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LOGISTICS MODELING OF A WIDE AREA DECONTAMINATION OPERATION USING WASH DOWN TECHNIQUES

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INTRODUCTION

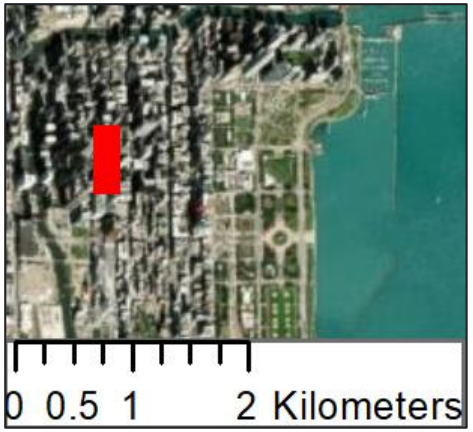
- Compressing the late-phase recovery/remediation timeline may help reduce adverse consequences from a large-scale nuclear contamination release
- Requires decontamination methods that are readily adaptable to myriad situations with manageable waste
- Need framework to evaluate the timeline of available decontamination strategies based on resource availability and operating limitations

Field-demonstration of IWATERS vehicle decontamination.[1]

1. U.S. EPA. Technical Report for the Demonstration of Wide Area Radiological Decontamination and Mitigation Technologies for Building Structures and Vehicles. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-16/019, 2016.

HYPOTHETICAL CONTAMINATION EVENT

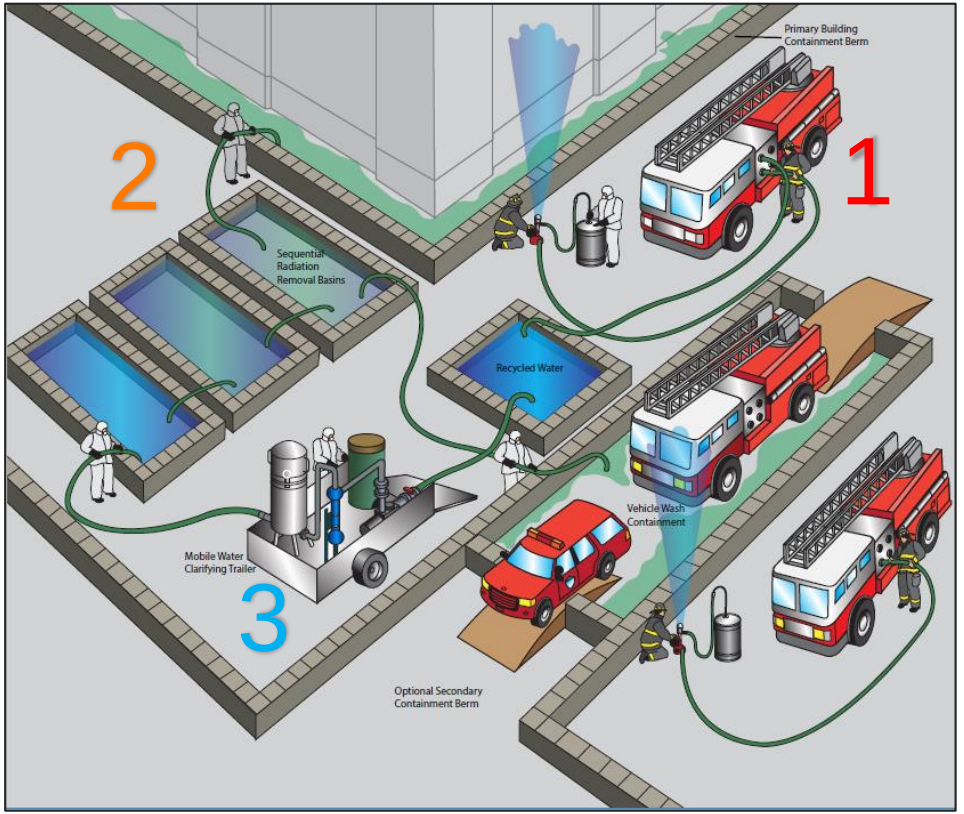
- 65,300 m^2 of downtown Chicago, IL contaminated with Cs-137
  - Uniform contamination at or below the 5th floor of buildings
- Decision to use the Integrated Wash Aid Treatment Emergency Reuse System (IWATERS) to clean the area
- Operations simulated with the Analysis for Mobility Platform (AMP) and GoldSim



Snapshot of scenario boundaries in ArcGIS at 1:8000 and 1:99,000 scales

IWATERS

- Rapid, non-destructive decontamination/remediation of an urban environment
- Benefits:
  - Preserves the water resource
  - Uses readily available equipment and materials
  - Flexible deployment options
- The hypothetical scenario used fire suppression pumps to apply wash solution and sand/vermiculite treatment beds



Cartoon depiction of an IWATERS deployment scheme.

Michael Kaminski, Nadia Kivenas, Chris Oster, Will Jolin, Katherine Hepler, and Matthew Magnuson "Integrated Wash-Aid, Treatment, and Emergency Reuse System (IWATERS) for Strontium Contaminations," Paper 17390, Waste Management Symposia 2017, Phoenix, AZ, March 5 – 9, 2017. Copyright © by WM Symposia. All Rights Reserved. Reprinted with permission

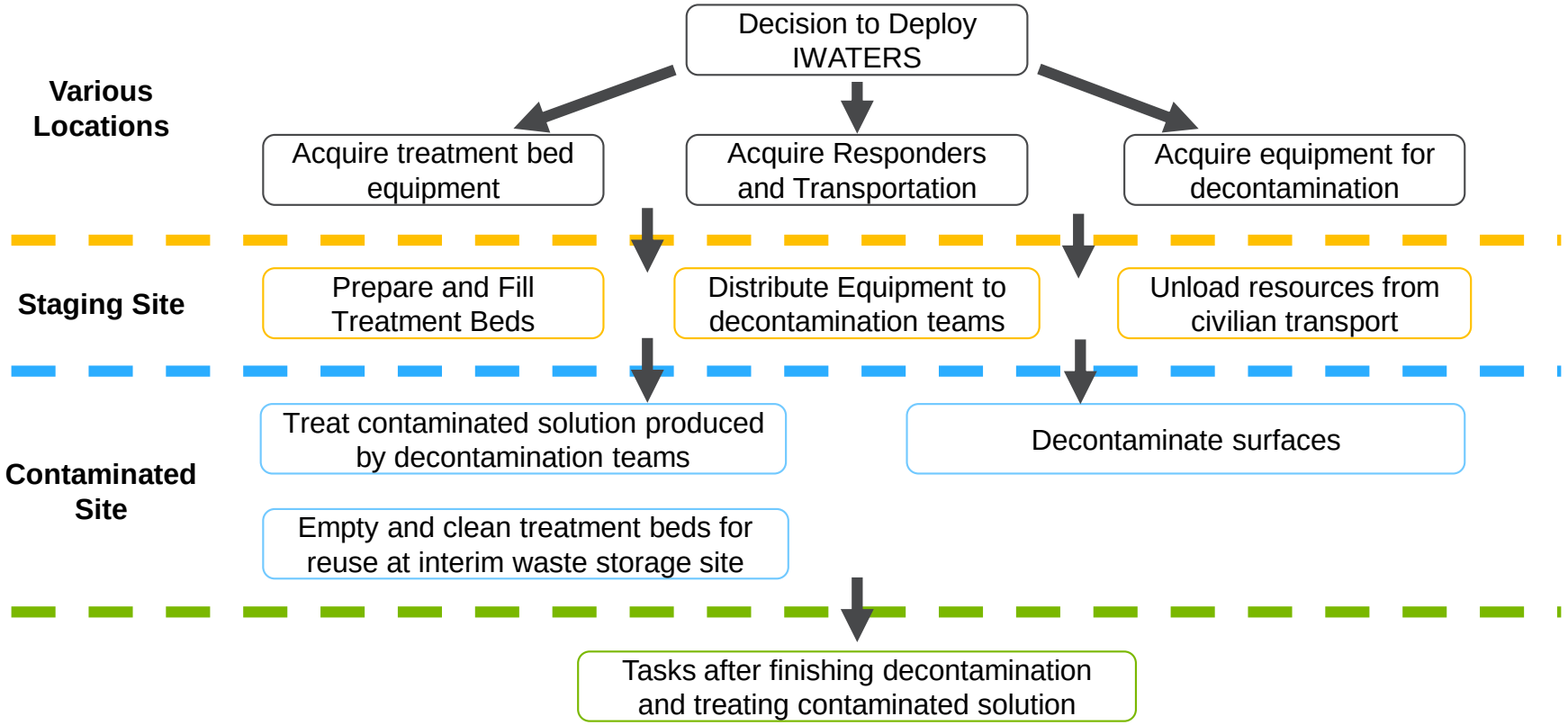
OPERATING PARAMETERS AND RESOURCE REQUIREMENTS

- Practical guidance for IWATERS usage dictated decontamination parameters
- Treatment beds were designed using contaminant transport simulation
  - 40-foot shipping containers filled with 1.5 ft of a sand/vermiculite mixture
- Gathered information about resource needs and availability from suppliers, responders, and emergency management personnel

Select scenario parameters

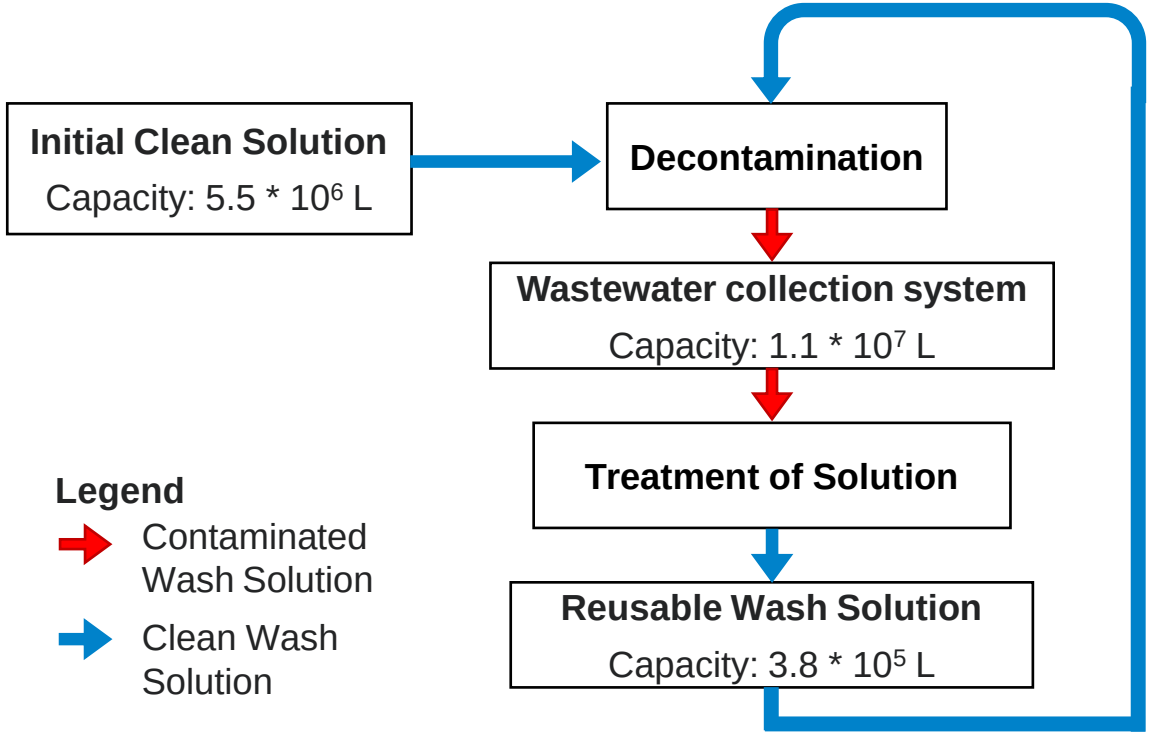
Variable	Value
Areal Decontamination Rate (per team)	0.4 m^2/min
Wash Solution Flowrate (per team)	340 L/min
Percent of wash solution initially available	10%
Wash Solution	0.1M KCl
Decontamination Efficacy	30%
Clay infill percentage	30% (wt.)
Clay infill per bed	6060 kg
Bed Exhaustion time	0.92 days
Treatment bed flowrate	446 L/min

TOP-LEVEL CONCEPTUAL DIAGRAM

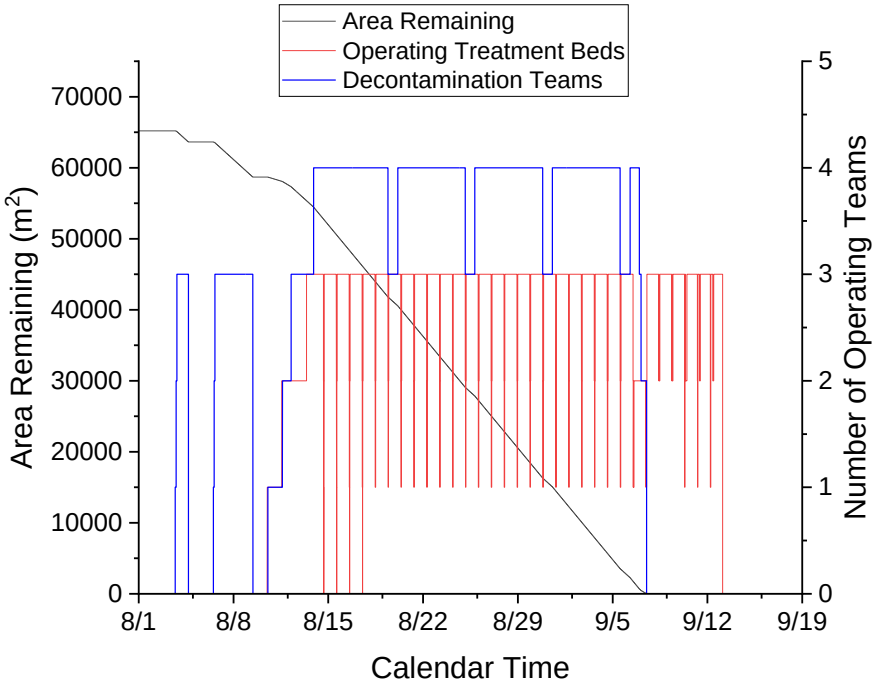


WASH SOLUTION CYCLE

- Lower and upper boundary conditions on the reusable wash solution dictate the addition and removal of decontamination teams



DEPLOYMENT RESULTS

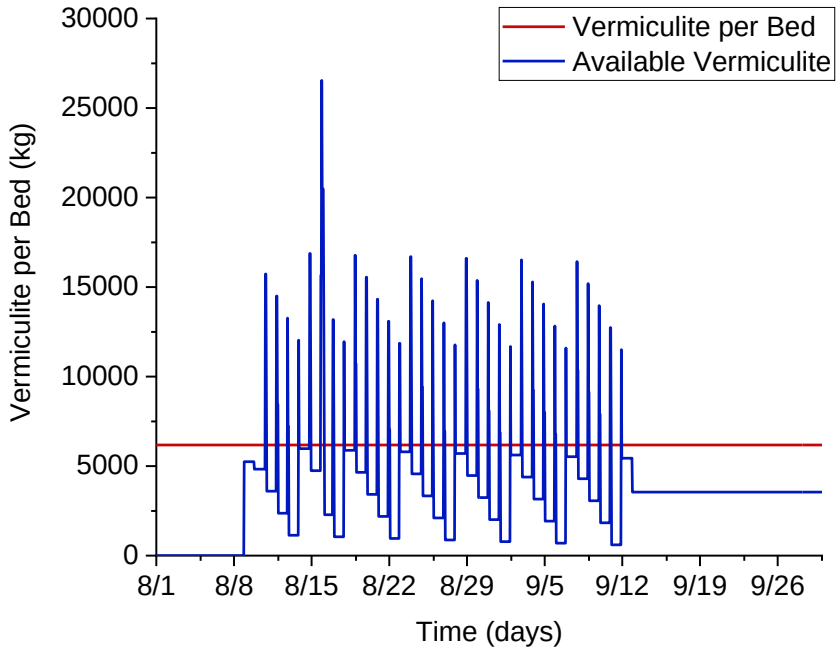


Total area to clean, decontamination teams operating, and treatment bed teams operating vs. time

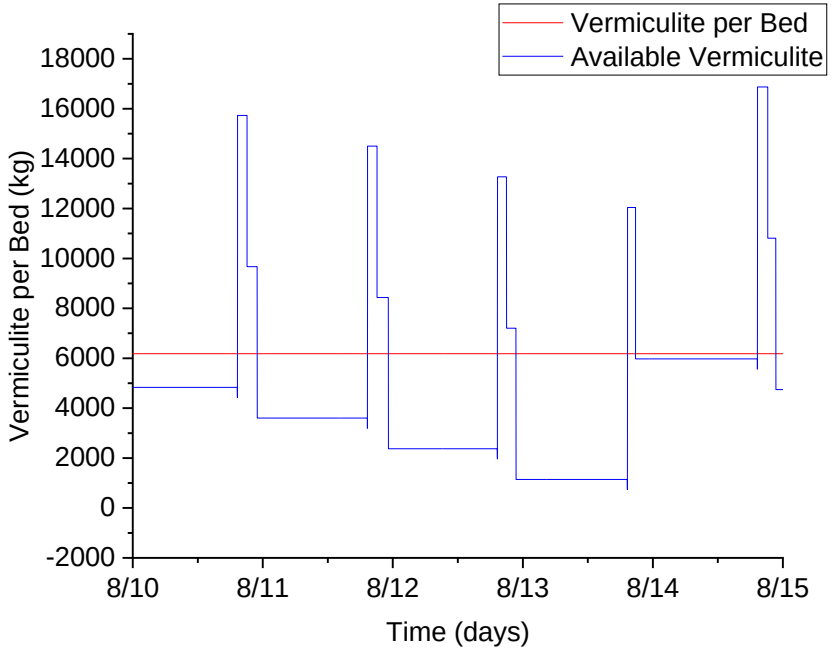
Deployment times and responder requirements

Maximum General Responders Required	232
Total Time Decontamination Teams Deployed	35 days
Total Time Treatment Bed Teams Deployed	38 days
Time to Complete Operations	49 days

VERMICULITE AVAILABILITY



Vermiculite clay inventory at the staging site vs. time and the amount of vermiculite required to make one treatment bed



Vermiculite availability and vermiculite required per treatment bed between August 10 and August 15. The withdrawals of vermiculite for each bed are apparent.

ITEMS EXCLUDED FROM SIMULATION

- Only material logistics of IWATERS – no information or financial transfers
- Living quarters for responders throughout operations
- Missing validation of wastewater collection system capacity assumption
- Possibility of teams working scheduled half-shifts
- Space available vs. space occupied by equipment at the contamination site
- Necessary equipment for treatment beds in addition to treatment bed containers, pumps, and hosing
- Statistical variations in treatment bed performance

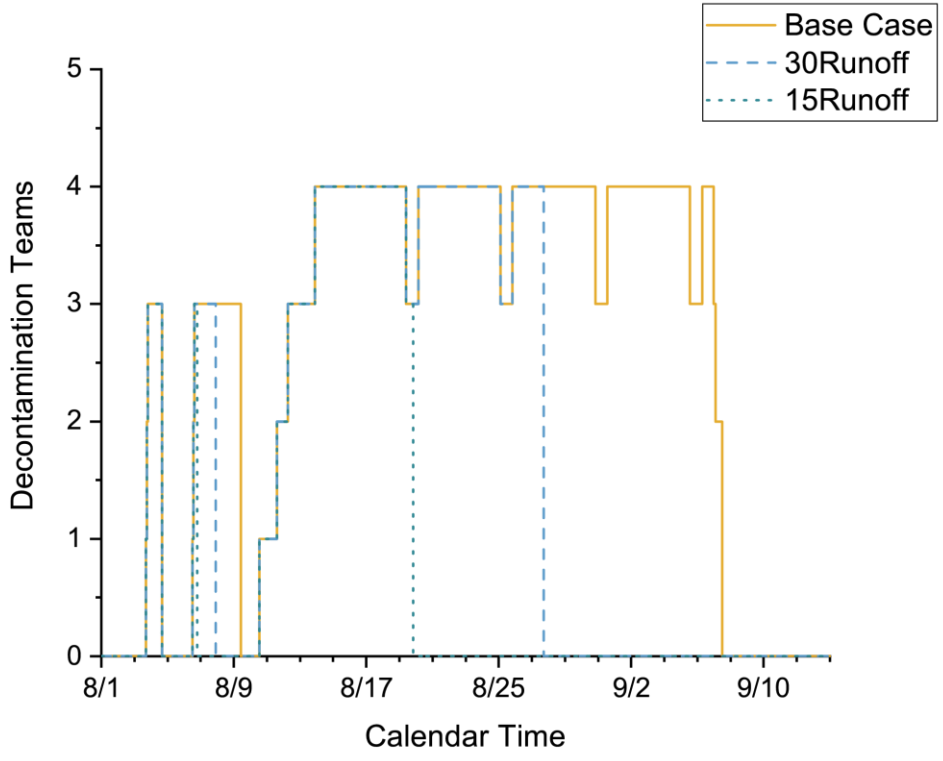
BONUS – CHANGES IN AREAL CLEANING RATE

- Experiments suggest wash solution runoff is effective at cleaning large concrete areas
- Slow one-pass pattern across top of contaminated façade instead of zig-zag pattern
- Identical resource availability and operating parameters except the areal cleaning rate and initial wash solution

	Base Case	30-minute Runoff	15-minute Runoff
Areal Rate	0.4 m^2/min	0.67 m^2/min	1.33 m^2/min
Initial Clean Water	5.5 * 10^6 L	3.3 * 10^6 L	1.7 * 10^6 L

BONUS – CHANGES IN AREAL CLEANING RATE II

- Reduced decontamination time by about 11 days and 18 days for the 30-minute and 15-minute runoff cases
- The required KCl salt and vermiculite were also reduced
- All three cases had vermiculite availability as a limiting factor



CONCLUSIONS

- Cleanup took 50 days, with decontamination and treatment bed teams active 35 - 40 days.
- Vermiculite clay availability is the limiting factor in all scenarios
  - Allowed treatment of $1.8 * 10^6$ L of contaminated solution per day
  - Improvements to the vermiculite availability or an increased contaminant concentration in used wash solution would reduce remediation timeline
- This work lays the foundation for future evaluations of different decontamination strategies with the goal of compressing the late-phase recovery timeline after a large-scale nuclear contamination event

ACKNOWLEDGEMENTS

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IWATERS DEMONSTRATION VIDEO

https://www.youtube.com/watch?v=IV7N2jWm6js&feature=youtu.be