RADIOLOGICAL WORK PLAN
JULY 2016

Prepared for:

Client Redacted

(Project specific requirements redacted on pages that follow)

Prepared by:

PHILOTECHNICS, LTD
201 RENOVARE BLVD.
OAK RIDGE, TN 37830
www.philotechnics.com

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1 INTRODUCTION

[redacted] (Client) has requested Philotechnics to perform a number [redacted] the decontamination of equipment, facilities and land shall be performed only be persons specifically licensed by the agency, NRC or another agreement state. Client has requested that Philotechnics provide the necessary radiological program requirements to demonstrate compliance for the performance of the work. The following 'Work Plan' describes the technical performance standards that will be maintained to accommodate the work and ensure radiological safety compliance during the performance. Philotechnics is specifically licensed to perform the decontamination and unconditional release surveillance of equipment and understands the requirements necessary to be met.

This Radiological Work Plan (Plan) was developed to meet the requirements of [redacted]; and all applicable local, state and federal guidelines and regulations to ensure compliance, and maintain worker and public exposure and safety As Low As Reasonably Achievable (ALARA). This Plan provides the approach, methods and techniques for the radiological decontamination and release of the pigs. The Radiation Program requirements have been cross-walked to ensure that the designs meet unconditional release surveys to implement the protocols of Philotechnics' Radiation Protection Plan (RPP) and procedures to demonstrate compliance with the [redacted] release for unrestricted use. These methods ensure technically defensible data of sufficient quality and quantity is acquired to verify compliance and aid in determining whether or not the pigs meet the release criteria for unrestricted use specified in regulation [redacted], "Release for Unrestricted Use" detailed in **Table 4-1 – Acceptable Surface Contamination Levels for TENORM** below. Historical utilization of the pigs reveals they were used to scrape, clean and inspect pipe internals resulting in a build-up of scale consisting of Technically Enhanced Naturally Occurring Radioactive Materials (TENORM), most notable ^{226}Ra and ^{228}Ra.

Client has procured Philotechnics, Ltd. (Philotechnics), a full-scope radiological and waste management service to provide health physics (HP) services related to the radiological decontamination and oversight for [redacted]. Upon release, the pigs will be returned to Client for later use. All codes, standards, laws and regulations as applicable shall establish the minimum requirements for project work.

Philotechnics is an industry leader in radiological and waste management service and is specifically licensed, with mobile radioactive materials licenses in California, Massachusetts and Tennessee.

Since 1981, Philotechnics has performed hundreds of field projects, providing trained and experienced personnel to perform required activities at various commercial, government and academia facilities. Radiological activities will be conducted under the provisions of Philotechnics State of Tennessee Radioactive Materials License Number R-01084-C23 (TN-RML) under reciprocal agreement with [redacted], and in accordance with the approved Plan.

2 ASSESSMENT, DESCRIPTION AND OPERATION

[redacted]

3 RADIONUCLIDES OF CONCERN

Radionuclides of Concern (RoC) include mineral impurities, ^{228}Ra and ^{226}Ra. The relative abundance of each is not known; therefore, Philotechnics will assume 50% of the activity is from the U/^{226}Ra chain and the rest is from the Th/^{228}Ra chain. Both radium isotopes are assumed to exist in equilibrium with their respective decay products.

Uranium series consists of eight (8) radioactive isotopes**:** ^{226}Ra, ^{222}Rn, ^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po, ^{210}Bi and ^{210}Po. ^{210}Pb, the final product, is stable.

Thorium series consists of nine radioactive isotopes**:** ^{228}Ra, ^{228}Ac, ^{228}Th, ^{224}Ra, ^{220}Rn, ^{216}Po, ^{212}Pb, ^{212}Bi and [^{210}Po/^{208}Bi]. ^{208}Pb, the final product, is stable. (^{210}Po and ^{208}Tl are due to branching in the decay of ^{212}Bi.)

4 RELEASE CRITERIA

The [redacted] has published release criteria for the RoC associated with mineral impurities (NORM and TENORM) in the petroleum industry in Table 6 of [redacted] presented in **Table 4-1 – Acceptable Surface Contamination Levels for TENORM** below:

TABLE 4-1 – ACCEPTABLE SURFACE CONTAMINATION LEVELS FOR TENORM

	Average [2,3,6]	Maximum [2,4,6]	Removable [2,3,5,6]
Alpha	5,000 dpm/100 cm^2	15,000 dpm/100 cm^2	1,000 dpm/100 cm^2
Beta-gamma	5,000 dpm/100 cm^2	15,000 dpm/100 cm^2	1,000 dpm/100 cm^2

[1]Where surface contamination by both alpha and beta-gamma emitting nuclides exists, the limits established for alpha and beta-gamma emitting nuclides should apply independently.
[2]As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
[3]Measurements of average contamination level should not be averaged over more than one square meter. For objects of less surface area, the average should be derived for each object.
[4]The maximum contamination level applies to an area of not more than 100 cm^2.
[5]The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area A (where A is less than 100 sq. cm) is determined, the entire surface should be wiped and the contamination level multiplied by 100/A to convert a "per 100 sq. cm" basis.
[6]The average and minimum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr (2μGy/hr) at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

1. Not transfer or release for unrestricted use equipment contaminated with TENORM in excess of a surface gamma radiation level of 200 μRem/hr at 1 cm excluding natural background; and

2. Not transfer land for unrestricted use where the concentration of radium-226 or radium-228 in soil averaged over any 100 m^2 exceeds the background level by more than 185 Bq/kg (5 pCi/gm), averaged over any 15 cm layer of soil below the surface, unless compliance [redacted] can be demonstrated.

5 ALARA ANALYSIS

Due to the extremely low doses associated with residual radioactivity on the pigs, a quantitative ALARA analysis is not expected to be required. A reasonable effort shall be made to decontaminate any detectable contamination in support of the ALARA principle.

6 SURVEY INSTRUMENTATION

6.1 Instrument Calibration

Laboratory and portable field instruments are calibrated at least annually with National Institute of Standards and Technology (NIST) traceable sources, where feasible, and to radiation emission types and energies that will provide detection capabilities and sensitivities required for the RoC. Records of instrument calibration shall be included with the final reports.

6.2 Functional Checks

Functional checks will be performed at least daily when in use. The background, source check and field measurement count times for radiation detection instrumentation will be specified by procedure to ensure measurements are statistically valid. Reference background readings will be taken in an adjoining non impacted area as part of the daily instrument check and compared with the acceptance range for instrument and site conditions. If an instrument fails a functional check, all data obtained with the instrument since the last satisfactory check will be evaluated for usability by the project manager (PM) or the PM's designee, and unusable data discarded.

6.3 Determination of Counting Times and Minimum Detectable Concentrations

Minimum counting times for background determinations and measurement of total and removable contamination will be chosen to provide a Minimum Detectable Concentration (MDC) that meets the criteria specified in this Plan. To account for variabilities in surface geometry and background count rates, Philotechnics has determined scan speeds and average MDC for a variety of hand-held detectors in HPO-105, Contamination Surveys.

Pig scoping survey protocol will consist of removable contamination measurements of internal and external surfaces. 100% of accessible surfaces will be surveyed. These pigging units are designed in a manner that allows disassembly to occur for replacement of wear parts. Where direct measurements cannot be made, Philotechnics will attempt to determine the likelihood that inaccessible surfaces may be contaminated, including disassembly where appropriate and feasible. Philotechnics will use convenient locations to obtain measurements where there is the highest probability of residual radioactivity, and ensure removable contamination measurements are acquired in inaccessible areas due to geometry, at a minimum. In the event contamination of inaccessible surfaces is likely and adequate

measurements cannot be made, the item will be disassembled and direct surveillance will be performed.

6.4 Decontamination/Dismantlement and Remedial Action Surveys

6.4.1 Decontamination/Dismantlement

Decontamination is the physical or chemical process of reducing and preventing the spread or potential exposure from contamination. Decontamination options include the use of commercially available materials and/or equipment that will effectively remove radioactive materials from surface areas so the contamination can be collected and properly disposed. Decontamination will include the use mild detergents and wet-wiping, or Hotsy sprayers, brushes, mild detergents and wet-wiping, if necessary.

6.4.2 Air Sampling

The customer has indicated the average contamination reading on the pigs prior to decontamination is ~ 1,000 counts per minute (cpm) on a pancake probe. Assuming 10% efficiency, this is about 50,000 dpm/100 cm^2. Average surface area of a pig is assumed to be 5 m^2. Therefore, the total activity on a pig is 5,000,000 dpm, or 2.25 µCi. Because each chain is in equilibrium, the activity of the chain is assumed to be divided evenly among the parent and each daughter. The tables below show the activity of each isotope in each chain and its inhalation annual limit of intake (ALI) from 10 CFR 20 Appendix B. Where more than one inhalation ALI is presented, the most restrictive is assumed. Fraction of ALI for each isotope is shown as F_{ALI}.

Table 6-1 – Annual Limit of Intake and Fraction of Annual Limit of Intake per RoC

Uranium Chain, 1.125 µCi				Thorium Chain, 1.125 µCi			
Isotope	µCi	ALI µCi	F_{ALI}	Isotope	µCi	ALI µCi	F_{ALI}
Ra-226	0.141	0.6	0.235	Ra-228	0.125	1.0	0.125
Rn-222 + daughters	0.984	10	0.0984	Ac-228	0.125	9.0	0.0139
				Th-228	0.125	0.01	12.5
				Ra-224	0.125	2.0	0.0625
				Rn-220 + daughters	0.625	20	0.0313

Note: Total Fraction of ALI present on one pig: 13.1

6.4.2.1 U.S. NRC Regulatory Guide 8.25

Air Sampling in the Workplace, recommends air sampling if the total amount of unencapsulated (loose) material to be processed in a calendar year exceeds 10^4 times the annual limit of intake (ALI).

6.4.2.2 U.S. NRC Document NUREG 1400

Air Sampling in the Workplace, provides guidance for estimating the potential intake from certain activities.
$I_p = Q \times 10^{-6} \times R \times C \times D$, where:

I_p	=	*Potential intake of radioactive material in ALI*
Q	=	*Total quantity of unencapsulated material to be processed in a year for a given work location.*
10^{-6}	=	*Brodsky's number*
R	=	*Release Fraction (assigned value = 0.01)*
C	=	*Confinement Factor (assigned value = 01)*
D	=	*Dispersibility (assigned value = 10)*

For a single pig, the value of Q can be expressed in terms of total ALI Fraction. Therefore,

$$I_p = 13.1 \times 10^{-6} \times 0.01 \times 1 \times 10 = 1.31 \times 10^{-6}\ ALI$$

NRC regulations require internal monitoring for any individual likely to receive an intake in excess of 0.1 times the ALI in a calendar year. Obviously if Philotechnics is decontaminating a few pigs, internal monitoring would not be required. The only accurate method of assessing intake of radon and its progeny is through the use of sophisticated and expensive air sampling equipment that is designed solely for radon measurement.

Conclusion:
Air sampling and bioassay are not required for decontaminating less than 100 pigs in a calendar year. Should Philotechnics obtain sufficient work such that we expect to decontaminate pigs and similar equipment on a frequent basis, we will invest in radon detection equipment.

6.4.3 Remedial Action Surveys

Remedial action surveys consist of scan surveys and/or large area wipes. These are conducted following remediation activities to establish the success or failure of the efforts to decontaminate the applicable area. Results of the survey are the decision basis for continued remediation. Remedial action surveys were designed to meet the objectives of the release surveys.

7 PHILOTECHNICS MANAGEMENT ORGANIZATION

The following management structure will be used for administration and implementation of this Plan.

PHILOTECHNICS MANAGEMENT ORGANIZATION FOR PROJECT Name, Corporate Position, Qualifications and Relevant Experience
[redacted]
[redacted]
[redacted]

Philotechnics' team of knowledgeable and experienced personnel selected for their relevant skills and proven success throughout the country and across multiple industries will ensure direct accountability for all phases of project activities.

8 PROJECT PERSONNEL

All work activities will be performed in accordance with Philotechnics' TN-RML, this Plan, and associated standard operating procedures. For on-site performance, Philotechnics will:

- Assign a highly qualified team of industry leading professionals, comprised of Philotechnics':
  - On-Site PM Team - VP – Rad Services, and VP-Radiological Engineering
  - Off-Site - Corporate Radiation Safety Officer (RSO), (summarized below), to ensure the radiological safety of all personnel, the environment, and meet the needs of both [redacted];
- Apply a life cycle approach, with the end goals designed in on the fore-front for hazards removal and mitigation, and release for unrestricted use;
- Use proven management practices to develop safety and quality into all work; and
- Utilize effective communications to coordinate all activities with [redacted].

8.1 Project Management Team

The Project Management Team will provide technical support of all aspects of the project and will be the point of contact with the client representative and Philotechnics management. The PM team's principal goal is to accomplish the requested work and oversight in a safe and compliant manner.

The following will ensure safety and quality performance on the project:

- Daily project coordination and direction
- Meeting client and Philotechnics requirements
- Providing effective leadership in direction, coordination, planning and control of activities to maintain regulatory compliance, safety, through continuous communications with project team members and the client and ensuring compliance with proper radiological hygiene practices and controls are maintained throughout the project performance.

8.2 Certified Health Physicist

A Certified Health Physicist (CHP) based out of our Oak Ridge office will be available to support the project planning and execution. The CHP will provide corporate-level oversight and support for this project. The CHP will ensure that work control documents and procedures are consistent with regulatory requirements; review project plans and reports for technical accuracy and completeness; advise project personnel in matters of instrument selection, ALARA considerations, waste characterization, and performance of surveys; and provide technical oversight for the entire radiation protection program.

8.3 Health Physics Technicians

HPTs will be responsible, under the direction of the Project Management Team for performing radiation surveys, decontamination and airborne radioactivity surveys. HPTs will meet the requirements of Philotechnics' Procedure HPO-005 – *Radiological Training Requirements*.

9 PROJECT TRAINING REQUIREMENTS

Client will provide personnel with site specific Contractor Orientation Training, if necessary.

9.1 Radiological Training

Basic Radiation Worker training will be completed and documented. The PM will maintain a copy of each individual's certification on site in the project file.

9.2 Project Specific Training

Prior to project start-up, personnel will attend an initial project-specific training session conducted by the PM. The training session will include the following items:

- Review of the Plan
- Project security control and operational work zones
- Emergency response and site evacuation procedures
- Project communications
- General safe work practices
- Data quality and chain of custody procedures, and
- Review of applicable regulatory standards as applied to project operations

9.3 General Safety Briefings

General safety meetings will be held at the beginning of each work shift, if the project encompasses more than a single work shift. The purpose of this meeting will be to discuss project status, potential problem areas, general safety concerns and to reiterate Plan requirements.

9.4 Visitor Orientation

All non-essential personnel and visitors will be briefed on the Plan requirements. Visitors will be escorted at all times and receive visitor training. Visitor training shall be administered to all personnel, contractors, and visitors requiring access to restricted areas. The scope of orientation shall be commensurate with the activities being performed and the risks involved. The orientation shall consist of the following:

- Project-specific health and safety orientation
- The location of restricted areas and escort requirements
- Posting and labeling identification of radiological areas and packages
- Requirement for PPE and dosimetry
- Escort requirements
- Review of Regulatory Guide 8.13 "Instructions Concerning Prenatal Radiation Exposure," Appendix B (required for female contractors or visitors)

Visitor training shall be valid only for the particular project at which it is administered. Escorts shall have a minimum of Basic Radiation Worker training.

9.5 Transportation Training

Persons who prepare hazardous materials for transportation or are otherwise responsible for safely transporting hazardous material will be trained in accordance with the requirements of 49 CFR 172, subpart H.

10 RADIATION SAFETY AND HEALTH AND SAFETY PLAN

A site-specific Radiation Protection Plan (RPP) and site-specific Health and Safety Project Plan (ssHASP) will be prepared for all on-site activities.

11 ENVIRONMENTAL MONITORING AND CONTROL

Some project activities may be performed outdoors. Baseline "As-Found" gamma scan surveys of the work area, to include an area extending 5' past the established controlled area boundary, will be performed using 2" x 2" Sodium Iodide (NaI) gamma scintillator prior to establishing the Radiologically Controlled Area (RCA) boundary and commencing decontamination. The process "As Left" surveillance will be repeated after the completion of all decontamination activities and prior to securing and removing controls from the RCA. The expectation is that no residual soil contamination above the "As Found" conditions will remain at the sites. If elevated activity is identified during the initial "As Found" Baseline gamma scan the conditions will be documented and reported. "Elevated activity" means activity that is 2 times the as-found baseline level.

12 RADIOACTIVE WASTE MANAGEMENT PLAN

Waste water, rags, plastic, and other Dry Active Waste (DAW) materials will be collected into drums or other suitable containers and transported to Philotechnics' Oak Ridge facility as radioactive waste.

13 TECHNICAL SCOPE AND PLANNED PROJECT ACTIVITIES

Decontamination and release activities will be conducted in compliance with Philotechnics' TN-RML. Philotechnics' approach for this project will be to provide the qualified staff, on-site and off-site labor, materials, equipment and analytical services in accordance with industry standard practices, recommendations and guidance discussed in Section 1 – Introduction above.

The project will be conducted according to the following work breakdown structure:

- **Pre-mobilization** – prepare decommissioning plan, finalize procedures, develop survey packages and procure equipment and supplies.
- **Mobilization** – mobilize personnel and equipment to the site.
- **Characterization Survey** – perform "As Found" surveillance.

- **Decontamination** – perform necessary decontamination.
- **Remedial Action Surveys** - monitor the effectiveness of decontamination efforts and ensure that surrounding areas are not cross-contaminated from remediation actions.
- **Release Surveys** – perform release surveys.
- **Demobilization** – ship equipment and supplies, demobilize personnel.

The following sections detail the approach to performing safe and efficient decontamination activities at the facility.

13.1 Radiological Characterization

Characterization surveys will be conducted to establish the levels and extent of residual contamination post pigging events. This information will aid in determining final decontamination methods and disposal options. Characterization surveys will consist of scan surveys with static measurements and removable contamination measurements (smears) of all accessible areas.

The purpose of scanning is to identify locations of elevated activity. Where elevated activity is identified, a smear will be taken at the location of highest activity identified during the scan. The boundaries of the elevated areas will be marked to aid in locating the area for remedial actions.

Characterization surveys will be conducted under the same quality assurance criteria and to meet the release surveys such that characterization data may be used as release survey data to the maximum extent possible. In addition, these surveys will assist technicians in the approach and extent necessary to decontaminate the "pig" units.

Prior to performing any decontamination, a characterization survey will be completed to document the current radiological status of the pig. Surveys will be completed in accordance with Philotechnics procedure HPO-105 – *Contamination Surveys*.

13.2 Survey Documentation

A survey package will be developed for each survey unit containing the following:

- Survey Instruction Sheets
- General survey requirements
- Instrument requirements with associated MDCs, count times and scan rates
- Survey Maps
- Overview maps detailing survey locations and placement methodology
- Survey Data Sheets
- Signature of Data Collector and Reviewer

13.3 Data Validation

Field data will be reviewed and validated to ensure:

- Completeness of forms and the type of survey has correctly been assigned to the survey unit.
- The MDCs for measurements meet the established data quality objectives; independent calculations will be performed for a representative sample of data sheets and survey areas.
- Instrument calibrations and daily functional checks have been performed accurately and at the required frequency.

14 REFERENCES

The following sections list the references, regulations and technical guidance documents that will be used throughout this decommissioning project.

14.1 General References

Philotechnics RML # (R-01084-C23) which allows D&D work at temporary jobsites.

Philotechnics Procedures

HP-IN-01 Rev. 1 "Portable Instrument Calibration Requirements and Response Checks";

HP-IN-02 "Contamination Survey Instrument Efficiency Determination";

HPO-004 "Conduct of Radiological Work";

HPO-005 "Radiological Training Requirements";

HPO-006 "Radiological Work Permits";

HPO-104 "Radiation Surveys";

HPO-105 "Contamination Surveys";

HPO-107 "Personal Monitoring and Decontamination";

HPTN-001 "Radiation Protection Program for Tennessee Licensed Activities";

HPOP-105 "Operation of Ludlum 2350-1 Data Logger"

14.2 Radiation Control References

Regulations

[redacted]