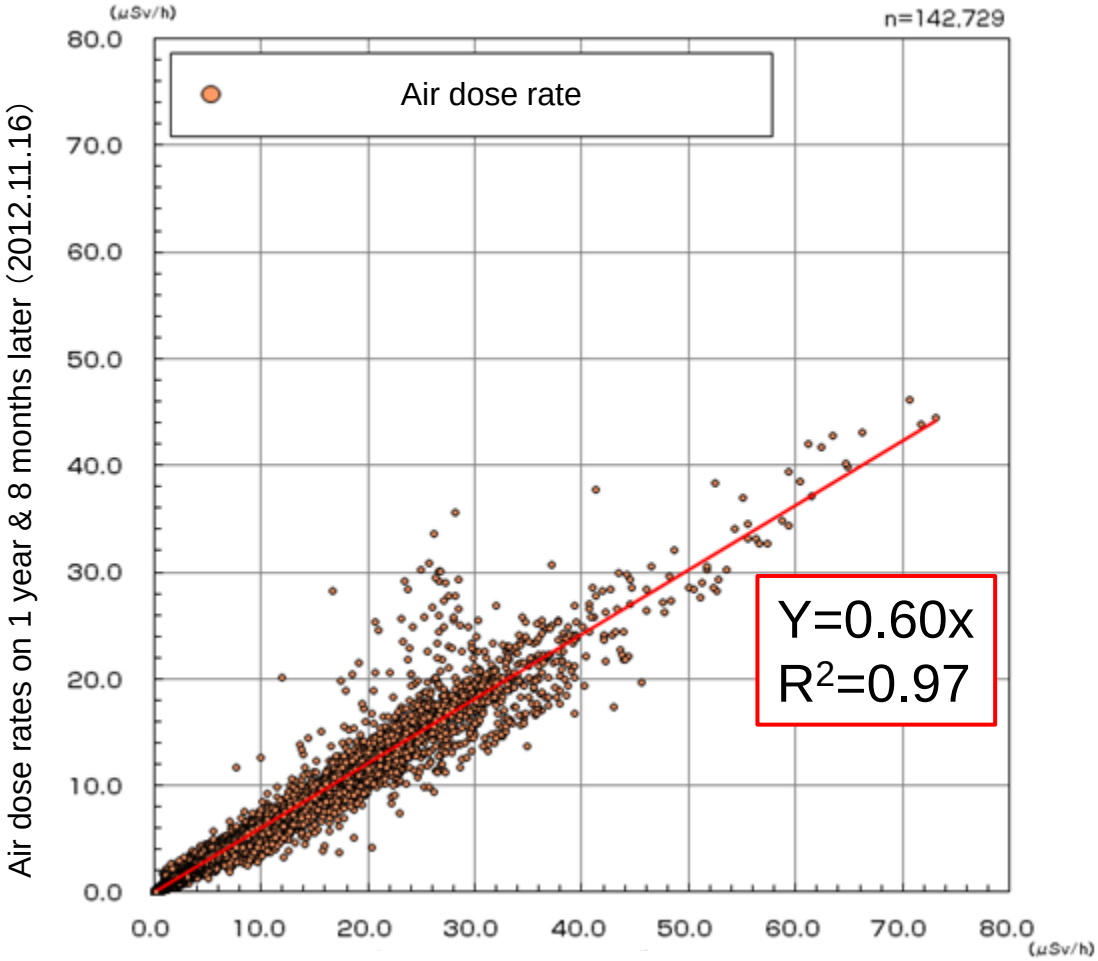
1 year and 8 months later
(2012.11.16)

Air dose rates at 1m from ground（μSv/h）



The natural radionuclides are included.

Air dose rates surveyed on two occasions (7 months and, 1 year & 8 months later)



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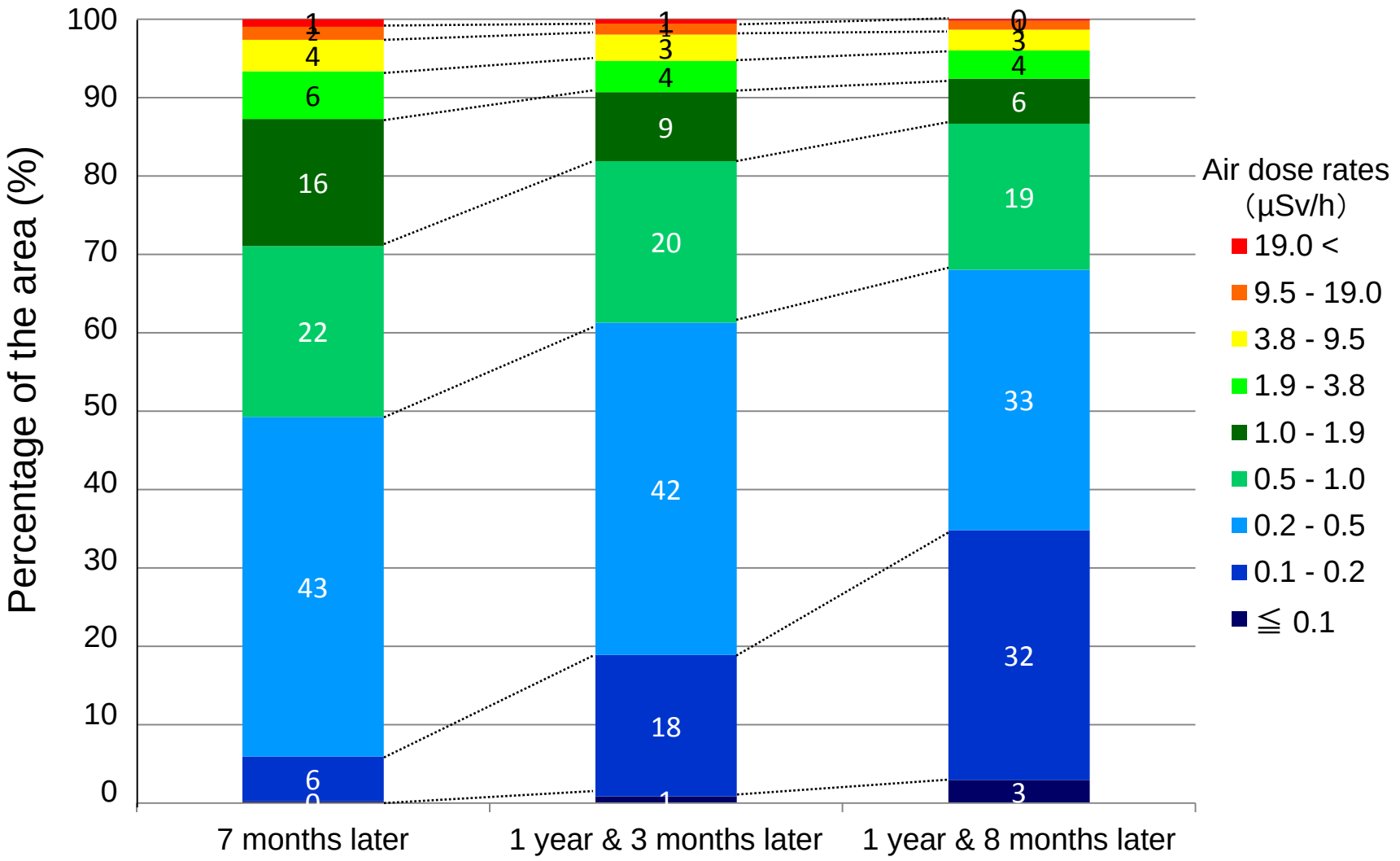
Modified; http://radioactivity.nsr.go.jp/ja/contents/7000/6749/24/191_258_0301_18.pdf

The percentage of the area in terms of air dose rates in the 80km zone (Table)

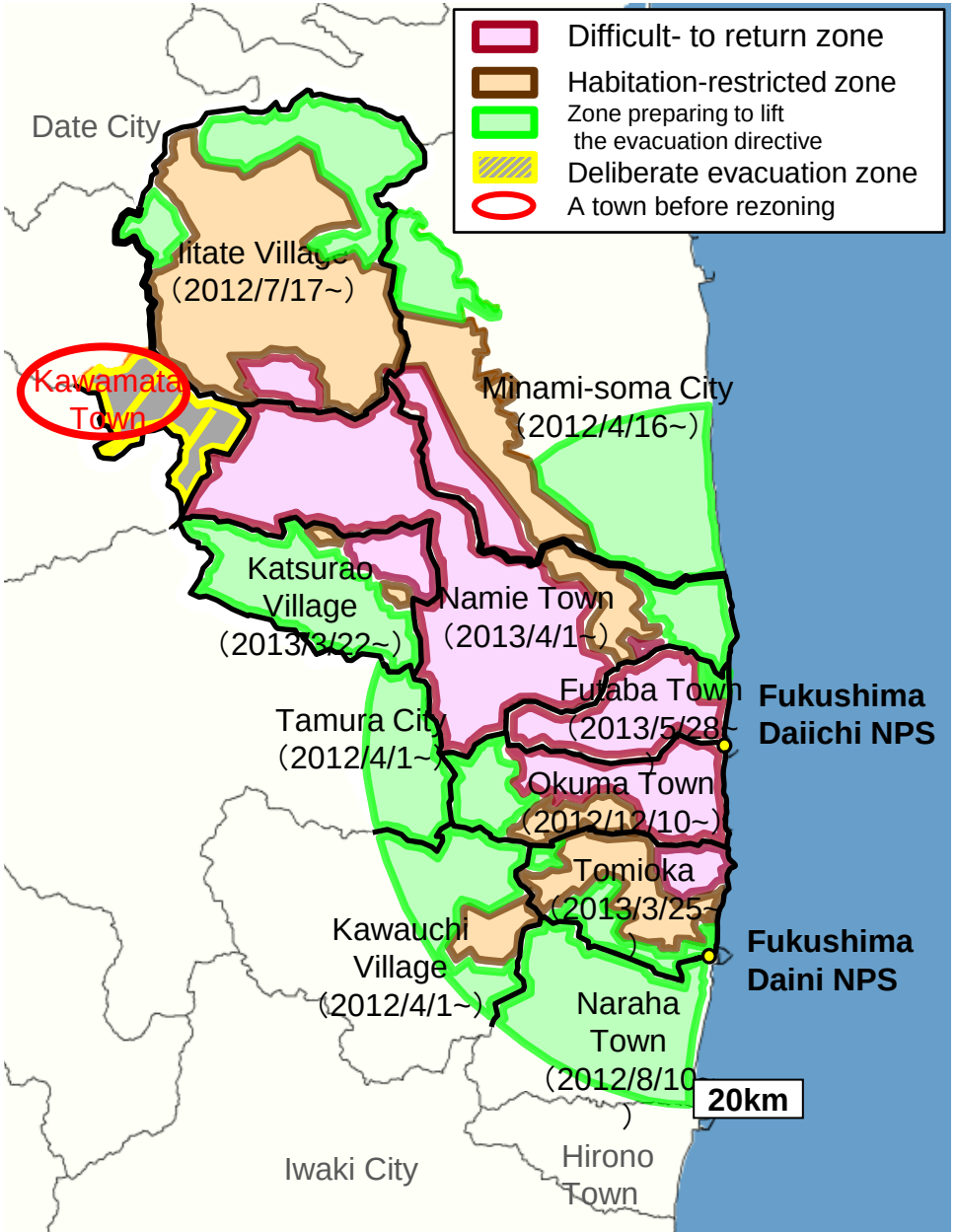
(%)

Air dose rates (μSv/h)	7 months later (2011.11.05)	1 year & 3 months later (2012.06.28)	1 year & 8 months later (2012.11.16)
19.0 <	1	1	0
9.5 – 19.0	2	1	1
3.8 - 9.5	4	3	3
(3.8 <)	7	5	4
1.9 - 3.8	6	4	4
1.0 - 1.9	16	9	6
0.5 – 1.0	22	21	19
0.2 - 0.5	43	42	33
(0.2 - 3.8)	87	76	61
0.1 - 0.2	6	18	32
≦ 0.1	0	1	3
(≦ 0.2)	6	19	35

The percentage of the area in terms of air dose rates in the 80km zone



Conceptual diagram of evacuation-directed zones （as of May 28, 2013 ）



Difficult-to return zone approx. 320km^2 #,$

Habitation-restricted zone; approx. 300km^2 $

Zone preparing to lift the evacuation directive; approx.460km^2 $

Deliberate evacuation zone; approx. 33km^2 $

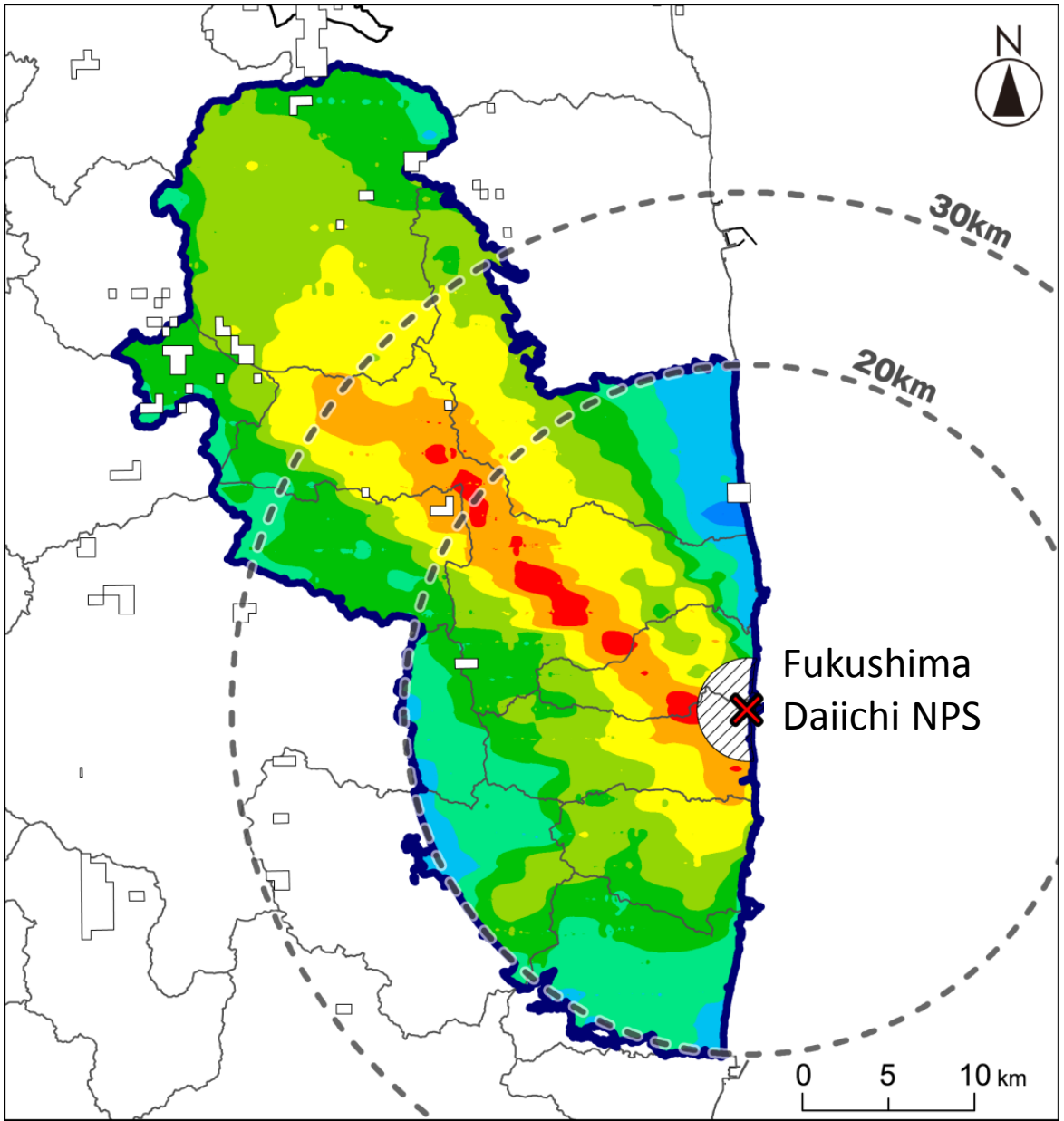
#. An area within 3km from Fukushima Daiichi NPS is excluded.

$. Snow coverage areas are excluded.

Revised "Regarding rezoning of the evacuation-directed and restricted zones in Futaba Town" issued by Nuclear Emergency Response Headquarters

http://www.meti.go.jp/english/earthquake/nuclear/roadmap/pdf/130507_assistance.pdf

Air dose rates in the evacuation-directed zones



2 years later
（2013.3.11）

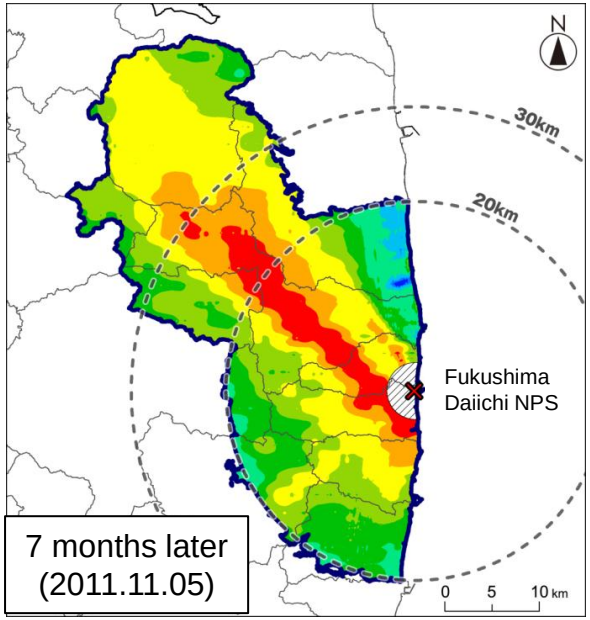
Air dose rates at 1m from ground（μSv/h）

	19.0 <
	9.5 - 19.0
	3.8 - 9.5
	1.9 - 3.8
	1.0 - 1.9
	0.5 - 1.0
	0.2 - 0.5
	0.1 - 0.2
	≦ 0.1
	Not measured

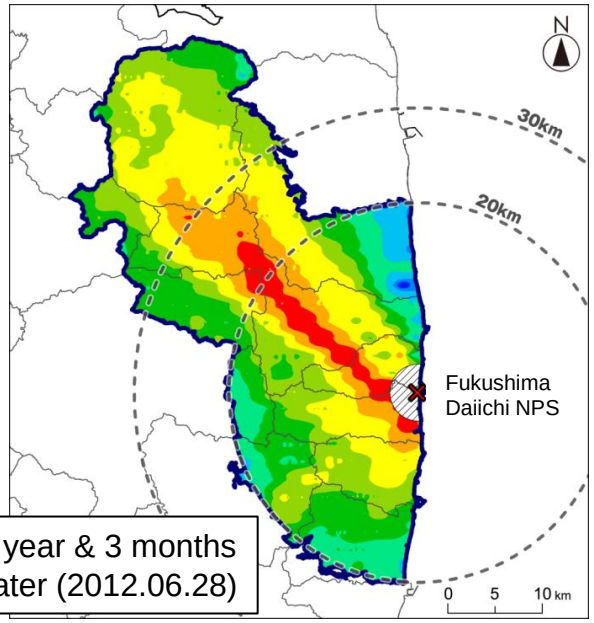
The natural radionuclides are included.

* The white zones surrounded by the solid lines: Snow Coverage Areas

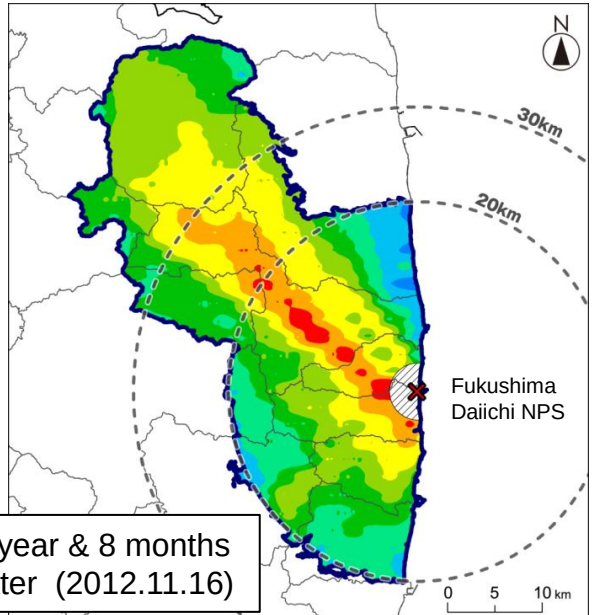
Air dose rates in the evacuation-directed zones



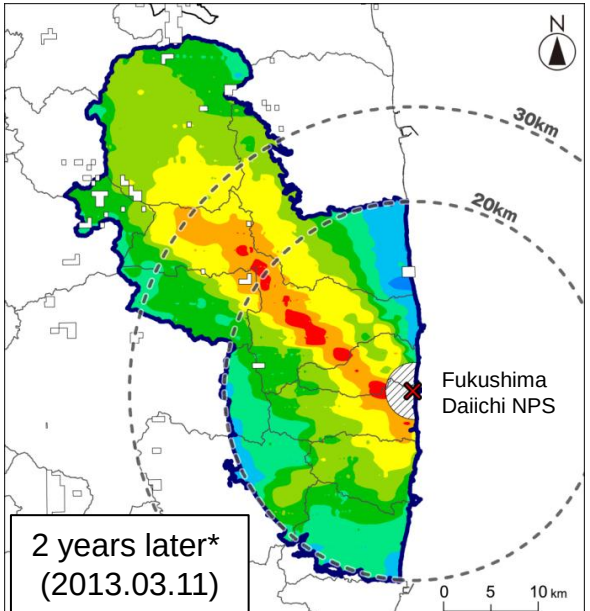
7 months later (2011.11.05)



1 year & 3 months later (2012.06.28)



1 year & 8 months later (2012.11.16)



2 years later* (2013.03.11)

Air dose rates at 1m from ground（μSv/h）

19.0 <
9.5 - 19.0
3.8 - 9.5
1.9 - 3.8
1.0 - 1.9
0.5 - 1.0
0.2 - 0.5
0.1 - 0.2
≦ 0.1

Not measured

The natural radionuclides are included.

- The white zones surrounded by the solid lines: Snow Coverage Areas

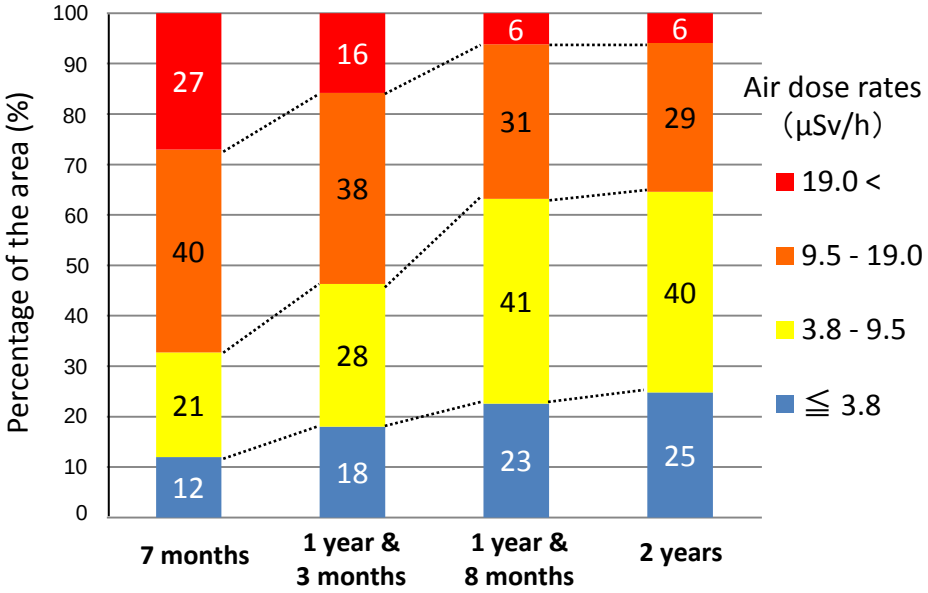
The percentage of the area in evacuation-directed zones (Table)

（Evacuation-directed zones: as May 28, 2013） (%)

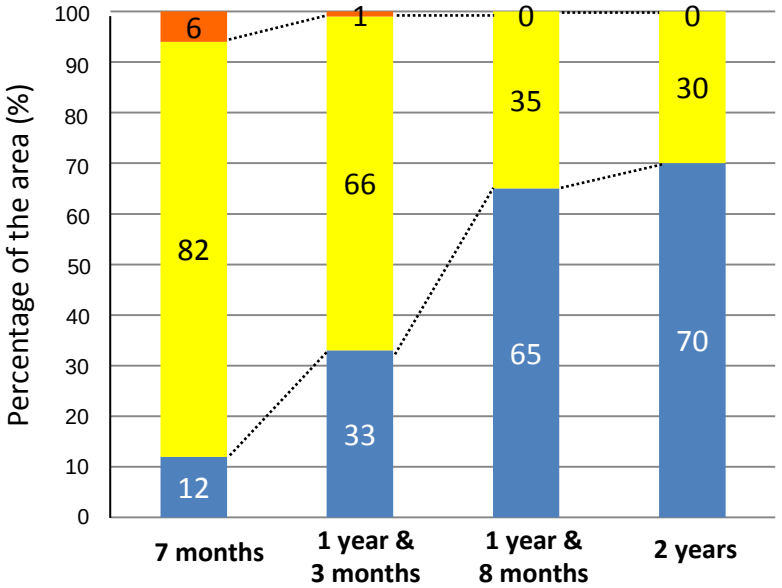
ref. P. 8	Air dose rates (μSv/h)	7 months later (2011.11.5)	1 year & 3 months later(2012.6.28)	1 year & 8 months later (2012.11.16)	2 years later (2013.3.11)
Difficult-to return zone	19.0 <	27	16	6	6
	9.5 - 19.0	40	38	31	29
	3.8 - 9.5	21	28	41	40
Approx. 320km²	≦ 3.8	12	18	23	25
Habitation-restricted zone	9.5 <	6	1	0	0
	3.8 - 9.5	82	66	35	30
Approx. 300km²	≦ 3.8	12	33	65	70
Zone preparing to lift the evacuation directive	9.5 <	0	0	0	0
	3.8 - 9.5	7	1	0	0
Approx. 460km²	≦ 3.8	93	99	100	100
Deliberate evacuation zone	9.5 <	0	0	0	0
	3.8 - 9.5	15	10	2	1
Approx. 33km²	≦ 3.8	85	90	98	99

The percentage of the area in evacuation-directed zones

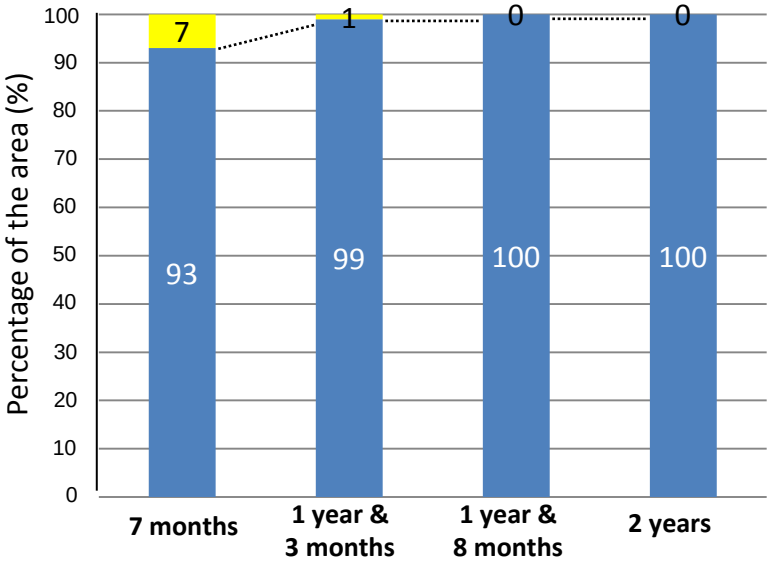
Difficult-to-return zone



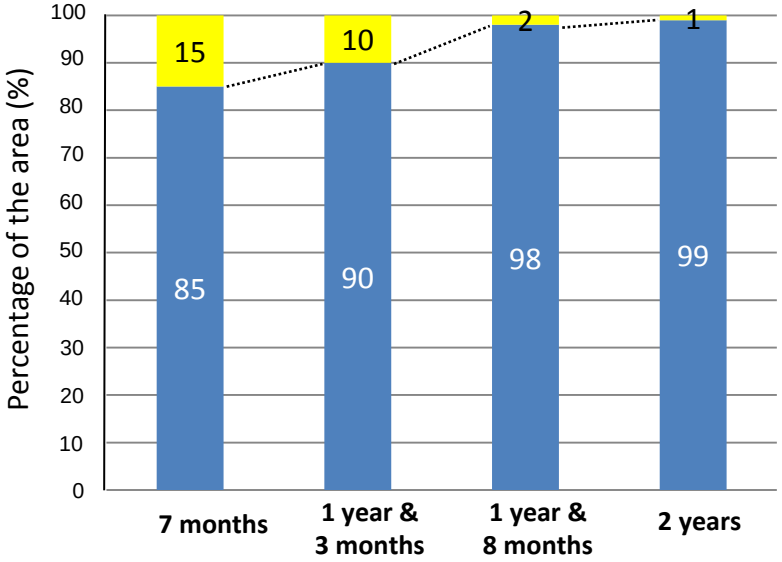
Habitation-restricted zone



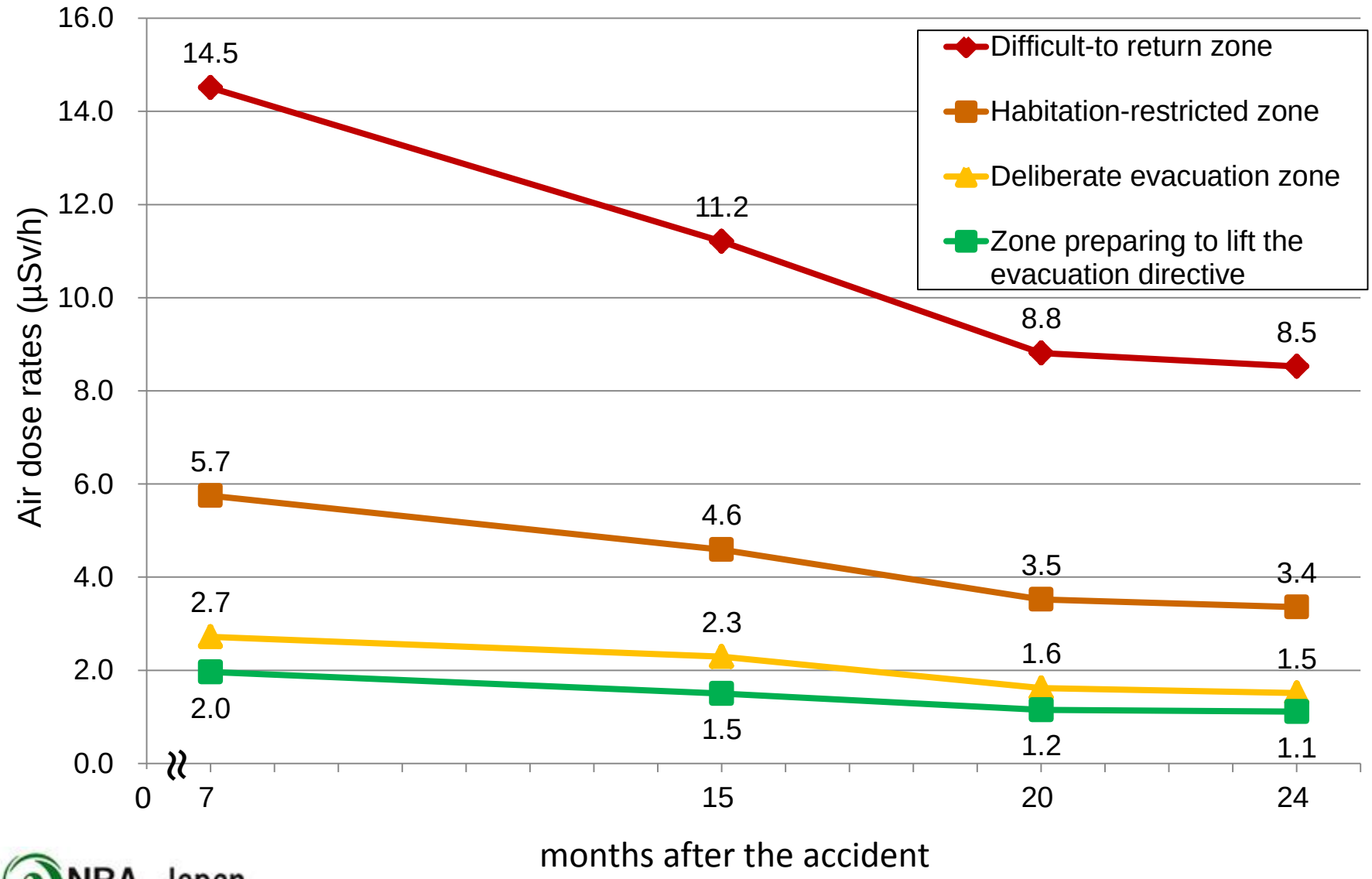
Zone preparing to lift the evacuation directive



Deliberate evacuation zone



Air dose rates (average) in evacuation-directed zones



#Standard deviations are omitted in the figure.

Summary

Surveys were carried out on five/four occasions across the two years that followed the March 2011 accident at Fukushima Daiichi NPS for measuring air dose rates using an aircraft mounted with detectors.
For that purpose, maps were created and compared each other.

1. Air dose rates in the 80km-zone reduced approx. 40% between 5 November 2011 and 16 November 2013, although physical decay was approx. 21%.
   The areas exceeding 3.8μSv/h decreased from 7% to 4%.

2. Air dose rates in the evacuation-directed zones between 5 November 2011 and 11 March 2013 are as follows:
   - 2-1. Difficult-to-return zone:
     The areas exceeding 19.0μSv/h decreased from 27% to 6%, and exceeding 3.8μSv/h , 88% to 75%, respectively.
   - 2-2. Habitation-restricted zone:
     The area exceeding 3.8μSv/h decreased from 88% to 30%.
   - 2-3. Zone preparing to lift the evacuation directive:
     The area was almost all below 3.8μSv/h, 2 years after the accident.
   - 2-4. Deliberate evacuation zone:
     The area was almost all below 3.8μSv/h, 2 years after the accident.