Radiological Surveys of 1600 km of In-Use Roads in Ichinoseki City, Japan Following the Fukushima Dai-ichi Reactor Accident - 17467

Jeffrey Lively *, Steve Rima *
* Amec Foster Wheeler

ABSTRACT

In March 2011, the Japanese Fukushima Dai-ichi nuclear reactor was damaged by a 9.0 magnitude earth quake and subsequent 15-meter tsunami. As a result of the nuclear reactor accident, radioactive material from the nuclear reactor and fuel storage pool (primarily radioactive iodine and cesium) was released to the atmosphere and carried by the wind as a plume that spread radioactive contamination across roughly 13,000 square kilometers of the countryside.

Amec Foster Wheeler's Radiological Services & Engineering Group mobilized a team of Engineers and Operators to Japan to implement a radiological survey (scan) of roads located in Ichinoseki City, Iwate Prefecture, north of Fukushima, using three of Amec Foster Wheeler's Orion *ScanPlot*[SM] advanced radiological scanning systems. The survey was performed in less than two months while the roads were kept open for public use, and was conducted with motorized scooters and battery-assisted bicycles. The survey was performed with operational support from Obayashi, Inc., a large Japanese construction company headquartered in Tokyo. Over a seven-week period, the *ScanPlot*[SM] systems covered approximately 1,600 kilometers of roads within Ichinoseki City and surrounding areas of Iwate Prefecture. *ScanPlot*[SM] systems recorded GPS locations and radiation dose rate levels from Cs-137 on the road's surface at one-second increments during the survey and displayed the dose rate reading in micro-Sieverts per hour (μSv/h) on the back of the bicycle or motor scooter in real-time on a results monitor so that members of the public would be able to see real-time data. Radiological survey data was provided to Obayashi daily for development of survey result maps for the city.

INTRODUCTION

On 11 March 2011, in the early afternoon (14:46:23 local time), Japan was rocked by 9.0-magnitude earthquake that caused widespread damage to the country's eastern coastal region. It lasted approximately six minutes, occurred at a relatively shallow depth of 24.4 kilometers (km), or 15.2 miles, with an epicenter of approximately 130 km (80 miles) east of Sendai City, Tohoku region. The earthquake was so powerful it reportedly moved Honshu, Japan's largest island, 2.4 meters east and shifted the Earth's axis by an estimated 10 to 25 centimeters. The tsunami wave generated was reported by some witnesses to be as much as 38 meters high. As a direct result of damage inflicted by the tsunami, a nuclear accident occurred at the Fukushima nuclear power plant and was reported as a potential public health emergency of international concern. In time, the International Nuclear Event Scale was raised to Level 7, the highest level. [1]

As a consequence of the nuclear reactor accident, radioactive material from the nuclear reactor and fuel storage pool (primarily radioactive iodine and cesium) was released to the atmosphere and carried by the wind as a plume that spread radioactive contamination across roughly 13,000 square kilometers of the countryside.

Many in the radiological protection community of scientists and engineers are familiar with the radioactive fallout deposition maps that soon emerged based on data collected from the many combined efforts to measure and understand the impacts of the accident on the populations living in the near vicinity and to establish protective actions (Fig. 1) [2]. Most of these maps were focused on the urgent need to establish evacuation zones and other spatially appropriate protective action measures in the interest of public health.

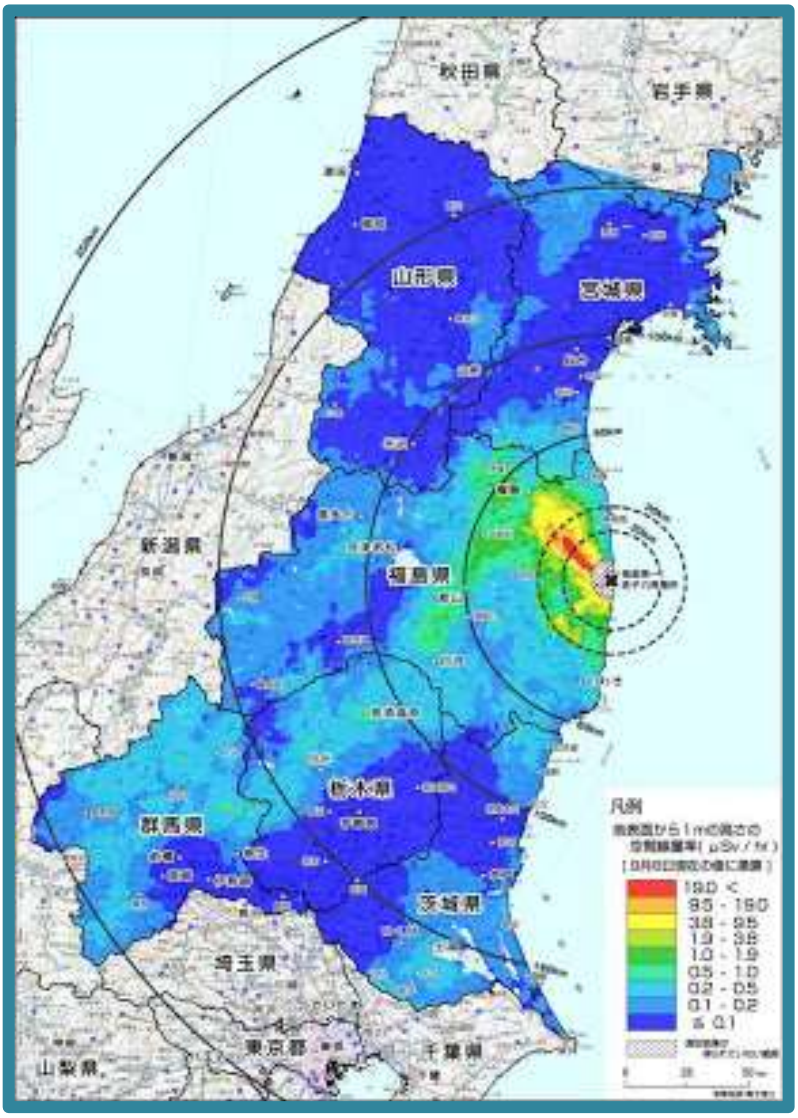

Fig. 1. Radioactive Plume Fallout [2]

As more data was collected and regions more distant from the Fukushima Dai-ichi reactor site were investigated, it became apparent that radioactive deposition was not simply a matter of prevailing wind directions. The importance of factors like surface topography features and coastal zone weather systems is evident in the deposition patterns that remain since the release was terminated. One can visualize the impacts of the central mountains to the west of the Reactor site as well as the coastal zone impacts on the deposition process. While most land-deposited contaminant was deposited within the immediately surrounding Fukushima prefecture with a dominant deposition feature trending toward the northwest (corresponding to the prevailing wind direction during the land deposition event), localized depositional features are evident as far south as Tokyo. Another localized deposition occurs to the north of the Fukushima Dai-ichi site and the city of Sendai centered on Ichinoseki City (Fig. 2). [2, 3].

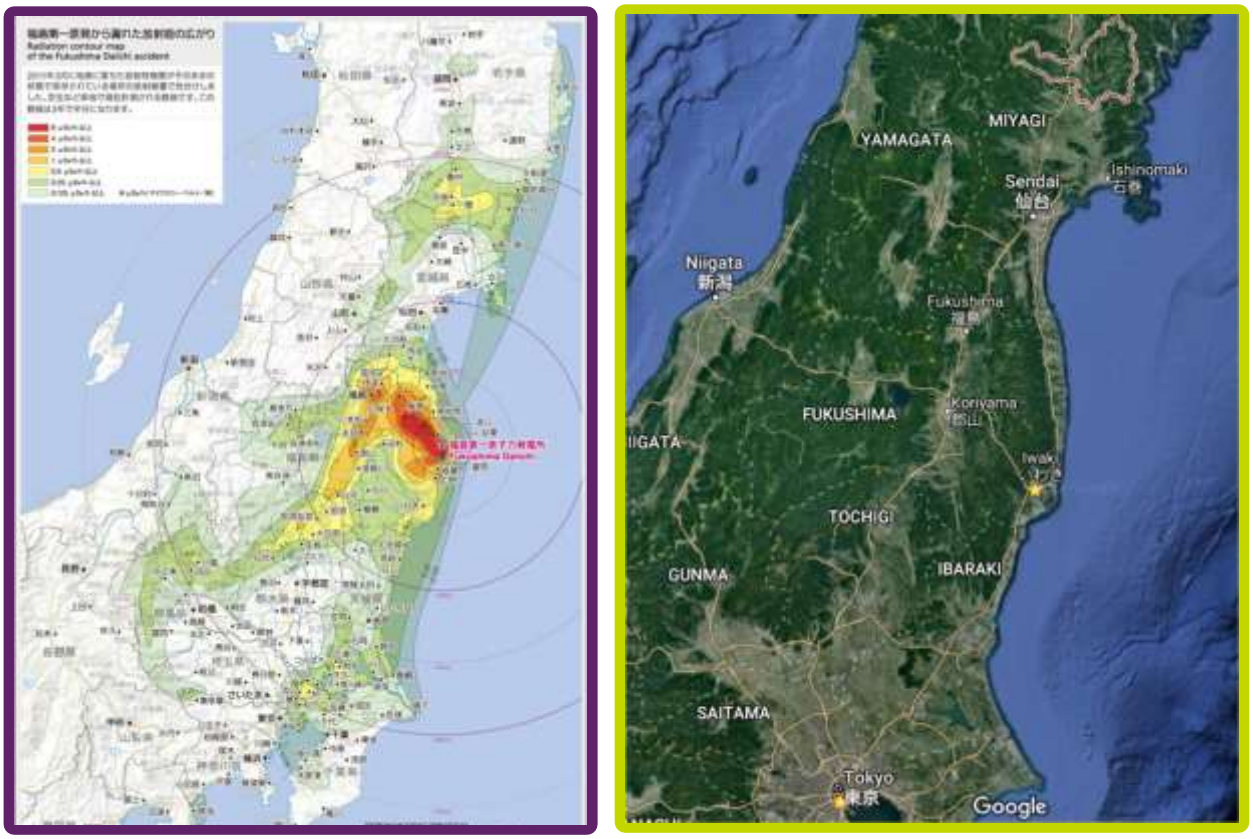

Fig. 2. Deposition of Radioactive Fallout & Eastern Japan Topography [2, 3]

Because of the locally concentrated deposition of fallout radioactivity in Ichinoseki City, health officials recommended a high-density ground-based radiation survey to better characterize the radiation levels and to uncover micro-spatial depositions of significance, should they be present.

Fig. 3. Ichinoseki City, Iwate Prefecture

DESCRIPTION

A team of Orion *ScanPlot*SM engineers and operators was sent to Japan in late April, 2013 to implement a radiological survey (scan) of roads located in Ichinoseki City. The survey was performed from April 23 through June 10, 2013.

Three *ScanPlot*SM radiological scanning systems were deployed and fitted to motorized scooters and battery-assisted bicycles which were then used to travel the many roads and pathways within the designated survey area (Fig. 4). The survey was carried out under contract to and in cooperation with Obayashi, Inc., a Japanese construction company headquartered in Tokyo.

Fig. 4. *ScanPlot*[SM] Equipped Fleet Used to Survey Roads of Ichinoseki City

Over the seven-week survey period, the *ScanPlot*[SM] systems covered approximately 1,600 kilometers of roads within Ichinoseki City and surrounding areas of Iwate Prefecture. The *ScanPlot*[SM] systems recorded and digitally logged GPS location and radiation dose rate (from the radioactive contamination on the road's surface). Scanning data was collected and digitally logged at one-second intervals during the survey. The current dose rate reading in micro-Sieverts per hour (μSv/h) was displayed on a large digital monitor/display mounted on the back of the bicycle or motor scooter such that any interested member of the public could observe in real-time the results that were being measured and acquired (Fig. 5).

Fig. 5. Considerable Public Interest Was Evident and Satisfied

It soon became apparent that a "road" as was comprehended by the American *ScanPlot*[SM] team was not quite the same in Japanese understanding! "Roads" as comprehended by the Japanese included not only paved roadways suitable for typical motorized vehicles, but also unpaved roads, driveways, mountain passes, pathways, walkways, forest trails, and even berms in rice paddies (Fig. 6). The wide-ranging terrain and survey conditions posed considerable challenges, but challenges that were successfully met with the survey project having been completed on schedule and within budget.

Fig. 6. Sample of Ichinoseki City "Roads" Surveyed

Radiological survey data was provided to Obayashi and to a specialty mapping subcontractor daily to develop survey result maps of the city.

RESULTS

Ichinoseki City lies on a north-south trending river valley between the central Japanese mountains to the west and a coastal mountain range to the east. These geographic features created conditions that favored fallout deposition in the city and its surrounding environs. The ground-based survey, completed nearly two years after the deposition event occurred, confirmed the presence of elevated deposition in the region but also revealed that environmental contaminant transport was effectively redepositing fallout contamination along erosional deposition features associated with the natural watershed of the land (Fig. 7) [3]. Figure 7 shows the completed and compiled ground-based radiation survey data collected on the Ichinoseki City roads during the project.

Overall, the levels of elevated radioactivity and the corresponding radiation exposure rates in the largest part of the city, were approximately 3-4 times higher than what is typical absent the contributions from the accident but well below the thresholds put in place by public health officials. The ground-based road survey served to:

- Improve public awareness of the localized conditions where they live and work,
- Provide a visible and comprehensive assessment of the immediate radiological conditions that might pose a threat to public health,
- Provide insight into the micro-localization of contaminant deposition as well as subsequent environmental transport characteristics,
- Assure residents that the radiological conditions in Ichinoseki City were within the safe exposure thresholds emplaced by public health officials, and
- Provide a comprehensively documented record of the conditions measured and observed.

CONCLUSIONS

Airborne radiological surveys and mapping provide a good overall (or "big picture") view of the deposition patterns of radioactivity following large scale releases such as those experienced as a consequence of the accident at Fukushima Dai-ichi. However, smaller scale variances with potential implications for exposures and public health management are not readily resolved with airborne data collection methods. A ground based measurement and data collection system such as the Orion *ScanPlot*^{SM} system is understand the locally-significant variances that are inevitably present. Data collected as described in this project produces the radiological deposition information that local public health officials and other decision-makers need in order to make informed follow-up recommendations in a post-emergency timeframe.

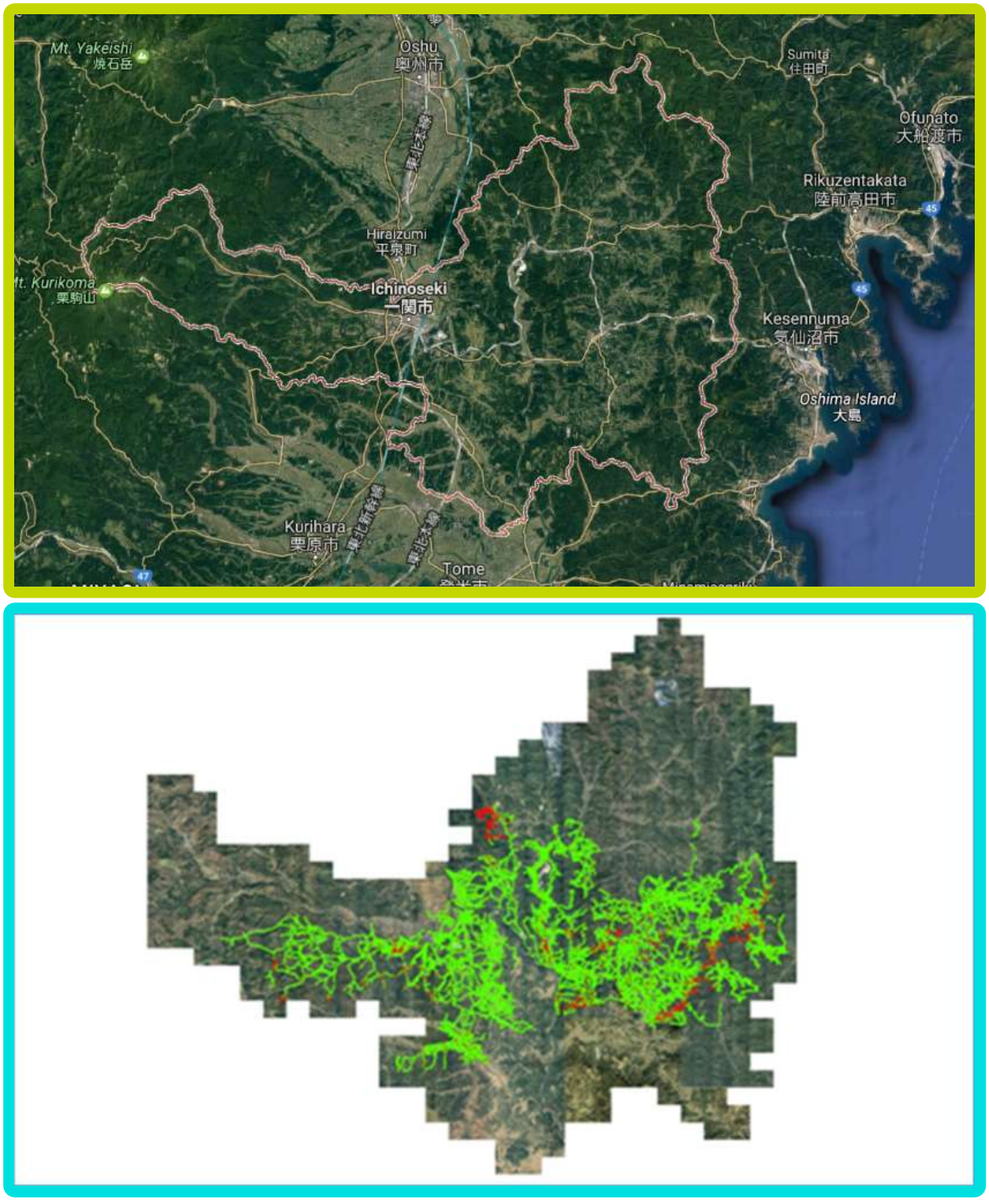

Fig. 7. Ground-based Radiation Survey Map of Ichinoseki City Roads

REFERENCES

1. "The Great East Japan Earthquake." WPRO. WPRO | WHO Western Pacific Region, n.d. Web. 16 Feb. 2017.
2. Hayakawa, Yukio. "Professor Yukio Hayakawa's Radiation Contour Map of the Fukushima I Nuke Plant Accident, Ver 7:." Nuclear-news. N.p., 28 Sept. 2012. Web. 16 Feb. 2017.
3. "Google Maps." Google Maps. N.p., n.d. Web. 16 Feb. 2017.