

August 2009



#### **EXECUTIVE SUMMARY**

This report was prepared by Entergy Nuclear Inc. (Entergy) and Shaw Consultants International, Inc. ("Shaw Consultants"), formerly Stone & Webster Management Consultants, Inc., under the direction of Entergy, to address the potential issues associated with constructing and operating a Next Generation Nuclear Plant ("NGNP") nuclear facility on an existing hydrocarbon-contaminated site. This assessment was at a high level intended to address a range of representative conditions as no specific site has been identified. A variety of senior staff within appropriate industrial resource business units were surveyed to collect and assemble insights, experience and recommendations from project managers, corporate management, and construction managers with related planning and field experience.

The occurrence of soil and groundwater contamination at process facility sites can vary considerably. The focus of this review was based on examples where petroleum-based contamination has been the key factor. However, the concepts addressed should provide an indication of what may be required when other forms of contamination are encountered.

This report provides a high-level review of potential technical and commercial issues related to existing site contamination which are likely to influence the planning, permitting/licensing, design, construction, operations and decommissioning of the nuclear process heat delivery plant. The assessment of these issues is based on a series of discussions with related experts within Entergy and Shaw Consultants and its affiliates.

Entergy Corporation is an integrated energy company engaged primarily in electric power production and retail distribution operations. Entergy is the second largest nuclear owner/operator in the United States, operating 12 nuclear units of varying designs at 10 plant sites. In preparing this report, Entergy utilized its extensive relevant experience in nuclear plant construction and operation, environmental management, new nuclear plant licensing, decommissioning, and nuclear plant life-cycle management. In 2007, Entergy received one of the first early site permits in the country from the Nuclear Regulatory Commission (NRC) for a possible new nuclear unit at the Grand Gulf site in Mississippi. Entergy prepared and submitted to the NRC two combined license applications for new nuclear plants at two different sites – through NuStart Energy Development LLC at Grand Gulf and River Bend Station near St. Francisville, La.

The Shaw Group has relevant experience and skills through various business units with senior staff experienced in planning and completing a variety of related construction, decommissioning/ decontamination and site remediation projects:

- Shaw Energy & Chemicals (process technology, design and construction of process industry facilities, safety and environmental engineering and controls)
- Shaw Environmental & Infrastructure (government projects, environmental controls and remediation)
- Shaw Fabricators (pipe and modular fabrication)
- Shaw Power (Nuclear, fossil, renewable and other power generation technology and projects)



In addition to The Shaw Group's extensive capabilities and experience related to NRC regulated facility design, licensing, construction, maintenance, and decommissioning, there is considerable experience with the specific requirements of a variety of brownfield development projects.

This report provides the collective experience obtained from a number of related projects and provides recommendations regarding workable approaches which will need to be addressed during each phase of an advanced nuclear reactor plant located on a brownfield process industry site.

Based on the assumption that significant soil and groundwater contamination exist at an NGNP site, the following conclusions and recommendations summarize the findings of the study.

- 1 The nuclear project Sponsor and Site Owner must work together to achieve a preliminary understanding of pre-existing site contamination based on a review of site history and completed characterization and monitoring efforts.
- 2 Additional site investigation work must be defined based on the selection of the site and preliminary arrangement of proposed facilities to develop the information needed to provide a formal baseline condition for the site and to define existing and new barriers to restrict contamination transport. This work can be included in a pre-operational monitoring phase coordinated with the collection of environmental data in support of an Early Site Permit Application (ESP) application and/or a Combined License Application (COL).
- 3 Specific responsibilities regarding existing and future contamination of the site need to be agreed between the Sponsor and Site Owner as part of a Host Site Agreement. Such an agreement would as a minimum address liabilities and decommissioning responsibilities/accountabilities [assuming that the Nuclear Plant Owner/Operator and the Site Owner are different legal entities].
- 4 Preferably, initial site preparation work will include removal of contaminated soil and installation of barriers by the Facility Owner subject to approval by the Sponsor, which provide confidence that there will be no further transport of contamination between the Facility and the Site during the life of the nuclear plant.
- 5 Project site preparation work should include the installation of a groundwater monitoring system under the nuclear plant above an underground liner or other form of vertical contamination transport barrier system. The operation of this groundwater monitoring system can provide the primary tracking mechanism to identify and capture any significant spills, leaks or discharges from the nuclear plant which could potentially impact soil or groundwater under the control of the Sponsor.
- 6 The foundation design of the nuclear plant should avoid disruption of contaminant transport barriers and leave adequate separation to support future decommissioning and demolition work without disruption to contaminant transport barriers. Nuclear plant designs with deeper foundations may be more problematic at some sites. In the unlikely event that deep pilings are required for the nuclear plant structures, special piling installation methods may be required to avoid or minimize disruptions to subsurface contamination transport barriers.
- 7 The NRC-approved Decommissioning Plan, Decommissioning Estimate and Decommissioning Fund requirements are intended to cover removal of fuel and removal of radiation contamination to levels that achieve thresholds needed to release the nuclear plant owner from responsibilities associated with the Operating License. The NRC requirements are not likely to be affected by the presence of contamination at or near the site. However, additional requirements for demolition and restoration of the site for other uses are likely to be imposed by the Site Owner through the



Host Site Agreement. Also, state and local environmental agencies may impose specific classifications to demolition wastes, soils and contaminated materials which could restrict site restoration options and increase related costs. Funding considerations would need to be considered since this would be outside the scope of the NRC-approved Decommissioning Fund.

- 8 The nuclear licensing process would be impacted by the presence of site soil and groundwater contamination in the following ways:
  - Site baseline environmental studies will need to include a detailed characterization of the Site, including soil and groundwater contamination
  - Site environmental impact analyses will need to include detailed analysis of effluents and emissions from the proposed facilities and their impact on the Site and surroundings which could consider the impacts on existing contamination
  - Detailed design information included with the COL application will need to include Site preparation and foundation designs. Details regarding barriers to contamination transport and groundwater monitoring will need to be identified.
  - The Environmental Report(s) for applicable ESP, COL, Limited Work Authorization Applications, and pre-license site activities permitted by other regulatory agencies would be impacted.
- 9 Siting a nuclear project on a process site is likely to generate considerable public interest. A wellconceived public outreach program will be needed to provide public access to information about nuclear technology, project planning, and how environmental requirements will be addressed.
- 10 The total impact on project costs can range widely based on project-specific conditions. A wellplanned project with reasonable site conditions should not experience additional costs at a prohibitive level. An early assessment of likely costs would be completed in the project planning phase and considered in the economics and risk analysis of the project. An example of possible costs encountered by a project which can manage existing contamination successfully to avoid extreme conditions impacting construction and operations are summarized below:

	Site characterization and pre-operational data collection	\$200 5001
•	She characterization and pre-operational data concetion	\$200-300K
•	Project planning and Host Site Agreement development	\$100-200k
•	Nuclear licensing (ESP, DC, COL)	~\$200k
•	Site preparation (if soil removal/barrier work is needed)	\$1-10M
•	Construction (assuming no impact on foundation design)	minimal
•	Operations (assuming no extreme contamination remains)	minimal
•	NRC decommissioning requirements (assuming	
	no major releases)	minimal
•	Site restoration (no major releases or disputes)	<\$1M

The attached report provides details of the assessment.

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#### ABSTRACT

Shaw Consultants International, Inc. ("Shaw Consultants"), formerly Stone & Webster Management Consultants, Inc., entered into a Consulting Services Agreement with Entergy Nuclear, Inc. ("Entergy") to prepare this report on the technical and commercial issues for Next Generation Nuclear Plant ("NGNP") construction, operation and decommissioning at existing process industry sites ("brownfield sites") with existing soil and groundwater contamination. This review is intended to support the planning for application of advanced nuclear reactors to be located in proximity to process industry facilities.

The occurrence of soil and groundwater contamination at process facility sites can vary considerably. The focus of this review is based on examples where petroleum-based contamination has been the key factor. However, the concepts addressed should provide an indication of what may be required when other forms of contamination are encountered.

This report provides a high-level review of potential technical and commercial issues related to existing site contamination which are likely to influence the planning, permitting/licensing, design, construction, operations and decommissioning of the nuclear process heat delivery plant. Our assessment is at a high level intended to address a range of representative conditions as no specific site has been identified. Our assessment of these issues is based on a series of discussions with related experts within Shaw Consultants and its affiliates.

The Shaw Group has relevant experience and skills through our various business units with senior staff experienced in planning and completing a variety of related construction, decommissioning/ decontamination and site remediation projects:

- Shaw Energy & Chemicals (process technology, design and construction of process industry facilities, safety and environmental engineering and controls)
- Shaw Environmental & Infrastructure (government projects, environmental controls and remediation)
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- Shaw Power (Nuclear, fossil, renewable and other power generation technology and projects)

In addition to The Shaw Group's extensive capabilities and experience related to NRC regulated facility design, licensing, construction, maintenance, and decommissioning, there is considerable experience with the specific requirements of a variety of brownfield development projects. This report provides the collective experience obtained from a number of related projects and provides recommendations regarding workable approaches which will need to be addressed during each phase of an advanced nuclear reactor plant located on a brownfield process industry site.

Based on the assumption that significant soil and groundwater contamination exist at an NGNP site, the following conclusions and recommendations summarize the findings of the study.

1 The nuclear project Sponsor and Site Owner will work together to achieve a preliminary understanding of pre-existing site contamination based on a review of site history and completed characterization and monitoring efforts.



- 2 Additional site investigation work will be defined based on the selection of the site and preliminary arrangement of proposed facilities to develop the information needed to provide a formal baseline condition for the site and to define existing and new barriers to restrict contamination transport. This work can be included in a pre-operational monitoring phase coordinated with the collection of environmental data in support of an Early Site Application ("ESP") application.
- 3 Specific responsibilities regarding existing and future contamination of the site need to be agreed between the Sponsor and Site Owner as part of a Host Site Agreement.
- 4 Preferably, initial site preparation work will include removal of contaminated soil and installation of barriers by the Facility Owner subject to approval by the Sponsor, which provide confidence that there will be no further transport of contamination between the Facility and the Site during the life of the nuclear plant.
- 5 Project site preparation work should include the installation of a groundwater monitoring system under the nuclear plant above an underground liner or other form of vertical contamination transport barrier system. The operation of this groundwater monitoring system can provide the primary tracking mechanism to identify and capture any significant spills, leaks or discharges from the nuclear plant which could potentially impact soil or groundwater under the control of the Sponsor.
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- 8 The nuclear licensing process would be impacted by the presence of site soil and groundwater contamination in the following ways:
  - Site baseline environmental studies will include a detailed characterization of the Site, including soil and groundwater contamination
  - Site environmental impact analyses will include detailed analysis of effluents and emissions from the proposed facilities and their impact on the Site and surroundings which could consider the impacts on existing contamination
  - Detailed design information included with the COL application will include Site preparation and foundation designs. Details regarding barriers to contamination transport and groundwater monitoring will need to be identified.



- 9 Siting a nuclear project on a process site is likely to generate considerable public interest. A wellconceived public outreach program will be needed to provide public access to information about nuclear technology, project planning, and how environmental requirements will be addressed.
- 10 The total impact on project costs can range widely based on project-specific conditions. A wellplanned project with reasonable site conditions should not experience additional costs at a prohibitive level. An early assessment of likely costs would be completed in the project planning phase and considered in the economics and risk analysis of the project. An example of possible costs encountered by a project which can manage existing contamination successfully to avoid extreme conditions impacting construction and operations are summarized below:

•	Site characterization and pre-operational data collection	\$200-500k
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#### ACRONYMS

ACM	Asbestos Containing Materials
AEA	Atomic Energy Act
CAA	Clean Air Act
CFR	Code Of Federal Regulations
COL	NRC Combined Construction And Operating License
CWA	Clean Water Act
EHS	Environmental, Health And Safety
EPA	Environmental Protection Agency
EPACT 05	Environmental Protection Act Of 2005
ESP	NRC Early Site Application
HTGR	High Temperature Gas Cooled Reactor
INL	Idaho National Laboratory
NGNP	Next Generation Nuclear Plant
NORM	Naturally Occurring Radioactive Material
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety And Health Act
PBMR	Pebble Bed Modular Reactor
PCB	Polychlorinated Biphenyls
RCRA	US Resource Conservation And Recovery Act
SDWA	Safe Drinking Water Act
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials

#### NOMENCLATURE

Brownfield	Type of site previously used for industrial activity		
Facility	Process industry plant, such as a refinery, petrochemical complex or chemicals production plant occupying the existing process site, whic includes the proposed nuclear plant site		
Greenfield	Type of site not previously used for industrial activity		
Host Site Agreement	Defines commercial relationship between Sponsor and Facility owner, including leasing land for the nuclear power plant Site and addressing potential liabilities related to site contamination		
Mixed Waste	Waste material containing both hazardous waste defined by RCRA and radioactive waste defined by AEA Site – Plot of land within the Facility leased to Sponsor for building the nuclear plant		
Site Owner	Same as Facility Owner, who leases the site to the Sponsor		
Sponsor	Nuclear plant project developer/owner, nuclear plant NRC license holder		



#### 1 PURPOSE AND SCOPE

This report presents the preliminary results of a review of technical and commercial issues that are likely to be encountered in the design and construction of the Next Generation Nuclear Plant ("NGNP") facilities at brownfield process industry sites with potential soil and groundwater hydro-carbon contamination. Shaw Consultants International, Inc. ("Shaw Consultants"), formerly Stone & Webster Management Consultants, Inc., entered into a Consulting Services Agreement with Entergy Nuclear, Inc. ("Entergy") to prepare this report in support of early planning for construction of advanced nuclear reactors used for process heat applications.

This report provides a high-level review of potential technical and commercial issues related to existing site contamination which are likely to influence the planning, permitting/licensing, design, construction, operations and decommissioning of the nuclear process heat delivery plant. The assessment is at a high level intended to address a range of representative conditions as no specific site has been identified. The assessment of these issues is based on a series of discussions with related experts within Shaw Consultants and its affiliates.

A wide range of conditions exists among process industry sites which may become candidates for the NGNP demonstration and commercial projects. Many of the observations and recommendations are based on work on similar projects where process and power generation facilities were installed and operated on contaminated sites, and based on nuclear plant construction and decommissioning experience from several projects.

The report identifies a number of assumptions as a basis for this study. Many of the nuclear licensing requirements for evolving High Temperature Gas Reactor ("HTGR") technologies have yet to be formalized, and the HTGR designs themselves are still evolving and may be impacted by some of the issues addressed in this report. The focus of this review is based on examples where petroleum-based contamination has been the key factor. However, the concepts addressed should provide an indication of what may be required when other forms of contamination are encountered.



#### 2 **REPRESENTIVE SITES AND EXISTING CONTAMINATION**

A number of assumptions regarding site conditions and contamination are presented in this section to form the basis for this review.

#### 2.1 Site Conditions and Contamination

The review of technical and commercial issues is based on the following assumptions and range of site conditions:

- The "Site" is an idle parcel of land within an existing, active process facility (the "Facility") proposed for use for a new nuclear power plant to supply steam, electrical power, or direct heating of process units to the Facility and possibly to export excess electrical power to the grid.
- The nuclear power plant will be designed, constructed and operated by a special purpose company (the "Sponsor") which will become the nuclear plant owner and which will be the NRC licensee.
- The Site will continue to be owned by the Facility Owner and the rights for the Sponsor to use the Host Site will be defined through a Host Site Agreement which will address all related responsibilities and liabilities.
- The new nuclear power plant will replace some of the existing steam and electrical power generating units at the Facility.
- The Facility is subject to regulations promulgated by various state and federal agencies within the USA. No specific facility location is specified, although a range of site characteristics are contemplated that are expected to be representative of US brownfield sites available in the petroleum refining, petrochemical and other industries.
- The Site was previously used for industrial purposes; i.e., the Site is a "brownfield" site as opposed to a "greenfield" site which has not been used previously for industrial purposes. Any pre-existing Site contamination will continue to be "owned" by the Facility.
- Soil and groundwater within the Site and below the surrounding Facility are contaminated with some combination of hydrocarbons, chemicals, and metals. The intent is to represent a range of site conditions likely to be encountered at process plants in the US.
- The Facility is presumed to have been subjected to an extensive, well-documented soil and groundwater investigation, which documents the Facility's background geological and hydrogeologic conditions; the types, concentrations and extent of contamination, and relevant regulatory requirements. Interpretation of existing documentation has considered the ability to ascertain bedrock groundwater conditions, and the ability to detect very low concentrations of chemical or radiological contamination which may become important.
- The Facility is presumed to be operating under the terms of an approved soil and groundwater remediation plan (the "Facility Remediation Plan"), which is based upon the foregoing investigations. The Facility Remediation Plan required installation of (a) some type of barrier to lateral and/or vertical groundwater migration to minimize and control the extent of contamination; and (b) some type of groundwater recovery, monitoring and treatment. In addition, the Facility Remediation Plan continues to require monitoring of contamination at specified points within the Facility and which may include points within the Site. Furthermore, the Facility has established written procedures and training programs to minimize exposure of contamination to the environment and to maximize worker safety.
- The presence of any naturally occurring radioactive material ("NORM") and legacy man-made radioisotopes such as those distributed by weapons atmospheric testing (including cesium and strontium) within the Facility in general and within the Site in particular is unknown. In all likelihood, such testing was not required and has not previously been performed.



- The feasibility of excavating contaminated soil within the Site prior to construction has not been determined.
- Underlying the site is at least one "impermeable" soil zone and at least one (deeper) water bearing zone. The water bearing zone may or may not be used as a source of public drinking water. However, the water bearing zone is regulated as a "water of the State."
- Geotechnical investigations for the nuclear power plant will require borings deep enough to penetrate an underlying water bearing aquifer.
- Preferably, foundations for the nuclear power plant can be designed to stay above existing or future barrier layers needed to isolate the new plant.

#### 2.2 Site Characterization Requirements

An existing brownfield site considered for a nuclear process heat plant must be carefully characterized to define existing contamination to determine potential impact on nuclear facility operations and to evaluate suitability of the site to comply with regulatory standards for siting nuclear facilities. Considerable existing information should be available to document site conditions, but additional work will be needed to support a detailed analysis of how a proposed nuclear unit can be isolated from surrounding contamination throughout its implementation, operation and decommissioning.

In general, protocols and quality assurance/quality control ("QA/QC") procedures promulgated by the EPA should be used to document site environmental conditions, including the types, concentrations and extent of site contamination. However, if this data will be used for nuclear safety analyses, then NRC quality requirements will be required. Pending further design development for nuclear process heat supply systems, a determination will be made whether data regarding site contamination is likely to have any material impact on nuclear safety analyses.

Independent of the characterization of site contamination, site geotechnical evaluations to support seismic analysis and foundation design will be subject to NRC quality requirements if needed to support nuclear safety analyses. In the event that soil samples important to geotechnical borings are heavily contaminated, some laboratories qualified to do this work for the nuclear industry may have difficulty handling such materials or using existing laboratory facilities and procedures. This would have to be evaluated in the planning phases of a project when levels and types of contamination are known.

Once site soil and groundwater contamination are known, then various candidate approaches for site preparation can be evaluated. Heavy contamination which would limit worker productivity may justify removal, stabilization or isolation work as part of the site preparation approach. Tradeoffs between various site preparation options and construction cost and schedule implications would have to consider specific site conditions and project requirements.

#### 2.2.1 Review of Existing Site Information

In order to properly characterize a potential site within an existing industrial facility, it is first necessary to document the following existing conditions:

- History of site use (suggesting possible exposures)
- Current physical, geotechnical, hydrogeologic, climatologic, ecologic and sociologic conditions;
- Site infrastructure availability of utilities such as electrical power (for both import and export), plant/instrument air and inert gases, process water, stormwater collection and drainage, wastewater treatment and discharge, solid and hazardous waste management and disposal, fire protection, security, and worker health and safety;



- Facility and Site access via highway, railroad and maritime vessels;
- Listing of existing applicable permits and agreements with local, municipal, state, federal and international agencies,
- Reports of site investigations indicating the known and expected types, concentrations and extent of potential hydrocarbon contamination at the Site
- Identification of onsite burial or disposal areas

All of the information listed above should be readily available within existing Facility documentation. However, additional investigations may be required to document specific geotechnical and contamination information for the Site. Information collection can include interviews with current and past Facility employees.

Environmental regulations within the USA require process industrial sites to maintain documentation regarding past spills of hydrocarbon products which have occurred during onsite processing, storage and transportation activities. One document which typically contains such a list of past spills is the Spill Prevention, Control and Countermeasure ("SPCC") Plan.

Separately, environmental regulations promulgated by the EPA during the 1980s required process industry facilities to (a) document the presence of soil and groundwater contamination, including the types, concentrations and extent of contamination; and (b) compare facility contamination to thresholds determined to be protective of human health and the environment. If contamination in excess of such thresholds was found, these facilities were required to prepare plans to reduce the potential for exposure to hydrocarbon contamination to levels below established thresholds. Site specific plans had to be submitted to the responsible federal, state, municipal and local agencies for review and approval prior to their implementation. In instances where removal of hydrocarbon contamination was neither practical nor economically feasible, facilities were allowed to implement measures to reduce the probability of exposure to site contamination. These measures could be administrative controls (e.g., facility procedures), engineered controls (e.g., physical barriers) and/or a combination of such control measures. In addition, these plans had to include measures to be undertaken by the facility to monitor (sample and analyze) contamination and submit periodic reports to the responsible agencies. As a result, process industry facilities with hydrocarbon contamination are probably subject to an approved, ongoing plan which includes extensive information regarding the facility's hydrocarbon contamination.

Regardless of the extent and reliability of existing Facility documentation, the Sponsor will need to conduct proper due diligence activities to document the pre-existing presence of hydrocarbon contamination at the Site. Existing information on the Facility should be used to focus the scope of work, expedite the schedule and minimize the costs associated with the Sponsor's investigations. If practical, environmental investigations should be combined and/or coordinated with geotechnical investigations which the Sponsor will also be required to conduct in order to finalize the site host agreement and project design bases.

#### 2.2.2 Development of Additional Site Information

In addition to the review of available documentation about the site, it may be necessary to update the "as-built" status of Facility diagrams, plot plans, underground drawings, etc.

Based on a review of available and updated information, it may be necessary to conduct additional site investigation work to satisfy the needs of the Host Site Agreement and an anticipated Early Site Permit application. Details from such work are also needed for planning foundation design and site preparation.



The nature and extent of existing contamination, soil conditions and underlying structures should be understood sufficiently to visualize existing subsurface barriers and potential pathways for contaminant transport. Any further borings taken at the site must be carefully planned and implemented so as not to disrupt any pockets of contamination or barrier layers which currently limit transport of existing contamination.

Many process plants in the Southeastern U.S. are underlain by clay layers which separate layers and pockets of sand, which in turn can contain or transport groundwater or liquid hydrocarbons that have been able to migrate there from surface spills or leaks. Such "lenses" of hydrocarbon contamination may be isolated by layers of clay and represent a stable situation relative to long term site remediation.

Conducting new subsurface environmental and geotechnical investigations at sites with known and/or potential soil and groundwater contamination adds a layer of complexity. The concern which must be addressed is the potential for boring activities to carry contamination into previously uncontaminated zones or to provide new pathways for extended impact of existing and new contamination. By puncturing layers that provide separation between existing layers, the borehole represents a potential pathway for migration of contamination from shallow zones to deeper zones. The severity of this potential depends upon a number of factors, including the types of soil and groundwater gradients. Fortunately, this problem has presented itself at numerous sites in the past, and proven techniques have developed which are capable of obtaining the required information while maintaining the security of each zone. Auger rigs should not be used in this condition.

In the event there is an underground water body present with access to process waters and drainage, the sediment in those water bodies should be asses to obtain a closure baseline.

The key information needed to prepare the necessary boring plans should be available within the Facility's existing documentation. Once the geology of the area of concern is identified with location of potential confining layers, soil types, and aquifer information, then it is necessary to define shallow geologic conditions and contaminants. A telescoping casing drilling program can be designed to fit the specific requirements of the site's geology. The drilling program will typically utilize a series of casings about the borehole, the diameter of which decreases sequentially with depth of the borehole. As the bottom of each zone is reached, an impermeable plug is installed to isolate the upper zone from deeper zones. Holes need to be fully cased and plugged, with clay or slurry installed in the casing bottom before stepping down to a smaller diameter. A new casing is then inserted through the plug and the borehole is advanced into the next zone. In addition, strict sampling and decontamination procedures need to be followed by the crew at the surface.

Special arrangements may be required to deal with capture and disposal of soil and groundwater generated from site characterization work. These arrangements may be significant and such arrangements need to be coordinated with existing site contamination management plans and permits/licenses.

This process is generally more expensive and time consuming, potentially adding 20 to 30 percent to the cost of site borings and roughly doubling the time needed to conduct such work. The definition of specific borings and their location may need to change in response to preliminary results and the discovery of important subsurface deposits, layers and characteristics.

The cost of additional site examination work to support a nuclear project can vary considerably depending on site conditions and project requirements. Representative costs of a site boring program using techniques which minimize disruption to subsurface structures could be on the order of one million dollars (\$1M).



#### 3 EXAMPLES OF SUCCESSFUL PROJECTS ON CONTAMINATED SITES

Nuclear power plant construction experience in the US predates the evolution of many of the environmental regulations that currently impact management of contaminated sites. Although there are instances where construction activities at nuclear plant sites have addressed soil contamination, the concept of separate ownership of the nuclear plant by someone other than the Facility Owner has not been applied in the nuclear power industry and therefore the experience base considered for this review is predominantly the construction of non-nuclear facilities.

Conversely, construction of new power and process facilities within existing process facility sites on property which was previously used for industrial purposes and which is (potentially) contaminated as a result is a commonplace occurrence. Accordingly, the process industry is well aware of the risks, hazards, and potential liabilities associated with such actions and has developed a considerable body of knowledge and procedures to allow for the safe and efficient reuse of such properties.

Shaw Consultants and their affiliates have participated in several recent projects including the expansion of existing process industry facilities, the installation of power plants on contaminated sites and within existing industrial facilities

The following project is representative of many routine expansions of process industry facilities by the owner within contaminated sites. This project demonstrates that Site Owners can successfully plan, permit and implement construction of new facilities on their own contaminated site:

• Port Arthur, Texas – This project involved major expansion of an existing petrochemicals facility. The site for the new units included portions of the site which were contaminated by previous facility activities. Accordingly, the project construction plans had to incorporate the requirements of the facility's government agency approved plan for continuing monitoring and remediation of site soil and groundwater contamination. In addition, construction work planning had to account for potential exposure to pre-existing hydrocarbon contamination.

Many power generation projects have been implemented on "brownfield" contaminated sites previously used for process industry or other industrial facilities. One example follows which demonstrates that power plant project developers can successfully deal with permitting and implementation of a project on a previously contaminated site which they have taken over ownership of.

• Rockford, Illinois – This project involved installation of new natural gas fired, combined cycle power generating units within an existing power plant. The power plant is located adjacent to a separate industrial facility, which contains contaminated areas subject to a government agency approved groundwater remediation plan. Contaminated groundwater from the adjacent industrial facility has migrated onto power plant property, including portions of the site on which the new generating units were constructed. Consequently, the plans for the new power generating units had to be designed to incorporate the requirements of the adjacent facility's groundwater remediation plan. In addition, worker safety plans for the new power generating units had to incorporate information on pre-existing site contamination.

Most relevant to this study, there have been several power plant projects implemented recently by power project developers on contaminated sites leased to them by the process industry site owner/offtaker. These projects demonstrate that workable Host Site Agreements can be implemented, and that supporting site investigation work and isolation of soil and groundwater contamination and related liabilities during the power plant life have been successfully resolved, often without elaborate and expensive physical barriers.



- Taft, Louisiana This project involved installation of a natural gas fired, combined cycle power plant within an existing petrochemical facility. The new power plant supplies steam and electrical power to its host facility and exports excess power to the grid for sale to Entergy. The site selected for construction of the new power plant was formerly used as the site for a previously decommissioned process unit. Design, construction and operation of the new power plant had to incorporate the requirements of the host facility's government agency approved plan for continuing monitoring and remediation of site soil and groundwater contamination.
- Ingleside, Texas This project involved installation of a natural gas fired, combined cycle power plant adjacent to an existing petrochemical facility. The new power plant supplies steam and electrical power to its host facility and exports excess power to the grid for sale to the local utility company. The site selected for construction of the new power plant was formerly used for agricultural purposes and was found to contain residual heavy metal contamination associated with defoliant usage. Accordingly, construction designs had to be amended to provide suitable worker protection.
- Lake Charles, Louisiana This project involved installation of a natural gas fired, combined cycle power plant within an existing petrochemical facility. The new power plant supplies steam and electrical power to its host facility and exports excess power to the grid for sale to the local utility company (Entergy). The site selected for construction of the new power plant was formerly used as the site for a (previously decommissioned) process unit. Design, construction and operation of the new power plant had to incorporate the requirements of the host facility's government agency approved plan for continuing monitoring and remediation of site soil and groundwater contamination.

The total additional time and cost associated with resolution of concerns related to the nature of existing site contamination and future responsibilities of the parties involved is difficult to isolate, but in the judgment of those involved could represent \$1-10 million per project.

#### 4 TYPES OF SITE CONTAMINATION

This report focuses on the following types of hydrocarbon contamination typically encountered at process industry sites:

- Soil contamination,
- Groundwater contamination, and
- Release of gases from contaminated areas.

Hydrocarbons are the most likely type of contamination to be found at process industry facilities. However, there are a number of other types of contamination which could also be encountered. Accordingly, the following types of contamination must be considered in addition to hydrocarbon contamination:

- Heavy metals,
- Asbestos containing materials ("ACM"),
- Polychlorinated biphenyls ("PCBs"), and
- Radon and other low-level sources of radiation, including background levels of naturally occurring radiation
- Groundwater tritium (H-3) concentrations and low-level concentrations of man-made radioactive materials such as Cs-137 and Sr-90 that are legacy materials from weapons atmospheric testing and Chernobyl.
- Naturally occurring radioactive materials ("NORM") and technologically enhanced naturally occurring radioactive materials ("TENORM") from industrial processes

Pending further design development of how nuclear heat delivery systems will be integrated with process industry systems, there will need to be an analysis of potential nuclear radiation transport mechanisms and their likely impact on process facilities, if any. This could impact secondary contamination of products, piping and equipment, handling and storage facilities and other equipment. Whether this potentially impacts existing contamination at the Site or the Facility will need to be determined.

Releases of hydrocarbon products to ground (i.e., "spills") invariably result in contamination of underlying soils to some degree. Complete remediation of such events may not be practical or feasible, depending upon site-specific circumstances. As a result, soils containing hydrocarbon contamination are potentially present at virtually all process industry facilities. The specific types, concentrations and extent of soil contamination are dependent upon (1) the types of hydrocarbons released and (2) the types of soils onto which hydrocarbons were released.

Virtually all soils contain water to some degree. Consequently, contaminated groundwater is typically associated with contaminated soil and the site-specific hydrogeologic conditions must be considered. The more porous or permeable the soil, the greater its water bearing capacity. In addition, more permeable soils have a greater transmissivity, meaning that water is able to pass through such soils more rapidly. Typically, the groundwater transmissivity of soils is reported in terms of centimeters per second ("cm/sec"). For design purposes, soils with groundwater transmissivity less than  $1 \times 10^{-7}$  cm/sec are considered to be impermeable. However, the groundwater transmissivity and the structural bearing capacity of soils do not necessarily correspond; i.e., soils with high structural bearing capacity may have either a high or low groundwater transmissivity and vice versa.

Soils contaminated with hydrocarbons will tend to evolve hydrocarbon vapors to a greater or lesser degree, depending upon the vapor pressure, soil affinity and water solubility of the hydrocarbons present. Soils with elevated concentrations of hydrocarbon contamination and/or which are contaminated with relatively volatile



hydrocarbons may result in localized concentrations of hydrocarbons in ambient air that are dangerous to human health and welfare in terms of toxicity and/or explosivity.

Other environmental and/or social conditions, such as ambient noise and traffic patterns/congestion, will also need to be considered and may be impacted by proposed site activities.

The extent and nature of site contaminants can have a first order effect on the time and cost required to demonstration to regulatory and permitting agencies that construction, operation and decommissioning activities are planned so as to minimize any potential impacts on workers and the public, and to satisfy stakeholders that their responsibilities can be managed effectively.

The term "mixed wastes" refers to material that contains both hazardous waste as defined by Resource Conservation and Recovery Act ("RCRA") (and its amendments) and radioactive waste as defined by Resource Conservation and Recovery Act ("AEA") (and its amendments). Mixed wastes are categorized for acceptance at disposal facilities, and the most severe categories may not lend themselves to acceptance at licensed disposal facilities. Mixed wastes of concern have a very limited history in the commercial nuclear power industry, resulting in instances where hazardous chemicals are used in highly radioactive environments, such as for water treatment or chemical cleaning operations. Leaks and spills of radioactive liquids have the potential to combine with contaminated soil or groundwater. The potential to create mixed wastes which involves existing Site soil or groundwater contamination will have to be explored when there is more definitive design and operational information available for evolving reactor designs. It is conceivable that gas cooled reactors will have less potential for radioactive contamination due to the absence of radioactive liquids and related storage and handling facilities. Measures to avoid the production of mixed wastes can include system design and selection of chemicals which will not result in hazardous waste production, through waste minimization planning.

#### 5 PLANT DESIGN IMPACT AND STRATEGIES

The design of a proposed nuclear plant within an existing process facility will include site preparation and foundation designs which need to address site conditions, existing constraints imposed by the host facility as well as the new requirements for a nuclear plant. In addition, the nuclear plant design will have to comply with existing environmental permits, including agency-approved plans for removal, containment and monitoring of hydrocarbon contamination at the proposed site. Finally, the nuclear plant design will have to incorporate existing environmental, health and safety ("EHS") programs into its construction, operating and maintenance plans. These existing data will be used to guide supplementary environmental and geotechnical investigations which the Sponsor will be required to conduct.

#### 5.1 Managing Groundwater Barriers

Ideally, the new nuclear plant will be designed to accommodate existing plans for management of hydrocarbon contamination at the proposed site. In particular, the new plant will need to avoid damage to or at least minimize interference with existing, approved groundwater barriers. Alternatively, it may be necessary or more practical to implement revised plans in order to satisfy the requirements for a nuclear plant. Typical options include the following:

- Remove (excavate) contaminated soils for relocation on the existing site by the Facility Owner, or for treatment and disposal at an approved onsite/offsite waste management unit and replace these soils with "clean" soils obtained from a separate location which are suitable for use as structural fill.
- Remove contaminated soils and any contaminated groundwater collected during site characterization and preparation activities for treatment at an approved onsite/offsite waste management unit and reuse remediated soils as clean fill. Proven examples include:
  - Biological treatment using aerobic and/or anaerobic microbes,
  - Chemical treatment within a liquid slurry reactor, and
  - Thermal treatment within a rotary kiln or other type of incinerator.
- Implement a program to reduce the concentration of hydrocarbon contamination *in situ*; i.e., without excavation. Proven examples include:
  - Biological treatment using aerobic and/or anaerobic microbes,
  - Biological treatment using groundwater pump and treat methods,
  - Chemical treatment using groundwater pump and treat methods, and
  - Chemical treatment using augurs for *in situ* mixing of soils and soil additives
- Implement a program to reduce the mobility of hydrocarbon contamination. Such a program could be integrated with project-related activities to increase the structural capacities of existing soils. Proven examples include:
  - o Chemical fixation of soils to reduce groundwater transmissivity, and
  - Chemical fixation of soil contaminants to reduce groundwater solubility and/or volatility.
- Install new/additional barriers to prevent migration of contaminated groundwater and/or evolution of hydrocarbon vapors from the proposed site. Proven examples include:
  - Synthetic liner (vertical and horizontal barriers)
  - Soil liner constructed by compaction and/or amendment of Site soils (horizontal barrier)
  - Sheet piling (vertical barrier)
  - Slurry wall (vertical barrier)
  - French drain (vertical barrier)

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- Groundwater recovery wells to intercept and reverse groundwater flow (vertical barrier)
- Cover and cap system using synthetic membranes, compacted/uncompacted soils, asphalt/concrete paving and vapor recovery piping to intercept hydrocarbon vapors)

Selecting from among these approaches for removal of existing contamination and the implementation of measures to ensure long term isolation of the Site will consider site information, specific available options and their effectiveness, costs, implementation requirements and associated long term risks and potential liabilities. Based on the nature of activities at the Facility, and the design of the proposed nuclear plant, it could be determined that potential liabilities are minimal or that they can be addressed without the implementation of expensive physical barriers. The suite of processes to be used for preparation of the Site will depend upon site-specific conditions, nuclear plant design and specific project requirements.

The likely cost impact of these arrangements is difficult to generalize because of their diversity and would be integrated with the Facility Owner and Sponsor's site preparation approaches and designs. Overall cost impact on a project could range widely from \$100k's to \$millions depending on site and project requirements.

#### 5.2 Foundation Design

Structural foundations are key elements for the design of a NGNP plant. At the same time, one of the key concerns with hydrocarbon contaminated soils is associated with pilings used as part of structural foundations. Driven pilings, in particular, have been shown to create pathways allowing hydrocarbon contamination to migrate vertically downwards through a confining layer of impermeable soil to an underlying groundwater bearing zone. Soil mixing and/or grout injection may be considered as alternatives, but spread footings are often preferred over pilings within areas of hydrocarbon contamination. However, there are a number of proven processes, such as cast in place pilings, which can be used to accommodate the use of pilings, depending upon site-specific conditions. Very few nuclear power plants have been built using deep pilings, given the nature of seismic requirements and a strong preference toward other foundation concepts to support nuclear licensing.

If a NGNP plant is to be constructed upon a site or adjacent to a site with existing hydrocarbon contamination, construction workers will have to be properly protected from exposure to said contamination. Typical measures included both administrative controls (procedures, training and monitoring) and engineered controls (personnel protective equipment and temporary/permanent barriers). In addition, workers will need to be examined for hydrocarbon contamination exposure prior to their start of construction, periodically throughout their time on the construction site and for an appropriate time after their end of construction. Construction sites involving hydrocarbon contamination require enhanced security measures to ensure that only properly trained and equipped personnel are allowed onto the construction site. Similarly, operations workers will have to be protected from hydrocarbon contamination which remains at the site after construction is complete. The primary difference is in terms of the potential length of exposure, which will typically be much greater for operations workers than for construction workers.

Site preparation and foundation design should provide the ability to remove foundations during plant decommissioning without disturbing a lower barrier liner which can be relied on to provide isolation of any contamination and waste streams between the nuclear plant and the Facility.

#### 6 HOST SITE AGREEMENT

It will be necessary for the nuclear project Sponsor to negotiate a legal agreement with the process Facility owner (the "Host Site Agreement") which thoroughly documents each party's rights and responsibilities with regard to the proposed project, including the following:



- Report
- Long-term, extendable Site lease tied to the nuclear facility operating license
- Availability and rates for utilizing Facility utilities, such as water, backup power etc.
- Site access
- Interfaces and interconnections with the Facility
- Definition of pre-existing Site contamination and ongoing remediation programs,
- Site investigations to document site-specific environmental and geotechnical conditions affecting the proposed project,
- Responsibilities for Site contamination discovered during construction,
- Responsibilities for wastes generated during construction,
- Responsibilities for wastes generated during operations,
- Responsibilities and Facility interfaces for Site security,
- Coordination of worker safety and training,
- Coordination of operations, procedures, safety and emergency response
- Responsibilities related to Site closure (e.g., nuclear power plant decommissioning).
- Responsibilities for costs associated with permitting/licensing, site preparation, operations and decommissioning

In particular, the Host Site Agreement needs to include clauses which indemnify the Sponsor against pre-existing site contamination and which indemnify the Facility against contamination caused by the Sponsor.

In addition, the Sponsor will need to incorporate specific requirements into each of the plans, procedures and specifications required for licensing and permitting, site preparation, construction, operation, and decommissioning.

As stated previously, a number of investigations are likely to be needed to document site-specific environmental and geotechnical conditions. Such investigations need to be coordinated with the Facility owner who will need to comply with its responsibilities associated with existing permits and licenses.

The time required to conduct site environmental investigations is generally about the same as the time required to conduct geotechnical investigations needed for foundation design. Note that NRC has minimum requirements for pre-operational environmental monitoring programs of at least 24 months. Unless there is discovery of unforeseen contamination, or special measures required to protect subsurface contaminant transport barriers, there may be limited schedule impact from conducting additional environmental investigations for a brownfield site. However, discovery of contamination during Site investigations or construction may introduce the need for additional work which could delay construction.

An NGNP plant that is properly designed, constructed, and operated and decommissioned on a brownfield Site is likely to require special efforts to deal with careful definition of responsibilities and long term liabilities associated with the management of existing and future wastes and contaminants. The key concepts which should support a successful Host Site Agreement are to separate as much as possible the responsibilities for building, operating and decommissioning the nuclear plant from any contamination and remediation activities associated with the host site. The obvious implications are that the Site Owner is in control of and manages site investigation and site preparation work so that there is no opportunity for the nuclear plant Sponsor to have any negative influence on the ability to comply with existing permits and planning connected to soil and groundwater contamination. The activities and responsibilities of the nuclear plant Sponsor can be limited to the latter phases of site preparation after any activities which disturb or impact existing contamination are completed by the owner. Operational impacts are closely managed by the nuclear plant operator to control and monitor any spills and releases within established boundaries



so that appropriate assurances are provided to the Site Owner and to interested permitting and regulatory agencies that no cross-contamination has occurred.

As part of the nuclear licensing and environmental permitting processes, each of the atmospheric emissions, discharges to surface water, releases to soil and groundwater, and radioactive/solid/hazardous waste streams will need to be carefully characterized and their specific properties documented to ensure that each waste stream can be managed within both environmental and nuclear industry regulations.

#### 7 SPECIAL CONSTRUCTION REQUIRMENTS

Construction of an NGNP project upon a heavily contaminated Site will need to address a number of issues unique to the site and existing contamination. However, these issues can be managed so that there is minimal impact on the nuclear plant Sponsor and the contractors involved with construction.

#### 7.1 Site Preparation

Site preparation activities can be divided into two phases, "Host Site Preparation" and "Project Site Preparation" as follows.

Host Site Preparation entails preparation of the site by the Site Owner (Facility Owner) to remove contaminated soils and water and to prepare boundaries which will define long term responsibilities regarding waste disposition. Pre-existing Site contamination will need to be removed and/or immobilized in order to satisfy geotechnical requirements for foundation design, maintain or create physical non-permeable horizontal and vertical boundaries to prevent contamination transport, ensure construction worker protection from toxicity, and allow mechanisms to support future monitoring of contamination and ultimate removal of material in support of decommissioning. Environmental monitoring of the Site and surrounding area may be needed during the Host Site Preparation phase to clarify the baseline condition for beginning project site preparation work.

Project Site Preparation entails the management of the site boundary by the nuclear plant Sponsor in order to support responsibilities associated with his obligations under the Host Site Agreement to isolate any effects of construction, operations and decommissioning within agreed boundaries. If an excavated site with new or existing barriers is provided to the Sponsor, then the project site preparation scope will include bringing in suitable replacement soils, possibly installing a separate groundwater monitoring system on the project side of the barrier(s), and allowing sufficient room between foundations and agreed boundaries so that decommissioning work can be completed without disruption to boundaries.

Figure 1 below summarizes the concept of site preparation, use of contamination transport barriers and groundwater sampling and monitoring, and placement of fill to leave room for eventual removal of foundations without disrupting barriers.





#### 7.2 Worker Safeguards

Under the guidance and direction of the Project EHS Plans and Procedures, construction and operations workers will be required to wear traditional personnel protective equipment ("PPE") within designated areas such as hard hats, safety glasses, hearing protection, flame retardant clothing, and proper footwear. However, excessive concentrations of hydrocarbon contamination in or below work areas might require additional PPE, such as goggles and face masks, breathing protection and splash-resistant clothing. Although a site should be properly prepared to avoid such exposures, experience with construction at contaminated sites has shown that occasionally unforeseen contaminants are encountered and it is prudent to anticipate such conditions where appropriate and to plan to provide workers with such additional PPE in the event such conditions are encountered. Construction labor productivity is significantly reduced under such conditions. Therefore, if there is significant risk of emergent contamination discovery, it is prudent to have provisional plans and equipment, and to provide some contingency for associated construction delay and cost increases.

Construction and operations workers will require additional training with regard to potential exposure to Site contamination. However, this additional training can be integrated with other training and many contractors and workers with experience in the process industry are familiar with associated safety practices. A more robust industrial hygiene sampling and analysis program may be warranted in these types of conditions during the construction phase.



#### 8 DECOMMISSIONING

Nuclear plant decommissioning requirements are formally defined by the NRC, which requires the preparation of an approved Decommissioning Plan, an approved Decommissioning Cost Estimate, and the maintenance of a dedicated Decommissioning Fund within specified guidelines. The Host Site Agreement is likely to introduce additional demolition and site restoration requirements.

#### 8.1 Decommissioning Plan

At the expiration of the operating license, the Sponsor (nuclear plant owner and NRC license holder) is responsible for decommissioning the plant. Decommissioning is defined by the NRC as the safe removal of the nuclear facility from service and the reduction of residual radioactivity to a level that permits release of the property for unrestricted use and termination of the Operating License. Two methods of decommissioning are currently considered for decommissioning plans for most operating nuclear units. One is DECON (the equipment, structures, and portions of the facility and site that contain radioactive contaminants are removed or decontaminated to a level that permits termination of the license shortly after cessation of operations). The second is SAFSTOR (the facility is placed in a safe stable condition and maintained in that state until it is subsequently decontaminated and dismantled to levels that permit license termination).

As governed by the Host Site Agreement, nuclear plant decommissioning is likely to extend beyond NRC requirements and include work to eliminate residual obligations associated with the separation of responsibilities associated with site contamination in the Host Site Agreement. In the extreme, the nuclear plant owner may be required to completely remove the entire nuclear plant equipment, structures and foundation from the site. However, it is more likely that if operations of the nuclear plant are well-documented and testing demonstrates that there is little or no contamination of the soils, structures and foundations, it may be preferable to leave some materials in place.

The Host Site Agreement is likely to require a detailed record of pre-existing site contamination, events occurring during construction and operation which are relevant to decommissioning, demolition and site restoration, and conditions for turning the site back over to the Site Owner. At the end of its life, the nuclear plant site will be carefully examined to confirm the integrity of boundary conditions at the limits of the site, isolation of waste streams, and detection or characterization of any new contamination that has taken place since construction. For example, a groundwater monitoring system operating over the life of the nuclear project could be relied upon to demonstrate that no significant leaks or spills have occurred, facilitating site reclamation requirements.

The Host Site Agreement may include some constraints on what the Site Owner can use adjacent property for in order to protect the nuclear safety case and the operating license. Some limits on explosion and chemical release hazards may apply, which are released when the nuclear plant ceases operations and nuclear fuel is removed from the site. The nature of such commitments and their implication is worthy of further study and is not addressed specifically within this report. This agreement may also specify the degree of site demolition and restoration work required to return the Site to the Facility Owner.

Provisions in the original engineering and design of the nuclear plant should facilitate removal of the nuclear plant equipment, structures and foundations without disturbing contaminant barriers.

Additional construction time and effort may be required for complete removal of contaminated soils, confirmation of conditions prior to installation of forms and foundations, participation by regulatory/permitting agencies and the Facility Owner to approve detailed site preparation drawings, and coordination with the Site Owner regarding disposition of contaminated material removed by excavation.



Should high levels of background radiation or chemical contamination be determined at the Site or surrounding areas, some additional procedures, equipment and training may be required to address worker and visitor radiation monitoring requirements.

State environmental requirements may be imposed which dictate the disposition of demolition wastes from the decommissioning and subsequent site recovery work that are outside the control of the nuclear plant owner and the Host Site Owner. The classification and specific disposal requirements of demolition wastes are set by state environmental agencies and can have a first order effect on decommissioning and site recovery costs. Therefore, it may be advantageous to include appropriate state agencies in the development of a detailed decommissioning plan so that demolition material classifications and disposal requirements can be agreed to and funded. If contamination from the host facility is successfully isolated over the life of the nuclear plant, it is unlikely that the nuclear plant owner would suffer any additional costs, schedule delay or liability as a result of decommissioning work and site reclamation.

If new contamination originating from the Facility impacts decommissioning waste material classification and disposal cost, it is likely that the nuclear plant owner will seek to hold the Facility Owner responsible. Under such circumstances, extended delays in decommissioning completion and extended dispute resolution process between the two parties could result, and the effectiveness of measures taken during site preparation, construction and operation to demonstrate compliance with the Host Site Agreement will be tested.

#### 8.2 Decommissioning Estimate and Site Restoration Costs

The decommissioning cost estimate will be developed according to NRC requirements covering the nuclear decontamination of the site. This estimate will be formally approved by NRC as a basis for establishing the Decommissioning Fund that will need to be supported by conservative investment vehicles by the plant owner.

It is not likely that the decommissioning cost estimate required by NRC would be affected by the presence of nearby site contamination. However, it is possible that state oversight of the Site Owner's long term remediation plan may impose some requirements on site decommissioning and restoration planning which are documented when environmental permits for the project are obtained.

The NRC decommissioning estimate does not address the full cost of site restoration. The cost of site restoration to its prior brownfield state may be an opportunity for the Site Owner to adapt the site for new uses. However, the time frame for such decisions is beyond the practical planning horizon given a potential economic life of the nuclear plant of up to 40-60 years. It is likely that a Host Site Agreement will identify the detailed requirements and responsibilities for site restoration and turnover back to the Facility Owner.

Therefore substantial uncertainties may exist for a specific project regarding those aspects of site decommissioning and restoration which go beyond current NRC requirements, particularly those subject to interpretation by state agencies. One area which has severely impacted previous nuclear decommissioning projects has been the classification and disposal requirements for demolition wastes. State environmental agencies must approve how demolition wastes, such as rubbelized concrete from plant structures, are classified and how they can be disposed of. For example, while Shaw was performing decommissioning of the Maine Yankee Nuclear Generating Station, the State of Maine mandated compliance to final status conditions that were more restrictive than federal guidelines. The State of Maine unexpectedly categorized decontaminated building demolition wastes as special wastes requiring out-of-state disposal which resulted in substantial cost and schedule impacts. It may therefore be advantageous to approach state environmental agencies during the plant licensing phase with a site restoration plan which clearly defines final status conditions and clarifies state requirements that address the classification and



disposal of demolition and other waste materials from the site. Formal agreement on the disposition of demolition wastes early in the project will provide some increased certainty in planning and budgeting for site restoration work.

#### 8.3 Decommissioning Fund

A Decommissioning Fund will need to be established to cover the eventual costs of decommissioning. The NRC uses a minimum decommissioning funding formula to assess the adequacy of decommissioning trust fund balances, based on generic assumptions. This NRC minimum decommissioning cost is only intended to cover the potential decommissioning work required to remove radioactive contamination from a limited set of equipment and structures. It is not intended to be a replacement for a site specific decommissioning cost estimate and does not include the following:

- cleanup of non-radiological hazardous material or radioactive contamination that has gotten into the environment
- restoration of the site to a "Greenfield" condition
- additional costs associated with deferring decommissioning (i.e., SAFSTOR)
- managing spent fuel after plant shut down

Additional state-mandated requirements for site restoration and the classification and disposal of site demolition material may impact required budgets for site restoration, but may not directly impact the amount of NRC decommissioning funding required.



#### 9 NUCLEAR LICENSING ISSUES

Nuclear licensing approaches for NGNP projects are still under development. The presence of site contamination is likely to impact the nuclear licensing process in several ways discussed in this section.

An Early Site Permit ("ESP") application would include a complete examination of the Site and characterization of existing contamination, the intended range of site preparation requirements, and the range of projected releases, spills or any other effluent and emission streams which could result from construction and operation of the NGNP project. Efforts to document the existing contamination at the site and to conduct additional site characterization work would be detailed in this application and in the permit. It is anticipated that the scope of effort related to the characterization of existing contamination, plans to provide and protect physical barriers, and plans to monitor groundwater below the Site would be undertaken in support of the preparation of a Host Site Agreement, and would also serve to support the ESP application and review process. The ESP public review process will introduce public comment and hearings, and could include detailed examination of related design and planning efforts.

Design certification ("DC") of a new reactor design is intended to address a range of site conditions and project requirements. The application process for design certification will address plant seismic requirements which impact foundation design, and the proposed arrangement of the nuclear island in terms of foundation depth and relative elevations. It may also need to address certain application requirements including characterization of waste streams, sources of radiation, potential leaks and spills, radiation monitoring, worker and visitor exposures, etc. A review of proposed design certification requirements and application approaches is needed to define what specific areas, if any, will need to address issues relating to foundation type and depth, isolation and monitoring of waste streams,

The combined Construction and Operating License ("COL") application will include information from the ESP and DC if available, and address specific design, operational, and site conditions to a high level of detail representing completion of preliminary design work on the project. At that stage, detailed drawings defining foundation design, replacement of existing soils, location and placement of barriers to contaminant transport, and groundwater monitoring systems will be required. The COL is likely to stipulate implementation of contaminant monitoring programs focused on detection of radiation leaks from the plant, as well as migration of contamination from surrounding areas.

Given NRC's limited familiarity with the design, construction and operation of nuclear plants on process sites and the potential implications of soil and groundwater contamination, it is likely that the Sponsor will incur additional costs for the application develop efforts and for the cost of NRC time to review and approve applications. An initial guess for these extra costs is on the order of \$200k.



#### 10 ENVIRONMENTAL REQUIREMENTS

Congress has promulgated a number of laws relevant to construction, operation, remediation and closure of industrial sites, including the following:

- Clean Air Act ("CAA") addresses contaminants (air pollutants) contained in atmospheric emissions;
- Clean Water Act ("CWA") addresses contaminants (priority pollutants) contained in discharges of wastewater, including stormwater, utility waters and process waters, to receiving streams (surface water);
- Safe Drinking Water Act ("SDWA") addresses contaminants contained in discharges, including injection wells, to groundwater;
- RCRA addresses generation, storage, treatment and disposal of "solid wastes" (which may be gaseous, liquid or solid), including "hazardous wastes" which exhibit one or more of the characteristics of corrosivity, flammability, reactivity and toxicity, and
- Occupational Safety and Health Act ("OSHA") addresses protection of workers during construction and operations.

The USEPA is responsible for implementation of the CAA, CWA, SDWA and RCRA, while the United States Occupational Safety and Health Administration ("USOSHA") is responsible for implementation of the OSHA. Each of these federal agencies has promulgated a number of regulations to implement the will of Congress. In addition, most States have established agencies and regulations corresponding to their federal counterparts, and the USEPA has typically delegated primary responsibility for administration of EHS regulations to the individual state agencies, with federal oversight. Separately, several States, including Texas and Louisiana, have established permitting programs for withdrawal and usage of both surface water and groundwater.

The existing Facility will probably have been permitted under one or more of the environmental programs listed above. Prior to start of construction for a NGNP plant within the Facility, it will be necessary to modify the Facility permits to authorize construction and operation of the NGNP plant. Alternatively, the Sponsor may prefer to obtain new environmental permits separate from the Facility. At the least, however, the Facility will need to obtain permits for any modifications to its approved soil and groundwater remediation programs. Typically, plans for remediation of soil and groundwater contamination are included in the Facility's RCRA permit. In some States (notably Texas), the operating permit is issued separately from the construction permit, after the permittee has demonstrated compliance with its permit conditions. In any event, there should not be any insurmountable issues associated with environmental permitting for a NGNP plant located within an existing petrochemical facility.



#### 11 PUBLIC OUTREACH

Construction and operation of a NGNP within the process industry is likely to represent a major media event, regardless of whether the Site is contaminated or not. Consequently, a well-conceived public outreach program should be planned well in advance of any announcements, which is coordinated closely with the Site Owner's public outreach efforts. Such an outreach program should address public information distribution mechanisms as well as outreach support related to upcoming public hearings.

Key issues to be addressed in such public outreach initiatives should include:

- Overview of the NGNP program
- Overview of new HTGR technologies and their benefits
- Overview of combined HTGR/process facility safety case and implications (why they can be located on process sites)
- Summaries of current plans by the Site Owner to manage and remediate existing contamination
- Planned efforts to characterize the proposed nuclear plant site in detail
- Establishment of barriers to prevent contaminant transport
- Plans for monitoring of groundwater
- Decommissioning and site reclamation planning

#### 12 IMPACT ON PLANT STAFFING, OPERATIONS AND MAINTENANCE

The NGNP plant will be staffed and operated by a qualified Nuclear Operator through an Operating Agreement with the Sponsor/Owner. This agreement will include an O&M plan which addresses plant staffing, training, procedures, worker health and safety, site radiation monitoring, fuel handling and storage, security, spare parts, maintenance planning, waste handling and disposal, and specific activities required by the NRC COL and various permits and licenses from local, state and federal agencies that have an oversight role.

The implications of the plant's location on a process site and the presence of soil and groundwater contamination are likely to add the following requirements for the Nuclear Operator to address:

- Possible adaptation of radiation monitoring procedures and equipment to address the presence of high levels of background radiation
- Inspection of physical barriers to contaminant transport and monitoring of groundwater collected under the nuclear plant site as required by the Host Site Agreement
- Worker health and safety procedures and training to address any contamination or process safety issues under the control of the Site Owner per the Host Site Agreement
- Restrictions on site activities and plant modifications per the Host Site Agreement
- Integration of emergency planning with the Site Owner per the Host Site Agreement
- Coordination of maintenance responsibilities at plant interface points as defined in the Host Site Agreement (e.g. water supply, power interconnections, shipping and receiving, communications, security)
- Exchange of periodic reports documenting waste discharges, emissions, and site activities that could impact the disposition of site contamination as required by the Host Site Agreement.
- Preparation of any reports required by permits or licenses related to waste handling and disposal including spills and accidental releases (these may be required whether or not there is site contamination)



#### 13 IMPACT ON PROJECT COSTS

Although difficult to generalize, potential cost impacts to various project phases are summarized below:

#### 13.1 Site Characterization

- Conducting a site investigation to determine soil and groundwater contamination This work is normally done anyway on a brownfield site and could typically cost on the order of \$100-200k.
- Special measures to conduct borings without disrupting existing barriers to contamination transport In the event that borings needed for site characterization or for geotechnical investigations may disrupt existing subsurface barriers to contaminant transport, special measures to manage such borings could potentially increase the cost of borings by 50-100%.
- Pre-operational survey to define background radiological contamination Soil and groundwater sampling to define existing radiological contamination may cost on the order of \$100k.

#### 13.2 Project planning

• Evaluation of subsurface conditions to design waste separation/isolation strategy

Some engineering work and commercial discussions may be required to establish an agreed basis between the Sponsor and Facility Owner for site preparation and long term management of liabilities associated with possible future contamination. This effort would be very project specific but a representative budget could be \$100-200k for engineering studies and legal consultations.

#### 13.3 Nuclear Licensing and Environmental Permitting

Although the scope of nuclear licensing activities may be adjusted to address issues related to site contamination, some additional effort and budget is likely to be required for the development of applications and the cost of NRC review, possibly on the order of \$200k. Securing environmental permits for use of contaminated sites may require additional effort primarily covered in the site investigation and long term waste management planning already in place by the Facility Owner and undertaken to support the development of a Host Site Agreement.

• Early Site Permit Application

Additional pre-operational data collection efforts are described above and would be conducted to support the development of a Host Site Agreement.

• Technology Certification

Pending further design development work by technology suppliers, there is currently no indication that technology certification would be significantly impacted by the application of HTGR technology on a contaminated site. Integration of nuclear and process safety issues and other related work are outside the scope of this review.



#### • Construction and Operating License

The development of COL application and its defense may be impacted by measures taken to address existing site contamination. However, this would be addressed within normal efforts related to defining site preparation, foundation design, training, worker safety and long term environmental monitoring requirements.

#### 13.4 Site Preparation

• Removal of contaminated material

The Sponsor and Facility Owner may agree that some contaminated soil and/or groundwater need to be removed to support replacement of soil as part of the foundation requirements, to improve worker conditions for civil construction, to allow placement of liners and groundwater sampling systems and to provide a clear baseline for managing future responsibilities. The Facility Owner may be able to relocate soils onsite within existing permit and onsite waste management requirements. The best possible case would be that no major additional costs result compared to excavation and removal of existing soils to support use of structural fill. Should state environmental requirements require special disposal of removed contaminated soil the cost of its disposal could become substantial (\$Ms to \$10Ms).

• Installation of contaminant transport barriers

In the event that major vulnerabilities to the disposition of existing subsurface contamination is identified during site investigation work, some additional work may be required to stabilize contaminated soils or install or maintain barriers to contaminant transport. Additional costs related to such work would be very project specific. Installation of clay liners as part of soil replacement in support of foundation design could add on the order of several \$100k's to the site preparation costs, but again this could vary substantially with project specific requirements. Many of the Gulf Coast process industry sites are underlain by clay which provides a natural barrier, and which could preclude special efforts to add underground liners.

• Installation of groundwater sampling system

Groundwater sampling systems can vary in design and in some cases need to be integrated with a liner system. In many cases, installation of a well and sampling system to draw water from an existing underground system could cost on the order of \$100-200k depending on the cost of drilling a well and special constraints. It appears that all new nuclear power plants will implement groundwater monitoring whether or not existing contamination exists, so this should not represent an additional cost attributable to existing site contamination.

#### 13.5 Operations

The presence of existing soil and groundwater contamination at a site may impact plant operating costs in extreme cases. Nuclear plants have extensive staffing, training, health and safety programs, radiation protection monitoring, and environmental monitoring, all of which could be affected in some ways. However, if suitable measures are taken during site preparation to remove or stabilize objectionable levels of soil and groundwater contamination, it seems reasonable to assume that no significant impact on annual plant operating budgets would result.



#### 13.6 Decommissioning and Restoration

• NRC Required Decommissioning Plan, Decommissioning Estimate, and Decommissioning Fund

NRC decommissioning requirements are limited to well defined obligations focused on fuel removal, removal, decontamination and disposal of radioactive equipment, material and surfaces, and release of obligations from the nuclear operating license. The presence of existing or nearby soil or groundwater contamination should not have a major impact on NRC decommissioning requirements under normal circumstances.

• Review of site restoration plan, criteria and waste materials classification with state environmental agencies

Site restoration requirements imposed by the Facility Owner and by state environmental agencies will exceed NRC decommissioning requirements. Given experience with the decommissioning of Maine Yankee and other nuclear facilities, state environmental regulation could have a first order impact on site restoration costs by setting difficult targets for site cleanup and categorizing demolition and other waste materials such that their removal and ultimate disposal can be very expensive. One way to approach this problem is to seek early definition of these requirements by submitting a detailed site restoration plan for approval during the permitting phase of the project. The cost of such an effort could vary widely but may be initially represented on the order of several \$100k's. Such an effort is likely to be undertaken whether or not significant existing contamination exists at the Site.

• Closeout of Host Site Agreement Responsibilities

After decommissioning and site restoration work is complete and accepted by the NRC and other permitting agencies, it is likely that the Sponsor's Host Site Agreement responsibilities will be complete and some form of closeout agreement will be executed to terminate the relationship and related responsibilities.

In the event that unexpected events have resulted in significant cross-contamination between the Site and the Facility it may become necessary to resolve responsibilities for certain site restoration costs. It is not reasonable at this stage to speculate on the cost of such activities.



#### 14 CONCLUSIONS AND RECOMMENDATIONS

The following observations are highlighted in the report and lead to the conclusions and recommendations presented below.

- a. Given long-term responsibilities related to the management and remediation of existing soil and groundwater contamination, the Site for the NGNP plant will continue to be owned by the Facility Owner (also referred to as the "Site Owner"). Conversely, the nuclear plant will be constructed, owned, operated and decommissioned by the Sponsor in accordance with the terms and conditions of a Host Site Agreement between the Facility Owner and the Sponsor. This Host Site Agreement will include a long-term lease for the Site and indemnities releasing each party from activities by the other associated with waste streams and contamination.
- b. Characterizing existing contamination to thoroughly document the pre-construction status of the site is critical to the distribution of responsibilities in the Host Site Agreement. Investigations to supplement existing Facility documentation will be required by the Sponsor to meet regulatory requirements associated with siting and operating nuclear facilities, but will need to be managed by the Facility Owner given the potential liabilities associated with disturbing existing barriers to contamination transport.
- c. Ideally the Facility Owner should completely decontaminate the Site prior to turnover to the Sponsor for site preparation work. Elimination of contamination facilitates management of related responsibilities between the parties over the life of the nuclear plant. However, if removal of existing contamination is not practical or economical, other measures can be employed to manage each party's responsibilities.
- d. Establishing physical barriers to contamination transfer provides the greatest assurances to both parties that they will not become liable for each other's activities. In the event that it is not practical or economic to create and maintain such barriers, it may be possible to manage responsibilities associated with migration of existing contamination or the introduction of new contaminants by closely tracking Site activities and monitoring groundwater. Site investigation activities, such as excavations and borings, must be carefully planned and implemented to avoid disrupting existing barriers between layers of contamination below the proposed plant. Deep soil borings may require special and more expensive drilling techniques that avoid disrupting layers of material that separate existing contamination from deeper aquifers or otherwise sensitive layers.
- e. Mixing of hazardous waste and radioactive waste (i.e. creation of "mixed waste") should be avoided through design and through operational and maintenance practices given the high cost and difficult logistics of the disposal of such wastes.
- f. Nuclear licensing applications for ESP and COL will need to include a detailed site subsurface characterization and plans to isolate or remediate existing contamination from any impacts of the planned facility.
- g. Engineering of the nuclear plant should consider nearby site exclusions and barriers needed to segregate potential contamination from areas where existing contamination are the responsibility of the site owner.
- h. Site preparation and foundation design need to support decommissioning, decontamination and removal of equipment and structures without disrupting barriers to crossover contamination.
- i. Decommissioning planning and implementation can be facilitated by plant lifetime isolation of any wastes, spills, leaks or other impacts from any surrounding areas. Monitoring of groundwater beneath the nuclear plant will be necessary to document that no radiation emanating from leaks or spills has left the nuclear site boundaries.
- j. Site background radiation can be significant relative to nuclear regulatory thresholds for nuclear power plants requiring possible modifications in how radiation exposure is monitored and tracked during operation and decommissioning phases. Also, the presence of certain chemical contaminants in soils near



the nuclear plant may impact radiation monitoring on personnel entering and leaving the site. Special procedures may be needed to minimize the impact of such effects.

- k. Commercial arrangements (Host Site Agreement) between the Facility Owner and the Sponsor (nuclear plant owner) will need to clearly resolve responsibilities for existing contamination and that produced by either party during the life of the nuclear plant until it is removed from the site.
- 1. The concept of two owners interfacing on one site (Facility Owner and Sponsor) opens up a number of additional technical, commercial and licensing issues that will be need to be addressed which are outside the immediate scope of this preliminary review of issues focused on existing site contamination.

Based on the assumption that significant soil and groundwater contamination exist at an NGNP site, the following conclusions and recommendations summarize the findings of the study.

- 1. A number of projects have been successfully completed where third parties have permitted, built and operated power generation facilities on existing contaminated process industry sites relying on host site agreements, detailed site characterizations, and effective design and operational approaches to manage potential liabilities.
- 2. The nuclear project Sponsor and Site Owner will work together to achieve a preliminary understanding of site contamination based on a review of site history and completed characterization and monitoring efforts
- 3. Additional site investigation work will be defined based on the selection of the site and preliminary arrangement of proposed facilities to develop the information needed to provide a formal baseline condition for the site and to define existing and new barriers to restrict contamination transport
- 4. Specific responsibilities regarding existing and future contamination of the site need to be agreed between the Sponsor and Site Owner as part of a Host Site Agreement.
- 5. Preferably, initial site preparation work will include removal of contaminated soil and installation of barriers by the Facility Owner subject to approval by the Sponsor, which provide confidence that there will be no further transport of contamination from the Facility into the Site during the life of the nuclear plant.
- 6. Project site preparation work should include the installation of a groundwater monitoring system under the nuclear plant above an underground liner or other form of vertical contamination transport barrier system. The operation of this groundwater monitoring system can provide the primary tracking mechanism to identify and capture any significant spills, leaks or discharges from the nuclear plant which could potentially impact soil or groundwater under the control of the Sponsor.
- 7. The foundation design of the nuclear plant should avoid disruption of contaminant transport barriers and leave adequate separation to support future decommissioning and demolition work without disruption to contaminant transport barriers. Nuclear plant designs with deeper foundations may be more problematic at some sites. In the unlikely event that deep pilings are required for the nuclear plant structures, special piling installation methods may be required to avoid or minimize disruptions to subsurface contamination transport barriers.
- 8. The NRC-approved Decommissioning Plan, Decommissioning Estimate and Decommissioning Fund requirements are intended to cover removal of fuel and removal of radiation contamination to levels that achieve thresholds needed to release the nuclear plant owner from responsibilities associated with the Operating License. The NRC requirements are not likely to be affected by the presence of contamination at or near the site. However, additional requirements for demolition and restoration of the site for other uses are likely to be imposed by the Site Owner through the Host Site Agreement. Also, state and local environmental agencies may impose specific classifications to demolition wastes, soils and contaminated materials which could restrict site restoration options and increase related costs.
- 9. The nuclear licensing process would be impacted by the presence of site soil and groundwater contamination in the following ways:



- Site baseline environmental studies will include a detailed characterization of the site, including soil and groundwater contamination
- Site environmental impact analyses will include detailed analysis of effluents and emissions from the proposed facilities and their impact on the site
- Detailed design information included with the COL application will include site preparation and foundation designs. Details regarding barriers to contamination transport and groundwater monitoring will need to be identified.
- 10. Siting a nuclear project on a process site is likely to generate considerable public interest. A wellconceived public outreach program will be needed to provide public access to information about nuclear technology and how environmental requirements will be addressed.
- 11. The total impact on project costs can range widely based on project-specific conditions. An early assessment of likely costs would be completed in the project planning phase and considered in the economics and risk analysis of the project. An example of possible costs encountered by a project which can manage existing contamination successfully to avoid extreme conditions impacting construction and operations are summarized below:

•	Site characterization and pre-operational data collection	\$200-500k
•	Project planning and Host Site Agreement development	\$100-200k
•	Nuclear licensing (ESP, TC, COL)	\$200k
•	Site preparation (if soil removal/barrier work is needed)	\$1-10M
•	Construction (assuming no impact on foundation design)	minimal
•	Operations (assuming no extreme contamination remains)	minimal
•	NRC decommissioning requirements (no major releases)	minimal
•	Site restoration (no major releases or disputes)	<\$1M



#### 15 RELATED REFERENCE DOCUMENTS

"Site Characterization Technologies for DNAPL Investigations," EPA 542-R-04-017, United States Environmental Protection Agency, September 2004.

"Guide to Site and Soil Description for Hazardous Waste Site Characterization, Volume 1: Metals," EPA/600/4-91/029, United States Environmental Protection Agency, March 1992.

"Fast Flux Test Facility: Safety Analysis Program," BNWL-1059, Battelle Northwest Pacific Northwest Laboratory, February 1969.

"Siting of Research Reactors," IAEA-TECDOC-403, International Atomic Energy Agency, 1987.

"Interim Staff Guidance on Evaluation and Acceptance Criteria for 10 CFR 20.1406 to Support Design Certification and Combined License Applications," United States Nuclear Regulatory Commission Office of New Reactors.

"Interim Staff Guidance on NUREG-0800 Standard Review Plan Section 11.2 and Branch Technical Position 11-6 Assessing the Consequences of an Accidental Release of Radioactive Materials from Liquid Waste Tanks for Combined License Application Submitted under 10 CFR Part 52," United States Nuclear Regulatory Commission.

"Interim Staff Guidance on Probabilistic Risk Assessment Information to Support Design Certification and Combined License Applications," United States Nuclear Regulatory Commission.

"Policy Issues Related to Licensing Non-Light-Water Reactor Designs," SECY-03-0047, United States Nuclear Regulatory Commission, March 28, 2003.

"Security Design Expectations for New Reactor Licensing Activities," SECY-05-0120, United States Nuclear Regulatory Commission, July 6, 2005.

"Legal and Financial Issues Related to Exelon's Pebble Bed Modular Reactor (PBMR)," SECY-01-0207, United States Nuclear Regulatory Commission, November 20, 2001.

Staff Responses to Public Comments on Draft Regulatory Guide DG-1143, Enclosure 3, United States Nuclear Regulatory Commission.

"Study of Potential Sites for the Deployment of New Nuclear Plants in the United States," United States Department of Energy, Dominion Energy, and Bechtel Power Corporation (Cooperative Agreement No. DE-FC07-02ID14313), September 27, 2002.

"Radiological Environmental Monitoring for Nuclear Power Plants," Regulatory Guide 4.1, United States Nuclear Regulatory Commission, June 2009.

"Reporting Procedure for Mathematical Models Selected to predict Heated Effluent Dispersion in Natural Water Bodies," Regulatory Guide 4.4, United States Nuclear Regulatory Commission, May 1974.

"Measurements of Radionuclides in the Environment Sampling and Analysis of Plutonium in Soil," Regulatory Guide 4.5, United States Nuclear Regulatory Commission, May 1974.

"Measurements of Radionuclides in the Environment Strontium-89 and Strontium-90 Analyses," Regulatory Guide 4.6, United States Nuclear Regulatory Commission, May 1974.



"General Site Suitability Criteria for Nuclear Power Stations," Regulatory Guide 4.7, United States Nuclear Regulatory Commission, April 1998.

"Terrestrial Environmental Studies for Nuclear Power Stations," Regulatory Guide 4.11, United States Nuclear Regulatory Commission, August 1977.

"Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications," Regulatory Guide 4.13, United States Nuclear Regulatory Commission, July 1977.

"Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) Effluent Streams and the Environment," Regulatory Guide 4.15, United States Nuclear Regulatory Commission, July 2007.

"Standard Format and Content of Site Characterization Plans for High-Level-Waste Geologic Repositories," Regulatory Guide 4.17, United States Nuclear Regulatory Commission, March 1987.

"Guidance for Selecting Sites for Near-Surface Disposal of Low-Level Radioactive Waste," Regulatory Guide 4.19, United States Nuclear Regulatory Commission, August 1988.

"Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," Regulatory Guide 4.21, United States Nuclear Regulatory Commission, June 2008.

"Methodology and Criteria for Siting Energy Plants in Idaho," Research Technical Completion Report Project no. A-048-IDA, Idaho Water Resources Research Institute, June 1976.

"Siting New Nuclear Power Station: Availability and Options for Government," Jackson Consulting (UK) Limited, April 26, 2006.

"A Sociological Perspective on the Siting of Hazardous Waste Facilities," CONF-850314—15, D.S. Mileti of Colorado State University and R.G. Williams of Argonne National Laboratory.

"Preparation of Supplemental Environmental Reports for Applications to renew Nuclear Power Plant Operating Licenses," Supplement 1 to Regulatory Guide 4.2, United States Nuclear Regulatory Commission, September 2000.



## ATTACHMENT 1 – RECENT PROJECT WORK PLAN FOR SITE INVESTIGATION IN SUPPORT OF NEW FACILITY CONSTRUCTION

The following work plan is excerpted from a recent project. Note that specific site conditions apply which may not be representative of other projects:

#### Purpose

- assess shallow soil and groundwater conditions to establish a current baseline.
- determine potential impacts (if any) in former waste management areas, and in areas of concern identified in a Phase 1 ESA
- define a groundwater plume associated with an existing facility investigation

#### **Previous Investigations**

A Site Reconnaissance Sampling effort over the entire property was completed.

The assessment findings can be summarized as follows: methylene chloride detected in one sample; bis(2-ethylhexyl)phthalate a common plasticizer detected in soil and groundwater samples; and an odor detected in boring 447 with 950 ppm detected in ambient air combustible gas field screening but no VOCs detected in soil or groundwater samples from the boring.

Subsequently soil and groundwater analytical results data was compared the state regulations.

The assessment findings can be summarized as follows: process and storage tank areas had aniline, benzene, chromium, lead, methylene chloride, and total petroleum hydrocarbon soil concentrations greater than assessment and cleanup levels; and process and storage tank areas had aniline, benzene, chromium, 1,1-dichloroethene, 1,2-dichloroethene, 1,2-dichloropropane, and vinyl chloride groundwater concentrations greater than assessment and cleanup levels.

The Facility Owner collected near surface soil (to 1-foot below ground surface) and concrete surface rinse samples in late July/early August 2007 as required for closure of their state waste permit.

Shaw screened the analytical reports and they indicate arsenic, lead, mercury, methylene chloride, and bis(2ethylhexyl)phthalate soil concentrations greater than state assessment and cleanup levels; and lead rinsate concentrations greater than state assessment and cleanup levels. The state approval of the closure is pending to date. An ongoing Resource Conservation and Recovery Act (RCRA) Facility Investigation is underway north of the site on an adjacent property currently operated others, and a portion of its groundwater plume extends south onto the Site property.

#### Safety

Shaw is committed to conducting field activities in a safe and cost-effective manner. A work plan is developed by Shaw based as well as a site specific Health & Safety Plan (HASP) prior to conducting site work. Owner will provide Shaw a site contact knowledgeable of the site to provide information about current site activities, hazards, required site orientation training, and if necessary or warranted, assist in locating the site's monitoring wells. Owner approved site activities will be coordinated with site operations personnel.



#### Scope of Work

To accomplish the objective of establishing a new baseline, Shaw is proposing to advance 11 shallow soil borings to a depth of approximately 5 feet below ground surface (bgs), and 11 deep soil borings to approximately 30 feet below ground surface or first groundwater-bearing unit, whichever occurs first. Soil samples will be collected from the 11 shallow and the 11 deep soil borings. The 11 deep soil borings will be converted to temporary one-inch diameter groundwater monitor wells to collect groundwater samples. The soil borings will be installed using hand auger and direct-push technology (DPT) drilling methods, and converted into temporary monitor wells by a licensed monitor well driller. Global positioning coordinates (GPS) will be obtained for each boring location. Sampling and analytical will be performed in accordance with state requirements.

The 11 shallow soil borings will be installed to a depth of approximately 5 feet bgs using a hand auger. Soil samples will be collected to assess soil conditions related to former waste management units in these areas. The proposed boring locations are presented in Figure 1.

Eight of the deep soil boring/temporary monitor wells will be installed as close as possible to the former sample locations selected during an earlier sampling event, in an attempt to compare chemical concentrations in soil and groundwater before owner's operations at the site to chemical concentrations in soil and groundwater after owner's operations at the site. The remaining three deep soil boring/temporary monitor wells will be installed to investigate other potential sources of soil and groundwater impact. A Temporary monitor well will be installed near the Complex "A" Maintenance Building to assess soil and groundwater impact from cleaning solvents (if any). A second temporary monitor well will be installed northeast of a Product Storage Tank area to determine the extent of impact from a previous spill documented in the area. A third Temporary monitor well will be installed near and adjacent intersection to further delineate the location of the plume related to the adjacent property. The proposed boring/temporary monitor well locations are presented in Figure 1.

#### Soil Boring and Temporary Monitor Well Installations

All soil borings will be approved by Owner personnel before any intrusive work begins. A hand auger will be used to collect soil samples to a depth of 5 feet in all deep soil boring/temporary monitor well and shallow soil boring locations to avoid damage to subsurface utilities and piping. Dual-tube DPT drilling methods will be used to collect soil samples from 5 feet to the boring termination (approximately 30 feet or first encounter with groundwater) in each temporary monitor well location. Shaw's scientist will visually characterize the soils using the Unified Soil Classification System, and record the observations on a soil boring form. Shaw's scientist will select the proper screen installation depth based on the presence of permeable zones and/or presence of groundwater. The soil samples will also be screened for volatile organic compounds (VOCs) using a photo-ionization detector (PID). One soil sample will be collected from each shallow soil boring, and two soil samples will be collected from each shallow and position above the groundwater saturated zone. In the event that no PID readings above background are observed, a soil sample will be collected in areas of noticeable soil discoloration/odor, or the boring termination. The shallow borings will be plugged by the drilling contractor in accordance with state regulations

The 11 deep soil borings will be converted to temporary monitor wells by installing one-inch diameter schedule 40 PVC slotted screen with 0.01 inch slots across the groundwater-bearing unit and feet of riser pipe from the top of the screen to approximately 2.5 feet above ground surface. It is anticipated that each temporary monitor well will require 5 feet of screen and 27.5 feet of riser pipe. The screen and riser will not be sand-packed or grouted in place; the screen and riser will be installed to prevent the soils from caving into the borehole such that groundwater samples can be collected. Each MW will be gauged using an electronic water level interface probe to detect the



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Attached Report

total depth of the MW and depth to groundwater. A PID will be used to monitor the breathing space between the monitor well and sampling personnel. Each MW will be purged using low-flow groundwater sampling procedures at a rate of approximately 100 to 500 milliliters (mL) per minute using a peristaltic pump equipped with dedicated, disposable tubing with the pump intake placed at the midpoint of the temporary monitor well screened interval. A flow-through cell will be used to monitor purge water quality parameters (e.g., temperature, pH, conductivity, dissolved oxygen, and oxidation reduction potential). A water sample will be collected when monitored water quality parameters are appropriately stabilized (with fluctuations less than 10%). Groundwater samples will be collected in laboratory-supplied containers in accordance with regulatory agency, industry, state, and laboratory protocols, and shipped under a chain of custody protocol to an accredited laboratory for analysis. Standard laboratory turnaround-time (TAT) will be requested. The temporary monitor wells will be plugged by the drilling contractor in accordance with state regulations.

#### Sample Analysis

All soil and groundwater samples will be submitted for analysis of VOCs by EPA Method 8260B; semivolatile organic compounds (SVOCs) by EPA Method 8270B; and 8 RCRA metals by Method 6010/4471/7470. Groundwater samples submitted for analysis of dissolved metals will be submitted in unpreserved sample bottles with instructions to the laboratory to filter and preserve the samples upon arrival to prevent excessive leaching of metals from groundwater samples anticipated to be laden with high total dissolved solids (clay particles). All soil samples will be analyzed for pH using Method 150.1. State QAQC protocols will be followed which requires analysis of appropriate duplicate samples, trip blanks for VOCs, and equipment blanks. A sample matrix is presented in Table 1.

#### Waste Handling

Shaw's drilling contractor will provide DOT-approved waste containers (55-gallon drums) for containment of soil cuttings, investigative-derived waste, and purge/decontamination water. The drums will be placed in an area approved by the Owner for temporary storage pending transportation and disposal at a later date. Shaw will arrange for transportation and disposal of the waste from this proposal, estimated to be four drums of soil and two drums of liquid.

#### Reporting

Shaw will prepare and submit a summary report documenting field activities and presenting an evaluation of the field and analytical data. Tables and figures summarizing the gauging and analytical results will be included, along with a site map showing the sample locations. Boring logs for all penetrations will be included in the report, along with waste manifests, and temporary monitor well completion and plugging reports completed by the drilling contractor and filed with the state.

#### Cost

The budget for this effort is in the \$50k-\$100k range.



## ATTACHMENT 2 – EXCERPTS FROM RECENT SITE ASSESSMENT PLAN FOR ADDITION OF A CHEMICAL PROCESS UNIT

The following excerpts are adapted from a recent plan to provide an assessment for front end engineering design (FEED) proposal for XYZ Chemical's proposed process unit located on a Texas site. Note that the site conditions represent a specific case which may not be applicable to other similar projects.

#### ENVIRONMENTAL ASSESSMENTS, PERMITTING AND GEOTECHNICAL INVESTIGATION

#### Safety

Shaw E&I is committed to conducting Site activities in a safe and cost-effective manner. The project will be managed by Shaw E&I's Houston office. A work plan will be developed by Shaw E&I based on this proposal, and Shaw E&I will develop a site-specific Health and Safety Plan (HASP) prior to conducting Site work. XYZ Chemical will provide Shaw E&I a site contact knowledgeable of the Site to provide information about current site activities, hazards, required site orientation training, and site access information. Approved site activities will be coordinated with XYZ Chemical personnel.

#### Soil and Groundwater Base Line Environmental Assessment

The objective of the base line assessment is to provide a professional opinion regarding pre-existing environmental impacts to soil and groundwater that may be associated with previous activities at the Site prior to construction of the proposed Unit. It is assumed that the Site property is not owned by XYZ Chemical, and that XYZ Chemical will obtain or facilitate access to the Site for Shaw E&I personnel. The base line assessment will consist of a modified and limited Phase I and a Phase II Environmental Site Assessment (ESA). The Site is approximately 520 feet by 920 feet or 11 acres, located adjacent to the north side of First Street, with Plant roads adjacent to the Site's northern and western boundaries. Currently, the Site is being used as a contractor's parking lot and appears to have been graded and covered with gravel or shell material. Historically, the Site appears to have been part of a tank farm, and readily available aerial photographs indicate one aboveground storage tank was located in the center of the western half of the Site. At this time, it is not known what products may have been stored in the tank. Also, other uses or activities that may have occurred on the Site are not known at this time.

The modified and limited Phase I ESA will assess past and present activities at the Site to determine if recognized environmental conditions may exist. The modified and limited Phase II ESA will assess current concentrations of chemicals of concern in the soil and groundwater. As part of the Phase II ESA report, Shaw E&I will evaluate the Site's analytical data to assess risk and recommend mitigation strategies. Shaw E&I will also generate an environmental remediation liability cost estimate for the Site. The Phase I and Phase II ESAs may be compiled into one report or delivered as separate reports. Any findings of soil or groundwater impacts that exceed reportable concentrations must be reported to the Site property owner.

#### Phase I ESA

The modified and limited Phase I ESA will assess past and present activities at the Site to determine if recognized environmental conditions exist. The assessment will be limited to:

• Acquisition and evaluation of Environmental Data Resources, Inc. (EDR) or equivalent search report documents, ASTM search radius findings, historical aerial photographs, historical topographic maps, city directories, and Sanborn maps based on a street address or global position satellite (GPS) coordinates.



- Telephone or in-person interviews with select personnel identified by XYZ Chemical as being knowledgeable of current and historical activities, known or possible soil and groundwater impacts, and prior assessments or remediation performed at the Site and/or adjoining properties.
- Site walk with knowledgeable Site personnel to visually observe Site conditions with respect to surface impacts, stored equipment, utilities, and structures. A property line visual observation of adjoining properties will also be performed for evidence of potential environmental conditions that may affect the subject property.
- Review of readily available information about the general geology, soil, and groundwater conditions of the Site and its surrounding area.

#### Reporting

The modified and limited Phase I ESA report will include a description of all activities performed by Shaw E&I including the results of data assessment and evaluation including report limitations. Supporting documentation such as photographs, search reports, maps, and documents provided by the Site property owner required to document the findings will be made part of the report. The Phase I ESA report may be combined with the Phase II ESA report.

#### Phase II ESA

Shaw E&I is proposing to advance 9 soil borings: 3 to a depth of 10 feet below ground surface (bgs) to assess soil impact around the former storage tank, and 6 to assess soil and groundwater impact across the Site. These six soil and groundwater assessment borings will be advanced to a depth of 25 feet bgs, five feet into the first observed groundwater-bearing unit (GWBU), or refusal, whichever occurs first. The soil borings will be installed using hand auger and direct-push technology (DPT or GeoProbe®) drilling methods. Soil samples will be collected from each boring and an attempt will be made to collect water samples from observed GWBUs. The proposed boring locations are presented in the figure below.



The Phase II soil and water sample collection efforts will be focused on the interval from the surface to the first apparent GWBU. Water samples will be collected from temporary monitor wells as is customary for phase II ESA groundwater screening assessments. Soil sampling and soil and water sample analyses will be performed in accordance with the Texas Risk Reduction Program (TRRP) 30 TAC 350 and regulatory agency guidance documents. Standard laboratory turnaround time (TAT) of 10 to 14 days will be requested. Global positioning coordinates (GPS) will be obtained for each boring location sampled. All borings and temporary monitor wells will be plugged by the drilling contractor in accordance with Texas Department of Licensing and Regulations (TDLR) regulations.



#### **Clearing Boring Locations**

Shaw E&I anticipates that staking and clearing utilities at potential boring locations will be coordinated with an XYZ Chemical escort knowledgeable of the Site. XYZ Chemical will obtain or assist Shaw E&I in obtaining Site access for the subsurface investigation and approval of proposed boring locations from the Site property owner. Texas One-Call will be notified to mark utilities prior to field deployment. Shaw E&I personnel will stake proposed boring locations and seek immediate concurrence from XYZ Chemical or Site property owner escort personnel based on their site knowledge and available as-built site maps. Shaw E&I personnel will use a metal detector and an electrical current locater to clear a 5-foot radius around each staked boring location. Each boring location will be hand cleared by probing and hand auger to 5 feet bgs immediately prior to advancing the boring with a drilling unit.

#### Soil Borings and Temporary Monitor Well Installations

All soil borings will be advanced by hand auger to a depth of 5 feet bgs and then advanced using DPT to proposed depth (3 to 10 feet and 6 to 25 feet), 5 feet into the first observed GWBU, or refusal, whichever occurs first. A Shaw E&I scientist will visually characterize the soil core using the Unified Soil Classification System, and record their observations on a soil boring form. The soil cores will also be screened for volatile organic compounds (VOCs) using a photo-ionization detector (PID). If a suspected GWBU is encountered in the proposed six deeper borings, a temporary monitor well will be installed. The Driller will install a 1-inch diameter Schedule 40 PVC 0.01-inch slotted screen from the total depth of the boring to 3 feet above the observed top of the GWBU, and 1-inch diameter Schedule 40 PVC riser from the top of the screen to approximately 2 feet above ground surface. No sand-packing, grouting, or surface completion will be performed. The Driller will plug each boring and temporary groundwater monitor well in accordance with TDLR regulations immediately after Shaw E&I collects samples. The Driller will decontaminate drilling and sampling equipment between borings to minimize the probability of cross-contamination.

#### Sample Collection and Analysis

Soil and water samples will be collected and analyzed using industry standards and protocols that are in accordance with TRRP regulations and guidance documents. At least two soil samples will be collected from each boring for laboratory analysis. Soil samples will be collected based upon the highest PID readings observed above background and positioned above the groundwater saturated zone, or in areas of noticeable soil discoloration/odor. In the event that no PID readings above background or areas of noticeable soil discoloration/odor are observed, the soil samples will be collected from the 5-foot bgs interval and from the soil groundwater interface interval, or from total depth of the boring if no groundwater interval is observed. Prior to collecting a water sample, an interface probe capable of detecting phase separated hydrocarbons (PSH) and water level within 0.01-foot will be used to determine if PSH is present and the depth to groundwater. A water sample will not be collected if PSH is greater than or equal to 0.01-foot. Interface probe and sample data will be documented on the boring log. A water sample will be collected using a disposable bailer or peristaltic pump and dedicated tubing.

Samples will be collected in laboratory-supplied containers in accordance with regulatory agency, industry, TRRP, and laboratory protocols, and shipped under a chain of custody protocol to an accredited laboratory for analysis. Standard laboratory turnaround time (TAT) of 10 to 14 days will be requested on all samples except for TPH analysis. A five-day laboratory TAT analysis of TPH samples will be requested to allow for sufficient sample hold time should additional analysis be required for TPH samples. Texas TRRP quality assurance/quality control (QA/QC) protocols will be followed, which requires analysis of appropriate duplicate samples, trip blanks for VOCs, field blanks, and equipment blanks.



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#### Brownfield Nuclear Power Plant Siting

Attached Report

Soil and groundwater samples will be submitted for analysis of total petroleum hydrocarbons (TPH) by Method TX 1005; VOCs by EPA Method 8260B; semivolatile organic compounds (SVOCs) by EPA Method 8270B; and 8 RCRA metals by Method 6010/4471/7470. If it is determined from the Phase I that only crude or fuel oils were stored at the Site, then benzene, toluene, ethyl benzene, total xylenes (BTEX), and methyl tertiary butyl ether (MTBE) by Method 8260 will replace VOC and SVOC analyses. Soil samples will also be analyzed for pH using Method 150.1. The analytical data will be compared to TRRP Tier 1 Assessment Levels. If soil or water sample TPH concentration is greater than the TRRP Tier 1 Assessment Levels, then the soil or water sample with the highest detected TPH concentration will be analyzed for TPH by Method TX 1006 and polycyclic aromatic hydrocarbons (PAH) by Method 8270. If a soil 8 RCRA metals concentration is greater than its TRRP Tier 1 Assessment Levels, then a synthetic precipitation leaching procedure (SPLP) analysis will be performed on that sample for that particular metal(s).

#### **Investigation Derived Wastes**

Shaw E&I's drilling contractor will provide DOT-approved 55-gallon drums for containment of soil cuttings, investigative-derived waste, and purge/decontamination water. The drums will be labeled with an unclassified label and placed at the Site at a location designated by XYZ Chemical or Site property owner personnel pending disposal determination. Shaw E&I personnel will collect an investigation derived waste (IDW) composite sample from each drum and have chemical analysis performed for waste characterization, and provide disposal recommendations based on the waste characterization. Disposal options may range from spreading the IDW on site to transport and disposal at a permitted landfill. These IDW and IDW drums will be the property of the Site property owner.

#### Report

Shaw E&I will generate a report that will contain supporting analytical documentation, photographs, boring logs, and site diagrams as deemed necessary to convey their findings and observations. GPS coordinates collected from boring locations may be used to post boring locations, monitor locations, or analytical results on aerial photographs. Field and analytical data may be stored in a database, and graphical information system (GIS) technology may be used to generate maps and tables. As part of the Phase II ESA report, Shaw E&I will evaluate the Site's analytical data in accordance with TRRP to assess risk and recommend mitigation strategies. Shaw E&I will also generate an environmental remediation liability cost estimate for the Site. The Phase II report may be delivered as separate report, or combined with the Phase I report. Any findings of soil or groundwater impact concentrations that exceed reportable concentrations must be reported to the Site property owner.

#### **GEOTECHNICAL ASSESSMENT**

Shaw E&I will conduct a geotechnical assessment to obtain information on the physical properties of the Site subsurface soil. This proposal is based on a total of 11 borings being advanced to three different depths: 3 borings to 75 feet bgs; 3 borings to 50 feet bgs; and 5 borings to 25 feet bgs. It is anticipated that boring depths greater than 25 feet bgs will likely encounter flowing sands that would require a mud rotary drilling methods to stabilize and advance the boring. Shaw E&I anticipates using a mud rotary drilling unit and Standard Penetration Test (SPT) in accordance with ASTM and Industry standards to advance the borings and collect soil cores for geotechnical analysis. It is anticipated that soil cores will be continuously collected the first 10 feet and then every five feet from 10 to 20 feet by SPT advancing Shelby tubes, and then every five feet from 20 feet to total boring depth by SPT advancing a split-spoon sampler.

#### **Clearing Boring Locations**



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#### Brownfield Nuclear Power Plant Siting

Attached Report

Shaw E&I anticipates that staking and clearing utilities at potential boring locations will be coordinated with an XYZ Chemical escort knowledgeable of the Site. XYZ Chemical will obtain or assist Shaw E&I in obtaining Site access for a subsurface investigation and approval of proposed boring locations from the Site property owner. Texas One-Call will be notified to mark utilities prior to field deployment. Shaw E&I personnel will stake proposed boring locations and seek immediate concurrence from XYZ Chemical or Site property owner escort personnel based on their site knowledge and available as-built site maps. Shaw E&I personnel will use a metal detector and an electrical current locater to clear a 5-foot radius around each staked boring location. Each boring location will be hand cleared by probing and hand auger, or utilization of an air knife, to 5 feet below ground surface (bgs) immediately prior to advancing the boring with a drilling unit.

#### Soil Borings

All soil boring will be advanced by hand auger or air knife to a depth of 5 bgs and then advanced using SPT and mud rotary drilling. Eleven borings are proposed: 3 to 75 feet; 3 to 50 feet; and 5 to 25 feet), or refusal, whichever occurs first. The Shelby tube or split spoon sampler will be advanced using a 140 pound hammer falling 30 inches or similar ASTM or Industry geotechnical method approved by Shaw E&I and XYZ Chemical to collect soil cores from Shelby tubes and split-spoon samplers for sampling and analysis, and the drill string advanced by mud rotary drilling when not sampling. It is anticipated that borings deeper than 25 feet bgs may encounter flowing sands that will require mud rotary drilling to stabilize and advance the boring. Mud rotary has been used in drilling costs estimates for all of the proposed geotechnical borings. The Driller will plug each boring in accordance with TDLR regulations.

#### Sample Collection and Analysis

Soil cores for geotechnical analysis and sampling will be collected using SPT to advance Shelby tubes and splitspoon samplers. A Shaw E&I scientist will visually characterize the soil core and record their observations along with SPT blow counts and pocket penetrometer measurements. Shelby tube soil cores will be continuously collected the first 10 feet and every five feet from 10 to 20, then split-spoon soil cores will be collected every five feet from 20 feet to total boring depth.

It is estimated that one sample every ten feet will be sent to a laboratory for analysis. The number of samples per boring analyzed may vary based on the lithology variations observed in the soil core. Geotechnical laboratory analysis is anticipated to be grain-size analysis, Atterberg limits, engineering USCS classification, water content, shear and compression tests. All laboratory testing will be performed in accordance with ASTM and Industry standards.

#### Investigation Derived Wastes (IDW)

Shaw E&I's drilling contractor will plug the borings from the bottom up by pumping grout through a tremie pipe in accordance with TDLR regulations. The Driller will attempt to use native soil clays without adding bentonite to formulate the mud rotary drilling mud. Based on current site knowledge, this estimate anticipates that some drill cuttings and drilling mud will be spread out and disposed of onsite. If the base line assessment identifies significant soil and groundwater impacts, all geotechnical drill cutting and drilling mud may be containerized and disposed of at an approved permitted landfill.

#### Report

Shaw E&I will generate a report that will contain supporting analytical documentation, photographs, boring logs, and site diagrams as deemed necessary to convey their findings and observations. GPS coordinates collected from



boring locations may be used to post boring locations or analytical results on aerial photographs. Field and analytical data may be stored in a database, and GIS technology may be used to generate maps and tables.

#### Schedule

It is anticipated that it will take 8 weeks to perform the work and deliver the reports discussed above. Standard analytical turnaround time of 10 days was used for this proposal. Some analytical results may take longer and some analytical turnaround time may be accelerated by paying a surcharge. Tasks will be performed concurrently. A projected schedule is provided below.

Week	Phase I		Phase II	Environmental Permits	Geotechnical
	Acquire	data,		-	
	Interviews				
1	Site walk			Draft permit	
2	Draft report		Collect samples	Draft permit	
3	Deliver report		Analytical	Draft permit	Collect samples
4			Analytical	Draft permit	Analytical
5			Draft report	Draft permit	Analytical
6			Finalize report	Finalize permit	Draft report
7				Submit permit	Draft report
8					Finalize report

#### BUDGET

The approximate work to perform the work described is in the range of 100k - 150k.



### ATTACHMENT 3 – H-3 AND NORM SAMPLING DURING PRE-OPERATIONAL ENVIRONMENTAL MONITORING

Approaches to determine pre-existing radiation levels are likely to be needed before the Sponsor takes over the site and assumes responsibility for future contamination. The following summary identifies a possible approach for addressing this during Pre-Operational Environmental Monitoring.

Based on prior uses and history of the site, the Sponsor and Site Owner are likely to consider the need to include a survey of site background radiation during the project's pre-operational environmental monitoring phase. The sampling program would be designed to establish background values so that any increase above background values would be attributable to reactor operation.

Tritium sampling of groundwater establishes background levels of naturally-occurring tritium in groundwater during pre-operational environmental monitoring. This background assessment will be needed to determine whether groundwater tritium detected during plant operation is of plant origin. Samples are obtained by drilling wells at several locations to depths representing the normal groundwater table and to the depths of water that could be used for drinking. There are several references available for establishing groundwater monitoring wells. The drilling of such wells would have to be carefully reviewed with the Site Owner to ensure that pockets of existing contamination are not unnecessarily disturbed.

As part of pre-operational sampling, surface soil samples should be collected from representative locations across the site and analyzed for NORM and TENORM radionuclides. These sample results will establish background levels of NORM and TENORM to use as a comparison to operational samples. Standard soil sample procedures are found in EPA and ASTM references.

Note that there is currently a NEI/EPRI initiative for operational groundwater monitoring at nuclear plants, which suggests that all new nuclear plants are likely to undertake groundwater monitoring. This could be mandated by NRC in the future.

#### Budget

The budget for such work could be on the order of \$100k, which could vary depending on the number of sampling points and whether sensitive drilling conditions exist. Cost of NORM sampling is a few thousand dollars (maybe \$300/sample) and H-3 sampling would be the cost of maybe 4-6 wells across the site plus water analysis of \$500/sample for 4 quarterly samples per well. Total costs for baseline sampling may run ~ \$100,000 depending on the cost of the wells.

