

# *Reactor Siting at INL*

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*SMR Lead*

**June 19, 2019**  
Micro-Reactor Workshop



[www.inl.gov](http://www.inl.gov)

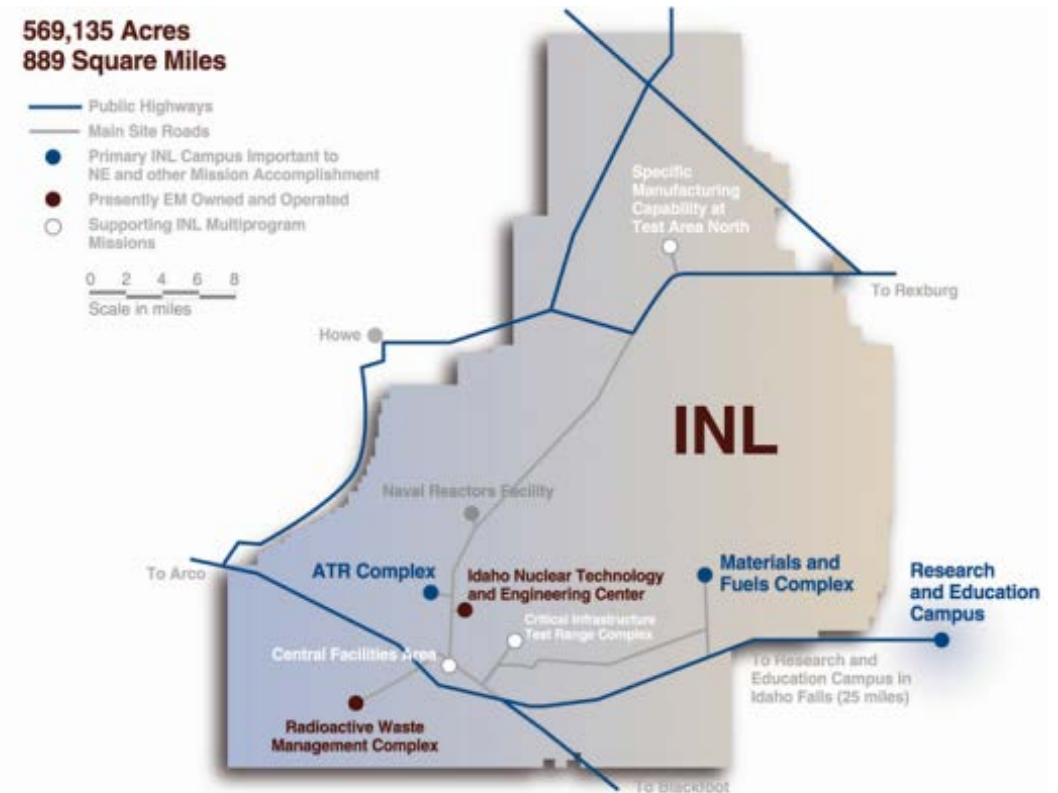


# *INL Site Visit*



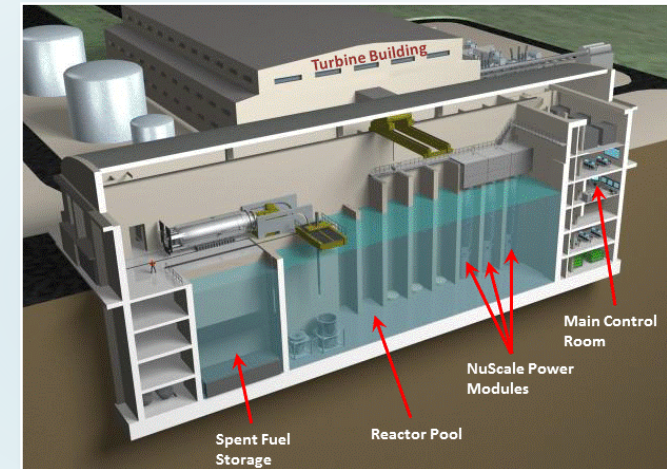
## INL Mission

- INL is the nation's lead laboratory for nuclear energy research, development, demonstration and deployment
- Our mission is to discover, demonstrate and secure innovative nuclear energy solutions, other clean energy options and critical infrastructure.
- Since 1949 INL has hosted 52 reactors and has 4 reactor operating now.
- Currently working to host multiple new reactors.
- Supporting additional technology development.
- Upgrades are on-going to improve siting.



## Enabling New Reactors

- **INL works with all vendors**
  - **INL works with industry on technology development and deployment**
  - **INL is supporting DOE in deploying new reactors**
- 
- **SMR Example**
    - UAMPS entered a site use agreement with DOE with intent to build a NuScale SMR on the INL site
    - Utah Associated Municipal Power Systems (UAMPS) is a not-for-profit group of 45 community owned power systems in 8 western states
    - DOE-ID discussing a Power Purchase Agreement (PPA)
    - Joint Use Modular Plant (JUMP) to enable accelerated demonstration, validation, and wide-scale deployment



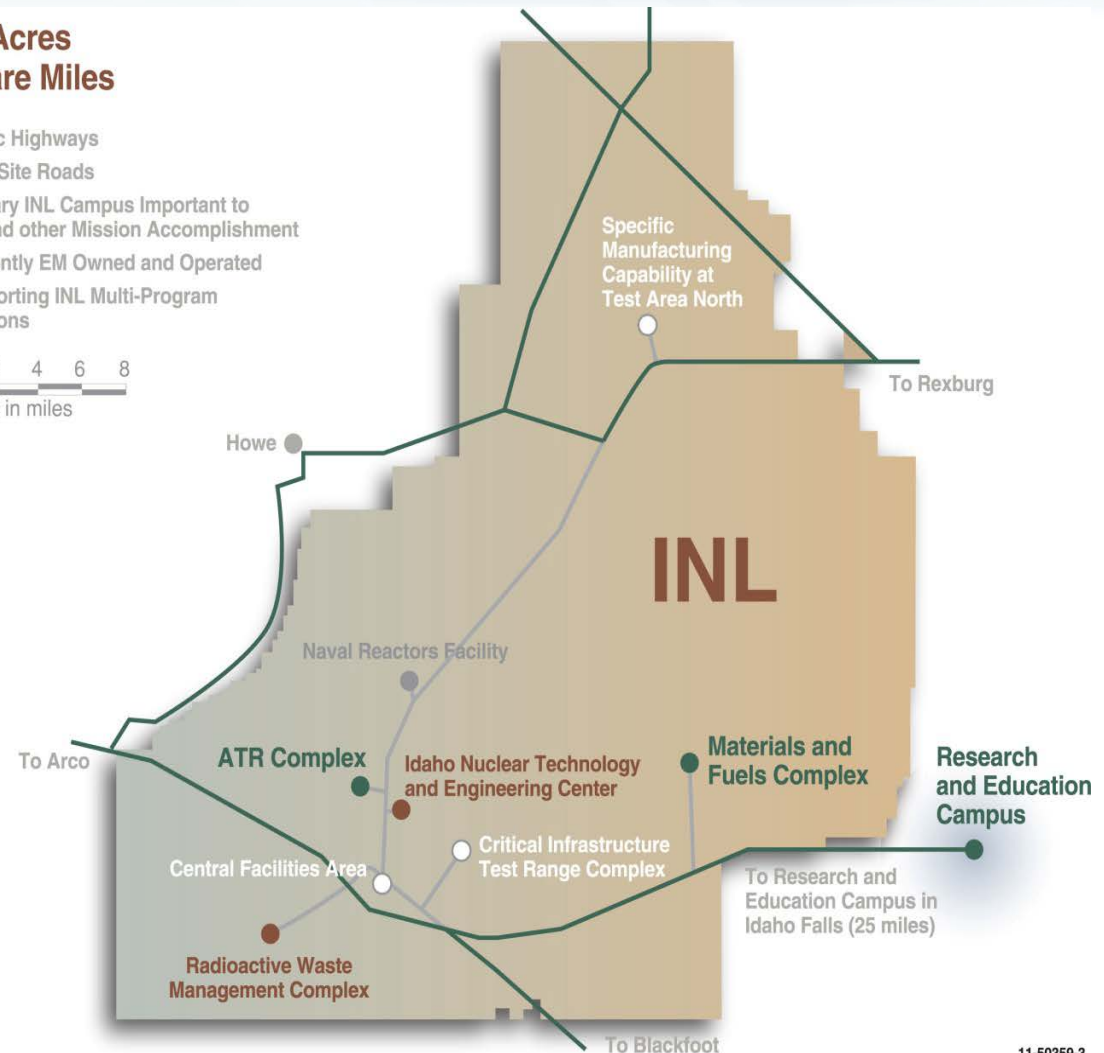
3-D view of Six NuScale Modules

# INL Site

- INL has a variety of sites for new reactors
- Unique requirements can be accommodated.
- Technology demonstration sites are being evaluated
- Micro-Reactor sites are being evaluated
- Established locations can be rapidly developed
- Opportunity to have separate operations

569,135 Acres  
889 Square Miles

- Public Highways
  - Main Site Roads
  - Primary INL Campus Important to NE and other Mission Accomplishment
  - Presently EM Owned and Operated
  - Supporting INL Multi-Program Missions
- 0 2 4 6 8  
Scale in miles



11-50359-3

## Site data

### Requirements, go/no-go in regulation, how much effort to mitigate

- **Go/No-Go examples**

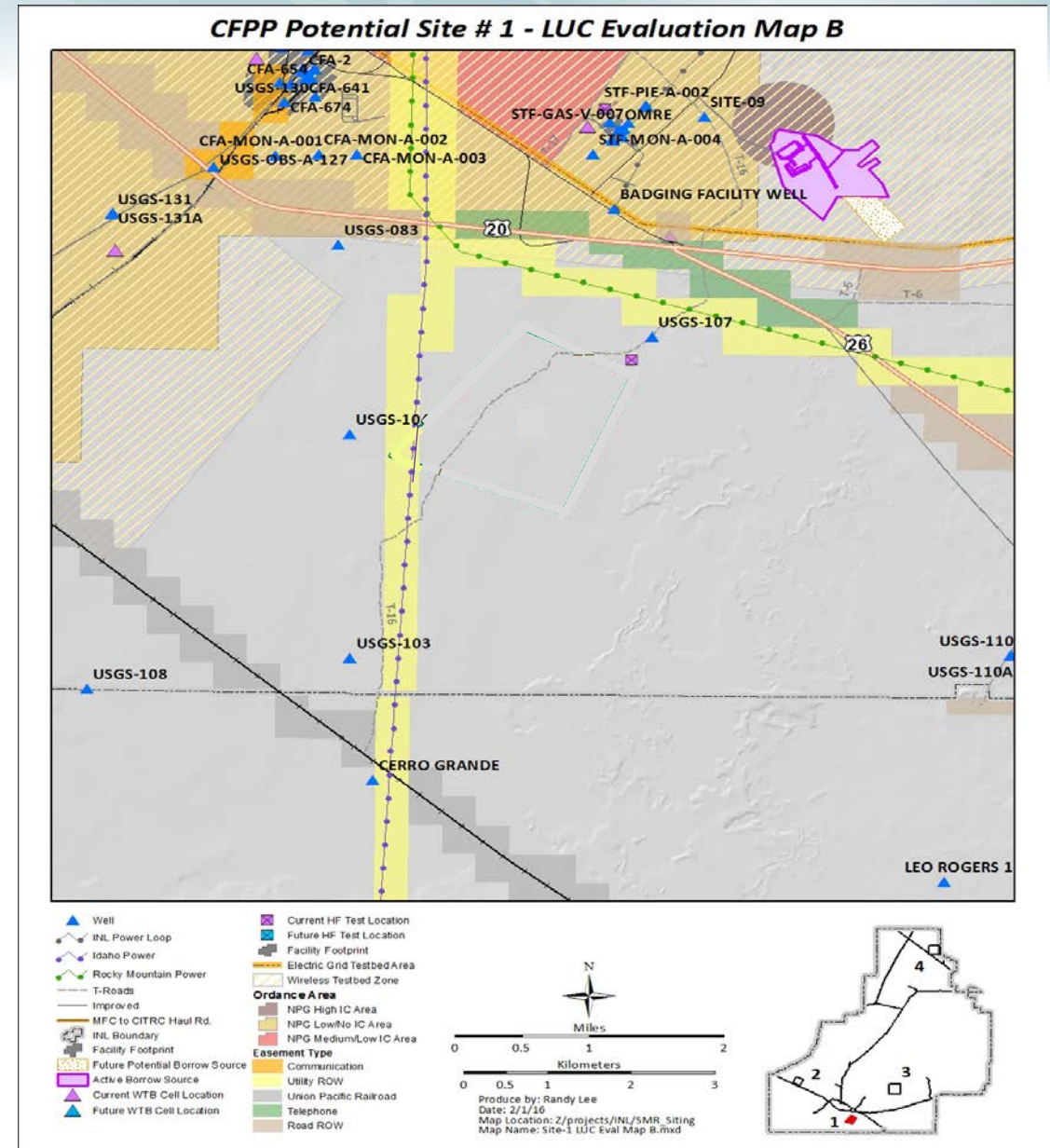
- >10 miles from an airport, <0.5 Peak Ground Acceleration, >5 miles from surface faults and capable tectonic structures, away from population center (>25,000 people), >5 miles from hazardous sites, >1 mile from rail line

- **Weighted information**

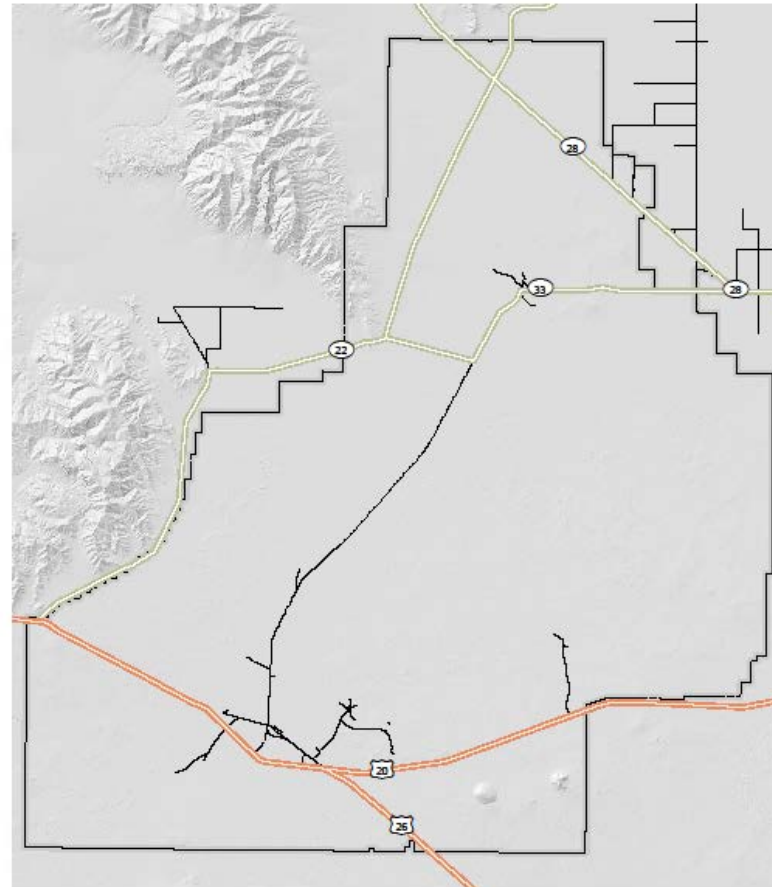
- **Seismic data**- faults, age, depth, history
- **Flooding**- history, severity
- **Volcanic**- hazards, criteria
- **Environmental**- wildlife, botany, grouse leks, song bird breeding, wetlands, on-going sampling sites, snake hibernaculum
- **Hydrology**- aquifer depth, water quality, yield, contaminates, discharge, water rights
- **Cultural**- historic peoples, historic homesteads
- **INL missions**– electronic quiet areas, geologic power plans, event effects on operations, historic operations, Naval Research Laboratory, complex project organization, explosive test range
- **Logistics**- Power lines, rail access, highway access, infrastructure investment, construction support, site area

# INL General Characteristics

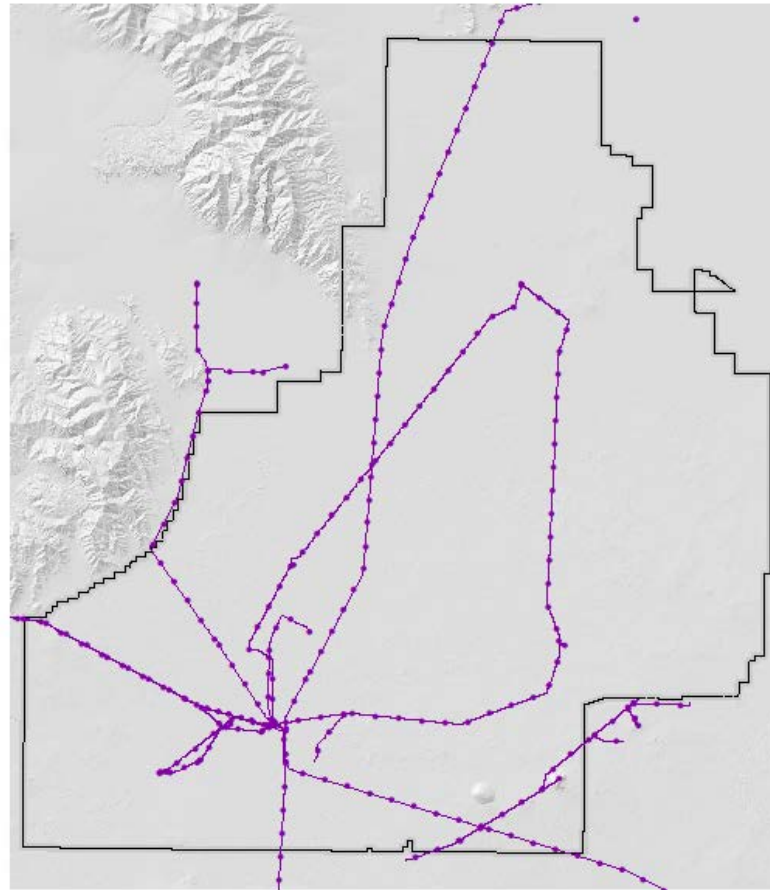
- **INL has an active GIS Geospacial Information System**
- **INL has works directly with NOAA, USGS**
  - Large amounts of data are available publically and on the web.
- **INL has GIS data on ~250 site characteristics**
  - Water, topography, infrastructure, cultural, environmental.....
  - Long term studies
  - Most data easily accessed
  - Multiple reactor sites, licenses and studies
- **Established procedure allows INL/DOE to evaluate new reactor proposals**
- **“INL Site Conditions and Properties”, INL/EXT-15-36721**



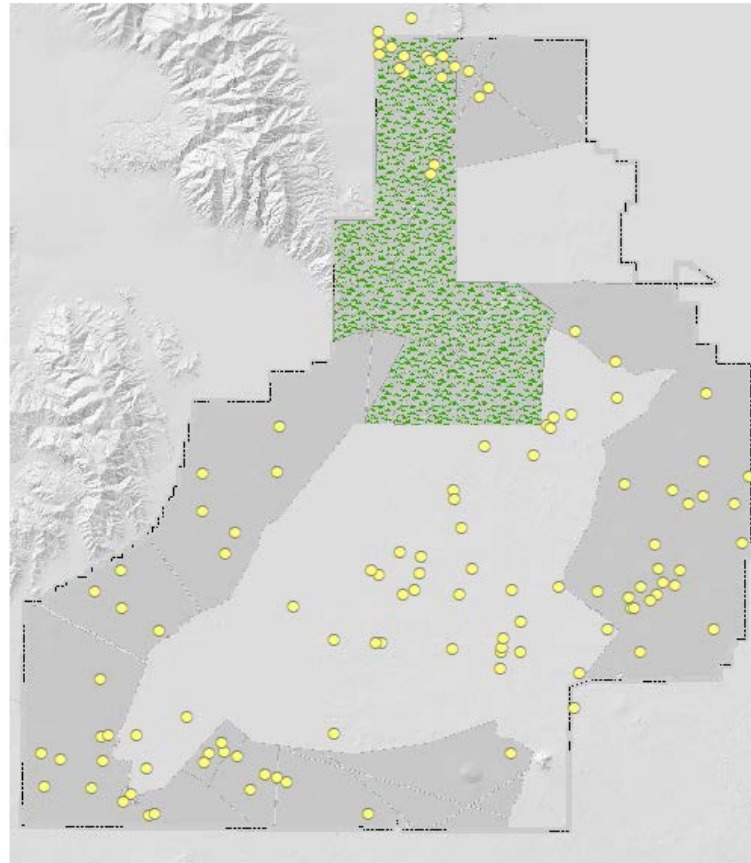
**Small Modular Reactor Siting - Transportation**



***Small Modular Reactor Siting - Transmission***



***Small Modular Reactor Siting - Important Species/Habitat***



# ***Project Development***

- **GAIN Web Site**

<https://gain.inl.gov/SitePages/SitePermitProcess.aspx>

- **Request Reaches DOE-ID**

- **Established DOE-ID Procedure to evaluate project**

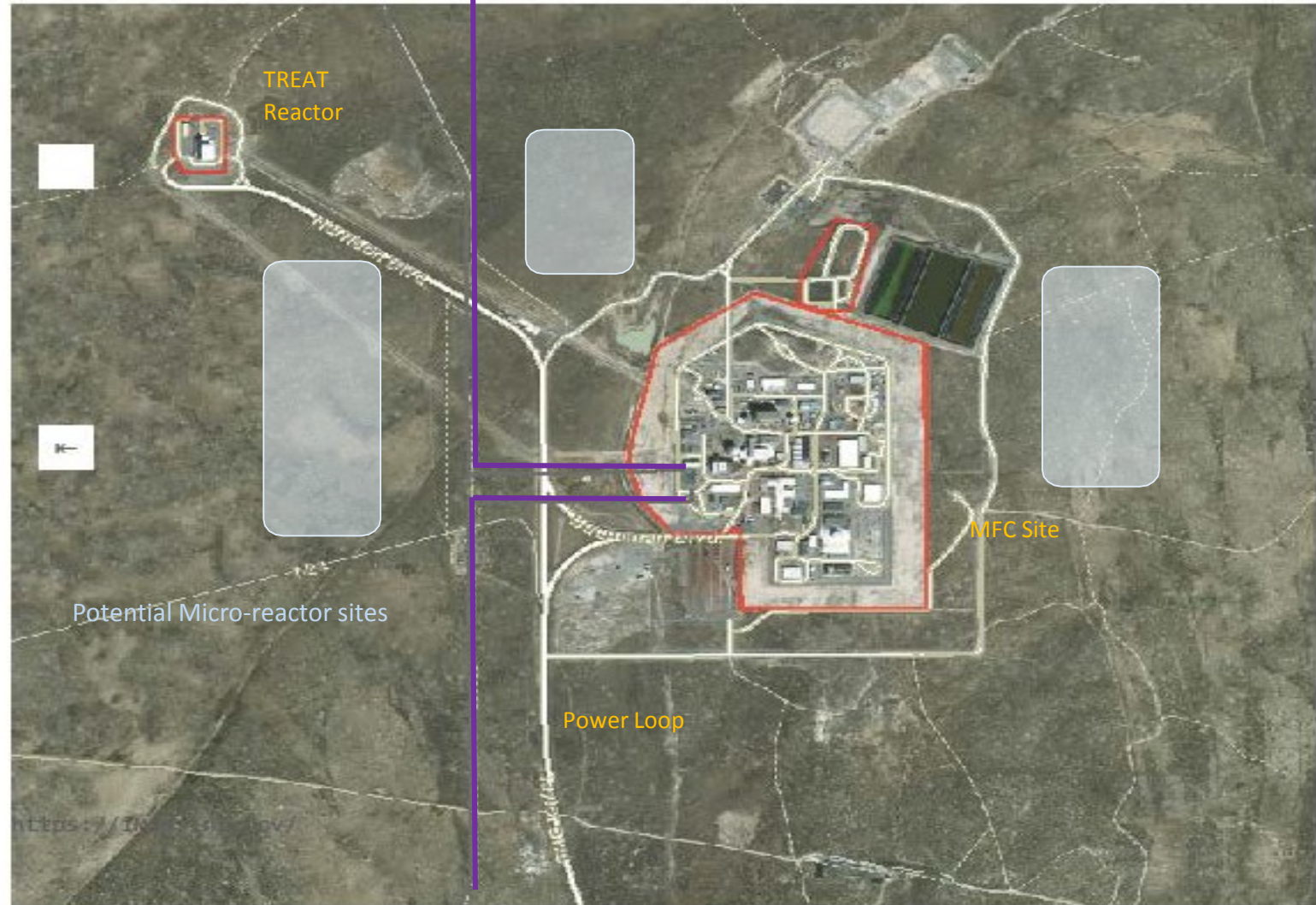
- Mission, support, business plan, costs, export control, technology maturity, licensing strategy, NEPA strategy
- Evaluated for development of Site Use Permit

- **Site Use Permit**

- Provides access and use of land on the INL site
- Use of the site
- Requirements and regulation
- Liabilities
- Operation
- Oversight, NRC or DOE

# MFC Map with potential sites

- Multiple potential sites exist near MFC.
- Multiple resources available



map2.inl.gov

# Existing Buildings That Could Support Microreactor Demonstrations under DOE Authorization

EBR-II Dome



PBF-612 (SPERT II)



ZPPR Reactor Cell



PBF-613 (SPERT IV)

- **FY2019 Activities**

- EBR-II Dome Safety Design Strategy
- EBR-II Recovery
- PBF-612 & PBF-613 engineering study

## ***DOE Site Development***

- **HALU, High Assay Low Enrichment Uranium <math><19.75\% \text{U}^{235}</math>**
  - Developing feed stock for advanced reactors
- **Senior Seismic Hazard Analysis Committee Level 3 (SSHAC) Analysis**
  - Establish the INL Probabilistic Seismic Hazard Analysis (PSHA)
  - General INL site upgrade that is a long lead item in reactor deployment
  - Takes diverse geologic data and creates NQA-1 accepted data for the NRC
- **Complete site LIDAR measurement**
- **Site wide NEPA analysis**
  - Rolls up multiple projects
  - Easier updates going forward

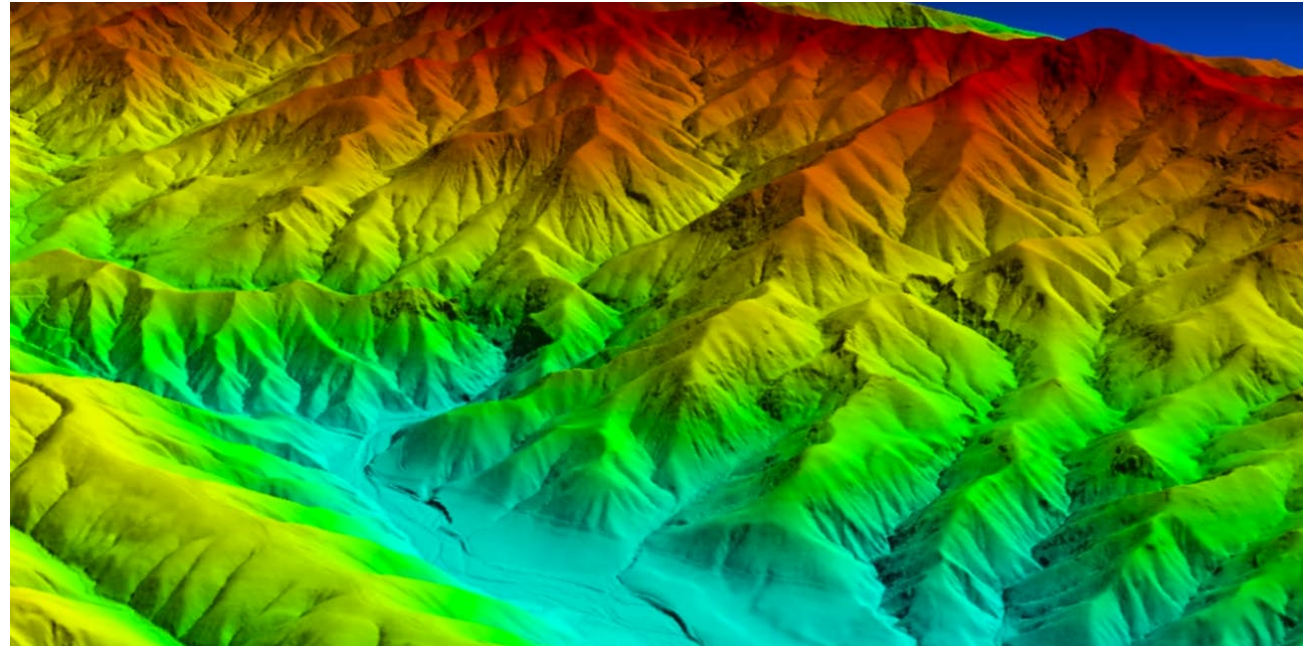


## ***LiDAR***

- Site wide high fidelity laser topography measurements
- Started June 6
- Completed at the end of the year
- Informs multiple analysis
  - Volcanology and flooding
  - Cultural artifacts

## ***Site Wide NEPA***

- Connecting NEPA analysis across the site
- Directly allows for project cross effects
- Simplifies and speeds NEPA evaluations
- Potential source for partner NEPA evaluations
- Early step toward NRC Early Site Permit



# ***JUMP to Demonstrate Integrate Energy Sources***

Establishes non-electric nuclear options licensing

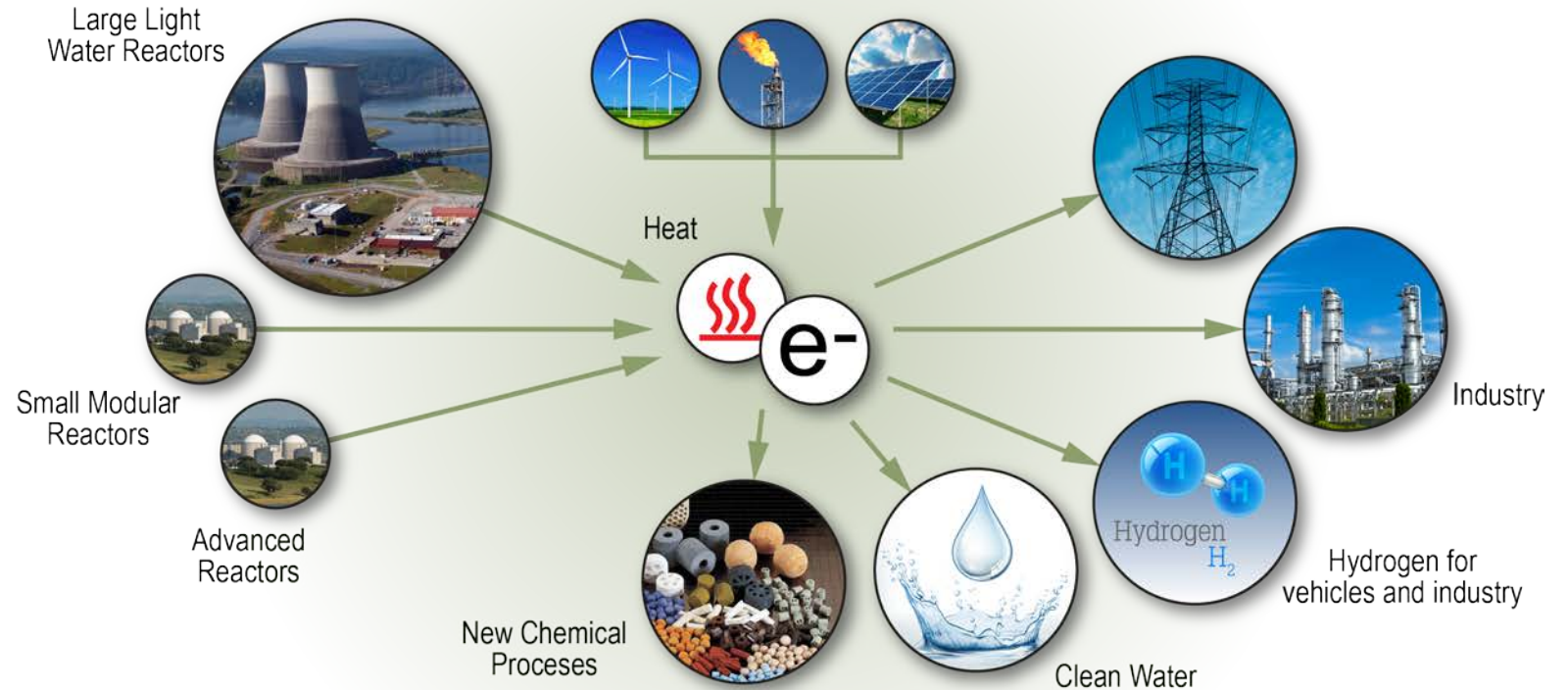
## **Today**

Electricity-only focus



## **Future**

Integrated grid system that leverages contributions from nuclear fission beyond electricity sector



***Flexible generators, Advanced processes, Revolutionary design***





Idaho National Laboratory



# INL Small Modular Reactors (SMRs)

Initial or development discussions with vendors on siting options

## NuScale

- CFPP Project with UAMPS
- Lead IPWR SMR
- NRC design submittal

## Westinghouse

- Lead reactor concept
- Micro reactor concept

## Transatomic Power

- Molten salt power reactor

## NGNP Alliance

- HTGR

## Flibe Energy

- sCO<sub>2</sub> thorium molten salt reactor

## Tri Alpha Energy

- Fusion System

## Molten Salt Critical Test Loop

- Low Power material test reactor

## Versatile Test Reactor

- New material test reactor

## Kairos Power

- Molten Salt Reactor and Technology

## GEH Prism

- Fast test and power proposal

## OKLO

- 2 MW portable reactor

## Elysium

- Small molten salt reactor

## Terrestrial Energy

- Molten salt reactor
- Advanced design status

## Terrapower

- 2 advanced reactor designs
- Adapting deployment strategy

## General Atomics

- Fast HTGR

## Holtec

- IWPR design

## X-energy

- 200 MWth Pebble bed reactor

## Micro Reactors

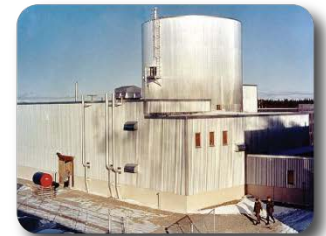
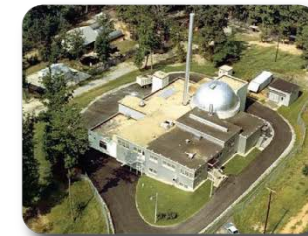
- Less than 20 MWe



# History of Microreactors in DOD Army Nuclear Power Program (1954– 1977)

- **Goal: Develop reactors for remote and isolated sites.**
- **Largely scaled-down version of technologies used for large reactors**
- **Objectives:**
  - Reduction or elimination of dependence on fuel sources
  - Reduction or elimination of logistics necessary for conventional power plants
  - Reliable operation
  - Limited refueling and maintenance
  - Reduced crew size, with goal of unattended operation
  - Transportability, mobility, and reaction times compatible with mission or equipment supported
  - Improved cost-effectiveness
- **Cost and reliability issues prevented these reactor designs from meeting Army’s needs**

Reactor			Operation	
Name	Type	T/E (MW)	Start	Shut
SL-1	BWR		1958	1961*
SM-1	PWR	10/1.85	1957	1973
ML-1	DGCR (N2)	3.4/0.33	1962	1966
SM-1A	PWR	20/1.6	1962	1972
PM-1	PWR	9.5/1	1962	1968
PM-2A	PWR	10/1.6	1961	1964
PM-3A	PWR	9.3/1.5	1962	1972
MH-1A	PWR	45/10	1965	1977



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