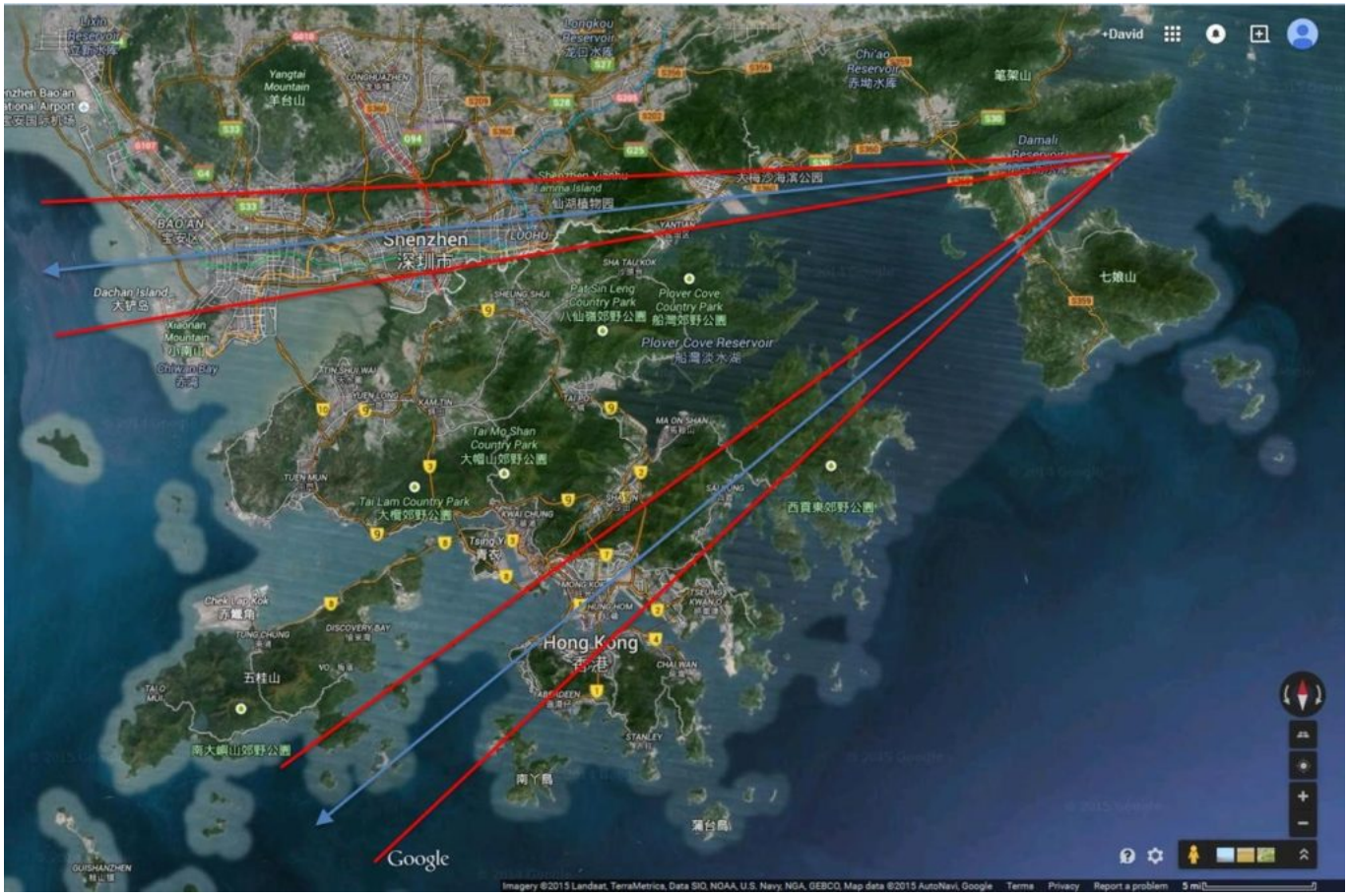
RADIOLOGICAL RISK FROM ACCIDENT OR ATTACK AT NUCLEAR ENERGY FACILITIES IN CHINA



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DAVID VON HIPPEL AND PETER HAYES

FEBRUARY 22, 2018

I. INTRODUCTION

In this essay, David von Hippel and Peter Hayes conclude that: "A worst case" event involving one of the Ling'Ao spent fuel pools could yield exposures sufficient to cause hundreds of thousands of premature cancer deaths and almost certainly require the abandonment of one or several big cities, depending on the prevailing wind direction at the time of the incident. At both reactors, stringent safety measures should be installed to reduce the risk of cooling failure in both the reactors and spent fuel pools. Implementation of many such measures may already be underway. In addition, the spent fuel pools at the Ling'Ao reactors should be reconverted to a non-dense-packed format to reduce the potential for radiological release in the event of a sustained loss-of-coolant incident."

The full report in PDF format (2.8MB) is found here.

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The views expressed in this report do not necessarily reflect the official policy or position of the Nautilus Institute. Readers should note that Nautilus seeks a diversity of views and opinions on significant topics in order to identify common ground.

Banner image: by the authors, using map from GoogleEarth.

II. NAPSNET SPECIAL REPORT BY DAVID VON HIPPEL AND PETER HAYES

RADIOLOGICAL RISK FROM ACCIDENT OR ATTACK AT NUCLEAR ENERGY FACILITIES IN CHINA

FEBRUARY 22, 2018

The Fukushima accident brought home to the world the lesson that the even events considered highly improbable—including the near-catastrophic failure of a nuclear spent fuel pool, with the release of a substantial fraction of the inventory of the cesium-137 (Cs-137) contained therein—can, in fact, happen, and when they do, the fragilities of technologies can be exposed in unexpected ways. A key problem with the concept of radiological risks associated with rare and severe incidents at nuclear reactors—whether accidents initiated by some combination of human error, technological failure, and/or natural disaster, or by attack on a nuclear facility by state or, more likely, non-state actors—is understanding the extent of such risks. Nautilus staff carried out approximate estimates of the radiological releases associated with scenarios of accident or attack for illustrative nuclear facilities in China. in this case the Daya Bay and Ling'Ao reactor complexes near Guangdong and Hong Kong.

A "worst case" event involving one of the Ling'Ao spent fuel pools could yield exposures sufficient to cause hundreds of thousands of premature cancer deaths and almost certainly require the abandonment of one or several big cities, depending on the prevailing wind direction at the time of the incident. At both reactors, stringent safety measures should be installed to reduce the risk of

cooling failure in both the reactors and spent fuel pools. Implementation of many such measures may already be underway. In addition, the spent fuel pools at the Ling'Ao reactors should be reconverted to a non-dense-packed format to reduce the potential for radiological release in the event of a sustained loss-of-coolant incident.

Conclusions from Daya Bay and Ling'Ao Results

The results of the radiological release modeling of scenarios for the Daya Bay and Ling'Ao (Phase I) nuclear power facilities provide a convenient way to compare the impacts of near-identical reactors in essentially the same location, but with one crucial difference—the use of dense-packed spent fuel pools at the Ling'Ao Phase I units. For the Daya Bay plant, the radiological impacts of a reactor-only incident as modeled would, if Chinese authorities use criteria similar to that of the USEPA to identify areas to be abandoned, require the evacuation and at least temporary abandonment of an area stretching from the reactors to nearly the borders of Shenzhen or (depending on wind direction) Hong Kong, though in the latter case most of the intervening area is ocean. An incident at the Daya Bay plant involving the spent fuel pool, assuming the participation and release fractions we have used are plausible in a "worst case" event, would be much more serious, with accumulated (50-year) doses in big cities as far away as Zhongshan and beyond considerably exceeding USEPA guidelines. As serious as such an incident would be, however, an incident involving one of the Ling'Ao spent fuel pools could be far worse, with exposures sufficient to cause hundreds of thousands of premature cancer deaths and almost certainly require the abandonment of one or several big cities, depending on the prevailing wind direction at the time of the incident.

The sum of these results suggests the following:

- At both the Daya Bay and Ling'Ao reactors, stringent safety measures should be installed to reduce the risk of cooling failure in both the reactors and spent fuel pools, including the installation of redundant emergency systems for water and power supply, and attention to potential common-mode failures involving, for example, loss of water, power, and or safe access to reactors or spent fuel pools. Implementation of many such measures is likely already underway as a result of the post-Fukushima safety reviews required of Chinese reactors.
- In addition, the spent fuel pools at the Ling'Ao reactors should be reconverted to a non-dens--packed format to reduce the potential for radiological release in the event of a sustained loss-o--coolant incident. This implies moving some of the existing inventory of spent fuel in the Ling'Ao Phase I pools to dry cask storage at the reactors, or to similar storage away from the reactors, as is the practice at Daya Bay. The result would likely be that the Ling'Ao pools would reach a steady state of transfers in and out within the next few years.
- Power plant operators in China should consider carrying out more detailed analyses of the seasonality of wind directions than were possible here to identify the lowest-risk times of the year, in terms of populations that might be exposed by an incident resulting in radiological releases, to undertake defueling and related maintenance that results in more and "hotter" spent fuel being present in spent fuel pools.

However low the risk of an incident like those modeled for the spent fuel pools at Ling'Ao might be, the radiological results of such an incident are potentially so severe, we would argue, that the relatively modest investment in out-of-pool spent fuel storage and related infrastructure cannot fail to be prudent and socially justifiable. See Annexes B and D to this Report for additional details of results of the analyses of incidents at the Daya Bay and Ling'Ao reactors, respectively.

III. NAUTILUS INVITES YOUR RESPONSE

The Nautilus Asia Peace and Security Network invites your responses to this report. Please send responses to: nautilus@nautilus.org. Responses will be considered for redistribution to the network only if they include the author's name, affiliation, and explicit consent

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