NWMI
NORTHWEST MEDICAL ISOTOPES

# ATTACHMENT 3

## Northwest Medical Isotopes, LLC

**Response to the**
**U.S. Nuclear Regulatory Commission**
**Request for Additional Information, Round 2**

**Environmental Review of the**
**Northwest Medical Isotopes, LLC**
**Construction Permit Application**
**(Document No. NWMI-2016-RAI-001, February 2016)**

**Public Version**

*Information is being provided via hard copy*

# Response to the U.S. Nuclear Regulatory Commission Request for Additional Information, Round 2

# Environmental Review of the Northwest Medical Isotopes, LLC Construction Permit Application

NWMI-2016-RAI-001, Rev. 0
February 2016

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# Response to the U.S. Nuclear Regulatory Commission Request for Additional Information, Round 2

# Environmental Review of the Northwest Medical Isotopes, LLC Construction Permit Application

NWMI-2016-RAI-001, Rev. 0

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| ***Approved by*:** Carolyn Haass | ***Signature*:** Carolyn C Haass |

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# TERMS

## Acronyms and Abbreviations

| | |
|---|---|
| $^{99}Mo$ | molybdenum-99 |
| $^{235}U$ | uranium-235 |
| ADUN | acid-deficient uranyl nitrate |
| ALARA | as low as reasonably achievable |
| CEQA | California Environmental Quality Act |
| CFR | Code of Federal Regulations |
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| Discovery Ridge | Discovery Ridge Research Park |
| EPA | U.S. Environmental Protection Agency |
| ER | Environmental Review |
| GIS | geographic information systems |
| $H_2$ | hydrogen gas |
| HEPA | high-efficiency particulate air |
| $HNO_3$ | nitric acid |
| HVAC | heating, ventilation, and air conditioning |
| ISG | Interim Staff Guidance |
| LEU | low-enriched uranium |
| MDNR | Missouri Department of Natural Resources |
| MHA | maximum hypothetical accident |
| MNRC | McClellan Nuclear Research Center |
| MURR | University of Missouri Research Reactor |
| $N_2O$ | nitrous oxide |
| $NO_2$ | nitrogen dioxide |
| $NO_x$ | nitrogen oxides |
| NRC | U.S. Nuclear Regulatory Commission |
| NWMI | Northwest Medical Isotopes, LLC |
| $O_2$ | oxygen |
| OSTR | Oregon State University TRIGA Reactor |
| PSAR | preliminary safety analysis report |
| RAI | request for additional information |
| RCRA | Resource Conservation and Recovery Act |
| RPF | Radioisotope Production Facility |
| SNM | special nuclear material |
| $SO_2$ | sulfur dioxide |
| TEDE | total effective dose equivalent |
| Terracon | Terracon Consultants, Inc. |
| U.S. | United States |
| U.S.C. | United States Code |
| UC | University of California |
| USGS | U.S. Geological Survey |

**Units**

| | |
|---|---|
| bgs | below ground surface |
| Ci | curie |
| cm | centimeter |
| dBA | A-weighted decibel |
| ft | feet |
| g | gram |
| gal | gallon |
| ha | hectare |
| hr | hour |
| in. | inch |
| kg | kilogram |
| km | kilometer |
| $km^2$ | square kilometer |
| L | liter |
| m | meter |
| $m^2$ | square meter |
| $m^3$ | cubic meter |
| mi | mile |
| $mi^2$ | square mile |
| mR | milliroentgen |
| mrem | millirem |
| mSv | millisievert |
| t | tonne (metric) |
| wt% | weight percent |
| $yd^3$ | cubic yard |
| yr | year |

| No. | Request for Additional Information |
|---|---|
| | **Air Quality** |
| **AIR2-1** | *The ISG augmenting NUREG-1537, Part 1, Section 19.4.2, "Air Quality and Noise," states that the ER should provide estimates of on-site and off-site vehicle and other emissions resulting from construction, operations, and decommissioning, including fugitive dust. The applicant's response to AIR-1D, which requested clarification on the construction workforce travel assumed in Table 19-56 of the ER, states, in part, that Table 19-63 accounts for the commuting workforce and routine deliveries to/from the radioisotope production facility (RPF). However, Table 19-63 pertains to vehicle emissions from operations. Table 19-56 of the ER identifies 100 for workforce travel during the construction phase but Table 19-6 identifies a peak workforce of 82 during construction. Clarify why 100 workforce travel was used in Table 19-56.* |

The peak workforce identified in Table 19-6 of NWMI-2013-021, *Construction Permit Application for Radioisotope Production Facility*, is assumed to be 82 during construction, with an average workforce assumed to be 38. By estimating the mileage for 100 vehicles (Table 19-56), the calculation bounded any potential emissions, including those by other service providers (e.g., for routine deliveries).

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|---|---|
| **AIR2-2** | *The ISG augmenting NUREG-1537, Part 1, Section 19.4.2, "Air Quality and Noise" states that the ER should provide a description of gaseous effluents (i.e., type, quantity, and origin), a description of gaseous effluent control systems, and detailed descriptions of the models and assumptions used to determine normalized concentration. Clarify the applicant's response to AIR-2A and AIR-2B. Specifically:* |
| **AIR2-2A** | *AIR-2A requested that the response include supporting calculations used in determining $NO_x$, $SO_2$, or $CO_2$ emissions resulting from the production process. Calculations for $NO_x$ emissions were not provided. Provide the supporting calculations or a detailed description of the assumptions used to determine $NO_x$ emissions from dissolution.* |

The current Northwest Medical Isotopes, LLC (NWMI) Radioisotope Production Facility (RPF) production process steps do not produce significant quantities of sulfur dioxide ($SO_2$) or carbon dioxide ($CO_2$) that contribute to facility emissions. However, small quantities of nitrogen oxides ($NO_x$) are evolved during the dissolution of low-enriched uranium (LEU) oxide from irradiated targets in the target dissolution process system and dissolution of fresh LEU metal receipts in the target fabrication process system.

Irradiated target material dissolution is based on reaction stoichiometry within the dissolver vessel.

**Equation 1**

[Proprietary Information]

The dissolver vessel condenser returns water vapor to the dissolver during operation, along with nitric acid from partial absorption of the nitrogen dioxide ($NO_2$), to produce the overall reaction shown as Equation 2 that defines $NO_x$ entering the subsequent dissolver offgas treatment process elements.

**Equation 2**

[Proprietary Information]

The annual irradiated target process load for describing $NO_x$ emissions is bounded by assuming dissolution [Proprietary Information]. This produces a bounding irradiated target dissolution throughput of [Proprietary Information] such that the bounding quantity [Proprietary Information]. The molecular weight of [Proprietary Information] such that the bounding target material is equivalent to [Proprietary Information].

Based on Equation 1, the bounding irradiated target dissolution source term is described by Equation 3, where the $NO_x$ is described as equivalent $NO_2$ mass (46.01 g $NO_2$/mole $NO_2$).

**Equation 3**

[Proprietary Information]

Presence of the dissolver condenser reduces the quantity of $NO_x$ entering the dissolver offgas system based on Equation 2. The bounding quantity of $NO_x$ entering the dissolver offgas system is described by Equation 4.

**Equation 4**

[Proprietary Information]

Offgas leaving the irradiated target condenser is routed to the dissolver offgas treatment system. Process elements affecting $NO_x$ emissions consist of a caustic scrubber, $NO_x$ oxidizer, and $NO_x$ absorber. The primary purpose of these treatment elements is to reduce non-condensable gas volume and remove $NO_x$, water vapor, and nitric acid ($HNO_3$) vapor such that residual gas leaving the treatment elements is acceptable for downstream fission gas treatment. The treatment element $NO_x$ removal performance is summarized as follows:

- Caustic scrubber – removes 95 percent of the $NO_x$ entering the caustic scrubber
- $NO_x$ oxidizer – removes 50 percent of the $NO_x$ entering the $NO_x$ oxidizer
- $NO_x$ absorber – removes 98 percent of the $NO_x$ entering the $NO_x$ absorber

The $NO_x$ leaving the $NO_x$ absorber is routed, via the process vessel vent system, to the Zone I exhaust plenum for emission via the Zone I exhaust stack. Equation 5 indicates the irradiated target dissolution emissions are bounded by 0.14 kg $NO_x$/yr as $NO_2$.

**Equation 5**

$$NO_x\ leaving\ caustic\ scrubber = \left(270\ \frac{kg\ NO_x}{yr}\right) \times (1 - 0.95) = 13.5\ \frac{kg\ NO_x}{yr}\ as\ NO_2$$
$$NO_x\ leaving\ NO_x\ oxidizer = \left(13.5\ \frac{kg\ NO_x}{yr}\right) \times (1 - 0.5) = 6.75\ \frac{kg\ NO_x}{yr}\ as\ NO_2$$
$$NO_x\ leaving\ NO_x\ absorber = \left(6.75\ \frac{kg\ NO_x}{yr}\right) \times (1 - 0.98) = 0.14\ \frac{kg\ NO_x}{yr}\ as\ NO_2$$

The target fabrication system includes process elements for dissolution of fresh uranium metal receipts and [Proprietary Information]. [Proprietary Information] dissolution stoichiometry is described by Equation 1. The uranium metal dissolution reaction is described by Equation 6.

**Equation 6**

[Proprietary Information]

The target fabrication process is based on a nominal production rate that fabricates [Proprietary Information]. Once steady-state operation has been established, fresh uranium metal dissolution is estimated to be required equivalent to [Proprietary Information] as makeup for recycled uranium process losses in the target fabrication system.

[Proprietary Information] will be processed by the target fabrication dissolver to address recycling out-of-specification materials generated during target fabrication. For a nominal production load of [Proprietary Information] if the production process was operated at the bounding throughput described for irradiated target dissolution.

The target fabrication dissolver must also support generation of a fabricated target inventory from fresh uranium metal during the initial year of operation. Table 4-1 of NWMI-2013-021, Chapter 4, indicates the target fabrication area nominal special nuclear material (SNM) inventory that would be created by fresh metal dissolution in the first year of operation is as follows:

- [Proprietary Information]
- [Proprietary Information]
- [Proprietary Information]
- [Proprietary Information]

The total target fabrication inventory from fresh uranium metal dissolution is [Proprietary Information]. Therefore, the nominal SNM inventory is estimated to create a nominal target inventory of [Proprietary Information]. The bounding target fabrication throughput is capable of producing the targets in approximately [Proprietary Information]. Based on operating 52 weeks/yr, the target fabrication system is available to support steady-state operation in the remaining 50 weeks of the first operating year.

The target fabrication system is not actually capable of supporting the bounding throughput of [Proprietary Information] used for estimating bounding $NO_x$ emissions from the irradiated target dissolver. Therefore, the target fabrication dissolver is assumed to support uranium recycle at an operating rate of [Proprietary Information]. Therefore, the total uranium dissolved in target fabrication is bounded by [Proprietary Information].

The molecular weight of uranium for LEU containing 20 wt% $^{235}U$ is [Proprietary Information] such that the first operating year uranium metal dissolved is [Proprietary Information]. Based on Equation 6, the bounding target fabrication dissolver source term from fresh uranium metal dissolution is described by Equation 7.

**Equation 7**

[Proprietary Information]

Nitrogen oxides generated by dissolution of [Proprietary Information] is difficult to predict prior to obtaining actual operating experience. However, conservatism in the bounding fresh metal dissolution estimate (equivalent to producing [Proprietary Information] is considered sufficient to address the uncertainty associated with [Proprietary Information].

Offgas from the target fabrication dissolver is routed, via the process vessel vent system, to the Zone I exhaust plenum for emission via the Zone I exhaust stack. Offgas treatment for removal of $NO_x$ from the target fabrication dissolver is not included in the current design because it represents a relatively small emission source. Inclusion of a target fabrication dissolver condenser may be found to be required for liquid level control in final design activities, along with other process steps that reduce the quantity of $NO_x$ emitted from the facility stack.

Table 1 provides a summary of the source terms and stack emissions for $NO_x$ generated by the RPF process systems.

**Table 1. Summary of Radioisotope Production Facility Process System $NO_x$ Source Terms and Stack Emissions**

| Process system | Bounding source term | Bounding stack emission |
|---|---|---|
| Irradiated target dissolution | 540 kg $NO_x$/yr as $NO_2$ | 0.14 kg $NO_x$/yr as $NO_2$ |
| Target fabrication dissolution | 42.5 kg $NO_x$/yr as $NO_2$ | 42.5 kg $NO_x$/yr as $NO_2$ |
| Facility total | 582.5 kg $NO_x$/yr as $NO_2$ | 42.64 kg $NO_x$/yr as $NO_2$ |

$NO_2$ = nitrogen dioxide. $NO_x$ = nitrogen oxides.

Primary process system reactions do not generate quantities of $CO_2$ or $SO_2$ as reaction products. However, actual materials may generate trace quantities of these components due to the presence of impurities or solution radiolysis. As an example, offgas from dissolution of uranium metal is reported to contain nitrous oxide ($N_2O$), $CO_2$, carbon monoxide (CO), and hydrogen gas ($H_2$) at concentrations that are approximately 0.1 percent of the total $NO_x$ ($NO + NO_2$) generated. Formation of $CO_2$ and CO is attributed to the dissolution of carbon impurities in the uranium that was dissolved. While $H_2$ and oxygen ($O_2$) are the dominant components produced by aqueous solution radiolysis, there is a potential for RPF solutions containing nitrate and sulfate solutes to generated trace quantities on $NO_x$ and $SO_2$ from radiolysis. The trace sources of these potential emissions have not been quantified and are unlikely to be present at measurable concentrations in the stack emissions.

| No. | Request for additional information |
|---|---|
| | Air Quality (continued) |
| AIR2-2B | *The applicant's response to AIR-2B, in part, references Table 4-75 of the preliminary safety analysis report (PSAR) and provides an inventory quantity. However, the RAI response and Table 4-75 do not identify the inventory turnover (e.g., monthly, year). Provide the inventory turnover.* |

The planned inventory is approximately 53 gallons (gal), and depending on nominal versus maximum target production rate, the turnover rate is estimated at 1 to 2 times per year.

| No. | Request for additional information |
|---|---|
| AIR2-2C | *The ISG augmenting NUREG-1537, Part 1, Section 19.4.2, "Air Quality and Noise" states that the ER should provide a description of gaseous effluents (i.e., type, quantity, and origin), a description of gaseous effluent control systems, and detailed descriptions of the models and assumptions used to determine normalized concentration. Provide the following ER references:*<br>• *EDF-3124-0001, 2015, Estimate of Excavation for the NWMI Radioisotope Production Facility, Rev. 3, Portage, Inc., Idaho Falls, Idaho, February 2, 2015.*<br>• *EDF-3124-0004, 2015, Calculation for the Determination of Fugitive Dust during Construction Activities from Construction Equipment, Rev. 1, Portage, Inc., Idaho Falls, Idaho, February 3, 2015.*<br>• *EDF-3124-0005, 2014, On-Road Emissions for Vehicles During Construction, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.*<br>• *EDF-3124-0006, 2014, Determination of Wind-Blown Dust during Construction Activities, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.*<br>• *EDF-3124-0009, 2014, Off-Road Emissions during Construction, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.*<br>• *EDF-3124-0014, 2014, Emission Modeling for Construction Activities using AERSCREEN, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.* |

The most recent revisions of the requested reference documents listed above are attached in Appendix A, B, C, D, E, and F, respectively.

| No. | Request for additional information |
|---|---|
| | **Alternatives** |
| **ALT2-1** | *10 CFR 51.45(b)(3) and the ISG augmenting NUREG-1537, Part 1, Section 19.5 "Alternatives" state that ER should summarize the history and process used to formulate the reasonable alternatives. Section 19.5.2 of the ER describes four sites that NWMI considered in its site selection process. Describe the process NWMI used to initially narrow down the large number of potential sites to the four sites described in the ER. Clarify whether NWMI considered potential sites at or near all existing research and test reactors. Clarify whether the process considered any regional/State-wide factors or any other regional-scale factors or constraints.* |

The selection of potential RPF sites was initially driven by the requirement to be co-located near a university research reactor that could provide irradiation services for the majority of NWMI molybdenum-99 ($^{99}$Mo) production. In addition, the university reactor needed to have:

- Experience supporting government and commercial industries
- Capability to support commercial irradiation on a regular basis
- Core configuration that could accept the NWMI targets
- Power required to meet the irradiation requirements

From a broad list of potential locations, NWMI conducted an informal evaluation process based on the experience and knowledge to down-select to the four sites for a more detailed evaluation.

As stated above, NWMI initially considered sites near a multitude of existing research and test reactors and down-selected based on the knowledge and experience of the team. The initial down-select did not include any specific regional or State-wide factors.

| | |
|---|---|
| **ALT2-2** | *10 CFR 51.45(b)(3) and the ISG augmenting NUREG-1537, Part 1, Section 19.5 "Alternatives" state that ER should summarize the history and process used to formulate the reasonable alternatives. Section 19.5.2 of the ER states that NWMI considered the University of Missouri Research Reactor (MURR) to be a viable site. Clarify whether NWMI considered Oregon State University TRIGA Reactor (OSTR) and McClellan to be viable sites, and what factors NWMI considered to make this determination.* |

As stated in NWMI-2013-021, Chapter 19.0, page 19-266 (paragraph before Table 19-88): "Based on the siting criteria established and using readily available public information and observations from site visits, the sites were scored using a scale of 1 to 5 (5 being most favorable, 1 being least). The NWMI team determined that all four of the sites are viable and acceptable, with Discovery Ridge selected as the preferred site of the proposed RPF (see Table 19-88 ["Evaluation of Alternative Sites"]). … The Discovery Ridge site total weighted score of 82 percent was followed by the MURR location. Given the high weighting of certain criteria (i.e., political and local logistical support, facility operations, and production logistics) and high scores for these criteria, the MURR and Discovery Ridge sites have an advantage over both the proposed McClellan Business Park and OSTR sites.

The proposed site at the McClellan Business Park ranks fourth for the RPF location. The McClellan Business Park score was 34 percentage points lower than the Discovery Ridge site, primarily due to a lack of political and local support, Federal and state taxes and incentives, limited available greenfield space, and weaker ties to the UC Davis reactor team. However, the site's strengths include an existing building and abundant available space. The OSTR site, which ranked third, had limited available space, transportation routes, and State and local financial incentives.

In consideration of these factors, the Discovery Ridge site was selected as the proposed site for the RPF. The siting alternatives of the MNRC Business Park and OSTR locations were not further evaluated. The MURR site was considered to be viable and was identified as a reasonable alternative; its evaluation is provided in the following subsections…"

| No. | Request for additional information |
|---|---|

The factors NWMI considered to make this determination include the following (Table 19-88):

- Political and local logistics support
- Facility operations
- Production logistics
- Transportation
- Radioactive, hazardous, and mixed secondary waste generation (e.g., air, liquids, solids)
- Federal, State, county, and local requirements to construct and operate facility
- Federal and State taxes and incentives
- Available space
- Construction costs
- Natural or human-made disaster potential

**ALT2-3** *10 CFR 51.45(b)(3) and the ISG augmenting NUREG-1537, Part 1, Section 19.5 "Alternatives" state that ER should summarize the history and process used to formulate the reasonable alternatives. The NWMI Site Alternative Study provided in the applicant's response to RAI ALT-2A describes some site-specific factors that NWMI considered to develop the scoring for each site under each category listed in Table 19-88 of the ER. The following RAIs pertain to the NWMI Site Alternative Study:*

**ALT2-3A** *For "Production Logistics," clarify the differentiating factor(s) for why NWMI assigned Discovery Ridge a score of 4 and MURR a score of 2 given that the study states that both facilities are the same distance to the primary and secondary reactors. In addition, clarify why NWMI gave OSTR and McClellan a score of 3 and MURR a score of 2 given that MURR is the location of the primary irradiation reactor.*

The "Production Logistics" score for MURR is incorrect. This value should have been a "4," the same as Discovery Ridge site, with a weighted value of 40. In addition, the "Facility Operations" and "Construction costs" for MURR were incorrect and should have been "2" for a weighted value of "20" and "3" for a weighted value of "6," respectively. The "Facility Operations" rating was due to the ability to operate a RPF in conjunction in a limited space and would be managed by MURR personnel not NWMI. The "Construction Costs" rating was lower than Discovery Ridge due to the limited space available next to the MURR reactor building for initial construction or future expansion and the need for the construction of below-grade connection to the reactor. The total corrected score for MURR is 217 with a weighted percentage of 72 percent. A revised Table 19-88 is provided below.

**Table 19-88. Evaluation of Alternative Sites (2 pages)**

| Siting criteria | DR | | MURR | | OSTR | | MNRC | |
|---|---|---|---|---|---|---|---|---|
| | Score | Wt. score | Score | Wt. Score | Score | Wt. score | Score | Wt. score |
| Political and local logistics support | 4 | 40 | 4 | 40 | 4 | 40 | 1 | 10 |
| Facility operations | 4 | 40 | 2 | 20 | 3 | 30 | 3 | 30 |
| Production logistics | 4 | 40 | 4 | 40 | 3 | 30 | 3 | 30 |
| Transportation | 4 | 32 | 4 | 32 | 2 | 16 | 3 | 24 |
| Radioactive, hazardous, and mixed secondary waste generation (i.e., air, liquids, solids) | 4 | 32 | 4 | 32 | 4 | 32 | 3 | 24 |
| Federal, State, county, and local requirements to construct and operate facility | 4 | 20 | 4 | 20 | 4 | 20 | 2 | 10 |
| Federal and State taxes and incentives | 5 | 15 | 5 | 15 | 3 | 9 | 1 | 3 |
| Available space | 5 | 15 | 3 | 9 | 1 | 3 | 2 | 6 |

**Table 19-88. Evaluation of Alternative Sites (2 pages)**

| Siting criteria | DR | | MURR | | OSTR | | MNRC | |
|---|---|---|---|---|---|---|---|---|
| | Score | Wt. score | Score | Wt. Score | Score | Wt. score | Score | Wt. score |
| Construction costs | 4 | 8 | 3 | 6 | 3 | 6 | 3 | 6 |
| Natural or human-made disaster potential | 3 | 3 | 3 | 3 | 4 | 4 | 2 | 2 |
| **Total** | | **245** | | **217** | | **190** | | **145** |
| **Weighted Percentage** | | 82% | | 72% | | 63% | | 48% |

DR = Discovery Ridge.
MNRC = McClellan Nuclear Research Center.
MURR = University of Missouri Research Reactor.
OSTR = Oregon State University TRIGA Reactor.

| No. | Request for additional information |
|---|---|
| | Alternatives (continued) |
| **ALT2-3B** | *For "Transportation," clarify why NMWI gave Discovery Ridge and MURR a score of 4 given that the study states that if the RPF is located at Discovery Ridge or MURR, more Rocky Mountain crossings would occur, which may increase the probability of delays. In addition, clarify the differentiating factor(s) for why NWMI gave OSTR a score of 2 and McClellan a score of 3.* |

Discovery Ridge and MURR were given a score of "4," because with placement of the RPF in either of those locations, the primary university reactor that provides the bulk of irradiation services for NWMI would be near (less than 20 miles from) the RPF. Transport of irradiated targets from either Discovery Ridge or MURR would not require crossing significant mountain ranges (e.g., Rocky Mountains) that could result in potential delays due to inclement weather. Because time is critical to NWMI's business, a site in close proximity to the irradiating reactor is preferable.

The second major bullet and associated second and third sub-bullets in NWMI-2015-RAI-001, *Response to the U.S. Nuclear Regulatory Commission Request for Additional Information, Environmental Review of the Northwest Medical Isotopes, LLC Construction Permit Application*, Appendix E, Page 21, stating that "all routes require crossing significant mountain ranges" and "If RPF was located at Discovery Ridge/MURR, more Rocky Mountain crossings may increase the probability of delays," was in error for the Discovery Ridge and MURR sites. These statements were intended to be applicable only to the McClellan and OSTR sites. The difference between a score of 2 for OSTR and 3 for McClellan was based on the additional distance and travel time required to ship irradiated targets from their respective site to the RPF (i.e., 200 miles or an additional 5 hours of travel time farther to OSTR than McClellan).

| No. | Request for additional information |
|---|---|
| **ALT2-3C** | *For "Waste Generation," clarify the differentiating factor(s) for why NWMI gave McClellan a score of 3 and the other three sites a score of 4.* |

McClellan was given a score of "3" due to the additional regulatory requirements by the state of California for the transport and disposal of any waste generated.

The regulatory requirements associated with storage, transportation, and disposal of waste are more rigorous in the state of California than in the states of Missouri and Oregon. Thus, a lower score was given to McClellan.

| No. | Request for additional information |
|---|---|
| ALT2-3D | *For Federal, State, and local requirements, clarify what State and local requirements are expected to be most significant at McClellan and less significant at the other three sites.* |

McClellan was expected to have additional or more significant State and local requirement than the other three sites. For example, the state of California requires a separate State Environmental Policy Act under the California Environmental Quality Act (CEQA) action for any new processing facility. In addition, the State (e.g., California Code of Regulations) and local requirements are expected to be more stringent and broader in scope in California (e.g., McClellan) than Federal regulations and less so at the other three sites. For example, if and when the waste leaves the state of California, the waste is treated as nonhazardous; for this reason, treating and disposing of hazardous waste in California is preferable in terms of environmental protection because California's protocols are more rigorous in comparison to those in Federal Resource Conservation and Recovery Act (RCRA) regulations and other State regulations.

The state of California, in general, has more stringent regulatory requirements that either the state of Missouri or Oregon. For example, if the RPF was to be sited at the McClellan site, the state of California would require a separate CEQA action for any new processing facility that is comparable to preparing a separate environmental impact statement.

| No. | Request for additional information |
|---|---|
| ALT2-3E | *For "Federal and State Taxes and Incentives," clarify the differential factor(s) for why NWMI gave OSTR a score of 3 and Discovery Ridge and MURR a score of 5 given that Oregon does not have sales tax and Missouri has a sales tax of 4.225 percent, the corporate tax is slightly higher for Oregon compared to Missouri, and the alternative study characterized property tax and incentives to be similar for OSU, Discovery Ridge, and MURR.* |

The state of Missouri offers several incentives that help provide a score of 5 compared to the other locations. Some of these incentives include the following:

- **Statewide works** – This program provides significant state incentives for eligible companies creating new jobs in Missouri; the incentives of the program are the retention of the State withholding tax.
- **Customized training grant** – This program provides customized training to employees that will help meet the specific needs of the employer through classroom skill training.
- **Recruitment assistance** – The Division of Workforce Development offers personalized recruitment assistance to help businesses meet their labor needs.
- **Energy exemption** – As of August 28, 2007, the state of Missouri allows manufacturers an exemption on energy purchases. These items may be exempted from State tax (4.225 percent) and local use tax, but not local sales tax.
- **Sales/use tax exemption** – Machinery and equipment used to establish a new or expand an existing manufacturing facility is tax-exempt, provided such machinery/equipment is used directly to manufacture a product ultimately intended for sale.

| No. | Request for additional information |
|---|---|
| ALT2-3F | *For "Available Space," clarify the differentiating factor(s) for why NWMI gave MURR a score of 3, OSTR a score of 1, and McClellan a score of 2 given that the study states that MURR only has availability for limited future expansion, whereas OSTR and McClellan both have sufficient space for future expansion.* |

OSTR was given a score of "1" due to the potential site provided by the university to NWMI was less than 1.0 hectares (ha) (2.5 acres) in size and no future expansion would be available. NWMI-2015-RAI-001, Appendix E, "NWMI Site Alternative Study," page 25, OSU Bullet 2, was in error. In addition, McClellan was given a score of "2" due to the limitations on the existing buildings and airport tarmac adjacent to the site (e.g., no construction can occur on the existing tarmac).

| No. | Request for additional information |
|---|---|
| ALT2-3G | *For "Construction Costs," clarify why NWMI gave Discovery Ridge and MURR a score of 4 and OSTR a score of 3 given that the study states that the construction cost for Discovery Ridge and MURR are expected to be similar to OSTR. In addition, clarify why the alternatives study states that the construction cost would be similar for Discovery Ridge, MURR, and OSTR whereas the applicant's response to RAI ALT-2B states that the construction costs would be higher at MURR and OSTR than at Discovery Ridge.* |

NWMI-2015-RAI-001 states in RAI ALT-2B that construction costs would be higher at MURR and OSTR than at Discovery Ridge. This statement is based on the land area constraints that were given for both MURR and OSTR. Discovery Ridge is a "greenfield" area that has been broken into three phases for development. Lot 15 of Discovery Ridge is part of the Phase II development, which has over 22.5 ha (60 acres) for development. The MURR score of "4" for construction costs was in error in NWMI-2015-RAI-001, Appendix E, page 26; this score should have been "3," as stated in RAI ALT-2B. ALT2-3A provides the revised table.

| Connected Actions | |
|---|---|
| CONN2-1 | *In RAI CONN-1A2, the NRC staff asked for information to evaluate the site-specific environmental impacts associated with the connected actions.*<br>*The applicant's response to CONN-1A2 states that refurbishment will require subcontracted personnel and will be temporary. Provide the total approximate number of workers needed to support modifications.* |

Based on similar work performed in the industry, the refurbishment of the overhead crane will nominally take two days and be performed by two individuals from a qualified mechanical subcontractor.

| Geologic Environment | |
|---|---|
| GEO2-1 | *The ISG augmenting NUREG-1537, Part 1, Section 19.3.3, "Geologic Environment," states that the applicant should identify the geological, seismological, and geotechnical characteristics of the site and surrounding area.*<br>*The applicant's response to GEO-1A and GEO-2 in part, indicates that the maximum depth for below-grade portions of the RPF could range from 17 to 23 ft. Section 19.3.4.3.2 of the ER states that groundwater was observed in Boring B-5 (located midway between Lots 14 and 15) and in Boring B-6 (located on Lot 10) at depths ranging from approximately 12–18.5 ft. Section 19.4.4.2.1 of the ER acknowledges that some dewatering may be required during construction. Given the identified potential for high water table elevations (or perched groundwater conditions) beneath the site, please describe and elaborate on how high water table elevations will be managed during construction, the projected rate and duration of dewatering, and the potential impacts on local groundwater sources and direction of flow. Also, please discuss the facility design considerations for permanently or seasonally high water tables as well as the implications for facility operations.* |

**Management high water table elevations**: As described in our response to WAT2-1, NWMI does not anticipate a high water table at the RPF site. There is no historical groundwater data specifically for the RPF site at Discovery Ridge. The nearest United States (U.S.) Geological Survey monitoring well provides an indication of the historical groundwater fluctuation and seasonal trends. The depth to groundwater at that well has varied from a minimum of 22.9 meters (m) (75 feet [ft]) to a maximum over 61 m (200 ft). Other monitoring wells in the area show a static water level from 55 to 99 m (180 to 325 ft) below the surface, while two wells drilled approximately 1.6 kilometer (km) (1 mile [mi]) east of the site encountered water at 10.97 and 11.89 m (36 and 39 ft). The response to WAT2-1 provides plausible explanations as to why water was found in two of the nine boreholes drilled across the Discovery Ridge site (Terracon, 2011).

Additional borings, within the RPF boundary, are planned. If the analysis of these new borings discovers high water tables, the final design will address that issue in detail.

**Projected rate and duration of dewatering**: NWMI does not anticipate a high water table or to encounter significant groundwater at the site. However, if encountered, as noted in NWMI-2013-021, Section 19.4.4.1.1, some dewatering due to groundwater and precipitation may be required during construction at the deepest excavation. Any water would be collected in a detention/retention pond. The dewatering rate is anticipated to be controlled by the precipitation for the site during the construction period. Section 19.3.2.1.2 states, on a monthly basis, rainfall amounts range from a high of 12.4 centimeters (cm) (4.89 inches [in.]) in May to a low of 4.62 cm (1.82 in.) in January. The proposed lot for the RPF at Discovery Ridge is approximately 3.0 ha (7.4 acres). Using the maximum rainfall rate and the entire site area, a conservative estimate of less than 1,400 g/hour (hr) is reasonable. The size of the excavation is a small fraction of the entire site area, so this estimate is conservative. The duration of the civil and foundation work is estimated at three to six months. The duration of the dewatering would be a fraction of the total duration (i.e., only when there is precipitation).

**Potential impacts on local groundwater sources and direction of flow**: NWMI does not anticipate any detrimental impact to local groundwater sources or directions of flow. As described in the response to WAT2-1, the site does not interact directly with local aquifers. Surface run-off would be collected in a detention/retention pond.

**Facility design considerations for permanently or seasonally high water tables**: The RPF will have design features to minimize the impacts of any seasonal high water tables. Foundations will be protected from water with barrier systems (e.g., sealants) and drainage will be provided to channel water away from the RPF.

**Implications for facility operations**: NWMI does not anticipate any impact on facility operations due to groundwater issues.

| No. | Request for additional information |
|---|---|
| | Human Health – Radiological |
| HH2-R-1 | *The ISG augmenting NUREG-1537, Part 1, Section 19.4.10, "Human Health" states that the ER should discuss the public health impacts from radioactive material and include dose rates. Section 19.4.10.1.3 of the ER states that "[e]xposure from $^{99}$Mo to the general public during the flight is assumed to be negligible and was not calculated." Provide a technical basis why NWMI assumes that exposure from $^{99}$Mo to the general public resulting from flight mode transportation is negligible.* |

The calculations for transportation of materials for the RPF (EDF-3124-0010, *Radiological Dose Consequences Associated with Transportation of Materials for the NWMI Radioisotope Production Facility*) assumed a dose rate of 10 milliroentgen (mR)/hr at one meter for the transportation cask used to transport the $^{99}$Mo product. Using the inverse square law ($R_1D_1^2 = R_2D_2^2$), the dose to the public when the plane is at a cruising altitude of 6,200 m (20,000 ft) would be 2.6E-7 mR/hr. This dose is significantly lower than background.

| No. | Request for additional information |
|---|---|
| HH2-R-2 | *The ISG augmenting NUREG-1537, Part 1, Section 19.3.8, "Human Health," states that the ER should provide effluent release points and expected radioactive effluent releases and exposures from construction, operational, and decommissioning activities. Table 11-2 in PSAR Chapter 11 titled "Radionuclide Stack Release Source Term Input to COMPLY" contains the types and quantities of estimated radionuclide gaseous releases under normal operating conditions.*<br>*Please provide a non-proprietary version of this table and the corresponding calculated maximum dose to the public from the normal operational stack releases used in determining 10 CFR 20.1101(d) compliance with the as low as reasonably achievable (ALARA) dose constraint.* |

Chapter 11, Table 11-2 of NWMI-2013-021 is provided on the following page and is now considered non-proprietary by NWMI.

The weekly radionuclides (curies [Ci]/week) generated for the maximum dose case were multiplied by 52 weeks to obtain the release rates in Ci/yr. The radionuclide releases were adjusted to conservatively account for one high-efficiency particulate air (HEPA) filter in the Zone I heating, ventilation, and air conditioning (HVAC) offgas treatment system (Chapter 9, "Auxiliary Systems," Section 9.1.2.2) in accordance with EPA 520/1-89-003, *User's Guide for the COMPLY Code*, which recommends that radionuclide particulate releases be reduced by an adjustment factor of 0.01. The noble gases and iodine releases were not reduced in the analysis. The following radionuclides were not available in the COMPLY database: $^{136m}$Ba, $^{137m}$Ba, $^{133m}$I, $^{97m}$Nb, $^{236m}$Np, $^{234m}$Pa, $^{112}$Pd, $^{144m}$Pr, $^{106}$Rh, $^{128}$Sb, $^{128m}$Sb, and $^{98m}$Y.

The following assumptions were used in the development of the analysis:

- **Meteorological data** – COMPLY meteorological wind rose file for Columbia, Missouri
- **Stack data** – Stack height 22.9 m (75 ft), diameter of 0.86 m (34 in.)
- **Building data** – Height 19.8 m (65 ft), width 24.4 m (80 ft), length 76.2 m (250 ft)
- **Receptor location** – Nearest receptor locations is the RPF fence line at 9.1 m (30 ft) from the stack
- **Agricultural data** – Food sources (e.g., milk, meat, vegetables) assumed to be home grown at receptor location

The maximum dose to the public from the normal operational stack releases was calculated to be 0.036 millisievert (mSv)/yr (3.6 millirem [mrem]/yr) at 9.1 m (30 ft) from the RPF. The results of the COMPLY analysis determine that the requirement of 10 CFR 20.1101, "Radiation Protection Programs," item (d) will be met for the RPF, such that air emissions of radioactive material to the environment will not result in a member of the public receiving a total effective dose equivalent (TEDE) in excess of 0.1 mSv/yr (10 mrem/yr) from these emissions.

**Table 11-2. Radionuclide Stack Release Source Term Input to COMPLY (2 pages)**

| Isotope | Release rate (Ci/yr) | Isotope | Release rate (Ci/yr) | Isotope | Release rate (Ci/yr) |
|---|---|---|---|---|---|
| $^{241}Am$ | 8.67E-17 | $^{237}Np$ | 1.63E-12 | $^{89}Sr$ | 3.69E-02 |
| $^{136m}Ba$ | 8.03E-08 | $^{238}Np$ | 7.07E-10 | $^{90}Sr$ | 3.02E-04 |
| $^{137m}Ba$ | 2.89E-06 | $^{239}Np$ | 3.49E-04 | $^{91}Sr$ | 2.36E-02 |
| $^{139}Ba$ | 1.03E-05 | $^{233}Pa$ | 4.14E-13 | $^{92}Sr$ | 5.57E-03 |
| $^{140}Ba$ | 7.99E-04 | $^{234}Pa$ | 1.59E-12 | $^{99}Tc$ | 4.04E-08 |
| $^{141}Ce$ | 6.02E-04 | $^{234m}Pa$ | 1.23E-09 | $^{99m}Tc$ | 3.29E-02 |
| $^{143}Ce$ | 3.52E-04 | $^{112}Pd$ | 7.43E-07 | $^{125m}Te$ | 8.55E-07 |
| $^{144}Ce$ | 9.87E-05 | $^{147}Pm$ | 9.39E-06 | $^{127}Te$ | 9.76E-04 |
| $^{134}Cs$ | 4.92E-10 | $^{148}Pm$ | 5.81E-09 | $^{127m}Te$ | 1.12E-04 |
| $^{134m}Cs$ | 2.08E-10 | $^{148m}Pm$ | 4.62E-09 | $^{129}Te$ | 1.89E-03 |
| $^{136}Cs$ | 7.16E-07 | $^{149}Pm$ | 6.44E-05 | $^{129m}Te$ | 9.73E-04 |
| $^{137}Cs$ | 3.06E-06 | $^{150}Pm$ | 6.75E-09 | $^{131}Te$ | 5.38E-04 |
| $^{155}Eu$ | 1.03E-07 | $^{151}Pm$ | 2.47E-05 | $^{131m}Te$ | 2.39E-03 |
| $^{156}Eu$ | 2.06E-06 | $^{142}Pr$ | 2.22E-10 | $^{132}Te$ | 2.58E-02 |
| $^{157}Eu$ | 3.28E-07 | $^{143}Pr$ | 8.15E-04 | $^{133}Te$ | 1.38E-05 |
| $^{129}I$ | 1.90E-13 | $^{144}Pr$ | 9.87E-05 | $^{133m}Te$ | 6.13E-05 |
| $^{130}I$ | 7.17E-08 | $^{144m}Pr$ | 1.38E-06 | $^{134}Te$ | 1.78E-05 |
| $^{131}I$ | 5.97E-04 | $^{145}Pr$ | 1.14E-04 | $^{232}U$ | 2.63E-12 |
| I132 | 1.56E-03 | $^{238}Pu$ | 1.31E-12 | $^{234}U$ | 2.48E-06 |
| $^{132m}I$ | 8.65E-08 | $^{239}Pu$ | 3.56E-09 | $^{235}U$ | 1.14E-07 |
| $^{133}I$ | 2.62E-03 | $^{240}Pu$ | 2.58E-12 | $^{236}U$ | 3.82E-08 |
| $^{133m}I$ | 4.36E-07 | $^{241}Pu$ | 9.31E-13 | $^{237}U$ | 2.40E-03 |
| $^{134}I$ | 2.69E-05 | $^{103m}Rh$ | 2.74E-04 | $^{238}U$ | 7.15E-08 |
| $^{135}I$ | 1.36E-03 | $^{105}Rh$ | 6.40E-05 | $^{131m}Xe$ | 1.66E+02 |
| $^{83m}Kr$ | 3.81E-10 | $^{106}Rh$ | 5.70E-06 | $^{133}Xe$ | 4.98E+02 |
| $^{85}Kr$ | 5.84E+01 | $^{106m}Rh$ | 1.05E-08 | $^{133m}Xe$ | 9.77E-04 |
| $^{85m}Kr$ | 1.92E-03 | $^{103}Ru$ | 2.75E-04 | $^{135}Xe$ | 9.51E-20 |
| $^{87}Kr$ | 1.80E-23 | $^{105}Ru$ | 2.12E-05 | $^{135m}Xe$ | 1.46E-27 |
| $^{88}Kr$ | 1.16E-07 | $^{106}Ru$ | 5.70E-06 | $^{89m}Y$ | 3.43E-06 |
| $^{140}La$ | 8.64E-04 | $^{122}Sb$ | 3.89E-11 | $^{90}Y$ | 2.94E-04 |
| $^{141}La$ | 1.11E-04 | $^{124}Sb$ | 6.56E-10 | $^{90m}Y$ | 5.70E-09 |
| $^{142}La$ | 1.24E-05 | $^{125}Sb$ | 1.67E-07 | $^{91}Y$ | 4.18E-02 |
| $^{99}Mo$ | 3.40E-04 | $^{126}Sb$ | 1.10E-07 | $^{91m}Y$ | 1.50E-02 |
| $^{95}Nb$ | 1.68E-04 | $^{127}Sb$ | 1.02E-05 | $^{92}Y$ | 2.03E-02 |
| $^{95m}Nb$ | 4.64E-06 | $^{128}Sb$ | 9.42E-07 | $^{93}Y$ | 2.68E-02 |
| $^{96}Nb$ | 3.06E-08 | $^{128m}Sb$ | 1.05E-07 | $^{93}Zr$ | 6.12E-09 |
| $^{97}Nb$ | 3.37E-04 | $^{129}Sb$ | 1.14E-05 | $^{95}Zr$ | 4.29E-02 |
| $^{97m}Nb$ | 2.98E-04 | $^{151}Sm$ | 6.84E-08 | $^{97}Zr$ | 3.14E-02 |
| $^{147}Nd$ | 2.81E-04 | $^{153}Sm$ | 9.44E-06 | **Total Ci** | **7.24E+02** |
| $^{236m}Np$ | 9.02E-15 | $^{156}Sm$ | 6.20E-07 | | |

Sources: Barrington, C., 2015, "NWMI Release #11 – Process Vessel Ventilation (PVV) System Estimate," (memorandum to G. Dunford, May 26), AEM Consulting, LLC, Richland, Washington, 2015, and NWMI-2013-CALC-006, *Overall Summary Material Balance – MURR Target Batch*, Rev. D, Northwest Medical Isotopes, LLC, Corvallis, Oregon, 2015.

| No. | Request for additional information |
|---|---|
| | **Human Health – Radiological (continued)** |
| **HH2-R-3** | *The ISG augmenting NUREG-1537, Part 1, Section 19.3.8, "Human Health," states that the ER should provide a description of the facility's radiological programs and radiological monitoring systems. In response to RAI GEO-1B and in the ER, NWMI has stated that there will be no liquid radioactive effluent releases to the environment or the sanitary sewer from the RPF, and therefore there will be no environmental liquid monitoring conducted. Given that there is no liquid environmental monitoring proposed for the site around the RPF:* |
| **HH2-R-3A** | *Please describe how the applicant plans to quantify an inadvertent liquid radiological release and determine the environmental impact of such release and associated radioactive dose to the public.* |
| | NWMI will establish a liquid environmental sampling program for the area around the RPF. The program will include baseline sampling and routine sampling. The program will also include ad hoc sampling to be performed in the event of a liquid radiological release to determine the environmental impact and associated dose to the public. |
| **HH2-R-3B** | *Please describe how the applicant will determine and quantify the environmental impacts and associated radioactive doses to the public from deposition of normal gaseous effluent release radionuclides from vent stack emissions to any nearby surface water and the underlying groundwater aquifer.* |
| | NWMI will establish a liquid environmental sampling program for the area around the RPF. The program will include baseline sampling and routine sampling to determine and quantify the impacts of normal effluents from the vent stack emissions. The sampling program will include sampling of nearby surface water and the groundwater monitoring wells. |
| **HH2-R-4** | *The ISG augmenting NUREG-1537, Part 1, 13b.2, "Analyses of Accident with Radiological Consequences," states the applicant's maximum hypothetical accident analyses should provide radiation dose estimates for the operating staff throughout the event and during recovery operations and also for the maximally exposed individual in the uncontrolled areas and at the nearest permanent residence. Section 19.4.11.1.1 of Chapter 19 of the ER does not provide calculated doses for the licensee staff, calculated doses at the fence boundary or the nearest residence. Please provide the calculated doses for the licensee staff as well as the calculated doses at the fence boundary and the nearest residence (as provided in the chemical Maximum Hypothetical Accident analysis). Also, please state whether these doses are within 10 CFR Part 20 limits.* |
| | The TEDE to the public located outside at the controlled area would be from 3.6 mSv (0.36 rem) at the nearest fence line 10 m (30 ft) to 7 mSv (0.70 rem) at the furthest fence line 91 m (300 ft). The TEDE to the nearest resident located 430 m away was calculated to be 31 mSv (3.1 rem). The highest TEDE to the licensee staff outside the building would be 7 mSv (0.70 rem) for a person located 91 m (300 ft) from the location of the stack. The calculations are provided in EDF-3124-0003, *Preliminary Maximum Hypothetical Accident to Support the Northwest Medical Isotope Facility Environmental Report*. The TEDE doses are greater than the limits of 10 CFR 20, "Standards for Protection Against Radiation." However, 10 CRF 20 limits are for normal operations not accident situations. The TEDE indicates that the maximum hypothetical accident (MHA) is the intermediate consequence event per 10 CFR 70.61, "Performance Requirements." |

| No. | Request for additional information |
|---|---|
| **HH2-R-5** | *Section 19.4.11.1.1 of Chapter 19 of the ER contains Table 19-83, "MHA Dose Analysis Results." The applicant states that the dose estimates are derived from EDF-3124-0003, 2015, Preliminary Maximum Hypothetical Accident to Support the Northwest Medical Isotope Facility Environmental Report, Rev. 1, Portage, Inc., Idaho Falls, Idaho, February 5, 2015. Please provide a copy of this document.* |

The requested reference document is attached in Appendix G. EDF-3124-0003 has been updated to Revision 2, which is the version attached in Appendix G. There are three minor differences between NWMI-2013-021 and this appendix, including:

- Stack height is 75 ft. In EDF-3124-0003, 22.86 and 22.9 m are both used in the text. The actual calculations use the non-rounded stack height of 22.86 m (75 ft).
- Density of air in the actual calculation of the EDF was 1,240 $g/m^3$; however, the text in NWMI-2013-021, Chapters 3 and 19, was in error and stated 1,250 $g/m^3$.
- EDF-3124-0003 (Rev. 2) was updated to reflect a 1.32 safety margin in the inventory (consistent with Chapter 13). As part of the updated calculations, the model results were truncated at 1,500 m (4,921 ft) away versus the 1,700 m (5,577 ft) results presented in EDF-3124-0003 (Rev. 1) and NWMI-2013-021, Chapters 13 and 19.

**Noise**

| | |
|---|---|
| **NOI2-1** | *The ISG augmenting NUREG-1537, Part 1, Section, 19.3.2, "Air Quality and Noise" states that the ER should provide a description of any current or past noise studies and analyses conducted at the proposed site or within an audible range of the site and predicted noise levels using the dBA-weighted scale and major sources of noise, including all models, assumptions, and input data. The applicant's responses to RAI NOI-2 and NOI-3 state that noise modeling was performed using Federal Highway Administration's Traffic Noise Model 2.5 and that changes from existing noise levels due to the increased workforce during construction, operation, and decommissioning would be less than 1 dBA. Provide the following information pertaining to the noise modelling conducted:* |
| **NOI2-1A** | *What baseline noise levels were assumed or calculated from the model and what is the basis for the baseline levels?* |

Baseline noise levels were modeled using peak traffic counts for U.S. Highway 63 in Missouri for traffic traveling at 112.7 km/hr (70 mi/hr). Using these traffic counts, the modeled baseline noise level is 68.8 dBA (A-weighted decibel) at the nearest residence.

| | |
|---|---|
| **NOI2-1B** | *The peak traffic count input value used in the model* |

Peak traffic counts used in the baseline noise modeling were 818 in the southbound lane and 1,002 in the northbound lane. Peak traffic counts used to assess facility impact were 918 in the southbound lane and 1,102 in the northbound lane (an increase of 100 vehicles traveling on U.S. Highway 63).

| | |
|---|---|
| **NOI2-1C** | *Clarify if the nearest resident mentioned in the response is the nearest resident from the proposed radioisotope production facility or nearest resident along Highway 63 and provide that distance.* |

The nearest resident used in noise modeling is nearest to both U.S. Highway 63 and to the proposed RPF. Approximate distance to the residence from U.S. Highway 63 is 85.3 m (280 ft), and the distance to the proposed RPF site is 792.5 m (2,600 ft).

| No. | Request for additional information |
|---|---|
| | **Preconstruction** |
| **PREC2-1** | *10 CFR 51.45(c) states that the applicant must include a description of impacts of the preconstruction activities performed by the applicant at the proposed site (i.e., those activities listed in paragraph (1)(ii) in the definition of "construction" contained in 10 CFR 51.4). The ER does not separate preconstruction from construction activities and resources. Provide the following:* |
| **PREC2-1A** | *A description of the preconstruction activities* |

Preconstruction activities are those that are not considered construction activities under the definition of construction currently provided in 10 CFR 51.4, "Definitions." Based on this definition, NWMI considers the following activities as preconstruction:

- Site exploration, including boring to determine foundation conditions and other preconstruction monitoring
- Site preparation, including clearing and grubbing, grading, installation of drainage, erosion and other environmental mitigation measures, and construction of temporary roads and borrow areas
- Erection of fences and other access control measures that are not safety- or security-related or pertain to radiological controls
- Facility excavation
- Construction of support buildings for use in connection with the construction of the proposed RPF, including construction equipment storage sheds, warehouse and shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and office buildings
- Construction of service facilities, including paved roads, parking lots, exterior utility and lighting systems, potable water systems, sanitary sewerage treatment facilities, and electrical systems
- Procurement or fabrication of components or portions of the proposed RPF occurring at other than the final, in-place location at the facility
- Erection of buildings that will be used for activities other than operation of the proposed RPF and that may also be used to house a training or laboratory facility

**PREC2-1B** *Duration of pre-construction activities*

The total duration of preconstruction activities is estimated to be approximately 60 days immediately prior to the start of construction except for site exploration and long-lead procurements. Site exploration will be completed in the second quarter of 2016 to support the completion of the RPF final design and construction drawings. In addition, long-lead procurements of components for the proposed RPF that occur at other than the final, in-place location will be initiated prior to construction. The impacts of these preconstruction activities are included in our construction activity analysis.

**PREC2-1C** *Average and peak-workforce required during pre-construction activities*

The average and peak-workforce required during preconstruction activities is estimated to be 40 percent of the peak and average workforce required for all RPF installations or a peak of 33 and average of 15.

**PREC2-1D** *Number of delivery trucks and offsite shipments during pre-construction activities*

The average number of delivery trucks during preconstruction is estimated at an average of 20 vehicles per week. Offsite shipments of waste and debris is estimated at an average of one per week during preconstruction activities.

| No. | Request for additional information |
|---|---|
| **PREC2-1E** | *Fuel consumed during pre-construction* |

As stated in Table 19-6 of NWMI-2013-021, the majority of the diesel fuel consumed during the RPF installation would be during the first three months of construction. These three months coincide with the preconstruction phase. Based on the average rate of 1,647 liters (L)/month (435 gal/month), the total fuel consumption is estimated at 28,000 L (7,395 gal) of diesel. Approximately 70 percent of the total 19,600 L (5,180 gal) are estimated to be used during preconstruction.

| | |
|---|---|
| **PREC2-1F** | *Volume of water required for onsite activities and the expected source* |

The majority of the water consumed during the RPF installation would be used during preconstruction activities. The volume of water required during preconstruction activities is estimated at less than 7,571 L/day (2,000 gal/day). The source of the water would be the Consolidated Public Water Supply District #1.

| | |
|---|---|
| **PREC2-1G** | *Estimated land disturbed and cleared during pre-construction activities* |

100 percent of Discovery Ridge Lot 15 (2.99 ha [7.4 acres]) will be cleared and grubbed during preconstruction activities.

| | |
|---|---|
| **PREC2-1H** | *Estimated material consumed for the pre-construction portion of activities that is presented in Table 19-7 of the ER* |

Table 2 provides an estimate of the percentage of material presented in Table 19-7 of NWMI-2013-021 that is assumed to be consumed during the preconstruction portion of activities.

**Table 2. Percentage of Materials Consumed During Preconstruction Phase**

| Material | Preconstruction | Amount (pre + construction) | | Material | Preconstruction | Amount (pre + construction) | |
|---|---|---|---|---|---|---|---|
| Concrete | 5% | 3,257 $m^3$ | 4,260 $yd^3$ | Asphalt | 95% | 245 $m^3$ | 320 $yd^3$ |
| Structural steel | 4% | 363 t | 400 tons | Stone granular material | 80% | 1,300 $m^3$ | 1,700 $yd^3$ |
| Miscellaneous steel | 2% | 45 t | 50 tons | Roofing | 8% | 4,645 $m^2$ | 50,000 $ft^2$ |
| Steel liner | 0% | 127 t | 140 tons | Precast concrete | 0% | 435 t | 480 tons |

| No. | Request for additional information |
|---|---|
| | Preconstruction (continued) |
| **PREC2-1I** | *Number of hours and material moved for the pre-construction portion of the activity and equipment identified in Table 19-51* |

The number of hours and material moved for the preconstruction portion of RPF installation activities for the equipment identified in Table 19-51 of NWMI-2013-021 are identified in Table 3.

**Table 3. Number of Hours and Material Moved for the Preconstruction Portion of the Radioisotope Production Facility Installation**

| Activity/equipment | Number of hours run | Material moved (t) | Material moved (tons) |
|---|---|---|---|
| Bulldozing | 100 | N/A | N/A |
| Loading of earth haulers from excavators | 100 | 10,886 | 12,000 |
| Loading of earth haulers from front loaders | 30 | 10,886 | 12,000 |
| Unloading of fill material from earth haulers | 100 | 21,772 | 24,000 |
| Compacting | 64 | N/A | N/A |
| Motor grading | 64 | N/A | N/A |

N/A = not applicable.

| No. | Request for additional information |
|---|---|
| | **Proposed Action** |
| **PA2-1** | *The ISG augmenting NUREG-1537, Part 1, Section 19.2, "Proposed Action" states that the application should provide a schedule showing the major phases of the proposed action. Section 19.2.1.1 of the ER identifies the start date of decommissioning, however, information on the duration of decommissioning activities (similar to what was provided for construction) is not included. Please provide information on the duration (e.g., months, years) of the decommissioning phase.* |
| | The duration of RPF decommissioning activities is estimated to take 18 to 24 months. |
| **PA2-2** | *The ISG augmenting NUREG-1537, Part 1, Section 19.2, "Proposed Action" states that the application should estimate the average number of truck deliveries and shipments of waste material offsite per day, week, or month during each of the major phases of the proposed action.*<br>*The applicant's response to RAI PA-4 states that Table 19-6 of the ER, row "Offsite radioactive materials and waste shipment," includes irradiated and unirradiated LEU targets, $^{99}$Mo shipments, radioactive waste, and low-enriched uranium (LEU) shipments. Table 19-6 identifies 10 offsite radioactive materials and waste shipments per week during operation, therefore approximately 520 shipments/year. Table 19-14 identifies 2 shipments/year of fresh LEU, 42 shipments/year of unirradiated LEU targets, 136 shipments/year of irradiated LEU targets, 104 shipments/year of $^{99}$Mo product, 2 shipments/year of spent LEU, and 200 shipments/year of radioactive waste, which results in a total of 486 shipments/year. Please explain the differences in the number of offsite shipments (520 shipment/year versus 486 shipments/year) identified in Table 19-6 and Table 19-14.* |
| | The values in Table 19-6 and Table 19-14 are effectively the same. The Table 19-6 number of offsite shipments was rounded up from 9.4 to 10 (for bounding purposes) when converted to shipments per week. Thus, 486 shipments per year divided by 52 weeks was rounded up to 10 shipments per week. |

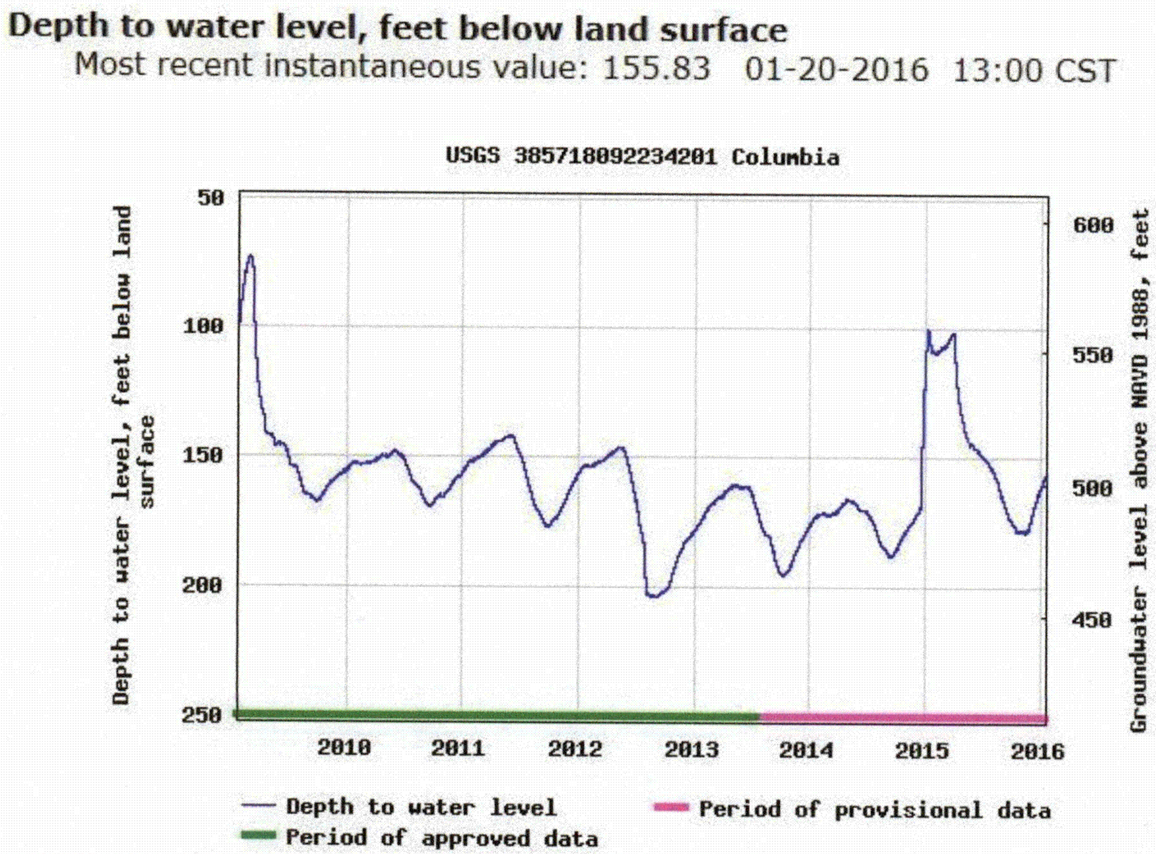
| No. | Request for additional information |
|---|---|
| **PA2-3** | *The ISG augmenting NUREG-1537, Part 1, Section 19.2, "Proposed Action" states that the application should describe the proposed action and provide a detailed description of the proposed action and the general progression of the project including, in part, pre-operational and operational activities.*<br>*The applicant's response to RAI PA-1 states that the impacts associated with the preoperational phase were considered within the operating phase of the RPF. Table 19-6 of the ER identifies 2 delivery trucks per week and 0.5 offsite radioactive materials and waste shipments per week during the pre-operation phase. Please identify and summarize the types of materials (for instance, LEU) that will be delivered and off-site shipments during the pre-operation phase, as was provided for operations in ER Table 19-14.* |

During the pre-operations phase, the RPF will receive chemicals and process supplies needed to complete construction and operability testing. A small quantity of natural or depleted uranium will also be received for equipment testing and process testing. The natural uranium will have to be flushed from the system and disposed of before LEU operations. No irradiated material will be handled in this phase; therefore, no corresponding data is shown in Table 19-14 of NWMI-2013-021.

| No. | Request for additional information |
|---|---|
| | Water Resources |
| **WAT2-1** | *ISG to NUREG-1537, Part 1, Section 19.3.4, "Water Resources," states that the applicant should describe site-specific and regional data on the physical and hydrological characteristics of surface water and groundwater, etc. Section 19.3.4 further states that the following groundwater characteristics should be provided for features that could be affected by the construction, operation, and decommissioning of proposed facilities as follows:*<br>a. *Historical and seasonal trends in groundwater elevation or piezometric levels.*<br>b. *Piezometric contour maps, water table contour maps, and hydraulic gradients (historical, if available, and current).*<br>c. *Depth to water table for unconfined aquifer systems.*<br>d. *Historical and current data from site wells (e.g., monitoring, background, corrective action, or other uses).*<br>e. *Hydrostratigraphy of the site, including cross-sections and hydrostratigraphic unit descriptions.*<br>f. *Qualitative description of groundwater aquifers, including identification of U.S. Environmental Protection Agency (EPA)-designated sole-source aquifers.*<br>*The information the applicant provided in the ER and response to RAI GEO-1 do not provide sufficient information with respect to the above referenced items, and site-specific information on groundwater conditions relative to the proposed RPF site and vicinity, including static water levels and groundwater flow direction. Please provide the information in items (a) through (e) above and in sufficient detail to specifically address the issue of whether groundwater encountered in previously completed soil borings across the Discovery Ridge Site reflects a surficial water-table aquifer or perched groundwater and/or whether this groundwater is a local water supply source.* |

| No. | Request for additional information |
|---|---|
| WAT2-1A | *Historical and seasonal trends in groundwater elevation or piezometric levels.* |

There is no historical groundwater data specifically for the RPF site. The nearest U.S. Geological Survey monitoring well (USGS, 2016) is 11.9 km (7.4 mi) to the northwest (Latitude 38°57'18", Longitude 92°23'42" NAD83) of the RPF site. This well provides an indication of the historical groundwater fluctuation and seasonal trends. Figure 1 shows the water level over the past seven years. The depth to groundwater at that well has varied from a minimum of 22.9 m (75 ft) to a maximum over 60.96 m (200 ft). As shown in Figure 1, the groundwater level normally peaks in July, dropping from 7.6 to 15.2 m (25 to 50 ft) in October.




Source: USGS, 2016, "USGS National Water Information System: Web Interface," http://waterdata.usgs.gov/nwis?program =uv&site_no=385718092234201&agency_cd=USGS, U.S. Geological Survey, Reston, Virginia, accessed January 20, 2016.

**Figure 1. U.S. Geological Survey Well 385718092234201 Depth to Water (WAT2-1A-1)**

| No. | Request for additional information |
|---|---|
| | Water Resources (continued) |
| WAT2-1B | *Piezometric contour maps, water table contour maps, and hydraulic gradients (historical, if available, and current).* |

There are no current Piezometric contour maps of the area. Figure 19-37 of NWMI-2013-021 provides the current water table contour map of the site. Figure 2 (on the following page) provides a map of the hydraulic gradient and groundwater flow direction map near and around Discovery Ridge.

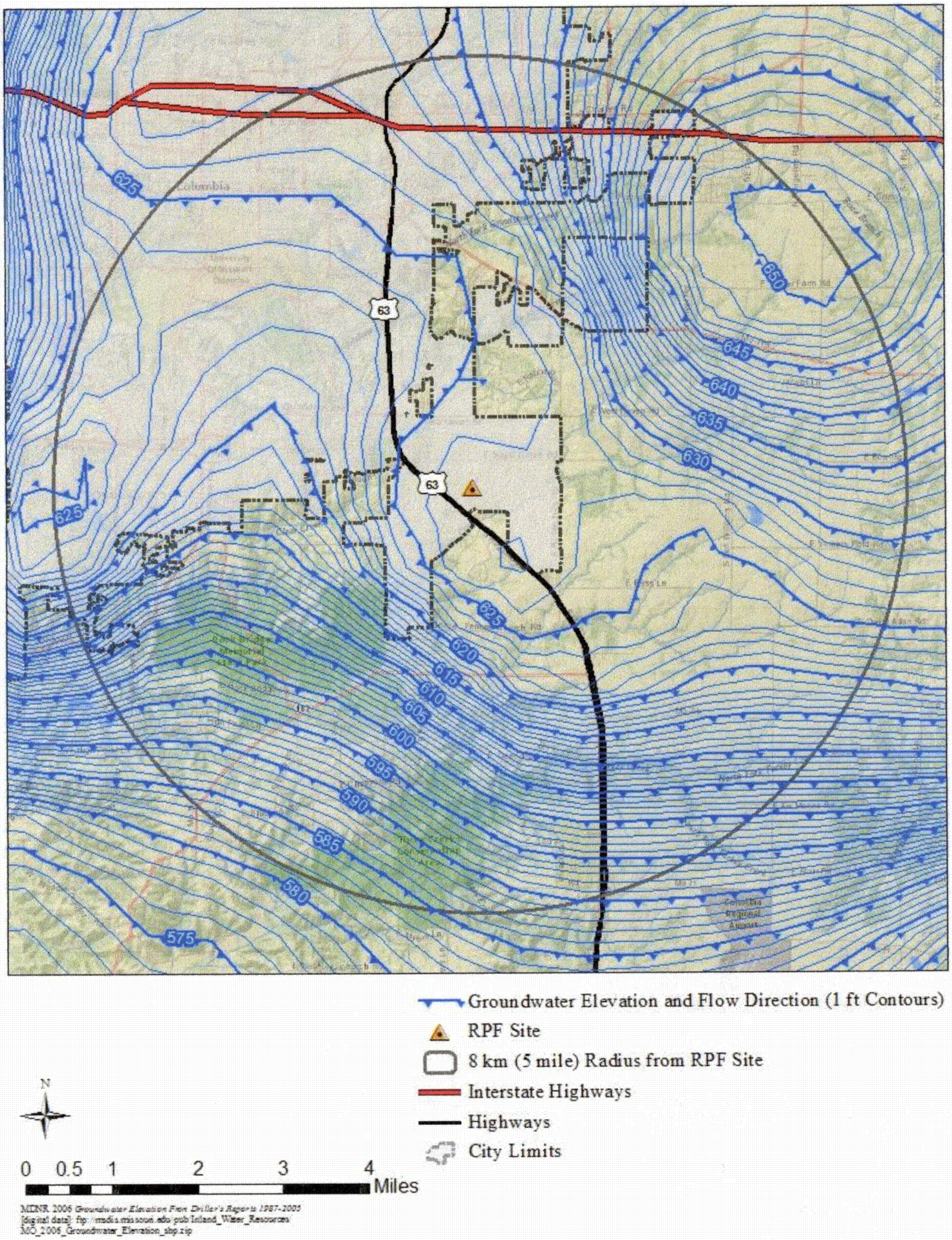



**Figure 2. Hydraulic Gradient and Groundwater Flow Direction Map (WAT2-1B-1)**

| No. | Request for additional information |
|---|---|
| | Water Resources (continued) |
| **WAT2-1C** | *Depth to water table for unconfined aquifer systems.* |

The Mississippian aquifer is unconfined in the Boone County area and underlies Discovery Ridge. The site has an estimated depth from 22.9 to 67.1 m (75 to 220 ft) below the ground surface.

| | |
|---|---|
| **WAT2-1D** | *Historical and current data from site wells (e.g., monitoring, background, corrective action, or other uses).* |

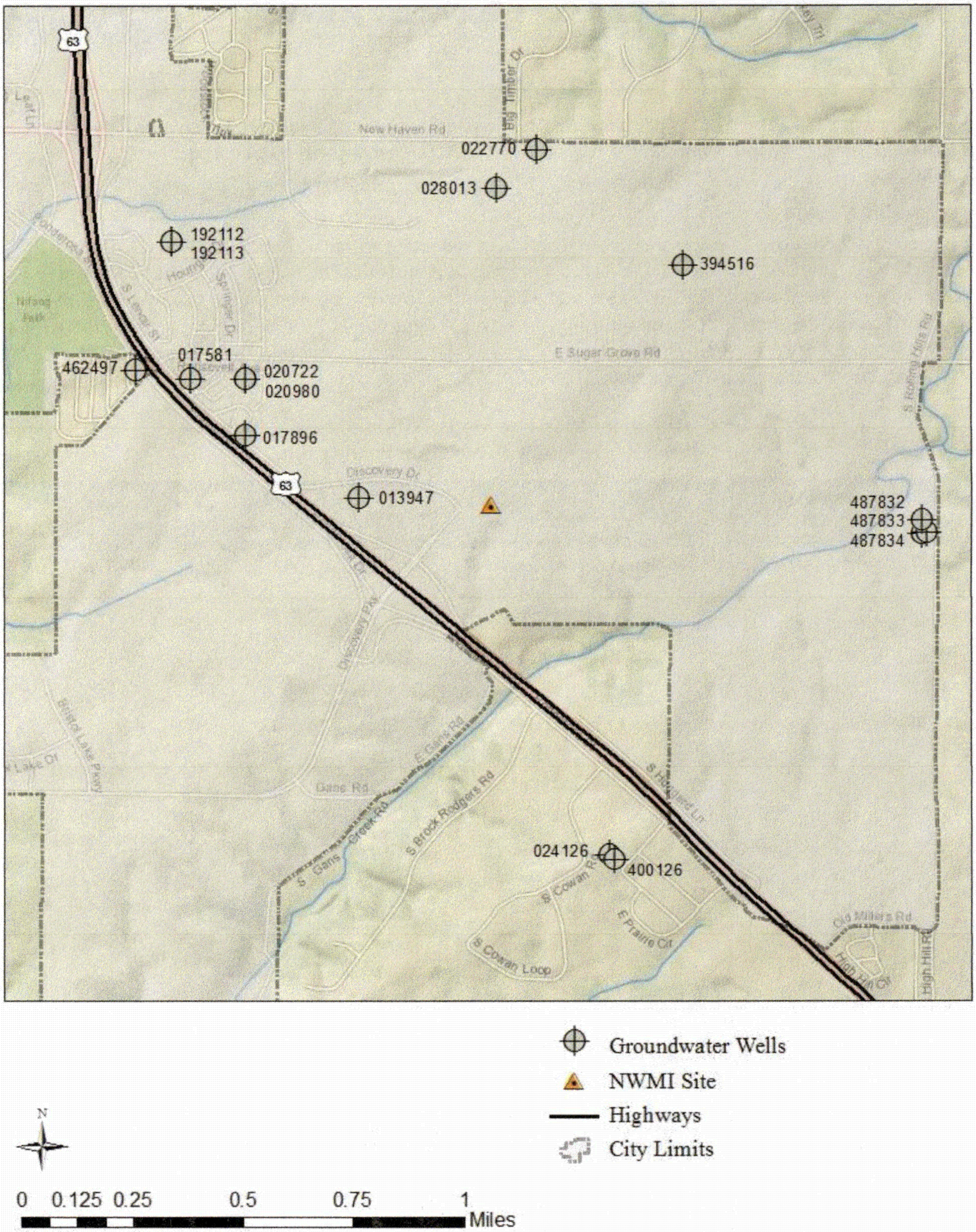
Figure 3 (on the following page) shows the location of the wells within 1.6 km (1-mi) radius of the RPF site (MDNR, 2006 and MDNR, 2014). Table 4 provides the historical data associated with each well recorded when the well was drilled. These wells primarily show a static water level from 55 to 99 m (180 to 325 ft) below the surface. Two monitoring wells drilled approximately 1.6 km (1 mi) east of the RPF site encountered water at 10.97 and 11.89 m (36 and 39 ft). No additional information is available on these boreholes or the water encountered.

**Table 4. Historical Data For Wells Within A 1-Mile Radius of the Radioisotope Production Facility Site**

| Well number | Well type | Owner | Date drilled | Drilled depth (ft) | Depth to bedrock (ft) | Static water level (ft) | Elevation (ft) |
|---|---|---|---|---|---|---|---|
| 13947 | Community public well | University of Missouri-Columbia | 9/13/55 | 587 | 60 | 270 | 810 |
| 17581 | Community public well | Gase Trailer Court | 5/11/05 | 525 | 40 | 230 | 804 |
| 17896 | Private well | Phillips Angus Farm | 11/20/58 | 505 | 40 | 300 | 792 |
| 20722 | Community public well | Edwin Gose Trailer Park | 1961 | 600 | 50 | 325 | 798 |
| 20980 | Community public well | Edwin Gose Trailer Park | 1961 | 600 | 50 | | 797 |
| 22770 | Non-community public well | Columbia Environmental Research | 7/1/64 | 1,100 | 70 | 312 | 820 |
| 24126 | Community public well | Boone Co Cons PWSD #1 | 12/1/65 | 1,190 | 60 | 300 | 820 |
| 28013 | Non-community public well | Columbia Environmental Research | 11/1/75 | 1,250 | 55 | - | 800 |
| 192112 | Water | Not identified | 7/8/97 | 720 | - | 180 | - |
| 192113 | Water | Not identified | 7/9/97 | 760 | - | 180 | - |
| 394516 | Domestic | Not identified | 10/20/06 | 766 | - | 200 | - |
| 400126 | Public | Not identified | 9/20/08 | 1,475 | - | 280 | 807 |
| 408872 | Heat pump | Not identified | 4/1/10 | 187 | - | - | - |
| 462497 | Soil boring | Not identified | 11/28/11 | 16 | - | - | - |
| 487832 | Soil boring | Not identified | 10/18/13 | 104 | - | - | - |
| 487833 | Monitoring | Not identified | 10/18/13 | 42 | - | 39 | - |
| 487834 | Monitoring | Not identified | 10/18/13 | 40 | - | 36 | - |

Sources: MDNR, 2014, "MO 2014 Wells (SHP) Geospatial Data," ftp://msdis.missouri.edu/pub/Geological_Geophysical/MO_2014_Wells_shp.zip, Missouri Department of Natural Resources, Jefferson City, Missouri, 2014.

MDNR, 2006, "MO 2006 Well Logs (SHP) Geospatial Data," ftp://msdis.missouri.edu/pub/Geological_Geophysical/MO_2006_Well_Logs_shp.zip, Missouri Department of Natural Resources, Jefferson City, Missouri, 2014.

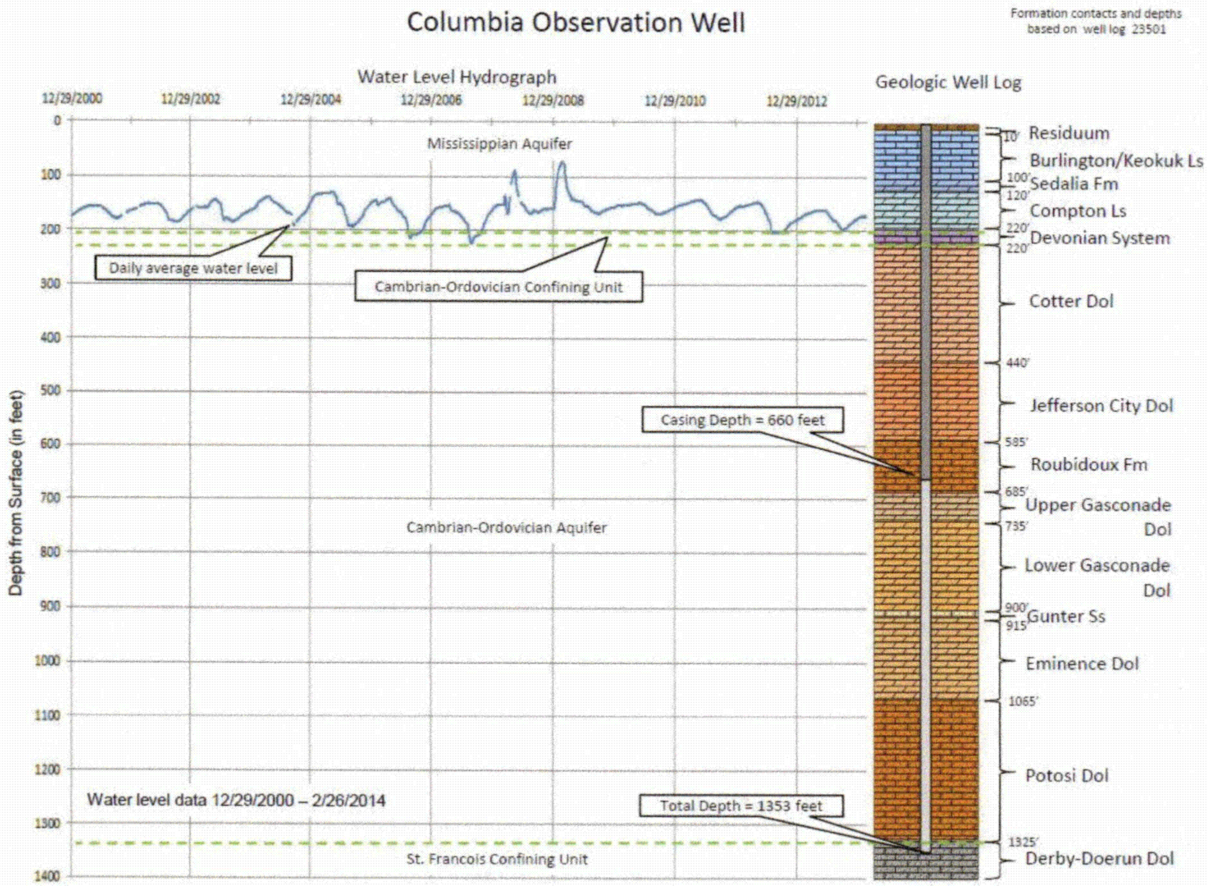



MDNR 2006 *Groundwater Elevation From Driller's Reports 1987-2005* [digital data]. ftp://msdis.missouri.edu/pub/Inland_Water_Resources/MO_2006_Groundwater_Elevation_shp.zip

**Figure 3. Wells Located within 1.6 Kilometer (1-Mile) Radius of the Radioisotope Production Facility Site (WAT2-1D-1)**

| No. | Request for additional information |
|---|---|
| | Water Resources (continued) |
| **WAT2-1E** | *Hydrostratigraphy of the site, including cross-sections and hydrostratigraphic unit descriptions.* |

Figure 4 provides a qualitative description of the groundwater aquifers (i.e., hydrostratigraphy) in the Columbia, Missouri area.




Source: MDNR, 2016, "Well Log No. 23501, Strathydrograph," http://dnr.mo.gov/geology/wrc/groundwater/strathydrographs/columbia.pdf, Missouri Department of Natural Resources, Jefferson City, Missouri, accessed January 25, 2016.

**Figure 4. Columbia Observation Well (WAT2-1E-1)**

| No. | Request for additional information |
|---|---|
| **WAT2-1F** | *Qualitative description of groundwater aquifers, including identification of U.S. Environmental Protection Agency (EPA)-designated sole-source aquifers.* |

There are two significant aquifers that underlie the RPF site: the Mississippian and Cambrian-Ordovician aquifers. The Mississippian aquifer is the uppermost aquifer in Paleozoic rocks in northern Missouri. The Mississippian aquifer underlies all of Missouri north of the Missouri River except for small areas near the Mississippi and Missouri Rivers where rocks composing the aquifer have been removed by erosion. The name "Mississippian" was given to this aquifer because it consists of limestone of Mississippian age. The geologic units that compose this aquifer include the Keokuk, Burlington, Fern Glen, Sedalia, and Chouteau Limestones. Of these formations, the Keokuk and the Burlington Limestones are the principal water-yielding units. Both formations consist of crystalline limestone and yield water primarily from solution cavities. In most places, the Mississippian aquifer is overlain by a confining unit of Pennsylvanian shale and sandstone and regionally the entire aquifer is underlain by a confining unit of Mississippian shale (USGS, 1997). However, based on the review of nearby well log data obtained from the Missouri Department of Natural Resources (MDNR) geographic information systems (GIS) database for wells located within a 1.6 km (1-mi) radius of the subject property, no Pennsylvanian shale or sandstone was noted. Only the eastern one-third of the Mississippian aquifer contains freshwater; the remaining two-thirds contain slightly saline to very saline water. Therefore, the chemical quality of the Mississippian aquifer varies extensively throughout the aquifer (USGS, 1997). Additional detail on water quality is provided in Section 19.3.4.2.2 of NWMI-2013-021.

The Mississippian aquifer averages about 60.96 m (200 ft) thick in Boone County but exceeds 121.9 m (400 ft) in northwestern Missouri. The thinnest portion of the aquifer is near the Mississippi and Missouri Rivers, where the aquifer has been dissected or partially removed by erosion.

The Cambrian-Ordovician aquifer system underlies the Mississippian aquifer in Columbia, Missouri north of the Missouri River. The Cambrian-Ordovician aquifer system contains very productive aquifers throughout an area of approximately 416,988 km$^2$ (161,000 mi$^2$) in Minnesota, Wisconsin, Iowa, northern Missouri, and northern Illinois. Many metropolitan areas depend on this aquifer system for municipal and industrial water supplies. The aquifer system is also used extensively for self-supplied industrial, rural, and domestic water supplies (USGS, 1992).

The Cambrian-Ordovician aquifer system is designated as one of 16 sandstone principal aquifers that underlies the U.S. The aquifer system includes several carbonate (limestone and dolomite) rock units with shale layers. Some of the sandstones are interbedded with carbonate units or, in places, contain secondary carbonate mineralization as cementation between grains. The Missouri River forms a natural boundary on the southern edge in Missouri and the southwestern edge in western Iowa. South of the Missouri River, the Cambrian and Ordovician rocks are included in the Ozark Plateau aquifer system, which is designated as one of the carbonate principal aquifers (USGS, 2012).

Freshwater is found in the Cambrian-Ordovician aquifer along a band approximately 80.5 km (50 mi) wide, which is parallel to and north of the Missouri River from Boone County eastward to the Mississippi River (USGS, 2012).

To better define the strathydrograph underlying the RPF site, two sources were evaluated. These sources include the MDNR strathydrograph for groundwater observation well (Well ID No. 23501, USGS well number 385718092234201 Columbia) located approximately 11.9 km (7.4 mi) to the northwest of the RPF site and well driller logs for wells located near the RPF site.

Figure 5 provides a strathydrograph for Groundwater Observation Well No. 23501 and provides geologic detail and the observed depths of both the Mississippian and Cambrian-Ordovician aquifers. Though located several miles from the RPF site, this strathydrograph provides an information on the hydrogeology in the region near the RPF site. The Mississippian aquifer is unconfined in this region and has historical daily average water levels that have ranged from a minimum depth of 22.9 m (75 ft) below the ground surface (bgs) to as deep as 67.1 m-bgs (220 ft-bgs).

Geologic well data from four driller's well logs (Well ID Nos. 013947, 017581, 017896, and 020722) located within 1.6 km (1-mi) of the RPF site were also evaluated to estimate the approximate depth to static groundwater level, depth to water-bearing geologic formations, and depth to aquifer systems underlying the RPF site (Figure 3). The GIS well data file reviewed (MDNR, 2006) provides the geologic stratigraphy within these wells as the following:

- **Glacial Drift** – Ranging from 0–18.3 m-bgs (0–60 ft-bgs), composed of topsoil, sand, clay, residuum, and/or gravel.
- **Mississippian System** – Ranging from 12.192–18.3 m-bgs (40–60 ft-bgs) and extending to depths of 85.3 m-bgs (280 ft-bgs) (Well ID Nos. 013974 and 017581).
- **Ordovician System** – Beginning at depths of 85.3 m-bgs (280 ft-bgs) (Well ID Nos. 013974 and 017581) and extending depths up to 182.9 m-bgs (600 ft-bgs) in Well ID No. 020722.

Static water levels are listed for these four wells at depths ranging from 70.1 to 99 m-bgs (230 to 325 ft-bgs) within the Mississippian and Cambrian-Ordovician aquifers. The MDNR well located nearest the subject property is Well ID No. 013947. This well is located approximately 0.48 km (0.3 mi) west-northwest of the subject property. The static water level measured in this well at the time of drilling (1958) was 82.3 m-bgs (270 ft-bgs).

There are no sole source aquifers in Missouri (EPA, 2016).

Based on the information detailed in RAI WAT2-1A through WAT2-1F, the groundwater identified in Boreholes B-5 and B-6 is not a surficial water-table aquifer and not a local water supply source. The source of the water encountered in Borehole B-6 could be from two other sources: (1) perched water from surface infiltration, or (2) potentially brought down the borehole during drilling.

Of the nine boreholes drilled by Terracon (Terracon, 2011) across the Discovery Ridge site, water was only identified in two, Boreholes B-5 and B-6. Borehole B-6 was located approximately one-third of a mile to the south of the Borehole B-5 and with a surface elevation 7.6 m (25 ft) lower. Borehole B-6 encountered weathered limestone at 5.2 m (17 ft) and refusal at 5.8 m (18.9 ft). Water was identified at a depth of 5.8 m (18.9 ft) for Borehole B-5, located on the eastern edge of the RPF site, and was drilled to 6.1 m (20 ft). According to the drill log, water was encountered at 5.2 m (17 ft) near the interface between sandy lean and fat clay. The water content of fat clay sample collected was 19 percent. This water content was similar to or less than the fat clay sample collected from the other boreholes where no water was encountered.

With the high water content of the soil and clay near the surface (24 and 34 percent, respectively), water could have seeped into the hole during the drilling process and was not noticed by the well logger.

Figure 5 provides a cross-section stratigraphic unit description of Discovery Ridge interpreted from the four Terracon bore holes that line up from east to west across the RPF site. This cross-section supports the potential that the water is not perched. The site-specific geotechnical and hydrological studies will better resolve this question.

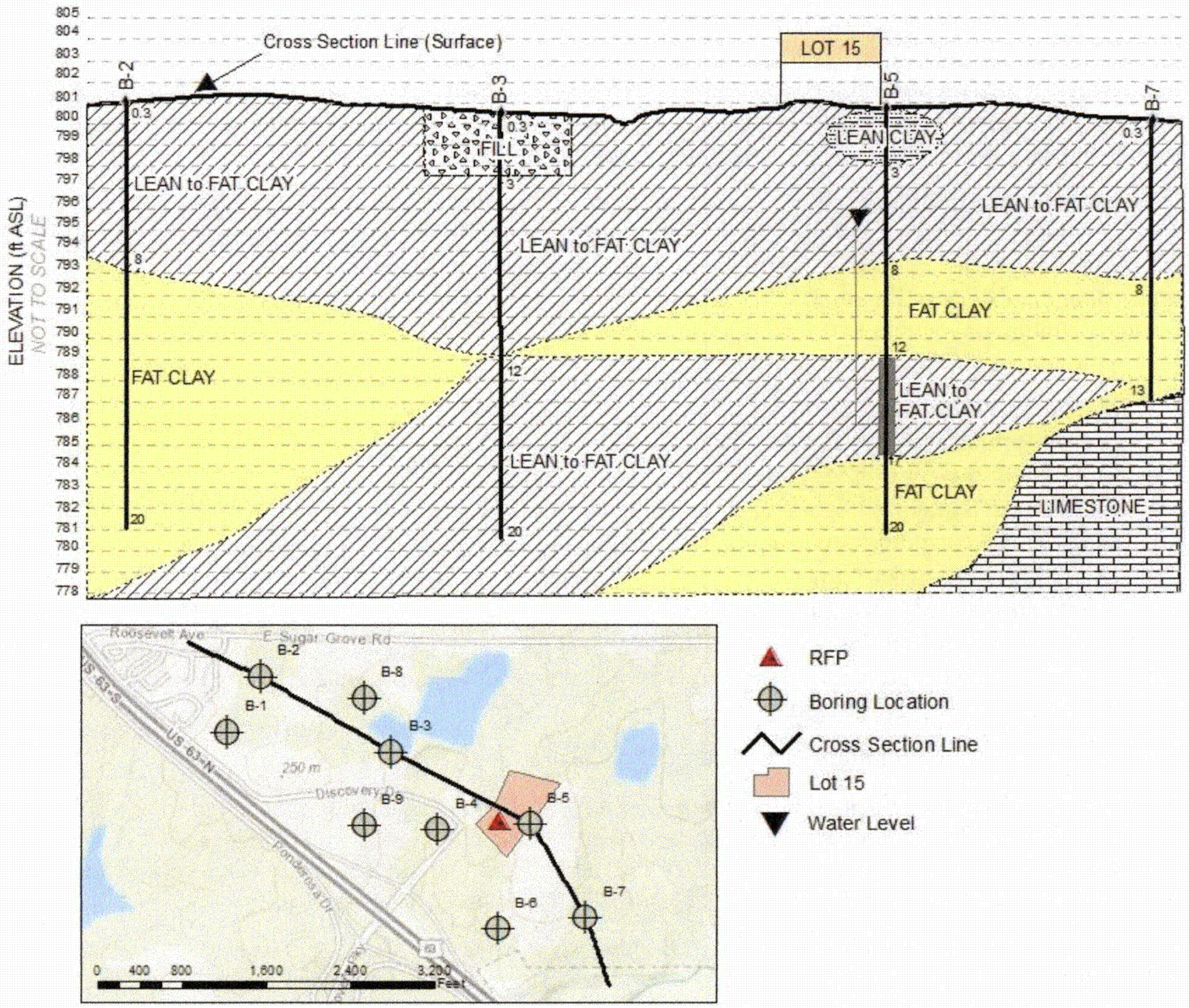



**Figure 5. Discovery Ridge Stratigraphic Unit Description (WAT2-1D-1)**

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NWMI
NORTHWEST MEDICAL ISOTOPES

# Response to the U.S. Nuclear Regulatory Commission Request for Additional Information, Round 2

# Environmental Review of the Northwest Medical Isotopes, LLC Construction Permit Application

NWMI-2016-RAI-001, Rev. 0
February 2016

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# APPENDICES