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Hydrologic Safety Review Conceptual Site Models and The Regulatory Requirements

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Outline

- Describe what conceptual site models are.
- Describe the current application of conceptual site models in SRP 2.4.13 “Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters”.
- Describe the regulatory basis for the development of conceptual site models.
- Describe the role of conceptual site models in the minimization of contamination RG 4.21 / 10 CFR 20.1406.
- Share lessons learned from “Liquid Radioactive Release Lessons Learned Task Force”.

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Modeling in Hydrologic Safety Reviews

- Primary intent is to ensure the safe operation of nuclear power plants under the most adverse conditions.
- Most adverse conditions require analyzing scenarios.
- Scenarios may or may not have equal likelihood of occurrence.
- The most severe scenario will be chosen from all plausible scenarios.

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Models……Why?

- To characterize the site in terms of:
  - General Hydrosphere
  - The response of watershed and major hydrologic features to hydrometeorologic events
  - Hydrogeology and aquifer parameters
- To better understand:
  - How the components of the hydrologic cycle interact with each other.
  - How the nuclear power plant interfaces with the hydrosphere.

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Models……Why?

- To analyze the impacts of severe natural hydrologic phenomena on the safe operation of a plant.
- To determine the necessity of additional safety requirements in response to threats from natural phenomena.
- To characterize the impact of postulated accident scenarios on the ecosystem and determine whether the regulatory requirements are satisfied.

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Conceptual Site Models

- Conceptual site models are high level systematic representations and descriptions of:
  - How the hydrologic and hydrogeologic features are represented at the site.
  - How the geometries of features represent physical realities.
  - How the hydrologic processes work at the site.
  - How the site specific hydrologic and hydrogeologic features fit within the established regional system.

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Conceptual Site Models…….

- How the nuclear power plant interfaces with the hydrosphere.
- How postulated external hydrologic events could affect the performance of the plant.
- How postulated accident scenarios develop within the hydrologic processes.
- How hydrologic processes will be affected post-construction as compared to pre-construction and changes in the postulated accident scenarios.

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Conceptual Site Models

- Are generally systematically documented in the form of detailed written descriptions and supported by maps, tables, process diagrams, multi-dimensional representations, geological cross-sections and other illustrations.
- Help to design future monitoring activities for optimal performance.
- Are usually constructed using the following components:
  - Geologic framework to characterize the subsurface for and fluid flow and transport
  - Hydrologic framework to identify fluid flow processes in the physical framework
  - Assessment of risk sources such as contaminant chemicals and plausible pathways

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Plausible and Conservative Models….

- All plausible conceptual site models need to be considered.
- Plausible models are required:
  - to make the argument defensible
  - to ensure the assumptions are acceptable
  - to ensure the conclusions are credible
- The applicant has to adequately demonstrate the process followed to identify plausible conceptual models.
- The applicant has to adequately demonstrate the process followed to determine the most conservative of all the plausible models considered.
- The applicant has to satisfactorily describe the processes affecting release, migration and fate of radionuclides.

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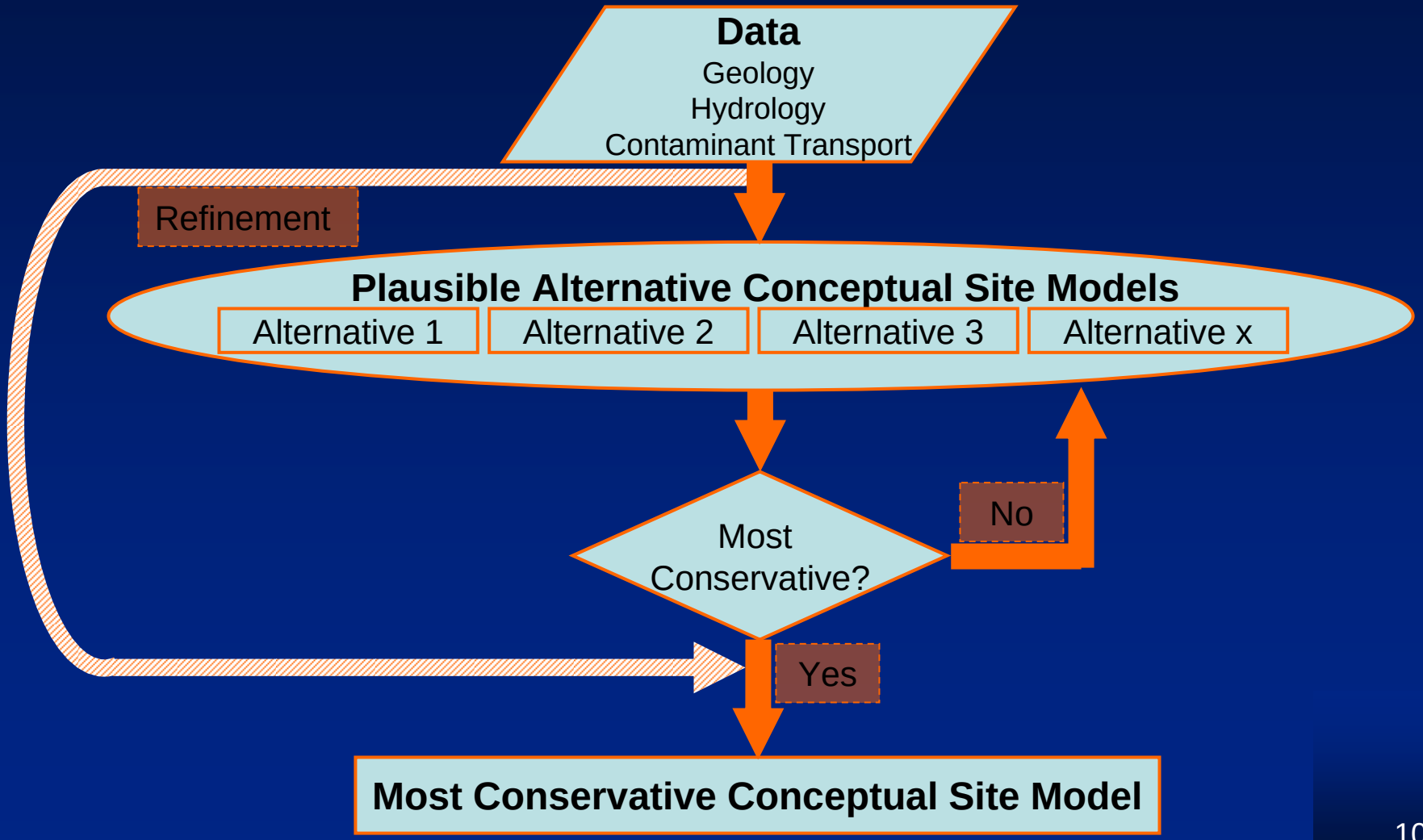
Development of Conceptual Site Model



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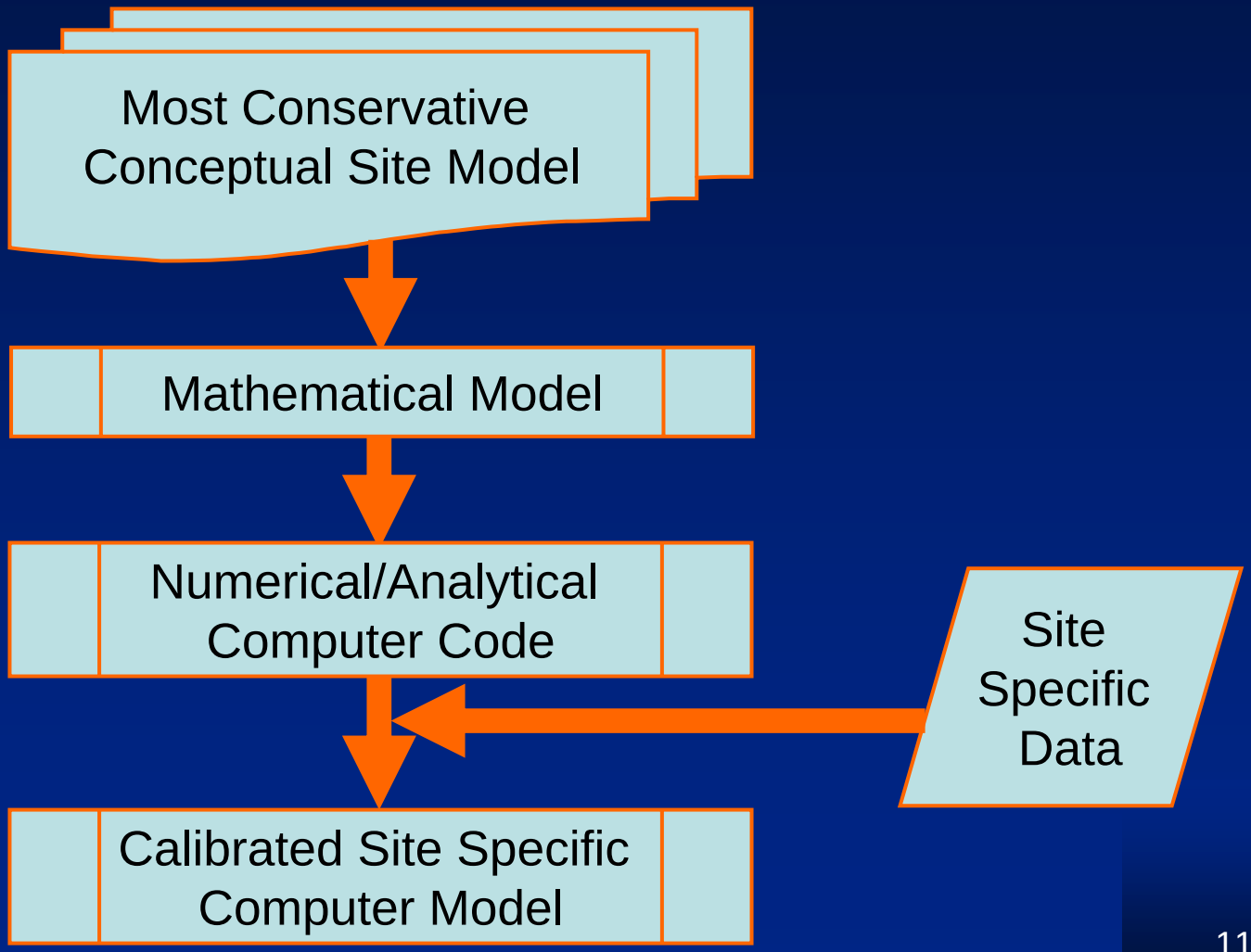
Evolution of Conceptual Site Model



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Numerical/Analytical Computer Models

- Could be developed using:
  - Commercial computer codes.
  - Publicly available computer codes.
  - Applicant developed “in-house” codes
- There is no specific preference to the choice of computer codes.
- The codes need to have:
  - Proper documentation
  - QA-QC and adequate testing
  - Prior application and published results
- The use of in-house codes is usually limited to small programs or spreadsheet applications.

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Conceptual Site Models and Accidental Releases of Radioactive Liquid Effluents

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SRP 2.4.13 "Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters"

The hydrogeological characteristics of the site that are presented in the FSAR are evaluated to determine:

- Effects of accidental releases of radioactive liquid effluents in ground and surface waters
- Effects on existing uses and known and likely future uses of ground and surface water resources.

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SRP 2.4.13……..

- The source term from a postulated accidental release is reviewed under SRP 11.2 following the guidance provided in Branch Technical Position (BTP) 11-6, “Postulated Radioactive Releases Due to Liquid-containing Tank Failures.”
- Areas of Review:
  - Alternative Conceptual Site Models
  - Pathways
  - Characteristics that Affect Transport

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Regulatory Criteria

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site.
- 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 2, for CP and OL applications, as it relates to consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

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Regulatory Criteria….continued

- 10 CFR 52.17(a)(1)(vi), for ESP applications, and 10 CFR 52.79(a)(1)(iii), for COL applications, as they relate to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

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Conceptual Site Models and RG 4.21 / 10 CFR 20.1406.

- Monitoring the operational or accidental release of radioactive liquid effluents is a requirement in order to minimize contamination.
- Monitoring radionuclide pathways requires determining optimal locations consistent with the identified most plausible and conservative pathways.
- Conceptual Site Models enhance the performance of monitoring systems, thus helping meet the monitoring requirements.
- Conceptual Site Models help determine where the contaminants are likely to end under the circumstances considered .

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Liquid Radioactive Release Lessons Learned Task Force Report (2006).

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Lessons Learned Task Force

- The Task Force was setup in response to incidents at Braidwood, Indian Point, Byron, and Dresden related to unplanned, unmonitored releases of radioactive liquids into the environment.
- The scope of the task force work included reviews of:
  - industry experience,
  - associated public health impacts (if any),
  - the NRC regulatory framework,
  - related NRC inspection and enforcement programs,
  - industry reporting requirements,
  - past industry actions following significant inadvertent releases,
  - international perspectives, and
  - NRC communications with public stakeholders.

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Lessons Learned…Observations

"… under the existing regulatory requirements the potential exists for unplanned and unmonitored releases of radioactive liquids to migrate offsite into the public domain undetected."

"…several of the reviewed abnormal release event scenarios did, or potentially could, impact ground-water sources relative to established EPA drinking water standards."

" For the Braidwood and Watts Bar sites where extensive migration of ground-water tritium has been identified, the source of the contamination was the inadvertent discharge of previously monitored liquid effluents through **unanalyzed environmental pathways**."

Liquid Radioactive Release Lessons Learned Task Force (2006)

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Lessons Learned…Current Practice Deficiencies

- Difficulties with detecting leaks.

"Some of the components that have leaked were not subject to surveillance, maintenance, or inspection activities by NRC requirements. This increases the likelihood that leakage in such components can go undetected. Additionally, relatively low leakage rates may not be detected by plant operators, even over an extended period of time."

"Portions of some components or structures are physically not visible to operators, thereby reducing the likelihood that leakage will be identified. Examples of such components include buried pipes and spent fuel pool."

"Leakage that enters the ground below the plant may be undetected because there are generally no NRC requirements to monitor the groundwater onsite for radioactive contamination."

Liquid Radioactive Release Lessons Learned Task Force (2006)

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Lessons Learned…Current Practice Deficiencies

- Sampling at seemingly obvious locations while neglecting other potential points of contamination.

  "Contamination in groundwater onsite may migrate offsite undetected. Although the power plant operator is required by NRC regulations to perform offsite environmental monitoring, the **sampling locations are typically mostly in the vicinity of the point of release of the normal discharge flow path**. For example, at Braidwood, most of the environment water samples were being taken near where the discharge pipe empties into the river, a distance of about 5 miles from the plant."

- The inherent difficulty in monitoring owing to the complexity of the subsurface.

  "Difficulty in monitoring and complexities Furthermore, if groundwater contamination is detected, it may be difficult to monitor and to predict the movement of the contamination in the groundwater. The flow of groundwater can be influenced by a variety of factors and can be quite complex."

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Conclusions

- Conceptual site models need to be included by analyzing all plausible models and selecting the most conservative one.
- The conceptual site model forms the basis for the subsequent computer model which in turn helps to analyze the data and processes outlined in the conceptual site model.
- The identification of alternate pathways is greatly enhanced by the development of conservative, plausible conceptual models.

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Conclusions

- The design of monitoring systems for radioactive liquid effluents benefits greatly from conservative conceptual models.
- In the event of release of liquid radionuclide effluents the conceptual models provide extremely valuable information about the pathways and mitigation measures.
- Conceptual site models help meet the requirements of 10 CFR 20.1406.
- Conceptual site models do not add additional requirements, they help meet the existing requirements.

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